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Integrating the Digital Twin of Decision Support Systems in Aeronautics

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Abstract. *A Decision Support System (DSS) is a computerized system that helps users make decisions. In the field of air transport, RAL has developed DSSs to support decision making in various settings, including surface transportation and national security. The purpose of this chapter is to explore the maintenance hypothesis of conditional status checking and propose supporting concepts, such as enhanced care and proactive maintenance. These concepts are further enhanced by robust validation and strategies to improve the effectiveness of care in an extraordinary way. Therefore, a decision support system framework is necessary to build today's flying maintenance framework. Maintenance Decision Support Systems (MDSS) offer a valuable tool for aeronautical support, enhancing maintenance efficiency and cost control. However, further research is required to delve into the associated topics of flying MDSS. Due to the diverse configurations and intricate structures of modern aircraft, a significant number of aircraft parameters need to be evaluated. To facilitate further research, it is essential to establish systematic procedures for compiling a valuable database and define research criteria to assess the sufficiency of existing information. Considering the cost issues associated with continuous flight position information, determining the criteria for data download should guide further research.*
Keywords: *Maintenance Decision Support Systems (MDSS), aircraft maintenance, aviation industries, cyber-physical systems (CPS) and cyber-physical production systems (CPPS).*

1. INTRODUCTION

The essential reason for aircraft maintenance is to maintain the diminished levels of original aircraft airworthiness, security, and reliability design at the lowest cost, which is of great significance to the operation of air transport endeavors. According to statistics, flight maintenance accounts for approximately 20% to 30% of direct operating expenses, excluding indirect costs incurred due to maintenance, such as flight delays, materials and spare parts, and corporate image. In recent years, with the rapid development of the civil aviation industry, a significant number of new technologies have been used in airplanes, which increase the complexity of civil aviation maintenance, particularly the use of digital information technology. Considering the modern aviation maintenance in the new situation, in order to adapt to the essential reason for aircraft maintenance, the diminished levels of original aircraft airworthiness, security, and reliability design at the lowest cost, which is of great significance to the operation of air transport endeavors. According to statistics, flight maintenance accounts for approximately 20% to 30% of direct operating expenses, excluding indirect costs incurred due to maintenance, such as flight delays, materials and spare parts, and corporate image. In recent years, with the rapid development of the civil aviation industry, a significant number of new technologies have been used in airplanes, which increase the complexity of civil aviation maintenance, particularly the use of digital information technology. Considering the modern aviation maintenance in the new situation, in order to adapt to. 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Based on insights, flight upkeep represents approximately 20% to 30% of direct operating expenses, excluding indirect costs incurred due to maintenance, such as flight delays, materials and spare parts, and corporate image. In recent years, with the rapid development of the civil aviation industry, a significant number of new technologies have been employed in aircraft, increasing the complexity of civil aviation maintenance, especially with the use of digital information technology. Considering the modern aviation maintenance landscape, the primary objective is to maintain the reduced levels of original aircraft airworthiness, safety, and reliability at the lowest possible cost, which is of great significance to the operations of air transport enterprises. According to statistics, aircraft maintenance accounts for approximately 20% to 30% of direct labor costs, excluding overhead costs due to maintenance, such as flight delays, material and spare parts, and corporate image. Recently, with the rapid development of the general aviation field, a significant number of new innovations have been utilized in aircraft, leading to increased complexity in general aviation maintenance, particularly with the use of computerized data acquisition. In light of the current situation in aviation maintenance, it is necessary to adapt to the new circumstances. The main objective of aircraft maintenance is to reduce airworthiness, enhance safety, and ensure the reliability of aircraft while minimizing costs, which is crucial for the efficient operation of flight operations. Insights show that an aircraft's maintenance accounts for a significant portion of direct operational costs, ranging from 20% to 30%, excluding indirect expenses related to maintenance, such as flight delays, materials, spare parts, and corporate image. With the rapid advancement of the civil aviation industry, numerous new technologies have been integrated into aircraft, increasing the complexity of civil aviation maintenance, particularly with the implementation of digital information technology. In response to the modern aviation maintenance landscape, the primary objective is to maintain the aircraft's airworthiness, safety, and reliability at the lowest possible cost, which is of utmost importance for the functioning of air transport endeavors.

2. DECISION SUPPORT SYSTEM

The aviation industry's recent emphasis on global information standardization has heightened the demand for easily accessible, precise, and user-friendly flight data among stakeholders. The need for a collaborative decision support system in aviation management is growing, as the majority of the current systems rely on disconnected, out-of-date proprietary components. This system would effectively deliver the appropriate data to the relevant users in a timely manner. By minimizing the possibility of human error and automating the extraction of crucial information from many systems, this system not only eliminates the need for manual data retrieval but also enables the exploration of previously inaccessible insights and hidden knowledge that would remain undiscovered within separate systems. In this paper, we outline our proposed methodology for creating a comprehensive integrated system that supports collaborative decision-making in data-intensive environments. The framework comprises various phases, each of which is thoroughly elucidated, and includes a dedicated section that focuses on evaluating the performance of the proposed system [1]. In light of evolving customer demands, escalating resource costs, and growing uncertainties, modern manufacturing organizations face a heightened need to adapt. The digitization of the production process provides an effective strategy for addressing these issues and a potentially viable solution. Digitalization includes both cyber-physical systems (CPS) and cyber-physical production systems (CPPS). In contemporary times, the concept of the digital twin has emerged as synonymous with the online aspect of CPS and CPPS. This paper explores a conceptual framework for the order management process, emphasizing the potential applications of a decision support system. The manufacturing system's digital twin concept serves as the foundation of the framework. A decision support system is necessary for forecasting the advantages and disadvantages associated with various options and recommending the best one to successfully handle growing individual and organizational goals. Such a system can autonomously present the best option for the production process with user approval. The primary component of this system is a thorough real-time representation of the entire production system, sometimes known as the "digital twin of the manufacturing system." The system identifies solutions that align with both local and global objectives by simulating numerous scenarios within a model depicting the current state of the system. The results of each decision are immediately apparent without causing any disturbances to the actual system. In this study, a conceptual framework for integrating the manufacturing system's digital twin into a decision support system is introduced, with a focus on its contribution to streamlining the order management procedure [2]. Of utmost significance in an intelligent multi-criteria decision support system, this research presents a novel method for assessing uncertainty in the decision analysis process. The developed system effectively guides users in making informed decisions when addressing decision problems. Once an appropriate decision analysis method is identified, users can simply click on the method name to access algorithmic instructions that provide guidance for solving the given problem. The MATLAB-based decision support system organizes the mathematical calculation stages, making it simple for users to adhere to the directions and enter the required information to produce the desired outcome [3]. In 1998, a recognized necessity emerged in Canada to create a decision support system (DSS) dedicated to ground aviation Search and Rescue (SAR) mission planning. The primary objectives encompassed two key aspects: including modules that record knowledge and experience to enable the best use of resources. The main objective was to help the SAR mission coordinator quickly and efficiently plan search operations, maximizing resource use, and enhancing SAR response capabilities. To fulfill the intended objective, we devised and implemented SARPlan, a SAR planning system grounded in search theory. SARPlan's core functionality revolves around generating an optimal plan that increases the likelihood of success by efficiently using the search resources at hand, increasing the chance of finding the search object [4]. Different levels of automation can be incorporated into intelligent decision support systems, ranging from full automation, which completely excludes the operator from the decision-making process, to minimal automation, where suggestions are made but the operator still has the final say. Greater degrees of automation usually yield the best results in situations requiring complex tasks that demand limited latitude in decision-making and pose little probability of system failure. However, using high levels of automation in time-critical systems characterized by multiple external and dynamic restrictions, such as air traffic control and military command and control activities, is not advisable. The complexity of the hazards involved, as well as the system itself, makes it difficult for automated decision assistance to be completely trustworthy and reliable in such situations. Automation is utilized in human-in-the-loop systems to handle repetitive, laborious, and boring activities while still allowing active engagement from operators. This strategy not only enhances safety but also provides system and human operators with the flexibility to quickly respond to unforeseen and unknown occurrences. However, the use of automation may have some noticeable negative effects on human performance, including reduced situational awareness, complacency, skill erosion, and the potential for automation bias. In this study, we will explicitly focus on the aviation industry to investigate the impact of automation dependencies on intelligent decision support systems. We will examine the phenomenon of automaticity bias in decision-making, which describes how people often overlook contradictory data when presented with a computer-generated solution because they assume it to be accurate. In fields that require quick decisions, this tendency could be more pronounced. Although automated decision-making tools are intended to reduce human error, if they are not designed with human cognitive limits in mind, they may inadvertently introduce new flaws into the system's operation [5]. Due to the remote locations of volcano processes and the wide geographic distribution of antecedent indicators preceding eruptions, operational volcano monitoring primarily relies on remote sensing. However, despite radar remote sensing's ability to operate under various weather conditions and effectively monitor changes, its potential contribution to operational monitoring has historically been limited. These limitations are primarily caused by the high costs associated with radar data, the traditionally slow data dissemination and processing techniques, and the constrained temporal sampling offered by space-borne radars. In this study, we address these limitations and present unique methods for data processing and data assimilation that enable successful integration of radar data into operational volcano monitoring decision support systems [6].

3. AIR TRANSPORTATION SYSTEM

Ensuring a consistently acceptable level of safety in the air traffic system is a critical priority within civil aviation. The objective of this paper is to enhance flight safety during en-route operations by employing deep learning models for route prediction. Specifically, the paper focuses on characterizing the uncertainty of model predictions using a Bayesian approach, thus providing valuable insights to mitigate potential risks. The proposed method encompasses four sequential steps. First, the Apache Spark collaborative computing engine processes a sizable number of raw messages in the Flight Exchange of Information Model (FIXM) format collected from the FAA. This facilitates the efficient extraction of route information. Moving on to the second step, two distinct types of deep learning models are trained to predict the flight path, considering different perspectives. Deep feed-forward neural networks (DNNs) are used to produce one-step predictions about the difference in latitude and longitude between the actual flight path and the desired flight path. Deep long short-term memory (LSTM) neural systems are also trained to anticipate the flight route over the long term. The DNN model has a single-step prediction horizon, which provides improved accuracy. On the other hand, the LSTM model has a longer prediction horizon but is less accurate. In order to capitalize on each model's unique capabilities and improve validation, both deep learning models are combined in the third step of the approach. The DNN prediction is used to fine-tune and adjust the LSTM forecast for the flight route in subsequent time intervals by evaluating the discrepancy between the predictions of the two models at the current time point. The multi-reliability approach is further expanded to encompass multiple aircraft, enabling the estimation of safety levels based on the horizontal and vertical separation distance between two planes. The computational outcomes clearly show the promising performance of the integrated model in correctly forecasting flight routes and efficiently measuring flight safety along the specified route [7]. Modern aviation systems are complex cyber-physical networks in the context of international travel and trade. However, as the demand for air travel grows, problems such as traffic congestion, flight delays, and their associated environmental effects are becoming more frequent. In anticipation of future demand growth, there is an urgent need for the development of innovative control techniques and system redesign efforts. These measures aim to mitigate delays and minimize excessive environmental impact, ensuring the smooth and sustainable functioning of the aviation system. This survey explores various instances where control and optimization algorithms for aviation systems, derived from real-world data, are formulated, implemented, and assessed through simulations and field tests. Such methods allow for the efficient handling of a variety of issues, including resource distribution among various stakeholders, operational uncertainty resilience, and the creation of decision-support tools that take into account the actions and involvement of human operators. In 2014, the world's air transport system supported an astounding 85 million flights, carrying 6.7 billion people and 102 million metric tonnes of cargo. Notably, almost one-third of these passengers came from the Asia-Pacific region, while one-quarter each came from Europe and North America. A notable annual traffic growth rate of over 10% was also observed in emerging areas in the Middle East (Airports Council International, 2015). Despite the existence of 42,000 airports worldwide (including 20,000 in the US alone), the demand for transportation is primarily concentrated in a small number of locations. More than one-third of all passengers pass through the top 30 airports, with congested hubs like Chicago O'Hare, Atlanta, and Los Angeles seeing more than 700,000 flight operations annually (Airports Council International, 2015; CIA, 2015) [8]. Many traditional methods for evaluating an airline's performance in keeping to schedule mostly concentrate on flight-centric delays. However, recent research has shown that variables other than flight delays can have an impact on passenger delays. For instance, flight cancellations and missed connections contribute significantly to passenger delays, and these factors are influenced by a multitude of variables. Thus, a comprehensive evaluation of on-time performance must consider these diverse factors and their impact on passenger delays. Regrettably, the unavailability of publicly accessible passenger travel data poses a challenge for researchers investigating the intricacies of these relationships. In light of this, the paper at hand proposes the development of algorithms aimed at modeling historical travel patterns and delays specifically for domestic travelers in the United States. To do this, the study expands the previously developed greedy recommendation approach to estimate the corresponding passenger delays and incorporates a multinomial systematic model for predicting prior passenger trips. The investigation and estimation of passenger delays for the entire 2007 calendar year are the main topics of the research provided in this paper. By carefully evaluating these anticipated delays, it is possible to gain important knowledge about the numerous aspects that affect the functioning of the national air transport system in the United States [9]. The air transport system represents a prime example of a large-scale complex system, the intricacies of which have yet to be fully comprehended, particularly concerning the propagation of delays and the interrelationships among different airports. To shed light on this issue, causal analysis offers a fresh perspective. Given its considerable improvements in addressing the problem of causation, Granger causality (Granger, 1969) was used as the primary method in this investigation (Frank et al., 2018). The Granger causality test was then used to design a delay causal network (DCN), which provided important insights into the unique features of various airports. This network research made it possible to explore the topological characteristics and temporal dynamics of the DCN, helping to clarify its fundamental characteristics [10]. In order to accommodate future development, the Next Generation Aviation System (Next Gen) is a proposed redesign of aviation operations. This paradigm envisions airplanes performing crucial air traffic management duties, such as modifying flight plans, predicting routes, and detecting collisions. This transformative approach seeks to enhance the efficiency and effectiveness of aviation operations to meet evolving demands. In this study, we put forward an advanced trajectory prediction algorithm for next-generation aviation, leveraging a flight dynamics model to accurately capture aircraft flight pattern changes. This model proves particularly valuable for short-term trajectory prediction, as it effectively considers correlations in prediction errors arising from flight maneuvers. Moreover, we enhance long-range trajectory prediction by incorporating the aircraft's verified or inferred intentions, thereby refining the accuracy and reliability of the predictions made. In this research, we present a computationally efficient analytical algorithm designed to determine the collision probability between aircraft, whether they are engaged in maneuvers or following a straight path. The proposed algorithm offers a balance between computational efficiency and accuracy in calculating collision probabilities. We used different aviation scenarios to test the algorithm's efficacy and demonstrated that it can produce correct answers while remaining computationally efficient [11]. Initially, deregulation gained significant popularity due to its role in reducing airfares, as a response to growing public dissatisfaction. However, the regulatory environment changed as a result of issues such as airport congestion, delayed flights, safety concerns, and increased prices in less competitive markets. These problems were consequences of the changing regulatory environment. Deregulation represents just one of the numerous factors influencing the aviation system.

Technological advancements, macroeconomic conditions, and public policies pertaining to economic regulation are equally significant in shaping the industry. To preserve the stability and efficiency of the system in the face of these interconnected effects, a comprehensive and coordinated strategy is required. The focus should be on improving the aviation system through the optimization of public policies affecting mergers, airport pricing, and investment, with the aim of achieving higher efficiency and effectiveness [12].

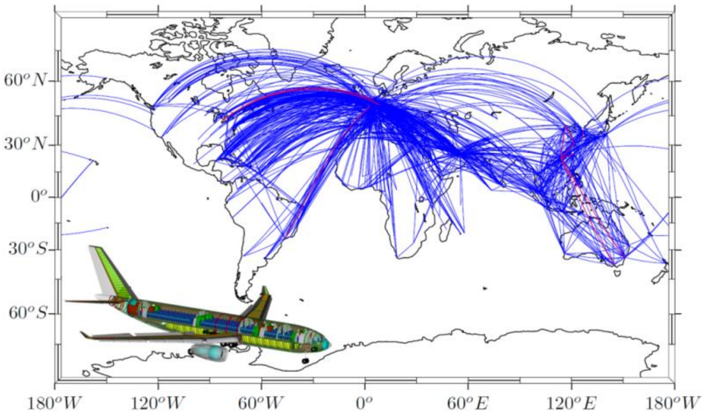

FIGURE 1. Geography of air transport system.

4. AIR TRAFFIC CONTROL

A dispatcher has the capability to make cautious decisions by considering the probability distribution of system failure times, taking into account specific system parameters. Furthermore, with the advancement towards Next-Gen technology, there is an increasing demand for automated operations to alleviate the information overload faced by flight crews. This paper presents a case study that evaluates a rerouting algorithm's performance under ambiguous conditions. To assess how well different rerouting algorithm's function, we have developed a simulation platform with specific constraints, such as ensuring separation between aircraft. There are several potential avenues for future research in this field. The current study has relied on simplified models for the simulation area, aircraft characteristics, and the positioning of neighboring airports, as well as radar and communication systems. However, the proposed method is highly versatile, allowing for the integration of more complex and sophisticated models for computer components. Further investigation could explore the incorporation of advanced models to enhance the accuracy and realism of the simulation. To enhance the realism of the simulation, future research could incorporate more accurate models for space availability at nearby airports. Instead of relying on a simplified lognormal distribution, developing a model that incorporates the dynamic changes in space availability based on the official arrival and departure schedules for each surrounding airport would be a more realistic approach. Additionally, the consideration of different distributions for random variables associated with aircraft, airports, radar, and communications would contribute to a more comprehensive and accurate representation of the system dynamics. In the future, the utilization of data mining techniques could be explored to generate the distributions based on available data sources such as flight time statistics and reported delay causes from the US Department of Transportation. By leveraging these techniques, more accurate and data-driven distributions could be obtained to improve the realism of the simulation. Furthermore, the reliability assessment conducted in this paper can serve as a foundation for undertaking reliability-based optimizations of system variables. For instance, optimizing variables like airport capacity and message delay based on reliability considerations can lead to enhanced system performance and efficiency [13]. In the project described in this paper, the design of the interface between air traffic controllers and the flight database was informed by an anthropological study of air traffic controllers. Presenting the UK's existing air traffic control system and the ethnographic research conducted to study air traffic control as a collaborative activity is discussed. This paper highlights the challenges faced in fostering collaboration between software developers and sociologists and illustrates how ethnographic studies have influenced the process of system design. The difficulties encountered in bridging the gap between these two disciplines are discussed, emphasizing the differences in perspectives, methodologies, and goals. However, the paper also demonstrates the positive impact of ethnographic studies on the systems design process. It reveals that such studies provide valuable insights that challenge conventional thinking in system design and offer alternative perspectives that contribute to the development of more user-centric and contextually appropriate solutions [14]. The air traffic control system in a specific region or country is responsible for overseeing and managing all aircraft within its airspace. It encompasses various tasks such as designing control sectors, coordinating flows between different airports, and maintaining separation between aircraft during different phases of flight, including takeoff and landing. The system operates at multiple levels, each serving the purpose of providing control, ensuring safety, and directing aircraft to their respective destinations within the designated airspace. Unforeseen delays can have a notable impact on the punctuality of aircraft arrivals. A crucial component of air traffic control is the inclusion of a module dedicated to sorting and scheduling incoming traffic for all operational landing runways at a central airport hub. This process, known as sequencing, determines the order in which aircraft will land and assigns a specific touchdown time to each aircraft within the assigned scheduling group. By efficiently sequencing and scheduling arrivals, air traffic control aims to optimize the flow of aircraft and enhance landing efficiency at the hub airport. The primary goal of the planning process is to minimize overall air traffic delays while ensuring a seamless flow of aircraft for all operational runways. Through effective analysis, it is possible to enhance safety, aid in the implementation of control measures for airlines, and gather valuable insights regarding the potential advantages of expanding runways. Aviation analysts and planners have long been striving to develop automated systems that can enhance traffic flow in complex air terminal areas. The escalating global air traffic volume and the persistent issue of terminal area delays have intensified the need for urgent systems development in this domain [15]. The current air traffic management system is under great stress due to the exponential growth of commercial air travel around the world, especially in the United States. As a result, a number of efforts and programs have been put forth to modernize air traffic control with the hope of improving effectiveness, efficiency, and safety. Reputable organizations like Eurocontrol, the Federal Aviation Administration, the Radio Technical Commission for Aeronautics (RTCA), and subject specialists including Wickens, Mavor, Parasuraman, and McGee have proposed these efforts. One of the key recommendations for enhancing air traffic control procedures is to provide users, such as pilots, airlines, and dispatchers, with greater flexibility in their operations within the airspace. This approach aims to empower users and enable them to make more independent decisions. An example of such a concept is the "free flight" proposal introduced by the RTCA in 1995. Further emphasizing the decentralization of control and decision-making in air traffic management is the idea of distributed air-ground traffic management, which was put forth by the National Aeronautics and Space Administration (NASA) [16]. Year after year, there has been a significant rise in air traffic, and with the increasing affordability and feasibility of passenger air travel, particularly for both short and long-distance journeys, the demand continues to grow. In the UK, this trend is evident with a steady annual increase of 6-7% in air traffic movements, which directly translates into higher workloads for air traffic controllers. Thankfully, throughout the history of international aviation, mid-air crashes in controlled airspace have been quite uncommon. The fatal accident rate for UK public transport operations is often four times lower than the global average, indicating one of the best aviation safety records globally, according to Richard Probity, Group Director of Safety Regulation at the UK Civil Aviation Authority [17]. An approach to examining the collaboration between agents involves the use of two fundamental concepts: knowledge-how and choice-to-cooperate (Millot à Hoc, 1997). The concept of knowledge-how encompasses an agent's individual model, including information acquisition and decision-making processes. On the other hand, the concept of choice-to-cooperate relates to how agents interact and cooperate with one another in a collaborative setting. In order to promote collaboration between artificial agents and/or human agents, cooperation can be realized through a variety of forms, functions, procedures, and controls (Lemoine-Pacaux à Grislin-Le Strugeon, 1998). An explanation of these ideas is given first, and then a demonstration of human-machine collaboration—specifically, the dynamic assignment of tasks—is shown second. Dynamic task assignment refers to the assignment and redistribution of tasks among human and machine agents based on real-time conditions and requirements. This collaborative approach allows for efficient task allocation, taking into account factors such as agent capabilities, workload, expertise, and changing operational conditions. By dynamically assigning tasks, the cooperation between human and machine agents can be optimized, leading to improved overall system performance and effectiveness. In the aviation sector, this kind of human-machine cooperation has been used to support air traffic controllers during times of heightened traffic. The cited study (Lemoine, Debernard, Crevits, and Millot, 1996) describes the support tools and integrated platform used in these scenarios, as well as the experimental evaluation using skilled controllers. The findings of these studies emphasize the significance of creating a shared workspace where each agent may manage their specific duties while taking into account the actions of other agents. The interaction between human operators and mechanical systems becomes more productive and efficient by offering a single workspace. This enables better cooperation, data exchange, and decision-making, ultimately improving the efficiency of the air congestion control system. Improved operational results are achieved when controllers manage their jobs more skillfully while considering the current actions of other agents, thanks to the integration of support tools and the development of a shared workspace. In the final section of the paper, the authors present the key elements of a common workspace within the context of human-machine collaboration. They discuss the contents and structure of this shared workspace, highlighting the essential information and tools included to facilitate cooperation and coordination among agents [18].

FIGURE 2. Shaping air traffic management for the future National Aerospace System

5. AIRCRAFT MAINTENANCE

In various publications, flight planning issues related to fleet allocation, aircraft routing, and maintenance management have been extensively discussed. One notable publication in this area is the article titled "Flight planning issues in Decision Support Systems" published in the journal Decision Support Systems, Vol. 48, pages 604-612 in 2010.The paper provides insights into decision support systems and their application in addressing flight planning challenges. It explores topics such as fleet allocation, aircraft routing, and maintenance management, aiming to improve the efficiency and effectiveness of flight operations. The article discusses methodologies, models, and algorithms employed in decision support systems, with a focus on their practical implications for the aviation industry. Furthermore, the publication references the Operations Research literature, indicating the utilization of relevant research and findings from the field of operations research in the context of flight planning. This suggests a multidisciplinary approach, integrating concepts and techniques from various domains to tackle complex flight planning problems. On the website www.elsevier.com/locate/dss, interested readers can view the article that is published in the Science Directs Decision Support Systems publication. Elsevier B.V. is the owner of the article's copyright, and all other rights are reserved. The DOI (Digital Object Identifier) for the article is 10.1016/j.dss.2009.11.010, giving readers a convenient reference number and access to the publication. An operational aeroplane maintenance routing challenge was the focus of a related, recent publication by the authors. They employed a branch-and-cost algorithm to try to reduce the amount of an aircraft's unnecessary permissible flying time. Constraints on the availability of maintenance resources were taken into account when formulating the problem and the branch-and-cost algorithm was used to assess how well maintenance routing alternatives worked. An overview of recent advancements in models and methods for the fleet assignment problem (FAP) is given in this study, with a focus on coordinating maintenance tasks. A full examination of the use of operations research and management science techniques in several facets of aircraft operations, such as fleet planning and repair routing, is also provided in another article. In a different paper, the authors discuss a multi-objective problem of scheduling preventative maintenance for aviation repair facilities and suggest using evolutionary algorithms to find economical solutions [19]. At the aviation division of Saudi Aram Co. in Tehran, Saudi Arabia, in the summer of 1997, a review of the work schedules for aircraft maintenance workers was conducted (Alfairs, 1997). The objective was to evaluate the current maintenance staff schedule in place and, if necessary, offer suggestions for improvements. The major objective was to determine the best work plan that would successfully fulfil the increasing demand for maintenance personnel while lowering costs and increasing productivity. The largest oil business in the world, Saudi Aram Co., is in charge of managing all facets of the oil sector, including exploration, production, refining, marketing, and distribution. It is impossible to understate the company's significance to Saudi Arabia's industrial development given the country's enormous reliance on oil earnings. When it comes to getting people and equipment from the corporation to remote regions like oil fields and exploration sites by plane, the aviation department is essential. The department's aircraft maintenance section is in charge of ensuring the substantial private fleet of the business is safe and airworthy. The fleet had 13 fixed-wing aircraft and 19 helicopters in 1997 For fixed-wing line upkeep, a timetable consisting of two complete eight-hour shifts each day was put in place from Saturday to Wednesday. However, the line's maintenance workers had to work a lot of overtime as a result of the increased number of flights, especially on the weekends, to keep up with the additional workload [20]. Every day, aircraft maintenance personnel encounter various challenges in their work. As an illustration, we conducted an analysis of the daily inspections conducted on a commonly used Cessna C.172B aircraft, which is often employed by flight schools. Our investigation concentrated mainly on the maintenance checks carried out before to the first flight of the day using the aircraft maintenance manual and flying manual as references. Working with maintenance specialists, we performed a hierarchical task analysis to thoroughly review the entire procedure with the goal of identifying subtasks and their corresponding phases. This investigation led us to the conclusion that the daily inspection process can be divided into the exterior check and the internal check Each check is then broken down into several tasks that concentrate on various flying components. Within these tasks, subtasks were identified, which involve specific procedures for inspecting individual instruments and are further broken down into several steps [21]. A combined approach of dynamic programming and heuristic techniques is employed to address the fleet allocation problem and the embedded maintenance schedule problem. A mathematical programming model is presented to optimize the allocation of maintenance manpower, ensuring the punctuality of the flight schedule. The major goal of [publication reference] is to reduce the costs of aircraft maintenance as well as associated expenses. To do this, the maintenance-scheduling problem is formulated mathematically, and the solutions are found by combining "depth-first searching" and "random search" techniques. To be received Gopalan and Dalluri suggest the utilization of Euler diagrams to incorporate key concepts like fleet allocation, maintenance opportunities, and aircraft numbers into flight schedule decisions. The flight cycle problem, considering specific flights, maintenance locations, periods, and required frequency, is solved using Lagrangian relaxation and sub-gradient optimization techniques to maximize the benefits obtained from specific connections. Maintenance planning studies commonly focus on the maintenance procedures related to nuclear power plants. Researchers have employed a Genetic Algorithm (GA) implementation to optimize the timing of component maintenance. In another study, a maintenance risk-cost model utilizing GA was developed for optimizing maintenance in a nuclear power plant. The paper presents a maintenance-scheduling solution that utilizes an evolutionary algorithm to simultaneously optimize cost and reliability [22]. Aircraft maintenance plays a vital role in ensuring flight safety within the overall system. Studies indicate that approximately 12 percent of major aircraft accidents can be attributed to lapses in maintenance and inspections (Marks and Krapper, 1994). There is a reported increase in the number of maintenance-related accidents, with a 55% rise in maintenance incidents and a 100% increase in accidents over the past decade (King, 1998). Human factors are significant contributors to these accidents. An in-depth analysis of recent aviation incidents and accidents reveals that they are not solely caused by technical failures or operator errors in performing tasks The underlying causes of these incidents can be traced back to organizational and managerial factors. Instances such as the Kotrora (SHK, 1993) accident and the Daventry incident (AAIB, 1996) emphasize the significance of internal communication, decision-making processes, implementation, and evaluation. Similarly, the BAC1-11 (AAIB, 1992) and Daventry incidents underscore the importance of sufficient manpower, a discerning monitoring system, and effective regulations [23]. Making a thorough plan for aircraft routing and scheduling that takes into account the Estimated Spread Distance (EPD) for every aircraft sequence is one way to reduce disturbances. With the use of the past distribution of ideal, non-propagating flight buffer delays, the goal is to reduce the EPD. The robust weekly maintenance of aircraft routing problem (RWAMRP) is the name of this optimisation issue. In order to address RWAMRP, a novel weekly line-of-flights (LOF) network model is built by combining a compact network model of flight cycle touring with a state-of-the-art flight string model (Barnhardt et al., 1998; Lannett et al., 2006) [24].

FIGURE 3. Aircraft maintenance and irregular shape of airplane

6. AIRCRAFT NAVIGATION

For effective multi-modal transportation, it is essential to quickly identify aeroplane diversions. When a flight is diverted, logistics providers must act quickly to change their transportation strategies to guarantee timely delivery despite the unexpected events. However, in reality, none of the parties that make up the supply chain communicate in real time about the status of flights. As a result, there is a demand for a method to detect diversion that uses data that is readily available to the public and operates without the involvement of various parties in communication. Without previous understanding of the planned flight path, spotting aberrant behaviour is difficult due to the reliance on public data. We address this issue by putting forth a prediction model that distinguishes between typical and anomalous behaviour based on the position, speed, and intended destination of the aircraft. The model identifies a potential diversion when a flight displays inconsistent patterns over an extended period. Through a quantitative evaluation, we demonstrate that our approach achieves high accuracy in detecting aircraft diversions and adjusting planned trajectories, aligning with existing research findings. By employing the predictive model, logistics companies can effectively respond to such events with improved response time [25]. In order to obtain exact vehicle placement, the bulk of contemporary aerial navigation systems use multi-sensor fusion techniques. But combining numerous sensors, like GPS and Inertial Measurement Units (IMUs), leads to expensive, complicated navigation systems that are unsuitable for small, disposable UAVs. This study focuses on the development of a simple and economical navigation system that only uses information from a single camera. The system creates navigation information relative to another vehicle using the camera data, which is suitable for autonomous UAV guidance and control. Natural examples of how to use visual information for building flight navigation methods include birds and insects. This study proposes two methods that rely on visual information for aerial navigation. The emphasis is on employing a single camera to track and navigate an aircraft in respect to an airborne target, such as another aircraft. These techniques are applicable to many different sorts of UAV operations, including leader-follower setups and formation flying [26]. The objective of scientific air navigation is to enable successful long-distance flights across the Atlantic Ocean, ensuring accurate course-keeping and reaching the destination without uncertainty, considering the constraints of limited fuel availability. Instead of developing entirely new solutions, the approach emphasizes the utilization of existing resources and adapting maritime navigation instruments to achieve precise and effective air navigation. Flight navigation operations should prioritize simplicity and efficiency, considering that flight navigators may lack experience in long flights. With aircraft flying at high speeds, often covering one mile per minute, and limited fuel resources, it is crucial for these operations to be swift. Drawing from the knowledge gained from previous voyages, a key aspect is to derive precise estimates of the average trajectory by analyzing the deviation of the needle and the effects of wind drift at each moment. However, when flying at high altitudes, the flat appearance of the sea provides insufficient visual information to assess the strength of the wind [27]. The use of computer-generated training aircraft raises two key questions: (a) whether active control or passive observation should be employed, and (b) what level of fidelity and visual detail is necessary for effective training. There is a scarcity of research specifically addressing the issues of active control and passive vision. A study conducted by Arête (1991) in June 4, 2016 and published in March 1996 found that passive vision provides an advantage in aircraft navigation. However, additional studies are required to further investigate and address these concerns. The mentioned study was downloaded from hfs.sagepub.com at University College London. In contrast, several other studies have demonstrated the advantages of passive vision over active participation when it comes to learning about small-scale spatial contexts, such as selecting a walking or travel direction. The advantages of passive vision have been supported by studies by Foreman, Foreman, Cummings, and Owens (1990), Gale, College, Pellegrino, and Doherty (1990), and van Wright (1957). Additionally, as noted by Cowan (1988), the literature on education and training often highlights the value of interactive engagement in the learning of knowledge [28]. The newly released Brown Water Navy doctrine, issued by the Department of Defence (DoD), emphasizes the operation of naval vessels in close proximity to enemy shores. Additionally, the Navy plans to enhance its reliance on unmanned aerial vehicles (UAVs) for various tasks, including reconnaissance. Given the increased utilization of UAVs in such scenarios, it becomes crucial to ensure their stealthy deployment during recovery by naval vessels. This means that the ship must put its own safety first by not giving the UAV any information about its whereabouts. It is clear that the only passive sensors that can provide relative position information are vision-based sensors. Additionally, infrared (IR) cameras are chosen as the best passive sensors because UAVs are predicted to work continually, regardless of the weather [29]. The difficulties in identifying and maintaining ground-based navigation aids (NAVAID), which result in restrictions on flight paths and airspace, are the root of the problems in air navigation. This problem has been resolved by the introduction of updated RNAV operations, which do away with the requirement for a direct connection between aircraft navigation and ground-based NAVAID. As a result, it improves accessibility for all aircraft and offers more flexibility for point-to-point operations. PBN (Performance-Based Navigation) is a concept that represents a substantial paradigm shift and improvement in sensor-based navigation, putting more of an emphasis on flight performance and precise flying abilities than on relying on the accuracy of navigational aids as is customarily done. Aviation navigation specifications, which specify the precise design of instrument charts and the choice of navigation sensors and equipment required to achieve these performance objectives, include the performance requirements [30].

FIGURE 4. Navigation system in airplane cockpit

7. CONCLUSION

The aviation industry's recent emphasis on global information standardization has heightened the demand for easily accessible, precise, and user-friendly flight data among stakeholders. The need for a collaborative decision support system in aviation management is growing as the majority of the current systems rely on disconnected, out-of-date proprietary components. Ensuring a consistently acceptable level of safety in the air traffic system is a critical priority within civil aviation. The objective of this paper is to enhance flight safety during en-route operations by employing deep learning models for route prediction. Specifically, the paper focuses on characterizing the uncertainty of model predictions using a Bayesian approach, thus providing valuable insights to mitigate potential risks. A dispatcher has the capability to make cautious decisions by considering the probability distribution of system failure times, taking into account specific system parameters. Furthermore, with the advancement towards Next-Gen technology, there is an increasing demand for automated operations to alleviate the information overload faced by flight crews. This paper presents a case study that evaluates a rerouting algorithm's performance under ambiguous conditions. In various publications, flight planning issues related to fleet allocation, aircraft routing, and maintenance management have been extensively discussed. One notable publication in this area is the article titled "Flight planning issues in Decision Support Systems" published in the journal Decision Support Systems, Vol. 48, pages 604-612 in 2010.The paper provides insights into decision support systems and their application in addressing flight planning challenges. For effective multi-modal transportation, it is essential to quickly identify aeroplane diversions. When a flight is diverted, logistics providers must act quickly to change their transportation strategies to guarantee timely delivery despite the unexpected events. However, in reality, none of the parties that make up the supply chain communicate in real time about the status of flights. As a result, there is a demand for a method to detect diversion that uses data that is readily available to the public and operates without the involvement of various parties in communication.

REFERENCES

[1]. Rusu, Laura Irina, Wenny Rahayu, Torab Torabi, Florian Puersch, William Coronado, Andrew Taylor Harris, and Karl Reed. "Moving towards a collaborative decision support system for aeronautical data." *Journal of Intelligent Manufacturing* 23 (2012): 2085-2100.

[2]. Kunath, Martin, and Herwig Winkler. "Integrating the Digital Twin of the manufacturing system into a decision support system for improving the order management process." *Procedia Cirp* 72 (2018): 225-231.

[3]. Sun, Xiaoqian, Volker Gollnick, Yongchang Li, and Eike Stumpf. "Intelligent multicriteria decision support system for systems design." *Journal of Aircraft* 51, no. 1 (2014): 216-225.

[4]. Ambegaonker, Ajeenkkya, Utkarsh Gautam, and Radha Krishna Rambola. "Efficient approach for Tendering by introducing Blockchain to maintain Security and Reliability." In 2018 4th International Conference on Computing Communication and Automation (ICCCA), pp. 1-4. IEEE, 2018.

[5]. Abi-Zeid, Irene, and John R. Frost. "SARPlan: A decision support system for Canadian Search and Rescue Operations." *European Journal of Operational Research* 162, no. 3 (2005): 630-653.

[6]. Cummings, Mary L. "Automation bias in intelligent time critical decision support systems." In *Decision making in aviation*, pp. 289-294. Routledge, 2017.

[7]. Gutu, Birhanu, Genene Legese, Nigussie Fikadu, Birhanu Kumela, Firafan Shuma, Wakgari Mosisa, Zelalem Regassa et al. "Assessment of preventive behavior and associated factors towards COVID-19 in Qellam Wallaga Zone, Oromia, Ethiopia: A community-based cross-sectional study." PloS one 16, no. 4 (2021): e0251062.

[8]. Meyer, F. J., D. B. McAlpin, W. Gong, O. Ajadi, S. Arko, P. W. Webley, and J. Dehn. "Integrating SAR and derived products into operational volcano monitoring and decision support systems." *ISPRS journal of photogrammetry and remote sensing* 100 (2015): 106-117.
[9]. Jasvinder Kaur, M. Ramachandran, Sathiyaraj Chinnasamy, Prabakaran Nanjundan, “Building Logistics Capabilities through Third-party Logistics Relationships Using COPRAS Method”, REST Journal on Data Analytics and Artificial Intelligence, 1(3), (2022):1-8.
[10]. Rathor, Ketan, Anshul Mandawat, Kartik A. Pandya, Bhanu Teja, Falak Khan, and Zoheib Tufail Khan. "Management of Shipment Content using Novel Practices of Supply Chain Management and Big Data Analytics." In 2022 International Conference on Augmented Intelligence and Sustainable Systems (ICAISS), pp. 884-887. IEEE, 2022.
[11]. Zhang, Xiaoge, and Sankaran Mahadevan. "Bayesian neural networks for flight trajectory prediction and safety assessment." *Decision Support Systems* 131 (2020): 113246.
[12]. Balakrishnan, Hamsa. "Control and optimization algorithms for air transportation systems." *Annual Reviews in Control* 41 (2016): 39-46.
[13]. Mishra, Anamika A., Krushnalee Surve, Uttara Patidar, and Radha Krishna Rambola. "Effectiveness of confidentiality, integrity and availability in the security of cloud computing: A review." In 2018 4th International Conference on Computing Communication and Automation (ICCCA), pp. 1-5. IEEE, 2018.
[14]. Barnhart, Cynthia, Douglas Fearing, and Vikrant Vaze. "Modeling passenger travel and delays in the national air transportation system." *Operations Research* 62, no. 3 (2014): 580-601.
[15]. Du, Wen-Bo, Ming-Yuan Zhang, Yu Zhang, Xian-Bin Cao, and Jun Zhang. "Delay causality network in air transport systems." *Transportation research part E: logistics and transportation review* 118 (2018): 466-476.
[16]. Chandran Subramani, Sathiyaraj Chinnasamy, Ashwini Murugan, Chandrasekar Raja. “Composite Material Selection for Structural Applications Using WPM Method.” Journal on Materials and its Characterization, 1(2), (2022):1-8.
[17]. Manjunath, C. R., Ketan Rathor, Nandini Kulkarni, Prashant Pandurang Patil, Manoj S. Patil, and Jasdeep Singh. "Cloud Based DDOS Attack Detection Using Machine Learning Architectures: Understanding the Potential for Scientific Applications." International Journal of Intelligent Systems and Applications in Engineering 10, no. 2s (2022): 268-271.
[18]. Hwang, Inseok, and Chze Eng Seah. "Intent-based probabilistic conflict detection for the next generation air transportation system." *Proceedings of the IEEE* 96, no. 12 (2008): 2040-2059.
[19]. Palanimuthu, Kogila, Eshetu Fikadu Hamba Yigazu, Gemechu Gelalcha, Yirgalem Bekele, Getachew Birhanu, and Birhanu Gutu. "Assessment of Stress, Fear, Anxiety and Depression on COVID-19 Outbreak among Adults in South-Western Ethiopia." Prof.(Dr) RK Sharma 21, no. 1 (2021): 440.
[20]. Morrison, Steven A., Clifford Winston, Elizabeth E. Bailey, and Alfred E. Kahn. "Enhancing the performance of the deregulated air transportation system." *Brookings Papers on Economic Activity. Microeconomics* 1989 (1989): 61-123.
[21]. Cohen, Marc-David, Charles B. Kelly, and Andrés L. Medaglia. "Decision support with Web-enabled software." *Interfaces* 31, no. 2 (2001): 109-129.
[22]. Manoharan, Hariprasath, Radha Krishna Rambola, Pravin R. Kshirsagar, Prasun Chakrabarti, Jarallah Alqahtani, Quadri Noorulhasan Naveed, Saiful Islam, and Walelign Dinku Mekuriyaw. "Aerial Separation and Receiver Arrangements on Identifying Lung Syndromes Using the Artificial Neural Network." Computational Intelligence and Neuroscience 2022 (2022).
[23]. P.K. Chidambaram, Chinnasami Sivaji, Ashwini Murugan, M. Ramachandran. “Performance Analysis of Materials Selection Using Weighted Product Method (WPM).” Journal on Materials and its Characterization 1(1), (2022):38-45.
[24]. Bentley, Richard, John A. Hughes, David Randall, Tom Rodden, Peter Sawyer, Dan Shapiro, and Ian Sommerville. "Ethnographically-informed systems design for air traffic control." In *Proceedings of the 1992 ACM conference on Computer-supported cooperative work*, pp. 123-129. 1992.
[25]. Kumar, Ashish, Ketan Rathor, Snehit Vaddi, Devanshi Patel, Preethi Vanjarapu, and Manichandra Maddi. "ECG Based Early Heart Attack Prediction Using Neural Networks." In 2022 3rd International Conference on Electronics and Sustainable Communication Systems (ICESC), pp. 1080-1083. IEEE, 2022.
[26]. Hansen, James V. "Genetic search methods in air traffic control." *Computers & Operations Research* 31, no. 3 (2004): 445-459.
[27]. Tasisa, Yirgalem Bekele, and Kogila Palanimuthu. "Psychosocial Impacts of Imprisonment among Youth Offenders in Correctional Administration Center, Kellem Wollega Zone, Ethiopia." Medico-legal Update 21, no. 2 (2021).
[28]. Metzger, Ulla, and Raja Parasuraman. "The role of the air traffic controller in future air traffic management: An empirical study of active control versus passive monitoring." *Human factors* 43, no. 4 (2001): 519-528.
[29]. Shorrock, Steven T., and Barry Kirwan. "Development and application of a human error identification tool for air traffic control." *Applied ergonomics* 33, no. 4 (2002): 319-336.
[30]. Pacaux-Lemoine, M. P., and S. Debernard. "Common work space for human–machine cooperation in air traffic control." *Control Engineering Practice* 10, no. 5 (2002): 571-576.
[31]. P.K. Chidambaram, Kurinjimalar Ramu, M. Ramachandran, Chandrasekar Raja. “A Review on Composite Material Selection Using DEMATEL Method.” Journal on Materials and its Characterization 1(1), (2022):28-37.
[32]. Bagde, Hiroj, Savitha Banakar, Alka Waghmare, Ashwini Bagde, Shailendra Singh Chaturvedi, and Santosh Rayagouda Patil. "Assessment of the Relationship Between Matrix Metalloproteinase-9 Promoter Gene Polymorphism and Chronic Periodontitis." Pesquisa Brasileira em Odontopediatria e Clínica Integrada 21 (2021).

[33]. Papakostas, Nikolaos, Poluzois Papachatzakis, Vangelis Xanthakis, Dimitris Mourtzis, and George Chryssolouris. "An approach to operational aircraft maintenance planning." *Decision support systems* 48, no. 4 (2010): 604-612.
[34]. Rathor, Ketan, Keyur Patil, Mandiga Sahasra Sai Tarun, Shashwat Nikam, Devanshi Patel, and Sasanapuri Ranjit. "A Novel and Efficient Method to Detect the Face Coverings to Ensurethe Safety using Comparison Analysis." In 2022 International Conference on Edge Computing and Applications (ICECAA), pp. 1664-1667. IEEE, 2022.
[35]. Alfares, Hesham K. "Aircraft maintenance workforce schedulingA case study." *Journal of Quality in Maintenance Engineering* 5, no. 2 (1999): 78-89.
[36]. Aswini, S., S. Tharaniya, RJ Joey Persul, B. Avinash Lingam, and P. Kogila. "Assessment of Knowledge, Attitude and Practice on Immunization among Primi Mothers of Children." Indian Journal of Public Health Research & Development 11, no. 3 (2020): 583-587.
[37]. De Crescenzio, Francesca, Massimiliano Fantini, Franco Persiani, Luigi Di Stefano, Pietro Azzari, and Samuele Salti. "Augmented reality for aircraft maintenance training and operations support." *IEEE Computer Graphics and Applications* 31, no. 1 (2010): 96-101.
[38]. Papakostas, Nikolaos, Poluzois Papachatzakis, Vangelis Xanthakis, Dimitris Mourtzis, and George Chryssolouris. "An approach to operational aircraft maintenance planning." *Decision support systems* 48, no. 4 (2010): 604-612.
[39]. McDonald, Noreen, Siobhan Corrigan, Colin Daly, and Sam Cromie. "Safety management systems and safety culture in aircraft maintenance organisations." *Safety Science* 34, no. 1-3 (2000): 151-176.
[40]. Chandran Subramani, M. Ramachandran, Chinnasami Sivaji, Kurinjimalar Ramu , "Environmental Impact Assessment of Using Decision Making trial and Evaluation Laboratory (DEMATEL) Method", Journal on Materials and its Characterization, 1(1), (2022):6-16.
[41]. Joshi, Shubham, Radha Krishna Rambola, and Prathamesh Churi. "Evaluating artificial intelligence in education for next generation." In Journal of Physics: Conference Series, vol. 1714, no. 1, p. 012039. IOP Publishing, 2021.
[42]. Liang, Zhe, Yuan Feng, Xiaoning Zhang, Tao Wu, and Wanpracha Art Chaovalitwongse. "Robust weekly aircraft maintenance routing problem and the extension to the tail assignment problem." *Transportation Research Part B: Methodological* 78 (2015): 238-259.
[43]. Rathor, Ketan, Sushant Lenka, Kartik A. Pandya, B. S. Gokulakrishna, Susheel Sriram Ananthan, and Zoheib Tufail Khan. "A Detailed View on industrial Safety and Health Analytics using Machine Learning Hybrid Ensemble Techniques." In 2022 International Conference on Edge Computing and Applications (ICECAA), pp. 1166-1169. IEEE, 2022.
[44]. Di Ciccio, Claudio, Han Van der Aa, Cristina Cabanillas, Jan Mendling, and Johannes Prescher. "Detecting flight trajectory anomalies and predicting diversions in freight transportation." *Decision Support Systems* 88 (2016): 1-17.
[45]. Johnson, Eric N., Anthony J. Calise, Yoko Watanabe, Jincheol Ha, and James C. Neidhoefer. "Real-time vision-based relative aircraft navigation." *Journal of Aerospace Computing, Information, and Communication* 4, no. 4 (2007): 707-738.
[46]. Patel BJ, Surana P, Patel KJ. Recent Advances in Local Anesthesia: A Review of Literature. Cureus. 2023 Mar 17;15(3):e36291. doi: 10.7759/cureus.36291. PMID: 37065303; PMCID: PMC10103831.
[47]. Barata, Jorge, António Mendes, Cândido Morgado, Fernando Neves, and André Silva. "Origins of Scientific Aircraft Navigation." In *45th AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit*, p. 5022. 2009.
[48]. Williams, Henry P., Scott Hutchinson, and Christopher D. Wickens. "A comparison of methods for promoting geographic knowledge in simulated aircraft navigation." *Human factors* 38, no. 1 (1996): 50-64.
[49]. Jisha, L., P. Jayaprabha, S. Gnanawel, K. Gowtham Kumar, and P. Kogila. "Assessment of the Prevalence of Febrile Seizure and Associated Factors among Children: A Retrospective Study." EXECUTIVE EDITOR 11, no. 03 (2020): 3179.
[50]. Sarveshwar Kasarla, Vimala Saravanan, Vidhya Prasanth, Manjula Selvam, "The Influence of Thermoelectric Properties of Nanomaterial and Applications", Journal on Materials and its Characterization, 1(1), (2022):1-5.
[51]. Yakimenko, Oleg A., Isaac I. Kaminer, William J. Lentz, and P. A. Ghyzel. "Unmanned aircraft navigation for shipboard landing using infrared vision." *IEEE Transactions on Aerospace and Electronic Systems* 38, no. 4 (2002): 1181-1200.
[52]. Rambola, Radhakrishna, Prateek Varshney, and Prashant Vishwakarma. "Data mining techniques for fraud detection in banking sector." In 2018 4th International Conference on Computing Communication and Automation (ICCCA), pp. 1-5. IEEE, 2018.
[53]. López-Lago, Manuel, José Serna, Rafael Casado, and Aurelio Bermúdez. "Present and future of air navigation: PBN operations and supporting technologies." *International Journal of Aeronautical and Space Sciences* 21, no. 2 (2020): 451-468.