Innovation in Teaching Learning Process

GUI Development for Aircraft Stability and Control

Name of the Innovation	:	**GUI Development for Aircraft Stability and Control**
Course Code and Name	:	**2AEPC302 - Aircraft Stability and Control**
Class and Semester	:	**Third Year - V Semester**
Academic Year and Term	:	**AY 2024 - 2025, Term - I**
Faculty Name and Designation	:	**Dr. K. M. Kiran Babu, Associate Professor**

Introduction:

Aircraft stability and control is a fundamental subject in aerospace engineering. Traditional teaching methods often rely heavily on theoretical equations, calculations, and analyses. While these methods are essential for foundational understanding, they can be challenging for students to visualize and apply in real-world scenarios. This can lead to difficulties in grasping complex concepts and developing a deeper understanding of aircraft dynamics. The development of a user-friendly Graphical User Interface (GUI) can significantly enhance the learning experience in Aircraft Stability and Control. Allow students to experiment with different aircraft configurations (e.g., wing geometry, center of gravity). A well-designed Graphical User Interface (GUI) for aircraft stability calculations makes students understand and appreciate the significance of course contents.

https://youtu.be/Yabbv2hdlcY

Motivation/Purpose of Innovative Technique:

The primary motivation for developing a GUI for Aircraft Stability and Control is to **transform the learning experience** from a predominantly theoretical and abstract one to a more **interactive, engaging, and intuitive** process.

Visualize Complex Concepts: The GUI will enable students to visualize abstract concepts like aerodynamic forces, moments, and aircraft motion in a dynamic and interactive manner. This will make learning more intuitive and easier to grasp.

Improve Comprehension: By providing a visual and interactive platform, the GUI will help students connect theoretical concepts to real-world flight phenomena more effectively.

Reinforce Learning: Interactive simulations and visualizations will reinforce key concepts and improve student retention of knowledge.

By addressing the limitations of traditional teaching methods, the GUI aims to create a more effective and rewarding learning experience for students of Aircraft Stability and Control. It will empower students to

Innovation in Teaching Learning Process

become more independent learners, develop a deeper understanding of aircraft dynamics, and better prepare them for future careers in aerospace engineering.

Procedure Followed:

Two Activity Based Assessment (ABA) Techniques were provided to students as a part of their In-Semester Evaluation(ISE) for a weightage of 20% of the overall assessment. The following are the details of the assessment.

Activity Based Assessment No 1

Class : T.Y. B. Tech, Semester - V

Course Code : 2AEPC302 **Course Title** : Aircraft Stability and Control

Development of a Graphical User Interface (GUI) for Aircraft CG Calculation

Graded Assignment : 20 Marks (50 % Weightage in ABA)
Deadline for Submission: 26th August 2024, (11:59 PM)

Objective:

Develop a user-friendly graphical user interface (GUI) application using Python or MATLAB to accurately calculate and visualize the center of gravity (CG) of an aircraft based on input parameters such as component weights, arm lengths, and fuel distribution.

Rationale: By successfully completing this assignment, students will gain practical experience in GUI development, numerical calculations, and aircraft engineering principles.

Requirements:

- **GUI Design:** Create an intuitive interface with clear input fields for component data, output displays for calculated CG, and visual representations of the aircraft and its CG.
- **CG Calculation:** Implement the necessary algorithms to accurately calculate the aircraft's CG based on standard engineering principles.
- **Output Display:** Present calculated CG values clearly and concisely, along with visual indicators of CG location relative to aircraft limits.
- **Error Handling:** Incorporate error checking and handling for invalid input data.

Note : Students may choose to incorporate advanced features such as CG envelope plotting, fuel management simulations

Deliverables:

- A fully functional GUI application.
- A report documenting the design process, implementation details, and testing results.

Evaluation Criteria: The assignment will be evaluated based on the following criteria:

- Accuracy of CG calculations.
- User interface design and usability.
- Code efficiency and readability.
- Adherence to programming standards and best practices.

Innovation in Teaching Learning Process

Activity Based Assessment No 2

Class : T.Y. B. Tech, Semester - V

Course Code : 2AEPC302 **Course Title** : Aircraft Stability and Control

Development of a Graphical User Interface (GUI) for Aircraft Stability Calculation

Graded Assignment : 20 Marks (50 % Weightage in ABA)
Deadline for Submission: 25th November 2024, (11:59 PM)

Objective:

Create a graphical user interface (GUI) to perform aircraft stability calculations.

Rationale: A well-designed Graphical User Interface (GUI) for aircraft stability calculations make students understand and appreciate the significance of course contents.

Requirements:

- **Clarity:** Ensure the GUI is user-friendly and intuitive.
- **Accuracy:** The calculations must be precise
- **Efficiency:** The GUI should be responsive and provide results quickly.
- **Flexibility:** Allow for various aircraft configurations and flight conditions.
- **Visualizations:** Consider incorporating graphs or charts to represent the results effectively.

Potential Features

1. **Input Parameters:**
   - Aircraft geometry (wing area, aspect ratio, sweep angle)
   - Flight conditions (altitude, airspeed, angle of attack)
   - Atmospheric data (density, temperature)
   - Control surface deflections (ailerons, elevator, rudder)
2. **Stability Calculations:**
   - Static stability (longitudinal, lateral-directional)
   - Dynamic stability (eigenvalues, damping ratios)
3. **Output Display:**
   - Numerical results (stability margins, time constants)
   - Graphical representations (root locus plots, Bode plots)
   - Visualizations of aircraft motion (pitch, roll, yaw)

Deliverables:

- A fully functional GUI application.
- A report documenting the design process, implementation details, and testing results.

Programming Tools and Libraries

- **Python:** with libraries like NumPy, SciPy, Matplotlib, and Tkinter or PyQt
- **MATLAB**: with its built-in GUI development tools and mathematical functions

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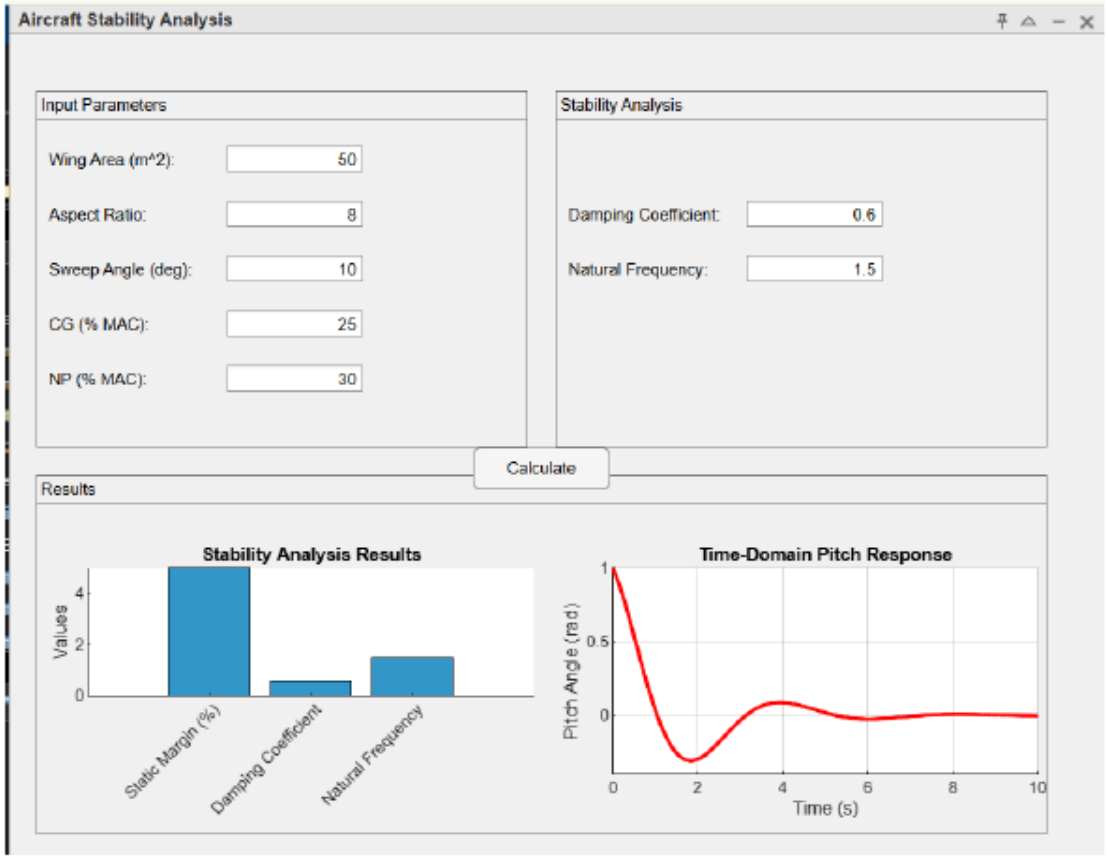
Innovation in Teaching Learning Process

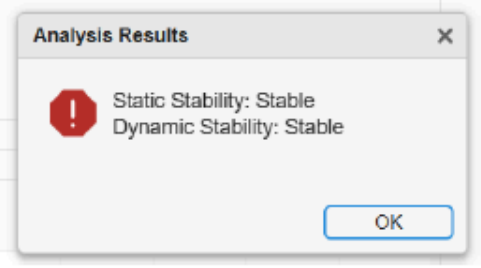
Evaluation Criteria:

The assignment will be evaluated based on the following criteria

- **Correctness:** The GUI accurately calculates stability parameters (static and dynamic) for various aircraft configurations and flight conditions.
- **User-friendliness:** The GUI has a clear and intuitive interface, making it easy for users to navigate and input data.
- **Visualizations:** The GUI effectively presents results through clear and informative visualizations (e.g., graphs, charts).
- **Error handling:** The GUI provides appropriate error messages and guidance when invalid inputs are entered.
- **Documentation:** The documentation is well-written, easy to understand, and provides clear instructions for using the GUI.

Outcome:





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Innovation in Teaching Learning Process

A Sample GUI Developed by Student as a part of Assessment

The students initially faced a challenge in understanding the expectations of the assessment on how to develop the GUIs, however after the detailed discussion during the tutorial hours the students were able to appreciate and understand the significance of the assessment process and technique used. The students were allowed and encouraged to use AI Tools for GUI Development as the mathematical modeling behind the GUI Development was the prime focus of the assessment, the assessment was carried for every student in person and the feedback was provided to revise their GUI. More than 75 % of the students were meeting the minimum requirements of the assessment. Few students exceeded the expectations, and the GUIs developed by them could be further improved for the next run of the course.

One critical feedback from the students was to allow them to work as a team for such activities, which can be accepted as such activities need discussions among them. The key lessons learnt from this activity/technique GUI Development for such complex topics can help students to appreciate the concepts better.

References:

1. Alneyadi, M., Alaryani, S., Asifewe, R., Hemdoui, I., Aasim, A., Okasha, M., ... & AlGhaithi, M. (2023). Interactive Graphical User Interface for Performance and Flight Dynamics Analysis of Battery-Powered Unmanned Aerial Vehicles. In *AIAA AVIATION 2023 Forum* (p. 4394).
2. Lietzau, Z. (2017, November 1). Building Graphical Aircraft Design Tools [Video file]. Retrieved from https://www.mathworks.com/videos/building-graphical-aircraft-design-tools-1558000003001.html
3. Andreatos, A. S., & Zagorianos, A. (2009, July). Matlab GUI application for teaching control systems. In *Proceedings of the 6th WSEAS International Conference on ENGINEERING EDUCATION* (Vol. 208, pp. 208-211).

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