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| DE | Dr. José Humberto Arroyo Núñez Director de Investigación y Posgrado |
| ASUNTO | Conclusión de Proyecto |
| FECHA | 28 de febrero de 2023 |

Por medio del presente documento le informo que el proyecto de investigación que lleva por título:

" Soft Skills Model for Employability in Mexico "

El resultado de este trabajo, ha sido publicado en una revista de alto impacto.

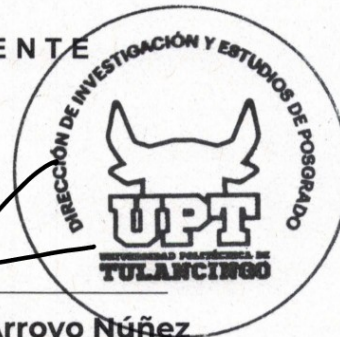
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Dr. Jose Humberto Arroyo Núñez
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Open Access Article

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Soft Skills Model for Employability in Mexico

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Abstract: Nowadays, soft skills are known as skills of the XXI century; in Mexico, it is necessary to promote or promote soft skills to encourage productivity, employability, and improve the quality of life of people or young professionals, so it is essential to know those skills that, in addition to the basic knowledge, employers require since skills necessary to contribute to the same objectives of the companies can be determined [1]. In any organization, certain competencies acquired by employers are required, and that is where soft skills play an important and fundamental role in companies, soft skills are considered a holistic concept of competence that involves the mobilization of knowledge, attitudes, and values to meet complex demands [2]. The objective of this research was to design a model for the employability of companies in Mexico. The methodology used for this research was a quantitative approach, causal correlational scope, and non-experimental, translational, and causal correlational research design [3]. Factor analysis was used to prevent two variables from measuring the same and multiple regression to determine the influence of soft skills on employability [3] in large companies in transformation in the State of Hidalgo, Mexico. The research instrument contains 22 items with a Likert scale from totally agree to strongly disagree, with a Cronbach's alpha of .830. The results were that the soft skills that influence employability are recognition, control of emotions, creative thinking, understanding of feelings, analytical reflections, own feelings and empathy, and relating and understanding with others; it could be concluded that hard work is needed with the integration of previous soft skills with employers.

Keywords: soft skills, employability, conceptual model.

墨西哥就业能力的软技能模型

摘要: 如今, 软技能被称为二十一世纪的技能; 在墨西哥, 有必要促进或促进软技能, 以鼓励生产力、就业能力和提高人们或年轻专业人员的生活质量, 因此了解这些技能是必不可少的, 除了基本知识外, 雇主还需要这些技能, 因为可以确定为公司的同一目标做出贡献所必需的技能[1]。在任何组织中, 都需要雇主获得某些能力, 这就是软技能在公司中发挥重要和基础作用的地方, 软技能被认为是能力的整体概念, 涉及调动知识、态度和价值观以满足复杂的需求要求[2]。本研究的目的是为墨西哥公司的就业能力设计一个模型。本研究使用的方法是定量方法、因果相关范围以及非实验、转化和因果相关研究设计[3]。在墨西哥伊达尔戈州的转型中, 使用因子分析来防止两个变量测量相同, 并使用多元回归来确定软技能对



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Por medio del presente documento le informo que el proyecto de investigación que lleva por título:

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Open Access Article

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Municipal Management and Population Development: Case of Hidalgo, Mexico

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Abstract: The administration at the municipal level and its management are the first governmental instance that receives and attends to the needs of the citizens, so it provides elements that should allow people to have a better quality of life, the present research establishes the objective of determining if the management elements evaluated in the municipalities and selects those that can present an alignment with the development of the population based on the Human Development Index results, present a positive relationship, for which a concurrent mixed methodology is used, which involves quantitative information obtained from statistics of official sources, and is analyzed with Spearman's rho statistic using the SPSS statistical program and, complementarily, the qualitative aspects are approached based on semi-structured interviews with management personnel of municipal administrations, researchers and academics from institutions of higher education, as well as state level officials with activities in municipal aspects. The main findings indicate that although there are correlations with average levels between economic development and income and health indexes, they are not notable in the well-being and improvement of citizens' conditions. The contributions of the interviews show that although the processes related to municipal planning, the alignment of public policies and the establishment of mechanisms for citizen participation have improved, the municipalities present challenges in terms of improving the well-being of the population.

Keywords: municipal management, human development, evaluation.

市政管理和人口发展：墨西哥伊达尔戈案例

摘要：市级行政及其管理是接收和关注公民需求的第一个政府部门，因此它提供了应该让人们过上更好生活质量的要素，本研究确定的目标是确定是否根据人类发展指数结果，在城市中评估并选择能够与人口发展保持一致，呈现正相关关系的管理要素；为此，使用并发混合方法，其中涉及从官方来源的统计数据中获得的定量信息，并使用斯皮尔曼的 rho 统计分析，使用社会科学统计程序的统计包，作为补充，定性方面是基于半-与市政当局的管理人员、高等教育机构的研究人员和学者以及在市政方面开展活动的州级官员进行结构化访谈；获得的主要发现让我们认为，虽然经济发展与收入和健康指标之间的平均水平存在相关性，但它们在公民福祉和改善公民条件方面并不显著；访谈的贡献表明，尽管与市政规划、公共政策的协调和公民参与机制的建立有关的进程有所改善，但市政当局在改善人口福祉方面





TARJETA INFORMATIVA

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Por medio del presente documento le informo que el proyecto de investigación que lleva por título:

“Identificación de comorbilidades asociadas a Covid-19 en el estado de Hidalgo mediante métodos de agrupamiento

Identification of comorbidities associated with Covid-19 in the state of Hidalgo through grouping methods.”

El resultado de este trabajo, ha sido publicado en una revista de alto impacto.

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Identificación de comorbilidades asociadas a Covid-19 en el estado de Hidalgo mediante métodos de agrupamiento
Identification of comorbidities associated with Covid-19 in the state of Hidalgo through grouping methods

C. Enríquez-Ramírez ^{a,*}, M. Raluy-Herrero ^a, M. Olvera-Cuellar ^a

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Resumen

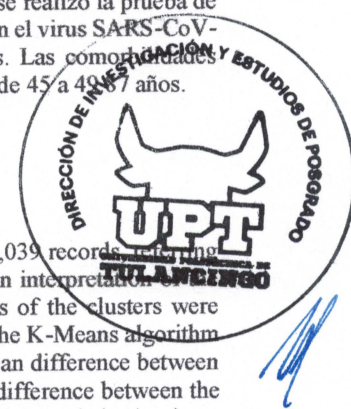
Se analizaron tres algoritmos de agrupación K-Means, DBSCAN y EM, en una base de datos abierta, con 10,039 registros, referente a los casos de COVID-19 presentados en el estado de Hidalgo, México. La finalidad de este estudio es obtener una interpretación de las comorbilidades asociadas a la COVID-19 mediante la implementación de los algoritmos mencionados. Los resultados de las agrupaciones fueron validados con el índice de silueta, como técnica de evaluación de la calidad de los algoritmos, obteniendo como mejor clasificador en este comparativo al algoritmo de K-Means. Además, se realizó la prueba de Tukey HSD para identificar la diferencia de medias entre los grupos de las comorbilidades relacionadas con el virus SARS-CoV-2, identificando la existencia de una diferencia significativa entre las medias de los grupos obtenidos. Las comorbilidades asociadas que se identifican en este estudio son diabetes, hipertensión y obesidad, en un rango de edades de 45 a 49.87 años.

Palabras Clave: Agrupación, K-Means, DBSCAN, EM, COVID-19.

Abstract

Three clustering algorithms, K-Means, DBSCAN and EM, are analyzed in an open database, with 10,039 records, referring to COVID-19 cases presented in the state of Hidalgo, Mexico. The purpose of this study is to obtain an interpretation of comorbidities associated with COVID-19 by implementing the aforementioned algorithms. The results of the clusters were validated with the silhouette index, as a technique for evaluating the quality of the algorithms, obtaining the K-Means algorithm as the best classifier in this comparison. In addition, the Tukey HSD test is performed to identify the mean difference between the groups of comorbidities related to the SARS-CoV-2 virus, identifying the existence of a significant difference between the means of the groups obtained. The associated comorbidities identified in this study are diabetes, hypertension, and obesity, in an age range of 45 to 49.87 years.

Keywords: Cluster, K-Means, DBSCAN, EM, COVID-19.



1. Introducción

Se analizan tres algoritmos de agrupación K-Means, DBSCAN y EM, en una base de datos abierta referente a los casos de COVID-19, proporcionada para su consulta o estudio de los casos asociados a la enfermedad a nivel nacional, CONACyT (2022). En este trabajo se obtienen los registros asociados al estado de Hidalgo, México.

La finalidad de este estudio es obtener la mejor interpretación de las enfermedades

asociadas al virus SARS-Cov-2, mediante el uso de técnicas de agrupamiento propias del aprendizaje automático.

El uso del aprendizaje automático (ML por sus siglas en inglés) se está convirtiendo en un recurso principal para la identificación de ciertos patrones que se tienen en grandes conjuntos de información, pero que no son muy evidentes en la ejecución de consultas simples. Su área de aplicación es cada vez más amplia, ya que su implementación abarca la educación, los negocios y el campo de la salud, entre otras.

Para un adecuado uso de los diversos algoritmos de ML, tanto en el campo supervisado como en el no supervisado, se requiere de conjuntos de datos en los cuales se pueda, con base

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Por medio del presente documento le informo que el proyecto de investigación que lleva por título:

**" Multiple-Frequency Force Estimation of Controlled Vibrating
Systems with Generalized Nonlinear Stiffness"**

El resultado de este trabajo, ha sido publicado en una revista de alto impacto.

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A.TENTAMENTE


Dr. José Humberto Arroyo Núñez
Director de Investigación y Posgrado



Article

Multiple-Frequency Force Estimation of Controlled Vibrating Systems with Generalized Nonlinear Stiffness

Francisco Beltran-Carbajal ¹, Juan Eduardo Esquivel-Cruz ², Hugo Yañez-Badillo ³,
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Abstract: An on-line estimation technique of multiple-frequency oscillatory forces combined with the Hilbert–Huang transform for an important class of actively controlled, forced vibrating mechanical systems with nonlinear stiffness forces is proposed. Polynomial parametric nonlinearities are incorporated in the significantly perturbed vibrating system dynamics. This class of nonlinear vibrating systems can exhibit harmful large-amplitude vibrations, which are inadmissible in many engineering applications. Disturbing oscillations can be also provoked due to interactions of the primary mechanical system to be actively protected against dangerous vibrations with other forced uncertain multidegree-of-freedom nonlinear vibrating systems. Taylor’s series expansion to dynamically model uncertain vibrating forces into a small time window for real-time estimation purposes is employed. Intrinsic mode functions of multiple-frequency vibrating forces can be then obtained by the Hilbert–Huang transform. Uncertain instantaneous frequencies and amplitudes of disturbing oscillations can be directly computed in temporal space. An active vibration control scheme for efficient and robust tracking of prescribed motion reference profiles based on multiple frequency force estimation is introduced as well. The presented closed-loop on-line estimation technique can be extended for other classes of nonlinear oscillatory systems. Analytical, experimental and numerical results to prove the estimation effectiveness are presented. Numerical results show reasonable estimation errors of less than 2%.

Keywords: mechanical vibrations; nonlinear stiffness; polynomial nonlinearity; active vibration control; harmonics estimation; Hilbert–Huang transform

MSC: 93C10



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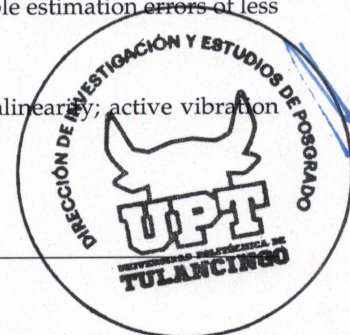
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1. Introduction

Development of on-line accurate time-domain estimation strategies of multiple-frequency oscillating forces for vibration analysis and control in weakly damped dynamic mechanical systems with nonlinear spring stiffness forces represents an open relevant research problem. In this regard, the oscillatory dynamic behavior of an important class of nonlinear physical systems has been modelled by the Duffing equation in which cubic stiffness nonlinearity is incorporated [1]. Phenomena that can occur in a forced nonlinear oscillator with a cubic spring stiffness force term have been modelled by the Duffing equation [1]. Undesirable nonlinear behaviors of hysteresis, chaotic oscillations, jump and a variety of bifurcations are some phenomena than can be exhibited by this class of vibrating systems [2,3]. Super-harmonic



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Por medio del presente documento le informo que el proyecto de investigación que lleva por título:

"Varroa Destructor Classification Using Legendre–Fourier Moments with Different Color Spaces."

El resultado de este trabajo, ha sido publicado en una revista de alto impacto.

Se anexa al presente documento la evidencia de la publicación.

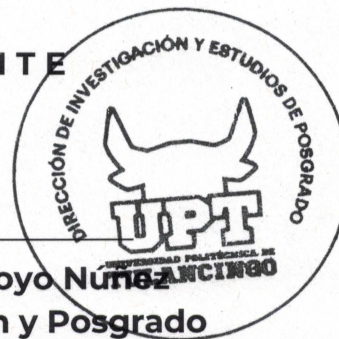
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Dr. José Humberto Arroyo Núñez
Director de Investigación y Posgrado





Article

Varroa Destructor Classification Using Legendre–Fourier Moments with Different Color Spaces

Alicia Noriega-Escamilla , César J. Camacho-Bello * , Rosa M. Ortega-Mendoza , José H. Arroyo-Núñez and Lucía Gutiérrez-Lazcano

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Abstract: Bees play a critical role in pollination and food production, so their preservation is essential, particularly highlighting the importance of detecting diseases in bees early. The Varroa destructor mite is the primary factor contributing to increased viral infections that can lead to hive mortality. This study presents an innovative method for identifying Varroa destructors in honey bees using multichannel Legendre–Fourier moments. The descriptors derived from this approach possess distinctive characteristics, such as rotation and scale invariance, and noise resistance, allowing the representation of digital images with minimal descriptors. This characteristic is advantageous when analyzing images of living organisms that are not in a static posture. The proposal evaluates the algorithm’s efficiency using different color models, and to enhance its capacity, a subdivision of the VarroaDataset is used. This enhancement allows the algorithm to process additional information about the color and shape of the bee’s legs, wings, eyes, and mouth. To demonstrate the advantages of our approach, we compare it with other deep learning methods, in semantic segmentation techniques, such as DeepLabV3, and object detection techniques, such as YOLOv5. The results suggest that our proposal offers a promising means for the early detection of the Varroa destructor mite, which could be an essential pillar in the preservation of bees and, therefore, in food production.

Keywords: Legendre–Fourier multichannel moments; honey bee; Varroa destructor



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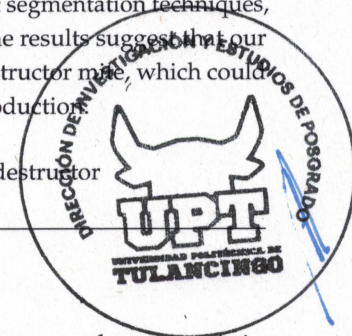


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1. Introduction

The honey bee (*Apis mellifera*) is a species native to Africa, Europe, and western Asia; its management has contributed to the presence of this species in all continents except Antarctica and some oceanic islands [1]. They are vital as pollinators, visiting more than 90% of the world’s principal crops [2]. They also generate essential products such as honey, pollen, propolis, and royal jelly, producing jobs mainly in rural areas [3]. Hence, reducing their population could affect the production and quality of food whose crops depend on insect pollination [4]. Despite its relevance, a decline in bee diversity has been recorded due to climate change, pesticide use, and loss of natural habitats [5]. In addition, diseases associated with fungi, bacteria, viruses, and invertebrate parasites threaten the health of bees [2]. These diseases tend to spread to nearby bee populations due to commercial management, mass breeding, transport, trade, and physical contact between bees, especially during harvesting, representing a problem for conserving wild bee species.

The worldwide transmission and spread of the ectoparasitic mite Varroa destructor is the main factor in increasing viral infections. Furthermore, it inoculates in the larvae and adults, causing the death of hives [6]. A decrease in production of 45% is estimated in a swarm of domestic bees infested with Varroa, which causes economic losses due to sanitary treatments, the repopulation of the packs, the treatment of secondary diseases, and labor [7]. Currently, different chemicals and application methods keep the mite population



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Por medio del presente documento le informo que el proyecto de investigación que lleva por título:

"Motion-Tracking Control of Mobile Manipulation Robotic Systems Using Artificial Neural Networks for Manufacturing Applications."

El resultado de este trabajo, ha sido publicado en una revista de alto impacto.

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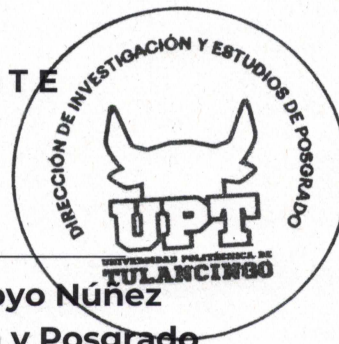
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ATENTAMENTE


Dr. José Humberto Arroyo Núñez
Director de Investigación y Posgrado



Article

Motion-Tracking Control of Mobile Manipulation Robotic Systems Using Artificial Neural Networks for Manufacturing Applications

Daniel Galvan-Perez ¹, Francisco Beltran-Carbajal ^{2,*}, Ivan Rivas-Camero ¹, Hugo Yañez-Badillo ³, Antonio Favela-Contreras ⁴ and Ruben Tapia-Olvera ⁵

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Abstract: Robotic systems have experienced exponential growth in their utilization for manufacturing applications over recent decades. Control systems responsible for executing desired robot motion planning face increasingly stringent performance requirements. These demands encompass high precision, efficiency, stability, robustness, ease of use, and simplicity of the user interface. Furthermore, diverse modern manufacturing applications primarily employ robotic systems within disturbed operating scenarios. This paper presents a novel neural motion-tracking control scheme for mobile manipulation robotic systems. Dynamic position output error feedback and B-Spline artificial neural networks are integrated in the design process of the introduced adaptive robust control strategy to perform efficient and robust tracking of motion-planning trajectories in robotic systems. Integration of artificial neural networks demonstrates performance improvements in the control scheme while effectively addressing common issues encountered in manufacturing environments. Parametric uncertainty, unmodeled dynamics, and unknown disturbance torque terms represent some adverse influences to be compensated for by the robust control scheme. Several case studies prove the robustness of the adaptive neural control scheme in highly coupled nonlinear six-degree-of-freedom mobile manipulation robotic systems. Case studies provide valuable insights and validate the efficacy of the proposed adaptive multivariable control scheme in manufacturing applications.



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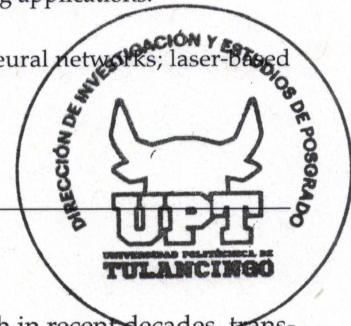
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Keywords: robotics; mobile manipulation robotic systems; artificial neural networks; laser-based manufacturing; robust control; active disturbance control

MSC: 93C10

1. Introduction

The robotics industry has experienced unprecedented growth in recent decades, transforming manufacturing operations completely [1–3]. Mobile manipulation robotic systems have emerged as efficient and versatile tools for automating various tasks in industrial environments [4–6]. This progress, however, has presented challenges in controlling the motion of robotic systems in manufacturing applications that require high levels of precision and reliability [7]. The need for enhanced accuracy in robotics comes from the requirement for precise manipulation of objects in manufacturing scenarios [8]. Accurately planned



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| DE | Dr. José Humberto Arroyo Núñez Director de Investigación y Posgrado |
| ASUNTO | Asunto Conclusión de Proyecto |
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Por medio del presente documento le informo que el proyecto de investigación que lleva por título:

"Microcontrollers programming for control and automation in undergraduate biotechnology engineering education."

El resultado de este trabajo, ha sido publicado en una revista de alto impacto.

Se anexa al presente documento la evidencia de la publicación.

[Microcontrollers programming for control and automation in undergraduate biotechnology engineering education - ScienceDirect](https://doi.org/10.1016/j.dche.2023.100122)

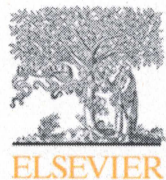
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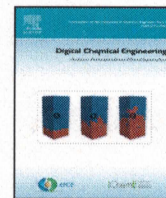

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Original article

Microcontrollers programming for control and automation in undergraduate biotechnology engineering education

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Control theory

ABSTRACT

This paper presents the utilization of the ESP32 microcontroller as a teaching tool for signal acquisition, processing, and control theory in biotechnological engineering. The ESP32 microcontroller, equipped with Bluetooth and WiFi capabilities, offers an affordable and versatile solution for educational purposes. By leveraging the Arduino© software, students can easily learn microcontroller programming and utilize various peripherals such as sensors and actuators. Several practical exercises related to process control have been conducted using this microcontroller. Additionally, remote process monitoring and control are enabled through integration with a database. Furthermore, concepts of artificial intelligence are explored using the Edge Impulse platform to obtain an artificial neural network that can be downloaded onto the ESP32. Positive feedback from students highlights the effectiveness and engagement of utilizing these microcontrollers, and the integration of internet connectivity enhances the overall learning experience.

1. Introduction

In recent years, the rapid advancement of technology, particularly the internet, has led to significant transformations in both industry and education. Industry 4.0 has brought about a digital revolution, where digitalization has become a pervasive factor in various aspects of industrial processes (Kakkar et al., 2021). Intelligent manufacturing has become a reality, and the Internet of Things (IoT) has enabled the seamless acquisition and transmission of data from numerous sensors. This has facilitated remote access and control, allowing individuals to remotely monitor and manipulate machines and systems from anywhere. The COVID-19 pandemic has further highlighted the importance of IoT, as it has facilitated remote work and allowed for effective factory monitoring and control via the internet.

Similarly, the field of education has also embraced these technological advancements. In Mexico, it is increasingly common to find universities that have adopted a competency-based approach (CBA) to learning (Malhotra et al., 2023). This approach places the learner at the center of the educational process, where students actively construct their knowledge by integrating information from diverse sources. In this context, the role of the professor shifts from being a sole provider

of knowledge to that of a facilitator, guiding and supporting students in their learning journey.

In Mexico, there is a notable disparity in budget allocation between private and public universities. While competency-based approach (CBA) is commonly adopted in public universities as the preferred learning model, the utilization of specialized software is often limited due to licensing fees. This issue is even more pronounced in developing countries, where the integration of technology in education is slow and sometimes inadequate (Jhurree, 2005). As a result, the use of open-source software has emerged as a viable alternative to facilitate teaching and equip students with valuable skills and abilities. For instance, Barry (2009) highlighted the benefits of free software for education in Sudan, while Thapa and Gautam (2021) discussed a similar case in Nepal.

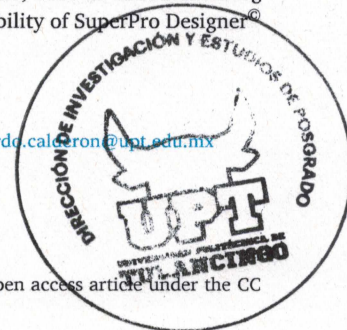
SuperPro Designer[®] is a remarkable software widely used in various industrial applications, including the simulation of chemical reactions, phase separation, homogenization, chromatography, and evaporation. It offers powerful capabilities for process optimization and has been extensively studied for economic evaluations, such as debottlenecking analyses (Foo, 2023). However, the accessibility of SuperPro Designer[®]

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| ASUNTO | Conclusión de Proyecto |
| FECHA | 14 de diciembre de 2023 |

Por medio del presente documento le informo que el proyecto de investigación que lleva por título:
"Robust Motion Control for Aerial Robotic Systems in Monitoring Applications"

El resultado de este trabajo, ha sido publicado en una revista de alto impacto.

Se anexa al presente documento la evidencia de la publicación.

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Robust Motion Control for Aerial Robotic Systems in Monitoring Applications

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Abstract—Mobile robots usage have allowed a property performance of complex tasks in various fields without human intervention. Unmanned aerial robots have been successfully used in monitoring applications within indoor and outdoor scenarios. The main contribution of this research is to introduce a novel robust neural sliding-mode control for a four-rotor aerial robot in monitoring tasks. To verify the effectiveness of the proposed motion control scheme, it is considered a simulation scenario where the vehicle is subjected to unknown disturbances while the robot is flying towards different operation points, as required in real-time monitoring applications. Barrier polynomials are suitably integrated in the motion control scheme to smooth the system motion. Additional case study is also included where B-spline artificial neural networks are efficiently introduced for improving the system performance while maintaining its stability despite random undesired abrupt position changes due to the induced forces by wind. Finally, to highlight the effectiveness of the introduced controller, the vehicle is simulated in a virtual scenario where a rapidly exploring random tree (RRT) algorithm is implemented for determining the best path in a constrained space. This preliminary results effectively promote the development of cyber-physical systems for monitoring application management, as required in the electric power systems.

Index Terms—Aerial Robotic System, Motion Control, Neural Sliding Modes, Monitoring Applications.

I. INTRODUCTION

The quadrotor is an underactuated system that presents a highly nonlinear dynamic behaviour and is capable to hovering and vertical take-off and landing (VTOL). Those capabilities have attracted the researchers attention from different technological fields. Notwithstanding, uncertainty, parasitic and unmodeled dynamics, external disturbances, difficult the operation and flight of the quadrotor system. Thus, effective automatic control schemes must be proposed for ensuring the system functioning even in hostile environments. This kind of vehicles have successfully implemented in monitoring applications since can gather detailed target data from different perspectives, any physical contact with the target is unnecessary and they can they reach inaccessible areas in hostile environments.

One of the most relevant proposed theories within the automatic control is the sliding modes theory, which have been effectively employed for controlling complex high-order nonlinear dynamic systems [1]. The main drawback for implementing sliding modes based-control is that high-frequency oscillations with finite amplitude (chattering) are present in the control inputs, since it is required the design of a sliding surface and the action of discontinuous signals for ensuring

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| ASUNTO | Conclusión de Proyecto |
| FECHA | 14 de diciembre de 2023 |

Por medio del presente documento le informo que el proyecto de investigación que lleva por título:

"Tracking Control Approach of Speed Profiles of Induction Motors used in Electric Vehicles"

El resultado de este trabajo, ha sido publicado en una revista de alto impacto.

Se anexa al presente documento la evidencia de la publicación.

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Tracking Control Approach of Speed Profiles of Induction Motors used in Electric Vehicles

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Abstract—Electromobility is an area in growing development that seeks to make the transport sector more efficient through electric vehicles with the development of new automatic control technologies and the incorporation of renewable energies. In this context, efficient speed control in electric vehicles is essential, and applicable in vehicles powered by an electric motor, this allows the vehicle to be brought from a state of rest to an operating condition desired by the user in a controlled manner. For following planned speed trajectories for the operation of a vehicle powered by a three-phase induction motor a control strategy is presented in this paper. The results of the computer simulation verify the effectiveness in the implementation of the controller in an electric vehicle considering its dynamics, its systems of power transmission and a three-phase induction motor.

Index Terms—Automatic Motor Control, Bezier Curves, Electric Vehicles, Electromobility, Induction Motor.

I. INTRODUCTION

New technologies have been developed due to the growing demand for electric and hybrid vehicles [1]. Electric vehicles in the transportation sector typically incorporate at least one electric motor, which serves as the primary component for converting electromechanical energy for vehicle propulsion [2]. The power transmission system in electric transportation necessitates a wide operating speed range and high efficiency in torque and speed generation by the motor [1]. In most electric vehicles, an electric motor is commonly connected to a reduction gear (gearbox) and a mechanical differential [3]. Induction motors are an attractive option for electric vehicle applications due to their robustness, cost-effectiveness, low maintenance requirements, and well-established technology [4]. When analyzing motor options for electric vehicles, both permanent magnet motors and induction motors are considered, with a focus on achieving high efficiency [5].

A fundamental challenge is presented by the displacement control of induction motors for high dynamic performance applications. This is attributed to the non-linear dynamics that describe the conversion of electrical energy into mechanical energy [6]. Furthermore, the occurrence of unknown external loads and variations is possible during the operation of the induction motor. Efficient regulation of various voltage control inputs and several outputs, such as stator speed, magnetic flux, and torque, is achieved by the dynamic model of the induction motor [7]. Consequently, the use of induction motors is limited to industries where speed regulation is not required. However, the increasing technological development of recent years in areas of understanding such as power electronics and superior construction techniques for microprocessors, allow the use of controllers to regulate the speed of induction motors [8]. In this context, control strategies relying on Proportional, Integral, and Derivative (PID) controllers are the most commonly employed in the industry. However, traditional controllers have the possibility of exposing constraints to obtain universally robust performance in the presence of uncertainty and exogenous perturbations that vary with age, requiring a precise understanding of the mathematical model and the boundaries of the nonlinear dynamical system [9].

In recent years, various inquiries have been made in relation to trajectory tracking. The proposed control approaches are based primarily on electronic power steering (EPS), active steering system (AFS) or steering by system (SWB) [10]. Although, there are some applications of these engines in which specific drivers were created for all of them [11]. On the other hand, there is the application of specific controllers for this type of motors such as the Fuzzy controller [12] or Fuzzy based on observers [6], there are also controllers directly applied to the axial flow as field oriented control [13] or adding optimization in genetic algorithms [14]. However,