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Presentation of the Content

In the first article we present, *Synthesis of barium ferrite, using barite mineral ore and a metallurgical waste*, by ROSALES-SOSA, Ma. Gloria, GARCIA-YREGOI, Manuel, ROSALES-SOSA, Blanca Idalia and SERVIN-CASTAÑEDA, Rumualdo, with ascription in the, Universidad Autónoma de Coahuila, as the next article we present, *Development and nonlinear mathematical modeling of a hybrid land autonomous vehicle that applies agrochemicals to ornamental plants*, by HERNÁNDEZ, Carlos, FARÍAS, Nicandro, GARCÍA, Noel and BENAVIDES, J. Reyes, with ascription in the, Instituto Tecnológico de Colima, as the next article we present, *Design of a convolutional neural network for classification of biomedical signals*, by JALOMO, Jaime, PRECIADO, Edith and GUDIÑO Jorge, with ascription in the Instituto Tecnológico de Cd. Guzmán, as the last article we present, *Information system for the management of intelligent traffic lights*, by ORTIZ-FIGUEROA, Alejandro, CHÁVEZ-VALDEZ, Ramona Evelia, VERDUZCO-RAMIREZ, Jesús Alberto and VILLAVICENCIO-JACOBO, Ismael with ascription in the Instituto Tecnológico de Colima.

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Synthesis of barium ferrite, using barite mineral ore and a metallurgical waste**Síntesis de la ferrita de bario, empleando mineral de barita y un residuo metalúrgico**

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Abstract

Samples of barite mineral ore, were ground to a mesh of 250, and then were subjected to a leaching stage with hydrochloric acid at different times, then; the leached barite mineral ore was subjected to a carbonation stage controlling different parameters such as pH, temperature, time and speed of agitation. Finally, it was subjected to a sintering stage with the Fe₂O₃ precursor obtained from the waste powder of the steelmaking company's rolling process, in a temperature range of 1000 and 1200 ° C, for 12 and 24 times. The materials obtained are characterized by infrared spectroscopy (IR Spectroscopy), X-ray Diffraction (XRD) and Scanning Electron Microscopy (SEM).

Barite mineral, Ferrite, Carbonation**Resumen**

Muestras de mineral de barita, fueron molidas hasta una malla de 250, luego fueron sometidas a una etapa de lixiviación con ácido clorhídrico a diferentes tiempos, posteriormente, el mineral de barita lixiviada se sometió a una etapa de carbonatación controlando diferentes parámetros tales como pH, temperatura, tiempo y velocidad de agitación. Finalmente se sometió a una etapa de sinterización con el precursor del Fe₂O₃ obtenido del polvo de residuo del proceso de laminación de empresa siderúrgica en un rango de temperatura de 1000 y 1200 °C, por tiempos de 12 y 24 horas. Los materiales obtenidos son caracterizados por espectroscopia infrarroja (Espectroscopía IR), Difracción de Rayos X (DRX) y Microscopía Electrónica de Barrido (MEB).

Mineral de barita, Ferrita, Carbonatación

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† Researcher contributing as first author.

Introduction

A fundamental part of modern technology is made up of devices that use ferromagnetic alloys as components. Since the last decades of the last century, a remarkable development of these alloys has been achieved with new compositions and production methods that open unprecedented technological, economic and ecological perspectives due to high yields, economies of scale, possibility of weight and size reduction, and low environmental impact of the equipment that contains them. However, these materials are produced only in some developed countries. (Marcelo Pagnola, 2015).

Hexagonal (hard) ferrites are used to make permanent magnets, they have the general formula ($\text{AFe}_{12}\text{O}_{19}$), they are low-density materials and have a high coercive field; The good magnetic properties of these materials are attributed to their high crystalline magnet anisotropy. A very important hexagonal ferrite is $\text{BaFe}_{12}\text{O}_{19}$, known under the trade name Ferroxdure.

Barium hexaferrites type M, whose chemical formula is $\text{BaFe}_{12}\text{O}_{19}$, are one of the most widely used magnetic compounds in the world due to their ease of obtaining and their physical properties, such as: high resistivity, high coercivity, relative low magnetic saturation and high retentivity. Its crystalline structure is similar to that of the magnetoplumbite mineral (Mariño-Castellanos *et al.*, 2016).

Those responsible for magnetic behavior are ferric ions, where not all ions have magnetization in the same direction. Of the 12 ions available per unit cell, 8 have a magnetic moment in one direction and 4 have a magnetic moment in exactly the opposite direction, resulting in only 8 ions contributing to the resulting magnetization. These ceramics have applications in generators, alternators and motors; its electronic uses are found in magnets for loudspeakers, telephone receivers, and in devices for closing doors and toys (Eduardo Camargo, 2011).

To obtain inorganic solid materials and in general when it comes to oxides, one of the most traditionally used procedures has been the so-called "ceramic method" (Gaona Jurado *et al.*, 2007), which consists essentially of mixing compounds in the most homogeneous way possible precursors in stoichiometric amounts and subjecting said mixture to a heat treatment at high temperatures, so that a chemical reaction in the solid state takes place that originates the product sought.

Barium ferrite is usually obtained at an industrial level using the ceramic method, that is, by reacting BaCO_3 and Fe_2O_3 at high temperatures, obtaining the $\text{BaFe}_{12}\text{O}_{19}$ ferrite.

The research for the synthesis and formation of barium ferrite has not stopped, as carried out by (Garcia Casillas *et al.*, 2011), it is reported that by the chemical co-precipitation method, it obtained a precursor formed by iron and barium hydroxides and carbonates that when calcined at temperatures above $730\text{ }^\circ\text{C}$, they were transformed into barium ferrite. He also practiced the microemulsion method, resulting in a fine precursor of iron and barium hydroxides and carbonates that, when calcined at temperatures above $760\text{ }^\circ\text{C}$, becomes barium ferrite.

(Shao L. *et al.*, 2018) I prepare compact hexagonal barium ferrite ceramics ($\text{BaFe}_{12}\text{O}_{19}$) with excellent magnetic properties from powder with the optimal grain size, studied in detail the dependence of the microstructure and the magnetic properties of ceramics with powder grain size.

The single-phase hexagonal barium ferrite powder with a grain size of 177 nm, 256 nm, 327 nm and 454 nm was obtained by calcination under different conditions. Scanning electron microscopy revealed that the 327 nm powder was beneficial in obtaining a homogeneous grain size and compact ceramic.

(Zhou E. *et al.*, 2018) used two-pass sintering (TSS) which has been used to make hexagonal barium ferrite ceramics ($\text{BaFe}_{12}\text{O}_{19}$) with high density and fine grain size. Densification, microstructure and magnetic properties were investigated.

The sample prepared by the TSS process with the first step sintering temperature of 1325 °C, the second step sintering temperature of 1300 °C and a retention time of 20 hours showed a density of $98.01 \pm 0.25\%$ of the density theoretical (5.29 g/cm^3) and exhibited a uniform microstructure with a small average grain size ($2.92 \pm 0.05 \mu\text{m}$). Using the TSS process they were able to obtain dense, fine-grained BaFe₁₂O₁₉ ceramics with high saturation magnetization.

The latest research on barium ferrites has already reached advanced fields in nanotechnology, such as that reported by (Iqbal S. *et al.*, 2019) where it investigated the use of barium ferrite nanoparticles for electromagnetic interference (EMI) which it is one of the main causes of the failure of electronic devices.

I perform a synthesis of barium ferrite nanoparticles (BaFe₁₂O₁₉) using the sol-gel technique for an efficient application of EMI protection. These nanoparticles were annealed at 400 °C, 700 °C and 850 °C to investigate the effect of temperature on the protection efficiency and morphology of the BaFe₁₂O₁₉ nanoparticles.

The studies showed that the BaFe₁₂O₁₉ nanoparticles annealed at 850 °C exhibited a crystalline pure phase hexagonal structure with a high magnetic moment.

One reason for the impact of carrying out the project is the search for better synthesis methods for barium ferrites. In this project, the barite mineral was used for the synthesis of barium ferrite, since in the state of Coahuila there are large deposits of barite ore, mainly in the lagoon and coal mining region.

Another important reason arises from seeing the problem represented by the generation of large by-products of some companies in the town, in this case from the steel company, where Fe₂O₃ is obtained as a by-product with little rejection, it is proposed to study it for the formation of materials magnetic evaluating its properties with respect to the variant quality of Fe₂O₃. Regarding the iron oxide to be used, currently a steel company in the region recovers this compound as a by-product of the cold rolling mill around 100 tons per month, which has around 76% iron oxide.

In this work, the barite mineral (BaSO₄) was used, which was ground and leached with hydrochloric acid (HCl), at three different times. Subsequently, the direct conversion method was used, from which the carbonation of barite in an aqueous medium was carried out using a solution of sodium carbonate (Na₂CO₃) in stoichiometric ratio.

After obtaining the barium carbonate (BaCO₃), a calcination was carried out to obtain the barium oxide (BaO), which combined with the ferric oxide (Fe₂O₃) results in the formation of barium ferrite (BaFe₁₂O₁₉).

The materials obtained are characterized by the analysis techniques of Infrared Spectroscopy (IR Spectroscopy), X-Ray Diffraction (XRD) and Scanning Electron Microscopy (MEB).

Methodology

To carry out the process of obtaining barium ferrite, it was necessary to transform the barium sulfate that contains the barite to barium carbonate, for which it was necessary to grind, leach and carbonate the barite mineral and subsequently it was carried out the ferretation of the material, in the calcination stage.

A. Grinding

In the barite ore grinding stage, a crusher and a ball mill, brand BICO Inc., were used in order to obtain a particle size of less than 250 meshes.

For the granulometric analysis, a ROTAP was used. For the determination of the sample weights, a Scientech SA120 digital analytical balance was used with an accuracy of ten thousandths after the decimal point.

B. Leaching

The main objective of leaching is the separation or elimination of impurities within the barite mineral, such as aluminum, titanium, sodium, strontium ions, etc. These impurities also called solutes contained in a solid phase, by contact with a liquid solvent selectively dissolves them, and may be a simple physical solution or a chemical reaction that frees the solute from the solid matrix.

The solid-liquid leaching or extraction of the mineral was carried out with a mesh smaller than 250. The sample was 50 grams, which was placed in a 500 ml Erlenmeyer flask, using 4, 6 and 8% HCl as a leaching agent, in times of 5, 10 and 15 minutes. They were subsequently filtered on Whatman No. 40 filter paper and washed with 10 ml of hot distilled water. The filter paper with the sample was placed in a watch glass and the water was allowed to evaporate in a desiccator.

Inorganic acid	Concentration (%)	Time (min.)
HCl	4, 6 and 8	5, 10 and 15

Table 1 System used for leaching

C. Carbonation

The dried sample was placed in a 500 ml Erlenmeyer flask, with sodium carbonate (stoichiometric calculation determined for each of the samples plus 40% excess respectively) and 150 ml of distilled water, this mixture was placed on a magnetic stirring brand CORNING Model PC-620 120 VAC-1113 Watts Hz at 870 RPM.

The variables that were controlled were the temperature of 90 °C, the time of one hour and the pH of the reaction was kept between the values of 10 and 11.

Samples of 3 ml of the solution were taken at the times of 0, 15, 30, 45 and 60 minutes for the determination of the reacted fraction of the precipitated sulfate ion, for which the sample was placed in a 250 ml beaker 25 ml of distilled water, 1 ml of concentrated hydrochloric acid (HCl) and 2 ml of 10% barium chloride and boiled in a Bunsen burner for 2 minutes, filtering the precipitate with Whatman No. 40 filter paper, which were previously weighed.

The obtained crystals were collected from the filtered solution. At the end of the reaction for one hour, the sample was filtered and placed in a watch glass in a desiccator, and then the efficiency of conversion of barium sulfate to barium carbonate was weighed and calculated, according to the following reaction:



D. Calcination

For the formation of barium ferrite, 0.1 mol (15.33299 gr) of barium oxide and 0.1 mol of ferric oxide (15.9687gr) were weighed from pickling flakes from the lamination process of a steel company, with a content of 87.25% of iron.

The homogenized mixture was divided into equal parts and placed in the previously weighed alumina crucibles. The crucibles were introduced into the muffle furnace at temperatures of 1000 and 1200 °C, for times of 12 and 24 hours, waiting for the following reactions to occur:



This stage was carried out in a THERMOLYNE brand electric muffle (FURNACE 48000).

The chemical analysis of the barite mineral was performed by the Infrared Spectroscopy (IR) technique, in a Perkin Elmer 2000 FT-IR equipment.

A Bruker brand D8 ADVANCE X-Ray Diffractometer was used to determine the composition of the samples. The equipment was operated in a range of 2θ from 10 - 80 degrees, with an increase (step) of 0.020 degrees, with an increase in time (step time) of 1.2 seconds at a temperature of 25 °C. For the interpretation of results Match 5.1 software was used. The microstructure and aspects related to the morphology of the powders obtained as reaction products were performed in a Philips XL30 ESEM Scanning Electron Microscope.

Results

The chemical analysis of the barite mineral with the Infrared technique gave the following results, Zr 0.004%, Al 0.15%, Ti 0.176%, Na 0.282%, Sr 0.614%, S 8.333%, Ca 9.587% and Ba 57.45%, elements that are considered to be part of an expected composition of a barite mineral, which makes the barite mineral a good quality material to be used as a raw material for the synthesis of barium ferrite, since it contains a high percentage of barium, indicating that the amount of barium sulfate is high.

Regarding the leaching of the mineral with HCl, the HCl concentrations that were 4%, 6% and 8% found that when increasing the concentration of the acid, the percentage of leaching is increased, that is, the best results were obtained in the 8% concentration as shown in Figure 1.

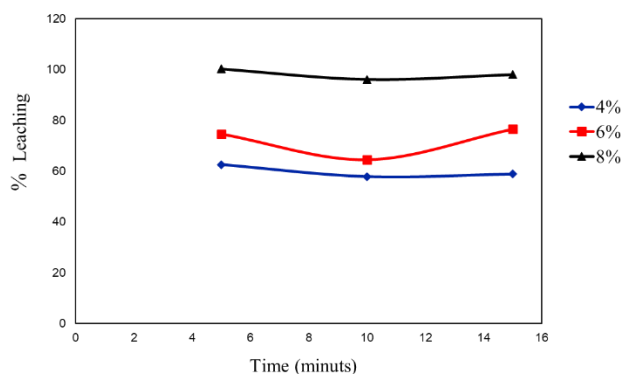


Figure 1 Leaching efficiency using hydrochloric acid as a leaching agent

Regarding the time, it was found that in all the concentrations of 4%, 6% and 8% of HCl they remain very stable in the three times of 5, 10 and 15 minutes with the exception of the concentration of 6% of HCl at the time of 10 minutes where you see a reduction in leaching efficiency.

Figure 2 shows the diffractogram of the barite mineral after having been leached with HCl, where we can see that most of the intensities correspond to the barium sulfate phase, according to the Match 5.1 software, corresponding to entry 96-900. -4486, said phase has an orthorhombic crystalline structure. Some intensities corresponding to the barium carbonate phase are also observed (entry 96-900-6846).

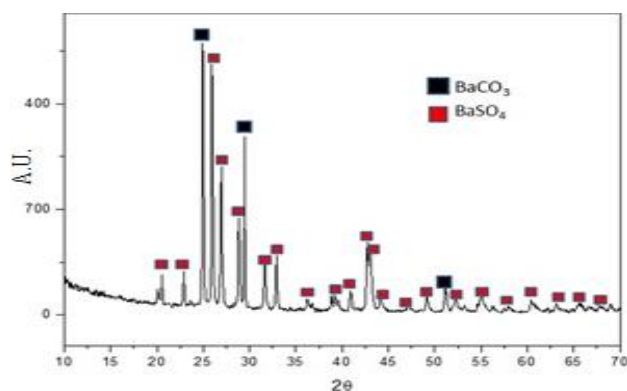


Figure 2 Barite ore diffractogram, leached with 8% HCl, for 15 minutes

There are no compounds of impurity elements, so we can say that the stage of leaching of the mineral was appropriate to eliminate some elements of impurity.

Regarding carbonation, Figure 3 shows the x-ray diffraction diffractogram, after the barite sample was carbonated with a 2M solution of Na_2CO_3 . According to the results, it can be seen that there are more intensities corresponding to the barium carbonate phase, compared to the barite sample that was only washed with HCl, which means that in the carbonation stage the elimination of large amount of sulfates, however there are some intensities corresponding to the barium sulfate phase.

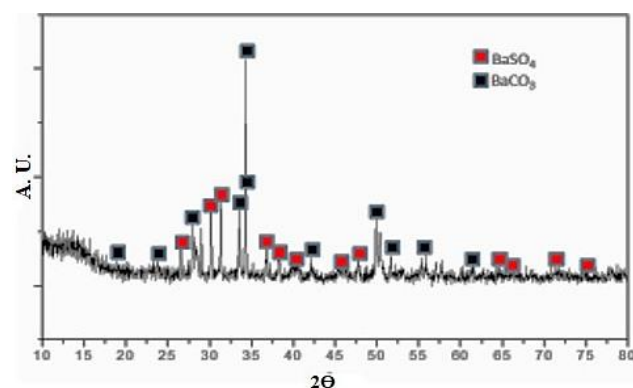


Figure 3 Diffractogram of the barite mineral sample leached with 8% HCl and carbonated with Na_2CO_3 2M

Figure 4 shows the micrographs of the carbonated barite mineral powders in 2M Na_2CO_3 solutions, which were previously leached with HCl. In it we can see bright white cubic particles, which are believed to correspond to the barium carbonate phase, but there are also other types of more opaque particles and in the form of different irregular plates, which could be barium sulfate particles. In general, isolated, scattered particles can be seen and some smaller regions show a certain degree of agglomeration, this behavior is due to the synthesis process of the same. The predominant size is $2 \mu\text{m}$. The corresponding EDS (Energy Dispersion Spectrometry) shows us the presence of the elements barium, carbon and oxygen, which are the elements of the compound barium carbonate, so we can say that the carbonation process was indeed efficient, however, if it differs with respect to the analysis performed with x-ray diffraction (XRD), which indicated the presence of the barium sulfate phase (Figure 3).

The EDS did not detect sulfur, an explanation would be because it is a lighter element, however, it is believed that, if it is present in the form of sulfate, this is demonstrated by XRD and the different shape and hue of the particles found in the observed micrograph. in Figure 4.

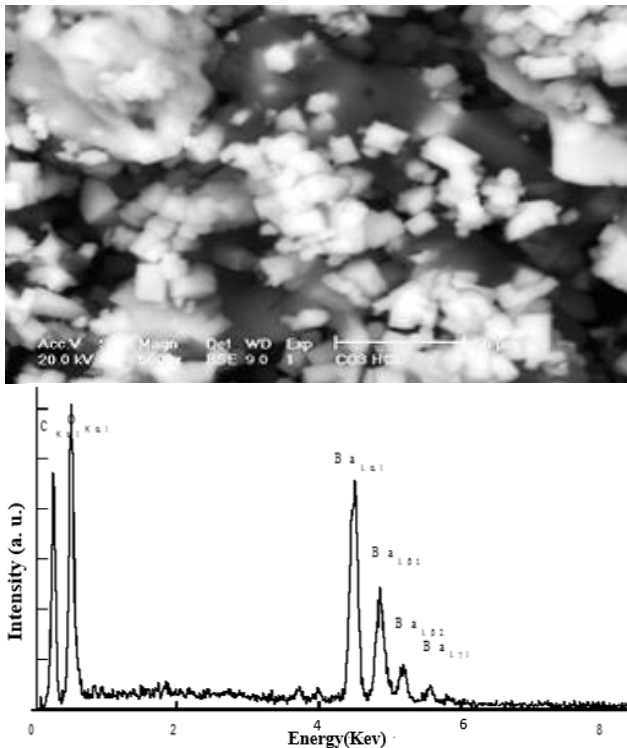


Figure 4 Micrograph and EDS of the carbonated barite powders in a 2M solution of Na_2CO_3

$\text{BaFe}_{12}\text{O}_{19}$ synthesis

Figure 5 shows the diffraction patterns of the products obtained when the samples were sintered at 1000 °C for 12 and 24 hours. According to these results, it was observed that if the desired compound was formed, barium hexaferrite, which means that all the barium carbonate present in the sample reacted with Fe_2O_3 from the steelmaking residue within 12 hours.

A very similar behavior was observed in the 24 hours reaction time. The new phase obtained was identified as $\text{BaFe}_{12}\text{O}_{19}$, according to Match 5.1 software, with entry number 96-100-9033, corresponding to a hexagonal crystalline structure, with network parameter a or equal to 5.8890 Å and c equal to 23.1820 Å.

However, as we can see, we also have the presence of barium sulfate, this phase, which was maintained after carbonation, remains after the sample has been sintered at high temperatures, which means that barium sulfate does not decompose at the temperature of 1000 and 1200 °C, even when increasing the reaction time to 24 hours.

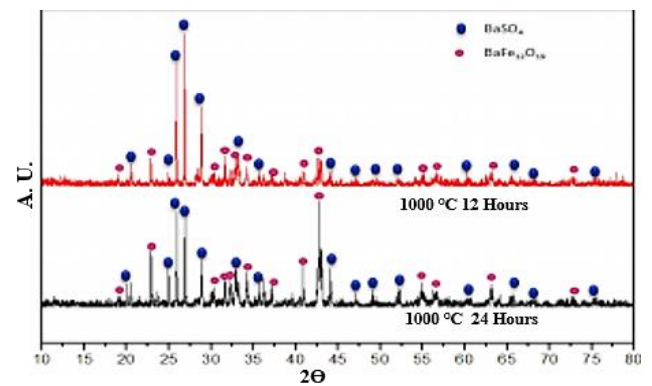


Figure 5 Diffraction patterns of the powders obtained by sintering the samples leached with 8% HCl calcined at 1000 °C for 12 and 24 hours

Figure 6 shows the diffraction patterns of the sintered samples at a temperature of 1200 °C. Barite samples leached with 8% HCl and heated with Fe_2O_3 at a temperature of 1200 °C for 12 and 24 hours are compared. The presence of the intensities that in composition correspond to the $\text{BaFe}_{12}\text{O}_{19}$ phase can be observed in both samples, but the BaSO_4 phase is also present, that is, they coexist in the two phases in the samples. Based on these results, a way would be sought for the ferrite, $\text{BaFe}_{12}\text{O}_{19}$, to have a higher crystallographic presence compared to BaSO_4 . To achieve this, to have a purer barium ferrite, the carbonation stage would have to be modified in the increase of the concentration of sodium carbonate and reaction time, in order to obtain greater purity of barium carbonate.

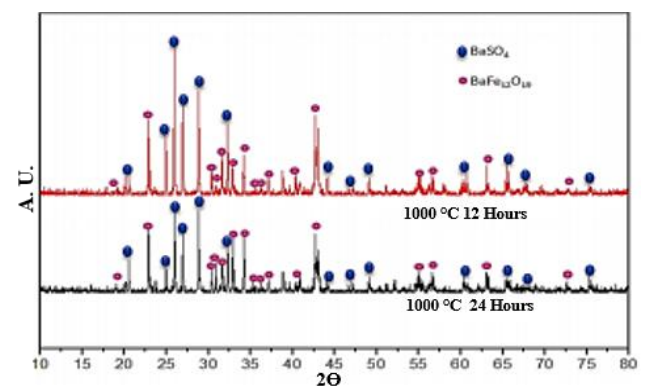


Figure 6 Diffraction patterns of barite samples leached with 8% HCl and heated with Fe_2O_3 at a temperature of 1200 °C for 12 and 24 hours

During the 1200 °C sintering step, the Barium Sulfate compound remains stable, because the decomposition reaction of barium sulfate to barium oxide would occur at a temperature of more than 1580 °C.

The microstructural details associated with the morphology of the products of the synthesis of ferritic compounds, using the barite mineral as the initial precursor of the barium ion and rolling powder as a precursor of the iron ion, from a sintering above 1000 °C, were evaluated after analysis of the structural changes determined by X-ray Diffraction.

Figure 7 shows the micrographs obtained when the mixture of barium carbonate and mill scale was sintered, at a temperature of 1200 °C for 12 hours of residence.

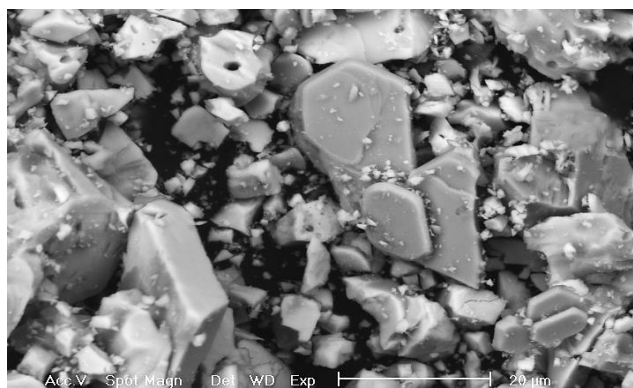


Figure 7 Micrographs of ferritic compounds obtained at a temperature of 1200 °C for 12 hours of reaction

According to the micrographs, it was determined that the growth of the particles of the new phase of $BaFe_{12}O_{19}$ occurs in the form of irregularly shaped plates. The presence of other smaller irregularly shaped particles on the plates is also observed, which could be treated of the barium sulfate phase.

Figure 8 shows the particles that in composition correspond to the compound $BaFe_{12}O_{19}$ obtained at a temperature of 1200 °C for 24 hours of reaction. This result is confirmed by observing the corresponding EDS, since it only indicates the presence of Barium, Oxygen and Iron. It can be assumed that, by increasing the reaction time, a greater diffusion of atoms occurs and the equilibrium sites of the barium hexaferrite phase are accommodated, since better defined plates are observed, these are observed in hexagonal forms, which is a growth typical of barium hexaferrite.

It can also be seen that, as the reaction time increases, a greater agglomeration of the particles occurs. Particles continue to be observed on the plates, most of which correspond to the barium sulfate phase, detected by x-ray diffraction.

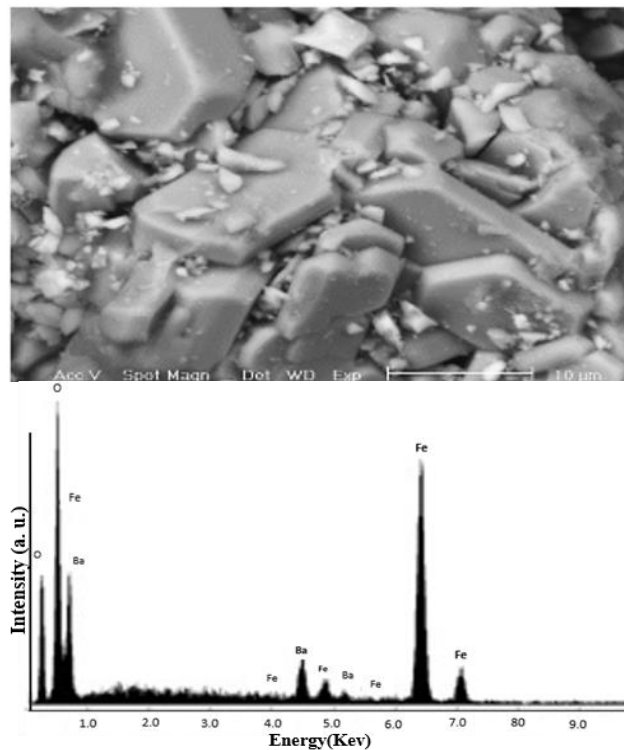


Figure 8 Micrographs and EDS of the ferritic compounds obtained at a temperature of 1200 °C for 24 hours of reaction

Conclusions

Hydrochloric acid is a good leaching agent because it removed many impurities from the barite mineral. The best result being found in a concentration of 8% HCl.

The barite mineral, leached with 8% HCl, for 15 minutes, was appropriate to remove some impurities.

Barite ore leached with 8% HCl and carbonated with 2M Na_2CO_3 . It shows that during the carbonation stage the removal of a large amount of sulfates was achieved.

Micrographs of carbonate barite ore powders in 2M Na_2CO_3 solutions, previously leached with HCl. Check that the carbonation stage occurred, but partially. The morphology of the powders was in cubic form with average particle sizes of 2 μm .

In the calcination stage, with the barium precursors of the barite mineral and with the iron residue as a source of Fe_2O_3 , the formation of the compound $\text{BaFe}_{12}\text{O}_{19}$ was favored at temperatures from 1000 °C in the time of 12 and 24 hours.

The barite leached with 8% HCl and heated with Fe_2O_3 at a temperature of 1200 °C for 12 and 24 hours found the presence of $\text{BaFe}_{12}\text{O}_{19}$ and BaSO_4 .

The formation of the $\text{BaFe}_{12}\text{O}_{19}$ compound powders occurred in the form of plates, which are best observed at 1200 °C and 24 hours of reaction, the agglomeration of several particles in the form of plates of various sizes was found.

References

Camargo Zambrano E., (2011), Estudio comparativo de algunas ferritas obtenidas por el método citrato. Trabajo de tesis para Maestro en Ciencias Químicas.

Gaona Jurado S., Sandoval D., Caneiro A., (2007), Efecto de la ruta de Síntesis en la obtención de polvos cerámicos manométricos de hexaferritas de bario. *Scientia et Technica*, No. 36.

García Casillas, Perla E. (2011). Estudio comparativo de las propiedades magnéticas de ferritas hexagonales de Bario obtenidas por los métodos de coprecipitación y microemulsión. *Boletín de la Sociedad Española de Cerámica y Vidrio*. 38.

Iqbal, S., Kotnala, G., Shah, J., Ahmad, S. (2019). Barium ferrite nanoparticles: A highly effective EMI shielding material. *Materials Research Express*.

Mariño-Castellanos, Pupo-Palma C., Vega-García A., Guerra-Dávila Y. (2016.) Correlación entre la microestructura de ferritas de bario tipo-M dopadas con Al y Co y sus propiedades estructurales y magnéticas, *Rev. Cubana Quím.* Vol. 28, no. 1, e-ISSN 2224-5421.

Pangola M., Sirquen H., (2015), Materiales Magnéticos Modernos. *Revista Petroquímica, petróleo, gas y energía* número 315, año 33, ISSN 2469-0139.

Shao, L., Shen, S., Zheng, H. et al. (2018). Effect of Powder Grain Size on Microstructure and Magnetic Properties of Hexagonal Barium Ferrite Ceramic. *Journal of Elec Materi* 47, 4085–4089 (2018).

Zhou, E., Zheng, H., Zheng, L., Zheng, P., Ying, Z., Deng, J., Zhou, J. (2018). Synthesis of dense, fine-grained hexagonal barium ferrite ceramics by two-step sintering process. *International Journal of Applied Ceramic Technology*, 15(4), 1023–1029.

Development and nonlinear mathematical modeling of a hybrid land autonomous vehicle that applies agrochemicals to ornamental plants

Desarrollo y modelado matemático no lineal de un vehículo autónomo terrestre híbrido que aplica agroquímicos a plantas ornamentales

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Abstract

The development of electronics, information and communication technologies have favored the dissemination of precision agriculture. While in other countries important scientific innovations are carried out and Hybrid Land Autonomous Vehicles (VATH) are used in various agricultural activities, in our country there is very little development in this regard and some of these production activities are still manual. This research presents the development and non-linear mathematical modeling of VATH for the automated application of agrochemicals in ornamental plants, for modeling the dynamics of longitudinal velocity, lateral velocity and angular velocity of turn or yaw that were simulated in SciLab are observed with the ISO 3888 standard. For the construction of this vehicle, we took an ATV and other low-cost electronic components that make it more affordable in the national agricultural industry will be considered as a motor base, compared to that proposed in other similar developments.

Autonomous Land Vehicle, Precision Agriculture, Formal Modeling, SciLab

Resumen

El desarrollo de la electrónica, las tecnologías de la información y la comunicación han favorecido la difusión de la agricultura de precisión. Mientras que en otros países se realizan importantes innovaciones científicas y se utilizan Vehículos Autónomos Terrestres Híbrido (VATH) en diversas actividades de agricultura, en nuestro país existe muy poco desarrollo al respecto y algunas de estas actividades de producción todavía son realizadas manualmente. En esta investigación se presenta el desarrollo y modelado matemático no lineal del VATH para la aplicación automatizada de agroquímicos en viveros de plantas ornamentales, para el modelado se observaron la dinámica de la velocidad longitudinal, velocidad lateral y velocidad angular de viraje o yaw que fueron simuladas en SciLab con norma ISO 3888. Para la construcción de este vehículo se tomó como base motriz una ATV (cuatrimoto) y demás componentes electrónicos de bajo costo que lo hace más asequible a la industria agrícola nacional, en comparación con lo propuesto en otros desarrollos similares.

Vehículo Autónomo Terrestre, Agricultura de precisión, Modelado Formal, SciLab

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Introduction

Autonomous Hybrid Land Vehicles (VATH) for the application of agrochemicals in nurseries has been increasing in recent years and one of the main problems for small entrepreneurs is the cost of it as mentioned (Navarro Cosme, 2016). The automotive industry is a leading sector in technological advancement, although the application of its advances in the mass production of consumer vehicles is very limited by the economic factor, given that there is strong global competitiveness among large multinationals. . This competitiveness, which is essentially economic, can be broken down into several aspects (economic, reliability and type of engine). On the one hand, there is the final cost of the product itself, but economic aspects must also be valued, such as those derived from its use, the reliability of the common elements and the motor itself, as well as those derived from the increase of value for the expectations offered.

Today's vehicles are equipped with many electronically controlled systems, the integration of which is increasing in complexity with the increasing number of features and technologies available to the customer. One way to solve this integration problem may be the introduction of a hierarchical control structure, where all control commands are calculated in parallel in a central algorithm, and where control must take into account interactions between vehicle subsystems, driver and vehicle (Bianchi, A. Borri, G. Burgio, & MD Di Benedetto, 2009).

This work shows a model with two degrees of freedom that represents VATH as a single front and one rear rim (Bicycle Model); the model includes the dynamics of the direction; roll and transfer angle are neglected in this model in order to study VATH response to slight changes in direction and constant longitudinal speeds.

The parameters analyzed in the plant (VATH) were carried out using the SciLab software, which is considered as free access software, so the cost of the analysis and the total of the vehicle are decreased, thus affecting the customer's economy.

State of the art

The vehicle built by (Carreño Aguillón, Vacca Melo, & Lugo Ariza, 2012) consists of not using a gearbox or clutch and replacing them with an electric power controller, coupling the electric motor to the differential input shaft. This solution is possible thanks to the fact that electric motors, unlike thermal motors, develop a high starting torque and offer, in general, a high speed range, the disadvantage of this work is that the steering is not electronic if not which is mechanical and requires human action.

On the other hand, (Pérez Rastelli, 2012) performed the control of the motors with a Proportional, Integral, Derivative (PID) control that fed to a Pulse Width Modulator or PWM for its control in English of the vehicle, in addition to a path profile calculation module powered by steering wheel position sensors to feed back the controller, presenting the area of opportunity in the Integral Proportional Controller (PI) which has inappropriate behavior and many oscillations in the transient.

While the work of (Tjonnas & Johansen, 2010), presents a yaw stability algorithm, combining with a low level of control of the longitudinal slip angle of the wheel and an adaptive law that estimates the maximum value of the parameter of the coefficient of friction of each wheel.

If we talk about energy economy we can take into account the work (Peredo Ramírez, 2020) where the cost benefit of feeding solar panels to a home is simulated and the viability of the project as in work (De la Cruz Fernández, 2020) Furthermore, (Ramirez Cid, 2020) demonstrates how it is possible to assemble a turbine at low cost and thus have one more option to supply VATH.

Methodology

The methodology used for this research is illustrated in (Figure 1)

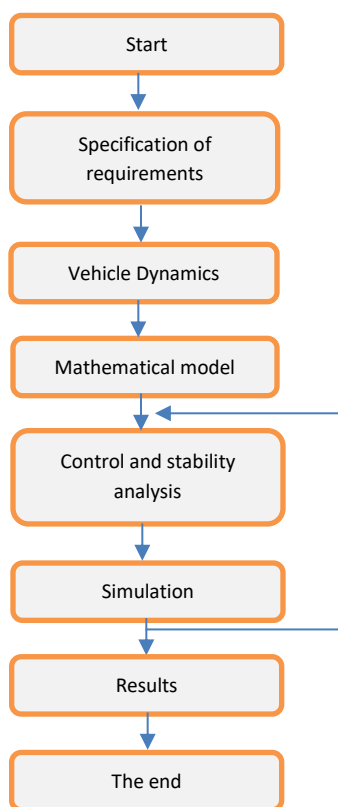


Figure 1 Simulation methodology

VATH Mathematical Model

The dynamic bicycle model (Figure 2) presented in this section is used in the simulations to estimate car values. In equation (1), the mathematical model of the vehicle used for the simulation is shown, in which three degrees of freedom are considered; longitudinal velocity, lateral velocity, and angular velocity yaw, where they can be expressed using the so-called Bicycle model (Ackermann, Guldner, Steinhausner, & Utkin, 1995)

$$\begin{aligned}
 m(\dot{v}_x - \omega_z v_y) &= a_x \\
 m(\dot{v}_y - \omega_z v_x) &= a_y \\
 j_z \dot{\omega}_z &= \mu(F_{f,y} l_f - F_{r,y} l_r)
 \end{aligned}
 \tag{1}$$

Where m , j_z are the mass and inertia of the vehicle with respect to the perpendicular axis, l_f l_r are the distances from the vehicle's center of gravity (CG) to the front and rear rim, a_x , a_y are the longitudinal and lateral acceleration, v_x , v_y are the longitudinal and lateral velocities of the CG, ω_z is the angular velocity yaw, μ is the coefficient of friction. Furthermore $F_{f,y}$, $F_{r,y}$ are the front and rear lateral forces of the tires and it is assumed that there is a high coefficient of friction between the tires and the ground.

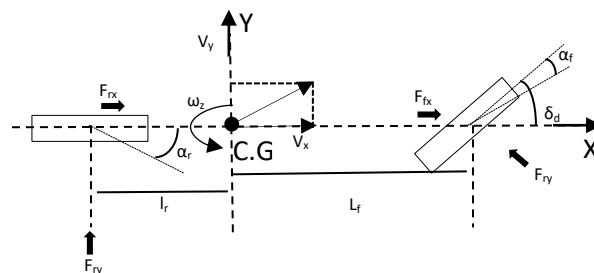


Figure 2 Bicycle Model

Source: (Ackermann, Guldner, Steinhausner, & Utkin, 1995)

The design specifications are taken from the IFAC reference example (Darenberg, 1993). They are mainly given in terms of maximum guide displacement and maximum steering angle and steering angle speed, all for safety reasons.

For the analysis of forces, the magic formula of (Pacejka, 2005) is used;

$$F_{j,i} = D_{j,i} \sin(C_{j,i} \arctan B_{j,i} \alpha_j) \tag{2}$$

With $i = x, y, j = f, r$. The constants $B_{j,i}, C_{j,i}, D_{j,i}$ in (2) they are experimentally determined (see Table 1). The slip angle of tires α_f, α_r defined as (Di Cairano, Tseng, Bernardini, & Bemporad, 2013);

$$\alpha_f = \delta_d - \frac{v_y + l_f \omega_z}{v_x} \tag{3}$$

$$\alpha_r = -\frac{v_y + l_r \omega_z}{v_x} \tag{4}$$

Where δ_d is the angle of the wheel:

$m = 200 \text{ kg}$	$D_{r,y} = 1011 \text{ N}$
$j_z = 460 \text{ kg m}^2$	$B_{f,y} = 6.9$
$l_r = 0.32 \text{ m}$	$C_{f,y} = 1.78$
$l_f = 0.68 \text{ m}$	$D_{f,y} = 934 \text{ N}$
$B_{r,y} = 10$	$\mu = 0.9$
$C_{r,y} = 1.32$	

Table 1 Relative parameters used in the simulation

Results

In this section the simulation response shown by SciLab is shown, under an ISO 3888-1 maneuver, known as a double steering wheel maneuver or as shown in (figure 3).

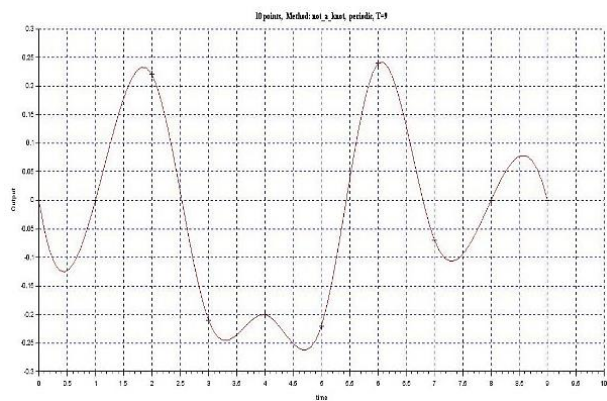


Figure 3 Movement angle in rad/s
Source: (Sandoval, Ruiz, Topete, & Gonzalez, 2016)

Next, work with programming in SciLab, with the Xcos Tool taking into account the values of (Table 1) and the following results are obtained (Figure 4, 5, 6):

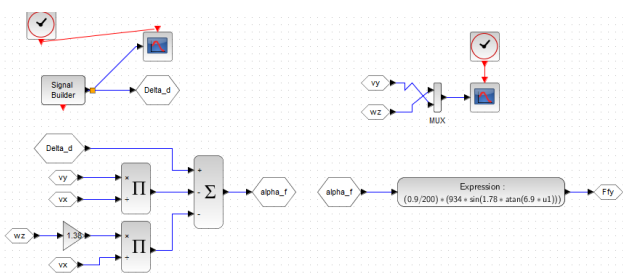


Figure 4 Design in VATH SciLab where Ffy is obtained and the oscilloscopes are shown

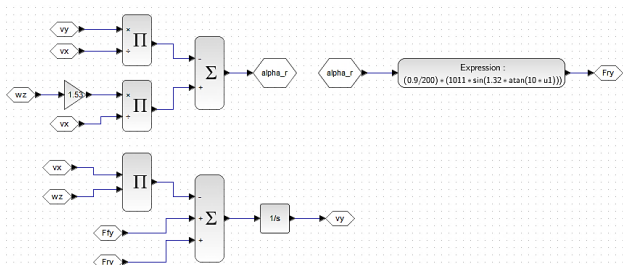


Figure 5 SciLab design of VATH where you get F_{ry}

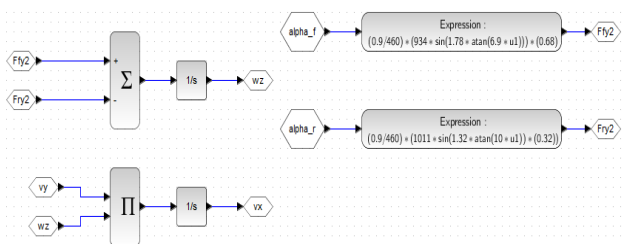


Figure 6 SciLab design of VATH where you get F_{fy2} and F_{ry2}

With the VATH mathematical model already simulated in the program with controlled angular velocity yaw (wz) and lateral velocity (Vy) with respect to a Reference System, it is observed in (figure 7).

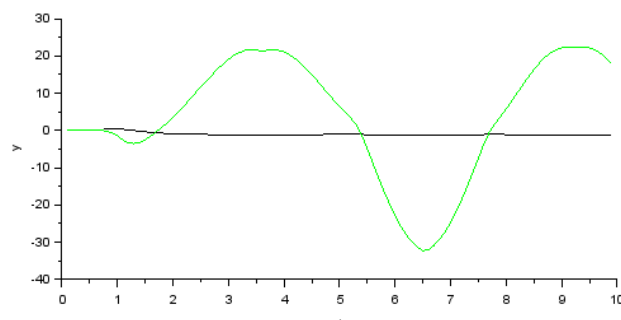


Figure 7 System response to ISO 3888-1 standard where the black line represents Wz and the green one Vy

Following the research methodology, the response of the System to a unit Step input is tested (figure 8) and the control results are obtained (figure 9):

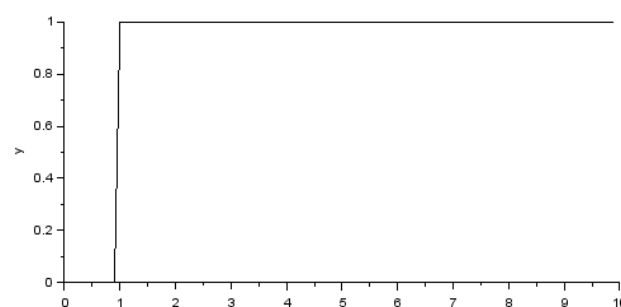


Figure 8 System Entrance to Unit Step

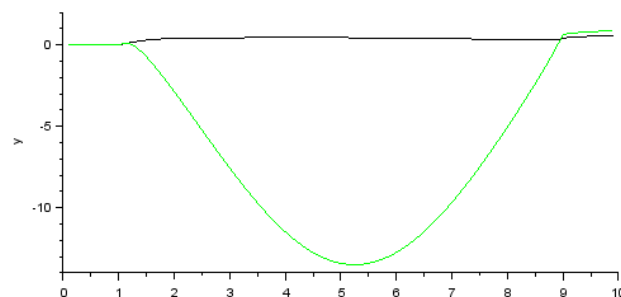


Figure 9 System Response to Unit Step where the black line represents Wz and the green one Vy

The system response only shows Vy in the negative order due to the nature of the motion that stabilizes at one value and there is no return to origin, so the lateral velocity decreases when the position is stabilized.

Finally, the system is tested in response to a rectangular unit pulse (figure 10) and obtaining the control results (figure 11):

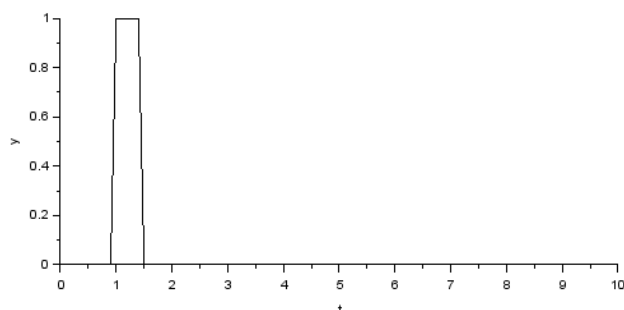


Figure 10 Rectangular unit pulse system input

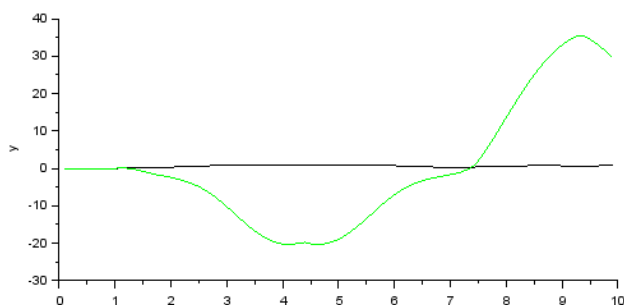


Figure 11 System response to a rectangular unit pulse where the black line represents W_z and the green V_y

In this case, we can see that the position returns to the origin, so the lateral speed of the return is shown in both positive and negative orders.

Mechanical and structural design

The overall appearance of the agricultural VATH was based on the Chassis of a mini ATV, a proven motorized transport that due to its already established geometry allows an efficient advance of the Project (figure 12).



Figure 12 Chassis design for agricultural VATH.

Once the simulation was carried out, the engine was coupled to the vehicle's chassis, the embedded module was mounted and it was taken to the field for testing (Figure 13).



Figure 13 Chassis under test

Annexes

Table of symbols

m	Vehicle mass	(kg)
j_z	Vehicle moment of inertia	(kg m ²)
l_f, l_r	Length from center of vehicle to front and rear tire	(m)
v_x	Longitudinal speed	(m/s)
v_y	Lateral velocity	(m/s)
ω_z	Vehicle yaw angular velocity	(rad/s)
α_f, α_r	Side slip angle of front and rear tires	(rad/s)
δ_d	Component of the rim angle imposed by the driver	(rad)
ω_z	Vehicle yaw angular velocity	(rad/s)
$F_{f,y}, F_{r,y}$	Front and rear lateral forces of the tires	(N)
$F_{f,x}, F_{r,x}$	Front and rear longitudinal forces of the tires	(N)
a_x, a_y	Longitudinal and lateral acceleration	(m/s ²)

Table 2

Conclusions

This research work proposes a linear three-degree-of-freedom model for VATH that applies agrochemicals using the SciLab tool to obtain the System's response, thereby predicting possible maneuvers of the vehicle operating in the field and at the same time reducing the expense necessary for the simulation of the possible environments to which the vehicle will be exposed.

One of the biggest advantages of this VATH design is that the steering is autonomous and therefore avoids the problems of wrong turning caused by the driver.

In this work, the areas of opportunity detected in the state of the art section were addressed, obtaining results that improve the research presented.

As can be seen in the images of the results, the response of the System is acceptable because it responds very quickly and the type of response is similar to the results obtained with the Carsim program (Sandoval Pérez, Herrera Segura, García, & Beejinez Macias, 2018) (Sandoval, Ruiz, Topete, & Gonzalez, 2016) (Matamoros Canseco, 2015), additionally the use of SciLab as a free access tool greatly economizes the design of the vehicle.

As future work, the results obtained by the simulation must be compared with field and real-time meters to be able to take specific control actions.

References

- Ackermann, J., Guldner, J., Steinhausner, R., & Utkin, V. (1995). Linear and nonlinear design for robust automatic steering. *IEEE Transactions on Control System Technology*, 3(1), 132-143.
- Bianchi, D., A. Borri, G. Burgio, & M. D. Di Benedetto. (2009). Adaptive Integrated Vehicle Control using Active Front Steering and Rear Torque Vectoring. *Joint 48th IEEE Conference on Decision and Control and 28th Chinese Control Conference*, (p. 1). Shanghai, P.R. China.
- Carreño Aguillón, E. d., Vacca Melo, E. A., & Lugo Ariza, I. (2012). Design and making of an autonomous, solar-energy-powered. *Tecnura*, 16(32), 91-106.
- Darenberg, J. A. (1993, Marzo 19). Automatic track control of a city bus. *IFAC Theory Report on Benchmark Problems for Control Systems Design*. European control conference.
- De la Cruz Fernández, E. (2020). Diseño de un sistema eléctrico aislado utilizando el software HOMER para electrificar el caserío Santa Rosa de Tumar en el distrito de Huambos.
- Di Cairano, S., Tseng, H., Bernardini, E., & Bemporad, A. (2013). Vehicle Yaw Stability Control by Coordinated Active Front Steering and Differential Braking in the Tire Sideslip Angles Domain. *IEEE Transactions on Control Systems Technology*, 21(4), 1236-1248.
- Matamoros Canseco, D. (2015). SIMULACIÓN DEL COMPORTAMIENTO DINÁMICO DE UN VEHÍCULO EN CARSIM. *PROYECTO FIN DE GRADO*. MADRID, madrid, España.
- Navarro Cosme, T. (2016). *Desarrollo de un prototipo de vehículo autónomo*. Valencia, España: etsinf.
- Pacejka, H. (2005). *Tire and Vehicle dynamics*. Elsevier.
- Peredo Ramírez, E. F. (2020). Diseño de un sistema de generación híbrido eólico solar para la electrificación rural al caserío Inneche del Distrito de Morrope Provincia y Departamento de Lambayeque. *Diseño de un sistema Híbrido eólico solar para suministro de energía eléctrica a zona rural en el estado de Chihuahua*. Culcyt.
- Pérez Rastelli, J. M. (2012). *Agentes de control de vehículos*. Universidad computense de Madrid, Posgrado, Madrid.
- Ramirez Cid, A. &. (2020). Diseño y simulación de un generador eléctrico por.
- Sandoval Pérez, S., Herrera Segura, E., García, J., & Beejinez Macias, J. (2018). Modelado y simulación de un vehículo en el software carsim. *Theorema*, 44-49.
- Sandoval, S., Ruiz, D., Topete, J., & Gonzalez, J. (2016). Observador lineal de dos grados de libertad en Matlab-Simulink-CarSim para. *Revista Tecnología e Innovación*, 1-10.
- Tjonnas, J., & Johansen, T. A. (2010). Stabilization of Automotive Vehicles Using Active Steering and Adaptive Brake Control Allocation. *18(3)*, 545-558.

Design of a convolutional neural network for classification of biomedical signals**Diseño de una red neuronal convolucional para la clasificación de señales biomédicas**

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Abstract

Biomedical signals are current case of Avant-garde study, thanks to advances in artificial intelligence, every day new methods are implemented that are useful for the treatment of this signals, mainly to detect anomalies or diseases with greater precision. A solution on base of the Deep Learning is proposed, this technology has proven to be efficient in handling high-level feature data, in it featured neural networks convolutionals (NNC) which are ideal in image management. In this paper, electrocardiographic signals (ECG) designed from a dynamic mathematical model in a two convolution layer NNC for classification are used.

Neural Network Convolutional (NNC), ECG, Dinamical model, Classification**Resumen**

Las señales biomédicas actualmente son un caso de estudio vanguardista, gracias a los avances en temas de inteligencia artificial, día a día se implementan nuevos métodos que sean de utilidad para el tratamiento de estas señales, principalmente para detectar anomalías o enfermedades con mayor precisión. Se propone la solución de la tecnología deep Learning (Aprendizaje profundo) la cual ha demostrado ser eficiente en el manejo de datos de características de alto nivel, en ella destacan las Redes Neuronales Convolucionales (RNC) las cuales son ideales en el manejo de imágenes. En el presente trabajo se emplean señales electrocardiográficas (ECG) diseñadas a partir de un modelo dinámico matemático en una RNC de cuatro capas de convolución para su clasificación.

Red Neuronal Convolucional (RNC), ECG, Modelo Dinámico, Clasificación

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Introduction

The analysis of biomedical signals has generally been carried out by the own inspection of health professionals, it is their word and criteria that determine the state of these signals. Today, we are working at an accelerated pace in the development of algorithms that are helpful in carrying out this work, thus providing a reliable support tool for the diagnosis of these signals. The data of the biomedical signals with which these algorithms are fed are mostly obtained from some database, acquiring them on your own is usually a challenge if you do not have the necessary equipment or authorization by means of an "informed consent" document from Test subjects to sample the signals, for the most part, the data obtained from medical equipment are usually encoded and it results in extra work having to decode them. A reliable way to acquire these signals and thus be able to implement them in the development of these algorithms is through the implementation of some dynamic model.

Currently, thanks to advances in Convolutionary Neural Networks, they have been at the forefront of pattern recognition applications, they can even exceed human capacity, as Graham shows in his article Fractional Max-Pooling [1]. This neural network is ideal for working with images, which play a very important role in computational vision. The image classification process includes image preprocessing, image segmentation, extraction of key characteristics and identification of similarities.

This article proposes the classification of biomedical images, in this case the ECG electrocardiographic signal using a convolutional neural network, using the mathematical dynamic model of the ECG signal proposed by Patrick E. McSharry [2] for the design and generation of the images.

In the next two sections of this document, the topics of "Convolutionary Neural Networks" and "Biomedical Signal ECG Using a Dynamic Model" are covered, the main topics required for the development of this work, in a later section the methodology for the development of the work (ECG biomedical signal classification by Convolutionary Neural Network) to finally detail the results obtained and conclusions in the last two sections.

Convolutional Neural Networks

Convolutional neural networks (RNCs) are very useful in practical applications, since 2012 these networks have become the algorithm for all computational vision tasks, generally working with all perceptual tasks. [3] They specialize in processing data that has a known grid topology, "time-series data" is considered to be a 1D grid that samples at regular time intervals, and "image data" is considered a 2D pixel grid. These types of networks are based on a mathematical operation called convolution because they perform the convolution of the input signal with respect to a transfer function that is found at the output of the neuron.

Their attributes make them perfect for analyzing images, one of the problems that any Deep Learning architecture suffers mainly is the large number of weights since they compare the pattern learned with respect to its input, assuming that the input is an image (Height x Width x Channels) each neuron would learn as many weights as pixels the image has, which is technically difficult.

The images replicate their most basic patterns quite a bit, which makes the convolutional neural network easier since it (2D convolutional for images) will basically look for the same pattern, but in different positions of the image.

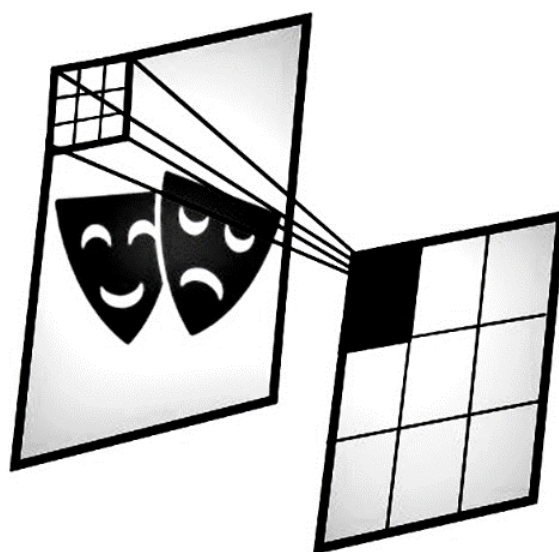


Figure 1 Looking for a pattern of an image

There are three types of layers that make up a convolutional neural network: convolutional layer, pooling layer and fully-connected layer.

Convolutionary Layer

It is the most important layer of an RNC, the neurons of the first convolutional layer are not connected to each of the pixels of the input image, but only to those that are within its receptive field. In the second convolutional layer each neuron is connected only to the neurons located in a small rectangle in the first layer. What sets this layer apart from the Fully-Connected layer is that the latter does have all of its neurons connected to the neurons in the previous layer.

This architecture allows the network to focus on low-level features in the first hidden layer, then assemble them into higher-level features in the next hidden layer, and so on.

Pooling layer

The objective of this layer is to subsample the input image in order to reduce the number of neural network parameters to be used, which benefits in reducing the computational load and the memory use of the equipment.

As in convolutional layers, in the pooling layer each neuron is connected to the output of a limited number of neurons in the previous layers, located within a small rectangular receptive field. This layer has no weights, all it does is get the maximum value (max-pooling) or the average value of all that window (avg-pooling).

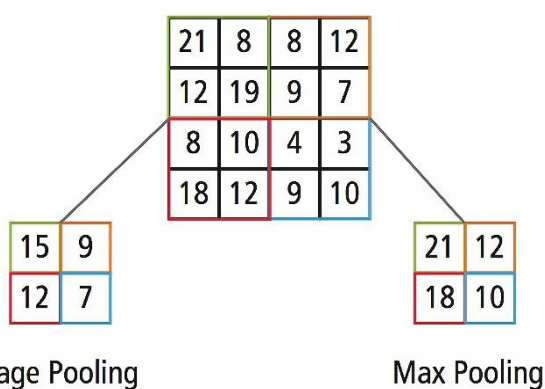


Figure 2 Pooling layer

Source: (<https://stats385.github.io/poolinglayers>)

Biomedical ECG signal using Dynamic Model

The ECG electrocardiographic signal is variable in time, it reflects the flow of ionic current that causes the heart fibers to contract and subsequently relax. This signal is obtained by recording the potential difference between two electrodes placed on the skin of the test subject or patient.

At the present time, the development and implementation of different algorithms for treating biomedical signals is continuously advancing, the dynamic model for the generation of synthetic electrocardiographic signals facilitates the evaluation of these algorithms without the need to resort to a data bank or generate the signs.

Dynamic Model

The model generates a trajectory in a three-dimensional space (3-D) with coordinates (x, y, z), with realistic PQRST morphology and described dynamic heart pulse. The purpose of this model is to provide a realistic standard ECG signal with known characteristics, which facilitates the comparison of different signal processing techniques.

Dynamic equations of motion are given by a set of three ordinary differential equations: [4]

$$\begin{aligned}\dot{x} &= \alpha x - \omega y \\ \dot{y} &= \alpha y - \omega x \\ \dot{z} &= -\sum_{i \in \{P, Q, R, S, T\}} a_i \Delta \theta_i \exp\left(-\frac{\Delta \theta_i^2}{2b_i^2}\right) - (z - z_0)\end{aligned}\quad (1)$$

For the study of the parameters of this model, the revision of [4] is suggested since its description is significantly extensive. Both \dot{x} , \dot{y} and \dot{z} are discussed in detail in the reference [4].

Biomedical ECG signal classification using the Convolutional Neural Network

ECG signal

For the generation of the signals that were used in the training of our RNC, the dynamic model of the ECG signal was programmed using embedded Simulink blocks.

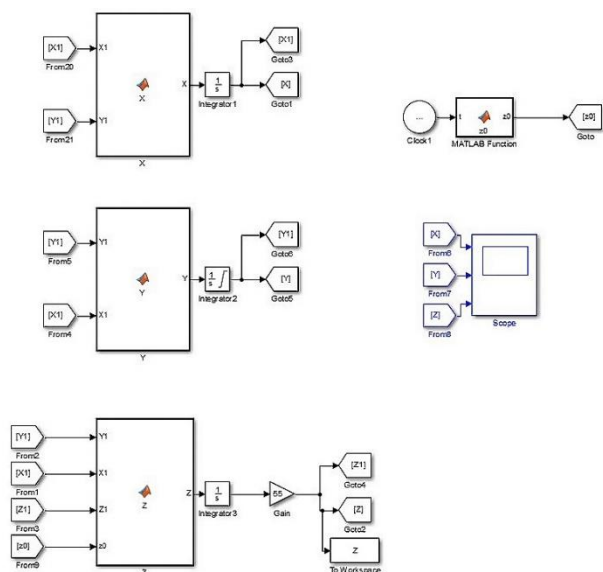


Figure 3 Modelo dinámico señal ECG programado en simulink

The following images show an ideal PQRST wave generated by the dynamic model, with the characteristic that its x and y axes are unitary.

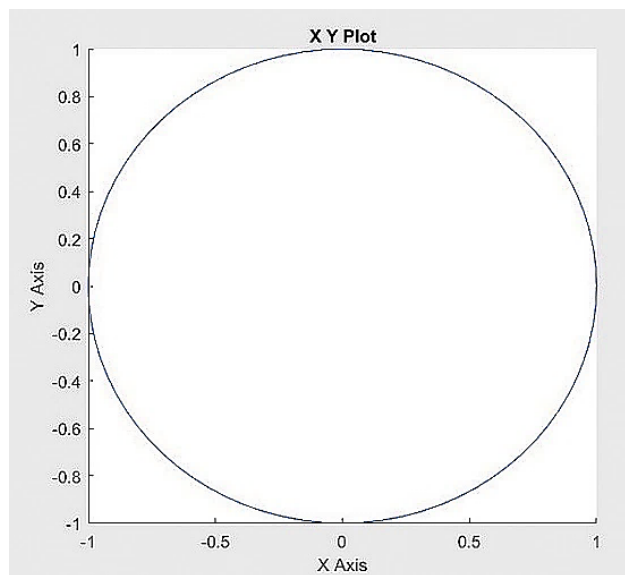


Figure 4 Unit circle generated by equations x and y

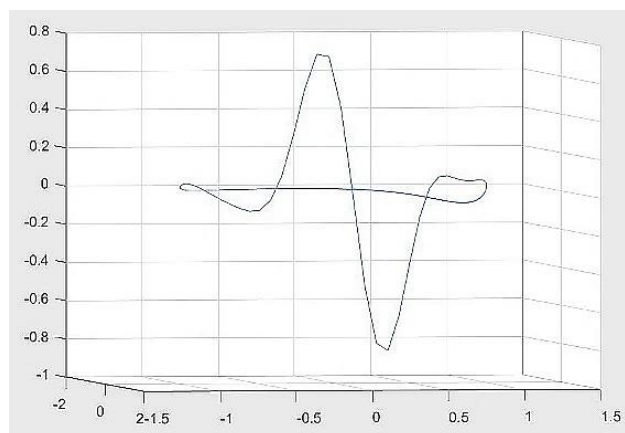


Figure 5 Typical path generated by the dynamic model (1) in the given 3-D space (x, y, z)

RNC

The classification to be made is of a binary type, that is, the RNC will show us if the ECG image that is being analyzed is of the abnormal type = 0 or normal = 1. The sequential model is used, which refers to the creation of a series of layers of sequential neurons (one after the other). Images are resized to 300 x 150 pixels. In the present work, the Google Collaboratory tool was used to make the results of our training more efficient, in this case decrease the loss and increase its accuracy, as mentioned in the article "Google Collaboratory as an alternative for the processing of a convolutional neural network" [8], in addition to being able to make use of computer tools with better characteristics such as a GPU which are not found in all conventional and standard equipment.

A. RNC architecture flow chart

The characteristics of the neural network architecture consist of 2 blocks with 2 convolutional layers and 1 MaxPooling layer each as shown in Figure below

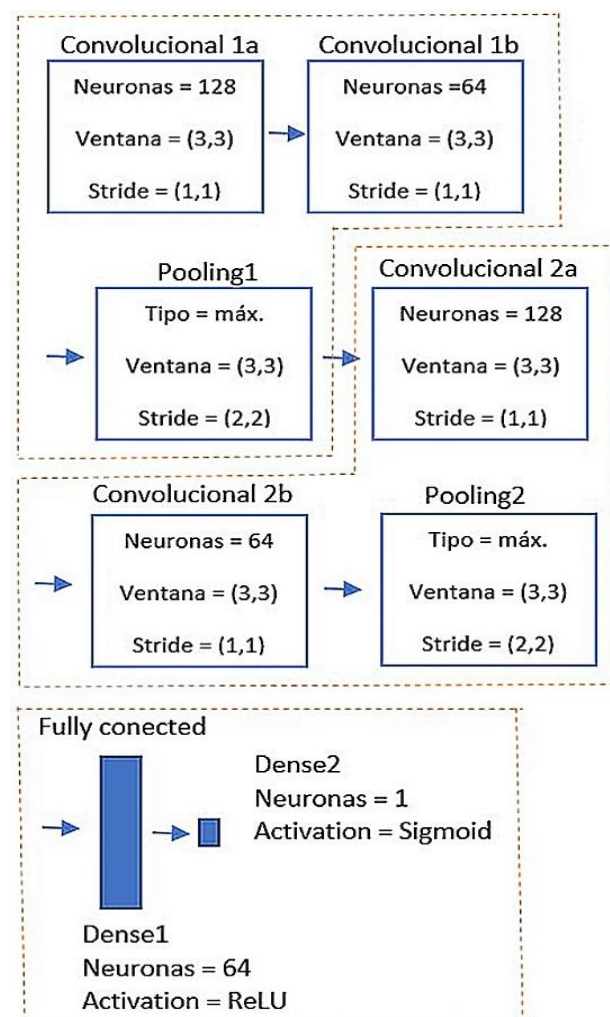


Figure 6 RNC architecture

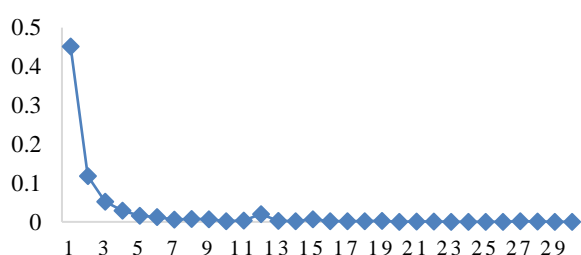
The convolutional layers consist of 128 neurons and 64 neurons respectively, as well as a window (3,3) and a stride (1,1), for MaxPooling layers the stride is used as (2,2). Subsequently a third block consisting of 2 Fully connected layers, in the last layer only a sigmoid neuron will be used to represent the probability of being normal or abnormal.

The network trains for 30 epochs where each one will have 1000 iterations. The iterations increase each time the weights are updated and the times increase each time all the samples of the dataset have been learned and it starts again, this means that they will be passed 30 times through the same example. The signals generated to train, validate and test our RNC were filed in 3 different folders, TRAINING, VALIDATION and TEST.

Results

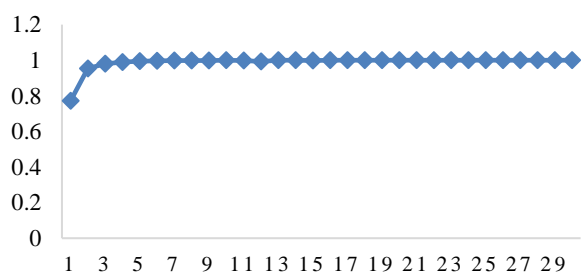
The results of the training of the network were favorable since the precision (accuracy) which indicates the performance that our model is having was increasing until reaching the values of 0.99, while the loss was decreasing until reaching the value of 0.00023, the latter indicates the difference between the value predicted by the model and the true value, which can be seen in the following graphs.

LOST



Graphic 1 Lost

PRECISION



Graphic 2 Precision

The network was tested with 27 images of normal and abnormal signals which were classified correctly in their entirety, below are some of the images which were classified correctly, 3 of abnormal type and 3 of normal type, it should be noted that these images do not belong to the data set with which the convolutional neural network was trained.

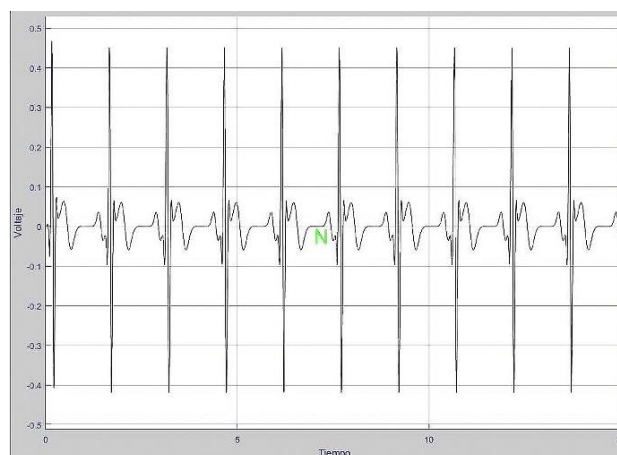


Figure 7 Result "Normal" 1

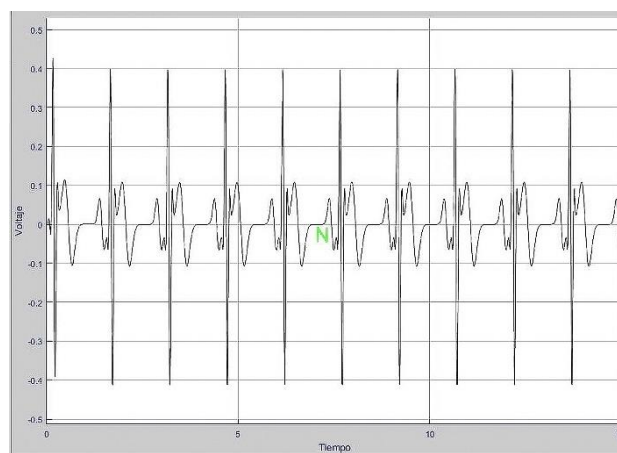


Figure 8 Result "Normal" 2

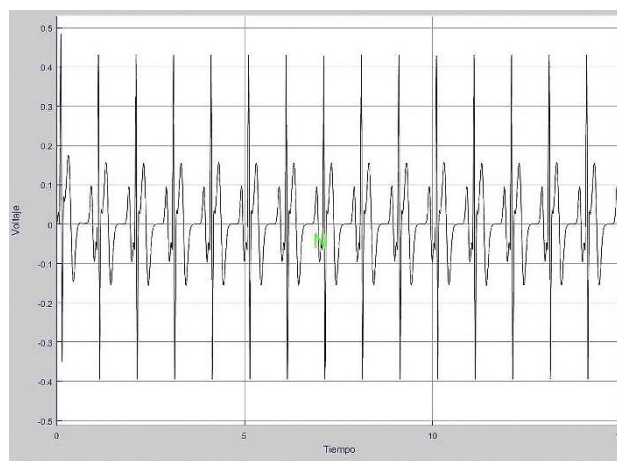


Figure 9 Result "Normal" 3

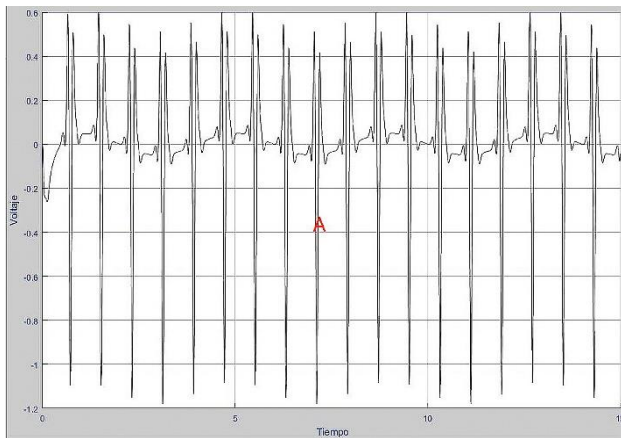


Figure 10 Result "Abnormal" 1

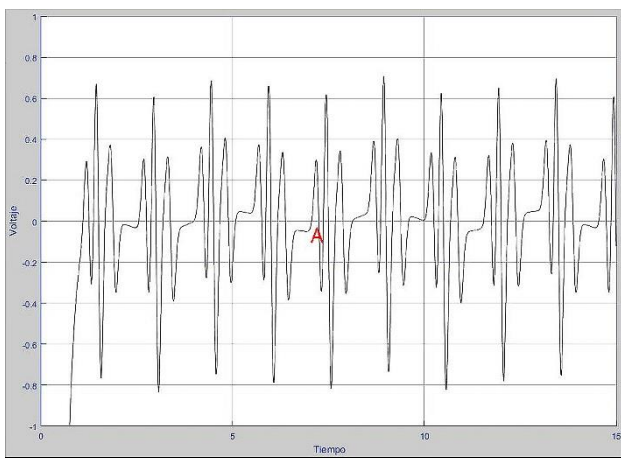


Figure 11 Result "Abnormal" 2

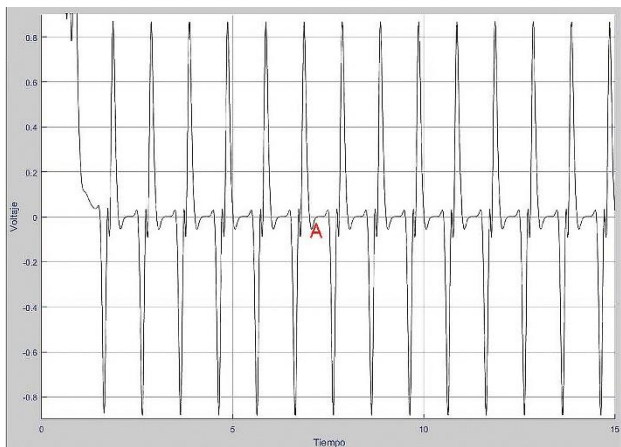


Figure 12 Result "Abnormal" 3

Conclusions

The results obtained allow us to corroborate how the technology of the Convolutionary Neural Networks is capable of analyzing various types of data equal to or more efficiently than human capacity, in this case classifying the images of the ECG signal as a professional would do. from health to visual inspection.

The training used for the network was sufficient for the classification performed, in this first case it was a simple classification with clear ECG images and without any noise, as real signal images would have, for this case study with noise it is necessary to modify these parameters network training, as well as its architecture parameters. The classification between ECG signal images by binary method is sufficient to be able to differentiate whether a signal is at rest or effort, as well as healthy or with a health problem. Aspects to consider and in which work has already begun is the management of real signals, as well as applying it to a medical case (which may be arrhythmia, cardiomyopathy, among others).

References

- [1] B. Graham, (2015). "Fractional Max-Pooling". arXiv:1412.6071.
- [2] E. Mcharry, Gari D, "A Dynamical Model for Generating Synthetic Electrocardiogram Signals", IEEE Trans.Biomed. Eng, vol. 50. March 2003.
- [3] F. Chollet, DEEPLARNING with Python. MANNING Publications Co, Shelter Island, NY 2018.
- [4] E. Mcharry, Gari D, "A Dynamical Model for Generating Synthetic Electrocardiogram Signals", IEEE Trans.Biomed. Eng, vol. 50. March 2003, pp 291.
- [5] A. Géron, Hands-On Machine Learning with Scikit-Learn & TensorFlow. O'REILLY, Shelter Island, United States of América 2017.
- [6] I. Goodfellow, Y. Bengio and A. Courville, Deep Learning. MIT Press, 2016. <http://www.deeplearningbook.org>.
- [7] T. Guo, J. Dong, H. Li, Y. Gao, "Simple Convolutional Neural Network on Image Classification", IEEE Int. Conf. Big Data Analysis. Eng. March 2017. doi: 10.1109/ICBDA.2017.8078730
- [8] BODERO, E. M., LOPEZ, M. P., CONGACHA, A. E., CAJAMARCA, E. E., & MORALES, C. H. "Google Colaboratory como alternativa para el procesamiento de una red neuronal convolucional". Revista ESPACIOS, 2020.

Information system for the management of intelligent traffic lights**Sistema de información para la gestión de la infraestructura de semáforos inteligentes de tránsito**

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Abstract

Derived from the population increase and urban growth, vehicle traffic has increased in the cities of Colima and Villa de Álvarez located in Mexico, and with it the problems of road safety and traffic management; the increasing number of roads and traffic lights implies recording the information of each one of these; Therefore, this article presents an information system for the management of intelligent traffic light infrastructure. In the software engineering process, the Agile Unified Process was used to manage the main risks early and guarantee the quality of the product during its life cycle. The system was tested at a prototype level with satisfactory results, as a result a web system contributes to improving road and citizen safety, since based on two vehicle data it connects with web services to other databases, and identifies Immediately form the incidents of vehicles that pass through the roads, including stolen vehicle, speeding and a panic button. The expectations are to scale it to the real environment, and make available to the corresponding authorities the information collected to favor decision-making.

Road infrastructure, Urban mobility, Vehicular traffic

Resumen

Derivado del aumento poblacional y el crecimiento urbano, el tráfico vehicular se ha incrementado en la zona conurbada Colima-Villa de Álvarez, México, y con ello los problemas de seguridad vial y la gestión del tráfico; el creciente número de vías y de semáforos, implica registrar la información de cada uno de éstos; por ello, en este trabajo se presenta un sistema de información para la gestión de la infraestructura de semáforos inteligentes de tránsito. En el proceso de ingeniería de software se utilizó el Proceso Unificado Ágil, para gestionar de forma temprana los principales riesgos y garantizar la calidad del producto durante su ciclo de vida. El sistema fue probado a nivel prototipo con resultados satisfactorios, como resultado se tiene el sistema web que contribuye a mejorar la seguridad vial y ciudadana, pues basado en dos datos de los vehículos se conecta con servicios web a otras bases de datos, e identifica de forma inmediata las incidencias de los vehículos que transitan por las vialidades, entre ellas vehículo robado, exceso de velocidad, botón de pánico. Las expectativas son escalarlo al ambiente real, y poner a disposición de las autoridades correspondientes la información recabada para favorecer la toma de decisiones.

Infraestructura vial, Movilidad Urbana, Tráfico vehicular

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Introduction

Currently the use of traffic lights continues to be the main tool for controlling vehicular traffic in cities, in some cases, it has been combined with video surveillance systems to recognize the identity of the vehicles that circulate on the roads as a factor to improve the road and citizen safety. The increase in traffic congestion is a challenge for society in general and with it the consequences that this represents. According to [1] these factors increase the stress of travelers as it leads to loss of time and problems related to health.

In the case of Mexico, information presented by [2] from the 2010-2015 intercensal population surveys and by [3] registered vehicle units 2010-2018 obtained their respective increases of 51.06% and 6.76%, which represents more than six. Sometimes the increase in the number of vehicles over the population in just eight years, in such a situation, the government and society make joint efforts to incorporate technological strategies that contribute to improving vehicular traffic.

As with the population and the acquisition of vehicles, road traffic accidents have also increased, according to figures from [4] in the state of Colima, in the last 20 years, these went from 1,604 to 5,310, which represents an increase 231%. These data justify the elaboration of strategies that improve urban mobility, among them the placement of intelligent traffic lights that according to [5] is defined as an intelligent device, to any physical object associated with computer resources and capable of communicating with other similar objects through any transmission method, logical protocol or with humans through a user interface and a communication standard.

The incorporation of Information and Communication Technologies (ICTs) in the area of mobility, have allowed the creation of solutions that have addressed similar problems. An information system was developed, which according to [6] detects, sends and receives alerts of incidents that any traffic light presents, with the main objective of determining the influence that an information system has on alerting the operation of traffic lights.

In the city of Huarmey, motorcycle taxis are the main means of transportation, [7] implemented a computer system that aims to automate and verify actions such as operating permits, infractions, pending debts, among others, to have better control over them.

In the case of [8], they proposed to establish a vehicle traffic management system in real time, basing its functionality on radio frequency identification (RFID). The system was applied in the city of Delhi, with the aim of having a control of each registered vehicle. On the other hand [9] implemented a system that works through video surveillance, the cheapest technique for monitoring, which allows analyzing both day and night conditions to control traffic and is characterized by providing indicators such as vehicle classification, vehicle density, vehicle count, license plate detection and incident detection. For their part [10] they designed a system that can monitor and control the traffic network remotely, based on the use of Embedded Web Servers, incorporating Linux as the operating system. Another contribution is that of [11] who developed an intelligent traffic system to control road congestion and reduce accidents, based on embedded web technology, using different sensors and communication protocols to connect with the hardware and software used. In turn [12], they carried out a real-time traffic monitoring system, based on the detection and tracking of objects, in order to measure parameters such as speed and vehicle density.

This research work proposes the implementation of an Information System for the Management of the Intelligent Traffic Light Infrastructure (SIGISIT), as a solution to the problem of vehicular mobility; allowing to manage, speed up and consult the information captured through the cameras associated with smart traffic lights, to promote citizen security. The SIGISIT is aimed at the State Public Security Systems as a computer tool for decision-making, and the creation of strategies that favor citizen mobility and security; In its preparation, the requirements of the metropolitan area Colima-Villa de Álvarez, Mexico were considered, although it can be adapted to the needs of any environment.

In its development the Agile Unified Process was used to control the software engineering process, and in its implementation technologies such as RFID, ANPR camera, Java Spring, PostgreSQL, JQuery and Bootstrap. The results obtained from the pilot test indicated that the system as a registration base can support decision-making regarding public safety in the metropolitan area, by virtue of identifying the vehicle data that circulates in real time and sending alerts according to the incidents found.

Methodology

For the development of this applied research, the Agile Unified Process (PUA) was used, which allowed controlling the software engineering process through iterations and increments; The final product was identified and divided into executable prototypes that gave the development team and the client a clear vision of the project. Figure 1 illustrates the PUA methodology, which [13] considers "serial for the large and iterative for the small"; It is described in four phases and seven disciplines, each phase can have one or more iterations depending on the characteristics of the project and the disciplines considered are executed in each iteration.

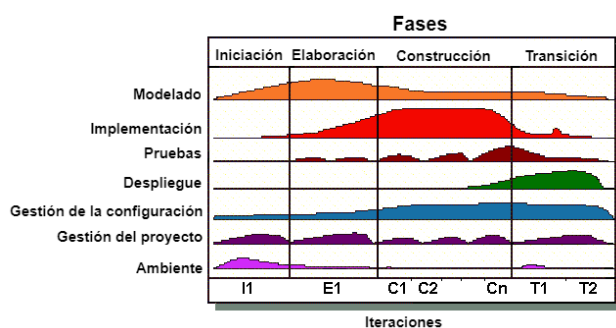


Figure 1. Agile Unified Process Methodology
Source: <http://www.ambysoft.com/unifiedprocess/agileUP.html>, 2005

As it was a small project, five iterations of four weeks each were defined; use cases were prioritized, so in each iteration the activities of:

Modeling: UML diagrams were developed, including use cases, requirements, classes, data and interfaces, using the trial of the Enterprise Architect Project tool.

Implementation: UML models were translated into code using Java programming with Spring framework, PostgreSQL for data management and Bootstrap in front-end development.

Testing: unit tests were applied to the system code, to ensure compliance with functional requirements, as well as integration tests of the various components.

Deployment: incremental deliveries were made and uploaded to the server; for reasons of computational infrastructure and scaling of functionalities, it continues in the pre-production phase.

Configuration management: The system has an administration panel that allows users and permissions to be configured. There is only one version in which changes continue to be incorporated to improve scope and performance.

Project management: The activities program was prepared, considering the tasks to be carried out, those responsible and the execution time; Deliverables and release dates were specified. Conditions were created for deliveries to be executed on time.

Environmental administration: the methodology was followed, favoring change management and risk management; In addition, the team had the necessary software, licenses and devices for the development of the system.

Working with the PUA methodology left the experience of identifying the roles in the development team and the activities that they involve; the iterations marked a slender and transparent job in the assignment and development of tasks; communication with the team and the client allowed the changes to be incorporated and the results to satisfy the client's requirements.

Results

As a result of this research, SIGISIT was implemented, which records the identification data of each traffic light, with them the traffic light network of the metropolitan area is monitored and visualized through a graphical interface based on maps.

With the support of a specialized ANPR camera, the system reads the license plate of the vehicle in circulation, the data obtained is compared with official information provided through a web service, in order to detect possible incidents in the vehicle that is circulating. Figure 2 shows the conceptual model of the system, as a contribution to the management of the infrastructure of intelligent traffic lights. It is a web information system that, through the prior registration of traffic lights, centralizes the acquisition of the data generated by the monitoring of vehicle flow to identify parameters such as density and incidents related to road and citizen safety. The cameras are associated with the corresponding traffic light through an IP address so that the system has remote access to each one. The cameras capture and send vehicle information to the information system via the Internet, for registration and consultation.

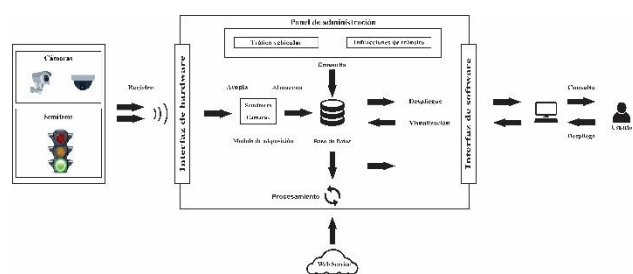


Figure 2 SIGISIT Conceptual Model
Source: self made

The system registers the information received from the cameras in the database and at the same time compares it with the information from the web service. If a match is found regarding the traffic incidents of the vehicle it identified, the corresponding alert is displayed on the administration panel.

Users of the system can consult the information of the traffic light network through the administration panel, which displays the incidents in real time and allows them to consult the detail of each traffic light. Figure 3 shows the main SIGISIT menu, in the scope presented here are the options of Cameras, Traffic Lights and Traffic Light Monitoring.

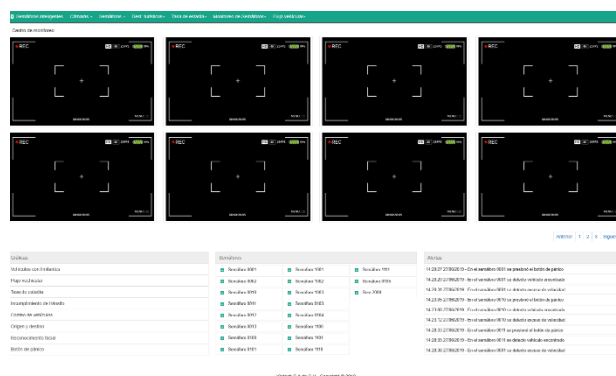


Figure 3 SIGISIT main menu
Source: self made

The system allows observing the incidents or alerts of a particular traffic light, as shown in Figure 4; The physical location of the traffic light is displayed, specifying the streets, coordinates, orientation, locality, state and country, and the details of the latest alerts associated with it are presented.

For traffic light monitoring, the data of each one was previously recorded, the respective cameras were associated and their location was marked using georeferencing. Figure 4 presents a list of the active traffic lights and the history of the traffic lights where there were incidents.

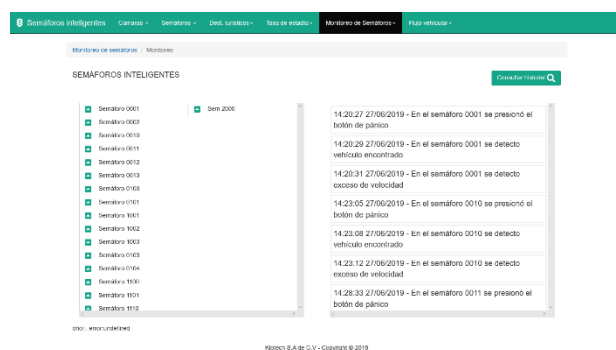


Figure 4 Traffic light monitoring
Source: self made

The system allows observing the incidents or alerts of a particular traffic light, as shown in Figure 5; the physical location of the traffic light is displayed, specifying the streets, coordinates, orientation, locality, state and country, and the detail of the latest alerts associated with it is presented.

Fecha	Alerta	Placa	Placa REPUVE	NIV	Chip REPUVE
2019-06-28 14:23:38.0	Se detectó exceso de velocidad	GZW-99-84		null	
2019-06-28 14:23:38.0	Se presionó el botón de pánico.	GZW-99-84		null	
2019-06-28 14:23:38.0	Vehículo Encorreado	GZW-99-84		null	

Figure 5 Traffic light history
Source: self made

From the traffic light monitoring view, the cameras associated with each traffic light can be accessed as shown in Figure 6. The model of this system considers video surveillance cameras, traffic light, traffic light cameras for the purpose of reading plates and intercom; for reasons of confidentiality, in the scope of this investigation only the functionalities of the traffic light camera are presented.

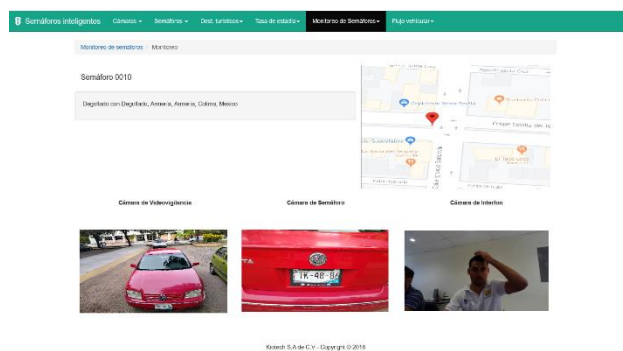


Figure 6 Cameras associated with the traffic light
Source: self made

As a result of the systematization of the monitoring, various alerts and notifications were implemented, so that the user of the system can link to the body in charge of the corresponding care, be they medical services or road safety services.

Tests

SIGISIT was subjected to a series of pilot tests in a controlled environment, based on a sample of 100 traffic lights operating simultaneously and verifying the expected indicators in relation to the programmed readings at the traffic lights as vehicles pass by.

Name	Model	Characteristics	Qty.
Traffic light	Three horizontal lights	Three lights traffic light.	100
ANPR camera	Freeway-cam Impinj Speedway Revolution r220	Capture vehicle license plates up to 255 km. Vandal-proof IK10 and IP67 housing.	1
RFID reader	SH-L7423 JPG	Support for two antennas. Read 200 labels per second.	1
RFID tag	SQL Three horizontal lights Freeway-cam Impinj Speedway Revolution r220	Passive RFID UHF. Frequency 860 ~ 960 MHz. 512 bit memory. Reading up to 8mt.	500
Vehicle plates	SH-L7423		500
Web service	JPG	Plates with nomenclature of the Mexican Republic	1

Table 1 Tools and equipment used
Source: self made

Table 1 shows the tools and equipment used for the development of this project.

Regarding the identification of vehicles by means of the vehicle plates and the readings of the labels, a result of 100 percent was obtained, however, the tests in real environment are pending.

Conclusions

In conclusion, SIGISIT manages to significantly improve the management of the traffic light network, highlighting the following contributions:

Specific and georeferenced identification of each traffic light; Identification and operation of the cameras associated with each traffic light; Traffic light alert history; Identification of incidents by reading plates and crossing information; Improvement in the communication flow of the organisms that intervene in the regulation of vehicular traffic and citizen security; Identification of trends by types of incidents; Elaboration of justified public policies in the information obtained.

Thus, the implementation of a web system for the management of the network of intelligent traffic lights favors government decision-making to develop public policies that contribute to road safety and citizen safety itself. In the future it is suggested that SIGISIT can be improved and expanded, enabling the system so that alerts or notifications are electronically channeled to the agencies that serve them; In addition, given the information it will store, algorithms can be implemented to identify possible trends in the types of accidents in certain roads or geographical areas..

References

- [1] O. Okorodudu, F., O. Okorodudu, P., & O. Atumah, L. (2018). A Novel Approach to Road Traffic Monitoring and Control System. *International Journal of Multidisciplinary Sciences and Engineering*, 29-33. Obtenido de: https://www.researchgate.net/publication/323535257_A_Novel_Approach_to_Road_Traffic_Monitoring_and_Control_System
- [2] Instituto Nacional de Estadística y Geografía (INEGI). (2018). Parque vehicular (Consultado: 2020/04/05). Recuperado de https://www.inegi.org.mx/temas/vehiculos/default.html#Informacion_general.
- [3] Instituto Nacional de Estadística y Geografía (INEGI). (2015). Encuesta Intercensal (Consultado: 2020/04/05). Recuperado de <https://www.inegi.org.mx/programas/intercensal/2015/default.html#Tabulados>
- [4] Instituto Nacional de Estadística y Geografía (INEGI). (2017). Accidentes de tránsito terrestre en zonas urbanas y suburbanas. (Consultado: 2019/01/18). Recuperado de: <https://www.inegi.org.mx/sistemas/olap/proyectos/bd/continuas/transporte/accidentes.asp>
- [5] Carabelea, C., Boissier, O., & Ramparany, F. (2003). Benefits and Requirments of Using Muli-agent Systems on Smart Devices. En H. Kosch, L. Boszorményi, & H. Hellwagner, Euro-Par 2003 Parallel Processing (págs. 1091-1098). Berlín: Springer-Verlag.
- [6] L. Carbajal Saboya, "Sistema de información y su influencia en la alerta de la operatividad de semáforos en la ciudad de Tarapoto", Licenciatura, Universidad Nacional de San Martín, 2019.
- [7] J. Gamarra Marquez, "Propuesta de Implementación de un Sistema Informático para el Control de Vehículos Menores en la Municipalidad Provincial de Huarney", Licenciatura, Universidad Católica los Sngeles Chimbote, 2019.
- [8] Saini, A., Chandok, S., & Deshwal, P. (2017). Advancement of Traffic Management System Using RFID. *IEEE*, 1254-1260. Recuperado de: <https://ieeexplore.ieee.org/document/8250669>
- [9] Nemade, B. (2016). Automatic Traffic Surveillance Using Video Tracking. *Procedia Computer Science*, 402-409. Recuperado de: <https://www.sciencedirect.com/science/article/pii/S1877050916001836>
- [10] R. Dube Rajendra., & S. Pawar Shushama. (2015). Design and Implementation of Traffic Monitoring System Base on Embebed Web Technology. *Revista International Journal of Science and Research (ISJR)*,6.14, 1943-1946. Obtenido de: <https://pdfs.semanticscholar.org/83b0/4464201f44f915164452e0edca2f56aa75aa.pdf>
- [11] Shrikhande N. Madhavi., Shende K. Dipali (2014). Embeded Web Technology in Traffic Monitoring Syten. *Revista International Journal of Innovative Research in Advanced Engineering (IJIRAE)*,1(4), 114-117. Recuperado de: <http://ijirae.com/images/downloads/vol1issue4/MYEC10084-21.pdf>
- [12] Kiratiratanapruk, K. & Siddhichai, S. (2009). Practical Application for Vision-based Traffic Monitoring System. *IEEE*. Recuperado de: <https://ieeexplore.ieee.org/document/5137245>
- [13] Ambler, S. (2014). The Agile Unified Process (AUP). Recuperado de: www.ambysoft.com/unifiedprocess/agileUP.html.

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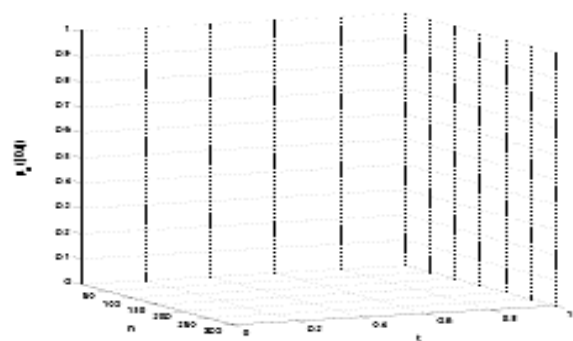
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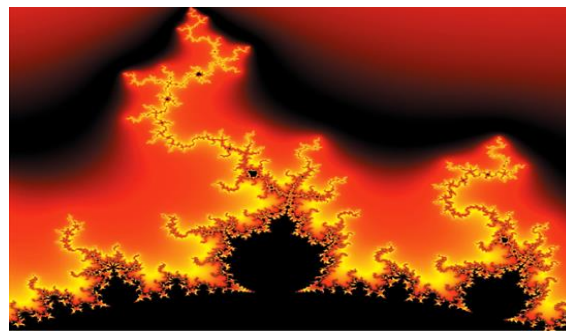


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