Enhancing Flight Navigation Mechanism for Optimal Route Planning and Risk Mitigation

Introduction:

In the aviation industry, ensuring safe and efficient flight navigation is paramount. With the goal of minimizing human errors and enhancing automated navigation mechanisms, this problem statement aims to develop a comprehensive solution that addresses various challenges encountered during flight navigation.
These challenges are unavailable GPS signals, adverse weather conditions such as fog, smoke, rain, snow, and factors like noise, electronic failures, and varying pressures due to weather conditions and altitude changes.

Objective:

The primary objective is to design, develop, and implement a robust software solution that leverages existing algorithms **to identify optimal flight paths** considering the aforementioned challenges. Additionally, **the solution should provide real-time risk assessment and suggest alternative routes** to pilots, airlines, and airport authorities for safe and efficient navigation. Added integration of a real-time health metrics tracker based on flight sensor data could also be useful to understand flight health.

Key Components and Requirements:

Data Collection and Management:

Participants are required to collect data continuously from open sources or create sample datasets that encompass various factors affecting flight navigation, including weather conditions, environmental variables, electronic system failures, and more.

Data should be stored in a structured database and exposed via APIs for easy accessibility and integration into the solution.

APIs references which can be used for sample datasets:

(Explore authentic and secure open source APIs/Datasource)

1. **Aviation Stack API**: https://aviationstack.com
2. **FlightAware API**: https://www.flightaware.com/commercial/aeroapi
3. **AviationWeather.gov API**: https://www.aviationweather.gov/dataserver
4. **NOAA National Weather Service API:** https://www.weather.gov/documentation/services-web-api
5. **OpenWeatherMap API**: https://openweathermap.org/api
6. **NASA EOSDIS API**: https://earthdata.nasa.gov/eosdis/daacs
7. **FAA NOTAMs API**: https://www.faa.gov/air_traffic/flight_info/aeronav/digital_products/dafd/
8. **ADS-B Exchange API**: https://www.adsbexchange.com/data/
9. **Kaggle Flights:** https://www.kaggle.com/datasets?search=flight

Scenario Identification:

Participants must identify and document various scenarios based on the collected data, highlighting potential risks and challenges during flight navigation.

Scenarios should cover a wide range of factors such as weather conditions, visibility issues, electronic failures, and other environmental variables.

Route Planning Algorithm:

Participants are expected to implement existing route planning algorithms or develop new ones to find the best navigation path considering the identified scenarios and challenges.

Algorithms should prioritize safety, efficiency, and reliability in route selection.

User Interface and Dashboard:

1. The solution should include a user-friendly interface that displays optimal flight routes along with associated risks and challenges.
2. A dashboard should provide real-time updates and alerts on weather conditions, environmental factors, and system status to aid decision-making.

Documentation:

Participants are required to create comprehensive API documentation, including a user guide for pilots / control center, technical documentation for development and support teams, and an Architecture Requirements Document (ARD) outlining the system architecture and design principles.

Evaluation Criteria:

- Accuracy and effectiveness of route planning algorithm in mitigating risks.
- User interface design and intuitiveness.
- Effective REST APIs and Database Design.
- Completeness and clarity of documentation.
- Performance and scalability of the solution.
- Innovation, new Ideas and creativity in addressing challenges.

Submission Format:

- Source code in any GIT version control system.
- Cloud - for hosting and data (preferable)
- Use Tech Stack of your choice (No restriction)
- Details about Tech Stack used and in the README.md file in the code

The Dual Risks of Faulty Wiring and Structural Damage in Aircraft

Problem:

Aircraft maintenance and repair are integral components of the aviation industry, serving as the backbone of safety, reliability, and operational continuity. The meticulous assessment and meticulous repair of dents, damage, detection of faulty wires and wear on aircraft fuselage, wings, and other components are paramount to ensuring flight safety, regulatory compliance, and public confidence.

First and foremost, the safety of passengers, crew, and cargo is the primary concern in aviation. Any compromise to the structural integrity of an aircraft, no matter how minor, poses a potential threat to safety. Damage, such as dents or structural deformities, can disrupt airflow, compromise aerodynamics, and weaken critical structural elements, increasing the risk of catastrophic failures during flight. Similarly faulty wiring poses a significant safety risk, as it can lead to electrical malfunctions within critical aircraft systems. These malfunctions may result in system failures, in-flight emergencies, or even fires, jeopardizing the safety of passengers, crew, and the aircraft itself.

Thus, thorough assessments and repairs are essential to maintaining the airworthiness of aircraft and safeguarding against potential accidents.

Use Cases:

1. **Operational Efficiency**: Streamlined maintenance processes ensure faster resolution, automated identification enhances workflow, and quick access to critical information expedites decision-making.
2. **Risk Mitigation** - Early Detection: Early identification prevents potential emergencies, proactive measures reduce accidents, and timely intervention minimizes repair costs and downtime.
3. **Enhanced Safety and Compliance**: Comprehensive reporting ensures regulatory compliance, accurate assessment contributes to overall safety, and reduced errors enhance compliance during maintenance activities.
4. **Technical Personnel Support**: VR technology aids in visualizing wire paths, simplified processes reduce extensive disassembly needs, and enhanced visibility leads to quicker problem-solving.
5. **Cost-Effectiveness**: Reduced downtime translates to cost savings, targeted repairs minimize overall maintenance expenses, and efficient processes result in quicker turnaround times.

Requirements:

To address both the issues of detecting and assessing damage on aircraft surfaces, as well as identifying faulty wires in harnesses, a comprehensive web application will be developed. This tool will leverage advanced imaging and analysis techniques to accurately detect damage and identify faulty wires. Key functionalities of this tool will include:

1. Repair Recommendations:
    - Generate repair recommendations based on the assessed damage and faulty wire locations.
    - Provide actionable insights for maintenance teams, including recommended repair methods and materials.
2. Faulty Wire Location Identification:

    - Implement algorithms to identify and locate faulty wires within aircraft harnesses.
    - Utilize advanced signal processing techniques to analyze electrical signals and pinpoint areas of concern.
3. Damage Assessment:
    - Employ machine learning algorithms to assess the severity and extent of damage on aircraft surfaces.
    - Provide detailed reports on the nature of damage, including size, location, and potential impact on structural integrity.
4. Image Analysis:
    - Utilize advanced imaging algorithms to analyze high-resolution images of aircraft surfaces and wire harnesses.
    - Identify and highlight areas of potential damage or faulty wiring for further assessment.
5. CAD 3D Projection:
    - Develop algorithms to identify the shortest path between two points, such as from the functional identification number to a specific location on the aircraft surface.
    - Utilize CAD 3D modeling to project the identified path and create a point or sphere representing the location of damage or faulty wiring.
6. Web Application:
    - Finally once the solution is ready, create an responsive web application (can choose whatever stack as you like) where an end-user can interact with the model prepared and get results.
    - There is no template for the UI. Use your imagination to create something user friendly.
    - Also, make sure to host it to any open source hosting platforms like netlify and utilize proper git version controlling.

Technology:

AI, CAD, ML, Web Development(Tech stack of your choice)

Evaluation Criteria:

- Tool should analyze the image correctly, highlight areas of damage and provide good recommendations to fix it.
- UI should be responsive
- Presentations should include a live demo of the prototype, highlighting key features, AI/ML algorithms, and potential use cases.
- Innovation and creativity in addressing challenges.

Submission Format:

- The project should be available in github or similar VCS.
- The project should be hosted in any open-source hosting platforms.
- A google docs would be shared where the details of the team, a summary/PPT of the project, Link to git repository, Link to the deployment.
- Details about Tech Stack used and in the README.md file in the code

Datasets: Roboflow universe

- https://universe.roboflow.com/capstone-tqtck/aircraft-dents-uxial
- https://universe.roboflow.com/youssef-donia-fhktl/aircraft-damage-detection-2