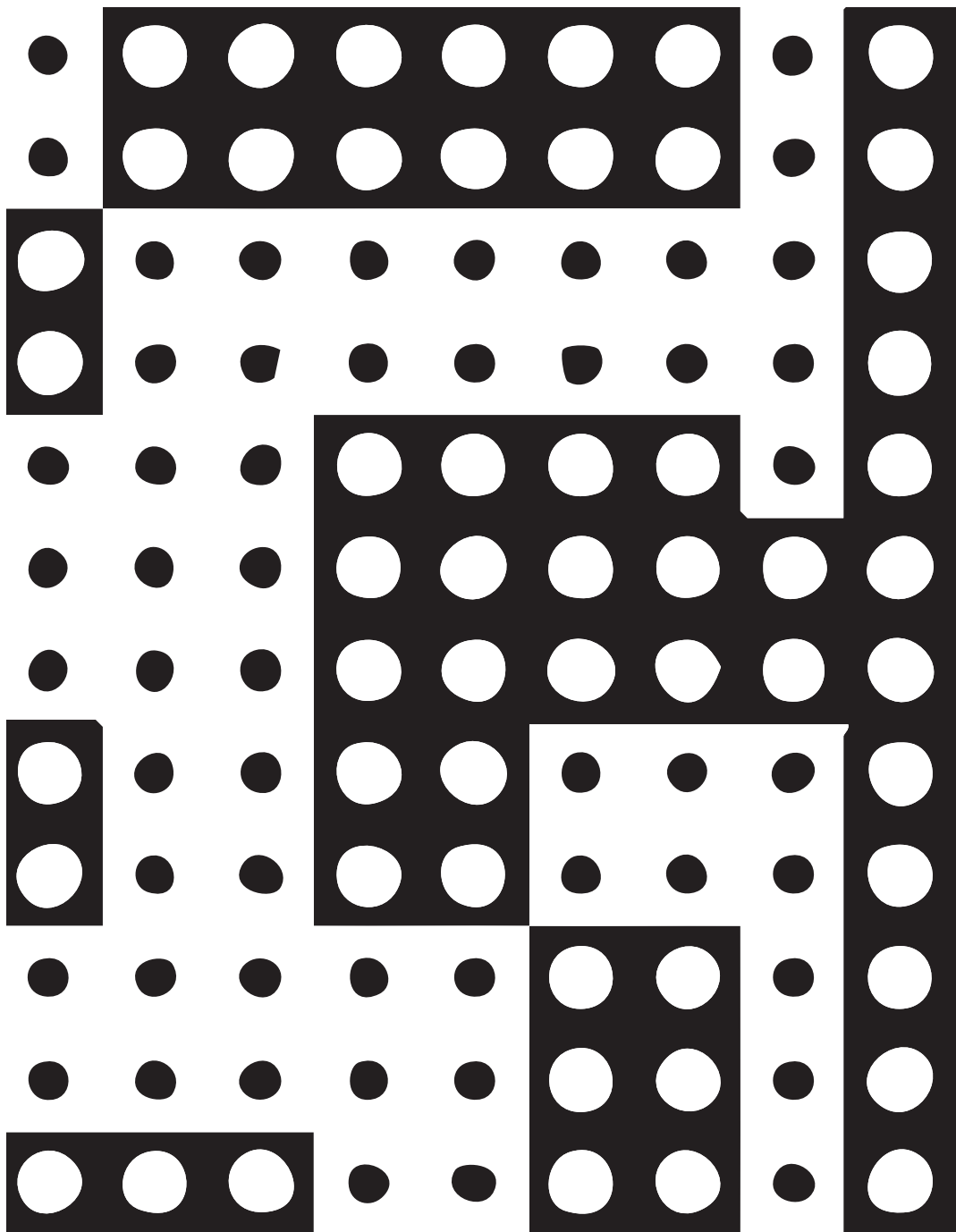




March 19th–20th

UPM, Madrid, Spain

Artificial Intelligence, Optimization & Digitalization International Workshop

MADRIDTECH 2025

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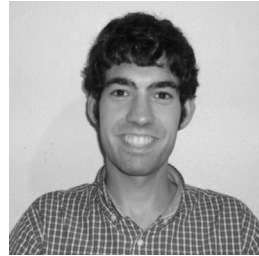
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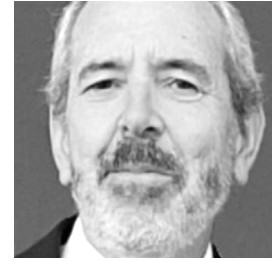
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SESSIONS

MARCH 19TH, 2025

TAMARA BORREGUERO, *AIRBUS*

Digitalization and AI in the aeronautical industry. Status, challenges and opportunities

In this talk, we will provide an overview of the key features of digitalization and AI implementation in the aeronautical industry. Additionally, we will explore specific successful use cases that highlight their impact. Finally, we will discuss the main challenges the industry must overcome to fully unlock the potential of Industry 5.0.

ALBERTO GARCÍA PÉREZ, *ITP AERO*

Development of a Crack Detection Model for Radiographic Inspections of the Tailplane of the F/A-18 Fighter Jet in the Spanish Air Force

ITP Aero has developed a crack detection model for the Spanish Air Force (Ejército del Aire), which has been in use since early 2024 for the structural condition inspection of the tailplane of the F/A-18 fighter jets. Currently, efforts are being made to obtain certification for this AI both in the EA and in the military field.

PABLO GARRIDO, *UNIVERSIDAD POLITÉCNICA DE MADRID*

The Smart Train of the Future

Over the last few decades, the concept of transport has evolved into the concept of mobility due to the appearance of new technologies, teleworking, the increase in population density in urban centres, or the growing concern about polluting emissions. The conclusion is clear: there is a need for efficient and sustainable mobility management that responds to the needs of society, with the railway as the vertebral axis.

In the railway sector, there are different stakeholders involved: infrastructure, operator and rolling stock. A large amount of information is generated that must be shared between all parties to try to optimise railway operation from an energy and economic point of view. Artificial intelligence plays a key role in this work, helping in the prediction of people's movements or the development of predictive maintenance programmes, minimising preventive maintenance and ensuring the quality of service and maximum levels of reliability and availability of a fleet of trains.

Solving the Team Orienteering Problem Using Decision Transformers

The Team Orienteering Problem (TOP) is a well-established combinatorial optimization problem with applications in logistics, tourism, and other domains. Traditional solutions often rely on heuristics, metaheuristics, or exact algorithms, but deep learning-based approaches are emerging as promising alternatives. This study explores the use of Decision Transformers (DT)—a reinforcement learning framework based on sequence modeling—to generate high-quality solutions for the TOP. By utilizing a dataset of diverse routes with varying quality levels, the objective is for the DT to learn to predict effective action sequences that maximize the reward.

ANTONIO RODRÍGUEZ UGUINA, *DECIDE4AI*

Periodic Vehicle Routing Problem for Waste Collection: A Round-Robin Multi-Start Approach

The Periodic Vehicle Routing Problem (PVRP) is a fundamental challenge in logistics, typically in waste collection problems, involving the planning of vehicle routes over multiple days while adhering to frequency constraints for node visits. This new approach can generate multiple high quality solutions in a short time, learning in each process through routes memory.

JUAN FRANCISCO GÓMEZ GONZÁLEZ, *UNIVERSITAT POLITÈCNICA DE VALÈNCIA*

Multi-Period Vehicle Routing with Time windows and Synchronization: A Novel Discrete Event Heuristic Approach

In the dynamic and complex environment of service sector logistics, planning for multiple periods is crucial for long-term operational vision. The Multi-period Vehicle Routing Problem with Time Windows and Synchronization addresses these challenges by focusing on efficient vehicle scheduling that requires synchronized actions among drivers. Our approach introduces a novel heuristic-constructive approach, introducing the flexibility and efficiency of Discrete Event Heuristic algorithm to provide high-quality solutions, aiming to minimize the overall duration needed for task completion, considering the proximity of tasks and delays caused by the need for synchronization.

MARC ESCOTO GOMAR, *UNIVERSITAT POLITÈCNICA DE VALÈNCIA*

A Simheuristic for the Stochastic Multi-Depot Traveling Facility Location Problem with Electric Vehicles

This paper addresses the traveling salesman problem with multiple depots, facility location and stochastic travel times, considering electric vehicles with limited battery capacity. Due

to stochastic variations in travel times, vehicles may risk running out of battery during their routes, leading to penalty costs for route failures. Given the NP hard nature of this problem, we propose a simheuristic approach that integrates Monte Carlo simulation with a metaheuristic algorithm. This approach handles both the stochastic aspects and the optimization requirements. Results show that our simheuristic outperforms the optimal or near-optimal solutions designed for traditional deterministic scenarios when applied in stochastic settings.

CARLOS ÁVILA CATALÁN, *UNIVERSIDAD REY JUAN CARLOS*

Optimization of Multi-Architecture Gas Turbines with a 3-Stream Joule-Humphrey Cycle Using a Physics-Acquainted Branch and Bound Method

Stricter air traffic regulations and environmental considerations are driving the need for more efficient gas turbine architectures, as traditional Joule-cycle turbofan engines approach their theoretical efficiency limits. To address this challenge, a multi-architecture gas turbine model has been developed, incorporating configurations that range from a conventional two-shaft turbofan to a three-stream core with reheating, intercooling, and recuperation. The optimization of these architectures is carried out using a hybrid approach that combines a multi-start strategy with a physics-acquainted Branch and Bound (B&B) algorithm. To ensure comprehensive exploration of the design space, an initial set of design points is generated through a Fractional Factorial Design (FFD), enabling a well-distributed sampling of the state space to facilitate convergence toward the global optimum. The system dynamics are modeled using a mixed-integer nonlinear framework, encompassing over 350 continuous and discrete variables, with eight key design parameters, including core mass flow, bypass ratio, third-stream ratio, reheated air fraction, Overall Pressure Ratio (OPR), heat exchanger surface areas, and air-to-fuel ratio. Weight variations are also accounted for using an in-house estimation model, ensuring a realistic assessment of performance. The proposed methodology effectively identifies optimized engine architectures with improved efficiency over conventional high-bypass-ratio turbofans, demonstrating the advantages of a structured multi-level optimization strategy in complex gas turbine design problems.

JAVIER ALEJANDRO CUARTAS MICIECES, *UNIVERSITAT POLITÈCNICA DE VALÈNCIA*

Wood2Wood: A Supply Chain Optimization Tool for Sustainable Wood Waste Management

I will provide a general overview of the Wood-to-Wood (W2W) project first, and then I will explain the Supply Chain Optimization Tool in more detail, including the different types of problems it addresses and the possible solutions to tackle them.

RBM, Powerful Inference Machines

Restricted Boltzmann Machines (RBMs) are unsupervised machine learning models structured as bipartite neural networks. They capture statistical correlations in data through a Boltzmann weight derived from an energy function. In this talk, I will demonstrate how analyzing this energy function provides deep and interpretable insights into the data, establishing RBMs as powerful tools for inference. Notably, the RBM's energy function can be mapped onto a model of interacting spins, analogous to those extensively studied in statistical physics. Unlike traditional pair-wise interaction models commonly used in inverse statistical problems (such as maximum entropy approaches), this mapping inherently includes higher-order interactions. Importantly, this framework enables the inference of complex, higher-order interactions without requiring an explosion in the number of adjustable parameters. Furthermore, analyzing the evolution of the free-energy landscape's minima throughout the training process, approximated using mean-field techniques, uncovers hidden hierarchical relationships between data points. This approach provides a straightforward method for performing hierarchical clustering, enabling unsupervised classification and identifying key features that characterize distinct data groups.

ELENA PÉREZ BERNABEU, *UNIVERSITAT POLITÈCNICA DE VALÈNCIA*

Exploring Machine Learning Techniques for Insurance Client Classification

Insurance companies in the financial sector generate substantial volumes of data daily, ranging from policy transactions to customer interactions and risk evaluations. This growing data pool offers a valuable opportunity for these companies to use it strategically. We present a case study demonstrating how several supervised classification machine learning algorithms, including Logistic Regression, Random Forest, and Support Vector Machine, can be employed to identify and classify clients as either potential or non-potential for insurance companies. The results underscore the potential of selecting different models to enhance decision-making processes across various market scenarios.

AURÉLIEN DECELLE, *UNIVERSIDAD POLITÉCNICA DE MADRID*

Energy Based-Mode: Generative Machine Learning

In recent years, the capabilities of generative models have increased dramatically, achieving not only convincing generation of images but also text, music, and various types of data. However, the models behind these advances are so complex that it becomes impossible to understand or explain their functioning. An alternative to these approaches is the use of energy-based models (EBMs). These models have lower complexity and are also very effective at capturing the relevant statistics of real datasets. In this presentation, I will showcase the latest advances in EBMs: (i) how to systematize learning, (ii) how to leverage

learning to understand how the model's learned features emerge and how to make use of them, and (iii) how to relate the weights learned by the machine to concrete properties.

EDUARDO CARO HUERTAS, *UNIVERSIDAD POLITÉCNICA DE MADRID*

Influence of Self-Consumption on Electrical Demand Prediction

The growth of photovoltaic self-consumption presents new challenges in predicting electrical demand. Traditionally, demand forecasting models have considered user consumption as a relatively stable variable, dependent on factors such as weather, calendar, and economic activity. However, the integration of self-consumption systems introduces a new source of variability, as net demand on the grid is affected by distributed generation and its intraday variability. This talk will analyze the impact of self-consumption on the accuracy of demand prediction models, based on optimization techniques using Reg-ARIMA models. Case studies with data from the Spanish electricity market will be presented, highlighting the main challenges and opportunities for improving demand forecasting in an environment with increasing self-consumption penetration.

IRENE IZCO BERAATEGUI, *UNIVERSIDAD PÚBLICA DE NAVARRA*

Predicting Battery State of Health for Electric Urban Mobility Using Machine Learning and Simulation

As cities prioritize sustainability, awareness of environmental issues has accelerated the adoption of electric vehicles (EVs). In this context, electric urban mobility plays a key role in the transition to greener transportation systems. A significant challenge in this transformation lies in extending the lifespan of EV batteries. A failure in the battery system not only disrupts the service but also lowers public trust in technology. The core of this transition is the development of reliable Battery Management Systems (BMS) that optimize battery performance. This work investigates the role of intelligent BMS in enhancing battery state of health (SoH). By relying on Machine Learning/Deep Learning algorithms, the BMS can effectively predict potential issues to ensure uninterrupted service. The experiments were conducted using analysis from an extensive empirical battery dataset and data generated through agent-based simulation.

JESÚS SALGADO CRIADO, *UNIVERSIDAD POLITÉCNICA DE MADRID*

ALEJANDRO DURÁN BARRADO, *IBERDROLA*

Operationalising AI Governance Through Joint Industry and Academic Workshops

The UPM-Iberdrola Chair for Sustainable Development Goals which is coordinated by itdUPM is conducting research into the governance of responsible Artificial Intelligence (AI). While numerous entities have made public high-level principles for responsible AI, a critical gap exists in the practical application of these principles within organizational

contexts. This research addresses this deficit by focusing on the operationalization of AI governance in specific domains. The utilization of LLMs in customer service presents significant potential for enhanced user satisfaction and operational efficiency. However, without robust governance frameworks, unintended negative consequences can arise. Recognizing the inherent complexity of AI governance, compounded by the evolving regulatory landscape, this research adopts a collaborative methodology. To facilitate the development of practical guidelines, a series of closed workshops, conducted under Chatham House Rules, have been convened, involving practitioners from several service industries. These workshops provide a secure environment for participating organizations to share experiences and co-create best practices. The primary objective is to mitigate risks associated with LLM deployment, such as AI hallucinations or risk of anthropomorphization, while simultaneously fostering the realization of the technology's potential benefits.

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ANDERS SKOOGH, *CHALMERS UNIVERSITY OF TECHNOLOGY*

Prescriptive Decision Support for Maintenance in Digitalized Manufacturing

The digital transformation of the manufacturing industry is key for developing sustainable, resilient, and competitive factories of the future. Maintenance organizations are central in this transformation in order to install and secure dependability of advanced technical equipment. This talk will describe the future of maintenance in a digitalized manufacturing, both from an organizational and technical perspective. The development of prescriptive decision support using AI will be discussed and exemplified.

CAROLINA GARCÍA MARTOS, *UNIVERSIDAD POLITÉCNICA DE MADRID*

Forecasting Severity of Asthma Episodes Accounting for Air Quality Data: Application to Pediatric Patients

In this work the prediction of the severity of childhood asthma episodes using Machine Learning models is addressed. Air quality data available from different locations is included in this research. Identifying and handling critical variables and developing predictive models are crucial steps performed towards optimizing medical care in a hospital setting. Predictive models were developed for variables such as the length of hospital stay and the type of oxygen required, showing promising results but also limitations. The creation of a web application for hospital resource management represents a significant step towards the practical application of the findings, optimizing resources and facilitating the work and

decision making of healthcare professionals. This project demonstrates the power of Data Analytics to improve medical care, highlighting how relevant interdisciplinary approach in scientific research is.

AMIR FARMANESH, *UNIVERSIDAD POLITÉCNICA DE MADRID*

Performance of AI Oriented Contrastive Learning vs Convolutional Neural Networks (CNNs) in Quality Assessment of Zinc Coating Steel Coils

Quality control in zinc-coated steel coils is critical in industries such as automotive and construction, where defects in zinc coating can significantly impact product durability and safety. Traditional manual inspection methods are prone to errors and inconsistencies, especially in high volume production environments.

This paper compares the performance of two artificial intelligence techniques those are convolutional neural networks (CNNs) and contrastive learning, for automated quality assessment of zinc coated steel coils. We evaluate their performance in classifying the quality of zinc coatings, with a focus on defect detection. We implemented both CNNs and contrastive learning models, by using a dataset comprising 4,482 coil profiles with zinc thickness measurements and analyzed their performance. CNNs employed deep architectures with normalization and pooling layers to minimize overfitting, while contrastive learning utilized Siamese networks to learn feature representations from both labeled and unlabeled data.

Experimental results show that CNNs achieved high classification accuracy with an F1-score of 0.93 on the test set and 0.75 on gold-standard data. Contrastive learning, on the other hand, demonstrated variability in performance, with an F1-score of 0.61 for original data and 0.66 after data preprocessing transformations. Statistical analysis indicates that CNNs are robust in scenarios with ample labeled data, whereas contrastive learning excels in feature representation and generalization when labeled data is limited.

These findings have significant implications for real time industrial inspection, suggesting that contrastive learning can be a valuable tool for quality control, especially in situations with limited labeled data. The study also highlights the importance of data preprocessing in enhancing the performance of contrastive learning models.

CARLOS GARCÍA-CASTELLANO GERBOLÉS, *UNIVERSIDAD POLITÉCNICA DE MADRID*

Exploring the Potential of Decision Transformer in Production Scheduling: A Preliminary Analysis

The Decision Transformer (DT) is a novel reinforcement learning architecture that frames decision-making as a sequence modeling problem. Originally developed for offline reinforcement learning, DT has shown promise in various domains but remains relatively unexplored in production scheduling. This presentation provides an overview of the Decision Transformer framework and its potential application to scheduling problems.

Through a brief literature review and an exploratory analysis, we examine its suitability for optimizing scheduling tasks and discuss key considerations for effective implementation. Additionally, we outline good practices for leveraging DT in this context, addressing potential challenges and opportunities. While this study does not claim to provide definitive conclusions, it aims to initiate discussion on the role of sequence modeling approaches in scheduling optimization and identify areas for further research.

ANTONIO SÁNCHEZ HERGUEDAS, *UNIVERSIDAD DE SEVILLA*

Digital Twin Technologies (DTT) for the Digitisation of Equipment and Maintenance Workshop

Developing a digital twin requires consideration of several key aspects, such as the proper collection, analysis and utilisation of the data generated by the assets throughout their lifecycle. It is also essential to design a data model that accurately represents both assets and processes, as well as the creation of applications or microservices dedicated to analysis and simulation. The information generated needs to be stored efficiently, and the current trend favours the use of cloud platforms, where various database types are managed. The process is completed when the data is effectively visualised to support decision-making through dashboards, reports or real-time alerts. However, the design of a digital twin faces two main challenges: first, the creation of data models that are inheritable, scalable and compatible with other systems, which will allow the integration and growth of the twin, and second, the choice of the right platform for storage and execution of programmes, which must be able to handle large volumes of data, ensure its integrity and accessibility, while maintaining a viable cost for the business project.

ANDREI GARCÍA CUADRA, *UNIVERSIDAD POLITÉCNICA DE MADRID*

From a Raspberry Pi to an Otto Cycle Controller: Revolutionizing Motor Control

The Role of AI in ECU-Driven Motorcycle Systems Artificial Intelligence (AI) is revolutionizing the role of Electronic Control Units (ECUs) in motorcycle systems. While AI integration in motorcycles has traditionally lagged behind that of cars, recent advances in computing power, sensor miniaturization, and machine learning algorithms have enabled smart ECUs capable of real-time decision-making, predictive maintenance, and enhanced rider safety. As motorcycles become increasingly connected and automated, AI-driven ECUs are set to play a pivotal role in improving performance, fuel efficiency, and accident prevention.

JOSÉ ANDRÉS MORENO PÉREZ, *INSTITUTO UNIVERSITARIO DE DESARROLLO REGIONAL & UNIVERSIDAD DE LA LAGUNA*

Smart Tools for Green Industry 4.0 Based on Organic Waste

The implementation of a green industry in the context of the circular economy applied

to the management and reuse of organic waste requires leveraging technological advances associated with Industry 4.0. The deployment of sensor devices in vehicles and containers enables the use of Internet of Things advancements to monitor and optimize their management. Data Science allows for efficient and effective use of the large volume of data involved. Metaheuristic techniques enable the application of intelligent strategies to plan and optimize the process of collecting organic waste.

GUILLERMO GONZÁLEZ-SANTANDER, *BAOBAB SOLUCIONES*

Accelerating Optimization Models with Deep Learning: Predicting Solutions from Input Data

Optimization models often require extensive computation times, making it costly to execute runs that produce suboptimal outcomes. In this talk, we will review how deep learning can help predict the results of computationally intensive optimization models before execution. By estimating the expected outcomes from given inputs, decision-makers can proactively identify and adjust suboptimal input parameters, avoiding unnecessary computations and saving valuable resources. We review recent developments from the literature, highlight the key technical challenges, and illustrate practical strategies for integrating deep learning predictions into optimization workflows to enhance overall efficiency and performance.

MERCEDES GRIJALVO MARTÍN, *UNIVERSIDAD POLITÉCNICA DE MADRID*

Adoption and Functionality of Multiple Sclerosis Apps: A Market Analysis

The landscape of mobile applications for Multiple Sclerosis in Spain is growing, yet their impact on key healthcare stakeholders and patients remains insufficiently studied. This research specifically examines applications available in Spain and in Spanish, exploring their adoption among individuals affected by the disease. Initially, a comprehensive analysis of mobile applications available in the Spanish market for managing Multiple Sclerosis was conducted, drawing on the reference study *Mobile Apps Used for People Living with Multiple Sclerosis: A Scoping Review* by Salimzadeh et al. (2019). Apps available in Spain on Google Play and Apple Store were identified and classified, with their Key Performance Indicators (KPIs) evaluated and compared to the findings of the reference study. Furthermore, an in-depth examination of their functionalities was performed to assess their relevance and alignment with the needs of patients and healthcare professionals. The findings reveal that, although these applications provide features like symptom tracking, medication reminders, educational resources, and cognitive and physical training tools, their adoption remains low. Usage is largely concentrated on a few platforms, while many others experience minimal engagement. Contributing factors may include usability issues, limited integration with healthcare providers, and a potential mismatch between the available features and the actual needs of patients.

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