

# An RRT\*-informed Q-learning strategy for path planning of unicycle-type mobile robots in open-pit mines

*Una estrategia de Q-Learning informada por RRT\* para la planificación de caminos de robots móviles tipo unicycle en mineras de cielo abierto*

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This paper presents a hybrid path planning approach that combines autonomous machine learning methods with random sampling strategies. Specifically, Q-Learning is introduced as a global planning approach informed by a Rapidly-exploring Random Tree (RRT\*)-based sampling method as a local planning methodology. The proposed path planning strategy is based on the idea of combining the advantages of reinforcement learning, which is intended to learn the best control policy in conjunction with the RRT\* capabilities to quickly explore and generate feasible trajectories in high-dimensional spaces. By combining these two approaches, a balance is achieved between efficient exploration of the search space and exploitation of information from the environment for convergence towards an optimal policy. To evaluate and validate the effectiveness of the proposed method, a quantitative study was conducted involving performance comparison of the integrated method in different environments. It was used four scenarios to generate a reference path, including environments that allowed i) a straight path, ii) squared path, iii) intricate path, and iv) helicoidal paths, similar to those found in open-pit mines, all with terrain constraints along the path. The results obtained in simulation studies on autonomous unicycle-type robotic vehicles were favorable with high compatibility between the two hybrid approaches. It was demonstrated that the hybrid method significantly surpassed the individual limitations of Q-Learning and RRT\*, achieving better exploration of the search space and fast convergence towards a learned path compared to the methods used separately. The combination of the planner strategies achieved a 23.05% and 81.1% reduction in tracking errors costs, and a 27.0% and 40.6% reduction in control effort compared to QLearning and RRT\*, respectively. These results are expected to impact on the energy resource savings of autonomous robots when following planned paths in mining environments.

**Keywords:** Path planning, Q-Learning, RRT\*, autonomous mobile robot, mining scenarios.

# Probabilistic Seismic Hazard Assessment of Northern Chile: Integrating Seismic and GNSS Strain Data

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Probabilistic seismic hazard analysis (PSHA) is a widely used method for estimating the probabilities of ground shaking in engineering and public safety applications. PSHA relies on earthquake return period statistics derived from instrumental and historical data. However, the availability of historical data is often limited, leading to the use of instrumental catalogs covering shorter time periods (typically 70-120 years). There is an assumption that these short-term statistics can adequately represent return periods over longer timescales of 500-2475 years, which are commonly considered in PSHA. However, caution is necessary when extrapolating short-term data to longer-term hazard assessments. In recent years, advancements in geodetic techniques have led to significant progress in incorporating geodetic strain data along with seismic data for estimating Probabilistic Seismic Hazard Assessment (PSHA)[1-2]. This study adopts a logic tree approach to calculate PSHA using the classical Cornell–McGuire method at a  $0.1 \times 0.1^\circ$  grid interval by considering both seismic and GNSS (Global Navigation Satellite System) data. The study utilizes a homogenized earthquake catalog in terms seismic moment magnitude scale (Das Magnitude Scale  $M_{wg}$ ), published GNSS velocity data from various sources and ground motion prediction equations (GMPE) to create a PSHA map for Northern Chile. Seismic hazard maps were developed for peak ground acceleration (PGA) for 10% probabilities of exceedance in 50 years. PGA values derived from GNSS strain data and earthquake data at the surface exhibit a range of 0.45-1.79 g for a 10% exceedance probability over a period of fifty years.

**Keywords:** Probabilistic Seismic Hazard Assessment, GNSS Strain Data, Ground Motion Prediction Equations

# The Role of Light Environment on Predicting Spectral Bands for Forest Canopy Characterization

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Reflectance on the visible and near-infrared spectrum plays a crucial role in retrieving biophysical and structural knowledge about vegetation. In particular, vegetation indices exploit plant reflectance features for performing quantitative and qualitative evaluations of vegetation. However, the spectral reflectance on meaningful bands is not always available because of the cameras' spectral response restrictions. In order to overcome sensor limitations, previous works have demonstrated that conditional Generative Adversarial Networks, cGAN, can model the inter-correlation between electromagnetic bands and overcome the lack of reflectance continuity of multispectral imagers. Most previous works focused on developing deep-learning approaches to address spectral image reconstruction. However, the effects of different illumination conditions on the reflectance reconstruction require further evaluation. In particular, light environment variations over one day has visible effects on captured images. In this context, the prediction potential of the deep neural networks might be affected by light variations. Therefore, the present work investigates the spectral reconstruction performance of a cGAN in six lighting scenarios. Precisely, we assess the multispectral image generation at green and red-edge bands. Results showed that illumination conditions might affect the performance of cGAN models for generating spectral images. Nevertheless, the cGAN model can overcome different lighting conditions by training and validating it with samples that introduce diverse illumination conditions and vegetation types. In other words, the cGAN demonstrates its highest performance when trained with a comprehensive dataset that includes samples from various illumination conditions and study sites

**Keywords:** *Generative Adversarial Networks, Multispectral Reflectance, Lighting conditions forestry*

# Desarrollo de un Sistema de Recomendación de Proveedores Tecnológicos usando Algoritmos de Filtrado basado en Contenidos

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En este artículo se presenta una evaluación comparativa de varios algoritmos de recomendación utilizados en inteligencia artificial. A través de una metodología rigurosa y pruebas detalladas, se han evaluado y comparado seis algoritmos de recomendación: Random Forest Classifier, Decision Tree Classifier, K-Nearest Neighbours, Regresión Logística, Gaussian NB, y Support Vector Classifier. Los algoritmos se probaron en diferentes distribuciones de datos de entrenamiento y testeo, proporcionando una visión clara de su rendimiento en diversas condiciones. Los hallazgos más importantes indican que el algoritmo de Random Forest Classifier obtuvo el mejor rendimiento en términos generales, seguido de cerca por los algoritmos Decision Tree Classifier y KNearest Neighbours. Estos resultados son fundamentales para la implementación de nuevos sistemas de recomendación eficientes y efectivos.

**Palabras Clave-** *Sistemas de Recomendación, Algoritmos de Filtrado basado en Contenidos Evaluación de Algoritmos, Algoritmos de Clasificación, Aprendizaje Automático*



INFONOR

# Caracterización de Sismos en el Norte de Chile Utilizando Técnicas de Clustering para la Identificación de Posibles Puntos de Primera Respuesta

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En el presente artículo se explica el trabajo realizado para agrupar eventos sísmicos en el Norte Grande de Chile con el objetivo de identificar potenciales zonas geográficas donde se puedan desplegar posibles puntos de primera respuesta ante eventuales catástrofes que pudiesen ser provocadas por dichos eventos, lo anterior dada la alta potencialidad sísmica que tiene dicha zona. Para ello, se desarrolla el proceso de forma adaptada en base a las seis fases de la metodología CRISPDM, dentro de la cual se aplican seis diferentes algoritmos de clustering para agrupar los datos, evaluando los resultados a través de diferentes índices de validación interna. En los resultados se obtiene un amplio espectro de escenarios dada la cantidad de algoritmos utilizados, los ajustes de los hiperparámetros aplicados, las cantidades de grupos configuradas y los distintos tipos de distancias empleadas. En particular, destacan los resultados obtenidos por medio de la técnica de clustering DBSCAN, la cual genera las mejores agrupaciones, identificando las localidades de Achuleo, Norte de Pisagua, Pozo Almonte y Caleta Chipana como sectores candidatos a ser posibles puntos de primera respuesta. Finalmente se concluye que los algoritmos basados en densidad son los más recomendados para agrupar eventos sísmicos ya que tienen la capacidad de encontrar grupos con formas arbitrarias que no son necesariamente convexos.

**Palabras Clave-** Minería de Datos, Sismos, Clustering, DBSCAN, Norte Grande de Chile.

# Variable Neighbourhood Descent and Neighbourhood Uses for the Beam Angle Optimisation Problem

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Intensity Modulated Radiation Therapy (IMRT) is a standard treatment option for cancer patients. The primary objective of IMRT is to eradicate cancer cells from the tumour site while minimising harm to the Organs at Risk (OAR) surrounding it. The first step toward achieving this goal is determining the optimal beam angle configuration (BAC) for the treatment plan. In this paper, we propose studying a variant of the well-known variable neighbourhood search (VNS) algorithm, called Variable Neighbourhood Descent (VND), which explores the search space using two types of movements. The first movement (N1) replaces each beam angle in the BAC with a  $\pm 5^\circ$  beam angle, while the second movement (N2) replaces each beam angle in the BAC with a randomly chosen beam angle. Unlike traditional VNS-based algorithms, the VND algorithm ensures that the solution is better for all neighbourhood definitions. Results show that using N2 is more common in early iterations, often obtaining better improvements, while using N1 is more common in later iterations, maintaining stable improvements across iterations. We try our approach on a clinical prostate case from a hospital in Chile. The VND shows to be a robust algorithm that can obtain high-quality treatment plans, although it is slower than other VNS-based strategies.

**Keywords-** Variable Neighbourhood Descent, reduced Variable Neighbourhood Search, Local Search, Intensity Modulated Radiation Therapy, Beam Angle Optimisation

# Mejorando la recuperación de cobre por flotación mediante el uso de técnicas de Ciencia de datos y Aprendizaje automático

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En la industria la minería de cobre se está incrementando el uso de métodos de aprendizaje automático (machine learning) con el objetivo de mejorar la predicción de resultados en procesos de producción. En este documento, se presenta la experiencia de aplicar técnicas de ciencia de datos y de aprendizaje automático a datos históricos del proceso de flotación. Estos datos fueron recolectados utilizando un prototipo de equipo de flotación desarrollado en la Universidad Católica del Norte, en Antofagasta, Chile. El resultado de este proceso consiste en los siguientes procesos: 1) se desarrolló un proceso de Extracción, Transformación y Carga (ETL) para tener un mejor entendimiento de la dinámica del dominio y seleccionar las variables más relevantes en el proceso de flotación, y 2) se creó un modelo predictivo utilizando el algoritmo Random Forest (RF) para estimar la recuperación de cobre mediante el método de flotación. La combinación de estos procesos permitió generar recomendaciones sobre el manejo de las variables predictores para mejorar la recuperación de cobre en el contexto del prototipo de equipo de flotación. En este documento, se presentan detalles metodológicos y se describe el proceso utilizado para obtener los resultados antes mencionados. A medida que se avanzó a través de 3 iteraciones, la calidad de los resultados obtenidos con el modelo predictivo, generado mediante RF, fue mejorando. Al finalizar el proceso, se logró alcanzar una precisión del 98.98%, con una precisión en cada una de las clases superior al 95%. Estos resultados demuestran la eficacia y el rendimiento sobresaliente del modelo predictivo. Estos valores son altamente competitivos cuando se comparan con los obtenidos en otros estudios similares en el contexto de la industria 4.0.

**Palabras Clave-** Ciencia de datos, Aprendizaje automático, flotación, modelos predictivos, industria 4.0

# Metaversos en Educación: Una Mirada desde la Literatura

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La pandemia del COVID-19 dejó en evidencia la importancia de las tecnologías de la información en la educación y lo útiles que son, dándole valor a través de la implementación de TIC disruptivas como lo son la realidad virtual (VR) y la realidad aumentada (AR), que en su conjunto conforman lo que llamamos metaverso. En esta investigación se pretende abordar y analizar el metaverso como herramienta educativa y que impactos puede tener en el proceso formativo de los estudiantes. El diseño de esta investigación fue de carácter documental utilizando las bases de datos Web of Science (WoS) y Scopus, por ser consideradas como las principales bases de datos a nivel mundial, que reúnen publicaciones de impacto y relevancia científica, especialmente sobre tecnología educativa, aspecto directamente relacionado con el enfoque buscado en este artículo. La perspectiva de esta investigación se centra en mostrar a investigadores y comunidad educativa la situación actual sobre un tema que marca el futuro de los entornos virtuales de aprendizaje tanto a mediano como a largo plazo. Estamos ante un tema de investigación que se encuentra en un estado preliminar-exploratorio y, por lo tanto, puede haber cambios significativos en las tendencias de investigación propuestas en este estudio durante los próximos años. No obstante, es fundamental realizar una revisión de las principales contribuciones científicas en un tema de estudio con gran potencial para asegurar un óptimo establecimiento de sus bases teóricas y su posterior adopción como tema clave para la comunidad científica.

**Palabras Clave-** Entornos Virtuales, Metaverso, Realidad Aumentada, Realidad Inmersiva, Tecnología Educativa



# Aprendizaje profundo en imágenes de alimentos con etiquetas múltiples y ruidosas

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Los métodos de aprendizaje profundo han demostrado ser precisos para el reconocimiento automático de alimentos, pero su rendimiento depende no solo del diseño del modelo, sino también de la cantidad, variedad y calidad de los datos. Se pueden recopilar grandes volúmenes de datos de repositorios públicos, pero el proceso de revisión y anotación es una tarea extremadamente extenuante. Por este motivo, recientemente se han creado bases de datos no supervisadas. En ellas es muy probable que algunos de los datos obtenidos no se correspondan con los esperados, por lo que las etiquetas asignadas automáticamente serían ruidosas. Teniendo en cuenta que para ofrecer una dieta adecuada es necesario proporcionar información a nivel de los alimentos y/o ingredientes que componen las comidas y considerando además un proceso no supervisado para las anotaciones de los conjuntos resultantes. En este trabajo proponemos el diseño de un modelo de aprendizaje profundo robusto a etiquetas ruidosas para la tarea de clasificación de imágenes de alimentos a nivel de ingredientes, denominado ML-AFM. Para la evaluación, se utiliza el conjunto de datos público Food-101N, con anotaciones extendidas a nivel de ingredientes. Los resultados experimentales muestran que ML-AFM proporciona un mejor rendimiento que el modelo de la línea base, alcanzando un F1 de 76,56% y un AUPRC de 84,93%. Por lo tanto, proporciona una mayor robustez en el aprendizaje a partir de etiquetas ruidosas. Su rendimiento en la clasificación multi-etiqueta de ingredientes respalda su utilidad en aplicaciones prácticas de reconocimiento de alimentos.

**Palabras Clave-** Noisy labels, Ingredient recognition, Deep Learning, Multi-label recognition, Food analysis

# Potential Field-Based Trajectory Planning using Nonlinear Model Predictive Controller for Obstacle Avoidance of Autonomous Mobile Robots

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This work introduces a control approach based on trajectory re-planning using Nonlinear Model Predictive Control (NMPC) for autonomous mobile vehicles, facing obstacle avoidance in navigation environments. The proposed control approach solves a single optimization problem and ensures that the robot tracks a smooth and continuous parametrized reference. This is achieved by incorporating a nonlinear prediction model based on SkidSteer Mobile Robot (SSMR) dynamics and including constraints on both angular and linear speeds. Simulation tests were performed on circular and lemniscate trajectories usually used for control evaluation of holonomic robots, whereas a square reference trajectory was used for the experimental tests. Obstacles in the environment were considered as potential field functions, which are included as constraints into the optimization problem in the NMPC. The proposed strategy was assessed with control performance metrics for simulations and field tests on a Pioneer 3DX and SSMR Husky A200, respectively. The results showed that prioritizing the robot position reduced the tracking error and control effort by 15.3% and 15.8%, respectively, compared to results that only prioritized the obstacle position. The proposed strategy was intended to find a feasible trajectory that avoids obstacles; thereby successfully mitigating the collision risks and structural damage of the robot, operators, and the environment

**Keywords-** Obstacle avoidance, potential fields, trajectory planning, nonlinear model, predictive control, autonomous mobile robot

# Design of a strategy for the use of digital simulators in the teaching of physics to university students

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Currently there is a great problem in the Mexican Higher Education Institutions with the new students due to the deficiencies of knowledge that they present in the science area, this is due, among other factors, to the lack of motivation and interest of the students to learn science. This article proposes the design of a strategy for the use of free access digital simulators for students of the Physics Foundations course during the second four-month period of the Academic Program of Engineering in Animation and Visual Effects at the Polytechnic University of Sinaloa (UPSIN). , seeking to increase their interest in learning physical sciences, as well as offer a basic starting point that helps teachers and researchers to consider all the necessary characteristics for the design of strategies for the use of free access digital simulators in various subjects. In this strategy, digital simulators were used: virtual laboratory of free fall movement, I.E.S. Aguilar and Cano and Phet movement of a projectile; In addition, evaluation instruments were designed for each simulator, which were applied to the students after the teacher's explanation on two occasions. The first application of the instruments was without the use of simulators and the second with their support, seeking to determine in this way the impact generated by the use of free access digital simulators on the academic performance of students, in addition to analyze if they generated a greater interest in them to learn the physical sciences.

**Keywords-** Educational technology, digital simulators, motivation to learn, learning physical sciences

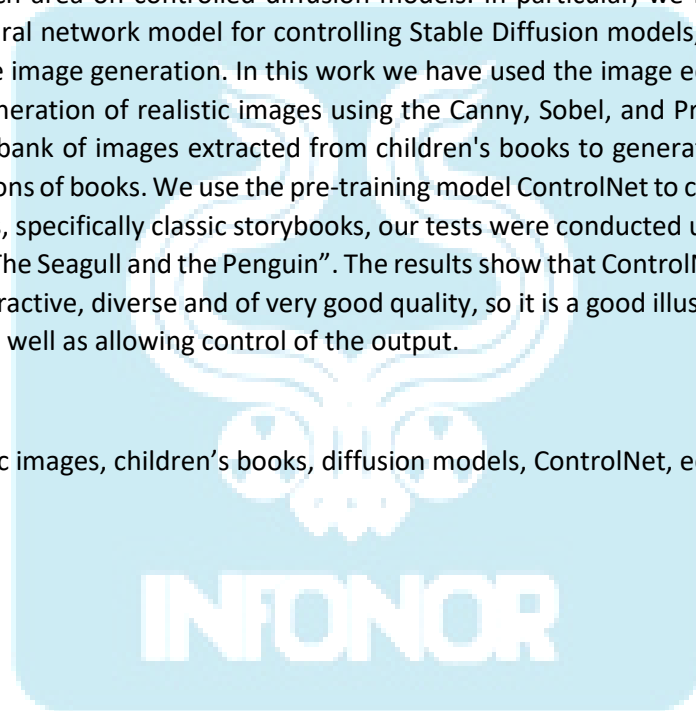
# Generation of realistic children's book images based on Diffusion Models

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In this article, we describe a model for the generation of realistic images for children's books using diffusion models, and we explain each step of the proposed model, but we focus on the review of the existing research area on controlled diffusion models. In particular, we focus on ControlNet. ControlNet is a neural network model for controlling Stable Diffusion models, and controls can be added to it to guide image generation. In this work we have used the image edges as a control, we have tested the generation of realistic images using the Canny, Sobel, and Prewitt edges, we also intend to design a bank of images extracted from children's books to generate realistic images to generate new versions of books. We use the pre-training model ControlNet to create realistic images for children's books, specifically classic storybooks, our tests were conducted using the books: "The Little Prince" and "The Seagull and the Penguin". The results show that ControlNet generates images that are visually attractive, diverse and of very good quality, so it is a good illustration generator for children's books, as well as allowing control of the output.

**Keywords-** Realistic images, children's books, diffusion models, ControlNet, edges



# Un Sistema basado en Programación de Restricciones para la Asignación de Turnos en una Empresa de Suministro de Combustible

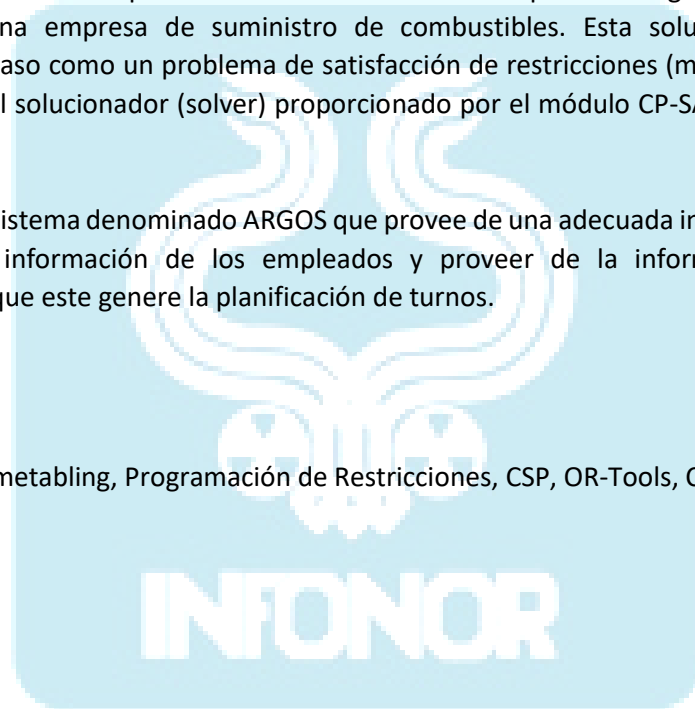
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Este artículo presenta la implementación de una solución para la asignación de turnos de trabajadores en una empresa de suministro de combustibles. Esta solución se basa en la especificación del caso como un problema de satisfacción de restricciones (model) y su resolución mediante el uso del solucionador (solver) proporcionado por el módulo CP-SAT de la herramienta OR-Tools.

Se implementó un sistema denominado ARGOS que provee de una adecuada interfaz a nivel usuario para gestionar la información de los empleados y proveer de la información necesaria al solucionador para que este genere la planificación de turnos.

**Palabras Clave-** Timetabling, Programación de Restricciones, CSP, OR-Tools, CP-SAT



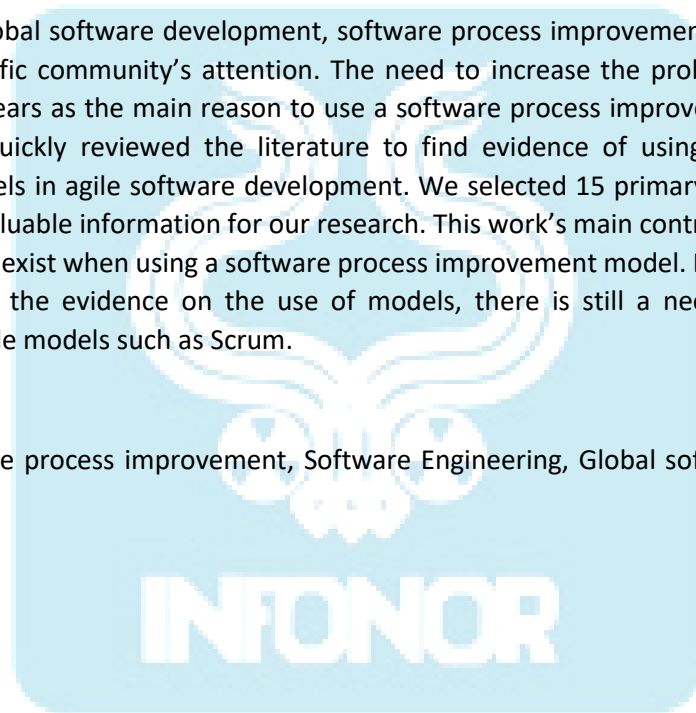
# Analysis of the Use of Software Process Improvement Models in Agile Development

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Nowadays, with global software development, software process improvement models have again focused the scientific community's attention. The need to increase the probability of success in these projects appears as the main reason to use a software process improvement model. In this article, we have quickly reviewed the literature to find evidence of using traditional process improvement models in agile software development. We selected 15 primary studies from which we could extract valuable information for our research. This work's main contribution is identifying the challenges that exist when using a software process improvement model. In conclusion, we can state that, despite the evidence on the use of models, there is still a need to facilitate their integration into agile models such as Scrum.

**Keywords-** Software process improvement, Software Engineering, Global software development, SPI, Agile



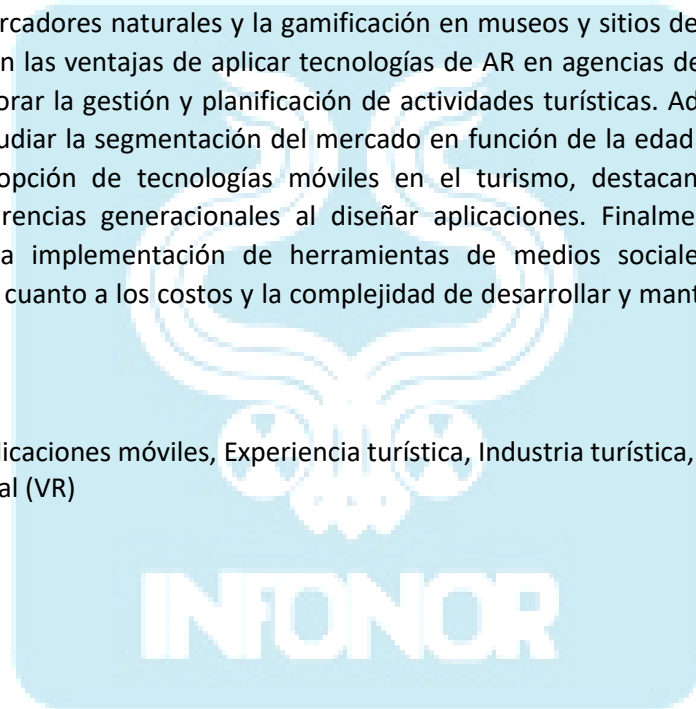
# Aplicativo móvil con tecnología inmersiva para la promoción del turismo

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<sup>1</sup>Universidad Privada de Tacna

La implementación de tecnologías de realidad aumentada (AR) y virtual (VR) en aplicaciones móviles tiene un gran potencial para mejorar la experiencia turística y promover el desarrollo de la industria turística. Este artículo de revisión analiza estrategias efectivas para implementar la AR en el turismo, como el uso de marcadores naturales y la gamificación en museos y sitios de patrimonio cultural. También se abordan las ventajas de aplicar tecnologías de AR en agencias de viajes y operadores turísticos para mejorar la gestión y planificación de actividades turísticas. Además, se examina la importancia de estudiar la segmentación del mercado en función de la edad de los usuarios para comprender la adopción de tecnologías móviles en el turismo, destacando la necesidad de considerar las diferencias generacionales al diseñar aplicaciones. Finalmente, se discuten las implicaciones de la implementación de herramientas de medios sociales en museos y las consideraciones en cuanto a los costos y la complejidad de desarrollar y mantener aplicaciones de este tipo.

**Palabras Clave-** Aplicaciones móviles, Experiencia turística, Industria turística, Realidad aumentada (AR), Realidad virtual (VR)



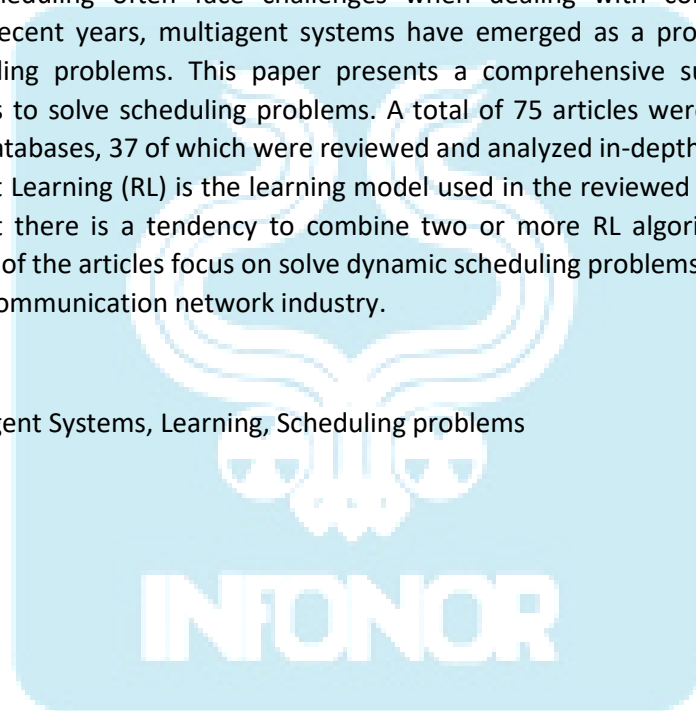
# Learning in Multiagent Systems to Solve Scheduling Problems: A Systematic Literature Review

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Scheduling problems are ubiquitous in various domains, requiring efficient allocation of resources and coordination of tasks to optimize performance and meet desired objectives. Traditional approaches to scheduling often face challenges when dealing with complex and dynamic environments. In recent years, multiagent systems have emerged as a promising paradigm for addressing scheduling problems. This paper presents a comprehensive survey of learning in multiagent systems to solve scheduling problems. A total of 75 articles were retrieved from the Scopus and WOS databases, 37 of which were reviewed and analyzed in-depth. The results indicate that Reinforcement Learning (RL) is the learning model used in the reviewed articles. Our analysis also identified that there is a tendency to combine two or more RL algorithms to be applied. Furthermore, most of the articles focus on solve dynamic scheduling problems from manufacturing and, wireless and communication network industry.

**Keywords-** Multiagent Systems, Learning, Scheduling problems





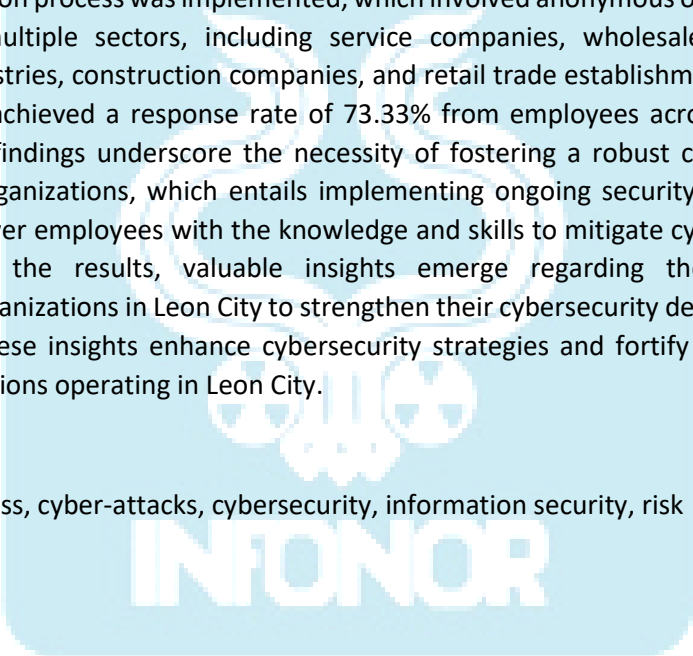
# Examining Cybersecurity Culture in Leon City Organizations: Insights from 2022

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Recent research indicates that public and private organizations around the world face cybersecurity breaches due to a need for more awareness among their employees. This study assesses the cybersecurity culture in different organizations across various Leon City, Mexico sectors. For this purpose, an evaluation process was implemented, which involved anonymous online surveys among employees from multiple sectors, including service companies, wholesale trade businesses, manufacturing industries, construction companies, and retail trade establishments. The study took place in 2022 and achieved a response rate of 73.33% from employees across the participating organizations. The findings underscore the necessity of fostering a robust cybersecurity culture within Leon City organizations, which entails implementing ongoing security awareness training programs to empower employees with the knowledge and skills to mitigate cyber risks effectively. Through analyzing the results, valuable insights emerge regarding the countermeasures implemented by organizations in Leon City to strengthen their cybersecurity defenses and minimize the risk surface. These insights enhance cybersecurity strategies and fortify the overall security posture of organizations operating in Leon City.

**Keywords-** Awareness, cyber-attacks, cybersecurity, information security, risk



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