Technological Trends in Computing

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Preface

The appeareance, development and success of computational tools and processes have brought about innovation in manifold topics of science and technology worldwide. Science and technology advances to fulfil mankind needs, have lately been triggered by innovation and development in computing science. The accelerated development pace of computing research has impinged on the increasing variety of topics on computational science.

This special issue of *Research in Computing Science* is titled Technological Trends in Computing. It contains 12 articles that were selected and based on a rigorous review process conducted by members of our Editorial Board. It is noteworthy that the content of this issue is a comprehensive set of results related to research projects and technological development. In this volume we present scientific contributions on topics of interest to the community involved in computing, engineering and related areas.

The intention of this issue is to be a compendium that comprises three main sections. The first one focuses on advances in Computational Intelligence; the second one, presents remarkable results related to Software Engineering and Computer Security; while the third includes Mechatronics and Parallel Processing contributions.

October, 2014

Juan Carlos Herrera Lozada
Mario Aldape Pérez

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Best Practices for Web Development using Grails and Django

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Abstract. A best practice is a technique or an important aspect that helps to develop Web applications more efficiently. Best practices on Web frameworks reduce the development time and effort, saving money, increasing the quality of code, enabling to create friendly and interactive applications. This paper is focused on identifying and providing according to the experiences and requirements of the users, the best practices for Web development by using Grails and Django Web frameworks. With these best practices, developers can develop more interactive and efficient Web applications, integrating features of Web 2.0 technologies with less effort as well as exploiting the framework benefits. As proof of concept we have developed a set of Web applications by using best practices as HTML5, Comet support, AJAX, ORM, extensibility, among others.

Keywords: Web frameworks, Grails, Django, Web 2.0.

1 Introduction

A framework is a high-level solution for the reuse of software pieces, a step forward in simple library-based reuse that allows the sharing of not only common functions but also the generic logic of a domain application. It also ensures a better level of quality for the final product, given the fact that an important fragment of the application is already found within the framework and it has already been tested [1]. There are many Java-based Web frameworks such as JSF and Struts, Ruby-based Web frameworks such as Ruby on Rails and PHP-based Web frameworks such as CakePHP, to mention but a few. Grails and Django have emerged as Web frameworks open source for their features as scalability, functionality, reduction of development time, increase the quality of code by using minimal resources. These Web frameworks are based on Groovy and Python respectively. Additionally, these Web frameworks allow developing applications in an easy and interactive way which are very important for software developers and Web engineering.

Best practices on Web development have been proposed and applied facilitating the development and improving the final product quality. Some examples are Testing a Website: Best Practices [2], Jakarta Struts Live and best practices [1], Struts Survival Guide, Basics to best practices [3], Applying best practices in website redesign: the Queens College Libraries experience [4], A Framework for Process Management in Service Oriented Virtual Organizations [5], Staying Afloat in an Expanding Sea of Choices: Emerging Best Practices for Eclipse Rich Client Platform Development [6].
This work is structured as follows. Section 2 discusses the state-of-the-art on the development of Web applications by using best practices. Section 3 provides a brief description and overview of the main Web frameworks for Web development. Section 4 addresses the description in detail of best practices on Web development. Section 5 presents a comparison and discussion among Ruby on Rails, JSF, Struts, CakePHP, Lift and Yii Web frameworks. Finally, section 6 remarks the conclusions and future work emphasizing our contribution.

2 Related Works

In recent years, several works have been proposed with the aim of obtaining the best practices of Web frameworks. Also, these works provide information related to some main features of Web frameworks. Jim et al. [7] determined the necessary knowledge for the internationalization of standards, maintenance, access and usability for people with disabilities as well as inspections and tests in the use of websites. The research introduced the IEEE Std 2001-2002 standard as a best practice to enhance websites design. Darlene F. et al. [8] discussed that most developers are focused on functionality specifically without taking into account the design and content bringing to implement reengineering. To solve this, a series of best practices is presented in order to create content and graphical interfaces of web applications in a clear way. Xufeng L. et al. [9] proposed a novel concept called Smart Business Object (SBO). In essence, SBOs are Web-ready business objects. SBOs have high-level, Web-oriented attributes, such as email, URL, image, video, documents, among others. Richard T. et al. [10] evaluated the experience of the developers, balance, agility, discipline, cost-benefit, maturity and competencies of organizations, for the determination of a set of best practice. J. Barrie et al. [11] emphasized the lack of evidence about the use of best practices used effectively. The research recommended disseminating information about them among evaluators and advisors. Alex N. et al. [12] analyzed that the mobile data traffic is most used on iOS and android platforms. The research proposed to use the best practices of desktop applications for fastest experiences in mobile applications. James M. et al. [13] examined the best practices in website re-design. The research established for its two interconnected parts, the web development process and web design. The authors demonstrated how best practices were applied to coordinate a library web site redesign project and to engineer the website for optimum usability, resulting in the creation of a new improved website. S. Rodrigo et al. [14] determined that

for most applications, there are multiple tasks that are repetitive, complex and prone to errors, which proposed a framework of multilayer object oriented automation of basic tasks for business applications. W. Harrison et al. [15] mentioned that the term "best practice" has often been misused in some publications, in this context they defined as experience the true meaning of a best practice contributing to a better performance.

As can be observed, the aforementioned works suffer from several drawbacks such as a) an analysis of different Web frameworks based on their best practices is missed; b) only the best practices of Java-based frameworks are well-known; c) there are not guides and reports for implementation of best practices with Django and Grails frameworks; This work tries to solve the aforementioned deficiencies by identifying and providing best practices as well as implementation examples.

3 Frameworks for Web Development

There are several types of Web frameworks: user interface-oriented such as Java Server Faces, document publishing-oriented as Coocon, event control-oriented such as Struts, actions and controls-based directly managing incoming requests with structure in particular as Grails, and component-based which encapsulate the logic of reusable components such as Tapestry [16]. The main objectives of a Web framework are: 1) rapid application development, 2) reuse existing code. The most widely used Web frameworks implement the MVC pattern and they have features such as tags support, HTML integration, form validation, extensibility, using templates, Ajax support and internationalization. Struts, JSF, CakePHP, Rails, Yii, Grails and Django are compared through their best practices. Table 1 shows seven Web frameworks which were chosen because they are the most used in entertainment-focused companies like Netflix, Facebook©, SKY©, ESPN©, Twitter© or YouTube©.

Table 1. Types of Web frameworks

Framework	License	General Description
Struts	Open Source, (Apache)	It is a Java-based open source used to create Web applications based on servlets and Java Server Pages technology (JSP) [17]
JSF	Open Source, (CDDL+GPL)	It is a Java-based web application framework intended to simplify development integration of web-based user interfaces [18]
CakePHP	Open Source, (MIT/X11)	It is a PHP-based having a basic structure for Web applications; its main purpose is to allow work in a structured and quickly without loss of flexibility [19].
Ruby on Rails	Open Source, (MIT)	It uses the MVC pattern written in Ruby, a programming language for dynamic types like Python, Smalltalk, and Perl [20].
Yii	Open Source, (BSD)	This framework is ideal for high performance, written in PHP 5 oriented rapid construction of large-scale applications. Its main

		goals are ease, extensibility and efficiency by using the MVC pattern [21].
Grails	Open Source (Apache 2.0)	Java-based framework that uses a scripting language called Groovy, but it has no specific IDE plugins for each one of the existing Java-based IDEs.
Django	Open Source, (BSD)	This framework uses Python programming language, which promotes rapid development and clean design, practical, concise and powerful dynamic Web pages. This framework uses the pattern (Model-View- Template) [22].

Although these frameworks are open source, they use different programming languages and other general characteristics. However, best practices are common among them.

4 Best Practices for Web Development

Best practices are activities, technical or important issues identified by users, who have rendered excellent service and they are expected to achieve similar results on similar contexts. The use of best practices has benefits such as save time, save money, increase code quality and create easy and interactive applications.

Best practices follow standards, unit testing, code reuse, version control and use recognized design patterns. In this paper, the main purpose was to gather and present a list of the most relevant engineering practices prevalent in the development community today by analyzing best practices reported by others studies of Web frameworks such as books and Web development community; identifying those that enable three of the most important quality criteria for success of Web applications 1) Reliability, 2) Usability and 3) Security. In Table 2, best practices selected for Web development are described in order to generate code quality, standardize the development, ease of maintenance, providing security and scalability, facilitate reuse, maintenance and integration evenly and encourage rapid application development.

Table 2. Best Practices for Web Development

Best Practice	Description
Scaffolding	It is a technique supported by some model-view-controller frameworks, in which the programmer may write a specification that describes how the application database may be used.
Internationalization	It is the process of designing an application in order to be adapted to various languages and regions.
Forms validation	It is the process of checking that a form has been correctly filled before it is processed. There are two methods for validation: client-side and server-side.
Using Templates	Templates allow modifying Web pages and reusing Web page compo-

	nents much simpler.
Customization for error messages	Custom error messages provide more informative, or friendly, feedback than standard error messages. It aims to the user to understand more clearly each mistake for a process that user performs.
Security	It permits prevention of common vulnerabilities such as SQL injection, loss of authentication and session management, access restriction fails to URL, among others.
HTML5	It establishes a series of new elements and attributes that reflect typical usage on modern Web sites.
AJAX Support	It is used for s asynchronous client-server interaction in order to develop interactive Web applications.
Comet Support	Comet is a technique that allows a Web application to push messages from server to client.
Extensibility	It adds functionality and customizes the behavior of the application with plugins or other options.
ORM	It is a programming technique for converting data between incompatible types systems in object-oriented programing languages.
Compliance to W3C Standards	They are a set of recommendations that serve as reference to build Web applications with quality, accessible, interoperable and efficient, where increasingly develop robust applications.

Some companies have adopted the use of best practices for the development of their own web sites. Some examples are official sites of Netflix©, Sky TV© Guide, Ticketbis©, Yellow Pages© and Vodafone Music©.

There are other best practices for software development such as: pattern matching, SiteMap, cloud computing, REST (Representational State Transfer) support, wiring, Parallel rendering, which they are out of the aim and scope of this work.

5 Comparative Analysis of Best Practices among Web Frameworks

In this section a comparative analysis of best practices for Web development is presented. Essentially, the selection of the best Web development framework has become more complex, specifically due to three reasons: 1) a broader perspective, the Web technology landscape has undergone a radical change; 2) there is more choice of technology; and 3) requirements for modern Web applications are changing. After an extensive research [23], the best Java-based frameworks Web were obtained, these frameworks are JSF and Struts. Grails is currently one of the most popular open source web framework for the Java platform due to it takes advantage of Groovy's dynamic language features. CakePHP is one of the best Web frameworks in the PHP programming language according to the top 10 ranking[1]. Finally Ruby on Rails is the most popular framework of the Ruby programming language[2].

[1] http://www.mustap.com/phpzone_post_73_top-10-php-mvc-frameworks.

This comparative analysis is supported by JSF, Ruby on Rails, Struts, CakePHP, Yii, Grails and Django Web frameworks as shown in Table 3.

Table 3. Best practices for Web development supported by Struts, JSF, CakePHP, Ruby on Rails, Yii, Grails and Django

Best Practices	Struts	JSF	Cake PHP	Ruby on Rails	Yii	Grails	Django
Scaffolding	No	Yes	Yes	Yes	Yes	Yes	Yes
Internationalization	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Forms validation	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Using Templates	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Customization for error messages	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Security	Yes	Yes	Yes	Yes	Yes	Yes	Yes
HTML5	No	No	No	No	Yes	Yes	Yes
AJAX Support	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Comet Support	No	No	No	No	Yes	Yes	Yes
Extensibility	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ORM	Yes	Yes	Yes	Yes	Yes	Yes	Yes

The support of best practices on Grails and Django-based Web applications are described below.

Scaffolding: Django has an interesting aspect by offering support to build friendly interfaces in order to dominate the CRUD (Create, Read, Update and Delete) operations by using SQLite3 database. Django has support for other databases as MySQL, Postgres and Oracle by configuring the settings.py file; to automatically generate the classes and methods in Python-based code to interact with the database.

Internationalization: Grails has support (i18n) by leveraging the MVC architectural pattern, customizing the text that appears in the views according to the user location. A Locale Object represents a specific geographical area, this will need to specify it by its language code in the Message Bundles folder in the properties files. In Fig. 1, a screenshot of a Grails-based Web application by using Internationalization switching to Spanish-México and English language is shown.

[2] http://en.wikipedia.org/wiki/Comparison_of_web_application_frameworks

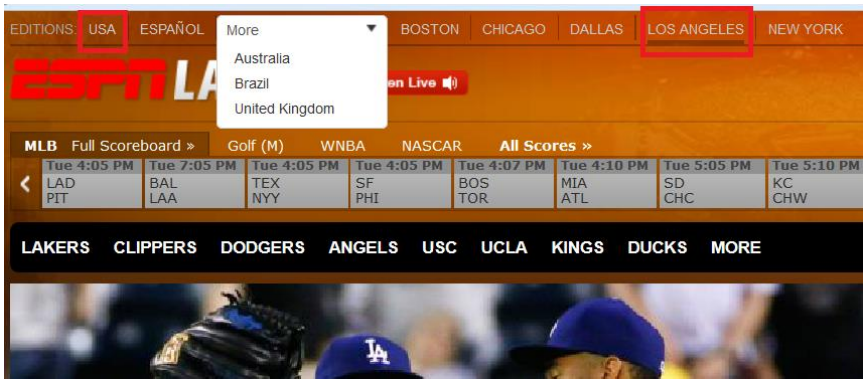

Fig. 1 Grails-based Web application using internationalization

Form Validation: Django provides some validation rules in the description of the fields within the file where the form methods are located but not in the view. By using the Python programming language, these fields are specified, for instance, required = True indicates that the field is required, throwing a warning message in the event when an entry is not valid.

Using Templates: Grails has a set of predefined templates which allows the rendering process of Web pages. The templates are located in a specific folder and their names always starts with low underlined. In Fig. 2, an example of the use of templates for a Grails-based Web application is shown. This Web application represents an online shopping web site displaying information about the author and other details in the footer.

Custom error messages: Warn user of possible problems and notify when the system state changes is simple with Django since into the design view such messages can be directly modified in the CSS files of the Web application.

Comet support: Grails provides Comet support through different plug-ins such as Atmosphere, Cometd, ICEPush, among others. CometD is a scalable HTTP-based event routing bus that uses an Ajax Push technology pattern known as Comet. This plugin allows to Grails-based application sending asynchronous notifications to HTTP clients by using CometD and the Bayeux protocol. The Atmosphere project is a portable Ajax-Push/Comet and WebSocket framework. ICEpush is purely web-based notification, allowing group members to receive a callback when a push is sent to a group. ICEpush allows adding Ajax Push collaboration features to any web application.

Fig. 2 Grails-based Web Application using templates.

In Fig. 3, an example of employing the Comet support by using a Web chat for the ESPN web site is shown. This example represents a Grails-based Web application which allows multiple conversations/interactions with students. The Atmosphere plugin is used and with this feature Web application is busy, dynamic and interactive.

Security: Django is designed to automatically protect Web applications in different ways. The most common is the user administration by generating a new project and a super user in the database in order to manage privileges to these super users or users normal. These files user management are implicit in the Django admin folder.
ORM: Grails not only leverages Hibernate under the covers as its persistence layer, but also implements its own Object Relational Mapping layer for Groovy, known as GORM. He Grails Object Relational Mapping (GORM) is a core component of the Grails web application framework and uses DSL- style techniques to apply persistence to regular Groovy classes. In Fig. 4 a Grails-based Web application with ORM support is shown. This Web application describes a pet hospital where the veterinarian adds information about the owner, which has one or many pets and each pet can have zero, one or many visits to the hospital. HypersonicSQL is used which is the default database in Grails.

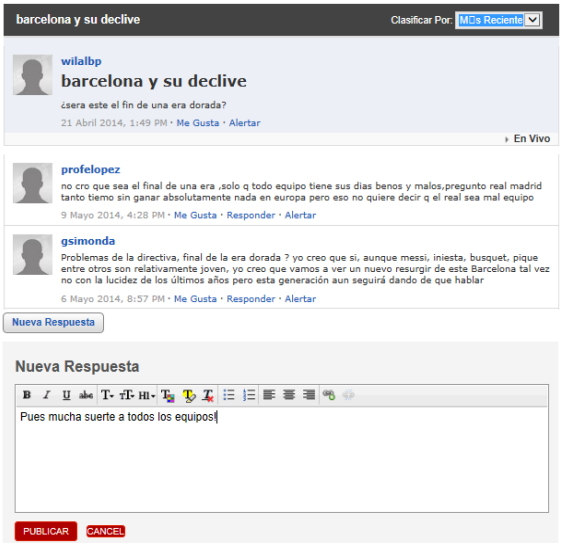

Fig. 3 Web Application Web using Comet with Grails

Fig. 4 Web Application using ORM with Grails

There are common problems with the development of Web-based projects such as: 1) developers frequently make the same mistakes in the development phase, which implies spend time and money, 2) spending huge amounts of time and money training new team members, 3) having difficulty with multi-person projects because each team member has his own way of doing things. In order to avoid these problems, this work intends to moti-

vate the use of Best Practices on Web development into the Software Engineering and Web engineering communities. As can been inferred, in this work best practices on Web development have been proposed and applied facilitating the development and improving the final product quality.

6 Conclusions and Future Work

We have presented a comparison of Web frameworks through of best practices in order to establish the best practices for Web development. The use of best practices allows developing better and more efficient Web applications. The results show that Django and Grails offer more features for developing Web applications than other frameworks. With the use of these best practices, Web applications were developed in an interactive, intuitive and secure way, improving the development effort and reducing the development time. Therefore best practices are very important in the software engineering community, due to the fact that such practices allow decreasing errors in the implementation phase.

As future directions, the authors are considering to obtain new best practices such as Caching, Testing, SiteMap and Wiring. Also, future research will include the comparison with other PHP-based Web frameworks such as Yii in order to provide a comprehensive analysis among them. This analysis will allow developers to choose the Web framework that more meet their requirements or the Web framework that has more advantages for a given project.

Acknowledgments

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Error Modelling Approach based on Artificial Neural Networks for Face Emotion Recognition

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Abstract. In this paper an approach based on modelling of recognition error with Artificial Neural Networks is presented to increase face emotion recognition in absence of any pre-processing or enhancement technique for feature extraction. This approach consists of two stages: in the first stage an ANN structure is defined for the recognition task by means of a Genetic Algorithm (Recognition ANN - ReANN). Then this structure is used to perform recognition on a test set Y to estimate classification error probabilities. In the second stage an additional ANN is defined to associate these error patterns with correct classification patterns using the same test set (Corrective ANN - CoANN). The composite ANN system then is tested with a different set Z. In recognition tasks performed with the ReANN it was observed that some emotions were more likely to be incorrectly classified than others. This was further corroborated with perceptual data. With the integrated ANN system (ReANN plus CoANN) it was observed that some of these emotions could be recognised more accurately. In general overall recognition was increased from 75% to 85% with this approach.

Keywords: Face Emotion Recognition, Artificial Neural Networks, Genetic Algorithms

1 Introduction

The recognition of facial emotions is a universal and innate ability in humans and is deeply involved in social communication [1]. For the development of more intuitive and intelligent artificial entities as interfaces and assistive robotic systems, face emotion recognition has become an important research subject [3].

Some works have been performed with significant results in this field. In [9] image pre-processing was performed in order to classify emotions. Methods like Discrete Wavelet Transform (DWT), PCA (Principal Component Analysis), 2D-LDA (Linear Discriminant Analysis) and Support Vector Machines (SVM) were used for feature extraction and classification tasks on the JAFFE database [4] reporting accuracies within the range of 90% to 95%.

Another work that used the JAFFE and YALE databases was presented in [6] where facial features were extracted by using the Gabor Filter in order to have representative facial deformation patterns. PCA was performed on these features for dimensionality reduction while the classification task was performed with a three-layer Artificial Neural Network (ANN) classifier trained with a backpropagation algorithm. An overall classification rate of about 96% was reported with this technique.

In [12] the combined implementation of Gabor Filter and Local Binary Patterns on images was presented for the development of a SVM classifier. Additional enhancement of this implementation was achieved with a Genetic Algorithm (GA). Classification tasks performed with the JAFFE and Cohn-Kanade databases reported a general recognition rate of about 96%.

Finally in [7] emotion recognition was performed on video data. Multi-scale morphological erosion and dilation operations were used as pre-processing techniques to extract features from eye and mouth regions. For each region an emotion recognition system was developed where each recognition system consisted of emotion-specific ANNs. Recognition rates between 73% and 87% were obtained.

In general, the works focused on facial emotion recognition require specialized pre-processing techniques for feature extraction prior to the recognition module. In this work we focus on the performance of the classifier/recogniser itself and its response, and we propose a post-processing technique which can improve the response of the recogniser independently of any pre-processing on the input data. This post-processing technique is based on the concept of error modelling which has been performed for speech recognition particularly when the patterns to be recognised have many disturbances [2,8].

With this technique an Artificial Neural Network (ANN) system is presented which is integrated by a recognition ANN (ReANN) and an error modelling ANN (corrective CoANN). Experiments performed with the JAFFE database presented a recognition rate of 85.00% which is similar to human semantic ratings [5] and is higher than the performance of the ReANN alone (77.50%).

These advances are presented in this paper as follows: in Section 2 the feature extraction method is presented while the development of the ReANN system is presented in Section 3. Then the details of the CoANN are presented in Section 4 while the performance results of the ReANN and ReANN + CoANN systems are presented in Section 5. Finally our observations and comments about future work are presented in Section 6.

2 Feature Extraction

For the present work the Japanese Female Facial Expression (JAFFE) database was used for the experiments. This database contains 213 images (approximately three image samples per emotion) of 7 facial emotions or expressions (Anger,

Disgust, Fear, Happiness, Neutral, Sadness and Surprise) posed by 10 Japanese female models. Some examples of the JAFFE database are presented in Figure 1. The size of the images in the JAFFE database is 256×256 pixels. From this database the following emotions were considered: Anger, Happiness, Neutral, and Sadness [11,10].

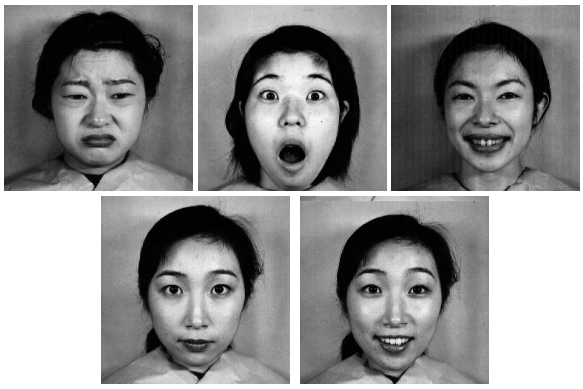

Fig. 1. Sample images from the JAFFE database.

Prior to feature extraction each image in the JAFFE database was reduced by a factor of 0.75 to reduce computational processing. This step has been performed by other works wthat involve image recognition [6]. Then each image was normalized to reduce dispersion and variability. In this way each image had a final size of 64×64 pixels.

The feature extraction consisted in the extraction of the most significant regions of the face that express emotion: when an expression is performed there are essential regions that describe the emotion and are useful to identify the associated emotional state. The regions containing the eyebrows, eyes and mouth were identified as the most important for emotion recognition. This is an extension on the regions considered in [7]. In Figure 2 the pixel intervals for each region are presented.

Each region is extracted and reshaped into a single feature vector p_{ij} which represents the i-th emotion expressed by the image of the j-th person. This process is performed for each image in the JAFFE database for the emotions considered in this work. Note that no other pre-processing technique is performed as we focus on the effect of the error modelling ANN on the classification performance of the (main) recognition ANN (ReANN).

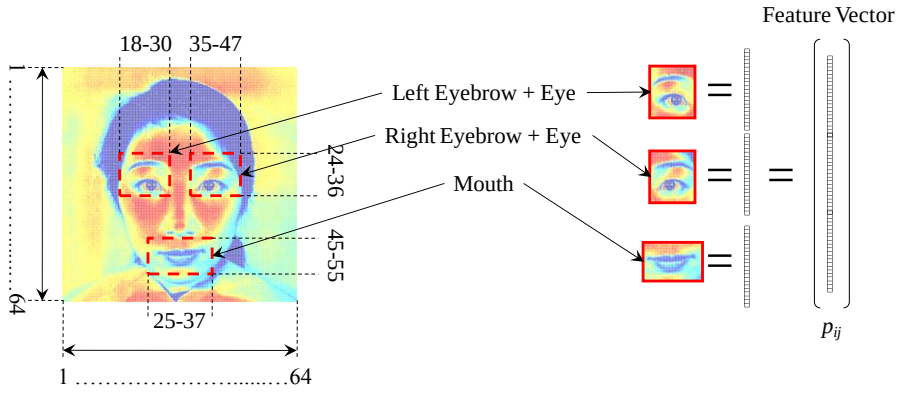

Fig. 2. Regions considered for feature extraction.

3 Estimation of the Recognition ANN

In Figure 3 the characteristics of the input and output vectors for the (main) recognition ANN (ReANN) are presented. The input vectors are the feature vectors p_{ij} while the output vectors consist of a sequence of integer numbers that represent the associated emotion for each input vector: "1" for Anger, "2" for Happiness, "3" for Neutral, and "4" for Sadness. For training of the ReANN the required output (reference) is the sequence of integer numbers describing the emotional state of each input vector from a training set X. Note that the actual output of the ReANN consists of real numbers instead of integer numbers. In the case of highly accurate recognition / classification the output would be very close to the required output and thus to the specified integer values. How different is the actual output from the required output is measured with an error metric which may consist of an euclidean distance or actual classification rate based on minimum error.

The performance of ANNs is dependent of many parameters such as the weights of the connections between neurons, the number of hidden layers and neurons, and the codification of inputs and outputs. For this work the error reduction between the actual and required output is accomplished by means of the estimation of a suitable architecture for the ReANN. Two Genetic Algorithms (GA1 and GA2) were considered for this goal and an overview of these GAs is presented in Figure 4.

The chromosomes for GA1 consists of fixed-length vectors as the values of the genes representing the number of neurons and transfer function are the same for all hidden layers. Binary coding is used in order to perform uniform crossover which leads to 16-bits vectors. In contrast the chromosomes for GA2 consists of variable-length vectors as the number of neurons and transfer function are

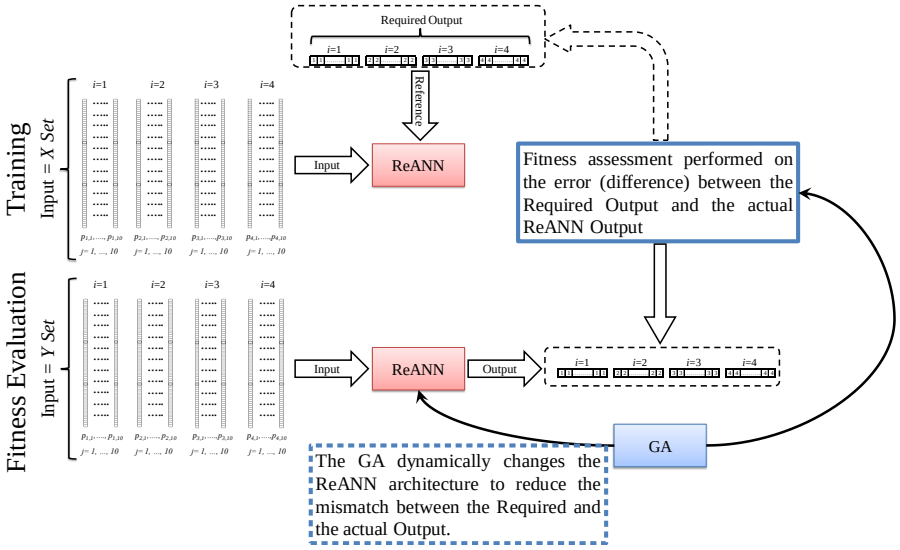

Fig. 3. Schemes for training and fitness evaluation for the ReANN and the GA.

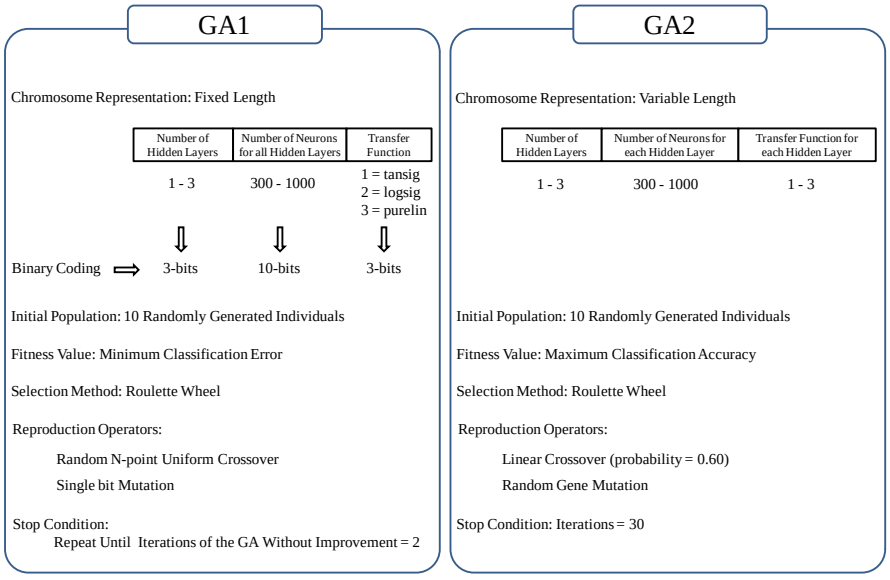

Fig. 4. Details of the Genetic Algorithms GA1 and GA2.

considered individually for each hidden layer. No binary coding is performed as linear crossover was used.

Each individual in the population for GA1 and GA2 represents an ANN configuration or structure which is trained with a set of images X (training set) and is evaluated with a set Y (GA fitness set) as presented in Figure 3. This process is performed for each individual which leads to ten output vectors where each one represents the coding of the most likely emotion i associated to each input feature vector p_{ij}. Then the euclidean distance between the actual output and the required (reference) output vector is computed and stored. The fitness value for each individual in GA1 represents the average value of the euclidean distances computed from the output vectors. In contrast for the GA2 the fitness value for each individual consists of the average correct classification percentage obtained with the associated ANN trained and evaluated on the X and Y sets respectively.

In Table 1 the constant parameters for the ReANN are presented while the architectures estimated by each GA are presented in Table 2.

Table 1. Constant settings of the ReANN

Setting	Value
Type	Feedforward
Training Algorithm	RPROP backpropagation
Epochs	1000
Error	0.0001

Table 2. Architectures estimated with the Genetic Algorithms GA1 and GA2

Genetic Algorithm	Architecture
GA1	Two hidden layers with 961 neurons for each one. Logsig transfer function for all hidden layers. Purelin transfer function for the output layer.
GA2	Three hidden layers: 1st layer with 859 neurons and purelin transfer function, 2nd layer with 456 neurons and logsig transfer function, 3rd layer with 144 neurons and tansig transfer function. Purelin transfer function for the output layer.

4 Corrective ANN based on Error Modelling

In order to improve classification an additional ANN termed as corrective ANN (CoANN) was designed. This ANN was established to refine the output of the ReANN considering the knowledge of the classification errors estimated during fitness evaluation. This process is similar to the modelling of a confusion matrix [2]. In Figure 5 the use of the CoANN is presented.

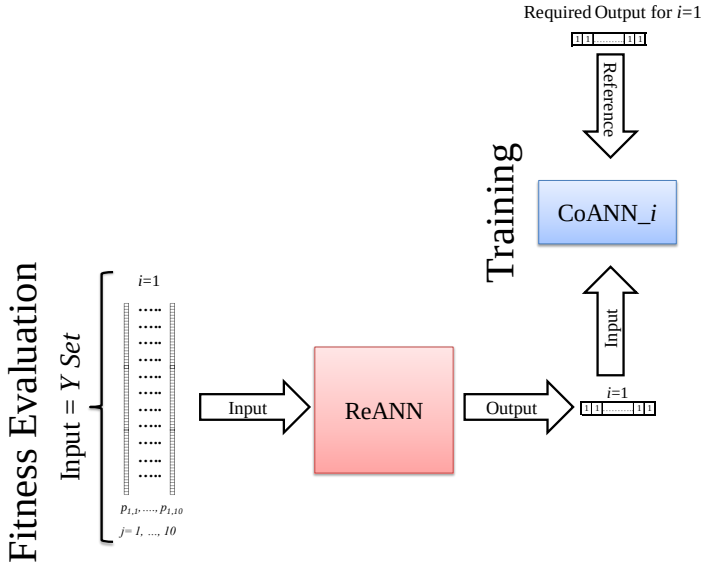

Fig. 5. Training of a CoANN for emotion i=1.

A CoANN was created for each i-th emotion. Due to the input and output vectors for the CoANNs being shorter than those for the ReANN the structure of the CoANNs was much simpler as presented in Table 3. No optimization was performed on these ANNs.

Under the integrated system ReANN + CoANN the recognition task is performed in two stages:

1. Initial classification is performed by the single ReANN where the input consists of image feature vectors and the output consists of real numbers associated to the most likely emotion.
2. The output of the ReANN is decoded by each CoANN_i in order to provide a refined output where the CoANN with the minimum error or euclidean distance is associated to the most likely i-th emotion.

Table 3. Constant settings of each i-th CoANN

Setting	Value
Type	Feedforward
Training Algorithm	Scaled Conjugate Gradient (SCG) backpropagation
Epochs	1000
Error	0.0001
Hidden Layers	2
Neurons	400 for 1st hidden layer, 200 for 2nd hidden layer
Transfer Function	Purelin

5 Performance of the ANN Systems

Each user in the JAFFE database has three image samples of each emotion. This made the separation of the database into three sets of images suitable as follows: the first sample images were used for the set X, the second sample images were used for the set Y, and the third sample images were used for the set Z. As presented in Figure 3 the sets X and Y were used for training and fitness evaluation purposes respectively. Thus final testing was performed with the set Z.

In Table 4 the recognition accuracy obtained with the GA-optimized ReANN on the set Z across all users in the JAFFE database is presented.

Table 4. Recognition Performance on the Test Set Z: GA-Optimized ReANN

ANN	Anger	Happiness	Neutral	Sadness	Total Recognition
with GA1	90.00%	90.00%	90.00%	30.00%	75.00%
with GA2	100.00%	80.00%	80.00%	50.00%	77.50%

While performance of the ReANN optimized with GA2 was higher than the performance of the ReANN optimized with GA1 (77.50% > 75.00%) both performances are under baseline reference performance available on the literature (up to 96% [6]). However this is expected as no complex feature extraction is performed (e.g., PCA or SVM extraction). In Table 5 the recognition accuracy obtained with the GA-optimized ReANN and the CoANNs on the set Z across all users in the JAFFE database is presented.

While the overall performance is still under baseline reported by other works an increase in classification was achieved over previous performance. It is important to mention that while recognition improved for Neutral and Sadness a decrease was obtained for Anger. However human perceptual data (semantic ratings) available for the JAFFE database [5] showed significant confusion of Sadness and Happiness with Neutral. By normalizing the semantic ratings pre-

Table 5. Recognition Performance on the Test Set Z: GA-Optimized ReANN with CoANN

ANN	Anger	Happiness	Neutral	Sadness	Total Recognition
with GA2 + CoANNs	80.00%	80.00%	100.00%	80.00%	85.00%

sented in [5] to recognition percentage it was obtained that the average level of correct classification was within the range of 80% to 90%. The performance presented in Table 5 is within this range.

6 Future Work

Considering the results obtained with the CoANN future work will consist in developing an emotion recognition system with the integration of pre-processing techniques as PCA, DWT or 2D-LDA. Because the corrective ANN (CoANN) produced a significant gain on the performance of the baseline ReANN, it may produce a significant gain on a recognition system with pre-processing. However this needs to be further studied with additional experiments. Also recognition experiments with more emotions and other databases must be performed in order to evaluate the effectiveness of the proposed method.

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Security in WEB Applications, Definitions, Risks and Tools

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Abstract. Security in WEB applications has become a major concern for the scientific and business communities today. An increasing amount of money is being spent for handling information security. . Therefore, giving the proper importance of handling information security, the paper focuses on: definitions of software security, vulnerabilities and risks, dealing with various threats and vulnerabilities, the risk ranking created by OWASP (Open Web Application Security Project) and describes different tools that can be used for security within a Web application using a test, some of them are Zed Attack Proxy (ZAP), BeEF (The Browser Exploitation Framework), Burp Suite, PeStudio, Xenotix XSS Exploit Framework, Lynis, Recon-ng, Suricata, WPScan, and O-Saft (OWASP SSL Advanced Forensic Tool).

Keywords: WEB Application, Reliability, Risk, Testing, Security Standard.

1 Introduction

Meanwhile the world is more connected, the need for security in the procedures used to share information become more important. Since it has generated an evolution of information systems using the Internet. According to [1-4] information systems are a mechanism that helps to collect, store, organize and disseminate the data contained therein; its purpose is to help users to get some kind of value of information that is in the system, regardless of the type of information that is stored and the type of desired value. The influence of the Internet in all processes and communication stages of current media covers the registration, handling, storage and distribution of information, whether the form of text, still and moving images, sound, etc.

From the perspective of software developers, the need for users to access information from anywhere on any device, they are frequently asked to fill registration forms, by entering the information required to specific tasks to operate. However, registration can be done by non-automated software and user data can be compromised or corrupted.

It is crucial for WEB applications to consider a defense system against various types of threats and attacks. Among the first lines of defense are the CAPTCHA images [5]. Its function is to identify if the user of the WEB application is a human user/or automated software designed to gain access to the WEB application. This software is named as Optical Character Recognition (OCR).

In order to guarantee safety aspects in WEB applications involve performing a variety of tests in a complex set of possible scenarios. Therefore, it is difficult to remove all security flaws and performance during the development of WEB applications.

According to [6], software vulnerabilities can be grouped in three categories: the design, development and implementation, and operation. Unfortunately, in the practice, analysts and designers of WEB applications do not specify security requirements, and often do not provide assessment for vulnerabilities in their design; where most security risks occur during the implementation stage [7]. So, this paper focuses on analyzing the characteristics of the most common risks defined by OWASP during the implementation phase, and the use of security tools to help in this complex task.

The paper is organized as follows; the second section contains the basics definitions about risks on WEB applications, security, vulnerability, and threats. It also shows the list of the 10 most common vulnerabilities according to OWASP taxonomy [7], and the guide vulnerabilities proposed in [8]. The third section presents the analysis of existing software tools under GNU-GPL license for the risks described in section two, which are based on questionnaires given in the guidance document in [8]; through descriptive pictures. The fourth section illustrates the use of the tools discussed in the implementation of a case study. Finally, conclusions and future work are presented in the fifth section.

2 Background

Definition 2.1. *A WEB application* consists of a set of WEB pages and components that interact to form a system running using WEB server (s), network (s), Hyper Text Transport Protocol (HTTP), and a browser, where its state changes according to the information users provide or request [8-9].

The issue of proper handling information security has been raised in various working groups around the world, such as IEEE, ISO and NIST. As result from those working groups, here some definitions based on the ISO/IEC17799 standard are presented[9] to provide adequate support for reading topics.

Definition 2.2. *Information security* is the preservation of confidentiality, integrity and availability of information, where: *confidentiality* is defined as ensuring that information is accessible only to those who are authorized to access. *Integrity* is defined as safeguarding the accuracy and completeness of information and processing methods. And *availability* is defined as ensuring that authorized users have access to information and associated assets when required.

Moreover, from the viewpoint of software developers, the information security involves a set of methodologies, practices and procedures that seek to protect information as a valuable asset and thereby reduce threats and risks to ensure that resources system to be used the way it was decided (namely *security*). Security cannot be a product, it is a process, and it is an activity that attempts to reduce risks. In order to clarify the terms used herein, the definitions "threat", "vulnerability" and "risk" adapted from [9-12] are listed next.

Definition 2.3. *Threat* is any circumstance or event with the potential to adversely impact a system through unauthorized access, destruction, disclosure and/or data modification or denial of service.

Definition 2.4. *Vulnerability* is a flaw or weakness in system's design, implementation, or operation and management that could be exploited to violate the system's security policy.

Definition 2.5. *Risk* is a function between the possibility of the occurrence of a potentially disastrous event (namely *threat*) and the inability to smoothly absorb the effects of the event (namely *vulnerability*).

In [8] a set of guidelines based on standards: ISO 9126:1991, IEEE 1233, IEEE 6190, IEEE 830, ISO / IEC 9646-1 is proposed (see references [10-14]). The guide is based on questionnaires, which indicate at each stage of development of a WEB application, what security issues are found in the application during each stage. The guide indicates which subjects have been validated. Some questions contained in the guide are: Is there a security protocol to avoid outside attacks and intrusions from hackers? Do you avoid program names and directories being seen,? Does it protect the integrity of their programs and data? Are the services offered are made via secure transaction channels?

Just to mention some questions you can give a general idea of the aspects to be taken into account for attaining security within a WEB application. During the *test* phase, you should check the requirements, analyze the design and perform code review. In case of errors or new requirements in WEB development, requires to determine the cost, time and impact of a change in the existing product. Also, to document the changes and verify the consistency of the changes. Some questions in this phase are: Which threats exist? What problems are caused? Where are they? Does the occurrence of a threat can trigger other? How often were presented threats? What was the damage? What elements of the application are most exposed? What tools are available to us to measure vulnerabilities? What capacity has to continuously assess threats?

These questions reflect, and it becomes more clear, that efforts for eradicate or treatment of threats don't need to be limited, but also is required a safety plan has to be started during all the development cycle of an application from initial design to maintenance phase. The guide give a good basis to implement security in WEB applications, in particular, this work focuses on the available tools to complement the security process.

The OWASP in [15] has released an updated ranking for the most critical risks affecting the WEB applications. This ranking, comes from the consensus and debate among experts [7], which is described in Tables 1 and 2. Moreover, in order to assess risks, three

steps are defined: (1) Assessment of the threat, (2) Analysis of vulnerability, and (3) The risk estimate as a result of linking the two parameters above. A template that can help you document the assessment is presented in Table 3.

The intrusion is the most difficult kind of threats, and there are more issues to consider and deal with. Attackers have a range of capabilities and motivations, where threats agents can arise from many groups of people. These potential attackers will also have a wide range of capabilities, resources, organizational support, and motivations. The following is a brief list of potential attackers/threats agents.

- **Hackers**, who have computer resources, knowledge, dedication and find it funny and challenging.
- **Employees**, who have inside knowledge, easy access, and do it on/without purpose.
- **Insiders, contractors, and competitors**, who have access to confidential information, and possess knowledge of operations and default passwords.
- **Traders**, who have computer skills and could financially gain.
- **Foreign governments**, which have resources (system expertise, computers, cryptographers, money), intelligence agencies, and an interest in military or cause economic damage.
- **Organized crime, extremist groups, and terrorist**, who have dedication, computer skills, to financially gain and harm groups they oppose.
- **Alliances of the above**, with a combination of reasons.

Based on the above' s descriptions (today's and tomorrow's situations), the following threats may be evident for WEB applications:

- **External intrusion** by unauthorized access or by customers who do more that they are allowed to do. Also, an intruder may interfere with the system users, such that the user cannot access to the system and use the service as they expected (denial of service).
- **Internal intrusion** by employees, it could be with or without the intention to do harm.

Furthermore, "Intel's McAfee WEB Protection" [16] considers the following threats to WEB applications.

- **Balancing risk and usability**. Usability and security in WEB applications cannot be necessarily mutually exclusive. Some measures taken to increase security often affect usability. It is necessary to consider intruders as "users", and to use security measures to identify if the user who interacts with the application if it is or not and intruder. For instance, the case of a user name and password used for registration that are expected by the procedures.
- **Data tracking**. The scope is to establish the "origin point" of the information (or data). The idea is based on a point-to-point view of data transfer and communication security; in the WEB application context, a security scheme needs to provide the capability and means to control access to the data, and to control its use. Thus, it is possible determinate if the request of a user are or are not validate.

- **Filter Check**. Through this process, data is validated. If to ensure that data are properly filtered to inside, it is possible "to eliminate" or "minimize" the risk of contamination or malicious data, which are used to cause undesired operation in the application (for example App Store prevent the error).

Table 1. OWASP 2013 Top 10 of Security WEB applications risk, first part.

RISK	DESCRIPTION
1. Injection	Injection flaws, such as SQL, OS, and LDAP injection occur when untrusted data is sent to an interpreter as part of a command or query. The attacker's hostile data can trick the interpreter into executing unintended commands or accessing data without proper authorization.
2. Broken Authentication and Session Management	Application functions related to authentication and session management are often not implemented correctly, allowing attackers to compromise passwords, keys, or session tokens, or to exploit other implementation flaws to assume other users' identities.
3. Cross Site Scripting (XSS)	XSS flaws occur whenever an application takes untrusted data and sends it to a web browser without proper validation or escaping. XSS allows attackers to execute scripts in the victim's browser which can hijack user sessions, deface web sites, or redirect the user to malicious sites.
4. Insecure Direct Object References	A direct object reference occurs when a developer exposes a reference to an internal implementation object, such as a file, directory, or database key. Without an access control check or other protection, attackers can manipulate these references to access unauthorized data.
5. Security Misconfiguration	Good security requires having a secure configuration defined and deployed for the application, frameworks, application server, web server, database server, and platform. Secure settings should be defined, implemented, and maintained, as defaults are often insecure. Additionally, software should be kept up to date.
6. Sensitive Data Exposure	Many web applications do not properly protect sensitive data, such as credit cards, tax IDs, and authentication credentials. Attackers may steal or modify such weakly protected data to conduct credit card fraud, identity theft, or other crimes. Sensitive data deserves extra protection such as encryption at rest or in transit, as well as special precautions when exchanged with the browser.
7. Missing Function Level Access Control	Most web applications verify function level access rights before making that functionality visible in the UI. However, applications need to perform the same access control checks on the server when each function is accessed. If requests are not verified, attackers will be able to forge requests in order to access functionality without proper authorization.

8. Cross Site Request Forgery (CSRF)	A CSRF attack forces a logged-on victim's browser to send a forged HTTP request, including the victim's session cookie and any other automatically included authentication information, to a vulnerable web application. This allows the attacker to force the victim's browser to generate requests the vulnerable application thinks are legitimate requests from the victim.

Table 2. OWASP 2013 Top 10 of Security WEB application risk, second part.

RISK	DESCRIPTION
9. Using Components with Known Vulnerabilities	Components, such as libraries, frameworks, and other software modules, almost always run with full privileges. If a vulnerable component is exploited, such an attack can facilitate serious data loss or server takeover. Applications using components with known vulnerabilities may undermine application defenses and enable a range of possible attacks and impacts.
10. Invalidated Redirects and Forwards	Web applications frequently redirect and forward users to other pages and websites, and use untrusted data to determine the destination pages. Without proper validation, attackers can redirect victims to phishing or malware sites, or use forwards to access unauthorized pages.

Table 3. Risk Evaluation Template

Threat Agent	Attack Vectors	Prevalence of Weaknesses	Defectivity weaknesses	Technical impact	Business Impact
Application-specific	Easy	Diffused	Easy	Severe	Specific by Application / Business
	Average	Common	Average	Moderate	
	Hard	Uncommon	Hard	Less	

- **Escape exits**. It is the process of verifying if escape strings were properly implemented and its counterpart to encode/decode special characters. So, its original meaning is preserved.

3 Tools for Security Testing

The following list of tools for security testing, which has analyzed in this work (see references [17-26]).

- **OWASP Zed Attack Proxy (ZAP)** is an easy to use integrated penetration testing tool for finding vulnerabilities in WEB applications. It is designed to be used by people with a wide range of security experience and is highly recommended for developers and functional testers who are new to penetration testing. ZAP provides automat-

ed scanners as well as a set of tools that allow you to find security vulnerabilities manually.

- **BeEF (The Browser Exploitation Framework)** is a penetration testing tool that focuses on the WEB browser. It allows the professional penetration tester to assess the actual security posture of a target environment by using client-side attack vectors.
- **Burp Suite** is an integrated platform that combine advanced manual techniques with automated tools, some of its components are: an intercepting Proxy, an application-aware Spider, an advanced WEB application Scanner, an Intruder tool, and a Sequencer tool.
- **PEStudio** is a tool for analyzing unknown and suspicious executable files. The goal of PEStudio is to detect malicious behavior, provide indicators and score the trust for the executable being analyzed. Since the executable file being analyzed is never started, it is possible inspect any unknown or malicious executable with no risk. \
- **OWASP Xenotix XSS Exploit Framework** is an advanced XSS vulnerability detection and exploitation framework. It provides Zero False Positive scan results with its unique Triple Browser Engine (Trident, WebKit, and Gecko) embedded scanner. It has more of 1500 different Payloads for effective XSS vulnerability detection and WAF Bypass.
- **Lynis** is an open source security auditing tool. Primary goal is to help users with auditing and hardening of UNIX and Linux based systems. The software is very flexible and runs on almost every UNIX based system (including Mac). It includes searching for installed software and determines possible configuration flaws.
- **Recon-ng** is a full-featured WEB Reconnaissance framework written in Python. It is designed exclusively for web-based open source reconnaissance.
- **Suricata** is a high performance Network IDS, IPS and Network Security Monitoring engine. Open Source and owned by a community run non-profit foundation, the Open Information Security Foundation (OISF). This is highly scalable, i.e. it can run one instance and it will balance the load of processing across every processor on a sensor Suricata is configured to use.
- **WPScan** is a vulnerability scanner which checks the security of WordPress installations using a black box approach, which is made in Ruby.
- **O-Saft (OWASP SSL Advanced Forensic Tool)** is an easy to use tool to show information about SSL certificates and tests the SSL connection according to given list of ciphers and various SSL configurations. It's designed to be used by penetration testers, security auditors or server administrators. The idea is to show the important information or the special checks with a simple call of the tool. However, it provides a wide range of options so that it can be used for comprehensive and special checks by experienced people.

From the description of tools for security testing above, table 4 achieve an overview from the tools and their relations with top security risk defined by OWASP, where “X” inside one box of the matrix indicates if the tool include the risk in its security test. However,

determining the necessary actions to eliminate hazards found, it is responsibility of test developer, since the tools only indicate the vulnerability.

4 Results

By using the guidelines proposed in [8] and the tools mentioned in the third section, the results illustrated in Figure 1 were obtained. Those were performed in 6 WEB massive use applications available today.

During the analysis of each tool, an important factor in determining the number of risks in the application is the number of breakpoints present. This refers to the ability of the WEB application to perform an action if detects a threated from the attacker (attack test in our analysis), forcing to take another route or scope (more tedious) to see if it can undermine the application, the more breakpoints found lower risks.

TABLE 4: ANALYSIS OF TOOLS VS TOPS SECURITY WEB RISK

TOOLS	RISK RANKING CREATED BY OWASP										PLATFORMS	LICENCE
	1	2	3	4	5	6	7	8	9	10		
OWASP Zed Attack Proxy (ZAP)	X	X	X	X	X	X	X	X	X	X	Windows/Unix	GNU/UNIX
BeEF (The Browser Exploitation Framework)	X	X		X	X	X	X		X	X	IExplorer Google Chrome Mozilla Firefox	Free Project
Burp Suite	X	X					X		X	X	Windows/Unix/ Web Browser	Free Software
PeStudio	X	X	X	X		X	X		X	X	Windows	Free Software
OWASP Xenotix XSS Exploit Framework			X					X			Windows / Unix	GNU/UNIX
Lynis	X	X	X	X	X	X	X	X	X	X	Unix/Linux	GNU/UNIX
Recon-ng	X	X		X		X			X		Windows	GNU/UNIX
Suricata	X	X	X	X	X	X	X	X	X	X	Windows / Web Browser	Open Source GNU/UNIX
WPScan	X	X	X								IExplorer Google Chrome Mozilla Firefox	Free Software
O-Saft (OWASP SSL Advanced Forensic Tool)	X	X	X							X	Windows/Unix	GNU/UNIX

Note also that each tool uses different methods to detect risks, so some despite having few breakpoints have fewer vulnerabilities detected , since the application is not considered important to protect these techniques used by software , often because they know they have nothing to lose in that way. It can be inferred that with reference to ZAP OWAS tool is able to identify and mitigate as many risks.

5 Conclusions and Future Work

This paper contributes with an analysis of available tools that can be used for the identification of security risks in WEB applications, based on the basic concepts of risks WEB applications, security, vulnerabilities, and threats. We focused the analysis on 10 of the most critical vulnerabilities according to the OWASP taxonomy and guidance given in [8]. According to the results, OWAS ZAP was the security tool with better score reported. Those results can be used to determine what the weaknesses points of the application are. As a future work, we will propose a list of best practices during the development phase that might help to reduce the number of risks found using the automated security set of tools.

FIGURE 1: VULNERABILITY FOUND IN WEB APPLICATIONS.

Kind of WEB application	Security Tool	Attacks number	Breakpoints	Risks Detected (according to the OWASP topology)										Technical impact
				1	2	3	4	5	6	7	8	9	10	
Registration Form Email Server	OWASP ZAP	100	31	13	2	0	0	0	0	0	2	1	28	Less
	OWASP Xenotic	100	20	8	6	1	0	0	0	0	1	0	20	Less
	O-Saft	100	17	2	1	3	1	1	0	1	0	0	11	Less
Blog Site	OWASP ZAP	100	0	60	2	1	2	1	3	0	0	0	2	Moderate
	Pe Studio	100	3	10	1	2	1	0	1	2	0	0	8	Less
	WP-Scan	100	0	87	3	4	0	0	0	0	0	0	0	Moderate
Web Data Repository	OWASP ZAP	100	7	35	11	78	1	1	2	0	112	1	1	Moderate
	Burp Suite	100	11	12	3	0	1	2	1	10	2	1	32	Less
University System of Registration and Qualifications	OWASP ZAP	100	13	74	12	3	0	0	14	0	1	0	64	Moderate
	O-Saft	100	12	8	1	0	0	0	4	0	0	0	13	Less
	BeEF	100	8	60	3	3	5	0	11	1	1	0	32	Moderate
Electronic Invoice Generation	OWASP ZAP	100	1	2	2	0	0	0	134	0	2	1	18	Moderate
	Burp Suite	100	7	0	1	1	0	0	86	0	1	0	0	Moderate
	PE Studio	100	3	0	1	0	0	1	103	1	0	0	1	Moderate
Internet Banking	OWASP ZAP	100	41	3	0	0	1	0	1	0	0	0	1	Less
	OWASP Xenotic	100	61	0	0	0	0	0	0	0	3	0	2	Less
	O-Saft	100	87	0	0	0	1	0	0	0	0	0	4	Less
	Pe Studio	100	18	2	0	0	1	0	0	0	1	0	0	Less

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Comparison of P2P Social Network Architectures

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Abstract. In recent years, online social networks have become very popular. Online social networks (OSN) have been useful to find former classmates or to improve our interaction with friends. Thus, a huge amount of information is generated and consumed by millions of people in these types of networks. Currently, most popular online social networks are based on centralized servers, whom are responsible management and storage all the information. Although the benefits of social networks are well known to most of us, these networks still have many challenges such as scalability, privacy or dependence. In this work, we evaluate P2P infrastructures as alternative platform for developing decentralized online social networks. In particular, we simulate and evaluate a specific social network called Tribler on two types of P2P architectures: super-peer and distributed. Our results shown that OSN based on super-peer reaches best download time than OSN based on a distributed P2P architecture.

Keywords: P2P architectures, on-line social networking, broadcast.

1 Introduction

Online social networks have become more and more popular every day, and many users use these networks to find former classmates or interact with friends. Social networks are also used to establish new relationships with other users, organize events with friends, promote personal work, share multimedia contents, publish comments or broadcast news. Today popular online social network are centralized and based on the client-server paradigm. This centralized structure introduces several drawbacks in the online social networks such as storage dependence, scalability, serious bottleneck, point of failure, security threats and privacy locally [13], [6]. Decentralized online social network infrastructures have been proposed to deal with these limitations. In this scenario, Peer-to-Peer (P2P) networks have emerged as a promising distributed information management platform. A P2P network is a distributed network formed by a group of nodes, which build a network abstraction on top of the physical network, known as an overlay network.

In a P2P system each peer can work both as a server and as a client at the same time. An important advantage of P2P networks is that all available resources such as processing, memory and bandwidth are provided by the peers [15]. Therefore, when a new peer arrives to the P2P system the demand is increased, but the overall capacity too. This is not possible in a client server model with a fixed number of servers. P2P paradigm allows that a distributed platform distributes its load and tasks on the participating peers. Traditionally, P2P networks have been mainly classified in two categories: media distribution and collaborative work, but social aspects such as interaction through applications for fun, publishing of messages visible for each other, updating the user status, advertising events or other interests to a group, etc. are not emphasized [13]. Nevertheless, the way how people connect with each other in social networks keeps a certain similarity with how P2P networks operate. Social networking sites allow users to find persons with similar interests, location or organization, addition to interaction with friends one already has [13]. Additionally, in a decentralized online social network users keep control of their data and can use the social network also locally, without Internet access.

The rest of this paper is organized as follows. In Section 2 we discuss related work, and in Section 3, we present our methodology and main components of each P2P infrastructure to be implemented. Then, we realize our implementation and simulations for Tribler in each P2P infrastructure in Section 4. In Section 5, we evaluate the performance of Tribler in both P2P infrastructures and analyze the results obtained from each. Finally, in Section 6 we present our conclusions and ideas for future work.

2 Related Work

Nature social connection between the human behind the computer and the large-scale P2P networks have found a fertile research area during the last years, and several P2P social networks such as Diaspora [1] [4], DECENT [3], Prometheus [5], PeerSON [2], and Tribler [6] have been proposed. Diaspora is a real-world Internet-scale decentralized online social network, and it was launched on November 2010 [4]. Diaspora has been mainly design to preserve the user privacy. A Diaspora network is formed by independent and federated servers, which are managed by individual users. The users' profiles are hosted in these federated servers, however, users can decide for themselves their preferred servers to store their information. In Diaspora, users can have a total control of their data by maintaining their own servers. Jahid et al. [3] present a modular architecture design for online social networks called DECENT, which employs a distributed hash table to store user data and features cryptographic protections. These features allow that this online social network can offer confidentiality, integrity, flexibility attributes polices as well as a fast revocation. In this way, user's data and their social relationship are not visible to unauthorized users.

Data availability in this social network is based on data replication and authentication of updates. Prometheus is introduced in [5] as a P2P service that collects and manages social information from multiple sources which are refereed as social sensors. Collected information is exposed through interface in order to implement non-trivial social inferences. This network employs user defined policies to control the access to social data. Social sensors are user applications used to collect information about interaction with others users via different devices or the web. Prometheus process this collected information in order to create a decentralized, directed and labeled multi-edged graph, which reports users who are connected and how they interact in social network. Another online social networks based on P2P paradigm is Tribler [6], which is a research project developed in the Delft University of Technology and Vrije Universiteit Amsterdam. Tribler runs over BitTorrent and exploits social phenomena to content discovery and download cost. Tribler is free software with a defined architecture and is currently available for Windows, Linux and Mac. Based on these findings, we select this social network as the online social network to be evaluated on two different P2P infrastructures. Performance of both infrastructures is evaluated in terms of download time. Buchegger at al. [2] propose PeerSON, which is a social network that addresses two limitations in the online social networks: privacy issues and the requirement of Internet connectivity for all transactions. To solve these problems the authors use encryption and access control coupled with a peer-to-peer approach. The various features provided by OSNs can broadly be classified into the categories of social link establishment, digital personal spaces, and means of communication [2]. These categories are represented in PeerSoN. To reach this goal, PeerSoN has a two tiered architecture. Logically, one tier serves as a look-up service. The second tier consists of peers and contains the user data, such as user profiles. PeerSoN currently uses a Distributed Hash Table (DHT) for the look-up service.

In this paper, we simulate an online social network on two different P2P infrastructures. To reach this goal we select Tribler as our reference social network to be implemented. On the other hand, Kademlia [12] and BitTorrent [7] are selected as the P2P architectures over which Tribler has been deployed.

3 Background

In this section we give a briefly description of Tribler and the P2P architectures used in our evaluation. We have selected these P2P architecture because Kademlia is a decentralized P2P infrastructure, while BitTorrent is hybrid P2P system based on super-peer. Tribler is an online-social network based on the BitTorrent protocol.

BitTorrent is a protocol designed for exchange of large P2P files on Internet. In a BitTorrent network a central server serves as core and manages bandwidth resources, routing and communication between nodes without knowing the identity of each node and without storing any information. Thus, the server will not share files of any kind to any

node and reduces the overload impact by distributing large files. In a BitTorrent network several basic computers can collaborate to efficiently distributing files to many requesting clients. A user uploads a file by creating a small torrent descriptor file and distributes it using conventional mechanisms as web o email. A BitTorrent network is formed by several actors and components such as peers, leechers, seeders, trackers and swarm. All users connected to the BitTorrent network are called peers. In this context there two types of peers: seeders and leechers [9], [10]. Seeders are users who have a file without consider if they were the original creator or they are just who published it. On the other hand, users that over time their behavior consists of downloading more files, than sharing it are called leechers. A tracker is responsible for the communication between peers, because it keeps a global registry of all the downloaders and seeds of the corresponding file [8]. Initially, clients need to communicate with the tracker to identify peers from where they can download a file. Once started downloading a file, communication service between peers can continue without a tracker. However, clients can continue to communicate with the tracker in order to obtain statistics from new peers. Finally, a swarm is formed by all peers who share a torrent. Swarming allows tolerating massive flash crowds for popular content [10].

On the other hand, Kademlia [12] is a distributed hash table protocol designed for decentralized P2P networks. Kademlia is deployed as a virtual network on an existing LAN/WAN network or Internet and its topology is based on the XOR metric. This metric is use to calculate distance between points in the key space [12]. Several benefits are derived from this novel approach such as participants can receive lookup queries form exactly the same distribution of nodes hosted in their routing tables or that they can send a query to any node within an interval. These facts allow that participants select routes based on latency or even send parallel asynchronous queries. Compared with previous P2P protocols, Kamelia's nodes send a reduced number of configuration messages to learn about each other. Collected knowledge is used to provide flexible routing via low-latency paths. In Kademlia, the timeout delays generated from failed nodes are avoided by using parallel asynchronous queries. Each Kademlia's node is identified by a 160-bit node ID. Kademlia protocol consists of the following RPCs: PING, STORE, FIND NODE, and FIND VALUE. These procedures allow to specify the network structure, regulates communication between nodes and exchange of information. The nodes communicate is realized via the UDP protocol.

We simulate Tribler on both P2P infrastructures described above. Here, we describe the main characteristics of this on-line social network. Decentralization, availability, integrity, cooperation and network transparency are the main challenges in P2P file sharing systems [6]. To deal with these challenges, Tribler has been proposed and implemented on top of the BitTorrent protocol. To reach this goal the authors have only realized modifications and extensions to the existing BitTorrent client software. Tribler architecture involves different concepts such as social groups, megacaches, taste buddy, collaborative download, list of friends, geo-localization, recommendation and peer similarity. Many of these components are integrated together via a user interface, which is a key and critical

part of tribler. User interface facilitates the formation of social groups. Bootstrapping is a task to find other peers in a P2P system. In BitTorrent this task is realized by a tracker. However, to solve this problem, Tribler uses super-peers and overlay swarm through an epidemic protocol called Buddycast. Super-peers are contacted by a Tribler peer to obtain an initial list of other peers in the system, while overlay swarm is used for content and peer discovery. Social phenomenon concept in Tribler has been implemented in the social networking module, which is responsible for storing and providing information related to social groups such as the group members, used IP numbers, etc.

In Tribler, megacaches are used as local storage to store each piece of context information received by a peer that is relevant to it based on its interest and tastes. This information is exchanged within social groups using the Buddycast protocol. As we have previously indicated, Tribler uses the BitTorrent protocol for downloading files. However, to achieve a significant increase in file download speed the BiTorrent Engine uses a collaborative downloader module which exploits idle upload capacity of online friends [6]. This collaborative module is based on a protocol called 2Fast [14], which helps to improve some limitations in the original BitTorrent protocol. In 2Fast, a peer can participate in a collaborative download taking one of two roles: collector and helpers. A collector peer is interested in obtaining a complete copy of a particular file, while a helper peer can provide assistance to a collector peer during a file download. Both peers work similar as in the BitTorrent protocol, however, a collector peer can optimize its download performance by dynamically selecting the best available data source from a set of helper peers [6]. In this protocol, a helper peer works under an altruist approach, that is to say, a helper peer collaborates without requesting anything in return.

4 Implementation and Simulation

The main thing in the functioning of the social network Tribler is file sharing. This system is based on a BitTorrent client which has the function of sharing and download a file on the social network. Our Tribler simulation is implemented in the Peersim simulator [7]. We have used this network simulator because it supports dynamicity and extreme scalability. Peersim is written in Java language and it can be used to simulate small and large-scale P2P systems. This simulation tool also allows us to measure the communication between the same nodes and communication time between them. Our online social network simulation uses the BitTorrent and Kademlia prototype developed by the Trento University for the Peersim simulator [16] [17]. Our implementation uses Java as programming language for developing the communication protocols. Peersim is composed of two simulation engines: the cycle-based model and a more traditional event-based model.

First, we implement the Tribler social network with BitTorrent on the PeerSim simulator. In this scenario, a .Torrent file to be shared by a peer must be published in a

specific directory, which can be recognized by the system as a file uploaded to the network to be shared. This file contains file name, file size, hash information and the tracker's address. A user must be connected to the Internet to be referenced to a tracker and he or she can be attached to the social network with other active users connected to the network, who share either an entire file that is of interest or part of the file still can easy downloading. To realize our Tribler implementation in BitTorrent, we modify the BitTorrent protocol based on cycles and event developed by the Trento University [16]. Main modifications made to the BitTorrent protocol to implement the Tribler social network in PeerSim are the following. First, all classes of the PeerSim simulator are decompiled. After this, GeneralNode.java class is specifically revised in order to fix the reputation rates. Here we also implement the methods to manipulate the types of reputation. These methods (good or bad reputation) are appended to BitTorrent.java class. Good reputation method is activated if peer is sharing the file. Otherwise, bad reputation method is activated if file is blocked for the requesting peer. In this same class, when the tracker is activated, it reviews the state of all nodes and the nodes that are in a failed status are not added to the system. Constantly, BitTorrent.java class activates the reputation method which detects if a node has a reputation 0. If this is the case, then this node is deleted from the network in order to realize faster downloads and reject future requests from this non-cooperative node. To observe and control the simulation results, we modify the statistics output in the BTObserver.java class.

Our reputation strategy used to implement Tribler in Kademlia is different to the strategy used in BitTorrent, due mainly to the difference of operation of both protocols. Reputation levels in BitTorent are based on shared pieces, while in Kademlia reputation levels are measured during a direct download from a node. Files only are downloading from nodes with high reputation (2 in a scale 0 to 5) to reach a reliable download. We add reputation levels and methods in the Kademlia protocol developed by the Trento University [16], specifically in the GeneralNode.java class. We add the methods for good and bad reputation in the Kademlia Protocol.java which is the main class of protocol. To simulate a file is given a date array in each node in the GeneralNode.java. Control for all the output variables used by the nodes is defined in the classes KademliaObserver.java and Kademliaprotocol.java.

5 Evaluation

In order to evaluate Tribler performance on Kademlia and BitTorrent, we build a BitTorrent network with the same number of nodes as Kademlia and with the same file to be downloaded. Our experiments evaluate the nodes with reputation levels. We consider 2500 nodes in both P2P networks. 15% of these nodes are seeders nodes while 85% are leechers nodes. The file size to be distributed is 100 MB. Initial reputation is random. If node's reputation rate is 0, then it removed from the system. Tribler's performance with

Kademlia protocol is shown in Figure 1, while Tribler's performance with BitTorrent protocol is shown in Figure 2.

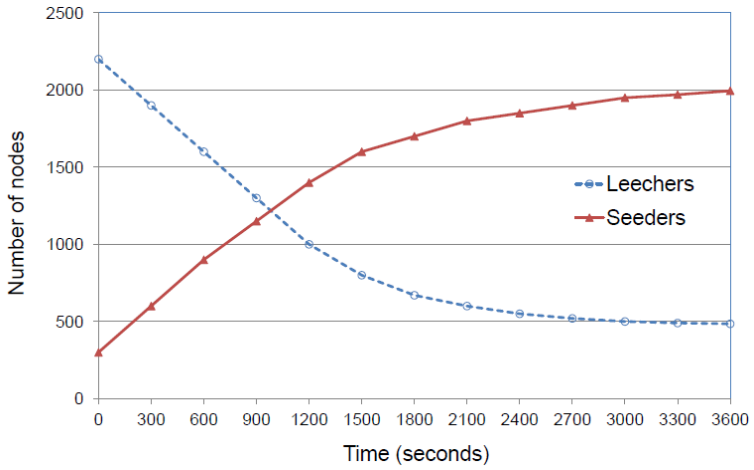

Fig. 1. Tribler's performance based on Kademlia protocol

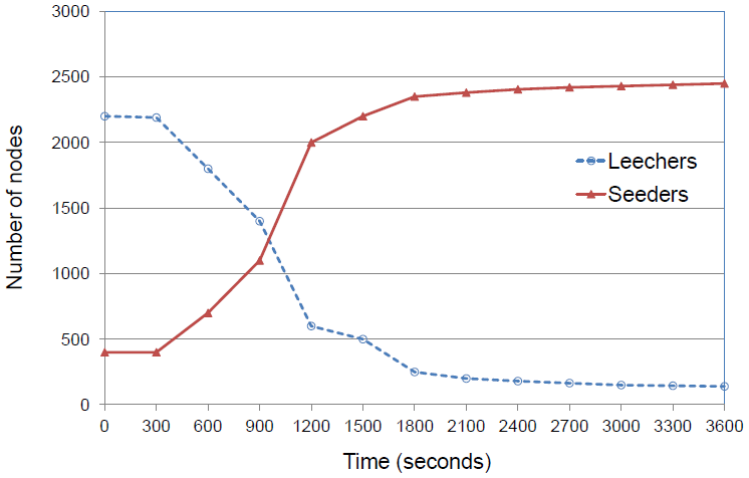

Fig. 2. Tribler's performance based on BitTorrent protocol

We can see that iteration starts with 2200 nodes because simulation removes nodes with low reputation or failed connection. We can observe how over time the number of leecher peers is decreased while the number of seeder peers grows more quickly. Non-

cooperative nodes reduce their reputation level while cooperative nodes continue active in the system.

On the other hand, in figure 3 is compared the number of leechers nodes in Tribler for both P2P infrastructures. Initially, we can see that the number of leechers in BitTorrent is higher than in Kademlia network. However, as time goes, leecher nodes in BitTorrent network are less than in the Kademlia network.

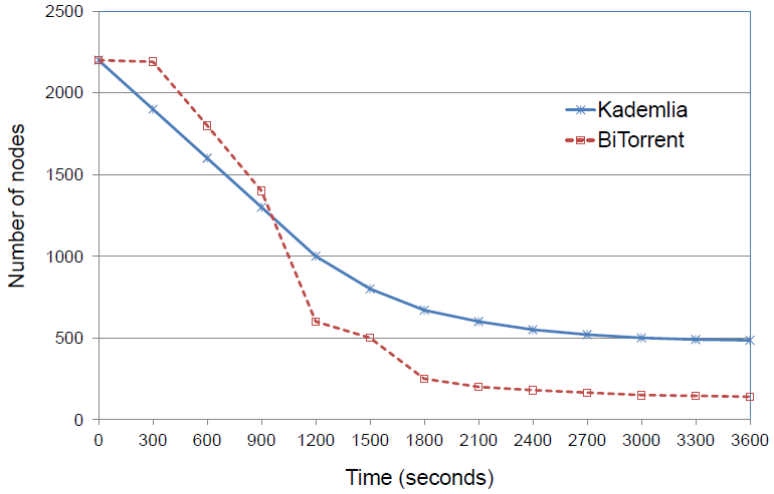

Fig. 3. Comparison of number of leechers in Tribler for both P2P infrastructures

Figure 4 compares the number of seeders nodes in both P2P networks. Initially, both infrastructures have a similar number of seeder nodes, but as time goes the number of seeder nodes in BitTorrent is increased in a large proportion compared to Kademlia. This means that in the BitTorrent network, a node can quickly retrieve the requested file, and so can become a seed node. In contrast, this conversion from a leecher node to a seed node node requires more time in the Kademlia network. Thus, BitTorrent has more available seeder nodes from which download the test file than Kademlia. This fact allows that BitTorrent presents a best performance to search and download a file compared to Kademlia.

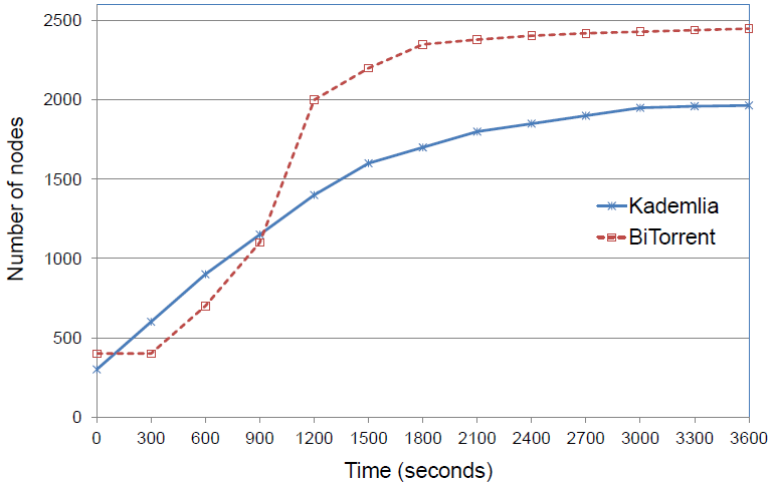

Fig. 4. Comparison of number of seeders in Tribler for both P2P infrastructures

We also compare the impact of the non-cooperative for Tribler in both types of P2P infrastructure. The same file of 100 MB is downloaded from both P2P networks. Figure 5 shows these results. We can see that Tribler based on BitTorrent can download the file faster than Tribler based on Kademlia, with an equal number of non-cooperating nodes. This is because as time passes Tribler based on BitTorrent eliminates non-cooperative nodes, which improves the system performance. Although the protocol ignores uncooperative nodes, due to their distributed topology each requesting node will take longer to find a new node from where to continue downloading the content. This causes the file download to be slower.

6 Conclusions

Online social networks have become very popular during the last years. However, centralized structure used by the online social networks introduces several drawbacks such as storage dependence, bottleneck, only point of failure, security threats and privacy locally. In this paper, we evaluated a social network called Tribler for two different P2P infrastructures: Super-peer (hybrid) and distributed. BitTorrent is our scheme used to simulate the super-peer infrastructure, while the Kademlia protocol is used to simulate the distributed infrastructure. Reputation strategies are integrated in both protocols as a way to isolate the non-cooperative nodes from the system. Our experiments were realized using the Peersim simulator and both P2P infrastructures were evaluated in term of delivery time. Our results show that Tribler with BitTorent presents a best delivery time

than Tribler with Kademlia. However, we believe that both infrastructures could have a different performance during a security threats.

As future work, we intend to extend our Tribler evaluation with both P2P infrastructures to scenarios with different types of security threats. More common security threats in P2P networks are Sybil and Eclipse attacks.

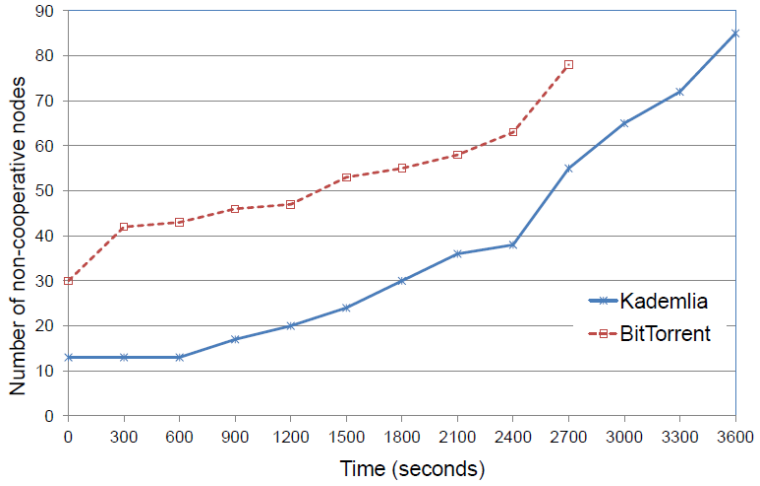

Fig. 5. Performance of P2P infrastructures in presence of non-cooperative peers

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Risk Detection of Malignant Tumors in Mammograms using Unconventional Computing

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Abstract. In this paper, we propose the use of Alpha-Beta associative approach as an Unconventional Computing method in the pre-diagnosis of malignant tumors of breast cancer, obtaining an accurate result in a simple way; trying to avoid invasive diagnostic methods like biopsies, as far as possible.
This proposal provides for the Alpha-Beta Support Vector Associative Machine created in 2008 and tested for classification of binary images. The results show that the classification model to detect malignancy is very competitive compared to others of the best known classification methods, having an accuracy of 81.85%.

Keywords: Breast cancer, binary images, Alpha-Beta Support Vector Associative Machine, unconventional computing, Otsu method.

1 Introduction

In this work we use the Alpha-Beta associative approach to pattern recognition by means of Alpha-Beta Support Vector Associative Machine (α-β SVAM) to detect the risk that a patient has a malignant type of breast cancer starting from mammograms classification.

Cancer is a malignant tumor generally characterized by loss of control of growth, development and cell division capable to reproduce metastasis or tumor spread. In Mexican women, from 2006, breast carcinoma has become the leading cause of death by cancer. According to the Instituto Nacional de Estadística y Geografía (INEGI) in 2009 occurred 4,964 deaths attributable to breast cancer, which accounted for 2% of all women's death [1]. The Instituto Nacional de Salud Pública (INSP) has shown that the review by mammography reduces women's mortality by breast cancer in 16% with appropriate treatment along 5 years [2]. The Clinical Practice Guideline for the Diagnosis and Treatment of

Breast Cancer by Mexican Ministry of Health, states all patients should have a clinical examination, establishing the following diagnostic procedures [3]:

* Imaging studies (mammography or breast ultrasound) and Magnetic Resonance Imaging (MRI) in special cases.
* Biopsies: fine needle, cutting needle biopsy.
* Histopathology.
* Additional studies (liver biometrics, clotting times, blood chemistry, bone scan, etc.).

However, biopsies of any type can represent unpleasant side effects for women who undergo this procedure, and 10% have serious problems with bruising, haemorrhage and infections in the cut or invasion areas [4].

Therefore, research has been conducted around the world , including the European Conference on Artificial Intelligence in Medicine (AIME) which work with technical topics of data mining, pattern recognition, image processing and natural language processing, and others [5].

Different techniques have been implemented to prevent the increase of this disease in women and, currently, also in men, we need to educate them and create a culture of prevention, [6-7], or by using Artificial Intelligence (AI) techniques to make an effective prediagnosis avoiding subjecting patients to invasive methods such as biopsies as far as possible.

In medicine different Intelligent Computing techniques are used [8-9] and within them, the methods that have shown better results are neural networks, fuzzy logic and genetic algorithms, of which the combination between fuzzy logic and neural networks is the most widely used method [10]. In this sense, the applications of Intelligent Computing techniques have been reared towards different particular problems, such as the use of Artificial Neural Networks (ANN) to model the behavior of schizophrenia [11], also they are used to diagnose urological diseases [12] and determining the seminal quality in fertility tests [13]. The Naïve Bayesian method (NB) was implemented for the celiac disease diagnosis (intolerance to wheat, barley, rye and oats) [14]. Also there is the implementation of a particular case of ANN, such as the Multilayer Perceptron (MLP) for purposes of diagnosis in cerebral lesions [15] or identifying periventricular leukomalacia, which is a brain damage in children that generates holes [16].

Some of the methods that have been tested with good results using data from cancer patients are:

*Genetic algorithms: [17].
*k-nearest neighbors (kNN): [18].
*Fuzzy Logic: [19].
*Support vector machines (SVM): [20-25].
*Artificial neural networks (ANN): [26-29].
*Semi-supervised learning (SSL): [30].
*Naïve Bayes (NB): [31].

There is an approach that despite not having many years of development, it has shown competitive results in different areas of knowledge, the associative approach. This approach has its roots at two pattern recognition models: the Alpha-Beta Associative Memories [32] ---whose α and β operators are the bases for almost every subsequent associative model--- and the Hybrid Associative Classifier [33] ---which is the first associative model designed specifically for pattern classification--- which combines two important models of associative memories to generate an efficient classifier. However, this approach has seldom been applied for classification of medical images. One successful antecedent in such topic is the model of the α-β SVAM [34]; designed for classification of binary images (black and white) as patterns, tested with image set of handwritten letters and numbers.

2 Methods

In this section the necessary techniques to get the best information from medical imaging (mammographies) are described, which will be classification patterns. One of this proposal's most important parts is the image segmentation by binarization, because α-β SVAM requires binary images to recover or classify them, this is presenting a dynamic thresholding technique. After that, the α-β SVAM algorithm is shown, which will be explain to understand how it classify an image like a pattern.

2.1 Image Binarization by Thresholding and the Otsu Method

Binarization is an image processing technique which reduces information in a two values digital image: 0 (black) and 255 (white).

Thresholding is a segmentation technique used to binarize images when there is a clear difference between the objects to be extracted and the background in an image.

Most thresholding techniques are based on the one-dimensional histogram statistics. There are parametric procedures where the gray levels distribution of an object class leads to find appropriate thresholds; also there are nonparametric methods where the thresholds are obtained optimally according to some criterion.

Otsu method is a nonparametric procedure that selects the optimum threshold by maximizing the variance between classes using an exhaustive search.

An image is a two dimensional function for the gray level intensity what contains $\boldsymbol{N}$ pixels whose gray levels are between *1* and $\boldsymbol{L}$. The number of pixels with $\boldsymbol{i}$ gray level is denoted as $\boldsymbol{f_i}$, and the occurence probability for image's $\boldsymbol{i}$ gray level is given by:

$$p_i = \frac{f_i}{N}$$

In two-level thresholding for an image (binarization), pixels are divided into two classes: C_1 with gray levels **[1, ... ,t]**; and C_2 with gray levels **[t+1, ..., L]**. Then the gray levels' probability distribution for two classes are:

$$C_1 : \frac{p_1}{\omega_1(t)}, \dots, \frac{p_t}{\omega_1(t)}$$
$$C_2 : \frac{p_{t+1}}{\omega_2(t)}, \frac{p_{t+2}}{\omega_2(t)}, \dots, \frac{p_L}{\omega_2(t)}$$

Wherein:

$$\omega_1(t) = \sum_{i=1}^{t} p_i \qquad \omega_2(t) = \sum_{i=t+1}^{L} p_i$$

Also, the average for C_1 and C_2 classes is:

$$\mu_1 = \sum_{i=1}^{t} \frac{i.p_i}{\omega_1(t)} \qquad \mu_2 = \sum_{i=t+1}^{L} \frac{i.p_i}{\omega_2(t)}$$

If μ_T is the average intensity of the image it's easy to show that:

$$\omega_1.\mu_1 + \omega_2.\mu_2 = \mu_t \qquad \omega_1 + \omega_2 = 1$$

Using discriminant analysis, Otsu [35] defined the variance between thresholded image's classes as:

$$\sigma_B^2 = \omega_1.(\mu_1 - \mu_t)^2 + \omega_2.(\mu_2 - \mu_t)^2$$

For two-level thresholding, Otsu verified that the t^* optimum threshold is chosen so that σ_B^2 is maximum [35]; that is:

$$t^* = max\{\sigma_B^2(t)\} \qquad 1 \le t < L$$

Applying a threshold t, the grayscale image, $f(x,y)$, will be binarized; labeling with '1' the pixels corresponding to the foreground and '0' are those of the background. Applying:

$$g(x,y) = \begin{cases} 1 <=> f(x,y) > t \\ 0 <=> f(x,y) \le t \end{cases}$$

The main advantage of this method is that thresholding makes no initial assumption, since it assumes that the optimum threshold can be described only in terms of their means and variances. However its disadvantage is that it is used when there is a clear separation between classes observing the image's histogram.

2.2 Alpha-Beta Support Vector Associative Machine [34]

An associative memory can be formulated, for operation as an input and output system, an idea that is outlined below:

$$x \rightarrow \boxed{M} \rightarrow y$$

Since the model of the α-β SVAM is autoassociative, we assume to have a pattern recognition problem, wherein the fundamental set has the form $\{(x^\mu, x^\mu)|\mu = 1,2,\dots,p\}$, with $x^\mu \epsilon A^n \; \forall \; \mu \epsilon \{1,2,\dots,p\}$, where $n, p \in \boldsymbol{Z}^+$ and $A = \{0,1\}$.

The x^μ vectors are column vectors and the index of components is increasing from up to down, as illustrated bellow:

$$x^\mu = \begin{pmatrix} x^{\mu_1} \\ x^{\mu_2} \\ \vdots \\ x^{\mu_n} \end{pmatrix}$$

One of the original ideas of the proposed model is trying to exploit the repeated information in the fundamental patterns. So, first a repeated pattern that contains information on all fundamental patterns is obtained; later this information is removed from the fundamental patterns, leaving only the information that differentiates a fundamental pattern of all others. This repeated information has inspired the new concept of support vector.

When an unknown pattern (can belong or not to the fundamental set) is presented to the model, which is intended to recognize with this model, we proceed to eliminate repeated information based on the pattern with this kind of information. This is simply the support vector for this fundamental set.

Now, we need to determine in some way, which of the fundamental patterns is less different with respect to this unknown pattern without repeated information (support vector). Is expected the less different fundamental pattern be the most similar. We just replace the missed information that was removed in the recovered fundamental pattern, and we have set the output pattern. We can see this method in Figures 1a and 1b.

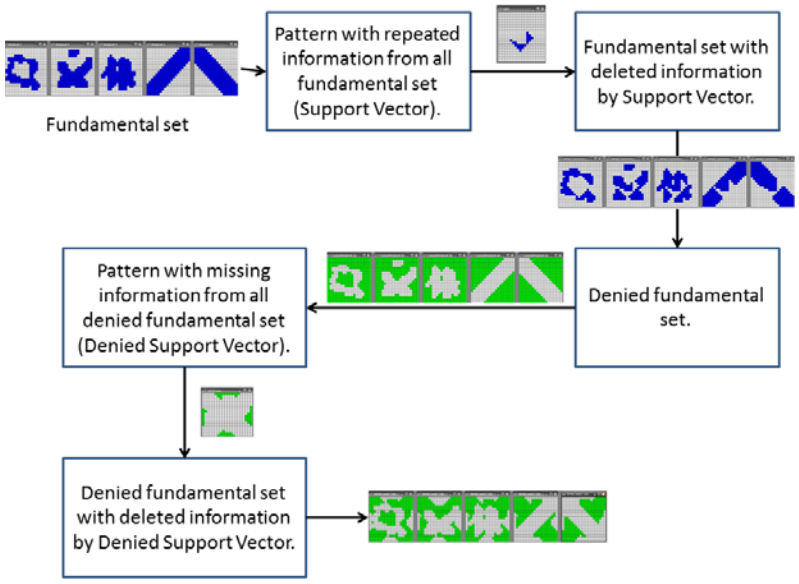

Fig. 1a. α-β SVAM Learning Diagram

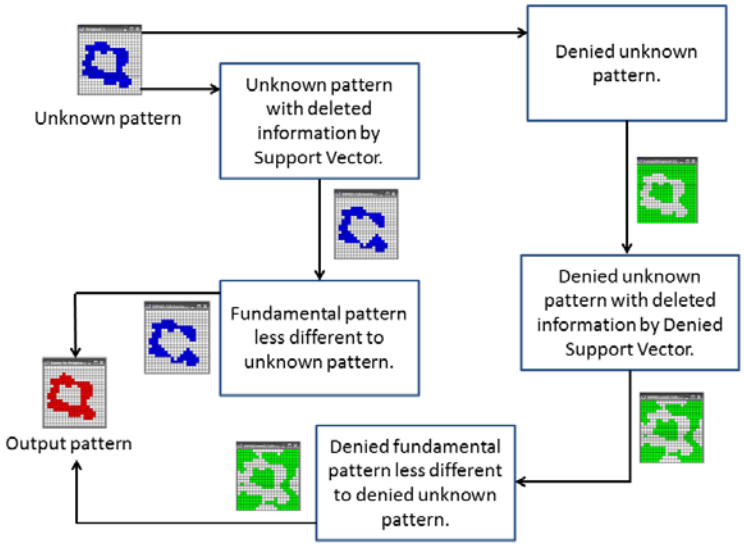

Fig. 1b. α-β SVAM Recall Diagram

3 Dataset

For the development of this paper the image set we used grayscale mammograms of 259 patients between 35 and 60 years old. The image set is courtesy of Dr. Miguel Angel Guevara and co-authors, members of the Breast Cancer Digital Repository Consortium, University of Porto, in Portugal, among others [36].

Each image is a pattern that must be reduced for use in the α-β SVAM model, applying in pixels to retrieve and classify the image. This process was carried out in Matlab, implementation using Otsu method for each image binarizing and scale the image from 3300x4080 pixels to 330x408. We reduced the size image, but the new format used allows large amount of information is not lost in the binary pixel values.

The Figures 2a and 2b show a mammography, first shows the original mammography, later we can see the binarized image applying Otsu method.

4 Results

To compare the accuracy of the proposed method in this work against other models conventionally used for cancer classification, the WEKA data mining and classification platform was used. In the particular case of the Multi Layer Perceptron neural network (MLP), the Matlab implementation was used instead of the one present in WEKA, given the improved memory usage characteristics offered by the former.

The α-β SVAM method was implemented with the Java language in the NetBeans Integrated Development Environment 7.4.

For validation purposes, the k-fold cross validation technique was used, with k=10 [37]. The experimental results exhibited by each model are shown in Table 1, while their corresponding confusion matrices are presented in Table 2. The metric used for comparison is overall accuracy, as seen in Table 1; and the confusion matrix allows us to review in detail the number of correctly cassified patterns for each case.

Table 1. Classification accuracy comparison.

Dataset	Algorithm	Accuracy (%)
Breast Cancer Digital Repository – D01	**α-β SVAM**	**81.85**
	k-NN	80.31
	Naïve Bayes	76.83
	SMO-SVM	72.97
	MLP	70.27

Fig. 2a. Original mammography (Source: [36])

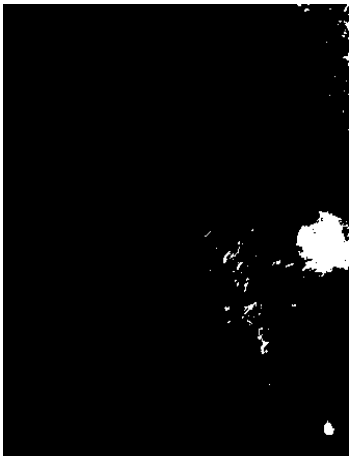

Fig. 2b. Binarized mammography by means of Otsu method

Table 2. Confusion matrix for each classifier.

		BENIGN	MALIGN
BENIGN	**α-β SVAM**	**131**	16
	k-NN	**131**	16
	Naïve Bayes	115	32
	SMO-SVM	110	37
	MLP	112	35
MALIGN	α-β SVAM	31	81
	k-NN	35	77
	Naïve Bayes	28	**84**
	SMO-SVM	33	79
	MLP	42	70

5 Conclusions

Based on the results obtained, we can conclude about the model accuracy percentage, the more competitive is α-β SVAM with 81.85%.

This proposal has shown being the best classification method compared to models with better global ranking for the breast cancer detection on the assumption that the cost of

misclassified cases as benign and malignant is the same. In other situation we can see that the amount of well classified patterns as malignant cases is slightly greater using Naïve Bayes classifier.

The most practical method is proposed in this paper, being designed to use the image as a binary pattern classification, whose advantages against other classification models are:

* The α-β SVAM method does not require feature extraction or measurements on each mammogram obtained by a medical specialist.

* Not required a computational algorithm for feature selection, because α-β SVAM delete the repeated information in images.

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Currency Exchange Rate Forecasting using Associative Models

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Abstract. Associative Models were created and used for pattern recognition tasks, but recently such models have shown good forecasting capabilities; by a pre-processing of a time series and some fit of the Model. In this paper, the Gamma Classifier is used as a novel alternative for currency exchange rate forecasting, where experimental results indicate that the proposed method can be effective in the Exchange Rate Time Series Prediction, compared to classical Machine Learning Models (ANN, SVM, MLP) and well known for the Financial and Economy Fields Box-Jenkins Models (AR, ARMA, ARIMA).

Keywords: Associative models, Gamma classifier, forecasting, exchange rate, time series, ARIMA, ARMA.

1 Introduction

The exchange rate forecasting is one of the most difficult and important tasks in modern study of time series prediction. Several factors influence in the value of a currency, such as oil prices, the rise or fall of imports of goods and services, inflation, consumer price index, interest rate, among others [1]. There exists a debate about what are the real factors that are affecting the currency value [2], this kind of problem with many variables, most of the times unknown, is usually treated as a stochastic and univariable problem [3, 4].

The Exchange rate as a critical issue of Financial Time Series Study has led into several forecasting models development for accurate and timely decision making, by the Economy, Financial and Statistical fields. For the analysis of financial time series, from economy perspective, the regression techniques are widely used and popular for their statistical properties [6]. Some of these models are AR, Ma, ARMA, and the more general ARIMA [4 -6].

On the other hand, Computer Science has various techniques for time series analysis and forecasting, some of these techniques are:

- Artificial Neural Networks [7].
- Support Vector Machines [8].
- Support Vector Regression [9].
- Fuzzy Logic [10].
- Associative Models [11, 18].

Another approach that has been rising for the financial time series forecasting is the combination of different models; this concept is based on the idea of improving the weaknesses of certain models with the strengths of others. These are called hybrid models and are the most prolific approach for financial time series forecasting in the actual literature. In 2010 Huang, Chuang, Wu and Lai create a Chaos-based support vector regressions model for Exchange rate forecasting [12], Khashei, Bijari and Ardali work on financial time series forecasting using an ARIMA with probabilistic neural networks [13] model, in 2013 Kazem, Sharifi, Khadeer, Morteza, and Khadeer used a Support vector regression with bio-inspired algorithm [14], in 2014 Wei, Cheng, and Wu, present a hybrid ANFIS (Adaptive Network-Based Fuzzy Inference System) based on n-period moving average model [15], also in 2014 Gharleghi, Shaariy and Shafighi did exchange rates forecasting using a Cointegration Based Neuro-Fuzzy System [16] and Minakhi, Majhi Babita, Majhi Ritanjali and Panda created a forecasting model for currency exchange rates using an adaptive ARMA model with differential evolution based training [17].

These sophisticated hybrid models are inherently difficult to implement, in addition to being computationally expensive. In this paper we study a simple and computationally efficient way to forecast currency exchange rates using an Associative Model, given the competitive results that the Associative Model Gamma Classifier has shown on previous works of Time Series Forecasting [18].

2 Gamma Classifier

As mentioned before, we use the Associative Model Gamma Classifier (GC). This work is strongly based on [18], however, the steps of the Gamma Classifier for exchange rate forecasting are a modification of the Algorithm shown in [18], described in section 3. For the forecasting of several points we used the separation method taken directly from [18].

The Gamma Classifier Algorithm for the forecasting task uses 3 important definitions, mentioned below; also it must do a pre-processing of the time series data, a codification of the time series, so the GC can treat the forecasting problem as a classification problem. This codification is named Modified Johnson-Möbius (MJM) see [18] for specific codification algorithm.

Definition 1 (Alpha and Beta operators). *Given the sets A = {0, 1} and B = {0, 1, 2}, the alpha (α) and beta (β) operators are defined in a tabular form as shown in table 1. The corresponding vector versions of both operators for inputs* $x \in A^n$, $y \in A^n$, *and* $z \in B^n$ *give an n-dimensional vector as output, whose i-th component is computed as follows.*

$$\alpha(x,y)_i = \alpha(x_i,y_i) \text{ and } \beta(z,y)_i = \beta(z_i,y_i)$$

Table 1. Alfa and Beta Operators definition

$\alpha : A \times A \rightarrow B$		
x	y	$\alpha(x,y)$
0	0	1
0	1	0
1	0	2
1	1	1

$\beta : B \times A \rightarrow A$		
x	y	$\beta(x,y)$
0	0	0
0	1	0
1	0	0
1	1	1
2	0	1
2	1	1

Definition 2 (u_β operator). *Considering the binary pattern* $x \in A^n$ *as input, this unary operator gives the following integer as output.*

$$u_\beta(x) = \sum_{i=1}^{n} \beta(x_i, x_i) \tag{1}$$

Definition 3 (Gamma operator). *The similarity Gamma operator takes two binary patterns —*$x \in A^n$ *and* $y \in A^m$*; n,m* $\in Z^+$ $n \leq m$ *— and a non-negative integer θ as input, and outputs a binary number, according to the following rule.*

$$\gamma_g(x, y, \Theta) = \begin{cases} 1 & if\ m - u_\beta[\alpha(x,y)\ mod\ 2] \leq \Theta \\ 0 & otherwise \end{cases} \tag{2}$$

The Gamma Classifier Algorithm for Time Series Forecasting is described below:
1. Convert the patterns in the fundamental set into binary vectors using the MJM code.
2. Code the test pattern with the MJM code, using the same parameters used for the fundamental set.

3. Compute the stop parameter $\boldsymbol{\rho} = \bigwedge_{j=1}^{n} \bigvee_{i=1}^{p} \boldsymbol{x}_j^i$
4. Transform the index of all fundamental patterns into two indices, one for their class and another for their position in the class (e.g. x^{μ} in class i becomes $x^{i\omega}$).
5. Initialize $\theta = 0$
6. Do $\gamma(x_j^{i\omega}, y_j, \Theta)$ for each component of the fundamental patterns.
7. Compute a weighted sum c_i for each class, according to this equation:

$$c_i = \frac{\sum_{\omega=1}^{k_i} \sum_{j=1}^{n} \gamma(x_j^{i\omega}, y_j, \theta)}{k_i}, \quad (3)$$

where k_i is the cardinality in the fundamental set of class *i*.
8. If there is more than one maximum among the different ci, increment θ by 1 and repeat steps 6 and 7 until there is a unique maximum, or the stop condition $\theta \geq \rho$ is fulfilled.
9. If there is a unique maximum among the c_i, assign ỹ to the class corresponding to such maximum.
10. Otherwise, assign ỹ to the class of the first maxima found.

Definition 4 (Separation). *Given a TS D with samples $d_1d_2d_3$ . . ., the separation s between a segment $d_i\, d_{i+1}$ . . . d_{n-1} (of length n) and sample d_j is given by the distance between the closest extreme of the segment and the sample.*

Based on this definition and the GC, the proposed TS forecasting method follows the algorithm presented below, considering a TS D of length l with a prediction (test) segment of length t, and a length for the patterns of size *n*.
1. Starting from the TS D, calculate the differences between successive samples in order to work with values relative to that of the previous sample. The new time series D' has length $l - 1$.

$$D_{lx1} \rightarrow D'_{(l-1)x1} \quad (4)$$

2. Build a set of associations between TS difference segments of length n and its corresponding difference with separation *s*, for positive values of $s = 1, 2, \ldots, t-1, t$. Thus, there will be a sets of associations of the form $\{a^{\mu}, b^{\mu}\}$ where $a \in R^n$ and $b \in R$, and the i-th association of the set is made up by $a^{\mu} = d_i d_{i+1} \ldots d_{i+n-1}$ and $b\mu = di+n+s-1$.
3. Train a different GC from each association; there will be t different classifiers, each with a distinct fundamental set $\{x^{\mu}, y^{\mu}\}$ for its corresponding value of s.
4. Operate each GC with all the input segments a^{μ}.
5. When multiple classifiers give different output values ỹ for the same data point in the differences TS D, there are two prominent alternatives to integrate them into one value ỹ.
   (a) Average the values given by the two classifiers with the same absolute separation $|s| = \{-s, s\}$; this is denoted as the combined method.
   (b) Average the values given by all available classifiers; this is known as the combined average method.
6. Convert back to absolute values by adding the forecast relative value (ỹ) to the original value of the previous sample, taken from D.

$$\tilde{y} = D_{i-1} + \tilde{y}_i^{'} \tag{5}$$

3 Proposed Model

The Gamma Classifier Algorithm for Exchange Rate Forecasting is described below:
1. Convert the patterns in the fundamental set into binary vectors using the MJM code.
2. Code the test pattern with the MJM code, using the same parameters used for the fundamental set.
3. Compute the stop parameter $\boldsymbol{p} = \wedge_{j=1}^{n} \vee_{i=1}^{p} \boldsymbol{x}_j^i$
4. Transform the index of all fundamental patterns into two indices, one for their class and another for their position in the class (e.g. x^{μ} in class i becomes $x^{i\omega}$).
5. Initialize θ,

$$\theta = (0.005) * \frac{1}{p} \sum_{i=1}^{p} x^i \tag{6}$$

6. Do $\gamma(x_j^{i\omega}, y_j, \Theta)$ for each component of the fundamental patterns.
7. Compute a weighted sum c_i for each class, according to equation (3).
8. If there is more than one maximum among the different c_i, calculate the average of all C_i classes that has a c_i maximum and assign the average divided by 10^d (to get the original scale of the time series S) to the unknown pattern ỹ.

$$average = \frac{1}{amount\ of\ maxima} \sum C_j \ where\ j = i\ \forall\ i\ \ such\ that\ c_j = \bigvee_{i=1}^{k} c_i \tag{7}$$

$$C_{\tilde{y}} = \frac{average}{10^z} \tag{8}$$

9. If there is a unique maximum among the c_i, increment θ by 1 and repeat steps 6 and 7 until there is more than one maximum, or the stop condition $\theta \geq \rho$ is fulfilled.
10. Otherwise, assign ỹ to the class of the first maxima found.

Opposed to the Gamma Classifier that seeks for a unique maximum for the class assignation for the unknown pattern ỹ, the proposed model seeks for several alike classes. The idea is to find similar classes (time series patterns) that have occurred in the past, and assign an average of those alike classes to the unknown pattern ỹ.

To do this the conventional initialization of Θ in 0 is not appropriate, because if we do this it takes more iterations to find similar patterns; also, on a low value of Θ, the lower amount of similar classes we will have (could be only two). Experimental results have shown that the best results are given when we have more than 2 similar classes, but we should be careful of not giving a high value of Θ because this could lead the classifier to

determine that classes are similar, and they are not, because, while Θ increases, the similarity between the features of the unknown pattern and the known patterns decreases.

For Θ initialization purpose we propose the equation 3.Experimental results also have shown that low size of n, (size of the pattern codification) between 4 and 6, have better performance that high values of n (10 or more).

4 Experiments Design

4.1 Data Sets

The time series used in these experiments were taken from 2 web sites, daily values of MXN/USD (Mexican Peso/American Dollar) and JPN/USD (Japanese Yen/USD) were taken from www.forecasts.org, and USD/GBP (USD/British Pound) monthly values, were taken from http://www.ny.frb.org/markets/fxrates/historical/home.cfm (Federal Reserve Bank of New York site), for MXN/USD we used the interval from 2010-12-01 - 2013-12-20, for JPN/USD we used from 2010-01-04 - 2012-12-31 and finally for USD/GBP we used from 1971-01-01 to 2013-11-01.

We create a set of experiments where we compare our proposed model against the classical forecasting models, under the very same circumstances; we take a whole time series and hold out the last 23 values (approximately the working days in a month) for the daily values, and hold out the last 12 values for the monthly values, then we use the time series (without the last 23 or 12 values) as an input of the models and forecast the next 23 and 12 values for of the series for the daily and monthly time series respectively, then we compare the results using the last 23 and 12 values held out before and calculating the errors.

4.2 Error Metrics

The error metrics used for the models comparison are Mean Square Error (MSE), Root Mean Square Error (RMSE) and Mean Absolute Percent Error (MAPE), also we calculate the Pearson's Correlation Coefficient (PCC) to see the behavior of the forecasted result. For MSE, RMSE and MAPE lower values are better, meanwhile for PCC closest values to 1 are better. The metrics equations are given as follows:

$$MSE = \frac{\sum e_t^2}{n}, \tag{9}$$

$$RMSE = \sqrt{MSE}, \tag{10}$$

$$MAPE = \frac{\sum \frac{e_t}{a_t}}{n}(100), \tag{11}$$

$$PCC = \frac{\sigma_{xy}}{\sigma_x \sigma_y}, \tag{12}$$

where:

e_t– mean error on time t, where: $e_t = a_t - f_t$.
a_t – is the actual value.
f_t – is the forecasted value, and
n – The amount of samples.
σ_{xy} – is the covariance of (x,y)
σ_x – is the standard deviation of x
σ_y – is the standard deviation of y

4.3 Models Construction

We used 3 tools for the models construction, for the regression models (AR, ARIMA, ARMA) we used Matlab 2013 which includes an Econometric toolbox that allows to create an ARIMA(p,D,q) model, and an Estimate function that uses maximum likelihood to estimate the parameters of the ARIMA(p,D,q) model given the observed univariate time series. For the Machine Learning Algorithms we used Weka 3.7.11 that now includes a forecast utility. The model configuration used for Multi-Layer Perceptron (MLP), Support Vector Regression, MLP Regressor are the default suggested by Weka Optimization class. Finally we implemented in Java Language the Gamma Classifier.

5 Experimental Results

5.1 Models Comparison

The models are ordered from lower to higher RMSE. The tables 2-4 show the performance of the models implemented for this work. The Gamma Classifier with Combined (C) method and Combined Average (CA) method are highlighted.

For GBP-USD predictions (Table 2), the Gamma Classifier with CA method has the second best performance and also it have the best PCC.

Table 2. GBP-USD results for 12 months ahead forecasted

Model	Correlation Coefficient	MSE	RMSE	MAPE
ARMA(10,3)	0.549237	0.000202	0.014223	0.515375
Gamma Classifier CA	**0.703234**	**0.000211**	**0.014516**	**0.037408**
SVRegression	0.562688	0.000301	0.017362	0.585531
AR 10	0.573760	0.000305	0.017465	0.636467
Least Median Squared Linear Regression	-0.414414	0.000567	0.023810	0.835851
Gamma Classifier C	**0.296301**	**0.000701**	**0.026479**	**0.993409**
MLP Regressor	-0.092631	0.000818	0.028593	1.042937
ARIMA(10,1,10)	-0.028813	0.000997	0.031568	1.174118
Gaussian Processes	0.562810	0.083368	0.288736	11.376421
Multi Layer Perceptron	0.607254	0.096973	0.311405	9.630076

For JNP-USD predictions (Table 3), the Gamma Classifier with C method has the third best performance; meanwhile the Gamma Classifier with CA method has the fourth best PCC.

Table 3. JNP-USD results for 23 days ahead forecasted

Model	Correlation Coefficient	MSE	RMSE	MAPE
Multi-Layer Perceptron	0.979428	0.468221	0.684267	0.701716
SVRegression	0.966534	1.904561	1.380058	1.089557
Gamma Classifier C	**0.580982**	**3.273381**	**1.809249**	**1.554930**
ARMA(10,3)	-0.719281	3.958358	1.989562	1.629965
Least Median Squared Regression	-0.732313	4.588599	2.142101	1.809652
MLP Regressor	-0.954679	4.707212	2.169611	1.768684
ARIMA(10,1,10)	-0.850739	4.802789	2.191527	1.849221
AR 10	-0.750468	4.861758	2.204939	1.887653
Gamma Classifier CA	**0.903806**	**5.372789**	**2.317928**	**2.446975**
Linear Regression	0.983064	18.519081	4.303380	3.947253

Finally, for MXN-USD predictions (Table 4), the Gamma Classifier with CA method has the third best performance and the third best PCC.

Table 4. MXN-USD results for 23 days ahead forecasted

Model	**Correlation Coefficient**	**MSE**	**RMSE**	**MAPE**
Least Median Squared Regression	-0.126938	0.011632	0.107851	0.657486
SVRegression	-0.291778	0.012311	0.110954	0.625846
Gamma Classifier CA	**0.180517**	**0.012805**	**0.113159**	**0.690101**
Linear Regression	-0.377727	0.012867	0.113432	0.661473
MLP Regressor	-0.347532	0.013522	0.116283	0.729020
ARIMA(10,1,10)	-0.074195	0.019713	0.140405	0.808322
AR 10	0.125089	0.024416	0.156257	0.944695
ARMA(10,3)	0.381415	0.025612	0.160037	0.996850
Multi-Layer Perceptron	0.271096	0.035570	0.188601	1.183675
Gamma Classifier C	**-0.466466**	**0.049240**	**0.221902**	**1.372825**

6 Conclusions and Future Work

The Performance of the Gamma Classifier is a promising model for the forecast exchange rate problem, it is simple for understanding, implementing and is computationally efficient. However, one open problem is find a way to decide which method for the result of the Gamma Classifier should be used, combined or combined average, because where Combined method does not have the best of the performances the Combined Average improve the results and conversely.

Empirical results have shown that ranges between 4 and 6 for the size of the pattern n have better performance. Other open problem is, find a way to determinate the optimal initial values of n and Θ for this kind of problem. This algorithm can be extended to other forecasting financial problems, because other financial problems present .similar features that exchange rate problem also does. Another approach for this forecasting task. is that the Gamma Classifier could be considered to be part of a hybrid model for the forecasting problem, given that, sometimes GC has better performance than classical financial or machine learning approaches.

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Integrated Greedy-Tabu-Search Method for the Economic Statistical Design of Shewhart Charts

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Abstract. Shewhart charts, also known as control charts, are important Statistical Process Control (SPC) techniques used for prompt detection of failures in a manufacturing process and minimization of production costs. Techniques have been used to find the chart's parameters that best comply with economic and statistical requirements. In this paper a method that integrates a Greedy and a Tabu-Search (TS) algorithm is presented to estimate these parameters for $\bar{X}$ control charts which are used for controlling process mean. When tested with different cost models and statistical restrictions with general failure distribution, and constant and variable sampling intervals, the performance of the proposed method was more accurate when compared to TS alone and a Genetic Algorithm.

Keywords: Control Charts, Economic Statistical Design, Greedy Algorithms, Tabu-Search

1 Introduction

Shewhart or control charts are tools used to determine whether or not a production process is in a state of statistical control, and thus, the entities being produced are within quality requirements. These requirements are set by Upper and Lower Control Limits (UCL, LCL). If the quality attribute or feature of sampled entities is not within these limits, then the process is in an out-of-control state (non-conforming entities are being produced). In this case is necessary to find and correct the assignable cause that originated this state (e.g., a failure) [9]. As presented in Figure 1 a control chart requires three main parameters: n, the size of the sample; h, the length of the sampling interval between samples; and k, the coefficient of the control limits [9]. These parameters are selected based on economic and statistical restrictions because there are costs and times associated to sampling and searching of assignable causes.

The Economic Statistical Design (ESD) [2,4,13,14] of control charts is the approach developed to design control charts considering the interactions between the chart's parameters and the time and money costs associated to the sampling

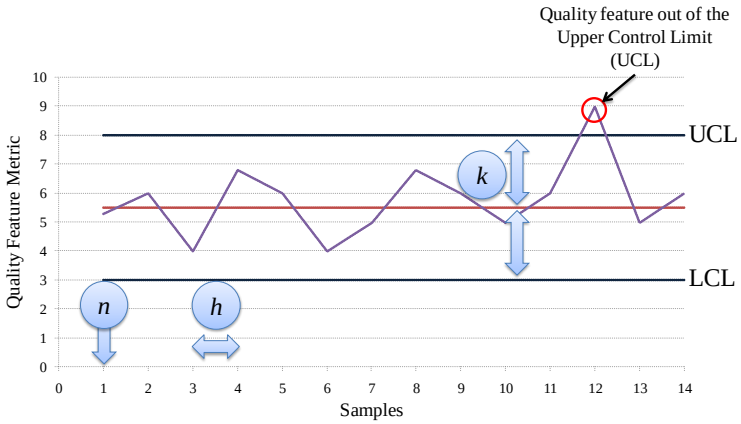

Fig. 1. General Control Chart.

and searching/repairing of an assignable (or multiple) causes of failure. The ESD considers the statistical requirements set by the error probabilities α (detecting an out-of-control state when the process is fine) and β (not detecting an out-of-control state when the process is not fine). Finding the most suitable values of n, h, and k considering the economic and statistical restrictions is not an easy task. This is because of the number of variables and the complexity of the cost function. The ESD of control charts is considered a problem for combinatorial optimization [8].

Among the techniques to find a suitable solution for the ESD of control charts, Hooke and Jeeves (HJ) [11], Genetic Algorithms (GAs) [2,4,13,8,7], Tabu Search (TS) [1] and Combinatorial Methods (CB) [14] can be mentioned. An advantage of TS is that hybridization (integration with other meta-heuristics) is possible to improve performance on combinatorial problems [10].

In this paper a hybrid TS metaheuristic is presented for the ESD of $\bar{X}$ control charts. This method is presented with the following characteristics: (1) integration of TS with a Greedy algorithm for initialization of the search space; (2) diversification of the search space for the TS algorithm performed with random uniform moves. Two case studies were considered to validate the performance of the integrated method defined as G-TS (Greedy-TS). Significant improvements were obtained with the G-TS method across different cost functions, restrictions, and settings when compared to TS alone and a GA.

2 Integrated Approach

The proposed approach integrates two algorithms as presented in Figure 2. It consists of a "Greedy" algorithm which generates a set of random solutions

that comply with the economic and statistical restrictions of the cost model of the control chart. With this algorithm an initial solution is produced for the Tabu-Search (TS) algorithm which performs improved search to find a better solution. The details of both algorithms are presented in the following sections.

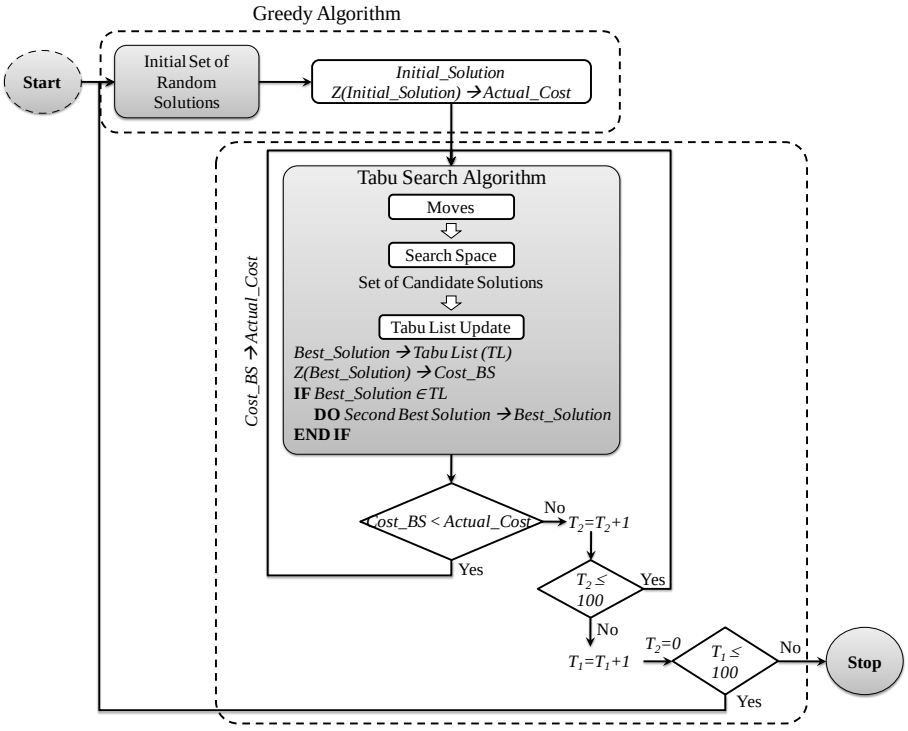

Fig. 2. Structure of the Integrated Greedy-TS (G-TS) Metaheuristic.

2.1 Greedy Algorithm

A greedy algorithm follows the problem solving heuristic of making the locally optimal choice at each stage with the hope of finding a global optimum. Although a greedy strategy does not in general produce an optimal solution, it may lead to locally optimal solutions that approximate a global optimal solution in a reasonable time [3]. In Figure 3 the structure of the greedy algorithm is presented where the following variables are initialized:

– $Total\_Solutions = 0$, this is the counter for the total number of solutions (up to 100) in the "Initial Set of Random Solutions" (see Figure 2).

- $Best\_Cost = Inf$, this is the reference for the best cost found on each iteration of the greedy algorithm. Initially, this value is set equal to Inf (infinite). Each time that a solution is found with a cost better than the reference (in this case, a minimum cost) this variable is updated.
- $No\_Best = 0$, if the best solution found in the present iteration of the greedy algorithm has a better cost than the reference ($Z\,(Best\_Initial\_Solution) < Best\_Cost$) then the algorithm is iterated again and the reference is updated ($Z\,(Best\_Initial\_Solution) \rightarrow Best\_Cost$). Otherwise the No_Best variable is increased by one. The algorithm is iterated until $No\_Best = 100$.

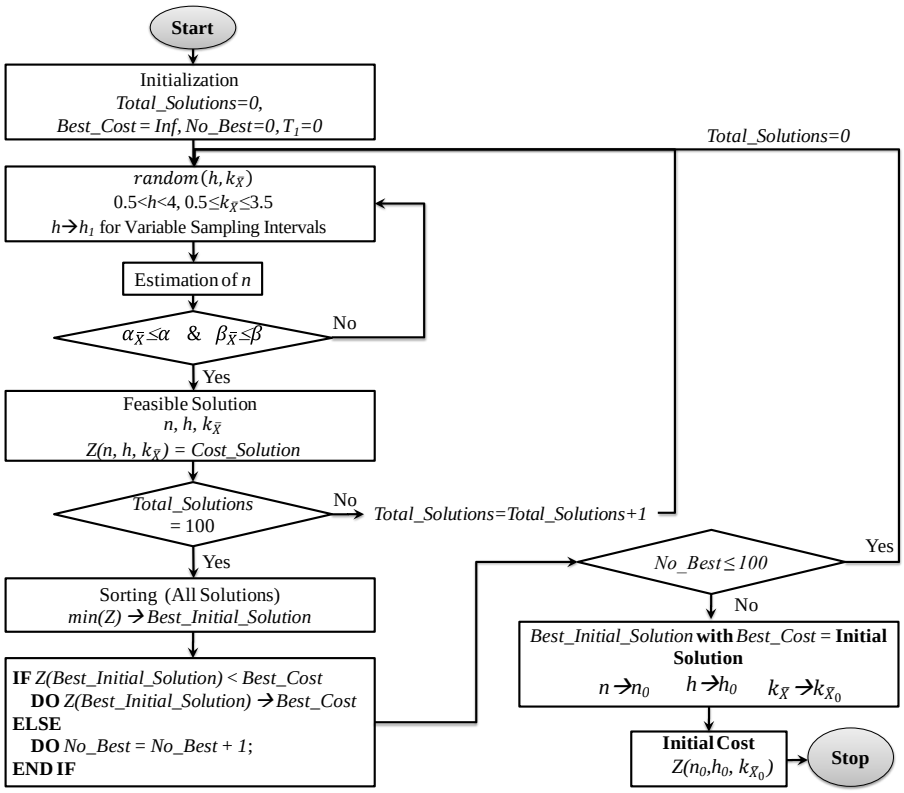

Fig. 3. Structure of the Greedy Algorithm.

The algorithm begins by estimating values for the parameters h and $k_{\bar{X}}$ of the $\bar{X}$ chart. These values are randomly generated with a uniform probability distribution with the following limits: $0.5 < h < 4$, and $0.5 \leq k_{\bar{X}} \leq 3.5$. Then, for

each pair h, $k_{\bar{X}}$, n is estimated by using the expression $n = \left(C + \frac{k_{\bar{X}}}{\delta}\right)^2$, where C is a value from a standardized normal distribution for a required value of β or α [**?**]. Then, for the solution formed by the parameters n, h and $k_{\bar{X}}$, the values for $\alpha_{\bar{X}}$ and $\beta_{\bar{X}}$ are computed. If these values are within given limits ($\alpha_{\bar{X}} \leq \alpha$, $\beta_{\bar{X}} \leq \beta$) then the solution complies with statistical restrictions, otherwise the set is re-estimated.

The complying set of values for n, h, $k_{\bar{X}}$ represents a "Feasible Solution" which is then evaluated in the cost function ($Z(n, h, k_{\bar{X}})$) to obtain its associated cost ($Cost\_Solution$). This process is performed 100 times leading to 100 feasible solutions ($Total\_Solutions = 100$). Then, the solution with the minimum cost ($min(Z)$) is considered the $Best\_Initial\_Solution$. If the cost of this $Best\_Initial\_Solution$ is better ($<$) than the reference cost ($Best\_Cost$), then this value is updated ($Best\_Initial\_Solution \rightarrow Best\_Cost$). If not, the variable No_Best is increased by one and the reference cost remains unchanged. After any of these scenarios, a new process is started with $Total\_Solutions = 0$. This is performed until $No\_Best = 100$. At this point, the final $Best\_Initial\_Solution$ obtained across all iterations of the greedy algorithm is considered to be the **Initial_Solution** for the Tabu-Search algorithm, and its cost the **Initial_Cost** (or reference cost) for the same algorithm.

2.2 Tabu Search (TS) Algorithm

TS is a meta-heuristic that can guide a heuristic algorithm from a local search to a global space to find solutions beyond the local optimality. It can avoid loops in the search process by restricting certain "moves" that would make the algorithm to revisit a previously explored space of solutions. These moves are kept hidden or reserved (are being kept "Tabu") in a temporal memory (a "Tabu List") which can be updated with new moves or released with different criteria [5,6]. The TS algorithm which is presented in Figure 2 and is based on the algorithm presented in [1] takes as input the **Initial_Solution** estimated by the greedy algorithm. This solution is diversified in order to explore a search space more likely to contain a better solution (global optimum). The TS algorithm considers the following variables:

- T_L, the number of iterations of the TS algorithm that a solution remains in the **Tabu List** (TL);
- $T_1 \leq 100$, the number of iterations of the integrated G-TS algorithm (see Figure 2);
- $T_2 \leq 100$, the number of iterations of the TS algorithm with no better solutions.

With the **Initial_Solution** the TS algorithm starts the search task, diversifying this solution into a set of new solutions that forms a **Search Space**.

The diversification is performed by means of "moves" over the elements of the **Initial_Solution** (n_0, h_0, $k_{\bar{X}_0}$). For the case study with variable sampling intervals, all j intervals are dependent of the length of the first interval h_1 as defined by $h_j = \rho h_{j-1}$ [11], hence only h_1 is to be estimated. For all new solutions the values of α's and β's are estimated to verify compliance of the statistical restrictions. If a solution does not comply, then $Z = Inf$ (infinite), otherwise Z is computed with the estimated parameters. As this is a minimization problem, the solutions are sorted based on their cost value Z in ascendant order, thus the first element would be that with the minimum cost of all new solutions, the **Best_Solution**.

To avoid search loops (revisiting solutions) and finding a local optimum, the **Best_Solution** is kept in a **Tabu List** (TL) for T_L iterations of the TS algorithm. If in the next iteration, the *Best_Solution* is already in TL, then the *Best_Solution* would be the second (or third, or fourth, etc.) best solution in the sorted Search Space. This enables the TS algorithm to produce more diverse solutions even if these are estimated from a "not so good" solution.

The **Actual_Cost** is updated with that of the *Best_Solution*, **Cost_BS**, and the TS algorithm starts again to produce a set of new solutions from the *Best_Solution*. If no *Best_Solution*/*Cost_BS* is obtained after T_2 iterations of the TS algorithm, the *Best_Solution* is stored and the G-TS algorithm is executed again (for up to T_1 iterations) to generate new initial values for h and $k_{\bar{X}}$. If T_1 reaches a given limit then the G-TS algorithm stops.

In contrast to the TS algorithm presented in [1] uniform random distribution is used to generate the moves for the diversification of n_0, h_0 and $k_{\bar{X}_0}$. For n_0 the upper limit for the uniform random move changes dynamically to $n_0/2$ instead of being fixed to 1. This enabled further exploration of the search space.

3 Results

3.1 First Case Study

The G-TS algorithm was tested to solve the cost model of Rahim *et al.* [12] for the ESD of $\bar{X}$ control charts with Gamma failure distributions and constant sampling intervals. In [13] the cost model of Rahim *et al.* [12] was adapted to consider general failure distribution for the ESD of $\bar{X}$ charts. This allowed the consideration of an additional failure distribution: Weibull.

Both failure distributions have a parameter related to the failure rate in a process which is defined as:

$$\lambda = \frac{\text{known number of failures}}{\text{Unit of Time}}. \quad (1)$$

λ is known as the *scale* parameter in the Gamma distribution and represents the known number of failures per unit of time. For the Weibull distribution

$\lambda = 1/c$ where c is defined as the time where the system is likely to fail. In order to explore the performance of the proposed algorithm, four failure rates were considered for λ: 0.5050, 0.2525, 0.1010, 0.0505. Also, for the Weibull distribution, three values for the *form* (f) parameter were considered: 2, 3, 4.

The solving methods considered for this case study were TS alone and GA. TS was implemented as presented in [1]. For the GA, the algorithm presented in [13] was considered. The data set used for this test was: μ=182, $\sigma = \sqrt{10}$, δ=0.50, Z_0=0.25, Z_1=1, D_0=50, D_1=950, a = 20, b =4.22, W =1100, Y =500, $\alpha_{\bar{X}} \leq$0.15, $\beta_{\bar{X}} \leq$0.20. The comparison of performances is presented in Table 1.

For the Gamma distribution, GA, TS, and G-TS provided values for n, h, and $k_{\bar{X}}$ that led to very similar costs Z independently of the failure rates. Significant differences are presented with the Weibull distribution for all parameter settings of *scale* and *form*. The significance of these results is discussed in Section 3.3.

3.2 Second Case Study

For the ESD of $\bar{X}$ control charts with variable sampling intervals the cost model presented in [11,13] was considered. If in a process there are $j = 1, 2, .., J$ constant sampling intervals, then $h_j = h$. When the sampling intervals are variable, h_j is different for each period j. In [11] Rahim *et al.* proposed the consideration of a specific number of J samples (sampling intervals) in the production cycle, $j = 1, 2, ..., J$, so the production cycle could be considered as truncated [13]. A truncated production cycle starts when a new component is installed and ends with a repair or after a fixed number of J sampling intervals. The model with variable sampling intervals considers the following:

- the first interval h_1 is randomly chosen;
- the length of the next sampling intervals are chosen as $h_j = \rho h_{j-1}$, where h_j is the sampling interval for sample j, and ρ is a decrement factor. The sampling intervals h_j are computed by applying the decrement factor to the successor sampling interval, thus $h_1 > h_2 > h_3 > ... > h_J$, because as time continues the sampling frequency must increase given the natural wear and tear of the components of the process [11].

Hence, for this case study, n, h_1, and $k_{\bar{X}}$ were estimated. The G-TS algorithm was tested against the GA presented in [13] with Weibull and Gamma distributions with different values of λ and *form*. The number of sampling intervals was J=5 and J=7 for the experiments with Gamma and Weibull distributions respectively. The results are presented in Table 2. In all cases, the G-TS algorithm found parameters that reduced the cost Z more than the parameters found with the GA. The significance of these results is discussed in Section 3.3.

Table 1. G-TS performance compared to TS and GA: Cost Model of Rahim [12]-Ruvalcaba [13].

Failure Dist.	Parameters	Technique	n	h	$k_{\bar{X}}$	$\alpha_{\bar{X}}$	$1-\beta_{\bar{X}}$	Z
Gamma	$\lambda = 0.5050$	GA	24	1.4703	1.4421	0.1493	0.8432	467.83
	$f = 2$	TS	24	1.4546	1.4396	0.1500	0.8438	467.81
		G-TS	24	1.4554	1.4396	0.1500	0.8440	467.20
Gamma	$\lambda = 0.2525$	GA	25	1.8820	1.4725	0.1409	0.8479	347.12
	$f = 2$	TS	25	1.8916	1.4719	0.1411	0.8481	347.12
		G-TS	25	1.8808	1.4767	0.1398	0.8469	346.77
Gamma	$\lambda = 0.0505$	GA	28	3.7413	1.6109	0.1072	0.8496	174.70
	$f = 2$	TS	28	3.8588	1.5585	0.1191	0.8615	174.70
		G-TS	28	3.7322	1.6255	0.1041	0.8462	174.70
Weibull	$1/c = 0.5050$	GA	28	0.6248	1.7025	0.0887	0.8272	549.91
	$f = 2$	TS	24	0.6521	1.4447	0.1485	0.8425	547.99
		G-TS	24	0.5857	1.5900	0.1118	0.8050	540.68
Weibull	$1/c = 0.2525$	GA	31	0.8378	1.9410	0.0522	0.8003	453.43
	$f = 2$	TS	25	0.8263	1.4788	0.1391	0.8464	449.41
		G-TS	23	0.7753	1.4975	0.1343	0.8161	442.71
Weibull	$1/c = 0.0505$	GA	37	1.4401	2.0884	0.0368	0.8297	284.97
	$f = 2$	TS	25	1.4165	1.4776	0.1395	0.8467	275.83
		G-TS	24	1.4156	1.6002	0.1095	0.8022	269.99
Weibull	$1/c = 0.5050$	GA	30	0.5776	1.8717	0.0612	0.8070	477.72
	$f = 3$	TS	24	0.6424	1.4458	0.1482	0.8423	480.69
		G-TS	23	0.6000	1.4986	0.1340	0.8158	469.79
Weibull	$1/c = 0.2525$	GA	29	0.6839	1.7663	0.0773	0.8228	408.44
	$f = 3$	TS	24	0.7421	1.4504	0.1469	0.8411	410.97
		G-TS	26	0.7000	1.6977	0.0773	0.8229	399.32
Weibull	$1/c = 0.0505$	GA	37	1.1217	2.0867	0.0369	0.8301	296.48
	$f = 3$	TS	24	1.1295	1.4471	0.1478	0.8419	286.28
		G-TS	27	1.0333	1.7130	0.0369	0.8301	279.20
Weibull	$1/c = 0.5050$	GA	30	0.6524	1.7662	0.0774	0.8346	435.03
	$f = 4$	TS	25	0.6264	1.4685	0.1420	0.8490	435.03
		G-TS	26	0.5527	1.6586	0.0774	0.8346	423.55
Weibull	$1/c = 0.2525$	GA	37	0.7094	2.0952	0.0361	0.8280	400.11
	$f = 4$	TS	26	0.6900	1.4892	0.1364	0.8555	387.85
		G-TS	26	0.7411	1.6682	0.0953	0.8109	371.89
Weibull	$1/c = 0.0505$	GA	33	1.0000	1.9180	0.0551	0.8300	288.86
	$f = 4$	TS	24	1.0432	1.4500	0.1470	0.8413	287.45
		G-TS	25	0.9000	1.6457	0.0998	0.8036	277.80

Table 2. G-TS performance compared to GA: Cost Model of Rahim [11]-Ruvalcaba [13].

Failure Dist.	Parameters	Technique	J	n	h_1	$k_{\bar{X}}$	$\alpha_{\bar{X}}$	$1-\beta_{\bar{X}}$	Z
Gamma	$\lambda = 0.5050$	GA	5	23	2.2430	1.5345	0.1249	0.8061	476.39
	$f = 2$	G-TS	5	25	2.6317	1.5450	0.1224	0.8302	472.59
Gamma	$\lambda = 0.2525$	GA	5	31	3.8033	1.7658	0.0774	0.8457	354.60
	$f = 2$	G-TS	5	24	4.0743	1.5059	0.1321	0.8273	352.64
Gamma	$\lambda = 0.0505$	GA	5	29	10.0290	1.6552	0.0979	0.8502	173.61
	$f = 2$	G-TS	5	30	10.4509	1.6009	0.1094	0.8724	173.43
Gamma	$\lambda = 0.5050$	GA	5	31	3.2457	1.7733	0.0762	0.8439	379.45
	$f = 3$	G-TS	5	26	3.1754	1.7027	0.0886	0.8015	377.04
Gamma	$\lambda = 0.2525$	GA	5	28	5.0753	1.5404	0.1235	0.8655	271.66
	$f = 3$	G-TS	5	28	4.9576	1.6702	0.0949	0.8354	271.50
Gamma	$\lambda = 0.0505$	GA	5	36	14.7360	1.7114	0.0870	0.9012	130.85
	$f = 3$	G-TS	5	25	15.2913	1.6382	0.1014	0.8056	130.06
Gamma	$\lambda = 0.5050$	GA	5	28	3.7286	1.7501	0.0801	0.8148	317.50
	$f = 4$	G-TS	5	27	3.8204	1.6122	0.1069	0.8379	316.91
Gamma	$\lambda = 0.2525$	GA	5	34	6.3295	1.9685	0.0490	0.8282	226.53
	$f = 4$	G-TS	5	26	6.2435	1.6992	0.0893	0.8024	223.60
Gamma	$\lambda = 0.0505$	GA	5	29	17.9552	1.5582	0.1192	0.8717	108.82
	$f = 4$	G-TS	5	27	17.9491	1.6731	0.0943	0.8225	107.79
Weibull	$1/c = 0.5050$	GA	7	56	1.0844	2.0527	0.0401	0.9543	570.79
	$f = 2$	G-TS	7	53	1.0852	1.4637	0.1433	0.9852	564.18
Weibull	$1/c = 0.2525$	GA	7	74	1.4193	2.2541	0.0241	0.9796	451.95
	$f = 2$	G-TS	7	58	1.3926	1.4809	0.1386	0.9900	441.30
Weibull	$1/c = 0.0505$	GA	7	97	2.8885	2.4514	0.0142	0.9933	219.30
	$f = 2$	G-TS	7	69	2.8611	1.4562	0.1453	0.9965	208.43
Weibull	$1/c = 0.5050$	GA	7	44	1.0507	1.8716	0.0612	0.9258	592.15
	$f = 3$	G-TS	7	47	1.0398	1.4501	0.1470	0.9760	590.32
Weibull	$1/c = 0.2525$	GA	7	52	1.3105	1.9964	0.0459	0.9462	526.48
	$f = 3$	G-TS	7	58	1.2839	1.4421	0.1493	0.9910	520.93
Weibull	$1/c = 0.0505$	GA	7	74	2.1194	2.2548	0.0241	0.9796	382.03
	$f = 3$	G-TS	7	60	2.1355	1.4895	0.1364	0.9914	373.52
Weibull	$1/c = 0.5050$	GA	7	46	1.0745	1.5272	0.1267	0.9688	601.08
	$f = 4$	G-TS	7	26	1.0286	1.4803	0.1388	0.8575	598.81
Weibull	$1/c = 0.2525$	GA	7	38	1.2172	1.7637	0.0778	0.9063	552.99
	$f = 4$	G-TS	7	47	1.2403	1.4945	0.1351	0.9734	551.20
Weibull	$1/c = 0.0505$	GA	7	53	1.8217	2.0087	0.0446	0.9486	448.55
	$f = 4$	G-TS	7	53	1.7649	1.4684	0.1420	0.9851	443.33

3.3 Analysis

In order to evaluate the statistical significance of the results presented in Tables 1 and 2 a "2-Sample t Test" was performed. For this purpose the hypothesis $H_0 : \mu_x - \mu_{G-TS} = 0$ where $x = \{TS, GA\}$ was considered. It is expected that if significant improvements are obtained then $\mu_x - \mu_{G-TS} \neq 0$ leading to H_0 being rejected. In Table 3 the results of the "2-Sample t Test" are presented for each case study considering a significance level of 0.05. For all cases the improvement achieved with the G-TS algorithm was statistically significant.

Table 3. 2-Sample t Test.

Case Study	Comparison	Conclusion
First	G-TS vs. TS	μ_{TS} and μ_{G-TS} are significantly different ($p < 0.05$)
	G-TS vs. GA	μ_{GA} and μ_{G-TS} are significantly different ($p < 0.05$)
Second	G-TS vs. GA	μ_{GA} and μ_{G-TS} are significantly different ($p < 0.05$)

In contrast to other TS implementations [1] where only an initial solution is randomly generated in the presented algorithm the greedy process provides an initial solution selected from a whole set which may be of better quality. The importance of the initial solution for the TS process is corroborated by the results reported in Tables 1 and 2.

4 Conclusions

The proposed G-TS algorithm achieved significant benefits when used for the ESD of $\bar{X}$ Shewhart / control charts with different probability distributions when compared with other methods such as GA and TS. These benefits were statistically significant with p-values < 0.05.

In addition, the integration of a greedy algorithm may lead to increase convergence of other heuristics by providing a more specific search region. This however has to be verified with other integration schemes (e.g., G-GA) and other cost functions.

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Unconventional Computing for Estimating Academic Performance

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Abstract. One of the relevant tasks of the teaching-learning process is that of evaluation. In this sense, estimating the academic performance exhibited by the final evaluation of a student, at the end of the current semester, has become of particular interest for students, parents, educators, educative managers and researchers alike. More specifically, the current paper is focused in determining whether a first semester engineering student at the Universidad Tecnológica de Pereira, Colombia, will pass or fail the Mathematics I course. This paper proposes the use of the Gamma Classifier together with Wilson Editing to solve the problem. Results observed are competitive against classic models of pattern recognition.

Keywords: Gamma classifier, academic performance estimation, Wilson Editing.

1 Introduction

The target of the institutions of higher education is to provide quality education to the students [1], yet high rates of dropouts and poor performance are a current problem for universities throughout the world.According to [1] despite all efforts to prevent freshmen desertion in Colombia, there are records that student desertion in the period 1994 to 2004 is on average 52%.

Based on this number from 2005; various tests were done to new students [1-2]. The aim is to record all information obtained from the tests and grades that students obtained at the end of semester in Universidad Tecnológica de Pereira.

We propose to use this dataset, which is based in a thorough study of student performance, and implement an associative model known as Gamma Classifier together with the Wilson Editing to determine with high probability whether the student will pass or fail the Mathematics I course.

The paper is structured as follows; the second section lists selected work related with classification. The third section presents materials and methods for the analysis. The results obtained from the experiments are presented in the fourth section. The conclusions and future work are presented in the last section.

2 Related Work

There are many works about education with different approaches to evaluate the academic performance. The University in Rajasthan (located in India) used a decision tree method to develop a classification task and evaluate the student performance. The University used information such as test, seminars and attendance [1].

Another interesting work was presented in [2]. In this work the researchers developed a system that predicts the success of students in online courses. This system is able to predict the student's performance (with a 70% accuracy) by mining the data recorded on 8 days.

An important problem related with the student's performance was presented in the work [3], where different algorithms were used such as One-R, C4.5, ADTrees, Naive Bayes and Bayes Net. Results indicate the factors such as family background and family's social-economical status, high school GPA and test scores impact in the student's decision to continue or drop out of college.

Studies in Colombia determine the factor, which influence in the final score in Mathematic I course. The results indicate with a 70.4% accuracy if a student passes or fails the course, by using a multiple logistics regression model [4].

Another classification method used in education is Support Vector Machines (SVMs). Dursun Delen [5] developed analytical models to predict and to explain the reasons behind freshmen student attrition. The results were that SVM's produced the best results with an overall prediction rate of 87.23%.

3 Materials and Methods

In this study, we propose use of the Gamma classifier and Wilson Editing to classify whether the students pass or fail the Mathematics I course and to improve classification of student's final performance.

Firstly, the tools to be used are hardware: Processor: 2.9 GHz Intel Core i5 and Memory: 8GB 1600 MHz DDR3 and Software: Eclipse 4.3.2, Python pydev 3.3.3, OS X 10.9.3, WEKA 3.6.10. Secondly, dataset is requested Universidad Tecnológica de Pereira in Colombia. Next, instance selection process is applied using data preprocessing and Wilson Editing. Finally, classification models are used and compared to versus Logistic Model Regression.

3.1 Data set

The data set for this study was collected and consolidated by Universidad Tecnologica de Pereira located in Colombia with an enrollment of 919 students, 29 attributes and 2 classes (class 0 which corresponds to fail has 515 patterns and class 1 which corresponds to pass has 404 patterns).

The dataset contains variables related to student's performance, social characteristics and student's health for a semester. Table 1 details a complete list of variables obtained from the student dataset.

However based on work done [4], we decided to use the same variables. (See table 2).

Table 1. Avalaible attributes (Source [4])

Factor	***Variable***	***Description***
Personal	*Sex*	*Sex*
	Age	*Age*
Socioeconomic	*Tipocole*	*Type of school*
	Estrato	*Social stratum*
Academic	*ICFES*	*Score from Instituto Colombiano para la Evaluación de la Educación*
	Subject1	
	Subject2	
	Subject3	
	Subject4	
	Subject5	
	Average	*Average*
	Vliteral	*Quantitative Literal Reading*
	Cliteral_1	*Quantitative Literal Reading*
	Cliteral	*Qualitative Literal Reading*
	Cinferen	*Qualitative Inferential Reading*
	Ccritico	*Qualitative Critical Reading*
	Cabstract	*Abstract Logical Thinking*
	Vinferen	*Quantitative Inference Reading*
	Vcritico	*Quantitative Critical Reading*
	Cverbal	*Verbal Logical Thinking*
	Clogico	*Logical Thinking*
Institutional	*Codprog*	*Program code*
Risks	*Rsalud1*	*Health coverage*
	Rsalud2	*Physical health*
	Rsalud3	*Nutrition*
	Rsalud4	*Mental Disturbance*
	Rsalud5	*Factor for Psychoactive Substance*
	Rsalud6	*Free time*
	Rsalud7	*Other responsibilities*

3.2 Preprocesssing data

Data preprocessing is an important step for improving data quality. This step helps to increase the accuracy and efficiency of the classifer when the data tend to be incomplete and inconsistent [6]. Thanks to this process, the data with which the classification will be carried out is through qualified data processing [7]. Data preprocessing methods are divided into the following categories [8]: Data cleaning, Data integration, Data transformation, and Data reduction. In our case, we have applied Data cleaning.

Data set has incomplete and inconsistent data, therefore, we replace all missing values using the mean or the mode of each attribute that belongs to a certain class. The measures used for each attribute are given in Table 2.

Table 2. Attributes obtained from student's records and the measures used to replace missing values in each attribute

Attribute	***Type***	***Measure used***	***# Replacement***	
			Class 0	**Class 1**
ICFES	Number	Mean	37	5
Codprog	Categorical	Mode	0	0
Casbtract	Categorical	Mode	116	43

In this study we have decided using Wilson Editing to delete patterns that are misclassified by the KNN rule (K=3) and to increase the accuracy of classifier [9]. The Wilson Editing algorithm is shown below [10].

```
Initialization: S←X
For each pattern xi∈X do:
         If it is misclassified using the KNN (k=3) rule with proto-
types in X-{xi}
         then S←S-{xi}
```

Wilson Editing is based on the distance between patterns to determine their similitude [11]. For this study, we used Manhattan distance (Eq. 1).

$$d(x,y)=\sum_{i=1}^{n}\left|x_i-y_i\right| \tag{1}$$

3.3 Classification

In this work, we chose an algorithm called Gamma Classifier [12]. This algorithm is based in the Gamma similarity operator. The sequences steps of Gamma Classifier are shown in figure 1 and figure 2.

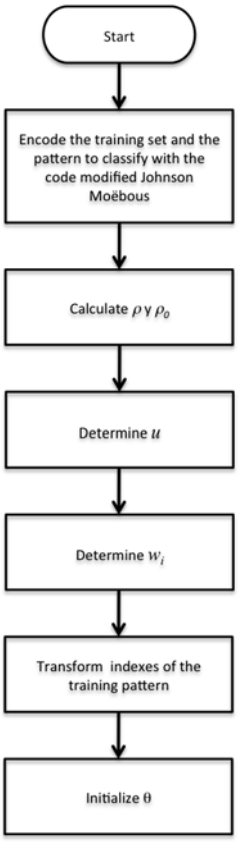

Fig. 1. Functions of Gamma Classifier part I (Source [12-13])

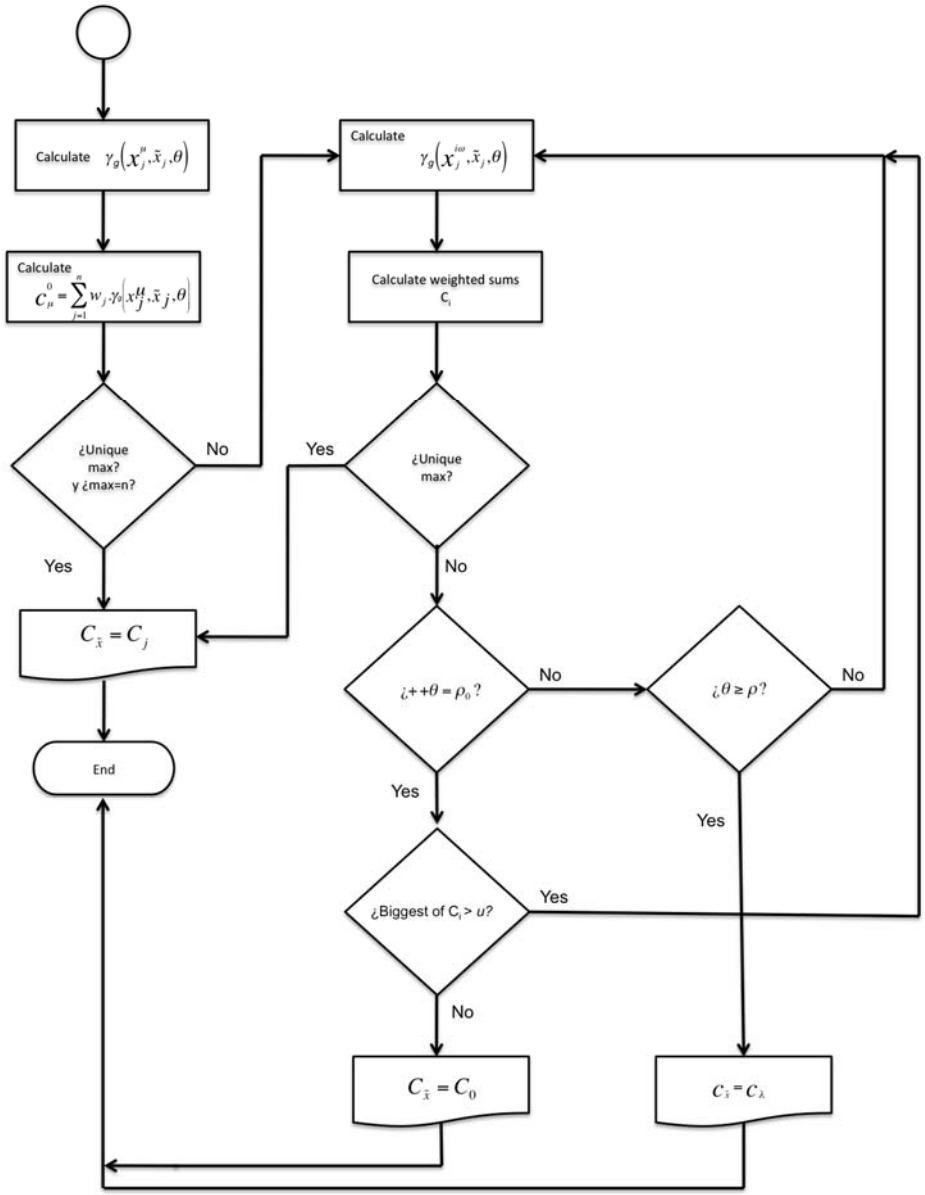

Fig. 2. Functions of Gamma Classifier part II (Source [12-13])

For more details about this classifier it is necessary to consult works [12] and [13].

4 Experiments

In this section, we present the experiments using Gamma classifier and Wilson Editing. We have also included experiments made in WEKA [14] using algorithms such as Naive Bayes, Bayes Net, Support Vector Machines, Simple logistic, and J48. These algorithms were selected based in the background (see section 2).

Firstly, we replaced each data, which has a missing value at least in a feature using mode or mean for each class because Wilson Editing does not accept tuples with Null value (See table 2).

Secondly, to improve the classifier's performance, it is necessary the weight assignment to the features. Based on work done [13] and the feature's graphs, we have decided to assign the following weights.

In Figure 3.A, we can observe that class 0 (students do not pass Mathematics I course) and class 1 (students pass the Mathematics I course) are not separated in cabstract feature because patterns almost have the same values, however, we can not ignore this feature then we assign the value 0.1. In codprog feature occurs the same situation as cabstract feature, classes are not separated, we can see that patterns, which belong to different classes, have very similar values and thus the classes are not separated and we can not ignore this feature the we assign the value 0.1 (See figure 3.B.)

The last one ICFES feature has some patterns, which it is possible to separate, thus, we decide to assign the value 1. This feature is shown in figure 3.C.

However, we performed several experiments varying each feature's weights until we obtained the best results.

Thirdly, using Wilson Editing to improve classifier performance indicates that 662 out of 919 tuples (class 0 has 302 patterns and class 1 has 362 patterns) were selected. Thus, were ignored 257 patterns of dataset.

The results using algorithms such as Gamma, Naive Bayes, Bayes Net, SMO, IBK, Logistic and Simple Logistic and Logistic multiple regression of this experiment are shown in figure 4.

5 Results

In this work, we used the data set, which was composed of three features such as ICFES, *codprog* and *cabtsract* and 662 records. Based on the stratified 10-fold cross validation, Gamma classifier and Wilson Editing produced the result with an overall classification rate of 77.3413% below of the support vector machines, Bayes Net, J48 and KNN. However, Gamma classifier obtained better results than Logistic Multiple Regression with an overall classification rate of 70.4%. The last one result was published in [4].

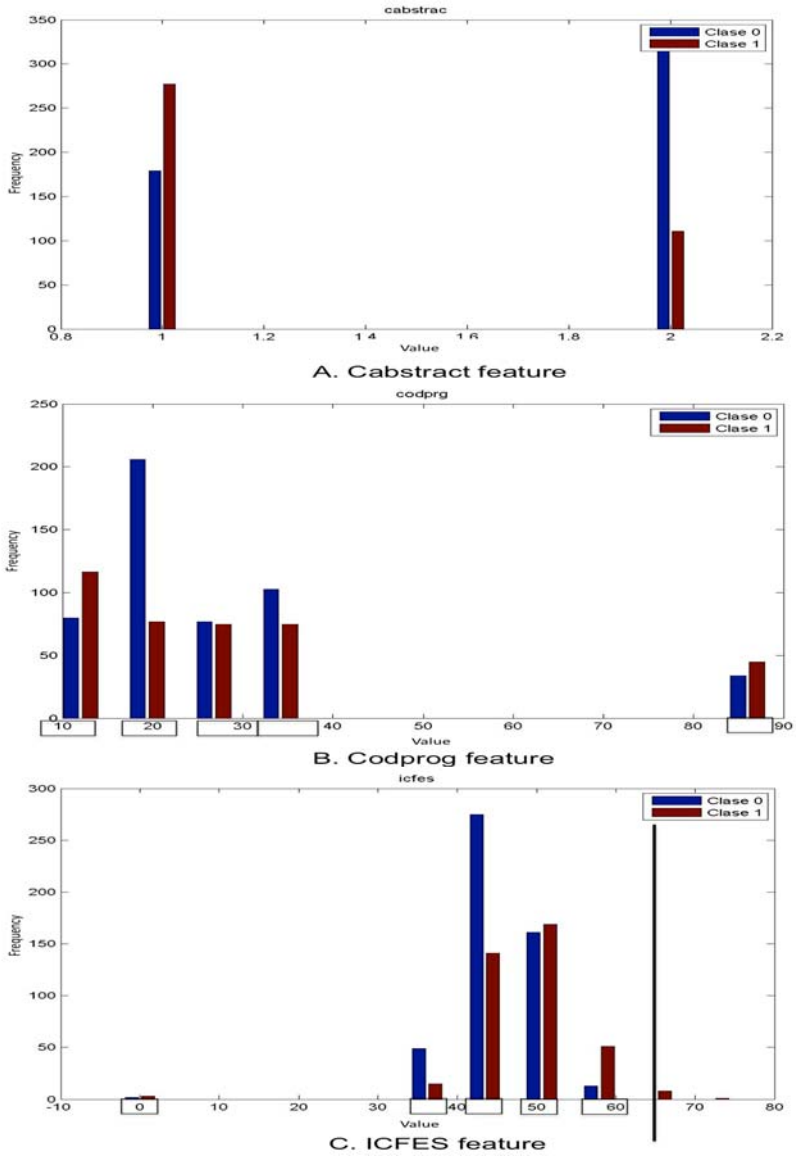

Fig. 3. Histograms of each feature used in this study

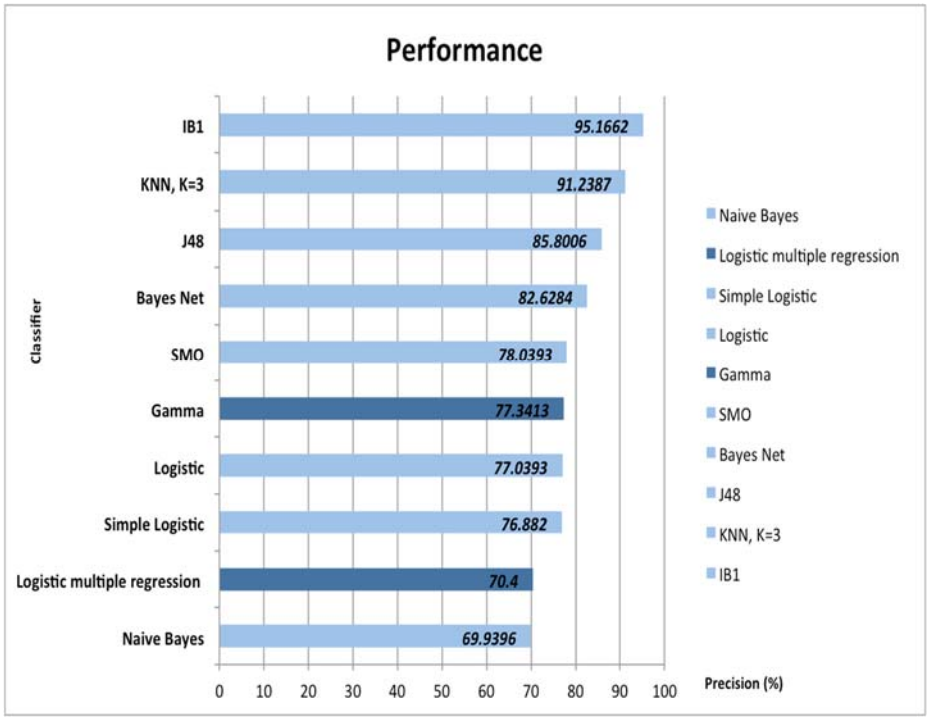

Fig. 4. Comparison graph between result of Gamma classifier and 8 algorithms in WEKA

6 Conclusions

Previous work [4] is outperformed from 70.4% to 77.3413% using Gamma classifier and Wilson Editing for identifying the students who are likely to fail Mathematics I course and to drop out the school in the first semester; regardless of unbalanced dataset. As a future work, other methods to deal with unbalanced dataset should be explored, as well as using other data preprocessing data techniques and use feature selection techniques to improve performance of Gamma classifier.

Acknowledgments

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A Survey on Anonymity in Location Based Services

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Abstract. Due to the increased use of Location Based Services (LBS), which require personal data of the user to provide the service, protecting the privacy of these data has become a challenge. An approach to provide privacy is through anonymity, by hiding the identity and location of the mobile device from the service provider or from any unauthorized party who has access at the user's request. Considering the afore mentioned, this paper gives a classification according to the architecture and approaches used in previous works, and presents a survey of solutions to provide anonymity in LBS including the open issues or possible improvements to current solutions. All of this, in order to provide guidelines for choosing the best solution approach to a specific scenery in which anonymity is required.

Keywords: Anonymity, blind signatures, cloaking areas, dummies, location based services, obfuscation, privacy.

1 Introduction

Location Based Services (LBSs) are defined as services that integrate location or position of user's mobile device with additional information so as to provide added value to a user [1]. Market trends show that LBS remain active among mobile users preferences, in this way it is important to keep looking ways for improving the privacy of these users.

The mobile device location information consists of latitude and longitude coordinates determined by a geo-location technique that can be implemented directly on the mobile device or with the active participation of the network infrastructure.

In general, a LBS architecture works as follows:

1. The user gets the mobile device position by its own means (using only the hardware on its mobile device) or with aid of some other entity (network infrastructure).
2. The user sends a request to the LBS provider (id information, location and the actual request).
3. The LBS answers the query by creating a reply message and sending it back to the mobile device.
4. The mobile user receives the reply message.

An illustration of the described architecture is shown in Figure 1.

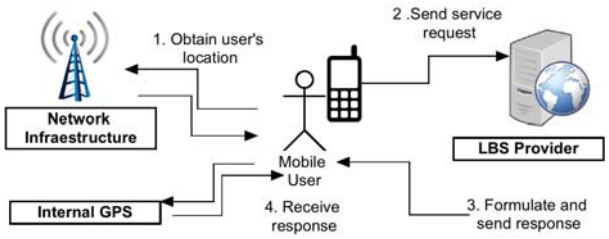

Fig. 1. Location Based Services General Architecture showing the entities that participate within the process and which actions are performed by each of them

In the described architecture, the request includes at least the user identity and the location information, assuming that this information travels in an insecure channel, it can be compromised either in its way to the service provider or when it is stored in any of the servers the LBS provider uses. Once the information is obtained, it can be used either to provide the service the user requested and/or with the intents of causing harm to the user as this information can reveal an individual's pattern of life (beliefs, preferences, activities and behavior).

The proposed solutions in the literature aim to provide the service as well as privacy to the user at the same time. These solutions can be either classified by the entities that participate in the solution or the technique they use.

The rest of the paper is organized as follows: Section 2 presents a proposed classification for the solutions that provide anonymity in LBS. Section 3 and 4 summarize some of the solutions to anonymity that have been presented in other articles, classifies the presented solutions by two approaches: cryptographic and not-cryptographic and then points out in each of them which architectural approach they implement. Section 5 gives a conclusion on the survey and possible future work.

2 Classification of Solutions

The solutions that provide anonymity can be classified either by the architecture (entities that participate to provide the solution) or by the techniques and methods they use.

2.1 Architectures to provide anonymity

The architectural solutions can be grouped into three categories [2] based on whether a third party is involved or not:

Non-cooperative or independent architecture. The mobile device by itself computes its location; it hides its identity and location using its own capability and then sends the request to the LBS provider. This is the simplest architecture but the most vulnerable to certain kinds of attacks (i.e. infecting the user´s device with a malware which alters the defined behavior to hide the data).

Centralized trust third party. It adds a trusted server that is responsible of performing the anonymizing technique, sending the request to the LBS provider and returning the result to the user. This approach is more robust in terms of privacy but the trusted server can become a potential bottleneck in the communication.

Peer to peer. This architecture consists of several mobile users trusting and cooperating with each other in order to compute their location or hiding it from untrusted entities.

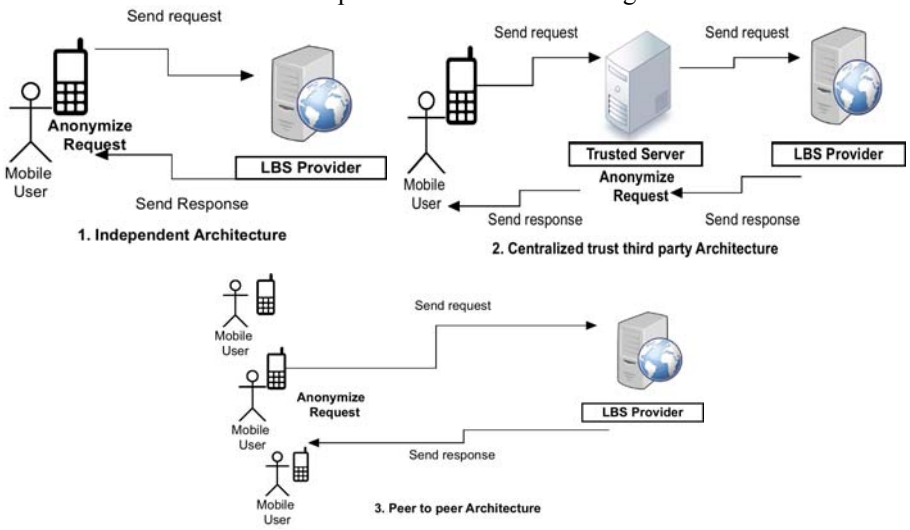

Fig. 2. Architectures to provide anonymity: Independent architecture, Centralized trust third party and Peer architecture

The Methods and Techniques to provide anonymity are described bellow:

2.2 Non-cryptographic approaches

Fake location information. Fake locations or dummies are generated and sent with the real user's location to the LBS provider; in this way the attacker cannot know for sure the true position of the user.
Cloaking techniques. A space area covering k users is formed and used to represent the user's precise location and then sent to the LBS provider.

Obfuscation Techniques. User's exact location is disguised by forwarding LBS provider less accurate location information.

2.3 Cryptographic approaches

Blind signatures. The blind signature scheme introduced by Chaum [3] is used to generate an authorized anonymous "Id" that replaces the real Id of the mobile user. This authorized anonymous id is used to make the request to the LBS.

Mix nets. Multistage system consisting of various mixes where each mix receives, decrypts and buffers messages until a number of messages have been received; once the messages are buffered the sequence of the messages is changed in a random way, encrypted and forwarded to the next mix. This procedure hides the correspondence between inputs and outputs in each mix.

Oblivious transfer. Method used in secure computing in which the sender (the LBS provider) sends some information to the receiver (the service user) but does not remember what was sent.

3 Proposed solutions using non-cryptographic approach

3.1 Fake Location Information

This set of solutions generally uses the independent architecture approach and the basic idea is to hide the user's real location among fake locations generated at the client (some dummies), before sending the request to the LBS provider. It protects user's privacy by providing k-anonymity, a metric to measure the degree of anonymity, which claims that a subject's identity is undistinguishable from at least $k - 1$ identities of other subjects.

The basic dummy technique [4] consists of a user sending its true position data with several false position data dummies to a service provider, who creates a reply message to all received position data. The user simply extracts the necessary information from the reply message. Two dummy generation algorithms are proposed.

The privacy-aware dummy-based technique (PAD) [5] seeks to improve the fact that in [4] they do not take into account the distances between dummies locations, thus they are not capable of controlling the area of the privacy region.

In [6] they deal with continuous queries (most solutions are focused on single or snap-shot queries) by injecting fake queries produced by neighbors according to user's speed and direction and with the aid of a Trusted Third Party which is responsible of finding the proper neighbors in order to achieve the k-anonymity required by the mobile user.

In MobiCache [7], mobile users form groups connected by an ad-hoc network, each time a user needs to make a query, the user first queries his group to get cached LBS related information from past queries they have made, if the cached information does not comply with the user's requirement, then the user has to make a live query to the LBS server using either the Dummy Selection Algorithm (DSA) or Enhaced DSA which guarantee that dummy locations selected have not been used before and contribute to the cache hit list in following queries.

In [8] the authors propose a Dummy-Location Selection Algorithm(DSA) which selects dummy locations using the entropy as a metric for location privacy and then spreads these dummies as far as possible so as that adversaries with side information(information about gender, social status, preferences among others) cannot figure out the real locations of the users.

The problem with these solutions is that most of the algorithms require a lot of processing power from the mobile device to produce the fake locations. If the number of dummies generated is very high, the latency in the network can increase. Other potential issue with this approach is that if the way the dummies were generated did not take into account other factors such as the environment, an attacker can end up discarding must of the dummies because it becomes too obvious that the real user was not at that place.

3.2 Spatial Cloaking

It is the most commonly used technique for protecting privacy in LBS. The basic idea is that the user's exact location can be blurred into a cloaking area that satisfies a degree of anonymity (given by a metric or specified by the user).

The solutions proposed in this area can be further classified by the architectural approach they use:

Centralized Trust Third Party Techniques

Described in [9-15], in these techniques, an anonymizer is responsible for hiding the user's exact location into the cloaked area that satisfies the privacy requirements and then sending the query to the service provider. The potential issues with these techniques are

those associated with the architecture itself, as the anonymizer can become a single point of failure and a single point of attack.

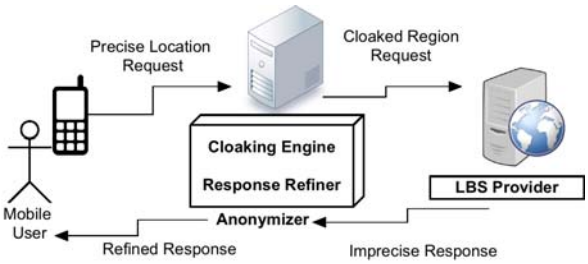

Fig. 3. Spatial Cloaking techniques with a Trusted Third Party, which computes the cloaking area and sends it to the LBS

Little variations to these techniques are presented in [16,17]: In [16] the cloaking region is generated randomly according to user's velocity and instead of sending the cloaking area, a substituted position is sent to the LBS Provider (center of the area).

In [17] the authors first use the Trusted Third Party to generate the cloaking region, once they have it they use a weighted adjacency graph (WAG) for the second phase of the method: the TTP requests the LBS Provider improved WAG information through the K-WAG Algorithm. Once the TTP has this information, it makes a selection for preferred objects and request the LBS provider for specific information about the selected objects. The LBS responds and the anonymizer can the return the response to the user.

Peer to Peer Architecture Techniques

The technique called PRIVÉ [18], a decentralized architecture for preserving the anonymity of users issuing spatial queries to LBS, provides superior k-anonymity privacy based on Hilbert space-filling which guarantees query anonymity even if the attacker knows the location of all users. They introduce a distributed protocol in which mobile entities self-organize into a faulty overlay network resembling a distributed B+ tree. The potential issue with this technique is that it may suffer from slow response time, since root-level nodes constitute potential bottlenecks.

MobiHide [19], a Peer-to-Peer (P2P) system for anonymous location-based queries in which participating mobile devices form a hierarchical distributed hash table indexing the locations of all users. The resulting system is used to construct the anonymous query belonging to K users.

Potential flaws of the solutions reviewed in [18, 19] are that they use a complex data structure that can give rise to difficulties in implementations. These issues led to the development of other solutions like the one presented in [20] where the idea is that mobile

users are able to work together to blur their locations into cloaked areas without using any fixed communication infrastructure.

In [21] authors propose a Distributed Spatial Cloaking Protocol in which users are required to build an ad-hoc network but do not need to trust each other. The initiator in the ad-hoc network chooses an agent that would be responsible of sending the query with the cloaked area to the LBS Provider.

A new approach to these techniques which also uses the spatial cloaking to achieve anonymity is the one used in [22], where the authors take advantage of Cloud Computing by replacing the Trusted Third Party by a cloud based server, in such a way that this server is in charge of computing the cloaked region but it is not trusted by the users. The communication between the users and the cloud based server is made by Orbot which is free proxy software available at Google play for android devices.

Areas of improvement in this type of techniques are that the system should remain usable even if there are less than k-users in the system and maintain the QoS even if the cloaked area becomes too large.

3.3 Obfuscation Techniques

This kind of solutions assumes the identification of users and introduces perturbations or inaccuracies into collected locations to decrease their accuracy.

In [23] the authors present three spatial obfuscation techniques to represent the user location as a circular region and using artificial perturbations of location information collected by sensing technology. The possible user locations are uniformly distributed within that region.

The algorithm Matlock presented in [24], uses matrix obfuscation, transforming the space and temporal dimensions of the location information with a small number of arithmetic operations achieving in this way low computational resources used.

In [25] path obfuscation techniques using hash chains and chains are presented. This solution is best suited for applications, which do not need to know the exact location of the user, but instead need to compute some metrics based on the information received (fitness apps, insurance apps). The user can choose to share the seed to de-obfuscate the path only to trusted users.

In [26] the authors propose using a TTP to combine ambient conditions to obfuscate the location information. The TTP uses four mechanisms to achieve this goal: First it uses r-anonymity to generate r-1 trajectories similar to the real user, then it uses the k-1 metric to produce an area containing k users, in order to avoid areas with high density, it uses the s-segment paradigm to produce a cloaked region with real world conditions and finally it uses the time obfuscation approach to confuse the LBS randomizing the query issuing time.

The possible improvements for these solutions could be: Achieving a higher degree of precision in query results, reducing the difficulty in the procedures employed, Evaluating

obfuscation techniques robustness against de-obfuscation attacks and Possibility to manage different privacy preferences expressed by users.

4 Proposed Solutions using Cryptographic Approach

4. 1 Blind Signatures

This set of solutions can be classified as using Trusted Third Party architecture, because they assume the existence of an entity besides the service provides which manages the authentication of users.

In [27] the authors present a scheme to generate an authorized anonymous ID, which replaces the real user ID. The scheme contemplates two phases: 1) Registration (generation of anonymous ID using blind signatures) and 2) Controlled Connection (Connection is provided given a valid anonymous ID is presented). An additional phase of re-confusion is introduced to replace an old anonymous ID.

In [28] the authors show a new mechanism for improving the registration and re-confusion phases in [27]. The mechanism implements blind signatures based on bilinear pairings, which seeks to delete the likability of the real ID with the authorized anonymous ID.

In [29] the authors describe a privacy protection scheme to preserve user's privacy during authentication and access control phases. It provides mutual authentication while allowing the users to anonymously interact with the desired service. They use the cryptographic primitives of blind signatures and hash chains in order to achieve these objectives through the authentication and key establishment protocols.

The solutions in [27-29] are vulnerable to a location tracking attack, where attackers analyze the moving path of a mobile user with the aid of location information, which they have collected.

In [30] an authentication protocol. It provides mutual explicit authentication between the mobile user and LBS provider and at the same time allows the user to interact anonymously. Blind signature scheme provides the generation of an authorized anonymous ID and ring signatures are used to mix the anonymous ID with a group of other authorized IDs.

The protocol claims to provide identity, location and trajectory privacy making it more robust than other solutions.

4.2 Mix Nets

Mix nets by their nature are designed to provide anonymity in communications. However most of the solutions are not applicable to the context of Location Based Services.

One exception to the afore mentioned is the proposal in [31] where the authors use a trusted proxy (anonymizer), which operates in periods of time called rounds. In each

round the requests from the users are stored. At the end of each round a series of operations are performed: generation of dummies, selection of queries based on a Binomial Distribution, cryptographic transformations and dispatching of queries to the LBS Provider.

This solution overcomes the difficulties of high latency designs and reduces imprecisions introduced by other techniques such as obfuscation or spatial cloaking. But they have to meet a minimum number of requests to be cached at the anonymizer.

4.3 Oblivious Transfer

In [32] the authors map the problem of protecting location privacy of the mobile user to an Oblivious transfer problem, where the issuer of the request receives only its corresponding reply and the service provider remains oblivious of the location of the user. Further on, they design some solutions based on different kinds of Oblivious Transfer (OT) namely Adaptive OT (implementing blind signatures), Dynamic OT and Proxy OT.

They propose the solutions but do not provide any father analysis on the correctness or feasibility of their proposals.

Based on [32], the authors in [33] propose an improved protocol by using two oblivious transfers where no third party is required to enable user's privacy.

They assume the existence of a total server, which is responsible of a group of LBS providers. The user has to perform a double OT implemented with blind signatures in order to get the key required response to the query.

This solution is thought for LBS that require payment. The computation overhead is minimum and it claims to provide higher degree of privacy compared to solutions, which use a cloaking area, or a third trusted party architecture.

5 Conclusions

It is necessary to propose new models that address new threats and attack models, which seek to break user's privacy in Location Based Services. These new models need to overcome the disadvantages of existing ones. Novel solutions approaches could combine different proposed solutions, to compensate the disadvantages of certain models with the advantages of others.

The job of updating or proposing a new survey will remain as an open task, as the development of new solutions to protect user's privacy in Location Based Services remains active; moreover it is necessary to classify the solutions by the privacy degree they offer, the attack model(s) from which they are resilient and the type of LBS to which they can be applied.

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Evolutionary Approach to Feature Selection with Associative Models

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Abstract. Feature selection aims to find ways to single out the subset of features which best represents the phenomenon at hand and improves performance. This paper presents an approach based on evolutionary computation and the associative paradigm for classification. A wrapper-style search guided by a genetic algorithm uses the Hybrid Associative Classifier to evaluate candidate solutions and thus approximate the optimal feature subset for different data sets. The results suggest that this is a feasible approach for feature selection, obtaining solutions equal or similar to the optimal solution while evaluating a relatively small fraction of the search space.

Keywords: Feature Selection, Neural Networks, Genetic Algorithms

1 Introduction

Information in excess often becomes redundant or presents irrelevant portions which rather than help describe the phenomenon at hand, hinder the ability to better understand it. In addition, the time most machine learning methods require to work on a data set is proportional to the number of features it contains. Therefore, reducing the number of features or selecting those which are relevant is crucial for improving processing speed and accuracy of classification. Thus, the field of Feature Selection aims to find ways to single out the subset of features which best represents the phenomenon and as such optimizes performance.

Feature selection algorithms can be divided into two main groups: *filters* and *wrappers*. Filter methods compute a subset of features based on analysis of the intrinsic properties of the features themselves[1]. These methods are classifier-agnostic since they solely rely on information about the features to make a decision about which ones are the most informative. Thus, they can be used

as a prior step to any classification method. In contrast, wrappers analyze performance of feature subsets based on a specific classifier[2]. Since this approach depends on a classification algorithm, the optimal subset obtained by one wrapper method may be different from the result of using the method with another classification technique. Because exhaustive search is computationally expensive, wrapper methods employ a heuristic search of the solution space to find a solution. Wrapper methods can be further divided into deterministic and stochastic searches [3].

Different approaches to feature selection have been proposed over the years. For example, using semi-supervised learning together with an ensemble classifier [4], selecting features by clustering [5], filtering features through the analysis of relevance and redundancy [6] and studying mutual information between variables to remove redundant ones [7].

Determining the starting point and the direction of the search is crucial to finding or approximating the optimal solution. Working with a population of candidate solutions (as opposed to a single one) allows the search to start in different points of the solution space. If the search can be guided to follow the most promising paths, there is a fair chance of arriving at the neighborhood of the optimal solution. A genetic algorithm (GA) thus can be used to perform a broad exploration of the solution space while exploiting the best solutions to steadily approach the optimal feature subset. Feature selection lends itself to a genetic search with a binary chromosome representation. Since each feature will either be selected or not, a feature subset can be expressed as a binary vector. For each component, a value of 1 shall represent a selected feature and a value of 0 shall mean the opposite. The use of a genetic algorithm to address the problem of feature selection was introduced by Siedlecki and Sklansky[8]. Furthermore, Yang and Honavar [9] adopt this approach to perform feature selection with a neural network.

In this paper, a genetic algorithm-based wrapper method for feature selection is proposed. This method employs an associative classifier as the method for evaluating feature subsets. The use of a wrapper-style feature selection method with an associative classifier was first proposed in [10]. This proposal executes an exhaustive search aided by parallel processing to reduce the time required. However, that approach is still too time-consuming, albeit guaranteed to find the optimal solution. As such, this work aims to find a balance between classification accuracy and the time needed to find a suitable feature subset.The preliminary results of the conducted experiments show that a GA coupled with an associative classifier exhibits rapid convergence to a near-optimal feature subset on different data sets. The rest of the paper is organized as follows. Section 2 provides a brief overview of genetic algorithms. Section 3 explains the associative classifier

employed in the proposed model. The proposed model is described in Section 4 and the experimental results are presented in Section 5. To conclude, Section 6 presents a discussion on the obtained results.

2 Genetic Algorithms

Genetic algorithm research was popularized with the work of Holland [11]. It is a branch of evolutionary computation which focuses on modeling the genetic evolution of organisms as it happens in nature, via recombination of genes and random mutations. A brief overview of genetic algorithms follows, although for a more complete review the reader is referred to Holland's work or the book by Engelbrecht [12].

Research in GAs has flourished recently; having been applied in several different areas. GAs have been used in anti-missile systems [13], vehicle design [14] and signal processing [15], among others.

The crux of a genetic algorithm is in the choice of operators which control how the candidate solutions will evolve and how the population will converge to a solution. These operators consist of the *crossover operator*, the *mutation operator* and the *selection operator*.

Crossover operators exist to produce new solutions via the exchange of genetic material between two existing "parent" solutions. That is, crossover enables the GA to exploit an area of the search space. In the case of feature selection, crossover hopes to pass on the genetic material representing the most useful features on to the next generation. Among the most used crossover operators are *one-point crossover*, *two-point crossover* and *uniform crossover* [12].

One-point crossover selects a point $1 < p < n$, where n is the number of values in the chromosome, at which to split the parent vectors. After that, an offspring is created by assembling the first segment of one parent and the second segment of the remaining parent. That is, given two parents A and B, a child solution C is given by:

$$C_i = \begin{cases} A_i, & i \leq p \\ B_i, & i > p \end{cases}$$

Similarly, two-point crossover works by selecting two crossover points, p_1 and p_2, splitting the parent chromosomes at those two points, and then swapping their middle segments to create an offspring. That is:

$$C_i = \begin{cases} A_i, & i \leq p_1 \\ B_i, & p_1 < i \leq p_2 \\ A_i, & i > p_2 \end{cases}$$

Two-point crossover can be generalized to n-point crossover by generating n points and swapping segments between the parents to create an offspring.

Uniform crossover generates an offspring by randomly selecting one of the parents from which to inherit each gene.

Mutation operators were initially conceived as background processes which bore little importance to the evolutionary process [11]. However, they are a powerful tool to enable further exploration of the search space and a timely mutation can potentially save a population trapped in a local optimum. Usually, low mutation rates are employed in GAs as a way to occasionally introduce new genetic material into the population.

A selection operator is in charge of deciding which candidate solutions will progress into the next generation and which ones will perish. This is often done by assigning a solution with better fitness a greater chance of being selected (Roulette Wheel selection) or by selecting a subset of the population and selecting the one with best fitness (Tournament selection)[12].

The general structure of a genetic algorithm is as follows:

1. Initialize the population.
2. Evaluate the fitness of every individual.
3. Apply crossover and mutation operators.
4. Apply the selection operators to decide the individuals who will progress to the next generation.
5. If a stopping condition has not been met, return to step 2. Otherwise, return the best individual.

3 Associative Models

An associative memory is a system which takes a codified input or pattern and produces an output which can be either a class label or another pattern. One of the main advantages of associative memories is that, when they are correctly designed, they can accurately recover a pattern even if it has been altered. This robustness against alterations makes them attractive for applications in which the input patterns are likely to be noisy.

A comprehensive review on associative memory models and their inner workings is presented in [16]. This section will focus on presenting the specific model used in this work, the Hybrid Associative Classifier with Translation (CHAT).

As the name suggests, CHAT is a hybrid between two prior associative models: Steinbuch's Lernmatrix and Anderson & Kohonen's Linear Associator [17]; specifically, it adopts the learning phase of the latter and the recovery phase of the former. The combination of these two models allows the CHAT to overcome some of the roadblocks exhibited by its predecessors: it can work with real-valued inputs (unlike the *Lernmatrix*) and it does not need its inputs to consist of a set of orthonormal vectors as the *Linear Associator* does. Aside from this combination, the input patterns are averaged and subsequently this mean vector is substracted from each pattern to assemble a new translated training set which improves classification accuracy.

The CHAT algorithm works as outlined below:

1. For each $x^1 ... x^p$ patterns in the training set, compute the mean vector

$$\bar{x} = \frac{1}{p} \sum_{i=1}^{p} x^i$$

2. Compute the translated input patterns $x^{1'}, ..., x^{p'}$

$$x^{i'} = x^i - \bar{x}$$

3. For each $x^{i'}$ which belongs to the k-th class, create a class vector y^i which has a value of 1 only in the k-th coordinate

$$y_m^i = \begin{cases} 1, & m = k \\ 0, & otherwise \end{cases}$$

4. Apply the learning phase of the *Linear Associator*
5. Apply the recovery phase of the *Lernmatrix*

4 Proposed Method

As stated above, this paper presents a wrapper-style feature selection model based on a Genetic Algorithm and an associative classifier. The objective is to build a feature selector which is relatively fast and robust against noise. This work borrows from [16] the classification algorithm employed; however, it attempts to obtain a feature subset which yields a better classification performance by exploring a portion of the solution space.

The proposed feature selection method is described in graphical form in Figure 1.

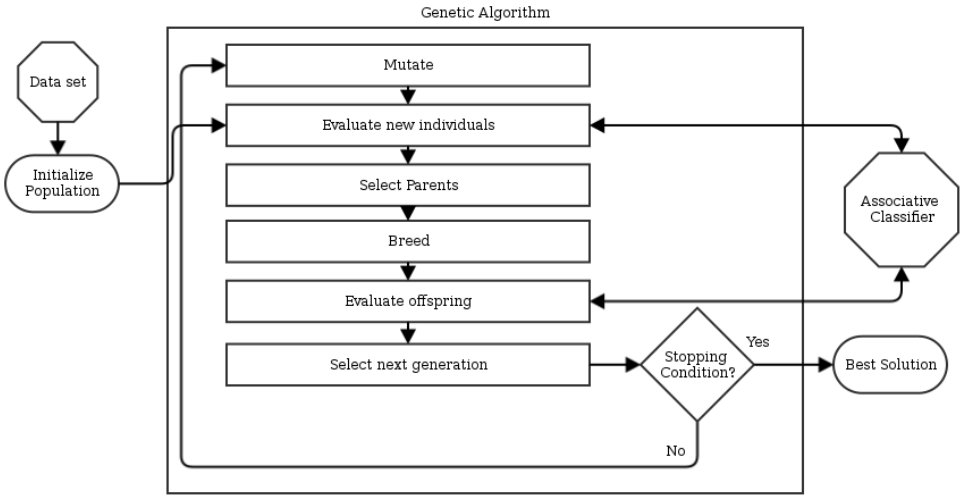

Fig. 1. Proposed method

The method follows the footprints of a GA: it begins by initializing a random population of candidate feature subsets and starting the search. The GA evolves the population by applying the mutation, crossover and selection operators specified by the user. Those candidates which appear more promising progress through the generations and gradually approximate the optimal solution. To obtain the fitness value of a candidate solution, a CHAT classifier is trained and then used to classify pattern in the data set using the subset of features selected by the solution. The estimation method used to obtain classification performance was 10-fold cross-validation.

The proposed algorithm was implemented in the R programming language [18], making use of its *parallel* package to speed up computation. The experiments were run on a PC running Arch Linux with an AMD A10 processor and 8GB of RAM.

5 Experimental Results

The aim of this work was to find a method to obtain better results than those produced by the algorithm presented in [16], while evaluating a fraction of the possible solutions than an exhaustive search would. The experimental results of applying a GA-based search to feature selection on the data suggest that this is in fact a feasible approach for data sets consisting of more than a dozen features, obtaining optimal or close to optimal fitness values with an important

feature amount reduction while evaluating much fewer solutions compared to an exhaustive search.

Data sets taken from the UCI Machine Learning Repository [19] were employed for the experimental part of this project. Specifically, the Breast Cancer, Heart Disease, Credit Approval and Hepatitis data sets were chosen.

The parameters shown in Table 1 were constant for all experiments.

A smaller population was used for the breast cancer data set to avoid reaching the target fitness in the first generation with a great likelihood (due to there being only 511 possible subsets) and thus failing to demonstrate the genetic search.

An exhaustive search was run prior to applying the GA in order to have two reference values against which to compare the performance of our method: number of candidate solutions evaluated and classification accuracy.

The search was stopped when one of the following conditions was reached:

1. The maximum number of generations was reached.
2. The maximum fitness computed by exhaustive search was reached.
3. 25 generations passed with no improvement on the best solution.

The population size was maintained at a constant number. To achieve this, after producing the offspring solutions, the n offspring replaced the n worst solutions of the original population.

Rather than time, this experiment measured the number of candidate solutions evaluated; unlike running time, this amount is independent of the machine used to run the experiments. For this purpose the program counted the number of solutions generated and evaluated.

Six different combinations of selection and crossover operations were tested in the experiments. Table 2 details each of these combinations. Mutation was kept at a constant probability of 0.15.

Tables 3 to 6 show the detailed results of the experiments conducted for this work. Specifically, they show the number of the experiment, the number of generations passed before stopping, the number of features selected and the fitness of the best solution found. Additionally, it presents the percentage of solutions evaluated relative to an exhaustive search, the percentage of approximation of the optimal solution and the dimensionality reduction of the best solution.

Table 1. Experiment parameters

Dataset	Features	Population	Offspring	Generations	Max Fitness
Breast	9	10	4	50	0.9780
Heart	13	100	40	50	0.8333
Credit	14	100	40	50	0.8564
Hepatitis	19	100	40	50	0.8507

Table 2. Operator combinations

Experiment	Crossover	Selection
1	One-point	Roulette
2	One-point	Tournament
3	Two-point	Roulette
4	Two-point	Tournament
5	Uniform	Roulette
6	Uniform	Tournament

Table 3. Experimental results - Breast Cancer dataset

Type	Gen.	Feat.	Fitness	Eval.	% Evaluated	% Optimal	% Reduction
1	18	4	0.978026	182	35.62%	100.00%	55.56%
2	28	7	0.976577	272	53.23%	99.85%	22.22%
3	34	7	0.976556	326	63.80%	99.85%	22.22%
4	12	5	0.978026	128	25.05%	100.00%	44.44%
5	6	6	0.978026	74	14.48%	100.00%	33.33%
6	28	2	0.976556	272	53.23%	99.85%	77.78%

Table 4. Experimental results - Heart Disease dataset

Type	Gen.	Feat.	Fitness	Eval.	% Evaluated	% Optimal	% Reduction
1	12	5	0.833333	1280	15.63%	100.00%	61.54%
2	10	5	0.833333	1100	13.43%	100.00%	61.54%
3	13	5	0.833333	1370	16.72%	100.00%	61.54%
4	13	5	0.833333	1370	16.72%	100.00%	61.54%
5	34	4	0.82963	3260	39.79%	99.56%	69.23%
6	6	5	0.833333	740	9.03%	100.00%	61.54%

Table 5. Experimental results - Credit Approval dataset

Type	Gen.	Feat.	Fitness	Eval.	% Evaluated	% Optimal	% Reduction
1	16	5	0.856522	1640	10.01%	100.00%	64.29%
2	16	3	0.856522	1640	10.01%	100.00%	78.57%
3	26	5	0.83875	2540	15.50%	97.93%	64.29%
4	28	1	0.855072	2720	16.60%	99.83%	92.86%
5	28	6	0.855072	2720	16.60%	99.83%	57.14%
6	29	8	0.855072	2810	17.15%	99.83%	42.86%

Table 6. Experimental results - Hepatitis dataset

Type	Gen.	Feat.	Fitness	Eval.	% Evaluated	% Optimal	% Reduction
1	29	5	0.832083	2810	0.54%	97.80%	73.68%
2	43	7	0.83875	4070	0.78%	98.58%	63.16%
3	65	6	0.839167	6050	1.15%	98.63%	68.42%
4	60	4	0.83875	5600	1.07%	98.58%	78.95%
5	64	9	0.839167	5960	1.14%	98.63%	52.63%
6	56	5	0.83875	5240	1.00%	98.58%	73.68%

It is clear from these results that the GA is capable of approximating the optimal feature subset to within 3% of classification accuracy; even outright finding the optimal solution in some test runs.

With regards to dimensionality reduction, the results show important cutdown on the number of features selected. For the bigger data sets, a reduction of half or more of the features can be observed in all cases. For the Breast Cancer data set, the dimensionality reduction is less noticeable; however, this is due to the small number of features.

Perhaps the key result observed in these experiments is the one concerning the time needed to approximate an optimal feature subset. It can be seen from the result tables that even the most inefficient experiments (the ones on the Breast Cancer data set) required less evaluations than an exhaustive search to find the optimal solution or one extremely similar to it in performance. The other data sets exhibited similar behavior: the more features, the less evaluations (relative to an exhaustive search) were needed to obtain a near-optimal solution. This is exacerbated by the fact that some runs stopped after 25 generations with no improvement, meaning the near-optimal candidate was found much earlier than these results suggest.

The results of this experiment showcase genetic algorithms as a way to relatively quickly search for a solution which reduces the number of features considerably

and improves classification accuracy. A discussion on these results will be offered in the next section.

6 Conclusions

Feature selection is usually faced with a choice between maximizing the accuracy of the classifier and minimizing the time needed for finding a solution. Past approaches have focused on studying the relationship between features to make a decision or constructing a feature subset by gradually adding or removing features in a determined region of the search space.

This study presents a genetic algorithm-based approach which is able to start seeking a solution in multiple places of the search space and then moves along a promising direction which leads to a near-optimal solution. Variants of the most important genetic operators were tested and their results compared to those produced by an exhaustive search. The results showed that this approach to feature selection obtains an approximately optimal solution in less time than an exhaustive search would need; especially so on data sets where the amount of features starts to prohibit full exploration of the solution space. This suggests that GAs are an useful tool for feature selection, especially for larger data sets: their ability to preserve blocks of relevant features along the generations helps the algorithm to converge to a near-optimal solution relatively quickly.

However, some considerations have to be taken into account which limit the power of this approach to obtain the optimal feature subset. In the first place, for extremely large data sets the best solution is unknown and several local optimums can exist in the search space and the GA can get trapped around these local optimums. It is difficult, if not impossible, to detect whether the algorithm has converged at a less-than-desirable solution. Secondly, the associative classifier used is best suited for working on two-class problems, as it generally struggles with multi-class problems. As such, the results produced by applying this approach to this kind of data sets present lesser classification accuracy.

Currently further work is being done with this feature selection model. Larger data sets with hundreds to thousands of features are being tested with this method. Additionally, different genetic operators are being used in an attempt to find the combination of these which yields better results. Other kinds of evolutionary algorithms should be tested in the future in order to determine if they can produce similar or better results than GAs; similarly, future research should also focus on coupling the GA with other classifiers.

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Network Control of a PVTOL System by means of an Event-Triggered Approach

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Abstract. Event-triggered control is a resource-aware sampling strategy that updates the control value only when a certain condition is satisfied, which denotes event instants. Such a technique allows a reduction of the control's computational cost and communications demand. In this paper, an asynchronous feedback is developed for event-triggered stabilization of a PVTOL (Planar Vertical Take-Off and Landing) system wherein the control loop is closed through an Internet connection. The proposed feedback ensures asymptotic stability to the desired position. Real-time experiments are carried out in order to show the convergence of the PVTOL to the desired position as well as robustness with respect to external disturbances. Results show that the proposed strategy can reduce the number of control updates and consequently reduce the communication traffic over the network without sacrificing performance of the whole system.

Keywords: PVTOL, Network Control, Event-Trigger, LQR Control, Attitude Stabilization

1 Introduction

A cyber-physical system (CPS) is the integration of computation with physical processes. Embedded computer networks monitor and control the physical processes, usually with feedback loops where physical processes affect computations and vice versa. The intersection between physical and information-driven (cyber) functions represents a challenge and results in innovation [1]. For CPS, the use of digital platforms and networks emerges as an obvious trend to save space, weight and energy. However, digital implementations can result in additional challenges, like determining how frequently the control signal needs to be updated and

applied such that the stability properties are still guaranteed.

In this context, Network-based control has emerged recently as a topic of significant interest in the control community. The reason for this is that in many practical systems it is difficult to install the physical plant, controller, sensors and actuators in the same place, and thus signals must be transmitted from one place to another. In modern systems, these components are often connected over the network media, giving rise to the so-called networked control systems [2],[3],[4]. Consequently, the traditional periodic control design cannot be applied anymore in *embedded and networked systems* (with limited resources) so resource-aware implementations are required. Recent work addresses alternative frameworks where the control law is event-driven. Whereas in the classical time-triggered approach the control law is computed and updated at the same rate regardless of whether it is really required or not, the *event-based paradigm* relaxes the periodicity of computations and communications by calling for resources whenever they are indeed necessary. A notable example is shown in [5] where the control law is updated less frequently than with a periodic scheme while still ensuring the same performance. Typical event-detection mechanisms are functions of the variation of the state (or at least the output) of the system, like in [6], [7], [8], [9], [5], [10], [11], [12], [13]. Stabilization of linear and nonlinear systems is analyzed in [14], [15], [16], [17], where the events are related to the variation of a Lyapunov function or the time derivative of a Lyapunov function (and consequently to the state too). Although event-based control is advantageous regarding computational resources, and many works report theoretical results (about stability, convergence and performance) only few works report practical implementation [18].

Among many embedded and networked cyber-physical systems, Unmanned Aerial Vehicles (UAVs) have received growing interest in research. They may prove useful for many civilian missions such as video supervision of road traffic, surveillance of urban districts, forest fire detection or building inspection. This progress was motivated by the enormous military/civil applications of such vehicles along by the technological progress in sensors, actuators, processors, power storage devices and communication technology. The Planar Vertical Take Off and Landing aircraft (PVTOL) represents a challenging nonlinear system problem that is often considered a benchmark model in aerospace engineering to design control laws for UAVs since it can be seen as the projection of a six degree of freedom flying body into a vertical plane attached to the body [19]. Furthermore, the dynamics of the PVTOL system includes many difficulties that explain the popularity of this model such as the under-actuation (three degrees of freedom for only two controls), or the non-minimum phase property (zero dynamics that are not asymptotically stable). This system also concentrates all the difficulties of the well known Brocketts integrator (also referred to as the unicycle) that one gets by neglecting the coupling factor and the gravity. Since

its introduction in [20], a great number of approaches have been proposed to control this peculiar system. The proposed control approaches can be classified into two families: trajectory tracking or path following control approaches [21,22] and stabilization control approaches [23,24,25,26]. In spite of the great number of papers found in the literature, the PVTOL control problem remains an active area of research.

In the present paper, a networked control systems, where the control loop is closed over a Internet connection is addressed. A deported event-triggered controller is designed to control a PVTOL system. The update policy is driven by events dependent on the time derivative of a CLF. The idea is to show that an event-triggered scheme could reduce the number of control function calls and consequently the network communications traffic even in such a case where rotor blades have to be actively controlled. The rest of the paper is organized as follows. In Section 2, the event-based control strategy for linear systems is detailed. Section 3 introduces the PVTOL mathematical model and states the problem of the control strategy for position stabilization. Experimental results are presented in Section 4 and discussions finally conclude the paper.

2 Event-Based Control for the Stabilization of Linear Systems

Let us consider the linear time-invariant dynamical system

$$\dot{x} = Ax + Bu \tag{1}$$

with $x \in \mathbb{R}^n$, $u \in \mathbb{R}^p$. For sake of simplicity, null stabilization with initial time instant $t_0 = 0$ is considered. Also, by *event-based feedback* we mean a set of two functions, namely ***i)*** an event function $e : \mathbb{R}^n \times \mathbb{R}^n \to \mathbb{R}$ that indicates if one needs to recompute the control law (when $e \leq 0$) or not (when $e > 0$) and ***ii)*** a feedback function $\gamma : \mathbb{R}^n \to \mathbb{R}^p$. The solution of (1) with event-based feedback (e, γ) starting in x_0 at $t = 0$ is then defined in [16] as the solution (linear case) of the differential system.

$$\dot{x} = Ax + B\gamma(m) \tag{2}$$

$$m = \begin{cases} x \text{ if } \quad e(x, m) \leq 0, x \neq 0 \\ m \text{ otherwise} \end{cases} \tag{3}$$

$$\text{with} \quad x(0) = x_0 \quad \text{and} \quad m(0) = x_0 \tag{4}$$

Here we recall the definition of semi-uniform Minimum Sampling Interval (MSI) event-triggered control:

Definition 1. *[16] An event-triggered feedback (γ, e) is said to be semi-uniformly MSI if for all $\delta > 0$, and all x_0 in the ball of radius δ centred at the origin $\mathcal{B}(\delta)$ the inter-execution times, that is the duration between two successive events, can be below bounded by some $\underline{\tau} > 0$.*

With this formalization, the control value is updated each time e becomes negative. Usually, one tries to design an event-based feedback such that e cannot remain negative (and so the control is updated only punctually). The time instants where it is negative can therefore be considered as *events* and m is the *memory* of the value of the state at the last event. In addition, one also wants two events to be separated with a non vanishing time interval to avoid the *Zeno* phenomenon. All these properties are encompassed in the *well-defined* property introduced in [16], where a well-defined event-based control is a piecewise constant control with non zero sampling intervals. In the same paper, it is proved that nonlinear systems affine in the control and admitting a Control Lyapunov Function (CLF) can be globally asymptotically stabilized by means of such event-based feedback.

Proposition 1. *Consider the linear time-invariant system $\dot{x} = Ax + Bu$. Let P be, the positive definite matrix solution of the Riccati equation*

$$A^T P + PA - \epsilon PBB^T P = -Q, Q > 0 \tag{5}$$

Then $V(x) := x^T Px$ is a CLF for the system since for all x, $u = -\frac{1}{2}\epsilon B^T Px$ with $\epsilon \in \mathbb{R}^+$ renders $\dot{V}$ strictly negative for $x \neq 0$.

Proof. The proof is trivial, since it is a slight variations of the well-know Lyapunov's results [27]

Then, we have the following theorem, which is a particular case of the *event-based universal formula* proposed in [16]:

Theorem 1 (Event-Based LQR Stabilization). *Taking the CLF $V = x^T Px$ for system (1), where P is a positive definite matrix solution of the Riccati equation (5), then the event-based feedback (e, γ) defined by*

$$\gamma(m) = -\frac{1}{2}\epsilon B^T Pm \tag{6}$$

$$e(x, m) = (\sigma - 1)x^T\Big(A^T P + PA\Big)x - 4\varepsilon x^T PBR^{-1}B^T P\Big(\sigma x - m\Big) \tag{7}$$

$$\textit{with} \quad \sigma \in]0, 1[$$

where m is defined in (3). Then the control law (6) is well-defined and the closed-loop system is asymptotically stable.

The idea behind the construction of event-based feedback (6)-(7) is to compare the time derivative of the Lyapunov function $V(x)$ in the event-based case, that is applying $\gamma(m)$, and in the classical case, that is applying $\gamma(x)$ instead of $\gamma(m)$. The event function is the weighted difference between both, where σ is the weighted value. By construction, an event is enforced when the event function vanishes to zero, that is hence when the stability of the event-based scheme does not behave as the one in the classical case. Also, events will be more frequent with smaller σ.

Proof. The proof was given in [16] for nonlinear affine in the control systems. The particular case of linear systems is hence trivial.

3 PVTOL Mathematical Model and Control

In this section the system's mathematical model is presented. Afterwards, the problem statement and the control design will be shown.

3.1 Mathematical Model

The PVTOL aircraft considered in the present work is composed of two independent motors which produce a force and a torque on the vehicle. The main thrust, T, is the sum of each motor thrust which is a function of the motors' angular velocities. The roll torque, Γ, is obtained from the difference between motors' thrust f_1 and f_2, that is

$$T = (f1 + f2) \tag{8}$$

$$\Gamma = l(f1 - f2) \tag{9}$$

where l is the distance between the rotor and the aircraft's center of mass.

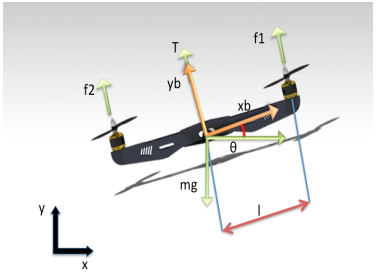

Fig. 1. PVTOL

From Fig. 1, we can have the following dynamic model of the PVTOL aircraft:

$$\begin{aligned} m\ddot{y} &= T\cos\theta - mg - c\dot{y} \\ m\ddot{x} &= -T\sin\theta - c\dot{x} \\ J\ddot{\theta} &= \Gamma - c\dot{\theta} \end{aligned} \tag{10}$$

where x, y denote the horizontal and the vertical position of the aircraft's center of mass, θ is the roll angle of the aircraft with respect to the horizon, m is the total mass of the aircraft, g is the gravitational acceleration, J is the moment of inertia and c is the damping coefficient which will be considered zero for design purpose. These equations describe the motion of the vehicle as a set of three coupled second order differential equations.
We introduce the state vector $\bar{x} = (x_1\ x_2\ x_3\ x_4\ x_5\ x_6)^T = (x\ \dot{x}\ y\ \dot{y}\ \theta\ \dot{\theta})^T$. The system is then represented in state variable form as

$$\begin{aligned} \dot{x_1} &= x_2 \\ \dot{x_2} &= \frac{T}{m}\cos x_5 - g - \frac{c}{m}x_2 \\ \dot{x_3} &= x_4 \\ \dot{x_4} &= -\frac{T}{m}\sin x_5 - \frac{c}{m}x_4 \\ \dot{x_5} &= x_6 \\ \dot{x_6} &= \frac{\Gamma}{J} - \frac{c}{J}x_6 \end{aligned} \tag{11}$$

In order to achieve the stabilization in a desired point x_e, it is convenient to redefine the state and the input so that x_e is an equilibrium point of the system with zero input. Letting $z = \bar{x} - x_e$, $u = T - mg$, the equations become

$$\begin{aligned} \dot{z_1} &= z_2 \\ \dot{z_2} &= \frac{u+mg}{m}\cos(z_5) - g - \frac{c}{m}z_2 \\ \dot{z_3} &= z_4 \\ \dot{z_4} &= -\frac{u+mg}{m}\sin(z_5) - \frac{c}{m}z_4 \\ \dot{z_5} &= z_6 \\ \dot{z_6} &= \frac{\Gamma}{J} - \frac{c}{J}z_6 \end{aligned} \tag{12}$$

The linearization of system (12) around the origin *i.e.* $z \approx 0$ (actually, $x \approx x_e$)with $c = 0$, yields

$$\dot{z} = Az + Bv \tag{13}$$

where

$$A = \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & -g & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}, \quad B = \begin{bmatrix} 0 & 0 \\ \frac{1}{m} & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 0 & \frac{1}{J} \end{bmatrix} \tag{14}$$

and the control vector is

$$v = (v_1 \ v_2)^T = (u \ \Gamma)^T \tag{15}$$

3.2 Problem Statement

The objective is to design a control law that drives the PVTOL to a specified constant position starting from any initial condition such that the linearization remains valid.
On the other hand, the PVTOL benchmark is equipped with two computers, called local computer and deported computer, an acquisition card, an Attitude Heading Reference System (AHRS) and an infra-red sensor. The AHRS, infra-red sensor and local computer continuously monitor the state x (angular and linear position and velocity) which is continuously broadcast over the network, and is denoted by $x(t)$ (see Fig. 2). Then, based on current state information and the last computed control signal, which is piecewise constant, the event-function decides when to calculate, to update and to broadcast the control signal over the network. The last step is carried out on the deported computer. Whenever the local computer receives a new control signal, it updates and applies the signals for the actuators (PWM signals).

Thus, the problem consists of showing that the PVTOL system can be stabilized by means of event-triggered feedback as defined in Section 2, *i.e.* with the control law (6) together with the event function (7). Another motivation is the reduction of network traffic. Reducing the traffic used for control (thanks to an event-triggered approach) allows i) to reduce traffic congestion over the network and ii) to broadcast other sensor data such as video.

3.3 Event-Triggered Control

Now, we have the main result.

Corollary 1. *Consider the PVTOL dynamics given by (10) and (12) and the CLF given by $V(z) = z^T Pz$. Then the event-triggered feedback (γ, e) defined by (6) with z as state variable, stabilizes the PVTOL system locally ($z \to 0$ i.e. $\bar{x} \to x_e$) . Furthermore, the feedback (γ, e) is semi-uniformly MSI and smooth on $\mathbb{R}^6$.*

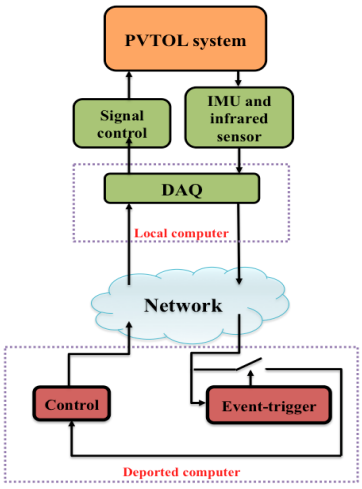

Fig. 2. Block Diagram

Remark 1. Assuming that the whole state of system (13) can be measured and (A, B) is a stabilizable pair, then, it is known possible to design a state-feedback control that minimizes the value of an (infinite horizon) quadratic cost functional defined by

$$J = \int_0^\infty \left(z^T Q z + \epsilon^{-1} u^T u \right) dt \tag{16}$$

where Q is a positive definite matrix and ϵ is a positive constant. The control law

$$u = -\epsilon B^T P z \tag{17}$$

stabilizes (13), where P is a positive definite matrix solution of the Riccati equation

$$A^T P + PA - \epsilon PBB^T P - Q = 0 \tag{18}$$

Note that the first and second terms of (16) correspond to the energy of the controlled output and the control signal respectively, and the LQR strategy has to minimize both. However, decreasing one requires the other to be large, and viceversa. The role of ϵ consists in establishing a trade-off between these conflicting behavior (the smaller ϵ is, the larger control is and smaller the output is).
Note that the optimal LQR feedback (17) is twice the event-triggered feedback

(6) . Therefore, the process of tuning the LQR is applicable for tuning the proposed event-based feedback which is important from a practical point of view.

4 Experimental Results

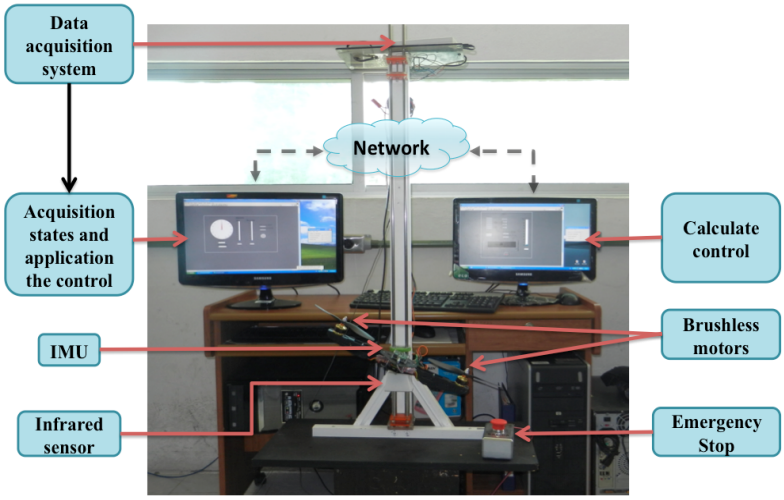

Fig. 3. System PVTOL of CCS-Lab

In this experimental section, the effectiveness of the network control is shown by means of the event-trigger approach proposed in section 2. The real-time stabilization tests were performed with the PVTOL system developed to the Control Systems Laboratory of the Electronics Faculty at Autonomous Puebla University (see Fig. 3). The system consists of a structure of carbon fiber for the frame, two brushless motors, an inertial measurement unit[1], an infrared sensor, the DAQ National Instrument[2] and a mechanical structure of aluminum. The prototype is connected to a computer that acquires the state vector and applies control signals to the motors. This data is sent through the network to a second

[1] `http://www.microstrain.com/inertial/3DM-GX1/`
[2] `http://sine.ni.com/nips/cds/view/p/lang/en/nid/203224/`

computer that calculates and returns the control signals (see Fig. 3). For this, both computers have the software Labview installed. In order to hover, the propellers generate enough force for elevation. One propeller rotates clockwise and the other one counterclockwise to create torque around the y axis. The rotational movement depends on the velocity difference between the two propellers.

Table 1 lists the main parameters associated with the PVTOL system.

Table 1. Parameters associated with the PVTOL

Symbol	Description	Value
m	Mass of the system	0.433 kg
d	Distance from pivot to each motor	0.163 m
J	Equivalent moment of inertia roll	0.0552 $Kg \cdot m^2$

The charts (a)-(i) present the results obtained in the two experiments. The charts (a)-(b) shows the altitude and linear velocity whereas angle roll and angular velocity are provided in the charts (c)-(d). The charts (e)-(f) show the control signals that contains the "thrust" and the "torque" and chart (g) is the Lyapunov function, which we can see decreases while the system begin stabilized. Charts (h)-(i) give the event function and a representation of the sampling instants where 1 means the control is updated and 0 indicates that is kept constant. The event function behaves as described in equation (7).

For the control law, the values σ and ϵ of the event function for all three cases are 0.89 and 1 respectively. The σ value determines the frequency of events.

Stabilization of PVTOL: In the first experiment, the stabilization of the PVTOL by the networked control is tested, bringing the system from $y = 0.35$cm to $y = 0.58$cm. The results are depicted in Fig. 4(a). The angle of the system remains stable around $\theta = 0$ degrees see Fig. 4(c). In Fig. 4(i), it is shown that some large intervals without any samples exist. This test was carried out in 6.5 seconds in which the control was calculated 266 times, which is 65 % of the feedback for continuous control. During this period, the Lyapunov function approaches zero, as can be seen in Fig. 4(g). Fig. 4(e) and Fig. 4(f) give the force required for stabilization.

The Robustness of network control to disturbances: The second experiment tested the robustness of the proposed control against disturbances. It started with the system in the point $y = 0.35$cm. In this first part, a

disturbance is applied in the angle $\theta = 0$. After the system was stabilized, the target altitude of $y = 0.58$cm was set, and another disturbance was applied in the altitude. Once the prototype reaches the equilibrium, the target altitude was changed to $y = 0.49$cm and another angular disturbance was applied, see Fig. 5(a). Fig. 5(c) shows the behavior of the x axis and angular velocity during disturbances. Fig. 5(g) shows how the Lyapunov function decreases while the system is stabilized. Likewise the event function, Fig. 5(h), is greater than 0 when there are disturbances causing more control updates. Fig. 5(i) shows the 484 times that the algorithm was calculates in 14 seconds.

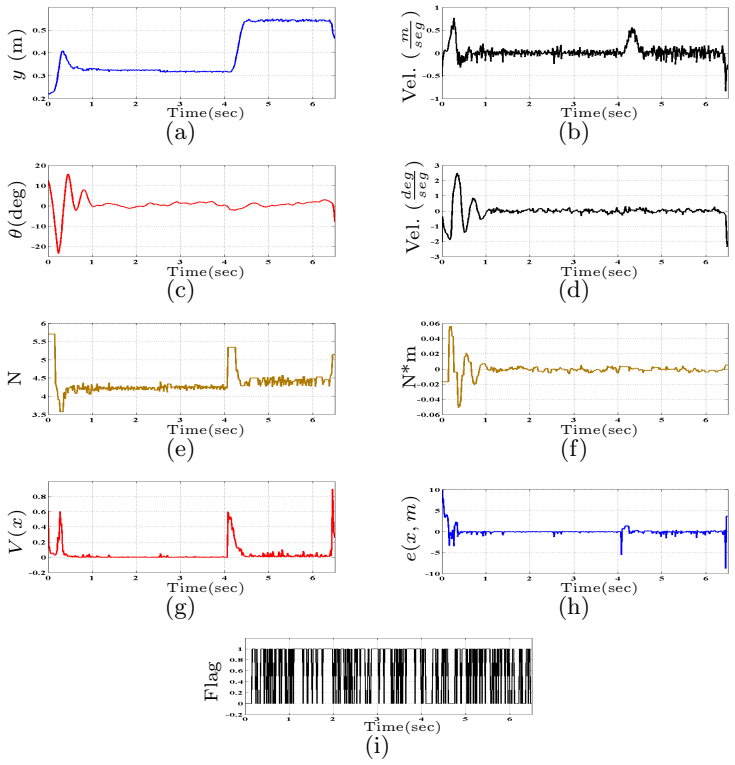

Fig. 4. Stabilization of PVTOL without disturbances

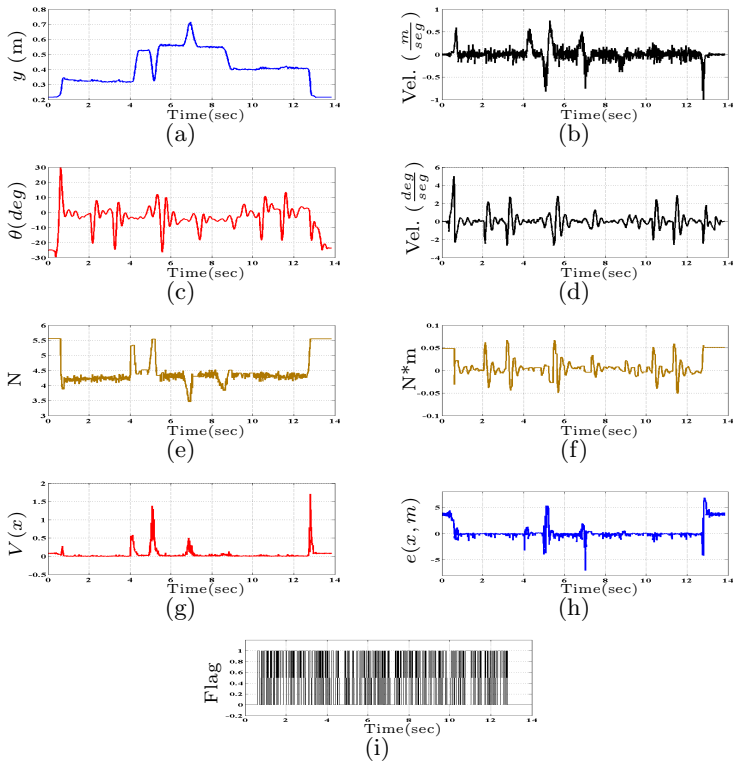

Fig. 5. Stabilization of PVTOL with disturbances

5 Conclusions and Future Work

The aim of this paper was to implement an event-based control strategy wherein the control loop is closed through a Internet connection. This work is based on the general formula introduced in [16] and the contributions of event-based LQR reported in [28]. The results obtained during the experiments showed the effectiveness of the proposed control strategy for the nonlinear system (although it was designed for the linearized system). The results also showed that the proposed strategy can reduce the number of control updates and consequently reduce the communication traffic over the Internet connection without sacrificing performance of the whole system. Although experiments only considered the altitude and angle, in future work the whole state will be considered.

Acknowledgment

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Parallelization strategy based on RenderScript reductions

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Abstract. RenderScript is a set of tools designed by Google to support parallel processing on mobile devices with Android. This tools were designed to run on different processing components such as Central Processing Units (CPU), Digital Signal Processors (DSP) and Graphics Processing Units (GPU) and it allows portability between mobile electronics devices such as Tablets and Smartphones. RenderScript has a runtime that decides where and how to execute commands list in parallel, it differs in coding and abstraction problem from others platforms used as Open Computing Language (OpenCL) and Compute Unified Device Architecture (CUDA). However, in this new parallelization paradigm kernel is not optimized for a specific architecture. There are not clear strategies for reduction algorithms implementation. For this reason this paper proposes several strategies for reduction algorithms implementation between vectors using RenderScript.

1 Introduction

A vector processor is a processor that can compute an integer value in an instruction, usually a vector instruction is equivalent to execution of a complete instruction at a loop, where each iteration works on each individual component of the vector. Vector memory operations are better than scalar operations because:

1. Each result is independent.
2. A single vector instruction replaces many scalar instructions.
3. They require a memory access pattern with a fixed access (adjacent).
4. In the problem is avoided a jumping in control loop.
5. Operations running more faster.

In this paper we explain two strategies for running a binary vector reduction for mobile devices (Smartphones and Tablets) using RenderScript.

1.1 RenderScript

Some applications can be developed using personal purpose processing such as computer vision and image processing. The applications that use RenderScript running inside the virtual machine Android, so Java application programming

interface is used to management resources and regulates the control life of programs of the kernel [4].

RenderScript represents a set of tools and a high level language for parallel computation intensive processing on Android devices, combined with sequential programming generates profits and optimize processes running in the execution model.

RenderScript makes work distribution across different threads and it optimizes use of all available processors on the device, it focus on the high performance applications on GPU, DSP, CPU and multiple cores. The RenderScript algorithms are perfectly balanced when it are processing, so any general-purpose application may be made and implemented widely using the maximal of resources on mobile device.

RenderScript Programming is based on next stages:

1. High performance kernels, all source code is written with a source code supported with C99 language.
2. An interface application (API) developed with Java,

1.2 FilterScript

FilterScript is a subset of RenderScript which contains restrictions to work in a variety of processors. In FilterScript the pointers are not allowed, so you can not read the memory directly and have to use API access functions of RenderScript[1].

1.3 Execution Model

The mobile device architecture has major differences with other traditional parallel systems such as a desktop system or a system for high availability.

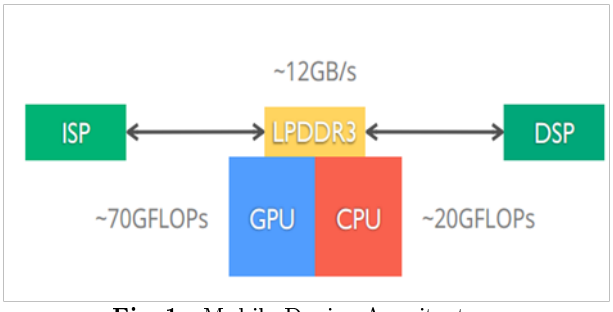

Fig. 1. Mobile Device Arquitecture

Communication between the CPU and the GPU is done through the DDR, LPDDR or MDDR memory (it's a type of synchronous DRAM special double precision for mobile devices) at 12Gb/s and an instruction set supports up to 70 GFLOPS on the GPU and up to 20 GFLOPS on the CPU. See Figure 1.

RenderScript was developed on the Low Level Virtual Manchine paradigm (LLVM). The execution model of an application in FilterScript or RenderScript shown in Figure 2.

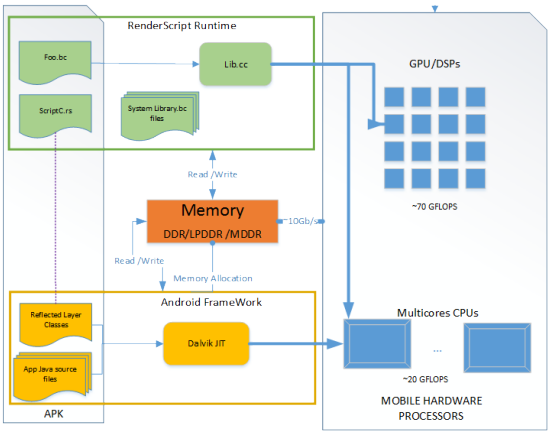

Fig. 2. Execution Model RenderScript based in [2]

This operation is as follows:

1. The execution program list is made in a language based on c99, is compiled with an intermediate format.
   (a) Encapsulated source code or KERNEL, is processed and creates a binary list not architecture dependent.
   (b) A special routine to compile binary list for one or more processors.
   (c) Special encapsulates are integrated according to the programmer needs for some common operations.
2. JAVA classes are created automatically by Development Kit.
3. Administration and enforcement resources are controlled by Java application interfaces.
4. They are integrate with the virtual machine, where are adding the executable binary and checklist as Java application.

2 Related work

In the literature, there are some proposals of how to code in RenderScript using other platforms of heterogeneous computing, however, not directly pose a programming strategy where are take advantage of all RenderScript tools, is the

case of [1], where the authors propose to use Heterogeneous Image Processing Acceleration (HIPA) to generate a image processing Kernel and to adapting to the RenderScript structure. The second proposal in [3], it shown the coding of a software implementation for translate OpenCl commands from to RenderScript.

After of the review of previous works that use applications and RenderScript code generation or strategies, are show that is not possible automatically export all the characteristics of a heterogeneous platforms and RenderScript computing resources are not optimally utilized; in [4] shown an alternative to programming high performance applications on android devices and show the Android architecture operation in APARAPI GPU, the authors focused their research on a performance study of the CPU and GPU using OpenCL on a GPU. the experiments were carried out in a Nexus 10 A15 CPU Dual-core, Quad core Mali-T604 GPU, and 2GB RAM.

Some algorithms require from an input data to define the number of elements of array reduced output, examples of these operations are: average cumulative sum, maximum, minimum, etc. A such operations within the parallel processing are called reduction operations.

There is a related work to the performance tests introduced by [5], they shown a the code that work on a HTC Desire smartphone. Dalvik Java source code was tested, the test consisted of implementation a set of twelve programs for Android platform using native code and Java, to evaluate the algorithm they found that only three applications run faster on Dalvik Java code and found performance issues.

In FilterScript and RenderScript, reduction operations used is not easy because a kernel implementation requires that length of input data should be equal to output data. Another important limitation is that is not possible to control over the numbers of threads that were invoked and this can only be changed by varying length characteristic of data input and output. Another paper presented by [7] performed additional performance tests where are comparing Android and Windows Mobile vs Java ME. They demonstrated where performance is better in Android. By other side, in [6] demonstrated a work where the native code is most efficient to develop high performance applications.

Analyzing existing studies have highlighted the need to attract new programming strategies for mobile parallel computing platform that supports general purpose programming; there are very few studies that show use of FilterScript or RenderScript, much less computation strategies vector on a platform of limited storing on Android Smartphones or Tablets, for this reason in this paper we focus to show two strategies for computing vector reductions in RenderScript implementations.

```
intsize;
void root(int32_t *v_out, uint32_t x,uint32_t y) {
if (x < divisor)
v_out[y] += v_out[sizey];
}
```

Listing 1.1. RenderScript kernel source code

```
intsize;
rs_allocation input;
float __attribute__((kernel)) root(uint32_t x) {
if(x < size)
return rsGetElementAt_float(input,x)+rsGetElementAt_float(
    input,size - x) ;

else
return 0;

}
```

Listing 1.2. Filterscript kernel source code

3 Solution proposal

RenderScript Lists exemplify programming strategies designed to use application interface for versions Android 4.1 in onwards. To solve reduction operations in RenderScript we have two possible strategies, these are exemplified with the cumulative sum of a vector of floating values on RenderScript and FilterScript version 2.2

3.1 First Strategy: RenderScript

The first strategy is to limit memory locations on threads running through identification number of thread.

Advantages:

1. Were performed on the same memory locations.
2. Ease of abstraction
3. Kernel in RenderScript be called recursively until the stop condition.

Disadvantages:

1. Threads are wasted.

The Kernel in RenderScript shown in Listing 1.2.

The Kernel in FilterScript shown in Listing 1.3.

```
1 float __attribute__((kernel)) root(const float2 v_in,uint32_t
    x) {
2 return v_in[0]+v_in[1];
```

Listing 1.3. Behavior of FilterScript and RenderScript kernel

3.2 Second Strategy: RenderScript and FilterScript

The second strategy is to use data structures provided by FilterScript and RenderScript. Is allow that input and output structures are the same size but can be of different type.

Advantages:

1. Invoked all threads are used.
2. Entire allocated memory is occupied.

Disadvantages:

1. Is necessary to change memory size for each reduction.
2. Algorithm must be adapted to the data structures.

In this case Listing 1.3 shows the behavior of FilterScript and RenderScript kernel

4 Results

With strategies proposed in the previous section, Mercator Series (equation 1) was implemented to calculate natural logarithm. This example was chosen because computation powers in the GPU have high computational complexity.

$$ln(1+x) = \sum_{n=1}^{\infty} \frac{(-1)^{n+1}}{n} x^n \tag{1}$$

This strategies was proved on a Tablet device with follow specifications:

Device:	Tablet Acer Iconia A1
RAM	Memory: 1GB RAM DDR3
Internal	Memory: 16 GB
Chipset:	MediaTek MT8125
CPU:	quad-core 1.2GHz
OS:	Android OS, v 4.2 Jelly Bean
GPU:	PowerVR SGX544MP3

Listing 1.4 shows the Kernel where is calculating the summation values.

For design of this kernel is used the second strategy proposed for implementation. Table 1 shows the average results.

It shows E1 as Strategy 1 and E2 as Strategy 2.

```
float2 __attribute__((kernel)) root(uint32_t x) {
float2 result;
int id = x+1;
result[0] = alter(id)*(pown(n,id)/id);
id = totalx;
result[1] = alter(id)*(pown(n,id)/id);
return result;
```

Listing 1.4. Mercator Kernel

Table 1. Average time results of running.

DATA	Dalvik	E1	E2
10	7.106161038	9	8
100	50.49752469	45	30
1000	2550	200	307
100000	6502500	20000	10000
1000000	4.22825E+13	15000	8000
1000000	1.78781E+27	12000	11000

Figure 4 shows time results, Figure 3 shows values obtained in the approximation obtained by Mercator series.

Energy consumption on device maintains a direct relationship with use and utilization rate of both CPU and GPU.

Table 2 shows resource usage percentage on device, table shows use of a device with a single core and a PowerVR GPU.

To calculate application consumption, when it is direct current (DC) electric power output at a certain moment by the product of the potential difference and

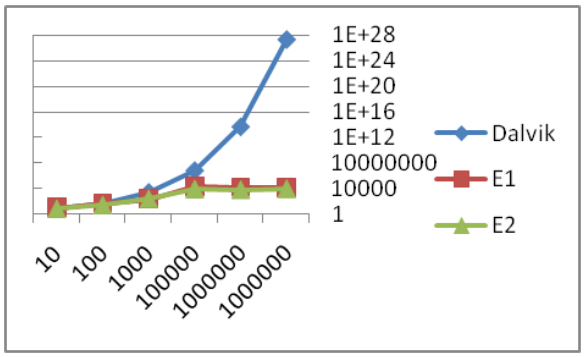

Fig. 3. Obtained values by Mercator series

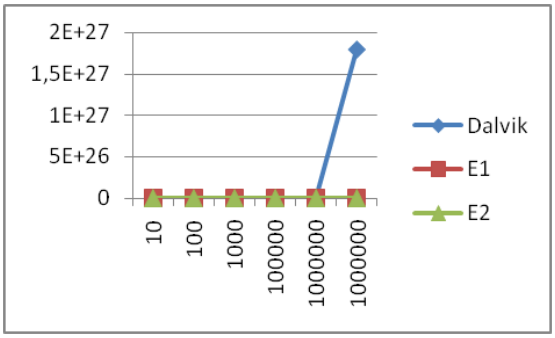

Fig. 4. Approximation obtained by Mercator series

Table 2. Resource usage percentage on device.

	Dalvik		E1		E2	
	CPU	GPU	CPU	GPU	CPU	GPU
10	40	2	10	40	22	42
100	60	4	12	50	24	45
1000	98	4	12	52	23	50
100000	100	4	15	55	25	48
1000000	100	4	15	55	27	50
1000000	100	4	16	70	28	60

the intensity of current passing through the device. For this reason the power is proportional to the current and voltage.

Equation 2 shows the corresponding expression

$$P = \frac{dw}{dt} = \frac{dw}{dq}.\frac{dq}{dt} = V.I \tag{2}$$

Where I is the instantaneous value of the current and V is the instantaneous voltage value.

If I is expressed in amperes and V in volts, P will be expressed in watts (W). The same definition applies when considering average values for I, V and P.

When the device is a resistor of value R or can calculate the equivalent resistance of the device, power can also be calculated using Equation 3

$$P = R.I^2 = \frac{V^2}{R} \tag{3}$$

DC voltage measured in normal operation is 4.2 Volts, When the calculation is performed at 100 percent the voltage in inductors (Vdrop) 14mVolts. Energy consumption by modifying Equation 3 is created equation 4

$$P = \frac{(Vbat)(Vdrop)}{R.} \tag{4}$$

Where Vbat is the nominal battery voltage 4.7 volts, Drop is voltage drop, where the voltage at 100% processor usage was 14 Volts in CPU and 12 GPU and mVolts. R represents the measurement resistance of 0.041 Ohms. Table 3 shows the final values of the power in Watts.

Table 3. Final values of the power in Watts

	DALVIK		E1		E2
	cpu	gpu	cpu	gpu	cpu
10	0,641951	0,027512	0,160488	0,550244	0,353073
100	0,962927	0,055024	0,192585	0,687805	0,385171
1000	1,57278	0,055024	0,192585	0,715317	0,369122
100000	1,604878	0,055024	0,240732	0,756585	0,40122
1000000	1,604878	0,055024	0,240732	0,756585	0,433317
1000000	1,604878	0,055024	0,25678	0,962927	0,449366

5 Conclusion

RenderScript, Google's parallel computing platform, is relatively new compared to other platforms and it continues with constant changes, which has led to its documentation is not quite complete. In RenderScript new strategies are needed for the implementation, since there is no control on number of threads to run like in others tools that have parallel computing platforms. . However, Google's platform has premise of being compatible with any number of devices and run the instruction list the most optimal manner in hardware available on your phone, also it can get excellent performance comparable to other platforms with the right programming strategies.

As reviewed in this paper, using RenderScript you can perform a lot of calculations in a short time on mobile devices, this opens the door for algorithms implementation that were previously inaccessible to these devices, for this reason scientific computing has a tool that can be of vital importance for algorithms validation.

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