Rey Aguirre
Gaby Gutierrez
Ryan Schwarzkopf
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Precision Skies: A Prepar3D Extension

Introduction

Flight simulation is a critical tool for aviation training, testing and mission preparation. Traditional flight training methods can be costly and risk-laden, whereas simulations offer a safer, more cost-effective alternative. Lockheed Martin's Prepar3D is a powerful flight simulator widely used in aviation, providing robust capabilities for flight training and analysis. Despite its strengths, there remains a need for enhanced tools to analyze and review flight data comprehensively. Our project, Precision Skies, addresses this gap by providing a sophisticated dashboard for visualizing and analyzing both real-time and recorded flight metrics.

Needs and Requirements

The project's target user group consists of engineers involved in aviation, flight simulation, and aerospace research. These users include professional engineers who design and test flight systems. Precision Skies supports tasks and activities such as real-time data monitoring during simulation sessions, historical data analysis for post-flight debriefings, and customizable metrics to focus on specific flight data relevant to their project. The tool also enables interactive data exploration, allowing users to zoom, pan, and examine flight metrics in detail. By catering to the needs of engineers, it aims to enhance the accuracy, efficiency, and depth of flight data analysis in both educational and professional settings.

Intellectual Merit and Broad Impact

Precision Skies introduces advanced data visualization capabilities specifically tailored to aviation engineering and research. By seamlessly integrating with Prepar3D, it provides a user-friendly interface for monitoring and analyzing crucial flight metrics, essential for rigorous

and effective training. This tool enhances the ability of trainees and instructors to focus on key performance indicators, making the training process more efficient and targeted. The intuitive design ensures that both new trainees and experienced pilots can benefit from its features, promoting a higher standard of training and preparedness.

Precision Skies offers several significant benefits at various levels. For trainees, it provides a safer and more efficient way to learn and refine flight techniques without the inherent risks of real-life training flights. Instructors benefit from detailed and actionable insights into pilot performance, facilitating more effective training outcomes. For the aviation industry and research, the tool enhances the overall training process, leading to better-prepared pilots and more successful mission outcomes. Additionally, for the field of aviation training, Precision Skies sets a new standard for flight data analysis in simulators. This innovation has the potential to influence future developments in training tools, contributing to broader advancements in aviation education and safety.

Final Product

Core Functionalities

The final design of Precision Skies includes the following core functionalities:

- Real-Time Data Visualization: Displaying live flight metrics such as altitude, airspeed, heading, pitch, bank, and magnetic heading using LiveCharts.
- Historical Data Analysis: Loading and analyzing recorded flight data to identify trends and areas for improvement.
- Customizable Metrics: Allowing users to select and focus on specific metrics relevant to their training needs.
- Interactive Charts: Enabling users to zoom, pan, and explore data in detail through intuitive graphical interfaces.

System Design

Functional Design

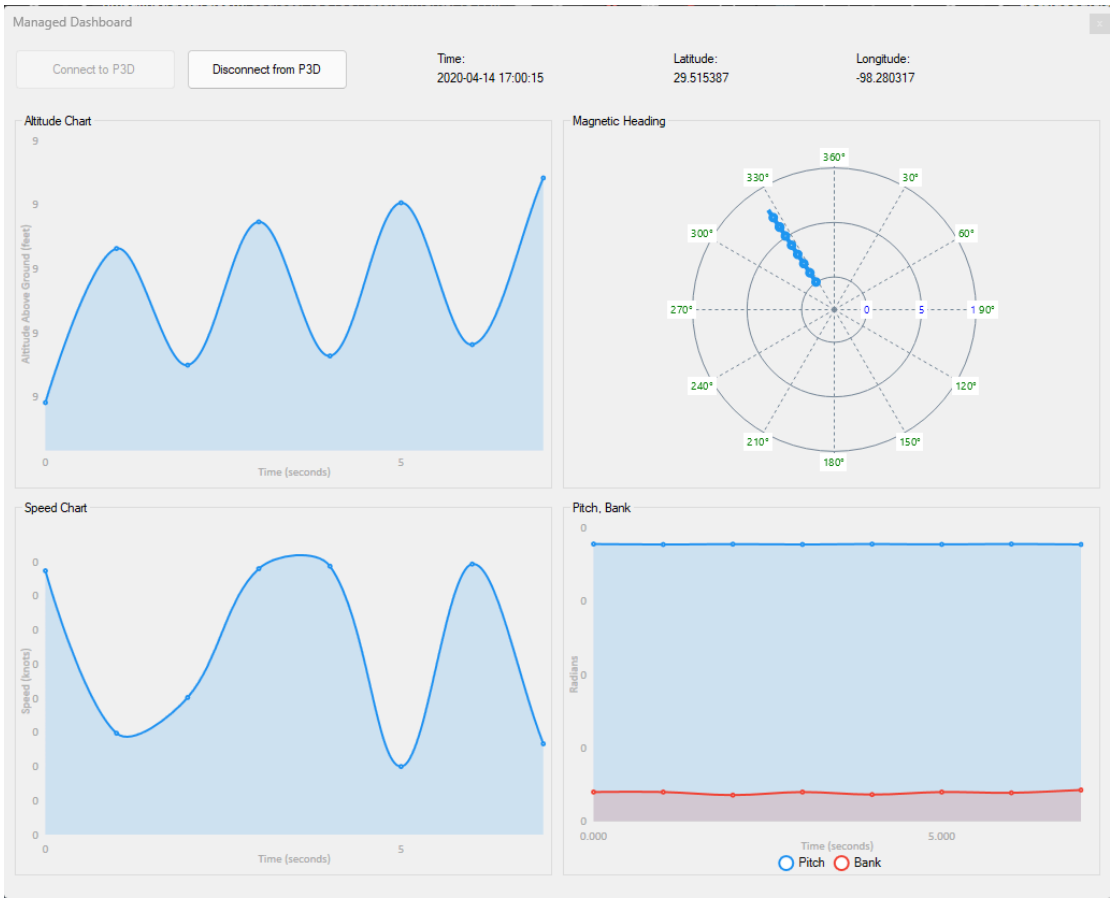
Precision Skies comprises a main dashboard application that connects to Prepar3D via the SimConnect API. It fetches real-time and recorded flight data, processes it, and displays it using dynamic charts.

System Architecture

The system is built using C# and .NET Framework, integrating with the SimConnect API for data retrieval and LiveCharts for visualization. The architecture ensures seamless communication between the simulator and the dashboard, allowing for real-time updates and historical data analysis.

Visual / UX Design

The dashboard features a clean and intuitive user interface, with distinct sections for different metrics. Users can easily navigate between real-time data and historical data views, customize the displayed metrics, and interact with the charts for detailed analysis.



Testing Implementation

Our testing strategy involved both unit tests for individual components and integration tests to ensure smooth communication between the dashboard and Prepar3D.

Design and Development Process

Our design process followed Agile methodologies, with development divided into two-week sprints. Each sprint focused on adding and refining specific features, guided by user feedback and testing results. This iterative approach allowed us to remain flexible and responsive to the needs of our users, ensuring that each feature was polished and functional before moving on to the next.

Technical constraints, such as the integration with SimConnect and ensuring real-time data updates, required careful architectural planning to maintain performance and reliability. Usability was a key consideration throughout the project, with a strong emphasis on creating a clean and intuitive user interface that would be accessible to both new trainees and experienced instructors.

Throughout the project, we learned valuable lessons about software engineering, teamwork, and user-centered design. Iterative testing and user feedback proved essential in shaping a user-friendly product, highlighting the importance of staying in close communication with end-users. From an engineering perspective, we gained experience in efficiently handling real-time data processing and visualization, which are critical for delivering a responsive and informative tool. Effective communication and collaboration were facilitated by tools like Slack and GitHub, underscoring the importance of teamwork in successfully completing complex projects. These lessons will inform our future work, both individually and as a team, enhancing our ability to tackle similar challenges in the future.

Future Work

While the product can be deployed as is, some future improvements could significantly enhance its usability and functionality. One potential improvement is allowing users to set custom data for graphs and add any number of graphs they need. This flexibility would enable engineers to tailor the dashboard to their specific needs, making the tool more versatile and user-friendly. Additionally, users could save their current environment to a toolbox, allowing them to easily load their custom dashboards when the program boots. Implementing a UI rebuild would be necessary to accommodate this dynamic design.

Another enhancement would be the addition of two new buttons: one to pause Prepar3D from the dashboard and another to pause retrieving data from Prepar3D without deleting the current values in the graphs. These features would give users greater control over their simulation and data analysis processes. Furthermore, a function to ensure that when values are inspected, scrolled, or zoomed-in on one graph, all other graphs display the same data values would improve the coherence and synchronization of data analysis.

Exploring the Prepar3D SDK for solutions to implement a feature that switches the loaded simulation recording to a specific timestamp when selected in a graph would also be beneficial.

This functionality would allow users to seamlessly correlate data points with specific moments in the simulation, providing a more intuitive and integrated analysis experience.

By addressing these future improvements, Precision Skies can continue to evolve and better serve the needs of aviation engineers and researchers. These enhancements will make the tool more flexible, user-friendly, and powerful, ultimately contributing to more effective and efficient flight data analysis and training processes.