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Presentation of Content

As a first article we present, *Digital filtering of myoelectrical signals from a person's forearm to probe accuracy of a physical electronic filter*, by COFRADIA-GARCIA, Gustavo, VAZQUEZ-CHAVEZ, Alejandro and JIMENEZ-RAMIREZ, Gabriel, with ascription in the Instituto Tecnológico Superior de Salvatierra, as second article we present, *Optimal Power Flow analysis for active power dispatch load dependent voltage Considering models,* by GARCÍA-GUZMÁN, José Miguel, TORRES-JIMÉNEZ, Jacinto and GONZÁLEZ-PONCE, María del Refugio, with ascription in the Instituto Tecnológico Superior de Irapuato, as the following article we present, Analysis of performance of AI planning algorithms and hybrid methodology in a problem of generation of learning paths, by MAYA-PADRÓN, Cristina, SANCHEZ-NIGENDA, Romeo, with ascription in the Universidad Politécnica de García and the Autónoma de Nuevo León, as the last article present, *Acquisition of myoelectric signals from the arm of person*, by VAZQUEZ-CHAVEZ, Alejandro, GARCIA-COFRADIA, Gustavo and RAMIREZ-ARENAS, Francisco, with ascription in the Instituto Tecnológico Superior de Salvatierra.

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Digital filtering of mioelectrical signals from a person's forearm to probe accuracy of a physical electronic filter

Filtrado digital de señales mioeléctricas del antebrazo de una persona y comparación con un filtro electrónico físico

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Abstract

Nowadays electromyogram (EMG) signals have a big huge motion of robotic applications Such, prosthesis, study activity of muscles, etc. The study of These signals is Important So They Can Be Extracted and be applied on Several use. But on This process there are some limitations. Some of them, the low amplitude (order of millivolts) and common noise on EMG signals. It make us to do an effort to Improve and / or Eliminate some trivial signals possible. So the present work it is focus on the filtering of EMG signals and then a subsequent activities in Those results Could be used in some applications of interest like Those marked above. In This paper it is Stated the filtering stage in Matlab With some generic filters (low and high pass) filters and wavelet family. Syms wavelet filters are used in signal processing Widely. Data (signals) Were Collected from the forearm muscles, it is the first stage That Involves acquisition and filtering phase of the study. The contribution is the comparison Between to filter and electronic physical Those results from software. That information will help us to choose the correct one in order to Obtain clear and useful information and probe the accuracy of the physical filter implementation in order to continue back some applications.

Filters, EMG signals, Wavelet

Resumen

Hoy en día, las señales de electromiograma (EMG) tienen una gran cantidad de aplicaciones tales como movimiento robótico, prótesis, estudio de la actividad muscular, etc. El estudio de estas señales es importante para que puedan extraerse y aplicarse en varios usos. Pero en este proceso hay algunas limitaciones. Algunos de ellos, la baja amplitud (orden de milivoltios) y el ruido común en las señales EMG. Esto nos forza a hacer un esfuerzo para mejorar y/o eliminar algunas posibles señales triviales. Por lo tanto, el presente trabajo se centra en el filtrado de señales EMG y luego en actividades posteriores, los resultados podrían usarse en algunas aplicaciones de interés como las marcadas anteriormente. En este documento está programado la etapa de filtrado en Matlab con algunos filtros genéricos (paso altas y bajas) y filtros de familia Wavelet Symlets o Syms. Los filtros Wavelets Syms son ampliamente utilizados en el procesamiento de señales. Los datos (señales) se obtuvieron de los músculos del antebrazo en una primera etapa de investigación que consiste en la adquisición y el filtrado. De esta forma se contribuye con la comparación entre un filtro electrónico físico y los resultados del software. Esa información nos ayudará a elegir la correcta para obtener información clara y útil y probar la precisión de la implementación del filtro físico para continuar con algunas aplicaciones posteriores.

Filtros, Señales EMG, Wavelet

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Introduction

The electromyogram (EMG) is a common medical procedure that uses electrodes to detect and measure electrical signals from muscle activity, which may be useful in intelligent recognition of different movements of the limb of a person. The EMG signal has been used since 1948 with the performance of the prosthetic hand. Commercial production with myoelectric prosthetic hand signals began in 1957 at the Central Research Institute of Prosthetics Moscow to drive a stepper motor. Later in this scheme Control strategy myoelectric a simple control scheme on widely analyzed and developed and off(Kobrinsky, 1960) (Popov 1965).

From this it has developed a wide variety of control schemes to translate the EMG signal. The variety of control schemes are typically classified according to the nature of the control, as sequence control and simultaneous control. In schemes sequential control, the EMG signals are translated using the following schemes: 1) control on-off, 2) proportional control, 3) direct control, 4) control finite state machine, 5) based control recognition patterns, 6) position control schemes, and 7) control schemes regression(Geethanjali, Ray, & Shanmuganathan, 2009)

In the sequential control surface electrodes were used to connect signals to the prosthesis human control, thus is possible to identify three to four possible locations from the residual limb to acquire signals. Surface electrodes in modern myoelectric prosthesis often embedded in the prosthesis and make contact with skin. These electrodes detect EMG signals from the skin surface and amplify muscle action, voluntary muscle contractions in the residual limb and are used to control the movement and functions of the prosthesis, this technique is preferable because of its easy access and non-invasive procedure, however the skill of the prosthetic hand is lower due to the limitation in identifying locations to acquire signals. Instead collection intramuscular EMG signals is an invasive technique and requires surgical ability to use implantable myoelectric sensor. However Intramuscular EMG signals provide access for the collection of EMG signals from multiple locations to provide multiple levels of control to the prosthetic limb(Litcher, Lange, & Hedin, 2010) (Farrell & Weir, 2005).

Currently there is research aimed at replacing external electrodes implantable myoelectric sensors fully include a wireless interface to the prosthesis. It is intended that myoelectric sensor read EMG signals electrode amplified intramuscular recording and transmitted wirelessly to a receiver in the prosthetic limb, causing the implant to remain in use by rechargeable battery and a transfer link inductive energy prosthesis(Litcher et al., 2010). The following Table 1.1, cites some applied work on the electromyographic signals (EMG). The following Table 1 lists some applied on the electromyographic signals (EMG), where biomedical and electronic applications work stand out.

Author / Application	Description
(Geethanjali et al., 2009)/ Biomechanics	Development of a four-channel EMG for driving a prosthesis.
(Kobrinsky, 1960) [two] (Popov 1965)/ **Biomechanics**	Performance of a prosthetic hand by EMG signal.
(Litcher et al., 2010)/ **electronics**	EMG development of wireless sensor for controlling prostheses.

Table 1 documented work done with EMG

Since we have seen some applications due to the processing of myoelectric signals, it is necessary to know that many of these signals contain trivial information. Therefore, in this paper a signal filtering acquired for comparison and test the validity of a physical filter implemented develops.

The Fourier transform TF is a particular case of wavelet transform TW, this because the TF only analyzes signals in the frequency domain, unlike TW which makes both time domain and frequency. For versatility the wavelet filters were applied to analyze the results obtained by this technique since the capture myoelectric electronics are made in a domain standard frequency of 50 -500 Hz (by law), ie the frequency is ranging , so the TW filters are suitable for these applications, plus they are high-speed filters. After analyzing the big picture of the electromyographic signals, it is to use some of these tools to analyze EMG signals the best possible way. The methodology to be followed in this work is shown. (Louis, 2018) (Louis, 2018)

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Methodology to develop

This paper will be presented three main stages; applying filters lowpass and highpass, the filter effect Wavelet Syms and finally comparing the result of the above two steps with the result of a physical filter to the same signal. It will work with the signal obtained arm crude, ie, before passing through any physical filtration stage. The following figure is the signal represents the original signal, Figure 1.

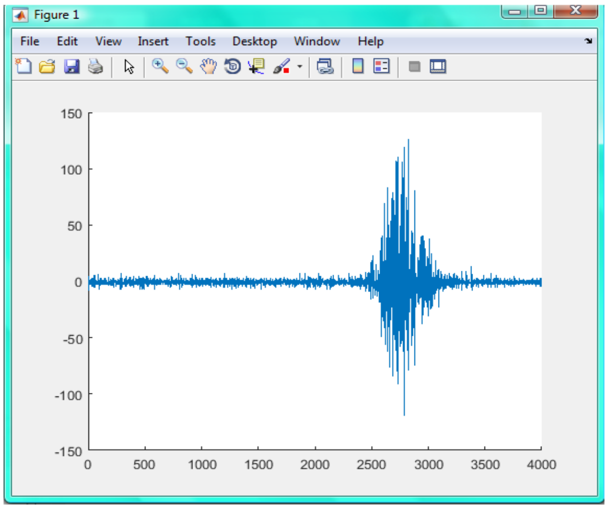


Figure 1 Representation of the original signal

The behavior of this signal is defined by approximately 4000 discrete values. Then it proceeds to do the filtering by some Matlab tools. It was applied one lowpass filter and one high pass, to attenuate some frequencies provided the cutoff frequency, 50 or 500 Hz for low and high frequencies.

The low pass filter allows signals below a cutoff frequency and attenuates signals above the cutoff frequency to smooth the signal high frequency noise.

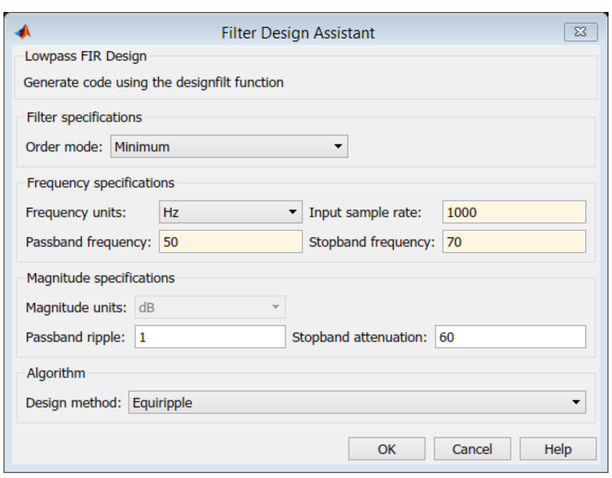


Figure 2 Characterization lowpass filter

In contrast the high pass filter attenuates signals or low-frequency noise, situated below the cutoff frequency to smooth the signal.

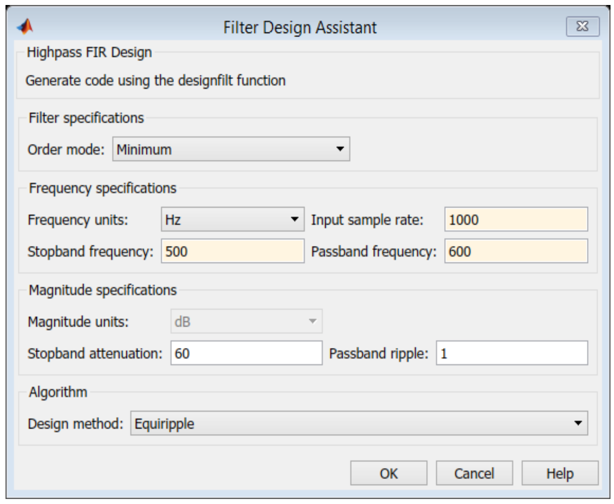


Figure 3 Characterization of the high pass filter

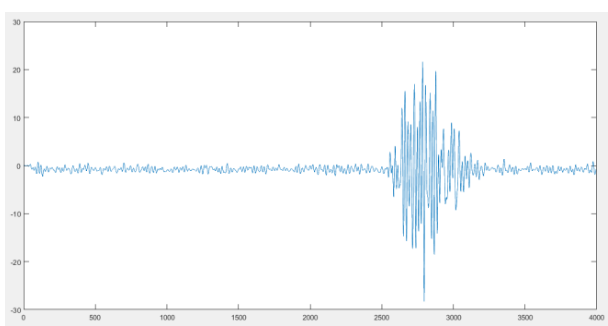
This same signal is passed by the filters Wavelet Syms family as mentioned above are widely used for filtering of such signals. For this application the function DWT (Discrete Wavelet Transform) for its acronym in English is written. These wavelets are compact support, less asymmetry and regularity, ie a reconstructed signal smoothly.

d = dwt (signal, 'sym1')

As the final results of the comparison of these filters with physical filtration to validate be presented in the next section.

Results

In this section the results of the above three steps are presented. Applying low pass filters and high pass result can be seen in Figures 4 and 5. It is clearly seen that the low pass is less concentrated as it eliminates those high frequencies according to the filter characteristics of Figure 2.



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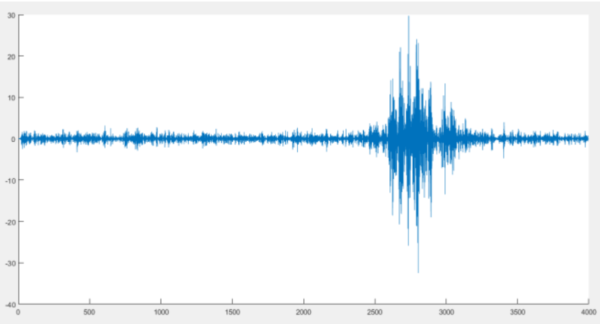

Figure 4 resulting signal after lowpass filter (top) and high pass (bottom)

In addition you can see the result of comparing these two graphs. The comparison between the signals lowpass and highpass shown in Figure 6 which shows that effectively when the high pass filtered, the concentration signal is denser.

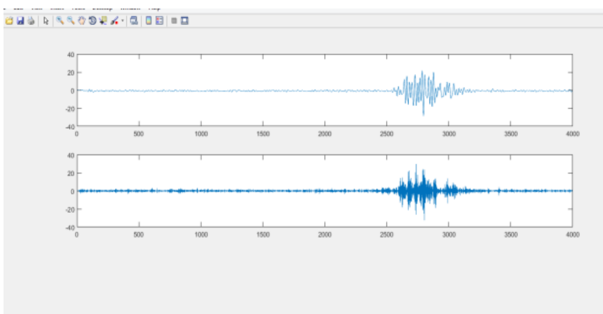

Figure 6 Comparison between the lowpass filter and highpass

When applying low pass filters and high pass, we see some signs of removing trivial to study the desired signal frequencies, as was done physically in the signal acquisition to make the comparison then develops. Then the result of applying a filter Wavelet Sym to the original signal of interest is shown. As seen in the image these filters have a shift to the left, avoiding further prevents further processing.

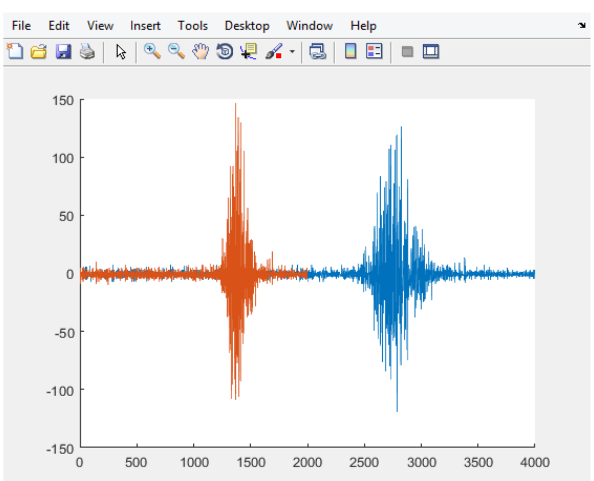

Figure 7 Comparison between Wavelet and applying the original signal

It is noteworthy that in applying this filter finer results and noise removal is obtained is made more faithfully. Plus it allows us, in a post-filtering process, controlling the main component for use in any application or future work.

The following figure shows the result of the first step of the signal acquisition for analysis (above Wavelet filter, filtering down physical). One can also observe the smoothing signal with the physical filter applied to the signal where commercial components which similarity results are shown as those obtained with the wavelet filter in Matlab were used. Physical stage uses conventional filter for external noise capacitors 2uF causing some low amplitude oscillations in the graph.

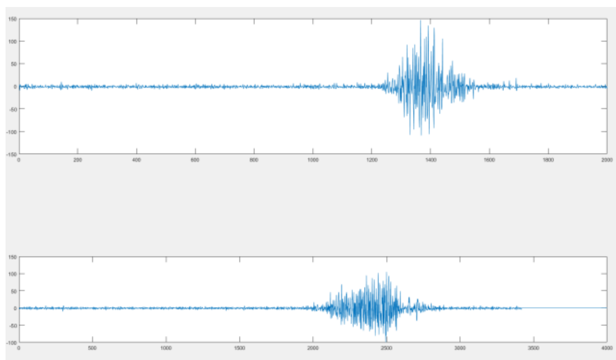

Figure 8 Comparison between Wavelet and applying physical filter

Annexes

generic code used

```
close all
clear all
senal=xlsread('Ejercicio.xlsx');
s = designfilt('lowpassfir', 'PassbandFrequency', 50, 'StopbandFrequency', 70, 'PassbandRipple', 1, 'StopbandAttenuation', 60, 'SampleRate', 500);
hold on
x=rand(100,1);
y=filter(s,senal);
d = dwt(senal,'sym1');
d2= dwt(senal,'sym20');
d15= dwt(senal,'sym15');
subplot(3,1,1),plot(senal)
subplot(3,1,2),plot(d2)
subplot(3,1,3),plot(d15)
```

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Conclusions

The filter wavelet family removes both high and low frequencies has the advantage that by applying transformed into the time domain and frequency in tandem, softens more accurately and linear any presence of noise more accurately because it of such signals.

It can be seen that compared to the physical filtering software filters have enough similarity therefore can corroborate its validity and the results at a later stage of analysis are good utility for use in any application.

Now that it has been validated by the results of the software, the possibility of applying the signal acquisition and filtering stages and subsequent applications will be taken such as those already mentioned at the beginning of this article.

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Article

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Optimal Power Flow analysis for active power dispatch load dependent voltage Considering models

Análisis de flujo de potencia óptimo para el voltaje activo dependiente de la carga de despacho considerando los modelos

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Abstract

This work is presented in the Optimal Power Flow (OPF) analysis to determine the active power dispatch of power systems When the voltage dependent load models are Considered in Such analysis. The load models Considered In This work are the exponential and composed models, are integrated into OPF Which formulation using an existent program developed in Matlab programming language. Two study cases With the IEEE power system of five nodes and New England power system are Carried out to determine the optimal active power dispatch and points of steady-state operation of These systems Considering load models. The case studies show That the load models have a significant effect on the FPO results, since the losses and the demand for power, Both active and reactive, decrease the generation cost Causing Also to decrease.

OPF, load model, active power dispatch, generation cost

Resumen

En este trabajo se presenta el análisis del problema de Flujos de Potencia Óptimos (FPO) para llevar a cabo el despacho de potencia activa de sistemas de potencia cuando se consideran los modelos de cargas dependientes de voltaje. Los modelos de carga considerados son el modelo exponencial y el compuesto, los cuales son integrados en la formulación de FPO usando un programa existente desarrollado en Matlab. Dos casos de estudio con el sistema de prueba de 5 nodos del IEEE y el sistema de potencia de Nueva Inglaterra son llevados a cabo para determinar el despacho de potencia activa y los puntos óptimos de operación de estado estacionario de estos sistemas considerando los modelos de carga. Los casos de estudio muestran que los modelos de carga tienen un efecto considerable en los resultados de FPO, ya que las pérdidas y la demanda de potencia, tanto activa como reactiva, disminuyen haciendo que el costo de generación también presente un decremento en su valor.

FPO, modelos de carga, despacho de potencia activa, costo de generación

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Introduction

The energy companies must achieve maximum efficiency while minimizing the cost of generation, so that the profitability of the generating units is indispensable. This necessitates the addition of an analysis Optimal Power Flow (FPO), because by this analysis can meet the demand of active power in the most optimal way. In 1962 importance to research FPO (Abdel & Narayana, 2003, Happ, 1977) and a rigorous mathematical approach for analyzing FPO was first proposed by J. Carpentier, who made it as a problem of nonlinear programming occurred (Ahmad, 1991).

Flow analysis Optimal Power (FPO) allows optimizing a subject to various restrictions objective function, thus the optimal state of steady state operation of the power system is determined. The objective functions may consider economic, security or environmental aspects of the electrical system. In this work this function corresponds the sum of cost functions power generation Activa2 (Ahmad, 1991; Ambriz et al, 1998). The restrictions are physical laws governing power generation, transmission capacity power system, the nominal design limits of the electrical equipment and the same operating system (Acha et al, 2004).

Restrictions are equality and inequality, they correspond to the first balance equations active and reactive power at each node of the electrical system, and the latter are those regarding operating system and physical limits. FPO studies have become an essential tool in the planning and operation of power systems. In operation, a FPO can perform actions considering the optimal monitoring system operating restrictions, while planning studies to determine optimal FPO serve scenarios considering the evolution of power systems (Pizano, 2010). FPO studies have become an essential tool in the planning and operation of power systems. In operation, a FPO can perform actions considering the optimal monitoring system operating restrictions, while planning studies to determine optimal FPO serve scenarios considering the evolution of power systems (Pizano, 2010). FPO studies have become an essential tool in the planning and operation of power systems.

In operation, a FPO can perform actions considering the optimal monitoring system operating restrictions, while planning studies to determine optimal FPO serve scenarios considering the evolution of power systems (Pizano, 2010).

FPO results are influenced by the models used for the main electrical components SEP such as transformers, generators, transmission lines and loads. Modeling latter a strong impact on the value of the objective function and the state variables of the system (El-Hawary & Dias, 1987), however, such modeling is difficult because of the different types of loads connected to the system electrical, environmental conditions and load levels thereof. Therefore, modeling loads in studies of SEPs is done considering various simplifications. Load models are classified into two types: static and dynamic models.

In this paper static models dependent voltage electrical charges to SEP are integrated to obtain the optimal dispatch of generation (DOG) considering such loads models and determine the impact of these charges on behalf of the study results FPO.

Analysis of Optimal Power Flow

In general, the mathematical formulation of the problem of FPO can be raised as a problem of nonlinear constrained optimization, in which the cost of active power generation of each generator is minimized without violating constraints of the system. The FPO problem is formulated as follows (Ambriz, 1998; Ahmad, 1991; Monticelli and Liu, 1992),

$$\begin{aligned} &\text{Minimizar} \; f(x) \\ &\text{Sujeta a} \quad h(x) = 0 \\ &\qquad\qquad g(x) \leq 0 \\ &\text{y} \quad y^{\min} \leq y \leq y^{\max} \end{aligned} \tag{1}$$

where y is the vector of state variables of the system, f (y) it is the objective function to optimize, in this case the cost function of active power generation, h (y) represents equality constraints given by equations balance of power and g (y) are the inequality constraints, which consist of the limits of the control and status variables and functional inequality constraints.

Modeling dependent voltage loads

The operation of a power system depends on the ability to match the electrical output of the generator units to the power system load. Consequently, the load characteristics have an important influence on the power flow studies (Kundur et al, 1994). For this reason it is very important to model the loads as close to practice, but this modeling is complicated because a bus typical load is composed of a large number of devices, for that reason the exact composition of the filler is difficult to estimate. In addition, the composition changes depending on many factors, including time (hour, day, season), weather conditions and the state of the economy (Concordia & Ihara, 1982).

Static loads modeling is performed based on the variables that affect the active and reactive power consumed in a given node. These variables are the voltages on buses and mains frequency (Rodriguez et al, 2013). Models dependent voltage loads used in the analysis of power systems are exponential and polynomial type, which are expressed for a node i, respectively, by (3) and (4) as follows (Kundur et al, 1994 ; Price et al, 1988),

$$P_{i,\exp}(V) = P_{i,0}\left(\frac{V_i}{V_{i,0}}\right)^{\alpha} \tag{2}$$

$$P_{i,ZIP}(V) = P_{i,0}\left(a_0 + a_1\left(\frac{V_i}{V_{i,0}}\right) + a_2\left(\frac{V_i}{V_{i,0}}\right)^2\right) \tag{3}$$

where P0, i V0, i represents the power and the rated voltage of node i, Vi is the voltage of node i at a given time, α is the coefficient of the exponential model and (0, 1, 2) represents the model coefficients polynomial, the sum of these coefficients is equal to 1. The polynomial model is also known as ZIP or compound. The same expressions apply for the reactive power, which in this case only the variable P, the exponential coefficient and the model coefficients are denoted ZIP Q, β and b, respectively.

FPO model considering charging models dependent voltage

FPO model used in this paper considers the incorporation of models dependent charge voltage in one unified framework solution.

The resulting pattern of OPF with loads is expressed as,

$$\min \quad C_T(P_{Gi}) = \sum_{i=1}^{Ng} a_i + b_i P_{Gi} + c_i P_{Gi}^2 \tag{4}$$

Sujeto a:

$$\sum_{i=1}^{ng} P_{Gi} - P_{Di} - \sum_{j=1}^{nl} P_{iny,i-j} = 0 \tag{5}$$

$$\sum_{i=1}^{ng} Q_{Gi} - Q_{Di} - \sum_{j=1}^{nl} Q_{iny,i-j} = 0 \tag{6}$$

$$P_{Gi}^{\min} \le P_{Gi} \le P_{Gi}^{\max} \tag{7}$$

$$Q_{Gi}^{\min} \le Q_{Gi} \le Q_{Gi}^{\max} \tag{8}$$

$$V_i^{\min} \le V_i \le V_i^{\max} \tag{9}$$

where

$$P_{Di} = \left\{P_{i,\exp}(V_i), P_{i,ZIP}(V_i)\right\}$$

$$Q_{Di} = \left\{Q_{i,\exp}(V_i), Q_{i,ZIP}(V_i)\right\}$$

Study cases

In this paper a case study is presented with the test system IEEE 5 node (Stagg & El-Abiad, 1968) in which the point of steady state operation of these power systems charging models is determined integrated voltage dependent on the formulation of Optimal Power Flow. This in order to evaluate the effect of such integration load models in the study of active power and at optimum balanced steady state of power systems. For the case studies presented in this paper the coefficients of the exponential model were α = 1.5 for the active power and β = 2.0 for the reactive power (Dias & El-Hawary, 1991), whereas in the case of the polynomial model or ZIP the following values (a0 = 0.55, a1 = 0 is adopted. 15, a2 = 0.35) and (b0 = 0.50, b1 = 0.12, b2 = 0.38) for active and reactive power, respectively. Convergence tolerance considered in the case study was 1x10-9.

The system of 5 nodes IEEE has three nodes load and an additional load connected to a bus generation. Thus, models dependent charge voltage are integrated into these nodes to then calculate optimum operating point of this stationary power system. It should be mentioned that the lower and upper limit generation is 10 and 200 MW, respectively, while the voltage limits are 0.9 ≤ Vi ≤ 1.1 pu. A summary of the results of the equilibrium point with both load models in the FPO shown in Table 1.

Parameter	fixed	Exp.	ZIP
Total cost ($ / hr)	747.97	656.78	700.76
Pdemandada (MW)	165	143.80	152.66
Ppérdidas (MW)	3.05	3.33	3.71
Pgenerada (MW)	168.05	147.14	156.38
Qdemandada (MVar)	40	29.42	35.87
Qpérdidas (MVar)	-25.29	-14.26	-13.30
Qgenerada (MVar)	14.71	15.16	22.57

Table 1 Comparison of results of the test system with 5-node load models

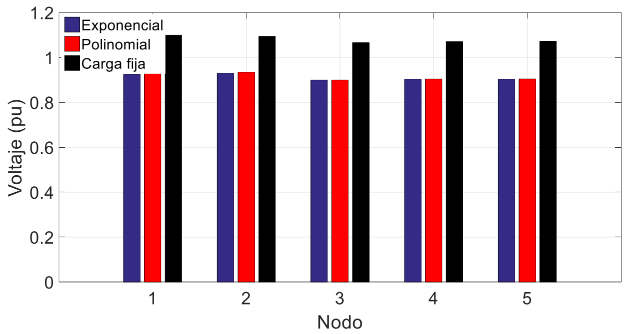

Figure 1 Nodal Voltages considering charging models

Figure 1 shows that the nodal system voltages of 5 nodes decrease when the load models are integrated, which causes decrease flows and reactive power. Furthermore, the results presented in the above table show that the generation cost is lower load models but is important to note that in the case of the exponential model generation cost that is still less. This reduction in cost is due to the decrease in active power generation, Figure 2, which in turn is caused by reduced losses and demand active and reactive power, Figure 3 and 4.

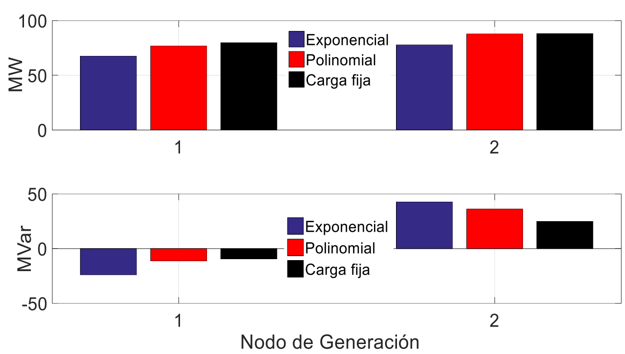

Figure 2 active and reactive power generated considering charging models

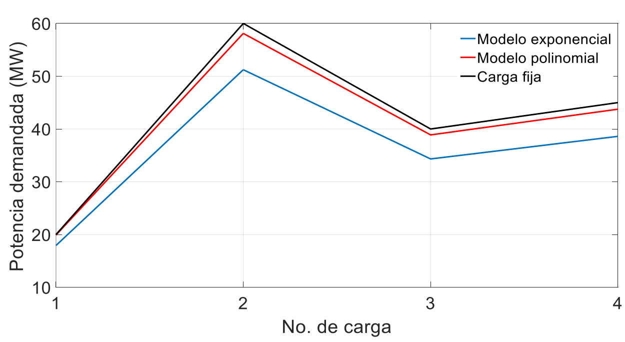

Figure 3 active power demanded considering charging models

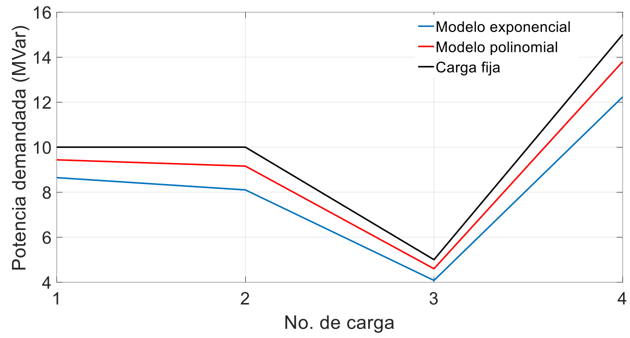

Figure 4 reactive power demanded considering charging models

In this sense, it is easy to infer that modeling the loads has a significant effect on the results of optimal balance point of steady state power system, which for this power system is in particular an operating point of the system cheaper power when loading these models are integrated.

Conclusions

An implementation of the model-dependent charge voltage in the formulation of FPO are presented in order to evaluate the impact of these models in the study of active power and in general the results of the optimum balance point of steady state Power systems.

The results obtained in the case studies showed that integrating models dependent charge voltage the active power losses are decreased and reactive, but also a decrease in power demand also occurs, which makes power generating and thereby decrease the cost of generation. Thus, the generation cost is lower with the two load models, but it should be noted that in the case of exponential model generation cost is even lower.

For the foregoing, it can be concluded that the modeling of the loads has a significant effect on the results of optimal balance point of steady state power system, which for this power system including a point of system operation power cheaper than when loading models are not integrated.

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Analysis of performance of AI planning algorithms and hybrid methodology in a problem of generation of learning paths

Análisis del rendimiento de los algoritmos de planificación de IA y la metodología híbrida en un problema de generación de rutas de aprendizaje

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Abstract

In this paper we present an analysis of the performance of two Artificial Intelligence pplanning algorithms, SGPLAN and LPG, in a problem of generation of learning paths (GLP). Likewise, two models were developed to represent this problem: a) as a model of Artificial Intelligence Planning, with the planning domain definition language (PDDL), which uses the planning algorithms SGPLAN and LPG for its solution; and b) as a mathematical model. It also presents a hybrid methodology of solution in which both planning and mathematical models are combined. In the experimentation the performance of the planning algorithms is evaluated to obtain solutions (plans) comparing the results obtained by both models. And finally, the performance of the planning algorithms is observed when modifying the planning models with information of solutions obtained with the mathematical model (hybrid method). We hope that the results obtained in this research serve to highlight the benefits of using AI planning and the planning algorithms SGPLAN and LPG for their solution. As well as showing the opportunity areas of such algorithms.

Artificial intelligence planning, Planning algorithm, Mathematical modeling, Hybrid methodology, Learning paths

Resumen

En este trabajo se presenta un análisis del desempeño de dos algoritmos de planificación de Inteligencia Artificial, SGPLAN y LPG, en un problema de generación de rutas de aprendizaje (GLP). Asimismo, se desarrollaron dos modelos para representar dicho problema: a) como un modelo de Planificación de Inteligencia Artificial, con el lenguaje de definición de dominios de planificación (PDDL), que utiliza para su solución los algoritmos de planificación SGPLAN y LPG; y b) como un modelo matemático. Se presenta además una metodología híbrida de solución en donde se combinan ambos modelos de planificación y matemático. En la experimentación se evalúa el desempeño de los algoritmos de planificación para obtener soluciones (planes) comparando los resultados obtenidos por ambos modelos. Y finalmente, se observa el desempeño de los algoritmos de planificación al modificar los modelos de planificación con información de soluciones obtenidas con el modelo matemático (método híbrido). Esperamos que los resultados obtenidos en esta investigación sirvan para resaltar los beneficios de utilizar la planificación de IA y los algoritmos de planificación SGPLAN y LPG para su solución. Así como mostrar las áreas de oportunidad de dichos algoritmos.

Planificación de Inteligencia Artificial, Algoritmos de planificación, Modelación matemática, Metodología híbrida, Rutas de aprendizaje

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Introduction

In this paper, an evaluation of the performance of two planning algorithms is carried out to solve a problem of generation of learning paths.

The planning algorithms are used to solve Artificial Intelligence Planning models. Commonly they are called "*independent planners of the domain*", this is because regardless of the planning model in question, to be an educational model like ours, of scheduling, purchasing, manufacturing, etc., they can obtain a solution (a plan) to said model.

Planners are special-purpose algorithms that use a formal planning language such as PDDL (planning domain definition language), with well-defined syntax, semantics, and demonstration theory (Russell & Norvig, 2004).

Two planning algorithms are considered: SGPLAN and LPG, which were selected for their high performance in the International Planning Competition, bi-annual event organized in the framework of The International Conference on Automated Planning and Scheduling (ICAPS), which is the premier forum for exchanging news and research results on theory and applications of intelligent planning and scheduling technology (ICAPS, 2018).

The planning model selected to evaluate the performance of the planning algorithms is the *problem of generation of learning paths (GLP)* (Sanchez, et.al, 2017).

The *problem of generation of learning paths* can be considered as follows: Considering that it has an academic program, which contains the subjects that the student must study, and that in turn each subject is composed of a set of themes or learning units, it is assumed that there are various learning activities modeled by the instructor/educator, so that the student can perform to each learning objective.

In this way, it can generate an ordered sequence of learning activities for the student to allowed him to minimize the total time he has dedicated to his activities, considering a utility (score) for each approved learning objective. It also considers, the precedence of learning activities and the activities considered as mandatory.

Therefore, we see that it is a complex problem, since activities must be selected that comply with the objective function that is to minimize the total time, complying with a set of restrictions such as mandatory activities, precedence in activities, considering an evaluation or score of approval defined by the user.

This problem (GLP) was modeled in two ways: like an AI planning model, using PDDL and as a mathematical model. It is worth mentioning that the order of activities is not considered in the mathematical model. To represent the precedence of activities we do the following: if a learning activity is selected and it has an activity that precedes it, the mathematical model is forced to select both activities. This is to ensure that in some way there is a sequence, as it would be the planning model, even if the all activities do not go in order.

Next, the methodology uses, the approach of both developed models, results, conclusions and references will be described.

Methodology

With regard to artificial intelligence planning

The methodology used in this work is as follows: The problem of generation of learning paths is modeled as an artificial intelligence planning model, this is done by the PDLL planning domain definition language (Fox & Long, 2003). The *planners* are used to obtain *solutions* from the planning models, and finally, as a result of the planning process, the plans are obtained, which are the learning paths. In Figure 1 you can see the complete picture of the *planning process*.

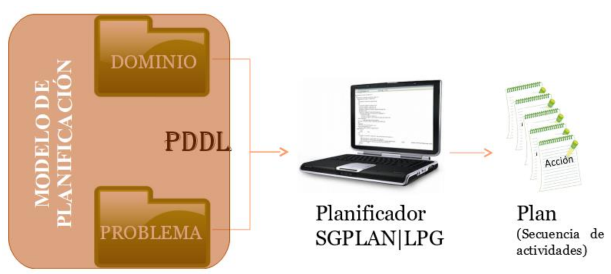

Figure 1 Planning process

In order to model the problem of generation of learning paths as a planning model, we use the PDDL 2.1 planning domain definition language.

PDDL is a language centered on actions inspired by the formulations "Strips" of planning problems. This is a standardization of the syntax to express actions using preconditions and post-conditions to describe the applicability and effects of the actions. The syntax is inspired by Lisp (Winston & Horn, 1989) (acronym for LISt Processing), so much of the structure of the domain description is a list as Lisp of the expressions in parentheses.

A *planning model* in PDDL is organized into two main parts: the *planning domain* and the *planning problem* (see the previous Figure 1). The *domain* is the construction of the model and the *problem* is an instance to solve of that domain. However, it is common to use the term planning domain to refer to the planning model itself. The following describes how the planning model is organized in PDDL:

1. ***Planning domain****:*

Which describes the rules of action and is composed of:

1.1. *Predicates*: These represent relationships between the objects. They help us describe a problem in the real world trying to represent the concepts of our problem through relationships between the objects that make it up.
1.2. *Fluents*: Functions that allow us to handle numerical values.
1.3. *Actions/Operators*: Ways to change the state of the world.

2. ***Planning problem***

It describes the state of the surrounding world and the goals/objectives, as well as the metrics to be optimized. It is composed of:

2.1. *Objects*: The things in the world that are of our interest.
2.2. *Initial state*: The state of the world in which you start. That is, the starting point of the search.
2.3. *Specification Objective*: Check if the current status corresponds to a solution to the problem.
2.4. *Metric to be optimized*: In the case of planning models that handle Fluents, select the actions that comply with the metric to be optimized.

The actions: they are part of the planning domain in PDDL (section 1.3 above) are the ways to change the state of the world. Next, its components are mentioned:

– *Specification of the action*: it is what the agent actually returns to the environment in order to proceed to do something. When it is inside the planner it serves as the name of the action.

– *The precondition*: is a conjunction of atoms (positive literals) or functions (fluents) that say what must exist (be true) before the operator can apply it.

– *The effect of an operator*: is a conjunction of literal (positive or negative) or functions (fluents) that tells how the situation changes when applying the operator.

Once the *planning model* has been developed as it is described above, the *planners* are used to solve it. We call it the *solution* of the result of the *AI planning process*. The term *solution* according to (Russell & Norvig, 1996) is a *plan* that an agent can execute and guarantees the achievement of the goal. That is, a sequence of *actions* that are executed in the *initial state*, and results in a *final state* that satisfies the objective.

Next, we describe the selected planners to evaluate:

SGPLAN: is a planner that was in the first place in the IPC of 2006 in the deterministic part of the competition. SGPlan partitioned a large planning problem into subproblems, each with its own sub-objectives. The version we use for our experimentation is SGPlan-5.

LPG: This planner has participated in the IPC and was awarded as the best automated planner in 2003 and later in the IPC 2004 was awarded as the best performance. LPG is a stochastic planner, based on searches in the forward state space. It is recommended for domains that have numerical quantities and durations like our GLP problem. The version we use for our experimentation is LPG-td-1.0.

With regard to mathematical modeling

In the scientific approach of decision making, the use of one or more mathematical models is required. These are mathematical representations of real situations that could be used to make better decisions, or simply to better understand the current situation.

A model of this type dictates behavior for an organization that will allow you to achieve better your goal(s).

The elements of a mathematical model are:

– *Function (s) objective*: In most models there is a function that we want to maximize or minimize.

– *Variables decision*: They are variables whose values are under our control and influence the performance of the system.

– *Restrictions*: In most situations, only certain values of the decision variables are possible.

There are different mathematical models that can be made, this is according to the nature of the decision variables and how the objective function and restrictions are defined. Among the different types of mathematical models are: linear models, non-linear models, integer models, non-integer models, binary models and mixed-integer linear programming (MILP) models.

Among these type of mathematical models, we are interested in the MILP model: If in a linear model only some variables are restricted to integers, then we have a mixed integer linear model.

With regard to combination of both methods

The mathematical model provides us with exact solutions regarding the selection of learning activities that minimize the total time, which is the objective function defined for our problem, but does not consider the ordering of learning activities. The planning algorithm seeks to do both, however, it throws very large GAPs, that is, the selection of activities is far above an optimal or exact solution,

Taking into account the above, we consider the solutions of the mathematical model and include them in the planning model (see figure 2). This aims to make it easier for the planning algorithm to obtain better solutions, since it will not make the selection of activities that optimize the objective function. Therefore that task will have been performed by the mathematical model. So the algorithms will consider the activities already selected by the mathematical model and will perform the ordering. The advantage of this hybrid methodology is to obtain better solutions, with respect to the GAP.

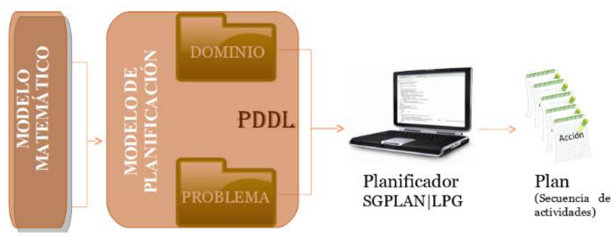

Figure 2 Hybrid methodology: planning process with the mathematical model

Approach of the developed models

We can raise the problem of generation of learning routes as one that automatically generates an ordered sequence of activities that allow optimizing a metric. Figure 3 shows graphically the GLP problem, where you have a subject, which has a number of themes or units of learning, these have specific learning objectives that are the sub-themes. Each subtheme has learning activities that must be done to meet that specific objective. The learning activities have duration, score and an associated resource, this is the time it takes to perform the activity, the score or utility obtained when doing it, which we assume is proportional to the duration and an associated resource such as a book, computer, etc., necessary to carry out the activity.

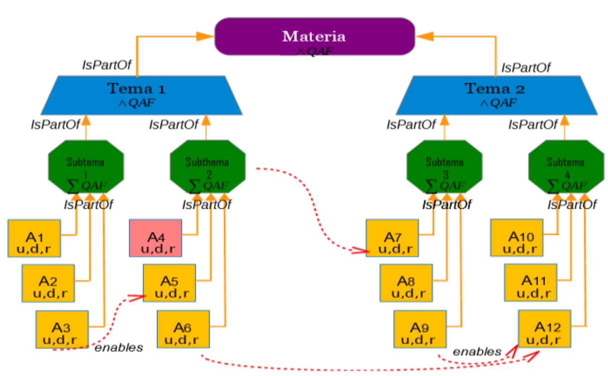

Figure 3 Graphical representation of the GLP problem

In addition to the above, you can see in figure 3 the red dashed arrows between the activities, this represents the precedence relations between the learning activities. For example, activity A5 is a reading of chapter 2 of a given book and activity A3 is the chapter1 that gives the introduction. So that there may be relationships of only one previous activity (1:1) or two previous (2:1).

Activity A4 is marked with a different color because it is a mandatory activity, that is, this activity must be part of the sequence of activities to be carried out. An example of this type of activity is an evaluation test.

$\sum QAF$: Represents the sum of the score or utility for each subtheme. This is important because this helps us to define the activities to be carried out according to what qualification or utility is expected of each subtheme.

$\wedge QAF$: This indicates that all the subthemes and all the themes of a subject must be done, to consider that it is fulfilled.

Planning Model

```
(:durative-action enroll-subject Materia1
:parameters (?s - student)
:duration (= ?duration 0)
:condition (and
(at start (available-subject Materia1 ?s))
(at start (not-approved Materia1 ?s))
(at start (<(credits-subject Materia1)(available-credits ?s)))
)
:effect (and
(at end (enrollment ?s Materia1))
(at end (decrease (available-credits ?s)(credits-subject Materia1)))
(at end (not (available-subject Materia1 ?s)))
))
```

Figure 4 Action to enroll a subject

Figure 4 shows the action of enroll a subject for a student. The characteristics of this action are: it has as parameters the student; it has no duration; preconditions: the subject must be available, the student must not have previously approved the subject, the credits of the subject must be less than what a student can take in a period (This is for control of the number of subjects to take, for example, a student wants to take 10 subjects in a period and the allowed is only 5 or 6, according to the credits that each subject has).

As a result of carrying out this action (effect of the action): the student is enrolled in the subject, so that he can perform any activity of it; the available credits decrease; the subject is no longer available to re-enroll, since it is the one that is studying.

Figure 5 shows the action that represents those activities that have no relation of precedence with any other activity, an example of this type of activities is activity A1 of figure 3 above. The characteristics of this action are: it has as parameters the student, the learning activity, the subtheme, the theme and subject; the action duration is according to each activity. The preconditions are: that the student is not busy; the student has enrolled the subject; the student has not done that same activity before; the activity belongs to the subtheme, this is part of the theme and the enrolled subject; the type of resource of the activity is available; the activity has no relation of precedence, and finally, that the score or utility of the learning activity is not greater than what is defined by the user as utility or maximum score per subtheme (prevents more activities from being performed in an unnecessary way).

The effect of performing the action: the student appears as busy and the necessary resource for the activity is not available during the time of the activity; increases the score or utility in the subtheme, (representing $\sum QAF$). At the end of the action, the student is available for a new activity, the utility or score of the subtheme decreases, and the activity is marked as done.

```
(:durative-action CHOOSE-LA-nothasreqs
:parameters (?s - student ?oa - LA ?subt - subtheme ?t - Theme ?subj - subject ?eq
- resource)
:duration (= ?duration (DurationLA ?oa))
:condition (and
(at start (free ?s))
(at start (enrollment ?s ?subj))
(at start (not-done-LA ?oa ?subj ?s))
(at start (isPartOfSubtheme ?oa ?subt))
(at start (isPartOfTheme ?subt ?t))
(at start (isPartOfSubject ?t ?subj))
(at start (KindResourceLO ?oa ?eq))
(at start (> (quantity-resource ?eq) 0))
(at start (not-has-reqs ?oa))
(at start (> (maxgrade-subtheme ?subt)(valueLA ?oa)))
)
:effect (and
(at start (not(free ?s)))
(at start (decrease (quantity-resource ?eq) 1))
(at end (increase (quantity-resource ?eq) 1))
```

```
(at end (not (not-done-LA ?oa ?subj ?s)))
(at end (increase (score ?subt ?s) (valueLA ?oa)))
(at end (free ?s))
(at end (decrease (maxgrade-subtheme ?subt)(valueLA ?oa)))
(at end (done ?oa))
))
```

Figure 5 Action to select activities that have no precedence relationship

For actions where activity precedence is taken, the following conditions are added in the precondition part of the action (see figure 6).

```
(at start (has-reqs ?oa ?req))
(at start (done ?req))
```

Figure 6 Sentences in the pre-condition of action of activities with precedence

Likewise, if you want to represent the precedence of two learning activities, it is as follows (see figure 7)

```
(at start (not(= ?req1 ?req2)))
(at start (done ?req1))
(at start (done ?req2))
(at start (has-multiple-reqs ?oa ?req1))
(at start (has-multiple-reqs ?oa ?req2))
```

Figure 7 Sentences in the pre-condition of the action of activities with precedence to two activities

To represent $\wedge QAF$, in the planning model it is divided by actions for themes and subject. To ensure that all subthemes of a theme are carried out, it is defined as follows (see figure 8).

```
(:durative-action PASS-Theme-Tema1 Materia1
:parameters (?s - student)
:duration (= ?duration 0)
:condition (and
(at start (enrollment ?s Materia1))
(at start (>= (score Subtema1 ?s)(mingrade Materia1)))
(at start (>= (score Subtema2 ?s)(mingrade Materia1)))
)
:effect (and
(at end (done-Theme Tema1 Materia1 ?s))
))
```

Figure 8 Action to complete a theme

This action has the following characteristics: it has as parameter the student; it has no duration; the preconditions are: that the student is enrolled in the subject, and that what has accumulated score for each subtheme is defined by the user (for each subtheme).

The effect of the action: the subject is marked as completed (if there are more themes in a subject, an action is made for each one). In the case of mandatory activities such as activity A4 in Figure 3, a predicate is indicated in the action to approve the theme (see figure 9).

```
(at end (done ?oa))s
```

Figure 9 Sentence for mandatory activities

Like the previous action, to indicate that all the themes have been done by subject, it is indicated in an independent action (see figure 10). This action is similar to the previous one, only that in this action the preconditions are: that the themes that comprise the subject have been completed. The effect of performing the action: is that the subject is completed. As in the theme, there is an action for each modeled subject.

```
(:durative-action PASS-Materia1
:parameters (?s - student)
:duration (= ?duration 0)
:condition (and
(at start (enrollment ?s Materia1))
(at start (done-Theme Tema1 Materia1 ?s))
)
:effect
(at end (done-subject-LA Materia1 ?s))
)
```

Figure 10 Action to approve subject

As it was already mentioned, the problem file of the planning model is an instance of the GLP problem, which indicates the student's situation, the learning activities that each subtheme has, the duration, score or utility of each activity, as well as the type of resource associated to each one of them, and the amount of them. It also shows the hierarchical relationship of which subtheme belongs to which theme and subject. Each problem file will be made according to the subject matter and the current situation of each student.

In addition to the previous information in the problem file, the objective and the metrics to be optimized are defined, this can be seen in figure 11, where it is indicated that the objective is for the student to approve a certain subject (or several), and the metric to optimize is to minimize the total time.

```
(:goal (and
(pass-degree Materia1 student1)
))
(:metric minimize (total-time))
)
```

Figure 11 Objective and metrics to be optimized

Mathematical Model

We developed a mixed integer linear programming (MILP) model. In it we relax the ordering restrictions of the activities. It does not consider the hierarchy of the network, since the intention is that it makes the selection of those activities of some subtheme that minimize the total time. This considers the activities that are mandatory, and if there is a relationship of precedence between activities, what it does is to ensure that both activities are included in the plan if one of them is selected by the mathematical model.

Assumptions

– The activities are done only once.
– In accordance with the metric to be optimized there will be activities that are not selected.
– All activities have a duration and utility (score).
– It is not considered the sequencing (order) of activities.

Parameters:

u_{ij} : Utility value of the learning activity *i* del subtheme *j*.
d_{ij} : Duration of the learning activity *i* del subtheme *j*.
$Kmin$: Minimum passing grade that the educational plans will have to meet in each subtheme.
$Kmax$: Maximum grade that a student can obtain per subtheme.
Sets:
M : Mandatory learning activities set, such that $m_{ij} \in M$ if the learning activity *i* of subtheme *j* is mandatory.
W : Binary matrix of size nxn learning activities, where $w_{ii'} = 1$ if learning activity *i* enable the learning activity *i'*, and $w_{ii'} = 0$ in other case.

Decision variable and auxiliary variable

$x_{ij} = 1$**,** if the learning activity *i* of subtheme *j* is completed. 0 in other case.

y_j: Auxiliary variable that represents the cumulative score or utility in the subtheme *j*.

Nature of the variables:

$i \in \mathbb{N}, i = 1, \dots, n$ learning activities
$j \in \mathbb{N}, j = 1, \dots, a$ subthemes

Mathematical model

Objective Function

$$\min z = \sum_{i=1}^{n} \sum_{j=1}^{a} d_{ij} x_{ij} \quad (1)$$

Restrictions:

$$\mathrm{j} = 1,2,\dots,a \sum_{i=1}^{n} u_{ij} x_{ij} \geq Kmin \quad (2)$$

$$\mathrm{j} = 1,2,\dots,a \sum_{i=1}^{n} u_{ij} x_{ij} \leq Kmax \quad (3)$$

$$\mathrm{j} = 1,2,\dots,a y_j = \sum_{i=1}^{n} u_{ij} x_{ij} \quad (4)$$

$$j, j' = 1,2,\dots,a \mathrm{i}, \mathrm{i}' = 1,2,\dots,n; \quad (5)$$
$$x_{i'j'} \leq w_{ii'} x_{ij}$$

$$\forall m_{ij} \in M$$
$$\mathrm{x_{ij}} = 1 \quad (6)$$

$$j = 1,2,\dots,a i = 1,2,\dots,n; \mathrm{x_{ij}} \in \{0,1\} \quad (7)$$

$$\mathrm{j} = 1,2,\dots,a y_j \geq 0 \quad (8)$$

The objective function (1) is to minimize the total time of the activities to be performed. The set of restrictions (2) ensures that the sum of the utility value of the selected learning activities is greater than or equal to a minimum passing score per subtheme. The restrictions (3) are similar to the previous ones, but for the upper limit of the rating for each subtopic. This set of restrictions may seem trivial for the objective function z, since in it we consider time, but it is important to bear in mind that the set of activities selected for the plan consider that they ensure a score or utility per subtheme. The set of restrictions (4) provides information on the cumulative score obtained in each subtheme.

The restrictions (5) guarantee that each relation of precedence (or enabling) between the learning activities are considered in the solution, that is, if there is a relation of precedence between two activities, although it is not considered which one occurs first and which one after, it is considered that if one is selected to be in the plan, the other is also. The restrictions (6) ensure that each mandatory learning activity is included in the plan. Finally, the restrictions (7, 8) establish the nature of the variables.

Results

We divided experimentation into two sections. In the first section, the comparison of both solutions is carried out: those generated by the planning algorithms and the solutions obtained by the mathematical model. In the second section the results of mixing the solutions of the mathematical model to the planning models are observed.

Comparison of both solutions

A generator was developed in Ansi C which generated 450 instances of the planning model and 450 of the mathematical model. The design of the instances considers three classes of different models, represented in table 1.

	Subjects	Themes	Subthemes	Learning Activities
Small	1	1	2	5
Medium	1	3	4	5
Large	1	5	6	5

Table 1 Classes of the instances

Model classes vary in the number of learning tasks they represent. For this we established a single subject and we varied the number of themes, subthemes and learning activities. We consider that a single student is modeled, the resources are unlimited, and the objective function is to minimize the total time, as defined in the mathematical model (1).

The characteristics of the instances can be seen in Table 2. Where we can see: 1) the percentage of precedence relationships presented in the model, being 0%, (has no relation of precedence), 20% and 80% of the total of activities.

Characteristics of the instances			
% Precedence relationships	% Type of precedence relationships	% Mandatory activities	Range of values in the utility
0%	0%	[0%, 10%, 20%]	[UF, RD]
20%	1:1 (20%) 2:1 (80%)	[0%, 10%, 20%]	[UF, RD]
	1:1 (80%) 2:1 (20%)	[0%, 10%, 20%]	[UF, RD]
80%	1:1 (20%) 2:1 (80%)	[0%, 10%, 20%]	[UF, RD]
	1:1 (80%) 2:1 (20%)	[0%, 10%, 20%]	[UF, RD]

Table 2 Characteristics of the instances

2) We consider that if there are relations of precedence they could be: to a single activity (1:1) or to two activities (2:1). Varying between 20% and 80% for each type

3) We distribute the mandatory activities in 0%, 10% y 20%.

4) We have two types of range of values assigned to the learning activities as utility: Uniforms (UF) and Random (RD). In UF the assigned value is + - 5 points of the average. The average is calculated as follows: the maximum grade (100) that could have an activity, among the amount of learning activities of a subtheme, for example, if there are 5 activities is 100/5 = 20, then each activity will be between 15 and 25 points each. It must be ensured that the sum of all is 100. For the RD values, random numbers are generated in a range of [10.70], having a wide utility between each activity. It must be ensured that at least half of the activities add up to 70 so that unfeasible instances are not generated.

Five different instances of the model were generated per test case for both models, it was established that the utility per subtheme is greater than or equal to 70.

The General Algebraic Modeling System, which is a high-level modeling system for mathematical programming and optimization (GAMS, 2018), is used to optimally solve mathematical programming models.

The resolution of the mathematical programming models provides optimal solutions in all generated instances. This in terms of the selection of activities that minimize the total time, defined in the objective function.

To identify the difference between the optimal solutions generated by the mathematical model and the planners' solutions, we calculate their GAP (difference with respect to the optimum). Figure 11 shows the GAP, organized by model classes and planners, and figure 12 shows all instances of the model (450) by planner.

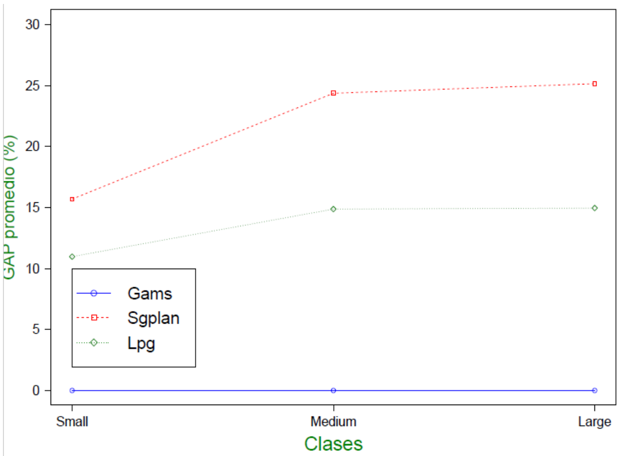

Figure 11 GAP of SGPLAN and LPG per class

In Figure 11 it is easy to observe that on average, SGPLAN has a larger GAP compared to LPG. Having a GAP between 15% and 25%, and LPG between 10% and 15% on average per class. It can also be observed that both algorithms increase their GAP by going from the small class to the large one.

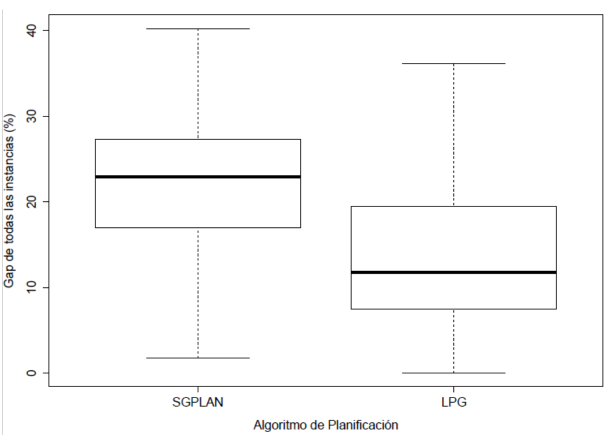

Figure 12 GAP of all instances

We show the average GAP for all instances (450) in Figure 12, where we can see that on average SGPLAN has a GAP of 21.66% and 13.59% for LPG. Regarding the percentage of optimal solutions found by the planners, we have that SGPLAN could find the optimal solution in 4.89% and LPG in 8.22%, being, in both cases, instances of the small class.

On the other hand, the percentage of instances resolved by both the mathematical model and the planning algorithms is high. GAMS resolved 100% of the instances, SGPLAN 97.78% and LPG 99.11%; being all unresolved instances of the medium and large classes.

With respect to the running time, we can see in Figure 13 that the time taken to solve the models is negligible, considering that all the solutions are in microseconds. However, we can see that GAMS takes more time on average to solve the instances, LPG is the second longest, considering that in large instances the time shoots from less than 20 to almost 100 ms. SGPLAN was the one that took less time to solve.

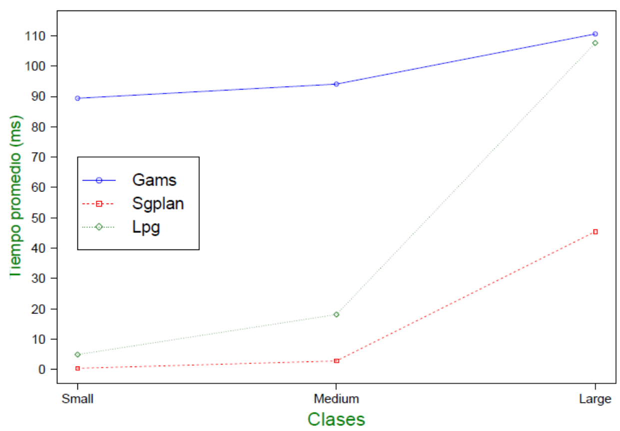

Figure 13 Running time in microseconds

It is interesting to see in Figure 14 the average cumulative utility per subtheme obtained by the planning algorithms and the mathematical model. The data, which is in ascending order by class, shows that although the planning algorithms come with a large GAP, their learning paths guarantee better grades for a student. It is observed that SGPLAN gives utilities around 85, LPG around 80 and GAMS around 75.

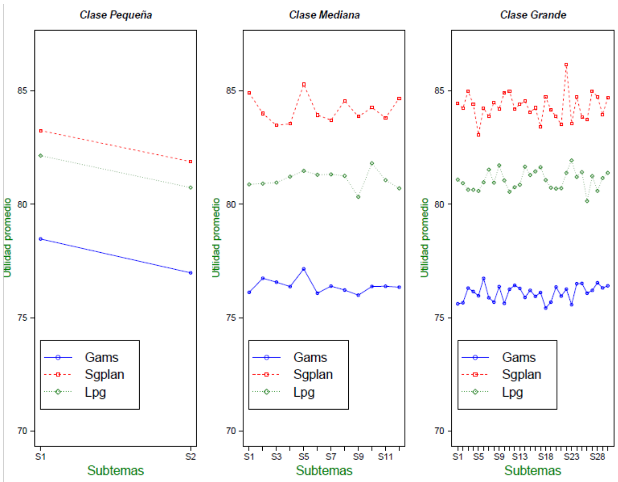

Figure 14 Average accumulated utility by subtheme

In conclusion we can say that LPG presents a better performance in terms of the quality of the solution with respect to SGPLAN, since it does not only have a lower GAP but also resolved almost 100% of the instances with a greater number of optimal solutions. However, in terms of computational time and the accumulated utility per subtheme SGPLAN is better.

Considering mathematical model solutions as entry into the planning model

The mathematical model provides us with exact solutions regarding the selection of learning activities that minimize the total time (objective function), without considering the sequence (ordering) of the learning activities. The planning algorithms seek to do both, but it throws very large GAPs.

For this reason we consider the solutions of the mathematical model and include them in the planning models so that the planning algorithms perform the ordering and obtain better solutions with respect to the GAP.

For experimentation we consider the same instances of the previous section modifying the planning models with the solution of the mathematical model. We ask to solve with the planning algorithms SGPLAN and LPG already indicated above.

The modification in the planning models is to leave in these models only the learning activities selected by the mathematical model.

There are two ways in which we can modify the goal in the planning model: the first is to put as objective: "approve the subject", leaving the calculation of the metrics equal. The other way is to establish as a goal: to "approve each of the selected learning activities" by the mathematical model, and to remove the calculation of the metrics, that is, the one that calculates the number of activities that can be carried out per subtheme.

Objective: Pass the subject

With respect to the percentage of resolved instances we have that, SGPLAN and LPG found a solution of 98.44% of the instances. This is not very different from the percentage of previous experimentation (without exact solutions). However, the solution time is shorter in both planning algorithms. Figure 15 shows the solution times of both planners in ms. The results are shown before (legend SGPLAN, LPG) and after mixing both solutions (legends SGPLAN-M, LPG-M). You can see that the solution times improve with respect to previous experimentation.

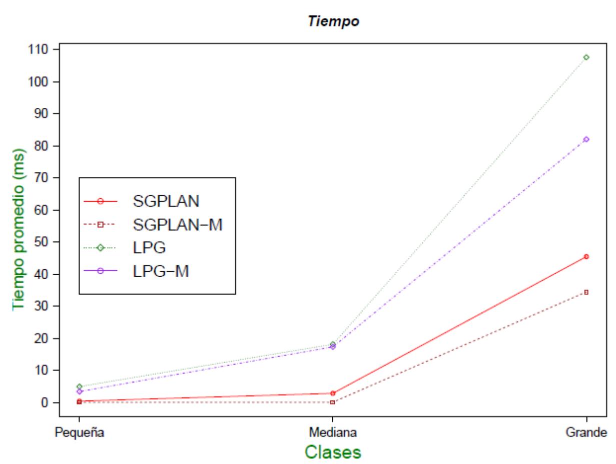

Figure 15 Average time of solution of both planning algorithms with objective of pass the subject

Objective: To do each activity

With respect to the percentage of resolved instances we have that, SGPLAN and LPG found 100% solution of the instances. Presenting a higher percentage of resolved instances both in the experimentation without exact solutions, and in the experimentation with the objective of approving the subject.

In the same way, it is observed that the solution time decreases in both planning algorithms. Figure 16 shows the solution times of both planners in ms. The results are shown like before (legend SGPLAN, LPG) and after mixing both solutions (legends SGPLAN-M, LPG-M). You can see that the solution times improve with respect to the previous experimentation, even decrease with respect to the experimentation with the objective of pass the subject. SGPLAN had a solution time reduction of 38.70% in the medium class and 49.54% in the large class. While LPG had a reduction of 33.78% in the medium class and 39.66% in the large class. This compared to the results without exact solutions.

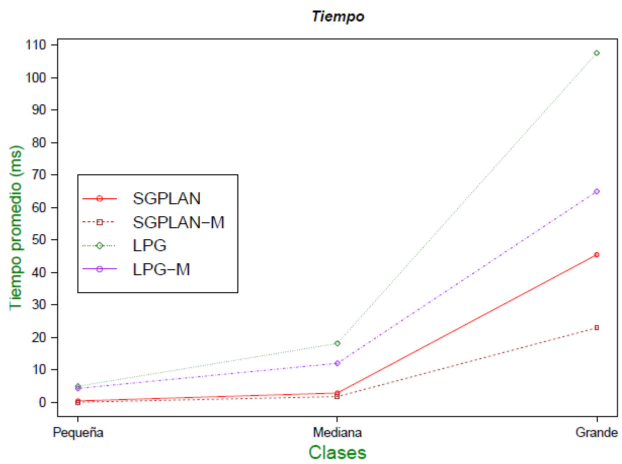

Figure 16 Average time of solution of both planning algorithms with the objective of to do each activity

In conclusion we can say that there is a benefit when the solutions of the mathematical model are included in the planning models. Since as we could observe in the results of the experimentation, the planning algorithms have presented difficulty in the selection of activities according to the established metrics.

Conclusions

In this article, two different models were presented to generate learning paths for students: Mathematical Modeling and Artificial Intelligence Planning. Experimentation was conducted to observe the performance of two planning algorithms: SGPLAN and LPG. We used a hybrid method in which we linked the mathematical programming and the AI planning to improve the quality of the solutions obtained of the planners. Noting that when both methodologies are linked, better solutions are obtained.

As part of future work we are considering to work in the development of a planning algorithm that adequately calculates the metrics of the actions and generates optimal solutions in the obtained plans. In addition to working on a user interface that allows interaction with students and generate a graphically the plans obtained.

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Acquisition of myoelectric signals from the arm of person

Adquisición de señales mioeléctricas del brazo de la persona

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Abstract

Digital filtering of mioelectrical signals from a person's forearm and electronic comparison with a physical filter. Nowadays electromyogram (EMG) signals have a big huge motion of robotic applications Such, prosthesis, study activity of muscles, etc. The study of These signals is Important So They Can Be Extracted and be applied on Several use. But on This process there are some limitations. Some of them, the low amplitude (order of millivolts) and common noise on EMG signals. It make us to do an effort to Improve and / or Eliminate some trivial signals possible. So the present work it is focus on the filtering of EMG signals and then a subsequent activities in Those results Could be used in some applications of interest like Those marked above.

Filters, EMG signals

Resumen

Filtrado adquicision de señales mioelectricas de un antebrazo para adquirir la interpretacion de los movimientos de la mano. Hoy en día, las señales de electromiograma (EMG) tienen una gran cantidad de aplicaciones tales como movimiento robótico, prótesis, estudio de la actividad muscular, etc. El estudio de estas señales es importante para que puedan extraerse y aplicarse en varios usos. Pero en este proceso hay algunas limitaciones. Algunos de ellos, la baja amplitud (orden de milivoltios) y el ruido común en las señales EMG. Esto nos forza a hacer un esfuerzo para mejorar y/o eliminar algunas posibles señales triviales. Por lo tanto en el siguiente trabajo se desarrolla un circuito de adquisicion utilizando componestes comerciales.

Filtros, Señales EMG

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Introduction

The electromyogram (EMG) is a common medical procedure that uses electrodes to detect and measure electrical signals from muscle activity, which may be useful in intelligent recognition of different movements of the limb of a person. The EMG signal has been used since 1948 with the performance of the prosthetic hand. Commercial production with myoelectric prosthetic hand signals began in 1957 at the Central Research Institute of Prosthetics Moscow to drive a stepper motor. Later in this scheme myoelectric Control strategy was extensively analyzed and a simple control scheme was developed on and off [1] [3] [4] [2].

From this it has developed a wide variety of control schemes to translate the EMG signal. The variety of control schemes are typically classified according to the nature of the control, as sequence control and simultaneous control. In schemes sequential control, the EMG signals are translated using the following schemes: control on-off, proportional control, direct control, control finite state machine, based control pattern recognition, posture control schemes and schemes control regression. [1]

In the sequential control surface electrodes have been used to connect the human control signals with the prosthesis, with this it is possible to identify three to four possible locations from the residual limb to acquire signals. Surface electrodes in modern myoelectric prostheses are often embedded in the prosthesis and make contact with the skin. These electrodes detect the EMG signals from the surface of the skin and amplify the muscular action, the voluntary contractions of the muscle in the residual limb and are used to control the movement and functions of the prosthesis, this technique is preferable due to its easy access and to the non-invasive procedure, however, the prosthetic hand's dexterity is lower due to the limitation in the identification of the locations to acquire signals.

In contrast, the collection of intramuscular EMG signals is an invasive technique and requires a surgical skill to use the implantable myoelectric sensor. However, intramuscular EMG signals provide access for the collection of EMG signals from multiple locations to offer multiple degrees of control to the prosthetic limb [5] [6].

Currently there are investigations that aim to replace external electrodes with fully implantable myoelectric sensors that include a wireless interface for the prosthesis. It is intended that the myoelectric sensor will read the EMG signals of the intramuscular recording electrode amplifying and transmitting wirelessly to a receiver at the prosthetic limb, causing the implant to remain in use by rechargeable battery and an inductive energy transfer link of the prosthesis. [5]

Since we have seen some applications thanks to the treatment of myolectric signals, it is necessary to know that many of these signals contain trivial information.

In this work we will present the stage of acquisition of a myeloelectric signal by means of operational amplifiers and filtering with said amplifiers.

The myoelectric signals of the movements of the hands will be obtained, in the following figure the signal of the figure 1 is shown.

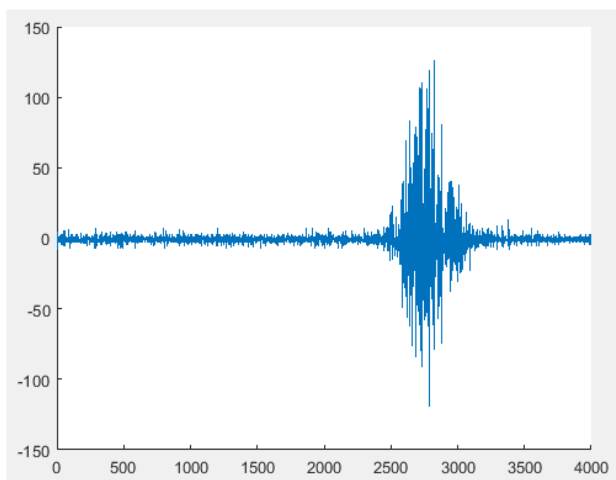


Figure 1 Acquired signal

The behavior of this signal is defined by approximately 4000 discrete values. An amplification stage was applied by means of the low pass filter instrumentation amplifier and one passed high, to attenuate some frequencies on condition of the cutoff frequency, at 50 and 500 Hz respectively for low and high frequencies.

The low pass filter allows signals located below a cutoff frequency and attenuates signals located above the cutoff frequency to soften the high frequency noise signal.

Results

In this section the acquisition circuit is developed which is applied a filter in the figure the finished circuit is shown.

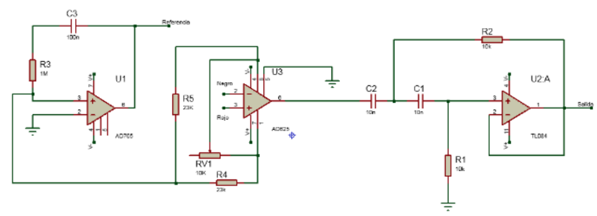


Figure 2 circuit

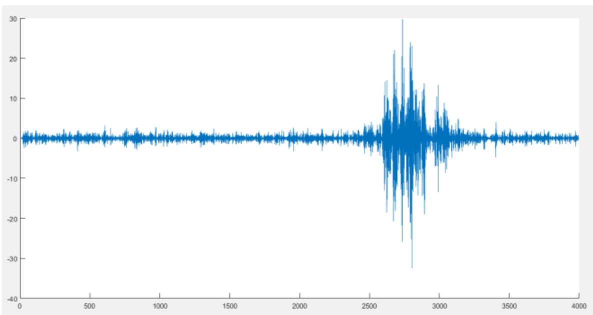
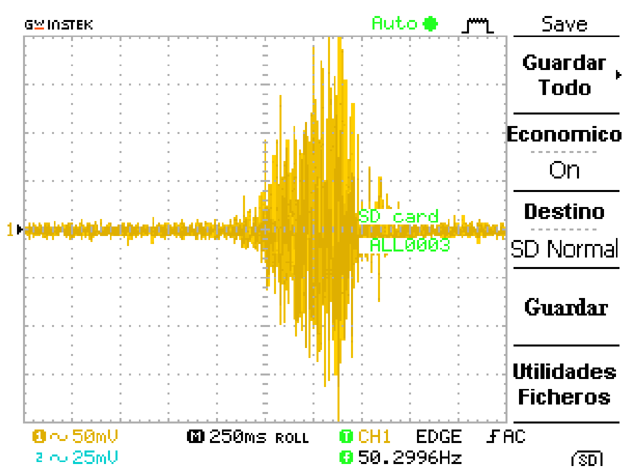


Figure 3 Resulting signal

It is worth mentioning that when applying this filter, finer results are obtained and the elimination of noise is done with greater fidelity.



Acknowledgement

I thank the Higher Technological Institute of Salvatierra ITESS for having deposited the confidence for this project to be developed.

I thank the University of Guanajuato (UG) and the department of multidisciplinary studies for their support in the project.

Conclusions

A myoelectric signal was acquired from the forearm which can be processed or applied digitally in a second stage of the project. The purpose of the project is better the acquisition and simplification of the circuit to facilitate reproduction.

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Institutional Affiliation of Author including Dependency (No.10 Times New Roman and Italic)

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Abstract (In English, 150-200 words)

Objectives
Methodology
Contribution

Keywords (In English)

Indicate 3 keywords in Times New Roman and Bold No. 10

Abstract (In Spanish, 150-200 words)

Objectives
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Contribution

Keywords (In Spanish)

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Introduction

Text in Times New Roman No.12, single space.

General explanation of the subject and explain why it is important.

What is your added value with respect to other techniques?

Clearly focus each of its features

Clearly explain the problem to be solved and the central hypothesis.

Explanation of sections Article.

Development of headings and subheadings of the article with subsequent numbers

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Products in development No.12 Times New Roman, single spaced.

Including graphs, figures and tables-Editable

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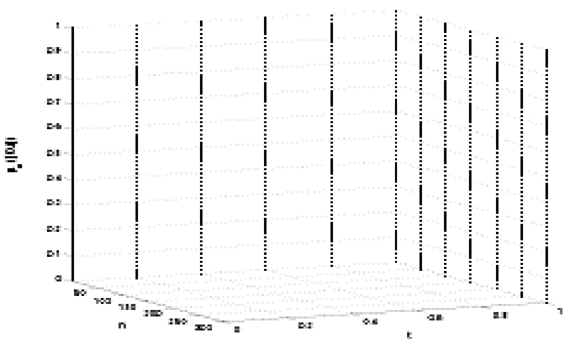

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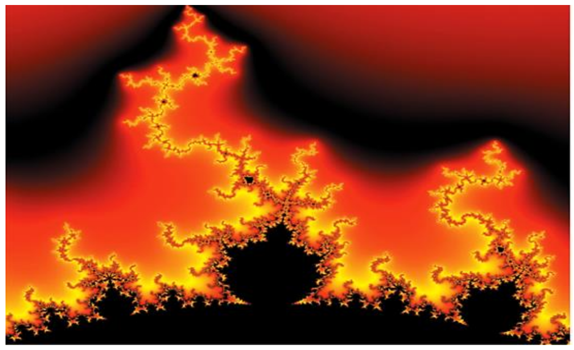

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