



# SHARE YOUR WORK PROCEEDINGS

2023 IEEE International Conference on Advances in Data-Driven Analytics and Intelligent Systems (ADACIS)

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# Foreword

The first edition of the IEEE International Conference on Advances in Data-Driven Analytics and Intelligent Systems (IEEE ADACIS'23) was held in the iconic city of Marrakech, Morocco, at the Conference Center (CC) of the renowned Cadi Ayyad University (UCA) from November 23rd to 25th, 2023.

IEEE ADACIS'23 was a cutting-edge event that brought together experts, researchers, and industry leaders to showcase the latest advancements in information technology and data science. The technical program was structured around a series of sessions featuring keynote speeches, panels, presentations, and hands-on workshops by leading experts and researchers in their respective fields. The program encompassed a diverse range of topics related to data-driven analytics, including Fintech, E-health, Industry 4.0, education, agriculture, and Data-driven models, covering the algorithms and frameworks of Big Data, Data Mining, Machine Learning, Data Security, and other aspects of data processing. The theme of the first edition of the ADACIS conference is "Data-driven applications."

The special session called "Share Your Work" is dedicated to providing a platform for researchers to share their ongoing and latest research results, directions, and projects. It was an exciting opportunity to exchange ideas, gain insights, and foster collaboration within the academic community. Importantly, it provided a chance to receive constructive feedback, leading to improvements in the quality of research and presentation skills, especially for junior researchers. Additionally, it inspired them to explore new research directions and innovative approaches.

For this special session, there were 22 submissions from different countries. Out of these, 18 papers were accepted, reflecting an acceptance rate of 81%. Each paper underwent a rigorous review process, receiving at least 2 reviews from 30 Program Committee members from around the world.

Novembre 23rd-25th 2023

M. Essalih, J. Bakkas, O. Alaoui Fdili , A. Chekry and S. Hourri , Marrakech, Morocco

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## Genome scan approach to predict climate response and adaptation of *Quercus suber* L., in the Maamora forest using specific SSR markers

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### Abstract

Climate change is having a negative impact on locally adapted species, such as the cork oak (*Quercus suber* L.), a key tree species in the Mediterranean. In Morocco, it represents a source of life and a noble species for many people. The Maamora forest is considered the largest forest in the Mediterranean basin with the highest diversity compared to other forests in their area of distribution in Morocco [1]. It requires much interest through management and conservation strategies. In our study, using SSR markers, we built a database of 240 individuals of the Maamora forest from which we determined signatures of local adaptation, through the « Genomic Scan » approach, we were able to detect *outlier* loci with a potential to be under divergent natural selection pressure, subsequently correlated with the climatic and edaphic conditions of the Maamora. Statistical analysis of the data shows a high allelic variation. The detection of *outliers*, carried out using BayeScan v2.1 software, revealed the presence of outliers *loci* in *Quercus suber* L. from the Maamora forest. In addition, the result of the analysis of the correlation of these outliers *loci* with climatic and edaphic data identified a significant correlation between one of the outliers with environmental variables. This finding suggests a possible adaptation of the cork oak specie from the Maamora forest to the changing environmental conditions [2], and can help to understand the mechanisms that are provided for the adaptive behavior to the environment condition of *Quercus suber* L.

### Keywords

*Quercus suber* L., Maamora forest; climate change; Genome Scan; local adaptation; *outlier loci*.

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## The Gender Gap in the Fintech era

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### Abstract

The fintech industry has emerged as a disruptive force, revolutionizing traditional financial services through the integration of technology and innovation. While fintech has brought about numerous advancements, it has also highlighted the implication of women in the use of several digital financial services. The emergence of Fintech products have also enforced to the financial involvement of women.. Financial technology (FinTech) innovations can also help deliver new financial products or services (banking, insurance, securities) and distribution systems, as mobile phones can meet women's convenience needs, reliability, security and confidentiality.

This paper hilights the role of digital financial services in improving and sustaining access, using digital financial services for women in MENA region by examining: (1) the changes in the gender gap, in terms of access to financial services and their use ,(2) the determinants of gender gaps in the usage of digital services to better understand the cross-country differences. Our key findings support the reduction of gender inequalities over the period 2017-2021 and demonstrate growing gender gaps in access and use of digital financial services. With regard to determinants of the gender gaps in the usage of digital financial services, we find that higher financial and digital literacy of women is associated with lower gender gaps in digital financial inclusion, and that socio-cultural factors also play a key role. The potential of digital financial services to increase women's access to and use of financial services and thereby increase women's economic participation, autonomy and empowerment is far from being fully realized.

### Keywords

Fintech; Gender Gap; Digital Financial Services, Financial Inclusion.

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## Sustainable Progress with Drones and Artificial Intelligence

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### Abstract

Artificial intelligence (AI) has become integral across industries, notably in the drone sector, where AI-driven applications address fire management, sustainable development, and traffic control [1]. This literature review examines AI's role in drone applications, focusing on fire prediction, risk analysis, surveillance, and intervention [2]. The predictive system amalgamates AI models and algorithms to anticipate abnormal fires, combining data analysis with forest fire statistical maps. Drones' authorization for simultaneous flight during fires and Europe's innovative intelligence drones enforcing road safety are discussed [1]. Mobility and monitoring capabilities of unmanned aerial vehicles (UAVs) are emphasized, with radar integration for speed measurement anticipated in the near future [3]. This review underscores AI's transformative impact on drones, highlighting advancements in fire management and surveillance while anticipating radar-equipped drones [4].

### Keywords

Drone; AI; UAV; UAS; GPS.

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## Application of Artificial intelligence in photovoltaic systems assessment

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### Abstract

As photovoltaic (PV) technology rapidly advances and the number and size of PV power plants grow, there is a growing need for more efficient and intelligent health monitoring strategies. These strategies are essential to ensure reliable operation and maximize energy availability from PV systems [1]. The integration of Artificial Intelligence (AI) in PV systems has brought about a paradigm shift in the photovoltaic energy landscape. AI techniques, encompassing machine learning, deep learning, and data analytics, have demonstrated their versatility by revolutionizing various aspects of PV systems, including solar resource assessment, energy forecasting, fault detection, system optimization, and grid integration [2]. This paper presents an up-to-date study on the integration of AI in PV systems; it will analyze the recent article employing AI in the PV field. It presents a comprehensive review that delves into the significance, benefits, and limitations of AI in PV systems, underscoring its role in driving the transition towards a greener and more efficient energy ecosystem. AI techniques have certain limitations, such as the amount of data required and the extensive computation times needed for training. As future directions, the hybrid neural network (HNN) approach, explainable AI and quantum machine learning stand out as promising avenues for research, presenting opportunities for advancing PV system optimization and performance.

### Keywords

Photovoltaic; Artificial Intelligence (AI); Renewable energy; Hybrid neural network.

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## Fintech: a catalyst for female entrepreneurship

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### Abstract

Following the emergence of technologies in all areas, particularly finance, the development of digital financial services (Fintech) works for financial inclusion, thus helping women to access essential banking and financial services. In addition, they create a more conducive environment for entrepreneurship.

Using data from Global Findex, we conducted a comparative study of the impact of traditional financial services on the one hand and digital financial services on the other hand on female entrepreneurship. We expect entrepreneurship to grow with increasing digitalisation of financial flows. The years of study are the year 2017 and the year 2021. Using a sample of 144 countries around the world, we concluded that there are statistically significant differences between the results obtained related to financial inclusion for the two years of study. Several variables are used, namely, having an account with a financial institution; borrow from a financial institution; have a credit card, use a mobile phone or the Internet to access an account; use the Internet to pay bills or buy something online and make or receive digital payments.

Our study has statistically shown that fintechs can be considered as accelerating factors financial inclusion of women entrepreneurs, by eliminating certain financial barriers and providing accessible tools and resources. Overall, fintechs increasingly offer solutions that improve access to financial services, equal opportunities and financial autonomy for women, which stimulates their entrepreneurship.

### Keywords

Fintech, Gender, Female entrepreneurship, Digital Financial Services, Financial Inclusion.

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## Adoption of the Moodle platform's "Test" activity in student learning assessment processes at the Graduate School of Technology of Safi

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### Abstract

In this paper, we present our approach to adopting Information and Communication Technologies for Teaching (ICTT) in the learning assessment processes of students at e Graduate School of Technology of Safi during the post-Covid19 years, and the improvements we have made to secure assessments and fight cheating. We'll start by presenting the "Test" activity of the Moodle Learning Management System (LMS) that

we've validated and retained, then we'll give a brief account of our experience of using this activity during assessments in the period of lockdown, and finally we'll present the improvements we've made to our configurations in the post-Covid19 years in order to secure our assessments and fight as far as possible against cases of cheating.

### Keywords

Safe Exam Browser, Moodle LMS, ICTT, E-Learning, "Test" activity, Covid19.

## Applying AI techniques to energy efficiency issue in Data Centre

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### Abstract

The world's ever-increasing need for internet access, social networking, and data storage has significantly raised the demand for Data Center (DC) services over the past decades. DCs, as one of the most energy-intensive enterprises, require energy-efficient strategies to optimize IT operations. DC aims to provision on-demand processing, storage and networking capabilities in a reliable and scalable way. In this context, proper maintenance of IT equipment within DC premises is crucial as it ensures a prolonged lifetime of servers and uninterrupted availability of resources. DC management teams' sustainable operation effort comprises various approaches to directly and indirectly, reduce DC energy consumption. AI techniques on energy (including thermal) consumption data of DC aim to provide an accurate picture of the DC consumption. In this work, several real energy consumption datasets coming from real DC are collected, and the cooling and environmental aspects of the DC are also considered for data analysis. This research aims to conduct a rigorous exploratory data analysis on each dataset separately and collectively followed in various stages. This work presents descriptive and inferential analyses for the feature selection and extraction process. Furthermore, a supervised Machine learning modelling and correlation estimation is performed on all the datasets to abstract relevant features. That would have an impact on energy efficiency in DCs.

### Keywords

Data Center; Thermal Management; Data Analysis; Energy Efficiency; AI Techniques; Machine Learning.

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## Mathematical Morphology to Automate Generation of Dynamic Arabic Letters: Preliminary Studies

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### Abstract

This work highlights the basic ideas to assist in the generation of Arabic letter encodings in a dynamic font, for the purpose of Arabic calligraphy, by means of mathematical morphology. To support the Kashida (Arabic text justification mechanism), the curves of the stretchable part of the outline must be linked in such a way to support the movement of the Arabic (rectangular) nib. The notion of skeleton in its usual form, based on discs and corresponding radii, does not directly allow the generation of outline curves that can be parameterized for stretching while supporting the motion of the nib. It is reviewed for a specialization based on a structuring element in the form of a rectangle rather than a disc. The approach consists of three main tasks. The first involves determining the path of the centroid of the Arabic nib (a rectangle with an inclination), the angles of inclination of the pen at each of the points along this path, and the external end points of the nib involved in the processing of bits. The second involves reducing the number of points on the path while maintaining the general topology. The third involves identifying the points on the outline corresponding to those of the centroid and constructing parameterized cubic Bézier curves passing through these points. The approach can be generalized to support the characterization of the movement of a polygonal object via the notion of a skeleton.

### Keywords

Mathematical Morphology; Skeletonization; Arabic Dynamic Letters; Kashida, Cubic Bézier

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## A Cyber-physical design for management systems of Photovoltaic installations

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### Abstract

This ongoing work presents a new approach to conceive cyber-physical systems that promote remote monitoring and control of photovoltaic generators. The physical layer is composed of solar panels, a battery bank, and a charge controller. The cyber layer contains sensors to sense environmental and operational data, a microservices platform to manage the system, communication networks, and an analytics dashboard to supervise and monitor, diagnose the infrastructure. The objective is to associate the benefits of cyber-physical systems approach with the advanced techniques in controlling inverters to build a robust system able to identify, expect, and control the performance and output of the PV generator. Preliminary results reveal that remote fault detection enables local energy management systems to adapt or moderate the negative effects of physical faults. Such systems will improve the robustness along with efficiency of PV systems.

### Keywords

PV; cyber-physical systems; MPPT; data analytics, cloud computing; IoT

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## Comparative Analysis of Naive Bayes and XGBoost for Spam Email Classification with Imbalanced Data

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### Abstract

In this paper, we will give an introduction to email communication and spam issues, followed by a literature review of different models of imbalanced data classification, and then we will present the XGBoost algorithm with its results. Email communication is critical in current communication platforms. The rise of spam emails, on the other hand, causes serious problems for both individuals and companies. This research aims to investigate and evaluate the performance of Naive Bayes, a traditional probabilistic technique, and XGBoost in categorizing spam emails, emphasizing scenarios with imbalanced data. After reviewing different research papers, we found that Naïve Bayes has become a standard method for spam categorization because of its speed and good performance. Recently, we have had many more complicated machine learning algorithms that have shown greater prediction skills in imbalanced data. We tested the XGBoost model using a high-dimensional dataset of 5170 entries. The experimental findings have shown that XGBoost exceeded Naïve Bayes in accuracy and total predictive power since it obtained a very high accuracy score of 91.67%.

### Keywords

Classification; High-dimensional data; Imbalanced data; Naive Bayes; XGBoost;

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## Semantic Modeling of SARS-CoV-2 Mutations: SARSMutOnto in Focus

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### Abstract

SARS-CoV-2, the coronavirus behind the COVID-19 disease, emerged at the end of 2019 and has rapidly developed into a global health crisis of unprecedented proportions [1]. This zoonotic virus, initially identified in Wuhan, China, is believed to have originated from bats and successfully made the leap to infect humans [2,3]. As this virus replicates within human hosts, it occasionally undergoes genetic changes, resulting in mutations in its RNA. Some of these mutations can confer advantages, making the virus more transmissible. For instance, certain mutations in the spike protein, which the virus uses to bind to human cells, can enhance its affinity for human cell receptors, thereby increasing infectivity and transmission. Additionally, mutations can contribute to immune evasion, allowing the virus to evade detection by the host's immune system, potentially prolonging the duration of infections and furthering transmission [4,5]. Moreover, the emergence of variants with mutations in regions targeted by vaccines or treatments can reduce their effectiveness, complicating efforts to control the virus. Therefore, monitoring and understanding these mutations are crucial in our ongoing battle against SARS-CoV-2, as they shape the virus's behavior and influence our strategies to combat it. In this work, our primary focus centers on examining the mutations within this virus. To facilitate this analysis, we introduce the SARSMutOnto ontology, a framework designed to model SARS-CoV-2 mutations as documented by Pango researchers. Within this ontology, we provide comprehensive descriptions for each mutation, including details regarding the affected genes and the virus's genomic structure. Furthermore, we represent sub-lineages and recombinant sub-lineages resulting from these mutations, preserving their hierarchical relationships. To streamline this process, we have developed a Python-based tool capable of automatically generating the ontology using diverse Pango source files. In the concluding sections of this paper, we present illustrative examples of SPARQL queries that harness the potential of this ontology.

### Keywords

SARSMutOnto; Ontology; genome structure; SARS-CoV-2; Lineage; Mutation.

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## Enhancing Stroke Care: Enriching Ontology through Voice-Enabled Chatbot Interactions

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### Abstract:

Stroke occurs when there is a sudden interruption of blood supply to the brain, resulting in a lack of oxygen to the affected brain areas. According to the French Ministry of Solidarity and Health, approximately 150,000 people experience a stroke each year in France, equating to one stroke every four minutes. Out of these cases, more than 110,000 individuals require hospitalization, and sadly, around 30,000 people lose their lives due to stroke.

The mortality rate is rising due to the delayed detection of stroke[1] symptoms, which often manifest gradually and discreetly. Additionally, stroke symptoms can vary based on gender, with females commonly experiencing headaches while males may endure excruciating pain. As a result, medical professionals frequently encounter challenges in distinguishing stroke from other disorders or diseases, leading to potential confusion and misdiagnosis. Our approach aims to achieve the following goals:

1. Constructing an ontology[2] for strokes: We aim to create a comprehensive ontology that encompasses various aspects of strokes, including risk factors, symptoms, treatments, and different types of strokes. This ontology will serve as a structured knowledge base for stroke-related information.
2. Developing a voice-based chatbot[3]: Our chatbot will utilize NLP[4] (Natural Language Processing) and Deep Learning[5] techniques to facilitate communication with users. It will be capable of converting spoken words into text, enabling voice-based interactions with the chatbot.
3. Utilizing patient information to enrich the ontology: The chatbot will gather relevant information from stroke patients through conversations. This information will be utilized to update and enhance the stroke ontology, ensuring that it remains up-to-date and relevant.

In summary, our approach involves constructing a stroke ontology, developing a voice-based chatbot using NLP and Deep Learning, and leveraging patient information to enhance the ontology.

### Keywords :

Stroke Disease ; Voice Chatbot ; Ontology; NLP; DeepLearning;

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# Enhancing Concrete Segregation Detection: Utilizing XAI for Elevated Precision and Transparency

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## Abstract

In the aftermath of the devastating seismic event that struck Morocco in September 2023, resulting in the collapse of numerous fragile structures and a significant loss of human life, the urgency to strengthen disaster preparedness and response capabilities has never been more critical. This juncture provides a unique opportunity to leverage the transformative potential of cutting-edge technologies, particularly Artificial Intelligence (AI) with a specific emphasis on Explainable AI (XAI) methods.

Concrete, being an essential construction material valued for its notable strength, durability, and versatility, sees extensive use in various infrastructure projects. However, the presence of concrete segregation presents a substantial challenge in both the construction and upkeep of concrete structures. Concrete segregation entails the uneven distribution of aggregates within the concrete matrix, which can lead to adverse effects. It jeopardizes structural integrity, diminishes performance, and potentially poses safety hazards.

Given these significant concerns, it is imperative to identify and quantify instances of concrete segregation. To address this necessity, the present study introduces an innovative approach for evaluating concrete segregation through the application of an image processing-based technique, Deep Learning, and Explainable Artificial Intelligence, this research not only enhances the accuracy and dependability of concrete segregation detection but also provides transparency in the decision-making process. This groundbreaking approach holds the potential to revolutionize concrete construction and maintenance practices, safeguarding the structural integrity and performance of infrastructure projects while mitigating safety risks associated with concrete segregation.

## Keywords

Explainable Artificial Intelligence; Deep Learning; Image processing; Concrete Segregation.

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## Detection of mobile traffic attacks using machine learning techniques

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### Abstract

Today's networks are designed to meet the future digital needs [3][4], as any undetected degradation at one or more telecom sites can lead to financial losses and customer attrition. To address this challenge, telecom operators have established specialized entities dedicated to monitoring network traffic and identifying unexpected events affecting network quality [1]. However, the effectiveness of these efforts is hampered by various constraints, such as adverse weather conditions [5] and hardware problems. This is why telecom operators are increasingly turning to artificial intelligence to optimize network operations and enhance predictive maintenance. This ensures the network's reliability and quality. In pursuit of these objectives, we have automated network surveillance using machine learning techniques to proactively mitigate damages and downtime, aligning with customer expectations for enhanced network quality. Our investigation led us to the utilization of a trio of statistical methodologies: upper and lower control limits, the Cumulative Sum (CUSUM) algorithm, and the Robust Stat Detector model. These approaches collectively address the organization's imperative to accurately detect network traffic anomalies.

### Keywords

Telecommunication ; Anomaly Detection ; Binary Classification ; CUSUM; Robust Stat Detector ; Upper & Lower limit control ; Mobile Traffic.

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## Theoretical Study of the Raman Spectra of water molecules encapsulated within Carbon nanotube

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### Abstract

The hybrid system consist of carbon nanotubes (CNTs) encapsulated with various molecules plays a crucial role in numerous applications [1-5], ranging from nanoscale engineering to biochemistry. In this study, our focus is on carbon nanotube encapsulated with water molecules(H<sub>2</sub>O@CNTs) [6-8]. Understanding the behavior of water molecules within CNTs is vital for optimizing the performance of these systems. In this theoretical study, we focus to find the optimal configuration of water inside CNT, using the Lennard-Jones potential to describe the van der Waals interactions between both molecules; water and carbon nanotube.

We calculate the nonresonant Raman spectrum of H<sub>2</sub>O@CNTs, in the framework of spectral moment method, together with a bond polarizability model. We concentrate in this work, especially on low- and high-wave number range. This approach allows us to extract valuable information about the behavior of water molecules confined within CNTs and evaluate the influence of various factors, such as CNT chirality and diameter and water filling factors.

Through the application of the spectral moment method on simulated Raman spectra, we gain insights into the vibrational modes and structural changes of the encapsulated water molecules. Our findings reveal intricate details of the interactions between water and CNTs, shedding light on the confined water's behavior and its influence on the CNT structure. This study contributes valuable knowledge to the understanding of fundamental interactions between water molecules and CNTs, advancing our comprehension of nanoscale confinement effects and facilitating further advancements in nanomaterial-based applications.

### Keywords

Water, carbon nanotube, van der Waals interaction, spectral moment method.

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## Exploring Cheminformatics: Predicting Molecule Solubility with Advanced Linear Regression Models

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### Abstract

In the realm of Cheminformatics, a captivating fusion of Informatics and Chemistry, we embark on a journey to enhance our understanding of a critical physicochemical property in drug discovery, design, and development - the solubility of molecules. This work is motivated by the ambition to reproduce linear regression models with an exceptionally high degree of performance. To achieve this ambitious goal, we leverage the power of PyCaret, a low-code machine learning library that streamlines the modeling process. Through a rigorous model comparison, we evaluate and select the optimal model based on several key criteria: (R<sup>2</sup>), (RMSLE), (MAE), (MSE), (MAPE) and (RMSE). The diverse set of models under scrutiny includes: Extra Trees Regressor, Random Forest, CatBoost Regressor, Light Gradient Boosting Machine, Gradient Boosting Regressor, Extreme Gradient Boosting, AdaBoost Regressor, Decision Tree, Linear Regression, Ridge Regression, Least Angle Regression, Bayesian Ridge, Huber Regressor, Random Sample Consensus, TheilSen Regressor, Elastic Net, Orthogonal Matching Pursuit, Lasso Regression, K Neighbors Regressor, Support Vector Machine, Lasso Least Angle Regression, Passive Aggressive Regressor. This study is a testament to the power of Cheminformatics, bridging the gap between Informatics and Chemistry, and underscores the significance of applying cutting-edge machine learning techniques to address fundamental challenges in the field of drug development and molecular science.

### Keywords

Cheminformatics, Solubility, Molecules, Artificial Intelligence, Linear Regression

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## Prototyping a SnO<sub>2</sub> Gas Sensor-Based System for Ammonia Detection

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### Abstract

In recent years, there has been a strong demand for sensitive, selective, and accurate detection techniques for ammonia gas [1-5]. Ammonia is a widely used gas in various industrial sectors. However, it is also a high toxic and corrosive agent that can pose significant threats to human health and the environment [1,6]. SnO<sub>2</sub>-based gas sensors are widely used to detect various toxic or harmful gases. Due to its high sensitivity, the system is capable of detecting low gas concentrations effectively, making it a cost-effective and safe option for deployment in domestic, industrial, or public environments[7].

In this work, we used a set of sensors with high sensitivity and a quick response time based on a thin film of SnO<sub>2</sub>. When exposed to ammonia gas in the vacuum flask's headspace, the sensor registered an increase in the output voltage. Conversely, during exposure to fresh air, the voltage displayed a decrease.

The preliminary results show a clear voltage variation at the output of each sensor over time for during ammonia exposures. As shown in Figures 1 and 2, the MQ2 sensor is more sensitive to ammonia than the other sensors MQ7 and MQ135, with a maximum voltage of 0.34 V in measurement 1 and 0.36 V in measurement 2 for MQ2 and no response for MQ7 and MQ135. To obtain a more sensitive and selective gas sensor operating at room temperature, it is necessary to develop the surface functionalization of SnO<sub>2</sub> so that the sensor is sensitive to ammonia between 0.2 and 10 ppm at room temperature[7]. However, the modified SnO<sub>2</sub> is more selective than the sensor we use.

### Keywords

Gas sensors, Ammonia, Electronic Nose

### Results

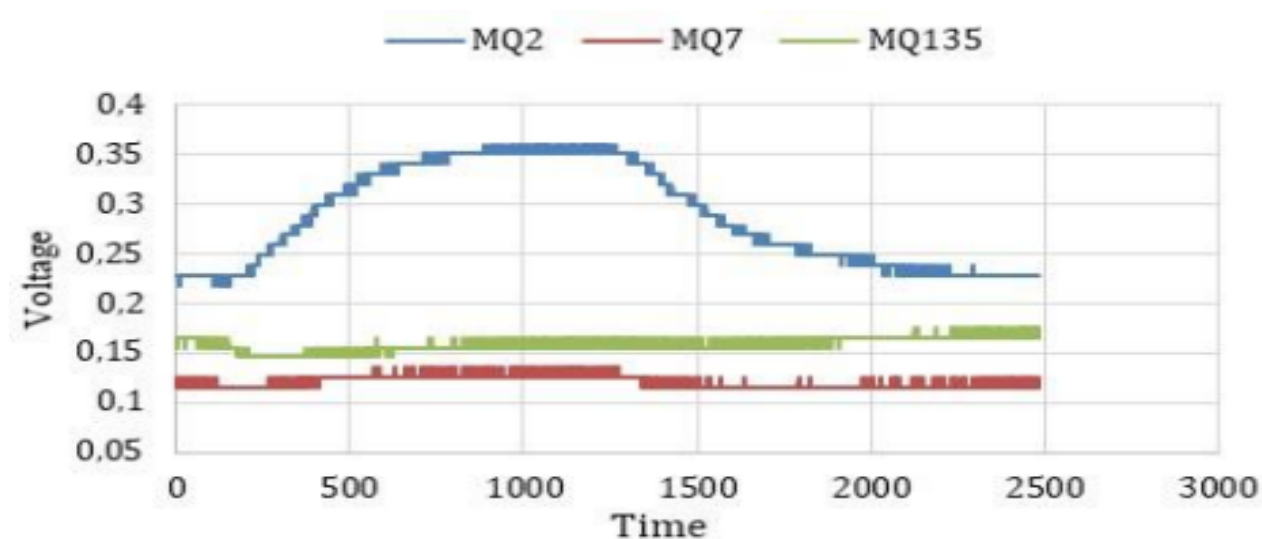


Fig 2. Sensors responses towards second sample of Ammonia



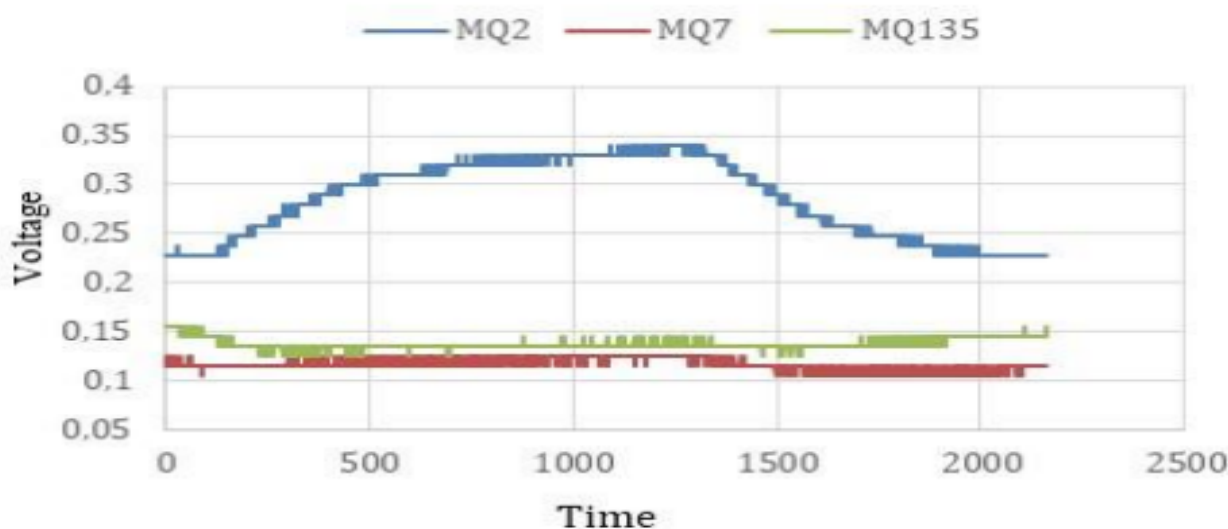


Fig 1. sensors responses towards first sample of Ammonia gas exposure

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## Customer sustainable behavior prediction

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### Abstract

"Data is often dubbed the 'new gold,' playing a pivotal role in driving organizational success in today's competitive landscape. Technological advancements have enabled companies to harness this data more effectively, aiming to enhance their overall performance.

Simultaneously, sustainable consumption has emerged as a decisive factor in consumer choices.

The surge in interest towards responsible purchasing has been remarkable, particularly over the past decade.

Drawing from various behavioral theories, our research delves into how these predictive insights can shape sustainable behaviors and influence consumer purchasing decisions.

Our primary goal is to decipher how forecasting customer behavior can catalyze sustainable decision-making, ultimately benefiting the broader community. This document endeavors to elucidate the multifaceted concepts underpinning our research, offering insights from both historical and academic lenses, setting the stage for an in-depth examination of the intricate relationships among these concepts.

### Keywords

Sustainable behavior; Future predictions; literature review; behavior prediction.

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