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Artificial Intelligence, IoT and their Future on Aviation Safety

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Abstract

Aviation is an industry considered to provide a safe mode of transport; even though that is the case over the past years several plane crashes and missing planes have been recorded. This paper aims to explore some of the technologies that are being adopted and to research new ways of integrating these technologies and techniques to provide a much safe environment for flying, the objectives are to pave way for the development of an aviation system that can detect objects using computer vision, detect anomalies and provide warning to the cockpit crew and most importantly this system be able to override cockpit crew control in certain critical situations where the is the pilot error that can cost lives, with the use of artificial intelligence and IoT.

Keywords: Aviation; Obstacle detection; Anomaly detection; Active smart cockpit; Tone analyzer; Critical safety system; Artificial Intelligence; IoT; Safety

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Introduction

The Internet of Things (IoT) refers to the giant connection of network that connects things and artificial intelligence is the ability for a computer or computer-controlled robot to achieve or perform a task commonly associated with intellectual beings [1]. With the growing applications of artificial intelligence and IoT many industries are adopting these technologies for varying business needs, so has aviation even though the use and applications are still in infancy, the applications of these technologies are vastly limited only to our ideas and time and very important to aviation in the scope that most aviation application is critical-system which failure can lead to tremendous loses.

Although air travel has and is still considered the safest mode of traveling, there are still some present dangers in aviation. The disappearance of Malaysia MH370 on March 8, 2014, the crash of German wing flight 9525 on March 2015, and the latest Sriwijava air Boeing 737 passenger plane. While aviation involves the continuous collection and monitoring of flight data and storing using FDR, ADS-B, FDUA even though these technologies are and have been in use for several years they have been severely lacking and have necessitated innovative multi-disciplinary technologies for ensuring aviation safety.

It is presently clear today how artificial intelligence is been used to train computer agents, that with a high level of accuracy can learn supervised or unsupervised and be able to perform a task with close to almost human intellect. Clear evidence of this is when January 2020 last year Airbus executed a successful fully automated takeoff with aims to fully automate the taxi and landing [2]. This system wants to take a radical approach deviating from the traditional use of flight data recorders, which are only useful when the crash plane is found and if the flight data recorder is not damaged, relating to various parameters applicable to explain the incidents or moments before and leading to the crash [3]. Replacing it with an active cockpit voice recorder, that will be able to analyze the pilots and with Artificial Intelligence be able to decide to notify the command center of a potential threat and with IoT enabling such communications possible [4].

Related work

Safety has always been a major concern in aviation, making sure that all systems in the airplane are up and running and working properly. Hence development and research in this area have gained some pace to realize a safe system, one such project is the AMELIA: Aircraft monitoring and electronically linked instantaneous analytic [5].

• A multi-layered edge computing system that detects automatically aircraft emergencies.

• Transmit only relevant data for quicker emergency responses.

• Help pilots communicate with outside expects to prevent crashers.

Survey: Here, a survey on the already published related books and research papers is taken into account by going through the recent papers and discussing the methods that got to be used in such a paper. For this project, 15 papers were taken into account, in addition to the base paper of the whole project **(Table 1)** [6].

Table 1: Survey on the already published related books and research papers.

S. No	Paper	Author	Proposed method	Description of methods	Merit	Demerit
1	Explainable artificial intelligence for aviation safety applications	Aditya P. Saraf, Kennis Chan, Martin Popish, Jeff Browder, and John Schade, 2020	Anomaly detection AI algorithms	Aviation research has increased the nature of current airspace by increasing reliance on autonomy	Prototype tool	Less likely to understand unless decisions are explained in a human-understandable form
2	AI in aviation exploring the fundamentals, threats, and opportunities of artificial intelligence in the aviation industry	The International Air Transport Association (IATA) -Celine Hourcade, David McEwen, Eric Léopold, Henk Mulder, Joseph Suidan, Juan Antonio Rodriguez, Juan Ivan Martin, Magdy Reda, Massimo Cicetti, Rob Eagles, Thomas Roetger, 2018	Trans-formative algorithms, generic algorithm, artificial neural networks, and de-confiction algorithm	The aviation industry has already started adopting some limited AI capabilities in business; however, there is now the opportunity to start with wider adoption of AI capabilities to support achieving business objectives	Fast implementation of solutions	Regulatory and ethical challenges and difficulty in accessing big data
3	The flight to safety-critical AI	Will Hunt	Unpredictable algorithm	AI safety-critical systems are often opaque and display unpredictable behavior which makes it hard to evaluate the reliability	Cost reduction	Software certification is expensive and time-intensive, heavily rely on data
4	Artificial intelligence roadmap a human-centric approach to AI in aviation	European Union Aviation Safety Agency, 2020	Deeper neural networks and generative adversarial networks	Aviation has always been an innovation forefront industry, the most disruptive innovation probably being AI. The possibilities of AI will increasingly be used in aviation and make autonomous flights	Systems enabled to make a complex decision	Complex programming techniques
5	Glass-Box: An intelligent flight data recorder and real-time monitoring system	Krihna M. Kavi and Mohamed Aborizka, 2001	Generic algorithms, Neural networks, Bayesian classification, inductive logic, data cleaning/ pattern discovery, and decision tree analysis	In this system, intelligent software agents communicate and collect flight data that can be correlated and data mined to construct scenarios that can lead to unsafe accidents	Using these analyses it is possible to develop intelligent agents hat and detect an unsafe condition in real-time	The use of a single agent to solve is complex and may not be feasible
6	Consideration of artificial intelligence safety engineering for unmanned aircraft	Sebastian Schirmer, Christoph Torens, Florian Nikodem, Johann Dauer	Deep learning techniques	The research on increased autonomous decision making in aircraft systems is growing and rapidly advancing	Makes operations safer	Problematic in safety-critical systems and machine learning techniques are hard to interpret for humans and rely much on the training data
7	Computation and energy-efficient image processing in wireless sensor networks based on reconfigurable computing	T.T.-O. Kwok and Y.-K. Kwok, 2006	Field programmable gate arrays and Scheduling algorithms	In wireless sensor network nodes are power-constrained and require raw data to which computation-intensive tasks can be done(e.g., image data)	Reduce the time of data sent	None

8	How it's possible to lose an airplane in 2014. http://www.wired.com/2014/03/malaysia-air/	Accessed: August 2016.	Learning and selective sampling, random sampling vs directed search and generalization and formal learning theory	Selective sampling a form of directed search that greatly increases the ability to connect network information based on previous batches of samples	Studied analytically	Depends on previous sample batches
9	Critical data analysis of flight data recorder for the safety of flight	Avinash Chandra Mani, Dr. Abhay Kumar Agarwal, 2018	Event detection	This gives a novel approach to effectively perform critical data analysis in a way that provides critical data after an accident and analysis to help pilots evade accidents	Provide airworthiness data	Big data needed
10	Beyond the black box	K. M. Kavi, 2010	Operating pressure ratio and engine pressure ratio	The flight data recorder is the source of accurate information as it logs aircraft data	Accurate results	Needs large amounts of data for analysis
11	Vision and challenges for realizing the Internet of Things	H. Sundmaeker, P. Guillemin, P. Friess, and S. Woelfflé, 2010	Fog computing	IoT and the success of cloud services have greatly advanced pushing the horizon of new computing paradigms and edge computing	Energy efficient	security
12	System identification and control of helicopter dynamics using flight data	S. Suresh, M. V. Kumar, S. Omkar, V. Mani, and P. Sampath, 2002	Neural network technique(delta method)	Helicopter flight dynamic complexity makes modeling and helicopter system identification a hard job. Artificial neural networks are then used	Easy to obtain desired feedback	Internal system structure may not be known
13	Enabling right-provisioned microprocessor architectures for the internet of things	T. Adegbija, A. Rogacs, C. Patel, and A. Gordon-Ross, 2015	Sensor fusion algorithms and image processing	IoT consists of embedded low-power devices with the ability to collect and transmit data	Fault tolerance	Open deployment makes them susceptible to attacks
14	Edge mining the internet of things	E. I. Gaura, J. Brusey, M. Allen, R. Wilkins, D. Goldsmith, and R. Rednic, 2013	Spanish inquisition protocol	Explore the benefits of edge mining on the internet of things smart sensing devices	Message reduction and in-network processing	None
15	Anomaly detection in onboard-recorded flight data using cluster analysis	L. Li, M. Gariel, R. J. Hansman, and R. Palacios, 2011	Inductive Monitoring Systems and Sequence miner behavior	The airline industry is shifting towards proactive risk management, which aims to identify and mitigate risks before accidents happen	Easy to implement And well-stated algorithms	Inductive monitoring systems functions only when training data is available

Methodology

To achieve the objectives of our research the following proposed techniques and models will be explored.

• Obstacle detection using computer vision onboard, the aircraft system using integrated artificial intelligent agents, should be able to recognize obstacles that can compromise the aircraft safety, give warning to the pilots and with the collaboration of human behavior science experts, give a time interval for the system to wait for a response from the pilots [7].

• Anomaly detection: Giving past data of airplanes that crashed or went missing, this might be the most data-intensive process to figure out peculiar scenarios that led to the crashes or disappearance of those plans and also coming up with likely scenarios that may cause such devastation, as a philosopher George Santayana said over 90 years ago "those who cannot remember the past are condemned to repeat it" **(Figure 1)**. These anomalies are not limited to but are inclusive of humans too. In instances of human anomalies the system has to provide a warning to the cabin crew, wait for a response if no response is given two things should be done by the system [8].

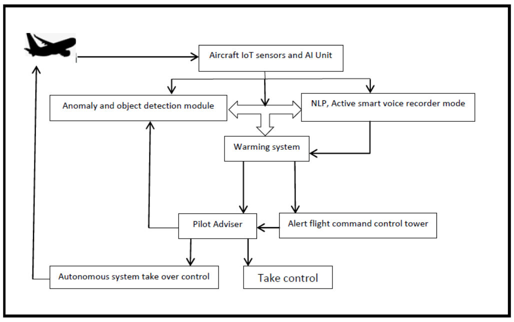

Figure 1: Overall system architecture.

- Inform the command center of the possibility of the threat at hand and wait for further instructions.

- in-case of communications failure and pilots unable to respond to the system warning, the system has to engage itself into auto-pilot for a couple of minutes staying on course and with the help of obstacle detection avoiding crashing it into mountains and buildings.

• Active smart cockpit and tone analyzer recorder: This will work like the traditional flight data recorder (black-box, FDR) with a twist, this proposed technique makes use of natural language processing to analyze tones in the pilots' voice to make distinctions whether they are panicking or not. A panic tone in a pilot might signal something serious, especially when dealing with critical systems in an industry like aviation [9].

• While the active smart cockpit will start transmission of relevant data back to the ground and only storing a portion of data before, this will be of particular interest in cases where the plane might disappear, the ground crew will be able to be part of the unfolding events and be in a better position to make informed decisive decisions to help prevent such an accident from happening [10,11].

System architecture

System architecture is the process of defining the components, modules, interfaces, and data for a system to satisfy specified requirements. The following is the architecture for the system [12].

Algorithm and techniques event detection algorithm:

1. Any segment of six residues or more in a native protein with <Pα> ≥ 1.03 and <Pα>><Pβ>, is predicted as helical.

2. Any segment of three residues or more in a native protein with <Pβ> ≥ 1.05 and <Pβ >><Pα>, is predicted as β-sheet.

3. Any segment of four or more residues in a native protein with <Pturn> ≥ 1.00 and P (α-helix)<P (turn)>P (β-sheet), is predicted as a turn sheet.

Anomaly detection AI algorithm: Anomaly detection AI algorithm is used to observe deviation from normal behavior. That detected behavior that does not behave normally is called outliers [13]. Depending on what anomalies can be included in our scope and other unseen anomalies regarding the aircraft.

Deep learning techniques: This technique is used to imitate the functionality of the human brain, by creating models used for classification and these models are made up of several layers of hidden layer called neural networks which can extract features from the data. Each layer starting from the left-most layer to the right-most layer extracts a low-level feature-like edge and subsequently predicting accurately [14-18].

Result and Discussion

The objective is to develop an aviation system that can be deployed to any passenger aircraft, with the integration of AI and IoT to ensure the safety of the aircraft, people, and the company by trying as much as possible to avoid and prevent such unforeseen circumstances from happening using available data and unsupervised learning to help the system understand and learn better of the different situations that are dangerous in aviation.

The system designs include multiple diagrams such as the architecture diagram which emphasizes the overall design of the system operations that describes the structure, behavior, and more views and analysis of performance. In logical design, the input and output of data in the system of an abstract representation of how data flows. It includes entity-relationship diagrams. While physical design dwells much on how input and output is explained relating to how data is feed to the system, and how that data is processed. Divided into many parts systems design gives a glimpse of how the project will look like from the user's point of view. In the system, we use system architecture, UML diagrams, and data flow just to show how the system coordinates.

Conclusion

In conclusion, the system is aimed to provide a high level of safety for aircraft by integrating human capabilities with artificial intelligence and IoT to enable the aircraft to make critical decisions in critical scenarios and to enable communication of relevant aircraft data and communication with expectations in situations of a possible crash.

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