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Journal of Health Sciences

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The works must be unpublished and refer to topics of clinical sciences, nutrition sciences, pharmacology, internal medicine, general medicine, internal medicine, preventive medicine and other topics related to Medicine and Health Sciences.

Presentation of Content

As the first article we present, *Sustainable design of dynamic elbow orthoses for adult rehabilitation treatment*, by Castillo-Aguirre, Alfredo Humberto, Báez-Guzmán, Ricardo, Cruz-Gómez, Marco Antonio and López-Aguilar, Genaro Robert, with adscription in the Benemérita Universidad Autónoma de Puebla, as the second article we present, *Performance comparison in optimization algorithms for heart disease detection model*, by Rojas, Rafael, Seseña, Hiram, Zúñiga, Mariana and Martínez, Moisés, with adscription in the Universidad Autónoma de Querétaro (UAQ), as third article we present, *Standardized tool for the identification and control of risks associated with tasks in the work environment*, by Cardona-Martinez, Clara, Ramírez-Benhumea, David Alejandro, Guevara-Hernández, Eduardo and Beltran-Medina, Paulina K, with assignment at the Technological University of Queretaro, as next article we present, *Optomechatronic system for robotic arm using neural networks for educational inclusion* by Blanco-Miranda, Alan David, García-Cervantes, Heraclio and Carrillo-Hernández, Didia, with adscription in the Universidad Tecnológica de León, as next article we present, *Design of an alarm system for the inclusion of people with disabilities in the educational environment*, by Cruz-Orduña, María Inés, Cruz-Luis, Rodrigo Eliseo, Hernández-Herrera, Jesús Alberto and Cruz-Castellanos, Jorge Luis, with adscription in the Universidad Veracruzana, as last article we present, *Determination and evaluation of unofficial or complementary tests of rosemary extract tablets (as a finished product)*, by Orta-Martínez, Felipe, Hernández-Salas, Claudia, Regalado-Barrera, José David and Flores-Treviño, Nora Elia, with adscription in the Universidad Autónoma de Zacatecas "Francisco García Salinas".

Content

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Article

Sustainable design of dynamic elbow orthoses for adult rehabilitation treatment

Diseño sustentable de órtesis dinámica de codo con fines de rehabilitación en adultos

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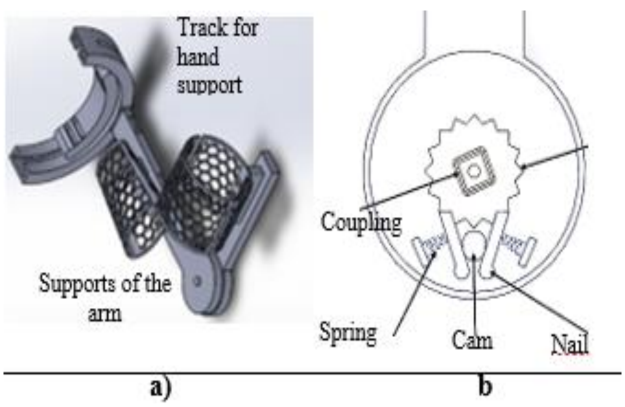
Abstract

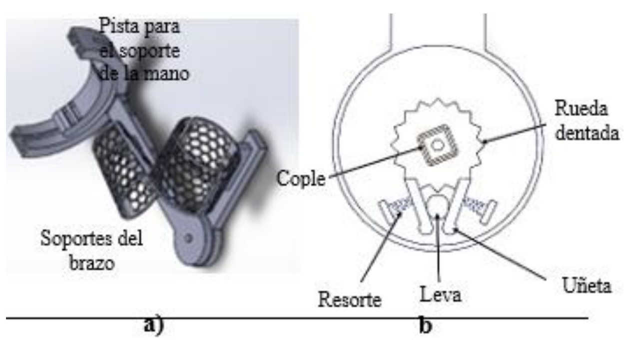
The elbow joint is prone to degenerative diseases, injuries from work, sports, or accidents. Rehabilitation often requires surgery and mechanical rehabilitation by health professionals. This research aimed to design a dynamic elbow orthosis using the finite element method for sustainable adult rehabilitation. Elbow orthoses can reduce treatment time effectively, but their high cost and importation limit accessibility. The study involved a mixed analysis of orthosis design and optimization, considering variables like anthropometric measurements, mobility ranges, biomechanical parameters, and mechanical design. Technical data from human anatomy were used to create biomechanical models, optimizing the orthosis design for sustainable systems. Future work will focus on further rehabilitation optimization by health professionals.



Elbow orthosis, Biomechanics, Finite element

Resumen

La articulación del codo está constantemente expuesta a enfermedades degenerativas y lesiones por actividades laborales, deportivas o accidentes. La rehabilitación suele requerir una intervención quirúrgica y rehabilitación mecánica por parte de personal de salud. Esta investigación buscó diseñar una órtesis dinámica de codo usando el método de elementos finitos para una rehabilitación sustentable en adultos. Las órtesis de codo reducen significativamente el tiempo de tratamiento, pero su alto costo y necesidad de importación limitan el acceso. Se realizó un análisis mixto en el diseño y optimización de la órtesis, considerando variables como medidas antropométricas, rangos de movilidad, parámetros biomecánicos, diseño mecánico y control de rehabilitación. Los datos técnicos de la anatomía humana se transformaron en modelos biomecánicos, optimizando el diseño de la órtesis para sistemas sustentables. La caracterización de la rehabilitación de la órtesis será objeto de futuros trabajos y optimización por parte del personal de salud.



Órtesis de codo, Biomecánica, Elemento finito

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Introduction

The human body has 360 joints in total. These are divided into 86 in the skull, 6 in the throat, 76 in the spine and pelvis, 66 in the thorax, 32 in each of the arms and finally 31 in each of the legs.

These are structures that connect two or more bone surfaces allowing; mechanical movements, provide elasticity, serve as a union between bones, bones-cartilage and finally bone tissue and teeth. The elbow is a joint that corresponds to the arm, it has two degrees of freedom, two movements, flexion-extension and pronation-supination.

The first movement has an arc of motion of 0°-160°, however, most activities are performed between 30° and 130°. The second has a range of mobility between 160°-170°. The elbow joint is constantly exposed to degenerative diseases, injuries generated by work activities, sports or accidents. To rehabilitate it, a surgical intervention is necessary in most cases, followed by constant mechanical rehabilitation by health personnel. Elbow rehabilitation consists of different therapies to strengthen it until the patient returns to their daily lives.

The therapies involve flexion-extension and pronation-supination exercises with the help of an elbow orthosis. (Gil-Henao et al., 2021). The elbow is one of the three main joints in the upper body kinetic chain, along with the shoulder and wrist.

This is essential for interaction and communication with the environment. A failure in health hinders nutrition, hygiene, recreation, work, and countless activities of daily living, decreasing the quality of human life. (Fuensalud, 2022).

Orthoses are a device applied externally to the body to improve joint mobility and can be classified as unloading, immobilization, stabilization-support, functional, postural, corrective and mixed. (Segnini et al., 2020) and (Sevik et al., 2024). The objective of this research was to design a dynamic elbow orthosis using the finite element method as an optimization tool, for sustainable rehabilitation purposes in adults.

The characterization of technical data obtained from human anatomy was transformed into biomechanical models, optimizing the design of the elbow orthosis in sustainable development systems.

The design and optimization of the dynamic orthosis for elbow rehabilitation aims to help patients by reconciling viability, sustainability and equity, complying with the three fundamental axes of sustainability; economic, ecological and social to improve the quality of life and human survival.

In such a way that the design of the elbow orthosis used CAD and CAE software tools for optimization, (CAD/CAM/CAE, 2022), the use of 3D printing.

The stress analyzes in the mechanisms were carried out by the finite element method; supported by SolidWorks software and finally based on the results, the materials for the manufacture of the orthosis were proposed, optimizing its mechanisms.

The rehabilitation characterization of the elbow orthosis will be the subject of future work and its optimization by health personnel.

Anatomy of the elbow joint

The elbow joint is made up of three joints; the humerus-radial, humerus-ulnar (flexion-extension movement) and intermediate proximal radio-ulnar (pronosupination movement), belonging to the human upper limb. However, they are considered as a single joint; because the joint cavity, the synovial membrane, the capsule and the ligaments are common in the three joints.

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This complex joint allows the forearm to approach or separate from the arm, through the flexion-extension movement and the orientation of the palm of the hand, through the pronosupination movement.

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The flexion-extension movement is 0°-150° and pronation-supination is 160°-170°, with arcs of movement in daily activities of pronation 80° and supination 85°. (Hamill et al., 2022).

The bone structure of the elbow joint is made up of three bone structures (humerus, radius and ulna) that coincide in three joints. The distal end of the humerus is made up of the trochlea (known as the condyle) and the olecranon fossae (coronoid fossa and radial fossa).

The faces of the condyle articulate with the head of the radius and a trochlea that articulates with the proximal end of the ulna, known as the ulna. The coronoid fossa receives the coronoid process of the ulna during complete flexion of the elbow, while in full extension the olecranon fossa is responsible for accommodating the olecranon of the ulna. The shallow radial fossa accommodates the edge of the radial head when the forearm is fully flexed. (Dalley et al., 2022).

The condyle-trochlea assembly can be compared to the association of a diabolo and a ball, crossed by a flexion-extension axis of the elbow. The condyle and trochlea are internally rotated by 3-8° and have a 94-98° valgus angle with respect to the longitudinal axis of the humerus. The distal part of the humerus has an angle of 30° along the longitudinal axis of the humerus. (Nordin et al., 2020).

The ulna (or ulna) is the longest, medial bone of the forearm that stabilizes the human upper extremity. The proximal end of the ulna articulates with the humerus proximally and with the head of the radius laterally. To articulate with the humerus, it has the olecranon that acts as a lever for the extension of the elbow, and it has the coronoid process in contact with the radial notch.

The olecranon and coronoid process form the walls of the trochlear notch of the humerus. The joint between the ulna and the humerus allows flexion and extension movements of the elbow, however, in the pronation and supination of the forearm a certain degree of abduction-adduction takes place. Inferior to the coronoid process is the tuberosity of the ulna that inserts the tendon of the brachialis muscle. (Dalley et al., 2022 and Koizumi et. Al., 2023).

On the lateral aspect of the body of the ulna is the crest of the muscle and the supinator fossa. The articular surface of the ulna has an angle of 4-7° of valgus with respect to the longitudinal axis of its diaphysis. This articular surface is rotated 30° posteriorly with respect to its longitudinal axis. (Nordin et al., 2020).

The proximal end of the radius has a short head. The superior surface of the radial head is concave to articulate with the humerus during flexion and extension. The head of the radius also articulates peripherally with the radial notch of the ulna.

The neck of the radius is a limiter of the head of the radius and the tuberosity of the radius is distal to the medial part of the neck and marks the boundary between the proximal end (head and neck). The radial neck has an angle of 15° with respect to the longitudinal axis. (Dalley et al., 2022). The joint capsule with capsuloligamentous joints that contribute to the static stability of the elbow include the anterior, posterior, and medial and lateral joint capsules. (Part et al., 2021). The ligaments form the complex thickening system of the medial and lateral region of the capsule, being responsible for 70% of the containment of distraction of the joint, in addition to 30% of the stability in varus and 40% in valgus.

The medial ligamentous complex originates in the lower middle area of the medial epicondyle and adopts a fan shape. This is made up of three fascicles, anterior medial collateral ligament, posterior or Bardinet and transverse or Cooper's ligament. (Chanlalit et al., 2023).

The lateral ligamentous complex is composed of 4 ligaments, lateral ulnar collateral, radial collateral, annular collateral and accessory collateral. The ligaments, lateral ulnar collateral and radial collateral originate at an isometric point in the anterior region of the lateral epicondyle, maintaining a constant tension throughout the flexion-extension arc of the elbow. The accessory collateral ligament extends from the annular ligament to the supinator crest. Finally, the annular ligament surrounds the radial head, with insertions on the anterior and posterior borders of the minor sigmoid fossa. Its anterior portion is tense in supination and the posterior portion in pronation. (Tortora et al., 2021).

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Flexion-extension and pronosupination movements are carried out by the action of the muscles that surround the elbow joint. Flexion is carried out by three muscles, the brachialis anterior; being the primary flexor of the forearm, the biceps brachii muscle; its contraction produces a flexor action when the forearm is in a neutral position (supination) and the brachioradialis muscle; it acts as a stabilizer when the forearm is mobile, and as a forearm flexor when it is fixed.

The primary extensor of the elbow is the triceps brachii muscle and is made up of three heads: long, lateral and medial. The muscular effectiveness of the triceps brachii depends on the position of the elbow. Between 20° and 30° of flexion, the action of the triceps brachii muscle is maximum, decreasing in favor of joint stabilization. In full extension of the elbow, the force exerted by the triceps brachii muscle tends to posteriorly dislocate the ulna. When acting on the flexed elbow, the dislocation component is nullified. Another extensor muscle is the anconeus, which is involved in regulating the extension and stabilization movement of the elbow.

The pronosupinator muscles are four, short and flat muscle; whose action is to uncoil, long muscle; which inserts into the apex of a curve and the supinator muscles. The supinator muscle, coiled around the neck of the radius and inserted into the supinator fossa of the ulna; biceps brachii muscle, is inserted at the apex of the supinator curve at the level of the radial tuberosity, the maximum effectiveness of this muscle occurs when the elbow is at an angle of 90°. The biceps brachii muscle has the most power of all the muscles that act in pronosupination.

The pronator quadratus muscle is coiled around the lower end of the ulna and acts to "unwind" the ulna in relation to the radius. Pronator teres muscle, inserted at the apex of the pronator curve, its moment of action is weak. (Netter, 2023). The flexion-extension movement is carried out through an axis, it is carried out by the humero-ulnar and humero-radial joints. The normal range of motion ranges between 0° and 140-146° of flexion and increases up to 160°, which is the maximum flexion. However, between 30° and 130° of arc of motion is performed in daily activities and is known as the functional arc of the elbow.

Bending movements are limited by factors such as; contact between the brachial and antebrachial muscle masses as a result of contraction during active flexion, bony collision between the radial head and the coronoid with the bottoms of their respective housing fossae, tension of the posterior capsule and the posterior fascicles of collateral ligaments, passive tension of the triceps brachii muscle, limited extension movements, contact of the peak of the olecranon with the bottom of the olecranon fossa, tension of the capsule and anterior fascicles of the collateral ligaments and passive tension of the flexor muscles.

To perform the pronosupination movement, the elbow is placed at 90° of flexion. Pronation movement is defined as medial rotation that places the thumb inward and the palm of the hand downward.

Supination is the movement that brings the thumb outward and the palm of the hand upward. The range of motion for pronosupination is around 160-170°, divided between pronation (80°) and supination (85°).

The pronosupination movement requires two joints, the proximal radio-ulnar and the distal.

Elbow pathology and rehabilitation

The human body is exposed to dislocations, sprains, sprains of joints, ligaments and other diseases, accompanied by road, work or sports accidents. These may or may not culminate in surgical intervention. In most cases, passive rehabilitation will be required, where a person or device mobilizes or immobilizes the patient's affected area.

Elbow pathologies are; fractures, dislocation and chronic instability, trauma, soft tissue injuries, infections and burns. Their rehabilitations are usually long-term, 6-12 months. (McMahon et al., 2021) and (Verstuyft et al., 2021). In the case of the elbow joint, it is subjected to a pre-established range of angular motion for a certain period of time. (Segnini et al., 2020). Rehabilitation of injuries is achieved by controlling the mobility of the elbow, to simultaneously recover joint range and muscle strength, in flexion-extension and in pronosupination. (Leal, 2021).

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The treatment methods provided by the therapist are usually manual with the use of various mechanical tools, that is, they are rehabilitation exercises for long days of therapeutic work, of great resistance and arduous rehabilitation work. (Ibarra, 2020) and (Graves, 2024).

In the international market, there are patents for elbow rehabilitators with different configurations that can use linear springs, torsion, pneumatics, electronics, hydraulics and mechatronics to control the movements of the elbow joint, which have evolved from mechanical to advanced mechatronic systems with autonomy that are programmed to be friendly in control by the patient, who possess a certain degree of mobility. (Segnini, et al., 2020).

An orthosis is a device applied externally to the body to improve its musculoskeletal function; it can be classified as static and dynamic. (Alvarado Huaranga et al., 2023).

There are three types of elbow rehabilitator orthoses; continuous passive motion rehabilitator (continuous motion reduces stiffness and pain), range of motion rehabilitator (designed for people with elbow stiffness), and dynamic flexion and extension rehabilitator (devices that allow movement of weakened muscles).

The dynamic orthoses that exist on the market focus on a single movement, flexion-extension, leaving aside the pronation-supination movement.

The only devices that cover these two movements are exoskeletons, which are usually imported and have high acquisition and maintenance costs and require levels of specialization in their handling. (Segnini, et al., 2020), therefore, it is of utmost importance to develop orthoses that are capable of meeting this need in an accessible way.

Investigation methodology

This research had a mixed approach, applying both quantitative and qualitative technologies, using systematic processes, as well as records and estimated data.

The objective of this research was to design a dynamic elbow orthosis using the finite element method as an optimization tool, for sustainable rehabilitation purposes in adults.

For this, the application of the quantitative method was relevant in the identification of control variables involved in previous studies such as; anthropometric measurements, ranges of mobility, biomechanical parameters, mechanical design and rehabilitation control.

The characterization of technical data obtained from human anatomy was transformed into biomechanical models, optimizing the design of the elbow orthosis in a sustainable development system. The records of results obtained by different Companies and medical suggestions from health personnel were considered as the application of the qualitative method that allowed the possibility of obtaining results from the estimation of variables, which played an important role in decision-making for control of rehabilitation.

The operational data resulting from this research determined special adjacent requirements such as an uncertainty in the way the orthosis adapts to the needs of each patient, among others. Finally, using the mixed method, an analysis of the control variables was carried out to allow the optimization of the model based on mechanical stresses in each component by the finite element method.

From the results obtained, a discussion of the results generated was carried out on the technological proposal that meets the parameters of sustainable development and the optimization of materials per element of the orthosis system.

Elbow biomechanics

Detailed knowledge of the biomechanics of elbow function is essential for the clinician to effectively treat pathological conditions affecting the elbow joint. (Nordin et al., 2020).

The cortical bone can support greater stress in compression, approximately 190 MPa and in tension it supports around 130 MPa, shear force 70 MPa, Young's Modulus of 17 GPa when the load is longitudinal or axial and when it was transversely its Young's modulus is 11 GPa.

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Cancellous or trabecular bone resists less load, 50 MPa in compression and 8 MPa in tension, Young's Modulus of 0.0-0.4 GPa.

Cancellous bone is up to 5 times more ductile than cortical bone, approximately 25% denser, and 5-10% more rigid. (Nordin et al., 2020).

The maximum force that a muscle can develop is 0.25 to 0.6 MPa. (Rueda, 2021).

Elbow kinematics in daily life are in the range for the case of flexion-extension of 30°-130° and for the case of pronation-supination around 50° for pronation and 50° for supination. Contractures are greater than 30° causing discomfort that causes loss of movement

A static analysis was carried out considering the positioning of the elbow at an angle of 90° and in supination, at the ends of the arm (wrist and hand), shown in figure 3. For this analysis, a mass of 12.5 kg was placed, which was determined based on NOM-036-1-STPS-2018 as the maximum established mass that a person can permissibly carry, that is, the maximum load allowed within the biological parameters is 25 kg, in both arms. (Leal, 2020) and (Secretaría de Trabajo y Previsión Social 2024).

Box 1

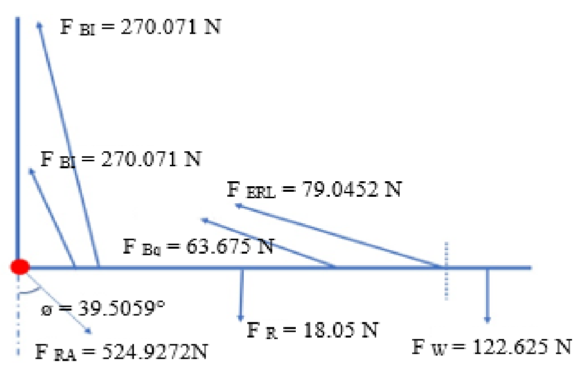

Figure 1
Free body diagram with muscle forces and resultant force at the elbow

The proposed elbow prosthesis consists of two mechanisms, the first consists of a support in which the palm of the hand is fixed and performs a semicircular movement, this range of movement was 160°, divided into 80° in pronation and 80° in supination, the second mechanism was considered fixed to the elbow flexion-extension mechanism.

The muscles for isometric exercises were considered as if it were a ratchet mechanism; This mechanism works to prevent the rotation of an axle in one direction and allow rotation in one direction only. It consists of an external or internal toothed wheel with oblique teeth and a claw that acts against the teeth.

It can be operated by means of a spring. or by the own weight of the nail, this mechanism allows us to regulate the movement ensuring a single direction of rotation.

Results

A finite element simulation of the 90° band fastener gives us a Von-Mises stress shown in Figure 2.

Box 2

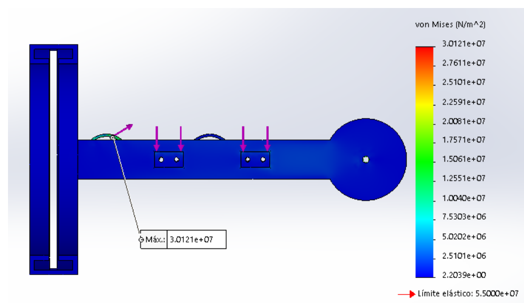

Figure 2
Maximum Von-Mises stress at 90°

An analysis of the piece of the upper part of the arm, when the forces acting on the piece that is fixed at the height of the biceps were studied to determine the forces of the elastic band that is fixed on the support, see figure 5.

Box 3

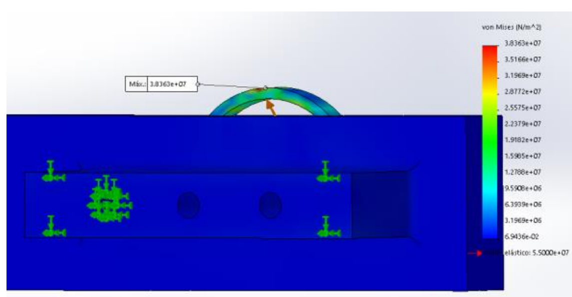

Figure 5
Stress when the elbow was at 90°

The main forces on the mechanism are formed on the support of the elastic band, considering a critical part of the mechanism, the forces generated by the ratchet shown in Figure 4.

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https://doi.org/10.35429/JOHS.2024.11.30.1.9

Box 4

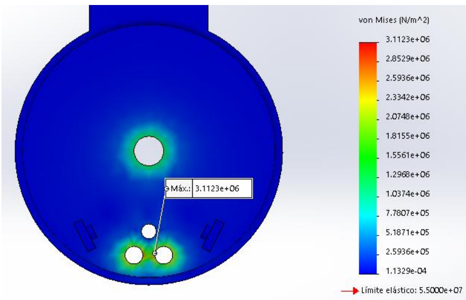

Figure 4
Stress in the mechanism generated by the ratchet

The analyzes carried out on the sprocket helped to determine the maximum stress, when the 90° elbow mechanism is fully extended, see figure 5.

Box 5

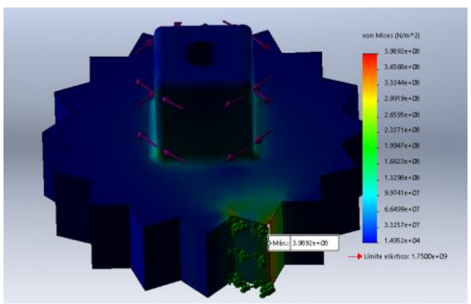

Figure 5
Stress on the sprocket when the mechanism is in the extended position and the elbow at 90°

The maximum force to which the fingernail is subjected in an extended position and the elbow at 90° generates a maximum stress of 14,465 MPa; however, as rehabilitation progresses, the patient must regain strength and mobility, increasing the load until reaching a maximum of 12.5 kg per upper extremity.

The elbow orthosis is composed of the following critical parts that make up the driving mechanism with their maximum forces shown in table 1.

Box 6

Table 1
Maximum stress in each piece.

Part name	Maximum generated stress
Forearm piece	30.121 MPa
Upper arm piece	38.363 MPa
Cogwheel	800.93 MPa
Second position nail	110.58 MPa
Third position nail	14.465 MPa

The mechanical characteristics of the materials for 3D printing are shown in table 2.

Box 7

Table 2
Characteristics of materials for 3D printing

Material	Young's modulus	Elastic limit	Flexural strength
ABS	2300 MPa	45 MPa	65 MPa
PLA	2346.5 MPa	49.5 MPa	103 MPa
TPU	26 MPa	8.6 MPa	4.3 MPa
PETG	2200 MPa	53 MPa	79 MPa

With the results obtained from the maximum efforts, it was determined that PLA and PETG were the appropriate materials for the manufacture of the body of the mechanism.

The ratchet mechanism must withstand the maximum forces generated in the gear wheel, which is why several materials were proposed for its manufacture such as; AISI 1045 steel, 1.6582 steel, 1.6587 steel, 1.6657 steel and 1.8519 steel.

The elastic limit of each material would not be able to withstand the stress generated in the ratchet mechanism, however, each one is characterized by the type of heat treatment to which it can be subjected to obtain better resistance, meeting the specifications. see table 3.

Box 8

Table 3
Characteristics of the steels for manufacturing the ratchet

Steel name	Tensile strength (MPa)	Elastic limit (MPa)	Heat treatment Tensile strength (MPa)
1045 AISI	630	530	1583
1.6582 Steel	900	600	1200
1.6587 Steel	980	685	1270
1.6657 Steel	1176	931	1180
1.8519 Steel	1100	900	1300

According to a proposed safety factor of 1.5 for the manufacturing of the parts, the nails could be manufactured by 3D printing, with materials such as PLA or PETG which provide a safety factor of 3.42 or 3.66 respectively. In the case of the nail, an AISI 4140 steel or a 1018 steel can be used.

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These two steels are widely used in the industry with an elastic limit of 390 MPa and the second of 370 MPa, with safety factors of 3.52 and 3.35 respectively, exceeding at all times the design feasibility and optimizing the technical specifications of each material (Hernández Soriano, 2023).

Conclusions

The results of the prototype of a dynamic orthosis for elbow rehabilitation managed to reproduce the flexion-extension and pronosupination movements, with a purely mechanical mechanism, which reduces the complexity of the prototype with a positive impact to cover the sustainable development parameters pursued in the objectives of mechanical design.

The proposal to carry out a design that covered the functionality and mechanical stresses per finite element that allow the selection of appropriate materials for the manufacture of each element ensures that theoretically the mechanism would not present failures during the rehabilitation activities.

Declarations

Conflict of interest

All the authors declare no interest conflict. They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this article.

Author contribution

Castillo-Aguirre, Alfredo Humberto: Contributed to the project idea, research method and technique, about to develop all the project.

Baez-Guzman, Ricardo: Apported the studies, and bases of the finite element of the orthoses.

Cruz-Gomez, Marco Antonio: Supported the simulation of the Project by the software ANSYS

López-Aguilar, Genaro Roberto: Resarched mutiple papers and information about the topic and verify the empleability

Hernández-Soriano José Luis: Contributed with the bases of the funtion and empleatibility of the orthoses of elbow with his tesis.

Availability of data and materials

The obtained data, about the efforts, and multiple forces, that can be repercute in the orthoses, in the case of the steels, that was mention in the project, can be upgrade with a thermal treatment, specifications: Steel 1045 AISI, Tensile strength (MPa): 630, Elastic limit (MPa): 530, Heat treatment Tensile strength (MPa): 1583; 1.6582 Steel (900, 600, 1200); 1.6587 Steel (980, 685, 1270); 1.6657 Steel (1176, 931, 1180); 1.8519 Steel (1100, 900, 1300).

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Abbreviations

CAD	Computer Aided Design
CAE	Computer Aided Engineering
CAM	Computer Aided Manufacturing

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Article

Performance comparison in optimization algorithms for heart disease detection model

Comparación de rendimiento en algoritmos de optimización para el modelo de detección de enfermedades cardiovasculares

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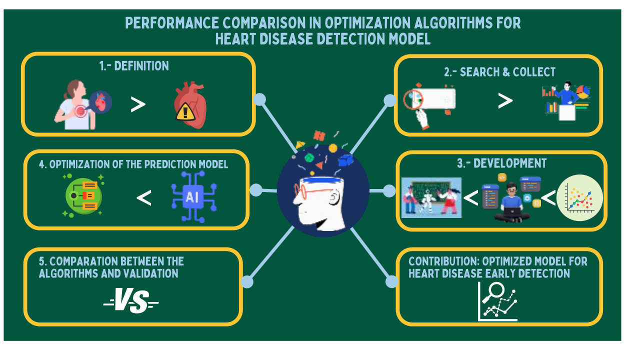
Abstract

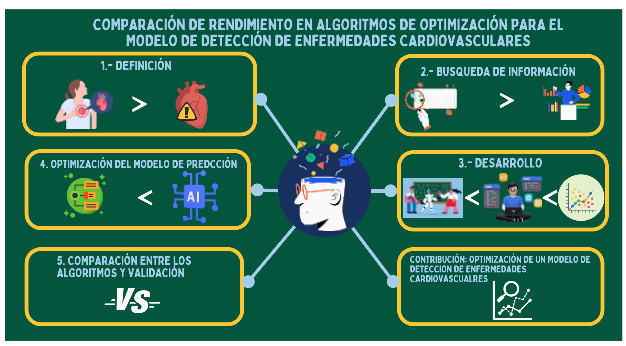
Cardiovascular diseases are the leading cause of mortality worldwide, necessitating robust predictive models for early diagnosis. This study evaluates and compares the performance of support vector machine (SVM) models optimized using genetic algorithm (GA) and particle swarm optimization (PSO) techniques. A publicly available dataset with health-related features was used, involving preprocessing steps like handling missing values, encoding categorical variables, and feature scaling. The models were assessed based on cross-validation accuracy, test accuracy, and F1 score. Convergence plots were generated to visualize the optimization process. Results highlight the effectiveness of GA and PSO optimizations in enhancing SVM model performance for predicting cardiovascular health outcomes. The comparison provides insights into the relative strengths of each optimization method, guiding the development of advanced predictive models for heart diseases diagnosis and management.



Cardiovascular disease; SVM; optimization algorithm

Resumen

Las enfermedades cardiovasculares son la principal causa de mortalidad a nivel mundial, lo que requiere modelos predictivos robustos para un diagnóstico temprano. Este estudio evalúa y compara el rendimiento de los modelos de máquinas de soporte vectorial (SVM) optimizados utilizando técnicas de algoritmo genético (GA) y optimización por enjambre de partículas (PSO). Se utilizó un conjunto de datos público con características relacionadas con la salud, que incluyó preprocesamiento de valores faltantes, codificación de variables categóricas y escalado de características. Los modelos se evaluaron en función de la precisión de validación cruzada, precisión de prueba y puntuación F1. Se generaron gráficos de convergencia para visualizar el proceso de optimización. Los resultados destacan la efectividad de las optimizaciones GA y PSO en la mejora del rendimiento del modelo SVM para predecir resultados de salud cardiovascular. La comparación proporciona información sobre las fortalezas de cada método de optimización, guiando el desarrollo de modelos predictivos avanzados para el diagnóstico y la gestión de ECV.



Enfermedades cardiovasculares; SVM; Algoritmo de optimización

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Introduction

Cardiovascular diseases (CVDs) are the leading cause of mortality worldwide (Mandala, 2024), (Sandeep Tomar, 2024) and (Ahmad, 2023). The risk factors include chest pain, resting blood pressure, cholesterol levels, and fasting blood sugar levels. Resting ECG, maximum heart rate, exercise-induced angina, and the pqrst segment also play significant roles in cardiovascular risk assessment.

These data highlight the need for a comprehensive approach to evaluating and managing cardiovascular risk.

In the field of CVD diagnosis, numerous studies and approaches have been developed, each with its strengths and challenges. Machine learning models, such as neural networks and decision trees, have demonstrated high accuracy in predicting heart diseases by analyzing large volumes of clinical data (Ramkumar, 2023), (Ogunpola, 2024) and (Nelson, 2023).

Additionally, signal processing techniques and medical imaging, such as echocardiography and magnetic resonance imaging, have provided valuable data to improve early detection. However, variability in data quality and the lack of standardization in data sets can lead to inconsistent results.

Another challenge is the complexity and cost of implementing some of these technologies in everyday clinical settings (Nagavelli, 2024). Despite these obstacles, the integration of multiple approaches and the continuous improvement of detection algorithms promise significant advancements in diagnosing and managing cardiovascular diseases (Krittanawong, 2017) and (Ramesh, 2024).

Comparing detection algorithms is crucial to identifying efficient methods in different clinical contexts and evaluating and comparing performance to highlight best practices (Immanuel, 2024).

This facilitates the development of more accurate and accessible diagnostic tools, ultimately optimizing clinical decision-making and reducing cardiovascular disease mortality.

To enhance the performance of detection models, this article proposes a comprehensive comparative analysis of three SVM models: a standard SVM, an SVM enhanced using GA, and an SVM enhanced using PSO, chosen for their distinct robust optimization approaches, proven effectiveness, and relative simplicity in implementation to enhance model performance in predicting.

This comparison aims to identify the most effective optimization technique for improving model performance in predicting cardiovascular diseases.

This work is presented as follows. Section two shows the context where the information is analyzed. In section three, the methodology presents the models to be implemented. In section four, the simulation results are examined and discussed. Finally, the conclusions of the work are presented in section five.

Analyzed information

EDA on Cardiovascular health dataset

For this study, a public heart disease database was utilized (Kaggle, 2024), encompassing various variables. Variables like age, sex, chest pain type, resting BP, cholesterol, FastingBS, RestingECG, Max HR, Exercise Angina, Oldpeak, ST_Slope, and the target variable HeartDisease. The dataset was balanced before use to ensure an equal number of male and female participants.

1. Distribution of the Target Variable (Heart Disease):

The Figure 1 shows the distribution of the "HeartDisease" variable, with categories coded as 0 (absence) and 1 (presence). The bar chart indicates a nearly balanced distribution, with slightly more participants without heart disease (category 0).

This near balance is advantageous for analyzing the dataset and building predictive models, as it helps ensure that the outcomes are not significantly biased towards one category.

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Box 1

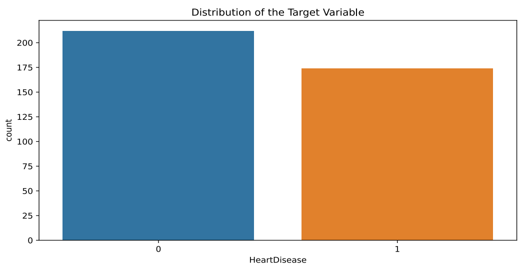

Figure 1
Distribution of target variable

1. Distribution of Chest Pain Type:

The Figure 2 shows the distribution of the "ChestPainType" variable with categories coded as 0 (asymptomatic), 1 (atypical angina), 2 (non-anginal pain), and 3 (typical angina). The bar chart reveals that category 0 is the most common, while category 3 is the least frequent. Categories 1 and 2 have moderate occurrences.

Box 2

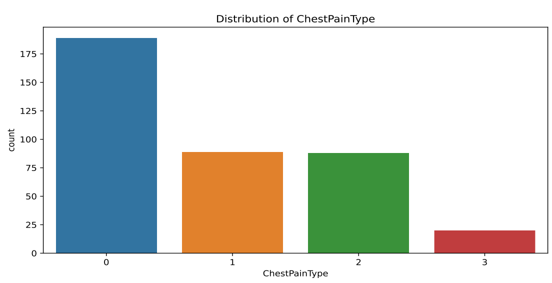

Figure 2
Distribution of type chest pain

2. Distribution of Sex:

The Figure 3 shows the distribution of the "Sex" variable in the dataset; This bar chart illustrates an equal distribution between the number of males and females. The bars representing males (coded as 1) and females (coded as 0) are of equal height, indicating that there is a balanced representation of both sexes in the dataset.

Box 3

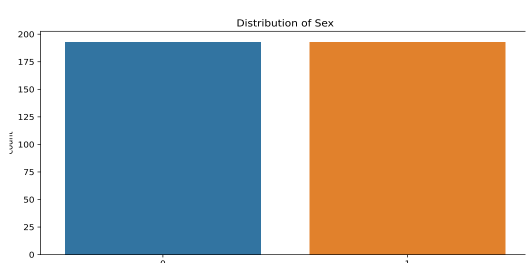

Figure 3
Distribution of sex

3. Distribution of Resting ECG:

Figure 4 shows the distribution of the "RestingECG" variable, with categories coded as 0 (left ventricular hypertrophy), 1 (normal), and 2 (ST-T wave abnormality). The bar chart indicates that category 1 (normal) is the most common among participants. Category 0 (LVH) has a moderate number of occurrences, while category 2 (ST-T wave abnormality) is the least frequent.

Box 4

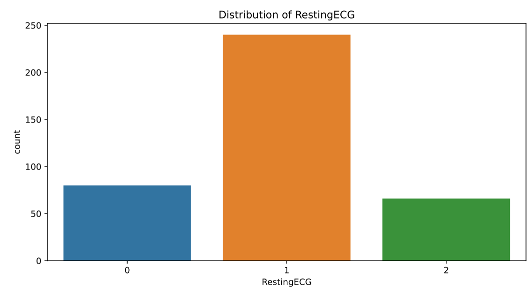

Figure 4
Distribution of resting ECG

4. Distribution of ST Slope:

Figure 5 shows the distribution of the "ST Slope" variable, with categories coded as 0 (downsloping), 1 (flat), and 2 (upsloping). The bar chart reveals an unequal distribution: category 1 (flat) is the most common, followed by category 2 (upsloping), while category 0 (downsloping) is the least frequent among participants.

Box 5

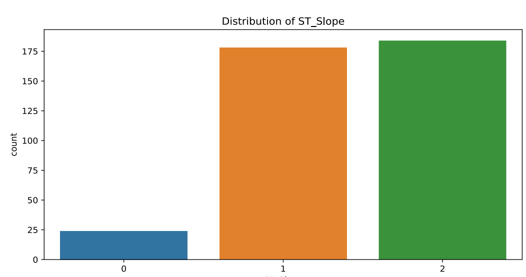

Figure 5
Distribution of ST_Slope

6. Correlation Matrix:

The correlation matrix provides a heatmap representation of the relationships between various features in the dataset. Key observations include:

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Box 6

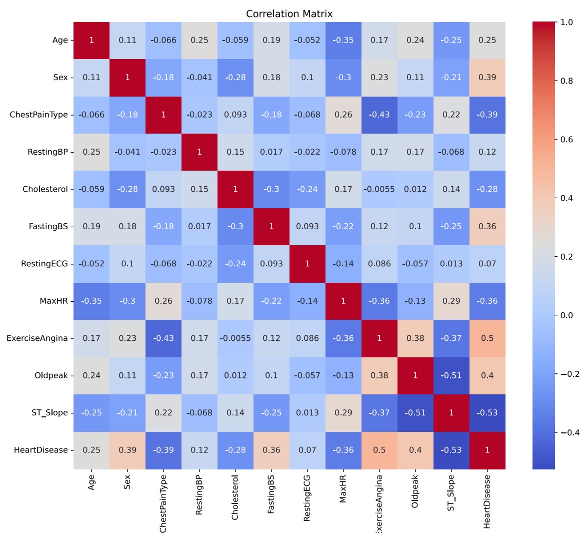

Figure 6
Correlational matrix

Strong positive correlation

- HeartDisease and Sex: There is a strong positive correlation between HeartDisease and Sex. This suggests that the likelihood of heart disease is higher in one gender compared to the other. Typically, a higher correlation with Sex often indicates that males (coded as 1) are more likely to have heart disease.

Strong negative correlation

- ST_Slope and HeartDisease: There is a strong negative correlation between ST_Slope and HeartDisease. This implies that as the ST_Slope value increases (from downsloping to flat to upsloping), the likelihood of heart disease decreases.

Moderate positive correlation

- FastingBS and HeartDisease: There is a moderate positive correlation between FastingBS (Fasting Blood Sugar) and HeartDisease. This indicates that higher fasting blood sugar levels are associated with a greater likelihood of heart disease.

- Age and HeartDisease: Age also shows a moderate positive correlation with HeartDisease, suggesting that older individuals are more likely to have heart disease.

Moderate negative correlation

- MaxHR and HeartDisease: Maximum Heart Rate (MaxHR) has a moderate negative correlation with HeartDisease. This suggests that individuals with a higher maximum heart rate are less likely to have heart disease.

Other correlations

- Cholesterol and Age: There is a positive correlation between Cholesterol and Age, indicating that older individuals tend to have higher cholesterol levels.

- RestingBP and Age: Resting Blood Pressure (RestingBP) shows a positive correlation with Age, suggesting that older individuals tend to have higher resting blood pressure.Weak of no correlation

- RestingECG and HeartDisease: The correlation between RestingECG and HeartDisease is relatively weak, indicating that resting ECG results may not be a strong predictor of heart disease in this dataset.

These visualizations provide valuable insights into the dataset, highlighting the distribution of key categorical variables and the relationships between various features.

This information is crucial for understanding the data and preparing it for further analysis, such as training a SVM model for predicting cardiovascular health outcomes.

Methodology

This study aims to evaluate and optimize SVM models for predicting cardiovascular health outcomes.

The methodology involves important steps shown in the following diagram:

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Box 7

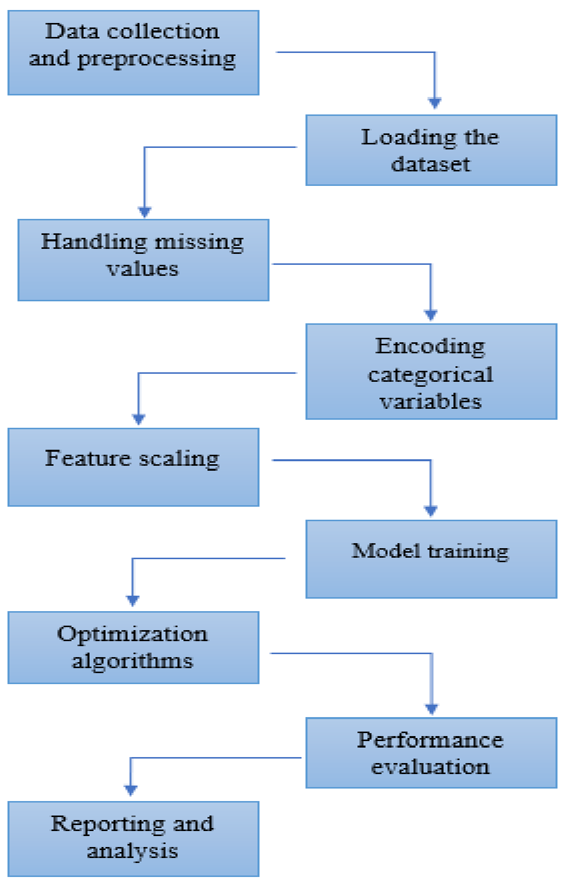

Figure 7
Methodology diagram

Data collection and preprocessing

The dataset used in this study was obtained from a publicly available source containing various features related to cardiovascular health. The data preprocessing steps include:

- Loading the Dataset: The dataset is imported into a Pandas DataFrame for further processing.

- Handling Missing Values: Any missing values in the dataset are removed to ensure completeness.

- Encoding Categorical Variables: Categorical variables, such as chest pain type, resting ECG, ST slope, sex, and exercise-induced angina, are converted into numerical format using label encoding.

- Feature Scaling: To ensure that all features contribute equally to the model, feature values are normalized using standard scaling.

Model training

The preprocessed data is split into training and testing sets to evaluate the model's performance. The training set is used to train the SVM models, while the testing set is used for validation. An initial standard SVM model is trained without any optimization to serve as a baseline for comparison.

Optimization algorithms

Two optimization techniques are employed to enhance the performance of the SVM models: GA and PSO. The methodology in this section is presented in the following diagram:

Box 8

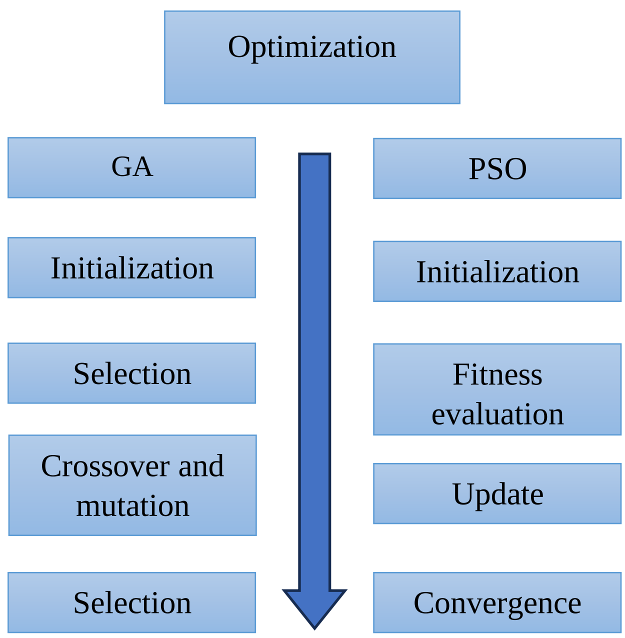

Figure 8
Optimization diagram

GA:

- Initialization: A population of candidate solutions (SVM parameters) is generated randomly.
- Selection: The fittest individuals are selected based on their performance (fitness) on the training set using cross-validation accuracy.
- Crossover and Mutation: Selected individuals undergo crossover and mutation operations to create new offspring, introducing variability and exploring the search space.

- Evaluation: The new population is evaluated, and the process repeats for several generations until convergence.

Box 9

Table 1

Hyperparameters of the GA

Parameter	Value
Population	50
Generations	20
Crossing	0,6
Mutation	0,3
Tournament	3

Box 10

Table 2

Mutation parameters

Parameter	Value
mu	0
Sigma	1
Probability of mutating each attribute	0,2

PSO:

- Initialization: A swarm of particles (candidate solutions) is initialized with random positions and velocities.
- Fitness Evaluation: Each particle’s position is evaluated using cross-validation accuracy on the training set.
- Update: Particles adjust their velocities and positions based on their own best position and the swarm's global best position, iteratively improving their solutions.
- Convergence: The process continues until the swarm converges to an optimal solution.

Box 11

Table 3

Hyperparameters of the PSO

Parameter	Value
No. of particles	50
Dimensions	2
Cognitive Coefficient (c1)	0,5
Social coefficient	0,3
Lower limit	[0.1, 0.0001]
Upper limit	[10, 1]
Iterations	20

Performance evaluation

The performance of the standard SVM, GA-optimized SVM, and PSO-optimized SVM models is evaluated using several metrics:

Cross-Validation Accuracy: This metric evaluates the model's performance on the training set using cross-validation, providing an estimate of how well the model generalizes.

Test Accuracy: The accuracy of the model is evaluated on the unseen test set to measure its predictive performance.

F1 Score: The F1 Score is calculated to assess the model's balance between precision and recall, especially important in imbalanced datasets.

Reporting and analysis

The results are reported in tabular and graphical formats, including convergence plots showing the fitness values across generations/iterations and performance metrics for each model. Discrepancies between cross-validation accuracy and test accuracy are discussed, considering factors such as overfitting and variability in the data.

Results

The provided tables and Figure 7 illustrate the performance and convergence of three different SVM models: Standard SVM, GA Optimized SVM, and PSO Optimized SVM. The Table 4 shows the convergence of the fitness values across 20 generations/iterations for each model.

The Table 2 presents the performance metrics, including Cross-Validation Accuracy, Test Accuracy, and F1 Score.
Convergence data

The Standard SVM model has a constant fitness value of 0,851852 across all 20 iterations. This indicates that the model's performance does not improve through optimization because it is not subjected to any optimization algorithm.

The GA Optimized SVM shows an initial fitness value of 0,748148, which improves over the generations, reaching a fitness value of 0,859259 by the 20th generation. This improvement reflects the effectiveness of the Genetic Algorithm in optimizing the model parameters, resulting in better performance.

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The PSO Optimized SVM starts with an initial fitness value of 0,800000. Throughout the iterations, there is a noticeable improvement, with the fitness value reaching 0,886667 by the 20th iteration. The PSO algorithm demonstrates its capability to enhance the model performance through iterative optimization.

Box 12

Table 4

Convergence data

Generation/Iteration	Standard SVM	GA	SWAR optimization
1	0,851852	0,748148	0,8
2	0,851852	0,777778	0,803704
3	0,851852	0,807407	0,833333
4	0,851852	0,814815	0,833333
5	0,851852	0,837037	0,833333
6	0,851852	0,837037	0,833333
7	0,851852	0,837037	0,866667
8	0,851852	0,840741	0,866667
9	0,851852	0,840741	0,866667
10	0,851852	0,844444	0,866667
11	0,851852	0,848148	0,866667
12	0,851852	0,848148	0,866667
13	0,851852	0,848148	0,866667
14	0,851852	0,859259	0,866667
15	0,851852	0,859259	0,866667
16	0,851852	0,859259	0,866667
17	0,851852	0,859259	0,866667
18	0,851852	0,859259	0,866667
19	0,851852	0,859259	0,866667
20	0,851852	0,859259	0,866667

Box 13

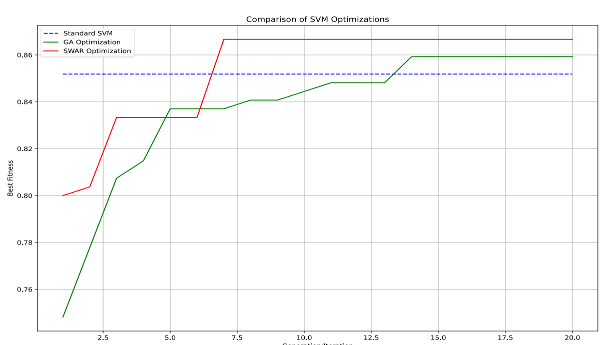

Figure 9

Convergence graphic

Box 14

Table 5

Performance metrics

Model	Cross-Validation Accuracy	Test Accuracy	F1 Score
Standard SVM	0,851852	0,853448	0,841121
Normal SVM	0,859259	0,844828	0,83018
PSO Optimized SVM	0,822222	0,87931	0,86792

Cross-validation accuracy

- The Standard SVM has a Cross-Validation Accuracy of 0,851852.
- The GA Optimized SVM shows a slightly higher Cross-Validation Accuracy of 0,859259.
- The PSO Optimized SVM has a Cross-Validation Accuracy of 0,822222, which is lower than the Standard SVM and GA Optimized SVM. This discrepancy suggests that while SWAR optimization improves the model performance during the optimization phase, it might notgeneralize as well as expected in cross-validation.

The tests were conducted using Jupyter notebook on an HP Omen 17-AN101LA computer, which features a 17.3-inch display, an Intel Core i7-8750 processor, 16 GB of RAM, a 1 TB hard drive, and a 4 GB NVIDIA GeForce GTX 1050 graphics card, operating under Windows 10 Home.

Conclusions

The results demonstrate that while the Standard SVM maintains a consistent performance without optimization, the GA and PSO optimizations enhance the model's performance. However, the PSO optimization shows superior results in terms of both Test Accuracy and F1 Score, indicating better generalization and balanced performance.

The discrepancy between the Cross-Validation Accuracy and Test Accuracy/F1 Score for the PSO Optimized SVM suggests the need for careful consideration of overfitting and generalization capabilities when applying optimization algorithms.

These findings emphasize the importance of evaluating machine learning models using multiple metrics and across different phases of the optimization process to gain a comprehensive understanding of their performance.

Declarations

Conflict of interest

The authors declare no interest conflict. They have no known competing financial interests or personal relationships that could have appeared to influence the article reported in this article

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Author contribution

Rojas, Rafael: Contributed to the project idea, research method and technique.

Seseña, Hiram Contributed to the project with the validation of the experiment.

Zuñiga, Mariana Contributed to the project investigating.

Martínez, Moises Contributed to the project with review and editing

Availability of data and materials

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Abbreviations

SVM	Support vector machine
GA	Genetic Algorithm
PSO	Particle swarm optimization
CVD	Cardiovascular disease
EDA	Exploratory Data Analysis
ECG	Electrocardiogram
BP	Blood Pressure
HR	Heart Rate

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Article

Standardized tool for the identification and control of risks associated with tasks in the work environment

Herramienta estandarizada para la identificación y control de riesgos asociados con las tareas en el ambiente de trabajo

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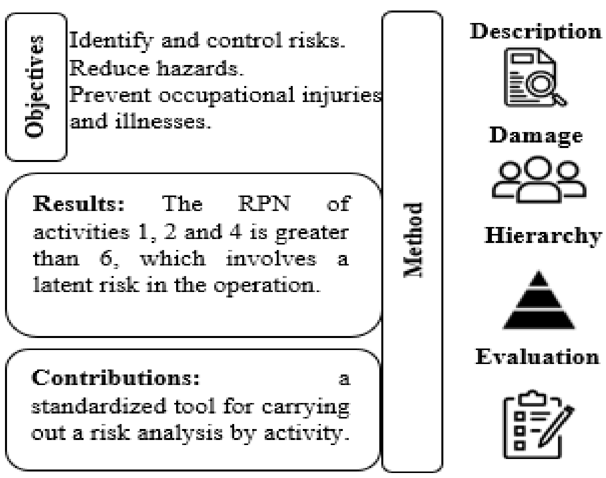
Abstract

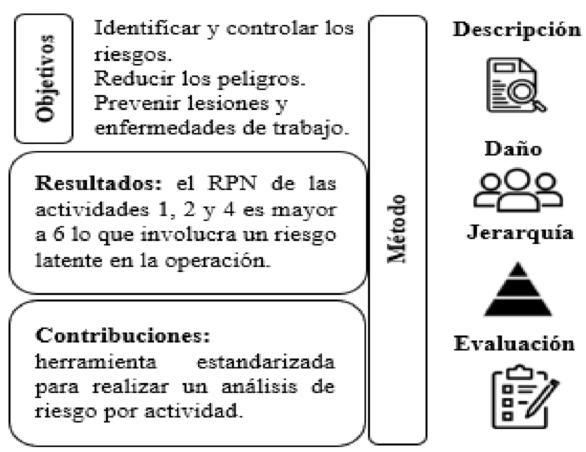
Performing a risk analysis by activity allows you to identify and control the risks associated with tasks in the work environment, reduce workplace hazards associated with the risks, as well as prevent or reduce injuries and illnesses in the worker. This article presents a standardized tool to perform a risk analysis by activity, each of the proposed stages is detailed, such as the description of the activity, identification of the risks present, description of the risks, identification of damage or potential effect, risk control hierarchy, identification of current controls, risk assessment and implementation of actions. Each of the stages takes you by the hand to systematically carry out a risk analysis by activity. Finally, the effectiveness of the tool implemented in carrying out a risk analysis is shown.



Risk analysis by activity, Hierarchy of Risk Control, Safety and hygiene

Resumen

Realizar un análisis de riesgos por actividad permite identificar y controlar los riesgos asociados con las tareas en el ambiente de trabajo, reducir los peligros del lugar de trabajo asociados con los riesgos, así como, prevenir o reducir las lesiones y enfermedades en el trabajador. En el presente artículo se presenta una herramienta estandarizada para realizar un análisis de riesgo por actividad, se detallan cada una de las etapas propuesta, tal como la descripción de la actividad, identificación de los riesgos presentes, descripción de los riesgos, identificación de daño o efecto potencial, jerarquía de control de riesgo, identificación de controles actuales, evaluación de riesgos e implementación de acciones. Cada una de las etapas lo llevan de la mano para realizar de manera sistemática un análisis de riesgo por actividad. Finalmente se muestra la efectividad de la herramienta implementada en la realización de un análisis de riesgo.



Análisis de riesgo por actividad, Jerarquía de control de riesgos, Seguridad e higiene

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Introduction

In the world of work, the identification of risks is crucial to safeguard all operational processes and risk analysis by activity is an instrument that allows us to distinguish, evaluate and mitigate or reduce all those risks associated with each of the activities within the business environment.

The concept of risk refers to the probability of an event, accident, or dangerous situation occurring that causes injuries, damages, or diseases that a person may be exposed to (Occupational Health and Safety Assessment Series, 2007). On the other hand, it is important to understand hazards, which refer to those inherent conditions capable of causing damage to people's health or damage to property (Open and Distance University of Mexico, 2024).

The safety of workers is very important, therefore, carrying out risk analysis for each of the activities performed allows the different hazards that may arise in each of the tasks to be clearly and accurately identified.

These analyses will help with the implementation and improvement of mitigation, prevention and correction measures of the risks, significantly reducing the probability that any type of identified risk will occur. In other words, accidents will be reduced and therefore the injuries that they entail.

However, there is very little information on how to implement risk-per-activity analysis.

This lack of information leads to poor or deficient implementation of these tools. This is why this article is of great importance, as it serves as a practical guide to improve the identification, mitigation or reduction of risks.

By understanding and effectively applying these bases, not only will operating risks be reduced, but your processes will also be improved by avoiding time wastage and safeguarding the safety of personnel. Many institutions lack these analyses, and this absence of risk identification can lead to poor assessments, omissions of critical risks and the poor application of control measures, ultimately resulting in an accident.

Developing an article that serves as a protocol to carry out a risk analysis by activity will not only facilitate the performance of these analyses but will also provide help to continue continuously improving risk control

The intention of this article is to provide the steps necessary to develop effective risk analysis by activity. First, the importance of risk analysis for the reduction or mitigation of these is raised. Subsequently, a standardized tool will be presented to carry out these analyses, which includes the identification of the activities, the evaluation of the severity, frequency, probability and impacts that the risks may cause, and the application of control measures.

Background

Companies must observe the risks to which workers are exposed when they perform activities that generate forced postures, repetitive movements, manual handling of loads, use of tools, manual equipment and/or handling of dangerous substances, which can affect their health or cause physical limitations or death.

Under this approach, risk analysis by activity is a useful tool to determine the risks present in the operation of machinery and equipment and to implement risk mitigation strategies.

According to recent studies of occupational risks registered in the Mexican Social Security Institute related to occupational risks determined by year of occurrence, according to the 2023 data, approximately 6,332 people were at risk for not wearing personal protective equipment, 143 people for lack of adequate clothing, 986 people for using inadequate tools or equipment, 20,473 people for using some inadequate help to lift, move, roll, etc., loads and 1,169 people for inappropriate stacking, this out of a total of 358,729 people who were exposed to a risk (Secretary of Labor and Social Welfare, 2024).

This section presents some works by different authors who contributed to this project. Guisela & Montalvo (Guisela & Montalvo, 2019) investigated which work activities with a higher risk of having cases of musculoskeletal disorders occurred in areas where mostly manual activities are carried out that require physical effort for a long time, causing injuries to the trunk and upper extremities.

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Hence the importance of investigating the risk factors associated with these pathologies and thus propose measures Corrective.

Cervantes and Hernández (Cervantes & Hernández, 2023) assessed the risks of biomechanical overload, in order to conduct anthropometric measurements for a prevention-oriented workplace redesign. The study showed that among the critical activities are the manual lifting of loads, performing static forced postures, repetitive movements of limbs. Their research was able to eliminate the danger of manual lifting of loads and reduce the risk of forced postures and repetitive movements of the upper limb.

Methodology

The risk analysis by activity is a very meticulous tool that aims to identify, evaluate and mitigate the risks that arise in each of the stages of the work processes (Cortés, 2012).

The following are the steps of the proposed tool for the identification and control of risks associated with tasks in the work environment, as shown in Figure 1.

Box 1

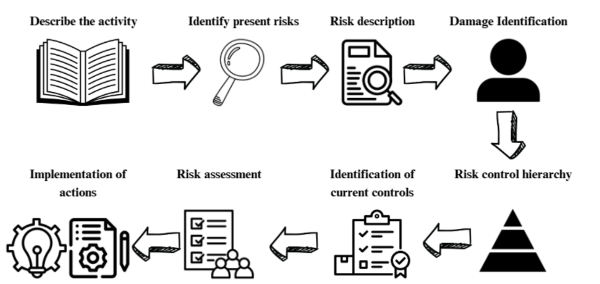

Figure 1
Steps to prepare a risk analysis by activity
Source: Own elaboration

To exemplify the standardized tool for the identification and control of risks associated with tasks in the work environment, a risk analysis is carried out by activity in the operation of a sit down electric lift truck, with a capacity of 3.5 tons, selecting only some of the activities that make up the risk analysis to exemplify the tool step by step.

The following are the stages of the standardized tool for the identification and control of risks associated with tasks in the work environment.

Describe the activity

First, each of the activities that make up a process must be defined and identified, from the simplest to the most complex, so that the risks and hazards will be evaluated.

Identify present risks

The identification of risks is crucial for conducting a risk analysis by activity, as it safeguards safety in the different work environments.

By determining the possible risks or dangers involved in each activity, accidents or problems can be prevented and therefore control measures can be taken before an incident occurs.

Risk Description

A specific and detailed description of the activity must be made, including how the danger or risk may cause or result in harm to the person when performing the task.

This description must be in accordance with the observations made by the analyst and with the help of the person who performs the activity, this collaboration between analyst and operator ensures that all the details of each process are recorded, so that the risk involved in carrying out said activity is specifically described.

Identifying the damage

The identification of damage refers to the physical effect of the risk or danger that results in an impact on the health and well-being of the person in charge of carrying out the activity. These effects can vary depending on the work environment and the person performing the task.

Risk control hierarchy

The control hierarchy aims to establish the best controls in the facility or workplace and consists of eliminating, minimizing or controlling the risks of exposure to hazards, to prevent the worker from taking individual actions that endanger him (Manuele, 2005). It is worth mentioning that controls can usually be combined at different levels to achieve an acceptable risk.

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The following types of controls are recommended in order of effectiveness, with the hierarchy clearly showing that each step is considered less effective than the previous one. Elimination is the most effective control and personal protective equipment (PPE) is the least effective, this does not mean that PPE is not useful or necessary to contribute to the safety of workers, however, if the risk is eliminated or replaced, this eliminates the need for the worker to wear any PPE, as seen in Figure 2.

Box 2

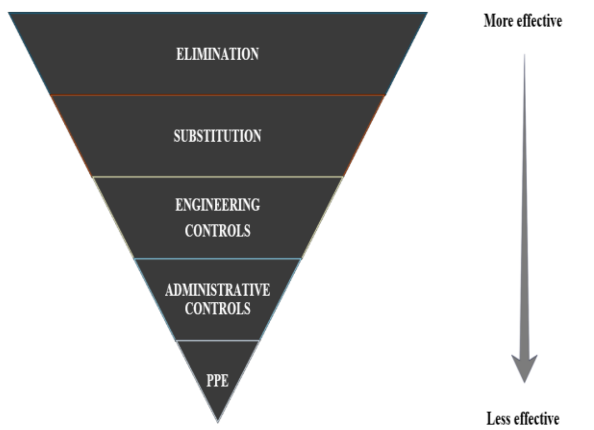

Figure 2
Hierarchy of Controls
Source: (National Institute for Occupational Safety and Health, 2024)

1. Elimination.

At this first level, alternatives are established to eliminate or suppress the risk that combats the root cause of the threats. This control is clearly the most efficient alternative to eliminate risk.

2. Substitution

Substitution together with elimination are the most efficient alternatives. At this level, the risk is not eliminated, but it is reduced to such an extent that way that the risk to which the worker is exposed is reduced.

3. Engineering controls

Ventilation systems; machine protection; sound boxes, circuit breakers, platforms and guards; Interlocks, lift tables, conveyors, and balancers, etc. are some of the engineering controls that are adopted to reduce the likelihood of risk.

4. Administrative controls

These controls are based on administrative instructions in which the worker is asked to follow some instruction or prohibit him from performing any activity, some most commonly used administrative controls are implementing warning signs, back-up alarms, beepers, labels or decals procedures, occupational safety procedures, job rotation, equipment inspections, the change of working hours, training, etc.

5. Personal protective equipment and elements

This last control is applied when it is not possible to apply any of the previous controls, there is a very wide variety of equipment and personal protection elements, for work at heights, head protection, hearing protection, respiratory protection, hand and arm protection, eye protection, among others (Secretary of Labor and Social Welfare M. , 2024).

Identification of current controls

In this section it is important to identify the controls that are implemented in the area, it is common to have some of them (Liberati, Farhad, & Dixo-Woods, 2018). In general, some of the controls that are frequently in place in the workplace are that workers already have training for personnel on topics focused on the identified risk, as well as training in the operation of machinery.

Additionally, certain designs are implemented to prevent the risks present, such as falls, hazardous materials, noise, confined spaces or manual handling. Among the controls applied to replace the risk are the reduction of energy, for example, by reducing the speed, force, amperage, pressure, temperature or noise of the machinery.

The implementation of some engineering controls on machinery or equipment such as ventilation systems, machine protection. They also find warning signs, some backup alarms, safety procedures, among others. As well as the use of some personal protective equipment. Considering that in many cases the control does not eliminate the risk, it is crucial to identify and assess these controls in order to carry out the analysis.

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Risk assessment

To assess the risk will be done according to the severity, frequency and probability of the risk with respect to a reference table. Severity, frequency and probability are generally classified on a scale of 1 to 5 or from 1 to 10, where each value is obtained by multiplying the value of the severity by the value of the frequency and the result multiplying it by the value that is assigned to the probability, the result of this operation is known as RPN (Risk Priority Number) see Table 1.

Box 3

Table 1

Steps to prepare a risk analysis by activity

		Severity					
		NM	First Aid	Waste of Time	Irreversible		
Frequency		1	3	6	10	Probability	
Monthly	1	1	3	6	10	1	Unlikely
Weekly	2	4	12	24	40	2	Possible
Diary	4	16	48	96	160	4	Likely
Hourly	6	36	108	216	360	6	True

Source: Own elaboration

The values obtained from the RPN are identified with a colour to facilitate their identification and determine the level of importance of the risk involved in the operation of the machinery.

Green identifies a minimum risk level, blue corresponds to a low risk level, yellow to a medium risk level and red to a high risk level. If the RPN value is greater than or equal to 6, risk control actions must be implemented.

Implementation of actions

This is one of the most important points of risk analysis by activity, it is the point at which additional actions or controls must be proposed to those that have been identified, in order to reduce the risk (Etherton, 2003).

Some of the actions that can be implemented are: reinforcing training on issues related to the identified risk, verifying that the systems are in optimal conditions, verifying the operation of emergency stops, placement of guards and interlocks as well as making safety observations during the activity so that real-time actions can be implemented to address the identified risk behaviours (Hjorth, 2018).

Results

Below is the development of each of the stages of the tool, presenting the results of the risk analysis by activity, which was carried out for the operation of the lift truck.

Describe the activity

Table 2 contains the description of 4 activities selected from the total of activities that resulted from the risk analysis by activity, which was carried out in the operation of the lift truck, each activity is given a number (Num) this will allow us to identify them in each of the stages of the analysis.

Box 4

Table 2

Description of the activity

Num	Description of the activity
1	Check that the forks are in good condition.
2	Check that the grill is in good condition.
3	Before starting the operation, put on your seat belt.
4	Address the cargo for transfer.

Identify present risks

The identification of risks is determined according to all factors involved in carrying out the activity. Table 3 shows the risks involved in the activity.

Box 5

Table 3

Possible risks

Num	Possible risk
1	Mech.- burst/compression. Work/walking surface-5S, Order and Cleanliness (Material on Surface/Out of Place Do). Ergo .- Healthy postures or without excessive effort (Over Effort). Lift truck / PIT-Equipment Conditions.
2	Human error, human behaviour. Work/walking surface-5S, Order and Cleanliness (Material on Surface/Out of Place Do). Ergo .- Healthy postures or without excessive effort (Over Effort). Lift truck / PIT-Equipment Conditions.
3	Human error, human behaviour. Ergo .- Healthy postures or without excessive effort (Over Effort).
4	Mech .- Mass and speed (kinetic energy - uncontrolled movement). Mech .- Impact. Lift truck/PIT-Operating Environment. Lift truck / PIT-Mis-Operation.

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Risk Description

A specific description of the task must be made in which the present risk must be detailed and that may result in a mishap for the worker, as shown in Table 4.

Box 6
Table 4
Activity number and specific description

Num	Specific description of the activity
1	Mech .- burst / compression: trapping of hands when checking that the forks are in good condition. Work surface / walking-5S, Order and Cleanliness (material on the Surface / Out of Place Do): when carrying out the activity the employee may lose sight of the risk points around him and may trip. Ergo.- Healthy postures or without excessive effort (Over Effort): when carrying out the activity, the employee may end up in uncomfortable postures. Lift truck / PIT-Equipment conditions: failure to perform the activity correctly may cause the lift truck to malfunction, which may cause injury to the employee.
2	Human error, human behaviour: when verifying that the grill is in good condition, the employee may lose sight of the risk points around him and may be hit. Work surface / walking-5S, Order and Cleanliness (material on the Surface / Out of Place Do): when carrying out the activity the employee may lose sight of the risk points around him and may trip. Ergo.- Healthy postures or without excessive effort (Over Effort): when carrying out the activity, the employee may end up in uncomfortable postures. Lift truck / PIT-Equipment conditions: failure to perform the activity correctly may cause the lift truck to malfunction, which may cause injury to the employee.
3	Human error, human behavior: not putting on a seat belt exposes the employee to injury. Ergo.- Healthy postures or without excessive effort (Over Effort): when carrying out the activity, the employee may end up in uncomfortable postures.
4	Mech .- Mass and speed (kinetic energy - uncontrolled movement): by not respecting the speed when the employee operates the lift truck, he or she may lose control of the unit and cause injury or death. Mech .- Impact: when operating the lift truck the employee may lose control of it and cause injury or death. Lift truck / PIT-Operating environment: Failure to consider the spaces available to operate the unit could cause injury or death to the employee. Lift truck / PIT-Mis-Operation: Operating the lift truck without prior training could result in injury or death to the employee.

Identifying the damage

Table 5 shows the damages that were identified in the activities that are being analyzed in the operation of the lift truck.

Box 7
Table 5
Damage identification

Num	Damage
1	-Entrapment of extremities of hands. -Trips/Falls/Slips. -Unhealthy postures. -Bruises, fractures, Interior, Death, installation or damage to equipment.
2	-Physical injuries. -Trips/Falls/Slips. -Unhealthy postures. -Bruises, fractures, Interior, Death, installation or damage to equipment.
3	-Physical injuries. -Unhealthy postures.
4	-Contusions, hematomas, fractures, death, damage to facilities or equipment.

Risk control hierarchy

Table 6 shows the risk control measures that will be implemented in the activities analyzed in the operation of the lift truck.

Box 8
Table 6
Risk control hierarchy

Num	Risk hierarchy
1	Administrative controls
2	Administrative controls
3	Administrative controls
4	Administrative controls

Identification of current controls

Table 7 shows the current controls implemented in the operation of the lift truck.

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Box 9

Table 7

Identification of current controls

Num	Current controls
1	- Training for the operation of the lift truck.
- 2	- Training for the operation of the lift truck.
3	- Training for the operation of the lift truck.
4	- Training for the operation of the lift truck.

Risk assessment

The evaluation of the risk associated with the operation of the lift truck is shown in Table 8

Box 10

Table 8

Assessment of severity, frequency and probability

Num	Severity	Frequency	Probability	RPN
1	3	4	2	**24**
2	1	4	2	**8**
3	1	4	1	**4**
4	10	4	4	**160**

Implementation of actions

The actions that are proposed to be implemented are presented in Table 9.

Box 11

Table 9

Implementation of actions

Num	Actions
1	- Perform safety observations when the activity is carried out to reinforce risky behaviours. - Staff training for ergonomics, 5's, order and cleanliness. - Implement a checklist for the lift truck inspection.
2	- Perform safety observations when the activity is carried out to reinforce risky behaviours. - Staff training for ergonomics, 5's, order and cleanliness. - Implement a checklist for the lift truck inspection.
3	-
4	- Perform safety observations when the activity is carried out to reinforce risky behaviours. - Operator Certificate, Training. - Feedback on the use of personal protective equipment. - Implement a checklist for the lift truck inspection.

From the results obtained from the risk analysis by activity, we observed that in activities 1, 2 and 4 the RPN of each of them is greater than 6. Therefore, these activities have a latent present risk and for this reason we must implement actions to reduce the risk.

The controls that are recommended to be implemented in each of them are Administrative Controls, and the actions are those specified in Table 10.

Box 12

Table 10

Risk assessment result

Num	RPN	Recommended controls	Additional actions/controls identified
1	**Half**	Administrative controls	- Perform safety observations when the activity is carried out to reinforce risky behaviours. - Staff training for ergonomics, 5's, order and cleanliness. - Implement a checklist for the lift truck inspection.
2	**Low**	Administrative controls	- Perform safety observations when the activity is carried out to reinforce risky behaviours. - Implement a checklist for the lift truck inspection. - Staff training for ergonomics, 5's, order and cleanliness.
3	**Minimum**	Administrative controls	-
4	**High**	Administrative controls	- Perform safety observations when the activity is carried out to reinforce risky behaviours. - Operator Certificate, Training. - Feedback on the use of personal protective equipment - Implement a checklist for the lift truck inspection.

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Conclusions

The application of the standardized tool for the identification and control of risks associated with the operation of the lift truck, allowed us to observe the hazards that arise in the operation and to implement mitigation, prevention and correction measures of the risks.

The risks that were identified include exceeding the speed of the vehicle, not having the right order and cleanliness of the work area, not making a check list in which the conditions in which the unit is located, not placing the seat belt and not using the appropriate personal protective equipment; This can result in the operator being exposed to present hazards such as limb entrapment, tripping/falling and sliding, awkward postures when operating the lift truck, having some type of fractures or resulting in the death of the operator.

The future work of this research includes the application of this tool in different operations within a work area, to decrease the probability of any type of identified risk occurring.

Declarations

Conflict of interest

The authors declare no conflict of interest. They have no known competing financial interests or personal relationships that could have appeared to influence the content reported in this article.

Author contribution

The contribution of each researcher in each of the points developed in this research, was defined based on:

Cardona-Martínez, Clara: Contributed to the project idea, research method and technique. She supported the design of the proposal. She carried out the data analysis and systematisation of results, as well as writing the article.

Ramirez-Benhumea, David Alejandro: Contributed to the research method and technique. He supported the design of the proposal. He carried out the data analysis and systematisation of results, as well as writing the article.

Guevara-Hernandez, Eduardo: He carried the systematisation of results, as well as writing the article.

Beltran, Paulina: She carried the systematisation of results, as well as writing the article.

Availability of data and materials

The data obtained in this article were taken from the operation of a sit down electric lift truck, with a capacity of 3.5 tons, of which we had availability at all times.

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Abbreviations

PPE	Personal Protective Equipment
Num	Number of activity
RPN	Risk Priority Number

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Article

Optomechatronic system for robotic arm using neural networks for educational inclusion

Sistema optomecatronico para brazo robótico con el uso de redes neuronales para la inclusión educativa

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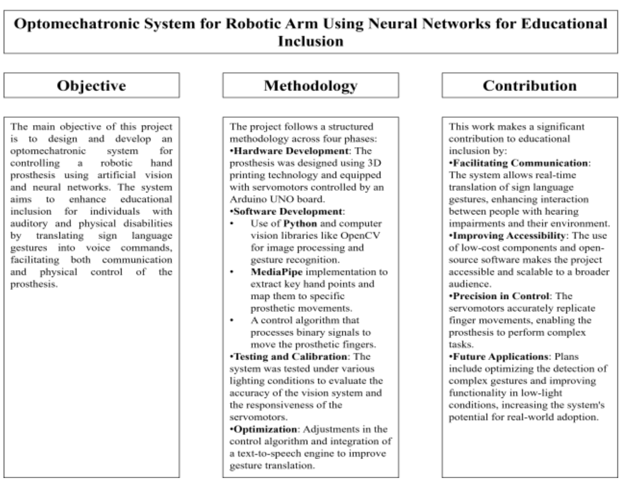
Abstract

The artificial vision system is crucial in technological advancements, offering innovative solutions for assisting people with disabilities. This study presents an optomechatronic system designed to control a robotic hand prosthesis using artificial vision to interpret hand movements and translate sign language into voice commands. The prosthesis operates through artificial vision-based control that maps hand positions to prosthetic fingers. This technology aids in direct communication between people with hearing impairments and others, enhancing inclusivity. The project emphasizes the use of low-cost and open-source software, making it accessible to a broader audience.

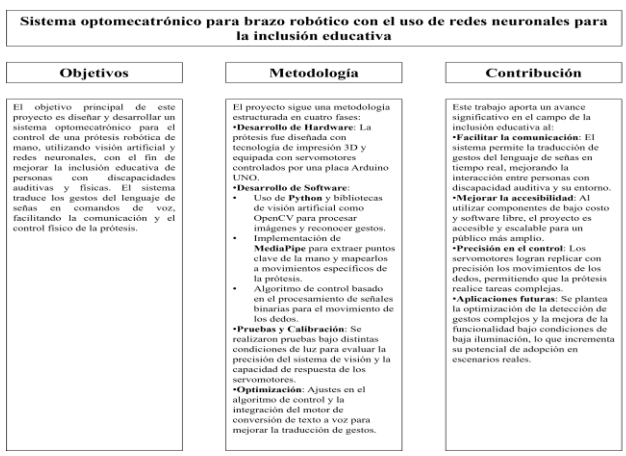

Optomechatronic System for Robotic Arm Using Neural Networks for Educational Inclusion

Objective	Methodology	Contribution
The main objective of this project is to design and develop an optomechatronic system for controlling a robotic hand prosthesis using artificial vision and neural networks. The system aims to enhance educational inclusion for individuals with auditory and physical disabilities by translating sign language gestures into voice commands, facilitating both communication and physical control of the prosthesis.	The project follows a structured methodology across four phases: •**Hardware Development**: The prosthesis was designed using 3D printing technology and equipped with servomotors controlled by an Arduino UNO board. •**Software Development**: • Use of **Python** and computer vision libraries like OpenCV for image processing and gesture recognition. • **MediaPipe** implementation to extract key hand points and map them to specific prosthetic movements. • A control algorithm that processes binary signals to move the prosthetic fingers. •**Testing and Calibration**: The system was tested under various lighting conditions to evaluate the accuracy of the vision system and the responsiveness of the servomotors. •**Optimization**: Adjustments in the control algorithm and integration of a text-to-speech engine to improve gesture translation.	This work makes a significant contribution to educational inclusion by: •**Facilitating Communication**: The system allows real-time translation of sign language gestures, enhancing interaction between people with hearing impairments and their environment. •**Improving Accessibility**: The use of low-cost components and open-source software makes the project accessible and scalable to a broader audience. •**Precision in Control**: The servomotors accurately replicate finger movements, enabling the prosthesis to perform complex tasks. •**Future Applications**: Plans include optimizing the detection of complex gestures and improving functionality in low-light conditions, increasing the system's potential for real-world adoption.

Artificial vision, Prosthesis control, Sign language

Resumen

Los sistemas de visión artificial son fundamentales en los avances tecnológicos, ofreciendo soluciones innovadoras para personas con diferentes discapacidades. Este estudio se centra en un sistema optomecatrónico diseñado para controlar una prótesis de mano robótica mediante visión artificial, que interpreta movimientos de la mano y traduce el lenguaje de señas en comandos de voz. La prótesis opera a través de un control basado en visión artificial que mapea posiciones de la mano a los dedos protésicos. Esta tecnología facilita la comunicación directa entre personas con discapacidad auditiva y otras, promoviendo la inclusión. El proyecto destaca el uso de software libre de bajo costo, haciéndolo accesible a una audiencia más amplia y a un costo bajo.


Sistema optomecatrónico para brazo robótico con el uso de redes neuronales para la inclusión educativa

Objetivos	Metodología	Contribución
El objetivo principal de este proyecto es diseñar y desarrollar un sistema optomecatrónico para el control de una prótesis robótica de mano, utilizando visión artificial y redes neuronales, con el fin de mejorar la inclusión educativa de personas con discapacidades auditivas y físicas. El sistema traduce los gestos del lenguaje de señas en comandos de voz, facilitando la comunicación y el control físico de la prótesis.	El proyecto sigue una metodología estructurada en cuatro fases: •**Desarrollo de Hardware**: La prótesis fue diseñada con tecnología de impresión 3D y equipada con servomotores controlados por una placa Arduino UNO. •**Desarrollo de Software**: • Uso de **Python** y bibliotecas de visión artificial como OpenCV para procesar imágenes y reconocer gestos. • Implementación de **MediaPipe** para extraer puntos clave de la mano y mapearlos a movimientos específicos de la prótesis. • Algoritmo de control basado en el procesamiento de señales binarias para el movimiento de los dedos. •**Pruebas y Calibración**: Se realizaron pruebas bajo distintas condiciones de luz para evaluar la precisión del sistema de visión y la capacidad de respuesta de los servomotores. •**Optimización**: Ajustes en el algoritmo de control y la integración del motor de conversión de texto a voz para mejorar la traducción de gestos.	Este trabajo aporta un avance significativo en el campo de la inclusión educativa al: •**Facilitar la comunicación**: El sistema permite la traducción de gestos del lenguaje de señas en tiempo real, mejorando la interacción entre personas con discapacidad auditiva y su entorno. •**Mejorar la accesibilidad**: Al utilizar componentes de bajo costo y software libre, el proyecto es accesible y escalable para un público más amplio. •**Precisión en el control**: Los servomotores logran replicar con precisión los movimientos de los dedos, permitiendo que la prótesis realice tareas complejas. •**Aplicaciones futuras**: Se plantea la optimización de la detección de gestos complejos y la mejora de la funcionalidad bajo condiciones de baja iluminación, lo que incrementa su potencial de adopción en escenarios reales.

Visión artificial, Control de prótesis, Lenguaje de señas

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Introduction

Optomechatronic systems, which combine mechanical, electronic and optical elements, have transformed the field of prosthetics, offering innovative solutions for people with disabilities.

With the help of artificial vision systems, designed to interpret visual data and execute precise mechanical responses, it has enabled the development of robotic prostheses capable of performing complex tasks, such as replicating human hand movements and translating sign language.

The importance of this project lies in its ability to improve communication for people with hearing and physical disabilities, particularly those who require hand prostheses. Traditional methods, such as Braille or tactile communication, have limitations, while a system based on artificial vision offers a more dynamic and real-time interaction.

This study presents a novel machine vision system designed to control a robotic prosthetic hand. Unlike other methods that rely exclusively on manual inputs or expensive hardware, our system uses low-cost components and free software, making it an accessible and scalable solution.

The central hypothesis is that a real-time machine vision system can effectively control a prosthetic hand while simultaneously translating sign language into voice commands, providing dual functionality for communication and physical movement.

The first section of this paper explains the mathematical basis of the elements of the project.

The second section describes all the elements that make up the project, both sensors and actuators, as well as their technical specifications and the development process for the generation of the final prototype.

In the next section, the results obtained with the prototype are presented, as well as the graphical user interface created for the control of the vision systems and modes of operation.

In the discussion section, reference is made to future work, as well as the areas of opportunity to be developed in the prototype for a better implementation in a real working environment.

Finally, the conclusion section describes the lessons learned from this research work, as well as its potential large-scale implementation.

1. Theoretical Framework

The development of machine vision controlled robotic prostheses involves a combination of several disciplines such as biomechanics, robotics, and artificial intelligence (AI), specifically in areas such as image processing. In the following, the theoretical background and mathematical basis of the main areas involved in this project are described.

1.1 Biomechanics of Human Motion

Biomechanics studies the movements of the human body and how forces act on joints.

In this case, the movements of the human hand, such as flexion and extension of the fingers, can be modelled using equations that describe the relationships between the applied forces and the resulting movements.

The movement of a finger can be modelled as a system of levers, where tendons, muscles and joints act as force application points and pivots. To model these motions, the torsional moment equations are used:

Formula [1]

Where:

τ is the torsional moment (N-m), F is the applied force (N), d is the distance from the pivot point to the force application point (m).

This equation is fundamental to the design of servo motors in prosthetics, as the torque required to move each finger must be considered, especially in conditions of resistance or when performing tasks that require force.

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1.2 Prosthetic Robotics

The control of robotic prostheses involves concepts of inverse kinematics, where, given a desired position of the end of an articulated system (in this case, the fingers of the hand), the angles to be adopted by the joints are calculated. In a robotic arm or hand, inverse kinematics allows the angles of the joints to be calculated to obtain an end position of the finger. The general equation for solving the inverse kinematics of a manipulator system with n degrees of freedom is:

$$\vec{q} = f^{-1}(\vec{x}) \quad [2]$$

Where:

$\vec{q} = [q_1, q_2, q_3, \ldots, q_n]$ are the joint angles of each joint, x is the desired end position (in this case, the position of the fingertip), and x is the desired end position (in this case, the position of the fingertip). f^{-1} is the inverse function relating the end position to the joint angles.

Numerical methods such as the Newton-Raphson algorithm or geometric solutions in simpler cases can be used to solve this system of equations. Accuracy in inverse kinematics is key for the prosthesis to perform precise and controlled movements.

1.3 Image Processing and Machine Vision

The implemented machine vision system uses image processing techniques to detect and track hand movements. In this context, feature detection is crucial.

To detect key points on the hand (fingers), a method based on edge detection algorithms, such as the Sobel or Canny filter, which calculates the intensity gradient of the images, is used.

The gradient of a two-dimensional image can be calculated as:

$$\nabla I = \left(\frac{\partial I}{\partial x}, \frac{\partial I}{\partial y}\right) \quad [3]$$

Where:

- $\frac{\partial I}{\partial x}$ is the derivative of the image in the direction of x,
- $\frac{\partial I}{\partial y}$ is the derivative of the image in the direction y.

These gradients allow for the detection of edges or intensity changes in the image, which are indicative of the contours of fingers and other key objects.

In addition, for hand detection, an algorithm based on the recognition of specific hand features is implemented, using techniques such as the active deformation algorithm and landmark tracking. The MediaPipe library is key in this process, which allows 21 key points (joints) of the hand to be extracted using a convolutional neural network (CNN). These points are used to map hand gestures to specific commands in the control of the prosthesis.

1.4 Servomotor Control

The control of the servomotors, which allow the movement of the fingers in the prosthesis, is based on the control of the angular position.

The position of each servomotor is adjusted by means of the pulse width control (PWM) signal, which can be described by the following equation:

$$\theta(t) = \frac{T_{on}}{T_{periodo}} \cdot 180° \quad [4]$$

Where:

- $\theta(t)$ is the angle of rotation of the servomotor as a function of time,
- T_{on} is the period during which the signal is high (in milliseconds).
- $T_{periodo}$ is the total period of the PWM signal (in milliseconds).

Precise control of the angular position allows the prosthetic fingers to move precisely and in accordance with the movements detected by the machine vision system.

1.5 Artificial Intelligence in Gesture Recognition

To improve the interaction between the user and the prosthesis, supervised learning techniques are employed to recognise specific gestures that correspond to hand movements.

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The gesture recognition system is trained using a labelled gesture dataset, where the neural network learns to classify new gestures based on features extracted from key points on the hand. The back propagation algorithm is commonly used to train neural networks by adjusting the weights w of the network based on the error E between the desired output and the actual output:

$$\Delta w = -\eta \frac{\partial E}{\partial w} \quad [5]$$

Where:

- η is the learning rate,
- $\frac{\partial E}{\partial w}$ is the gradient of the error with respect to the weights.

This model is implemented in the neural network to improve the accuracy of gesture detection and to optimise the control of the prosthesis.

2. Methodology

The methodology used in this project is divided into four main phases: hardware development, software development, system testing and optimisation.

2.1 Hardware development

The hardware of the hand prosthesis was designed using 3D printed materials and accessible electronic components. The main components include:

- **Prosthetic structure:** The prosthesis was 3D printed using *PLA* filament, selected for its durability and ease of use. Each finger of the prosthesis was designed to move independently by servo motors, providing flexibility and functionality, see Figure 1.

Box 1

Figure 1
Prototype robotic right hand prosthesis

- **Servomotors (MG995):** Each of the five servomotors was assigned to a finger. These servomotors allow precise control of the movement and maintain a constant torque, which is essential for replicating the grip and release movements of the human hand, see table 1.

Box 2

Table 1
MG995 Servo Motor Specifications

Property	Value
Weight	55 g
Dimensions	40.7 x 19.7 x 42.9 mm
Torque	8.5 kgf·cm (4.8V), 10 kgf·cm (6V)
Operating Speed	0.2 s/60º (4.8V), 0.16 s/60º (6V)
Operating voltage range	4.8V a 7.2V

Source: Electrónicos Caldas, 2022

- **Arduino UNO:** The Arduino UNO board served as the central control unit, managing the inputs of the machine vision system and translating those signals into specific actions of the prosthetic motors.

- **Sensor Shield:** An auxiliary board that facilitated the connection of the servomotors to the Arduino board and regulated the power required for their operation.

2.2 Software Development

- Software development included the implementation of algorithms for machine vision and servo motor control. The Python programming language was selected due to its simplicity and compatibility with open source libraries such as OpenCV and CV Zone.

- **Machine Vision System:** A camera was used to capture hand movements, and the software used the OpenCV library for image processing and object recognition, see Figure 2. The system identified specific hand gestures, such as the number of fingers raised, and mapped them onto corresponding prosthetic movements.

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Box 3

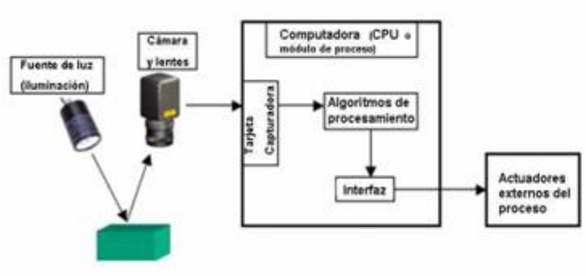

Figure 2
Schematic diagram of machine vision system
Source: *Researchgate, 2022*

- **Control Algorithm:** The control algorithm for the servomotors was designed to move each finger of the prosthesis in response to the detected gestures. The algorithm interprets binary inputs (1 for 'open' and 0 for 'closed') and sends these signals to the corresponding servomotor.
- **Sign Language Translation:** The system was also designed to interpret hand gestures corresponding to sign language, and translate them into voice commands using a text-to-speech conversion engine. This feature was implemented using the MediaPipe library for hand tracking and the Google API for speech synthesis.

2.3 Testing and Calibration

Several tests were performed to ensure the accuracy and responsiveness of the system. The prosthesis was tested under different light conditions and distances to evaluate the robustness of the machine vision system. The capture rate of the camera and the sensitivity of the servo motors were adjusted to minimise the delay between gesture detection and prosthesis response, see Figure 3 and 4.

Box 4

Figure 3
Detection of manual gestures and translation into prosthetic movements

Box 5

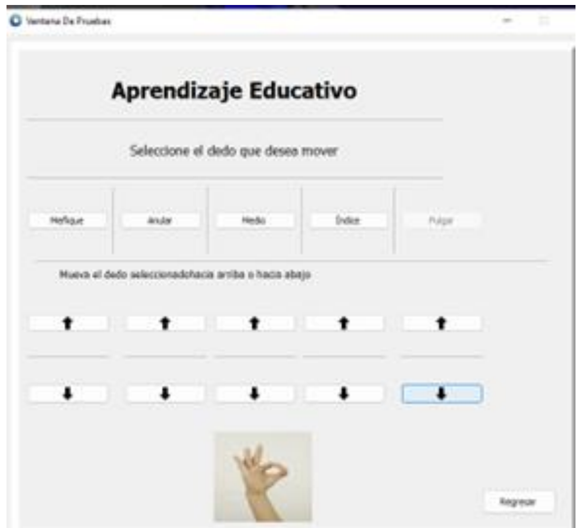

Figure 4
Learning interface

3. Results

3.1 Gesture detection and machine vision

The machine vision system was able to detect hand gestures with 95% accuracy in optimal lighting conditions. Figure 5 shows an example of real-time detection of hand gestures and their corresponding movements on the prosthesis.

Box 6

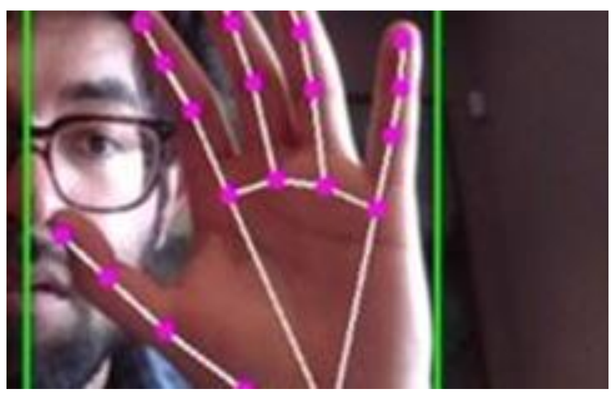

Figure 5
Detection of manual gestures and translation into prosthetic movements

However, in low light conditions, the accuracy decreased by 10%, highlighting the importance of constant light conditions for optimal system performance.

3.2 Servo Motor Response

The servomotors demonstrated high accuracy in replicating human hand movements.

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Each motor correctly performed its assigned tasks, which included opening and closing the prosthetic fingers. During stress testing, the servo motors exhibited a small delay (less than 0.5 seconds) when multiple fingers moved simultaneously. This delay was mitigated by adjusting the algorithm to process signals in parallel, see table 2.

Box 7

Table 2

Response times and accuracy in different conditions

Test Condition	Response Time [s]	Accuracy [%]
Normal lighting	0.2	95
Low illumination	0.35	85
Multi-finger movement	0.5	90

3.3 Sign Language Translation

The sign language translation function was able to interpret basic gestures, translating them into voice commands with a 90% recognition rate. The system was tested with a set of 20 common Mexican Sign Language (LSM) gestures, see Figure 6 and 7.

Box 8

Figure 6

Detection of manual gestures and translation into prosthetic movements

Box 9

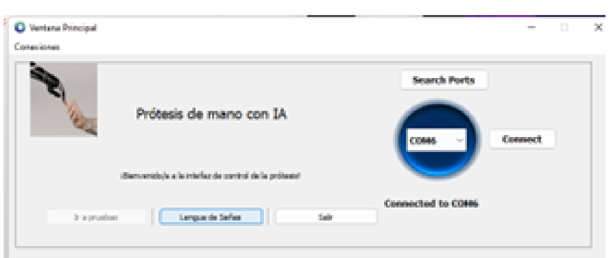

Figure 7

System start interface for operation selection

However, more complex gestures involving simultaneous movements of both hands were not recognised by the current system, an example of the serial communication of the servomotors is shown below, see Table 3.

Box 10

Table 3

Example of serial communication of servomotors

Posture	Meñique	Cancel	Medium	Index	Pulgar
Cero	0	0	0	0	0
Uno	0	0	0	1	0
Dos	0	0	1	1	0
Tres	0	1	1	1	0
Cuatro	1	1	1	1	0
Cinco	1	1	1	1	1

Source: Murtaza's Workshop, 2021

4. Discussion

The machine vision-based prosthesis control system has shown great potential for assisting people with hearing and physical disabilities.

The use of open source software libraries such as OpenCV and Python enabled the creation of a functional and accessible system. However, the system's performance in low light conditions and its limited ability to recognise complex gestures present areas for improvement.

Future iterations of the project should focus on:

- **Improving low-light performance:**

Integration of infrared sensors or improvements in image processing algorithms could optimise performance in sub-optimal lighting conditions.

- **Extending gesture recognition capabilities:**

Incorporating machine learning techniques would allow the system to handle a wider range of gestures, including those involving simultaneous movements of both hands.

- **Reduced delay:** Optimisation of the control algorithm could further reduce the response time between gesture detection and prosthesis movement.

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Conclusions

This study has successfully demonstrated the potential of a machine vision system for the control of a robotic hand prosthesis. By using low-cost hardware and free software, this project offers an accessible solution for people with disabilities, particularly those who rely on sign language for communication.

The current prototype translates hand gestures into prosthetic movements and interprets basic sign language gestures. While there are areas for improvement, such as reducing response delay and extending gesture recognition, the core functionality of the system has been validated.

With further development, this technology has the potential to be adopted on a large scale, improving the quality of life for people with physical and hearing disabilities.

Declarations

Conflict of interest

The authors declare that they have no conflicts of interest. They have no known competing financial interests or personal relationships that might have appeared to influence the article reported in this paper.

Authors' Contribution

Blanco-Miranda, Alan D.: Contributed the Project idea, research methodology and technical programming.

García-Cervantes, Heraclio: Contributed with the research methodology, design and prototype development.

Carrillo-Hernández, Didia: Contributed to the research methodology and programming of the computer vision algorithms.

Availability of data and materials

All data and results obtained are exclusive to the Universidad Tecnológica de León as part of its technological developments.

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Abbreviations

ANN	Artificial Neural Network
API	Application Programming Interface
IA	Artificial Intelligence
CNN	Convolutional Neural Network
LSM	Mexican Sign Language
PLA	Polylactic Acid
PWM	Pulse Width Modulation

References

Background

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Article

Design of an alarm system for the inclusion of people with disabilities in the educational environment

Diseño de un sistema de alarmas para la inclusión de personas con discapacidad en el entorno educativo

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Abstract

Currently the participation of students in earthquake drills is very important, even in places where there are no records of large-scale earthquakes, however, when a review of it is done, it is noted that the means of warning are usually sound instruments, which leaves people with hearing problems or hearing impairment with little possibility of immediate response. This is the raison of this work, the idea is to be able to attend to people with hearing impairment in an immediate response.

Earthquake, Alarm system, Inclusion

Resumen

Actualmente es muy importante la participación de los estudiantes en simulacros de sismo, aún en lugares donde no se cuenta con registros de sismos en gran escala, sin embargo, cuando se hace una revisión del mismo, se nota que los medios de aviso regularmente son instrumentos sonoros lo que deja con poca posibilidad de respuesta inmediata a las personas con problemas auditivos o con discapacidad auditiva. Esta es la razón de ser del presente trabajo, la idea es poder atender a las personas con discapacidad auditiva en una respuesta inmediata.

Temblor, Sistema de alarmas, Inclusión

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1. Introduction

Nowadays it is very common to see earthquake drills being carried out having to evacuate people in a certain time (ideally 3 minutes). However, we rarely worry about attending to students with visual or hearing impairment problems, which generate a key point in the evacuation time.

The nature and scope of this work is precisely with the support in the immediate response of people with hearing disabilities in earthquake simulation processes and in the evacuation processes of buildings of educational institutions.

It is worth mentioning that the work carried out shows data belonging to the Faculty of Mechanical and Electrical Engineering of the University of Veracruz, Poza Rica – Tuxpan Region, however, the idea is to be able to work on a general alarm system for educational institutions in general.

design of the alarm system mainly covers people with hearing disabilities, thus increasing the effectiveness of security measures in various environments. It is expected that this device will meet the sensory and cognitive needs of people with disabilities, reducing the time it takes to evacuate buildings by 10%, improving their ability to detect and respond to any emergency situation.

2. Statistics of people with hearing impairments

According to the Ministry of Health, hearing impairment refers to the lack, decrease or loss of the ability to hear somewhere in the hearing system, Now, in Mexico, approximately 2.3 million people suffer from hearing impairment, [1] of which more than 50 percent are over 60 years of age; just over 34 percent are between 30 and 59 years old and about 2 percent are children, this represents approximately 46,000 children in the country with hearing disabilities, however, secondary and high school students are not included in this statistic because as of 2018 [2] the number of people under 17 years of age with a disability was 580,289.

In addition, according to inegi data, the rate of people with disabilities in general has increased from 6.3 to 6.8 from 2018 to 2023 [3].

Although hearing impairment is the fourth disability presented in the statistics, it is considerably high the number of people who have this problem, this is reflected in Table 1.

Box 1

Table 1

Types of disability in the Mexican population.

Type of disability	Index	Number of people (millions)
Motor	69.7%	6.203
Visual	*45.4%*	*4.04*
Memory or emotional	28.7%	2.55
Auditory	19.4%	1.72
Speaking	9.6%	0.85

[3]

The table clearly shows that 1.72 million people in Mexico have hearing problems [3], therefore, this project generates a significant impact on the inclusion of people in society.

Although currently there are inclusion programs and support from the health secretariat, it is considered a great opportunity for the engineering area to insidir in society through projects related to inclusion issues and thus achieve close a little the gap of people with hearing impairment with society and make them more autonomous.

It is also worth mentioning that this condition can be congenital, that is, a condition with which one is born, or acquired, because it occurs at any stage of life through the passage of time and exposure to loud sounds or loud music, systemic arterial hypertension or diabetes mellitus.

3. Background

In the research entitled “Design and implementation of a home automation system using a Raspberry Pi card and controlled with an Android application for people with physical disabilities to perform basic household tasks”.

[4] shows a design of a home automation system which is intended to perform automation activities to mention the following, turn on lights, open door locks up and down blinds.

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Concluding that the items proposed in the design of Python language that allows receiving requests and in turn have control of various actuators have been met.

On the other hand, in the research entitled “Warning system used by sensors for obstacle detection for visually impaired people” [5] shows a design of a system for detection and monitoring of objects, so that visually impaired people can avoid obstacles and have an effective displacement. It also concluded that the use of ultrasonic sensors is a viable option for the development of devices and allows the guidance of people with disabilities.

In the research entitled “Study of lighting conditions within the facilities of the Faculty of Mechanical and Electrical Engineering Poza Rica - Tuxpan region” [6] shows a study of lighting for people performing daily activities.

In the research entitled “Design and implementation of an alarm prototype made up of infrared and vibration sensors applied to the community mainly to visually and hearing impaired pedestrians, installed to the traffic light system” [7] in general, a prototype was designed to test the traffic light system to which a vibration system was adapted with motors, infrared sensors, controlled by Raspberry pi.

Their contribution would help visually impaired people to move more efficiently and know when to cross the street.

In the Mexican standard NOM - 0O3 SEGOB/2002 [8], the characteristics of the signaling system for civil protection are specifically described, allowing the population to identify messages such as caution, no trespassing and obligation in order to act correctly.

4. Characteristics of the population

This section describes the target population of the project, for which a survey was conducted among the student community of the School of Mechanical and Electrical Engineering of the Universidad Veracruzana in the Poza Rica - Tuxpan region, which has a total population of 616 students, 59 teachers and 15 administrative staff, in addition, it has an infrastructure of 9 classrooms, an auditorium and two laboratories as enclosed spaces.

Figure 1 shows one of the classrooms of the School of Mechanical and Electrical Engineering, the space where the project is to be implemented.

Box 2

Figure 1

Classroom of the Faculty of Mechanical and Electrical Engineering [9]

Source: https://www.uv.mx/pozarica/fime/amplias-y-modernas-aulas-con-aire-acondicionado/

The survey conducted in support of this work was carried out in May 2024 through the google forms platform reaching 132 people from the student community, the results are shown below in figures 2 to 5.

Figure 2 corresponds to the question “Do you consider that you have hearing problems?”, figure 3 corresponds to the question “Do you use any device as a visual or auditory support?”, figure 4 corresponds to the question “Do you consider that you hear clearly?” and finally figure 5 corresponds to the question “In your free time, do you use hearing aids to distract you from any activity or to concentrate on it?”.

Box 3

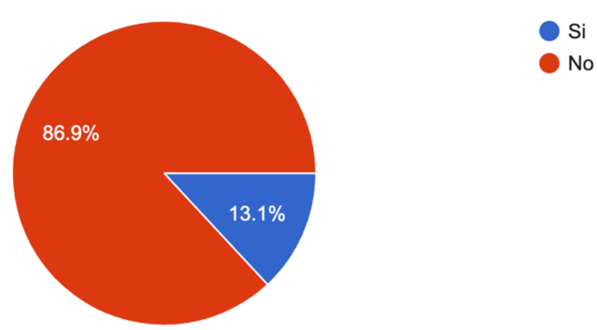

Figure 2

Answer to the question “Do you consider yourself to be hearing impaired?

Source: Student survey

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Box 4

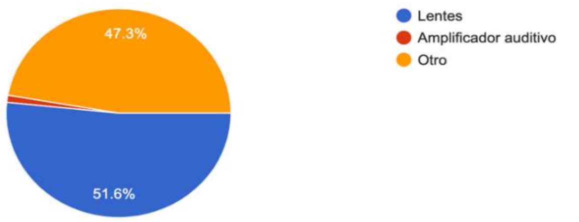

Figure 3

Answer to the question do you use any device as a visual or auditory support?

Source: Student survey.

Box 5

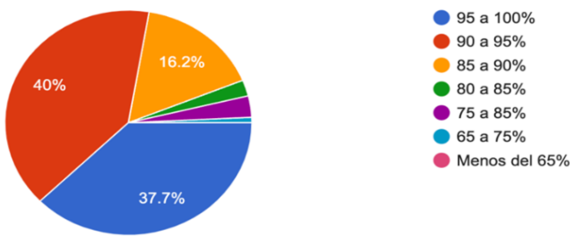

Figure 4

Answer to the question "Do you consider yourself a clear listener?

Source: Student survey

Box 6

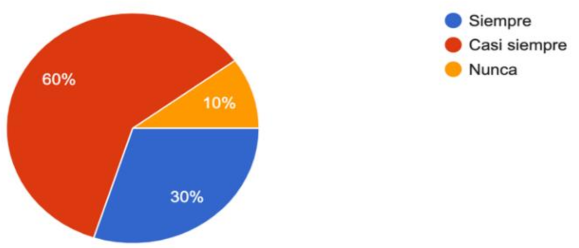

Figure 5

Answer to the question: in your free time, do you use headphones to distract yourself from or concentrate on an activity?

Source: Student survey

In addition, in the same survey, 51.5% of the respondents indicated that they identify the drill due to the megaphone or horn announcing the event. Also noteworthy in this survey is the fact that 2.3% mentioned that civil protection personnel had to pass through the spaces where they were to give them indications and that 17% of the respondents indicated that they have had problems hearing the alarm signals or know someone who has had problems hearing the alarms, which provides feasibility to the project being developed.

5. Alarm project design for people with disabilities

The proposed design has three main features, the first is the easy operation for the user, the second is a low cost and the third is that it is independent of residential power.

The idea is that the alarm system will have two warning lights, one of red color indicating the earthquake and another of a different color to indicate that there is an emergency of another type such as fire, smoke, among others, which are activated in three cases: first, when they detect the signal of the tremor through the internet interconnection, another case is through manual activation by the management or the people in charge of the drill and the last one through manual activation inside the classroom.

And the objective is to be installed in one of the front parts of the classroom so that it is visible to the hearing impaired, as shown in Figure 6.

Box 7

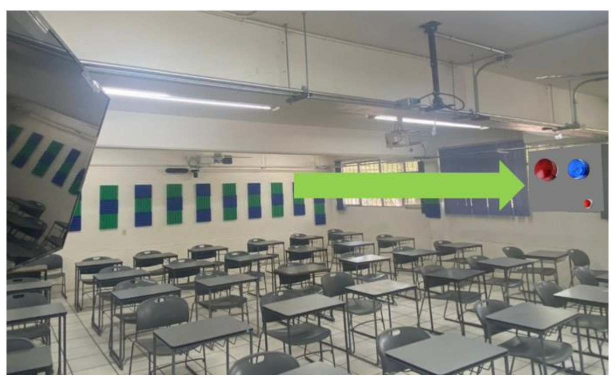

Figure 6

Implementation of the system in the classroom

For the design, we looked for elements that were easy to access economically, resulting in those shown in Table 2.

Box 8

Table 2

Cost of alarm system elements

Element	Cost
Warning light flashing red [10].	218.70
Warning light flashing blue [11].	129.00
Alarm button [11]	29.00
Solar panel 12V 5W [11]	323.00
Arduino Wifi [10]	626.00

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According to Table 2, a first approach to the cost of the project is approximately 1,325.70 pesos, however, some elements for optimal operation are not considered, such as cabling, connectivity devices and the panel in which it will be installed, but it is useful to realize the approximately low cost of the project.

6. Results

The first approach that was established was the one shown in figure 7, this shows 3 displays showing the 911 alarm signal connected to a regulated voltage source at 5 v and with an input switch.

Box 9

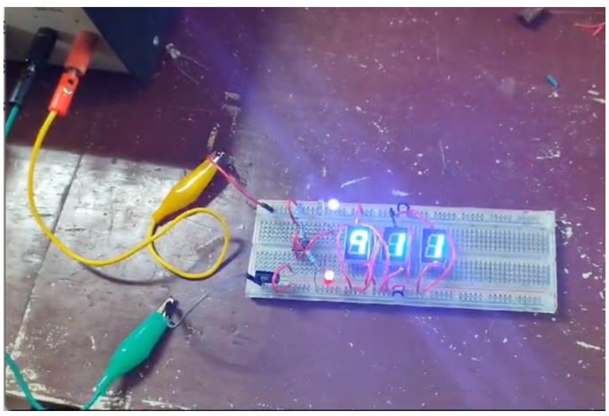

Figure 7
First approach to the alarm system idea

This prototype fulfilled two of the characteristics mentioned in the project, since it was easy to use and the cost was very low, however it presented other problems, among which are the size, the lack of autonomous connection and the wireless connection for its activation, so at this moment we are in the stage of purchasing the elements for the next approach to the project.

7. Conclusions

We achieved a first approach to the development of the alarm system and the design which are being considered important in the development of the project, although the construction and implementation is important, the idea is that this project can be incorporated in all educational institutions for the inclusion of people with hearing disabilities.

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Article

Determination and evaluation of unofficial or complementary tests of rosemary extract tablets (as a finished product)

Determinación y evaluación de las pruebas no oficiales o complementarias de comprimidos de extracto de romero (como producto terminado)

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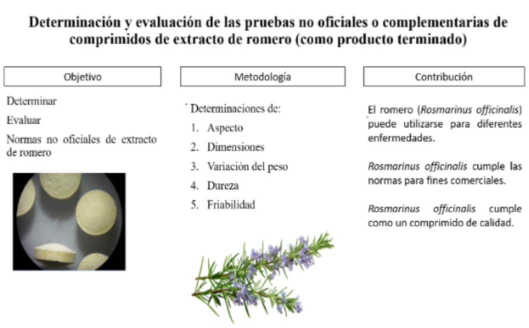
Abstract

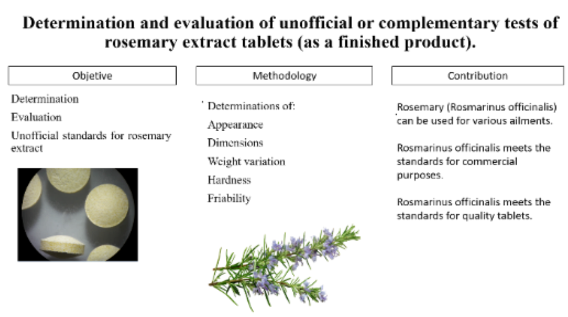
Rosemary (Rosmarinus officinalis) is a plant rich in active ingredients, it generates a tonic and stimulating action on the nervous, circulatory and heart systems, in addition to being choleretic, cholagogue, antispasmodic, diuretic, emmenagogue and antigodanotropic. The objective was to carry out unofficial tests in the production of rosemary tablets as a finished product. The appearance, hardness, weight variation and friability of the tablets were determined. The results show an appearance with irregular edges and faint yellow spots, the diameter of the tablets shows a P-value of 0.408, a thickness with a P-value of 0.458, and a tablet weight of a lower P-value. at 0.050, in hardness a P-value of .942, while in the friability tests values less than 1 were obtained. These results show acceptable values for the production of rosemary extract tablets, which can have commercial use.



Rosmarinus officinalis, Rosemary extract, Tablets

Resumen

El Romero (Rosmarinus officinalis) es una planta rica en principios activos, genera una acción tónica y estimulante sobre el sistema nervioso, circulatorio y corazón, además de ser colerético, colagogo, antiespasmódico, diurético, emenagogo y antigodanotrópico. El objetivo fue realizar las pruebas no oficiales en la elaboración de comprimidosde romero como producto terminado. Se determinó el aspecto, la dureza, la variación de peso y la friabilidad de las tabletas. Los resultados nos muestran un aspecto con bordes irregulares y manchas tenues de color amarillo, el diámetro de los comprimidos arroja un P-value de 0.408, un espesor con valor de P-value de 0.458, un peso de tabletas de un P-value menor a 0.050, en dureza un P-value de .942, mientras que en las pruebas de friabilidad se obtuvieron valores menor de 1. Estos resultados muestran valores aceptables para la elaboración de comprimidos de extractos de romero, lo cual puede tener uso comercial.



Rosmarinus officinalis, Extracto de romero, Comprimido

Citation: Orta-Martínez, Felipe, Hernández-Salas, Claudia, Regalado-Barrera, José David and Flores-Treviño, Nora Elia. [2024]. Determination and evaluation of unofficial or complementary tests of rosemary extract tablets (as a finished product). Journal of Health Sciences. 11[30]1-7: e61130107.

Introduction

Rosemary (Rosmarinus officinalis) is a Mediterranean plant whose term is derived from the Greek "(rhops and myrinos)" which means "marine shrub" due to its growth near the coast (Alonso, 2004). It is generally found wild in rocky and sandy areas near the sea, but due to its adaptability and low demand for cultivation, it reproduces easily in other areas.

Rosemary belongs to the Lamiaceae family (Labiatae Labiadas), it is a shrubby plant with prismatic stems, the leaves are narrow, acute and small, they are shaped like bright greenspikes with revolute margins and woody andbranched stems (Sotelo et al. , 2002 and Sardans et al., 2005).

Various chemical compounds have been reported in the plant, which have been generally grouped by various authors into phenolic acids, flavonoids, essential oil, triterpenic acids and triterpenic alcohols (Caribe and Campos, 1991; Botsaris, 1995 and Atti-Santos, 2005). Rosemary essential oil is the most qualitatively studied component.

Different research works affirm that depending on the geographicallocation where plants grow under conditions of soil type, climate and height above sea level, they generate different changes in the quantity and type of bioactive molecules present (Al-Sereiti et al., 1999 and Guerrero et al., 2007).

Tablets are one of the most used pharmaceutical forms. It is estimated that today, half of themedications are administered in this pharmaceutical form (Vanaclocha, 2003).

The advantages of this pharmaceutical form are that they allow precision in dosage, they are easy to use, they allow the formulation of poorly soluble active ingredients and they can be manufactured on a scale with the consequent reduction in costs, durability of the physicalcharacteristics for extended periods of storage, excellent physical, chemical, pharmaceutical and pharmacological stability and great ease of handling during the packaging and packaging processes (Vanaclocha, 2003 and Miranda, 2006).

Methodology

Aspect

5 tablets were placed in the Carl Zeiss Stemi DV 4 stereoscope to observe the tablets' regularedges, homogeneous color and absence ofstains (EUHU, 2000 and Játiva, 2009).

Dimensions

5 samples of 10 tablets were taken and the diameter and thickness of each tablet in millimeters were measured with the caliper, vernier or caliper, and the average of each sample was calculated (EUHU, 2000 and Játiva, 2009).

Weight variation

5 samples of 10 tablets taken at random from the sample to be analyzed were weighed, they were weighed individually, trying not to touch them directly with the hand using gloves or tweezers to prevent the fat that is on the fingers of the hands from increasing the weight of the tablet, and all the decimals shown on the analytical balance were recorded (EUHU, 2000 and Játiva, 2009).

Hardness

Five samples of 10 tablets each were taken and the hardness was measured with the HELMER brand durometer of each tablet. (EUHU, 2000 and Játiva, 2009).

Friability

10 samples of 10 tablets each were analyzed, first the 10 tablets were weighed together taking into account all the decimals of the analytical balance reading (initial weight), then they were subjected to the Roche equipment (friabilizer) for approximately 5 minutes (i.e. say 100 blows), after said time the tablets were weighed again (final weight), and with these weights the percentage of friability (EUHU, 2000 and Játiva, 2009):

Results

Aspect

The rosemary extract tablets, as can be seen in Figure 1, show irregular edges and faint yellow spots, with slight porosity.

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Box 1

Figure 1

Morphological observation of rosemary extract tablets (Pharmacy Laboratory, Chemical Sciences, UAZ, 2016).

Own elaboration

Diameter

As seen in Figure 2, the diameter of 5 samples of 10 tablets each was measured with a verniercaliper or caliper.

Box 2

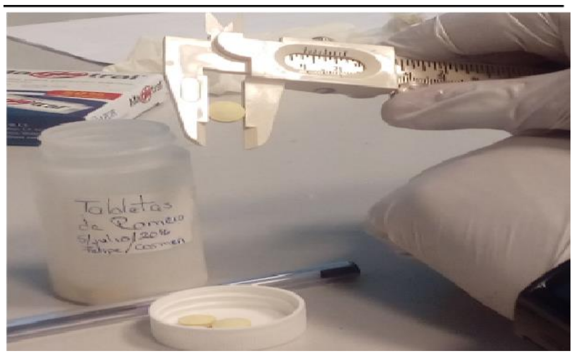

Figure 2

Measurement of the diameter of rosemary tablets (Laboratory of Pharmacy, Chemical Sciences, UAZ, 2016).

Own elaboration

The results of measuring the diameter of the rosemary extract tablets were tabulated in Table1.

Box 3

Table 1

Diameter of rosemary extract tablets

Tablets	M-1 (cm)	M-2 (cm)	M-3 (cm)	M-4 (cm)	M-5 (cm)
1	1.05	1.0	1.05	1.0	1.0
2	1.05	1.0	1.05	1.0	1.05
3	1.0	1.0	1.04	1.05	1.0
4	1.0	1.05	1.05	1.0	1.0
5	1.0	1.05	1.05	1.0	1.0
6	1.0	1.0	1.04	1.0	1.0
7	1.0	1.05	1.05	1.0	1.0
8	1.0	1.0	1.05	1.0	1.0
9	1.0	1.0	1.05	1.0	1.05
10	1.0	1.0	1.05	1.0	1.0
$\dot{x}$	1.01	1.015	1.048	1.005	1.01
S	0.02108	0.02415	0.00421	0.01581	0.02108
C.V.	2.087	2.3793	0.4017	1.5731	2.0871

M-1, M-2, M-3, M-4, M-5 = Samples 1 to 5, x = average, s = standard deviation and C.V. = Variation Coefficient.

The analysis of variance carried out on the results of the diameter of the rosemary extract tablets shows a P-value of 0.408, which indicates that there are no significant differences in the diameter of the rosemary tablets.

Thickness

Figure 3 shows how the thickness of the rosemary tablets was measured with a vernier caliper or caliper in 5 samples of 10 tablets.

Box 4

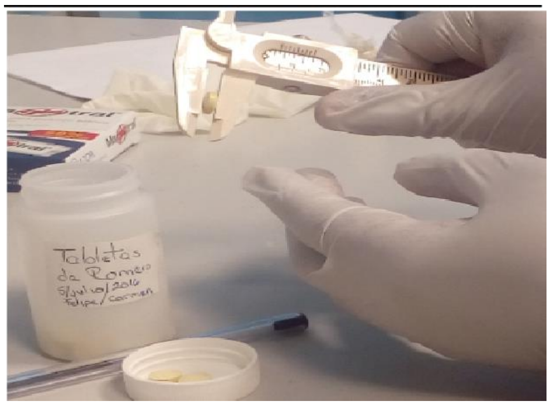

Figure 3

Measurement of the thickness of rosemary extract tablets (Pharmacy Laboratory, Chemical Sciences, UAZ, 2016

Own elaboration

The results of measuring the thickness of the rosemary tablets were tabulated in Table 2.

Box 5

Table 2

Diameter of rosemary extract tablets

Tablets	M-1 (mm)	M-2 (mm)	M-3 (mm)	M-4 (mm)	M-5 (mm)
1	4.8	4.8	4.5	4.7	4.8
2	4.5	4.8	4.5	4.7	4.8
3	4.8	4.8	4.8	4.8	4.8
4	4.8	4.8	4.7	4.8	4.8
5	4.8	4.7	4.8	4.8	4.8
6	4.8	4.8	4.8	4.8	4.8
7	4.8	4.8	4.8	4.8	4.8
8	4.8	4.8	4.8	4.8	4.8
9	4.5	4.8	4.8	4.8	4.8
10	4.8	4.7	4.8	4.7	4.8
$\dot{x}$	4.74	4.78	4.73	4.77	4.8
S	0.1264	0.0421	0.1251	0.0483	0
C.V.	2.6666	0.8807	2.6448	1.0125	0

Thickness of rosemary extract tablets. M-1, M-2, M-3, M-4, M-5 = Samples 1 to 5, x = the average, s= standard deviation and C.V. = Variation Coefficient.

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https://doi.org/10.35429/JOHS.2024.11.30.1.7

Weight variation

As shown in figure 4, 5 samples of 10 tablets were weighed with tweezers on an analytical balance, recording all the decimals of the balance reading

Box 6

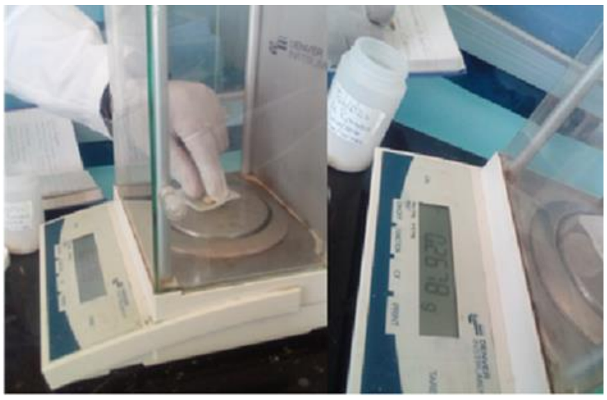

Figure 4
Weight of rosemary extract tablets (Laboratory of Pharmacy, Chemical Sciences, UAZ, 2016).

Table 3 shows the results of the weights of the 5 samples of 10 tablets each taken at random.

The results of measuring the thickness of the rosemary tablets were tabulated in Table 2

Box 7
Table 3
Weigh of rose mary extract tablet

Tablet	M-1 (g)	M-2 (g)	M-3 (g)	M-4 (g)	M-5 (g)
1	0.2667	0.2772	0.2676	0.2671	0.2701
2	0.2783	0.2777	0.2683	0.2654	0.2700
3	0.2624	0.2694	0.2624	0.2701	0.2717
4	0.2745	0.2698	0.2745	0.2700	0.2700
5	0.2825	0.2707	0.2625	0.2699	0.2699
6	0.2628	0.2717	0.2630	0.2701	0.2699
7	0.2581	0.2699	0.2599	0.2699	0.2701
8	0.2838	0.2674	0.2592	0.2699	0.2703
9	0.2691	0.2688	0.2688	0.2702	0.2697
10	0.2542	0.2701	0.2701	0.2702	0.2702
X	0.2692	0.2712	0.2656	0.2692	0.2701
S	0.0102	0.0034	0.0049	0.0016	0.0005
C.V	3.7890	1.2684	1.8637	0.6129	0.2057

M-1, M-2, M-3, M-4, M-5 = Samples 1 to 5, x = average, s = standard deviation and C.V. = Variation Coefficient.

The results of measuring the thickness of the rosemary tablets were tabulated in Table 2.

By subjecting the thickness data to an analysis of variance, a P-value of 0.458 is obtained, which indicates that there is no significant difference in thickness between each of the tablets in the sample.

The analysis of variance of the tablet weight samples shows a P-value less than 0.050, which suggests a difference between the weight of each of the tablets of the five samples.

Hardness

As shown in Figure 5, the 5 samples of 10 tablets were measured in a durometer.

Box 8

Figure 4
Measurement of hardness of rosemary extract tablets (Laboratory of Pharmacy, Chemical Sciences, UAZ, 2016).

Table 4 shows the hardness results of the 5samples of 10 rosemary extract tablets.

Box 9
Table 4
Hardness of rosemary extract tablets

Tablets	M-1 (N)	M-2 (N)	M-3 (N)	M-4 (N)	M-5 (N)
1	70	80	75	90	75
2	75	90	80	70	90
3	68	80	85	80	90
4	80	70	90	85	80
5	80	75	70	85	80
6	85	75	80	75	80
7	70	80	70	80	80
8	80	80	80	80	80
9	80	80	85	80	75
10	80	85	80	80	80
ẋ	76.8	79.5	79.5	80.5	81
S	5.692	5.5025	6.4334	5.5025	5.1639
C.V.	7.4114	6.9213	8.0918	6.8354	6.3751

M-1, M-2, M-3, M-4, M-5 = Samples 1 to 5, x = average, s = standard deviation and C.V. = Coefficient of Variation, N = Newton.

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According to the variance analysis carried out on the hardness of the tablets in Newton, itindicates that there are significant differences inthe hardness test since it showed a P-value of .942, however, this test passes since the allowedrange of hardness is from 70 to 90 Newton.

Friability

Figure 6 shows the evaluation of the friability of the rosemary extract tablet samples in the friabilizer.

Box 10

Figure 6

Determination of the friability of rosemary extract tablets (Laboratory of Pharmacy, Chemical Sciences,UAZ, 2016).

As shown in table 5, the friability percentage ofthe rosemary tablets is less than 1, which indicates that they have acceptable friability.

Box 11

Table 5

Friability of rosemary extract tablets

Samples	Friability (%)
1	0.209
2	0.310
3	0.290
4	0.340
5	0.337
ẋ	0.2984
s	0.03736
C.V.	12.5201

x = average, s = standard deviation and C.V. = VariationCoefficient

Table 6 shows the averages of the 5 samples of the diameter, thickness, weight, hardness and friability of the total rosemary extract tablets.

Box 12

Table 6

Averages of non-pharmacopoeial or complementary trials of Rosmarinus offisinalis extract tablets

Averag eof samples	Diamete rin cm	Thicknes sin mm	Weigh tin grams	Hardnes sin Newton	Friabilit y(%)
M-1	1.01	4.74	0.2692	76.8	0.209
M-2	1.015	4.78	0.2712	79.5	0.310
M-3	1.048	4.73	0.2656	79.5	0.290
M-4	1.005	4.77	0.2692	80.5	0.340
M-5	1.01	4.8	0.2701	81.0	0.337
ẋ	1.0176	4.764	0.2690	79.46	0.2972
S	0.01735	0.0288	0.0021	1.6226	0.0534
C.V.	1.7049	0.6047	0.7813	2.0420	17.9712

M-1, M-2, M-3, M-4, M-5 = Samples 1 to 5, x = average, s = standard deviation and C.V. = Variation Coefficient

In Figure 7 you can see the correlation that exists between the variables diameter, thickness, weight, hardness and friability of the rosemary extract tablets, where a) represents the correlation coefficient, b) the P-value and C) the number of samples.

Box 13

	Espesor en mm	Peso en gramos	Dureza en Newton	Friabilidad (
Diámetro en mm	a) -0.621 b) 0.264 c) 5	-0.832 0.0803 5	-0.0309 0.961 5	-0.114 0.855 5
Espesor en mm		a) 0.771 b) 0.127 c) 5	0.667 0.218 5	0.691 0.196 5
Peso en gramos			a) 0.0969 b) 0.877 c) 5	0.194 0.754 5
Dureza en Newton				a) 0.983 b) 0.00275 c) 5
Friabilidad (%)				

Figure 7

Correlation between unofficial or complementary tests

It can be seen in the previous figure (figure 7), that there is only a difference between Friability and Hardness, because it shows a P-value of 0.00275, while no significant difference is observed in the other variables.

Figure 8 shows that there is only a correlation between the hardness and friability of the rosemary extract tablets, since the higher thehardness the tablets have greater friability, which means that they are more resistant to wear or breakage during packaging and packaging. shipment of the medication.

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Box 14

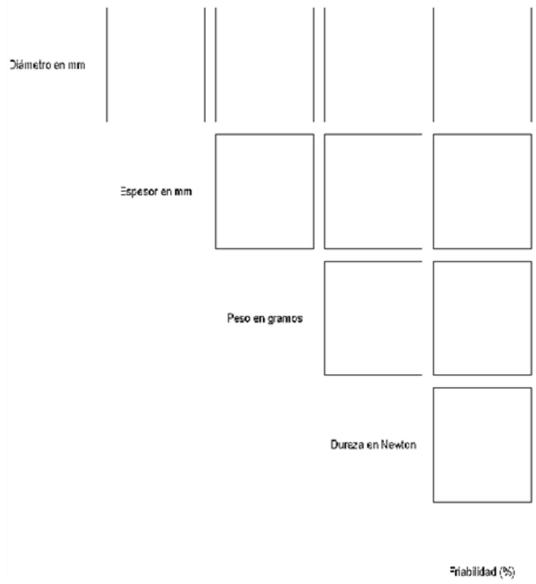

Figure 8
Correlation between the averages of the 5 samples of diameter, thickness, weight, hardness and friability

Conclusions

Rosemary (*Rosmarinus officinalis*) is a medicinal plant that can be used for different purposes. Rosemary extract is very important for its health benefits, since it has several pharmacological effects that can improve people's quality of life. If it is of good quality, it can be used as an active ingredient to make tablets of the same extract.

The medicine (*Rosmarinus officinalis* extract tablets) has the desired physical and organoleptic characteristics and/or properties, which guarantee that when official and unofficial tests are evaluated, it can be used for commercial purposes. The appearance, dimensions, weight variation, hardness and friability are unofficial tests in the production of rosemary extract tablets that determine a quality tablet.

Declarations

Conflict of interest

The authors declare that they have no conflicts of interest. They have no known conflicting financial interests or personal relationships that could have influenced the article presented in this paper.

Author contribution

Orta-Martínez, Felipe: Contributed to the development of the experiments for the determinations of the unofficial tests of rosemary.

Hernández-Salas, Claudia: Contributed to the analysis of the data and the writing of this article.

Regalado-Barrera, José David: Contributed to the translation of this article.

Fores-Treviño, Nora Elia: Contributed to the laboratory experiments for this research.

Availability of data and materials

For this research, open databases wereaccessed, platforms such as Google Scholar, Scopus, served as the basis for said work

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Abbreviations

Not applicable

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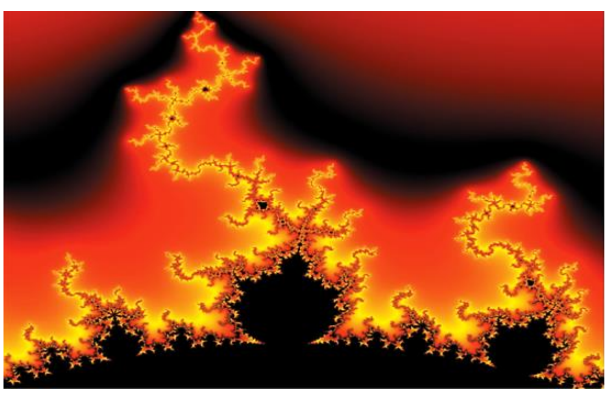

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