Digital Twin of Tello Drone using Matlab/Simulink

Group-1 :

Vikas Chelluru(S20200020252)
Viswa Teja Kalthuri(S20200020271)
Shaik Vazeer Ahamed(S20200020301)

INDIAN INSTITUTE OF INFORMATION TECHNOLOGY SRICITY

1. ABSTRACT

This project presents the development and integration of a comprehensive digital twin for a Tello drone using MATLAB and Simulink. The digital twin encompasses both control and perception aspects, enabling a seamless interaction between the physical drone and its virtual counterpart. The control commands are transmitted from Node-RED to an OPC UA server, which is accessed by MATLAB for real-time communication with the drone.

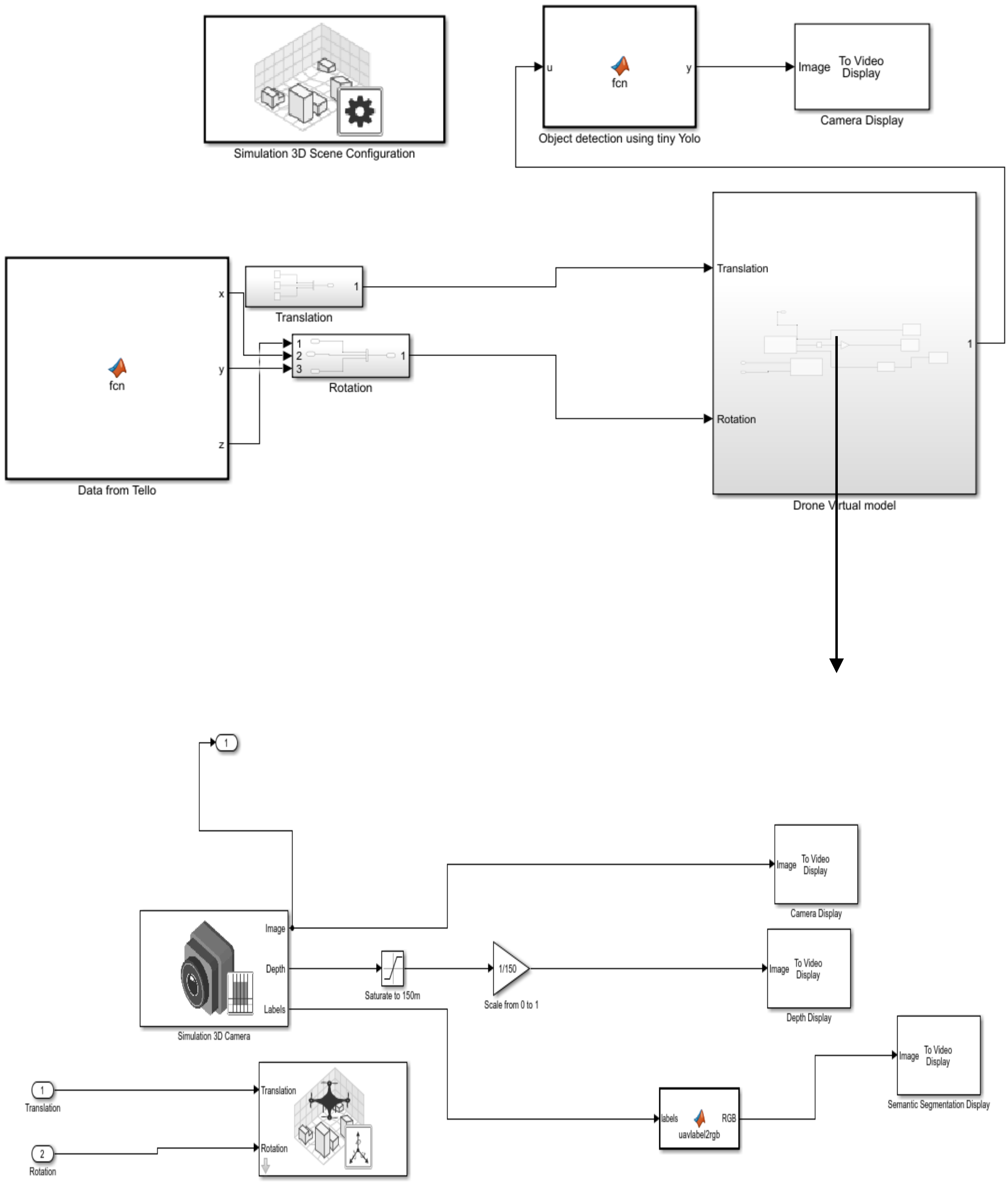
For perception, a Tiny YOLO model is implemented to process video data from the Tello drone's front camera. The model identifies and tracks green-colored objects, allowing the drone to autonomously follow the detected object. This capability enhances the drone's responsiveness to its surroundings, demonstrating an application of computer vision in drone navigation.

Furthermore, the project incorporates a diagnostic feature analysis using the Orientation data (x, y, z) collected from the Tello drone. The Diagnostic Feature Designer app in MATLAB is employed to detect anomalous behavior in the drone's movement, providing a valuable tool for preemptive maintenance and fault detection.

To enhance the visualization of the digital twin, the complete movement of the physical Tello drone is mirrored in a 3D simulation environment within MATLAB. This integration not only facilitates a holistic understanding of the drone's behavior but also allows for simulation-based testing and analysis.

In summary, our project demonstrates the successful creation of a digital twin that combines control, perception, diagnostics, and visualization aspects. The seamless integration of various technologies showcases the versatility and applicability of MATLAB and Simulink in developing sophisticated and interactive digital twins for unmanned aerial vehicles. The project contributes to advancements in drone technology by providing a comprehensive framework for real-time control, perception, and analysis, paving the way for future innovations in the field of autonomous systems.

2. BLOCK DIAGRAM



3. IMPLEMENTATION OVERVIEW

The project implementation began with the setup of the hardware components, employing a Tello drone as the physical entity to be mirrored in the digital twin. The communication infrastructure was established, connecting Node-RED to an OPC UA server, acting as a conduit for control commands transmitted to MATLAB.

In the realm of control and communication, MATLAB and Simulink were pivotal in crafting the logic that interpreted the commands received from the OPC UA server. The bidirectional communication channel formed the backbone of real-time interactions between the digital twin and the physical drone, ensuring seamless responsiveness.

The integration of computer vision technologies was a crucial aspect, where a specialized Tiny YOLO model was developed. This model processed video data from the Tello drone's front camera, focusing on the identification and tracking of green-colored objects. This capability empowered the drone to autonomously follow the detected object, showcasing the practical application of computer vision in drone navigation.

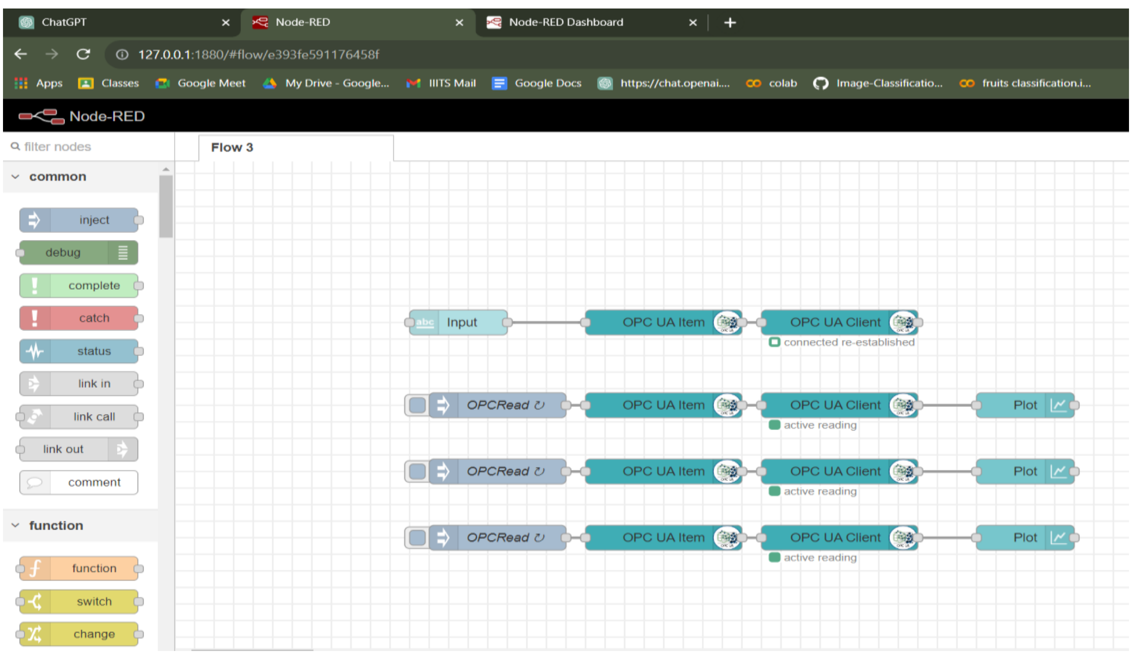
For diagnostic analysis, orientation data in the form of x, y, z coordinates was collected from the Tello drone. The Diagnostic Feature Designer app in MATLAB became instrumental in scrutinizing this data, enabling the identification of anomalous behavior in the drone's movement. This feature contributes significantly to preemptive maintenance and fault detection.

To enhance the visualization and comprehension of the digital twin, the complete movement of the physical Tello drone was replicated in a 3D simulation environment within MATLAB. This integration not only provided a visual representation of the drone's behavior but also facilitated simulation-based testing and analysis, contributing to a more holistic understanding.

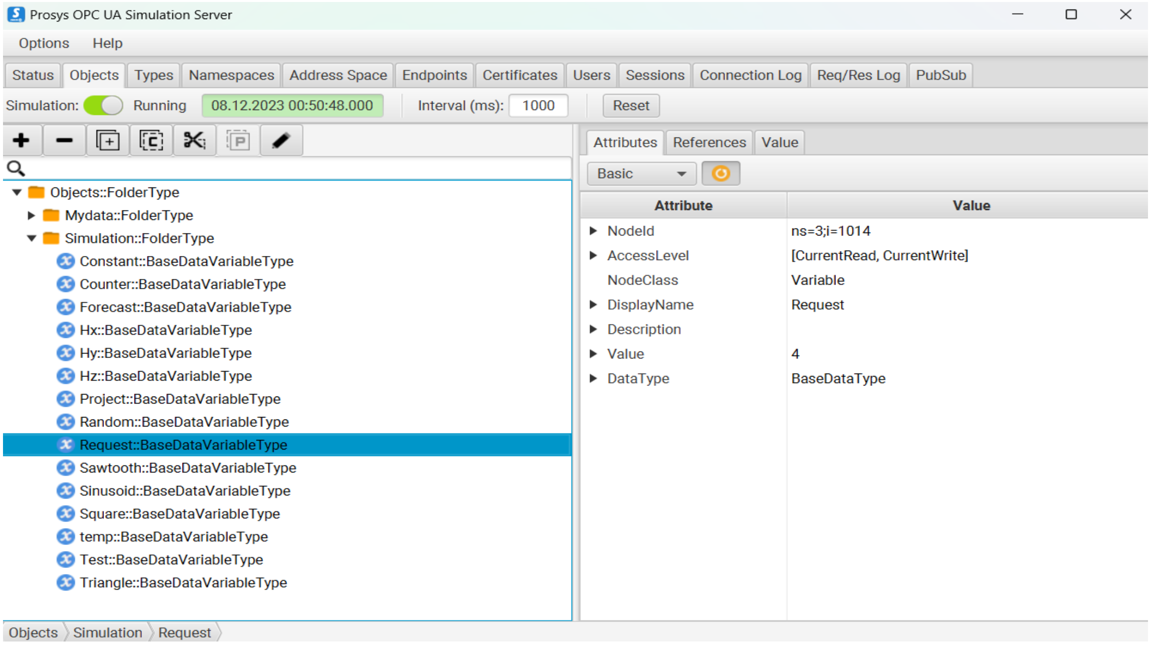
Looking forward, the implementation process identified potential areas for future enhancements, such as the incorporation of additional sensors or the expansion of object detection capabilities. The digital twin, established through this project, stands as a platform for further research and development in autonomous systems and drone technology, opening avenues for future innovations.

4. HARDWARE AND SOFTWARE MODULES

Tello Drone

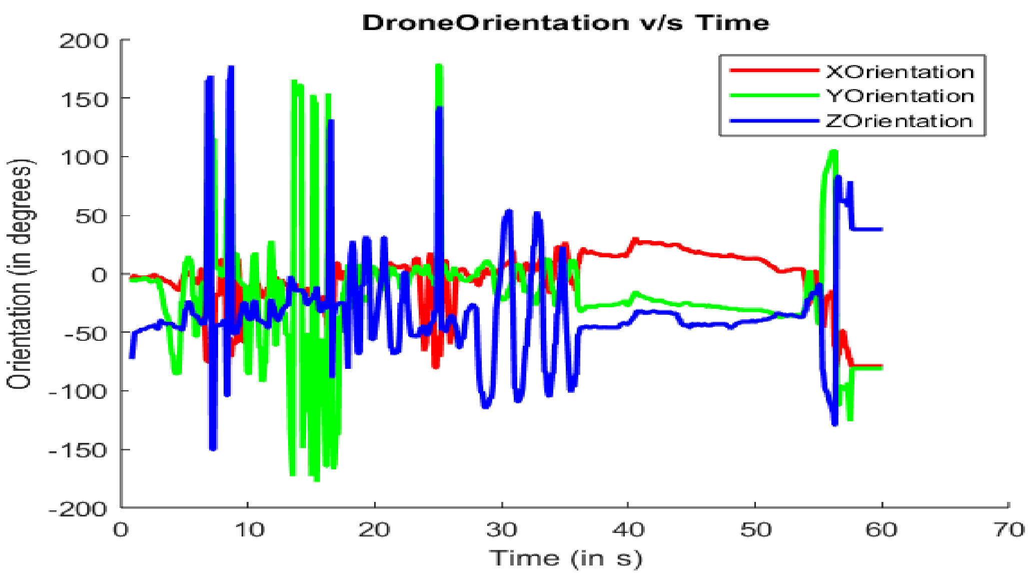


Node-Red

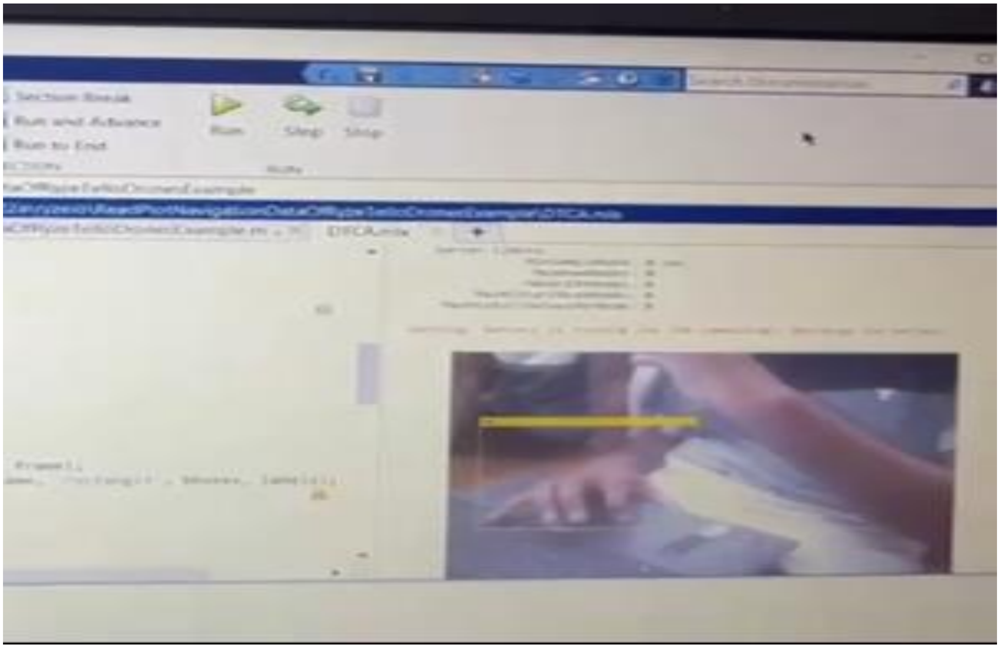


OPC-UA Server

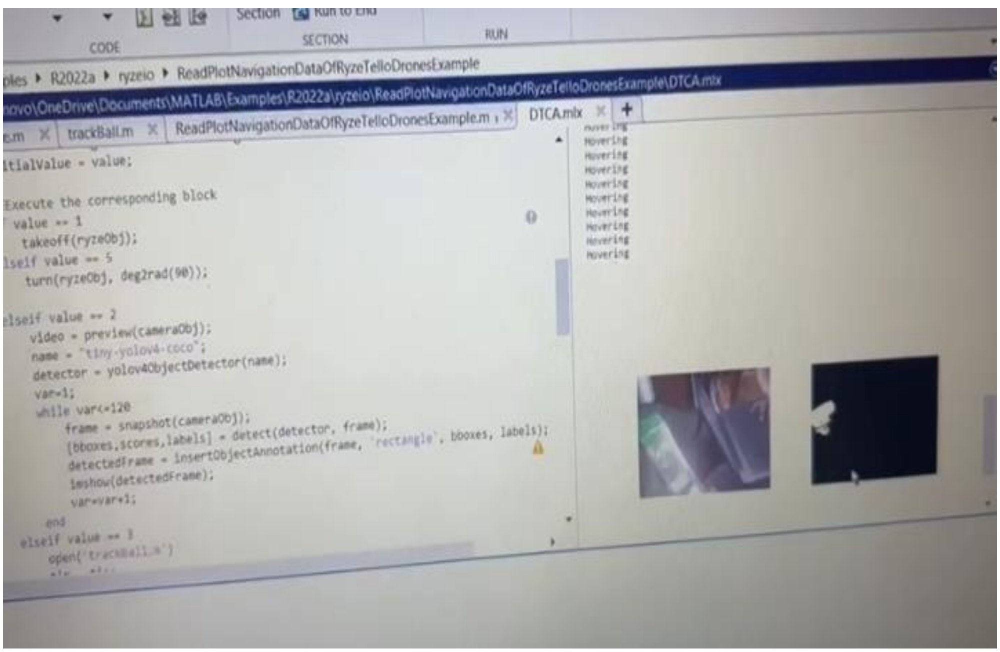
5. RESULTS AND OBSERVATION



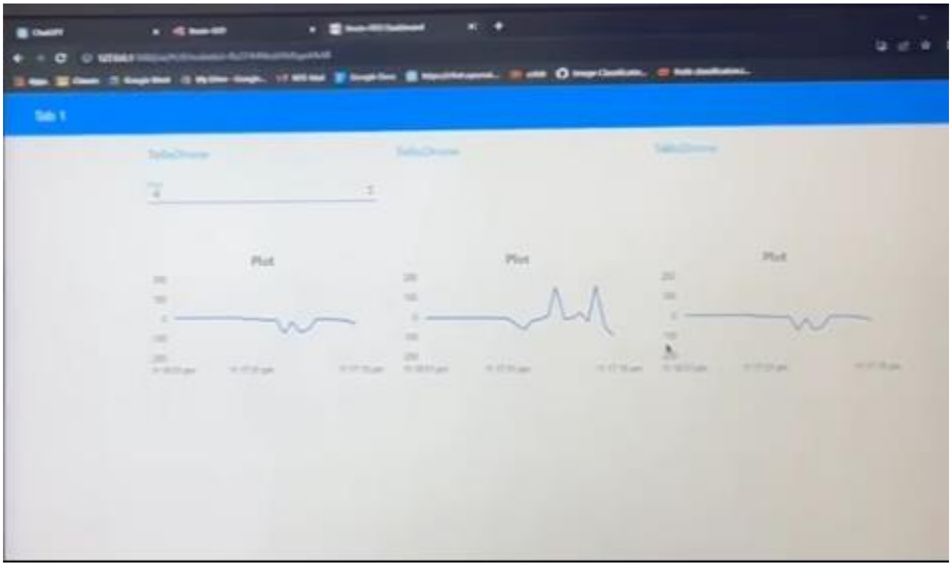
Orientation of Tello Drone



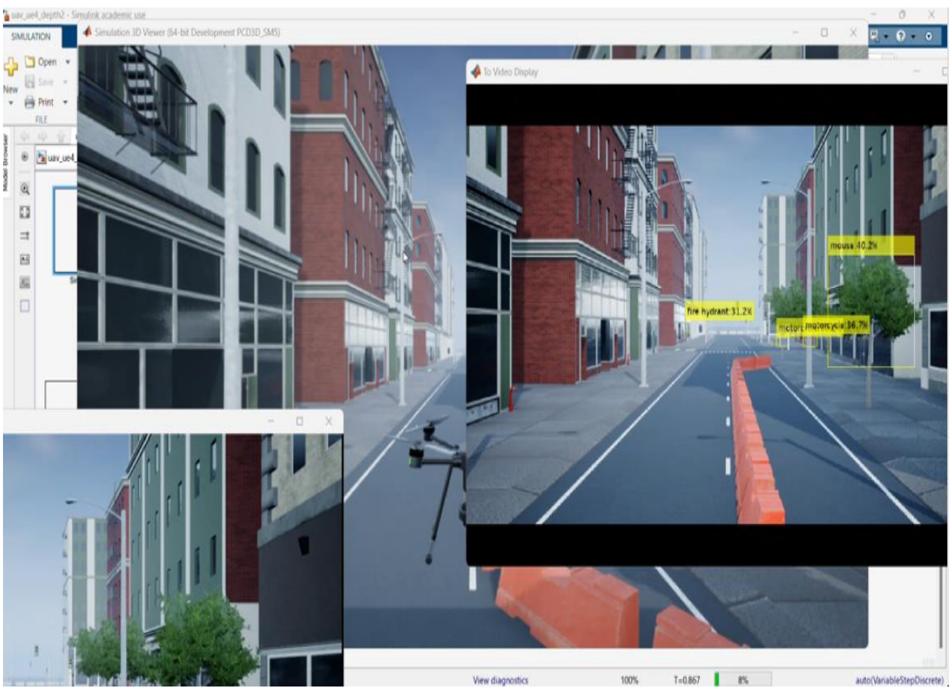
Object detection using Tiny YoloV3



Green colour tracking



Orientation data display



Simulation Result

6. Challenges in Connectivity

Connecting the Tello drone to MATLAB posed significant challenges, primarily centered around internet connectivity requirements. Unlike Node-RED, which relies on internet connectivity, the Tello drone network does not provide internet access. This limitation presented a major hurdle, requiring the exploration of alternative solutions to establish a seamless connection between MATLAB and the Tello drone. Addressing this issue became a critical aspect of the project.

7. Simulink Integration Difficulties

Integrating the Tello drone with Simulink introduced its own set of challenges, notably in the absence of supportive packages. While MATLAB provides supportive software for Tello connectivity, Simulink lacks dedicated packages, making the process of connecting the drone to the simulation environment more intricate. This disparity in available resources demanded a creative and resourceful approach to bridge the gap between Simulink and Tello, highlighting the need for custom solutions and adaptability in the integration process.

8. Limited Resources for Tello Connectivity

Working with the Tello drone in a MATLAB environment revealed a scarcity of readily available resources for connectivity. Unlike more mainstream devices, the Tello lacks a robust ecosystem of supportive tools and documentation. This scarcity of resources impeded the seamless integration of the drone into the MATLAB framework, requiring the project team to navigate through challenges and develop custom solutions.

9. Conclusion

In conclusion, the project encountered formidable challenges related to internet connectivity requirements, integration with Simulink, and the limited availability of resources for Tello connectivity in the MATLAB ecosystem. Despite these challenges, the project team demonstrated resilience and adaptability in devising innovative solutions. The successful navigation through these hurdles not only showcases the team's problem-solving skills but also emphasizes the importance of flexibility in addressing unforeseen challenges during the implementation of complex projects. Moving forward, these experiences contribute to the collective knowledge base for connecting unconventional devices like the Tello drone to MATLAB and Simulink, paving the way for more streamlined processes in future endeavors.