The Floating Satellite System as an Educational Platform for Space Applications

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Abstract

- In this paper, an approach is presented for building a small laboratory based Floating–Satellite(Float–Sat).
- This Float–Sat will serve as a test–bench for the students to learn basic satellite subsystems.
- This can also be used for the development and verification of different control algorithms and strategies for various kinds of space missions.

Mechanical Structure and Description of Float–Sat

- The Float–Sat is a hemisphere, whose open-side is directed upwards
- It consists mainly of a mechanical structure that contains the basic satellite subsystems with one reaction wheel mounted at the centre of the horizontal plane of the structure.
- This reaction wheel is used to control the orientation of the satellite in one dimension.
- Two deployable solar panels attached by flexible joints on the sides of the upper part of the structure are used to demonstrate the deployment mechanism and to verify the robustness of the attitude controller during the deployment.
- In addition, two movable masses have been deployed in the horizontal plane to adjust the Centre of Mass (CoM) of the structure. A battery–pack using four lithium iron phosphate battery is placed on the lower part of the structure with charging ports mounted on the outer part of the middle layer of the structure for easy charging access.

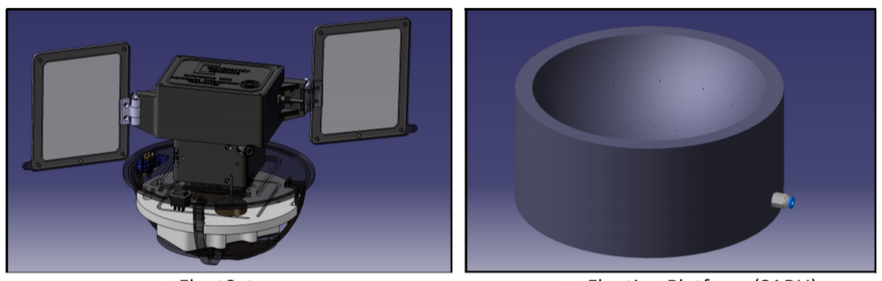

Figure 1: The Floating Satellite (Float–Sat) structure

- This structure is placed into an Acrylic glass hemisphere shell of a 20cm diameter that it is floating inside a Spherical Air Bearing Unit (SABU).
- The air bearing unit requires pressurized air input with a flow rate that may vary depending on the mass of the floating unit.

FloatSat Systems

- The Avionics included in the FloatSat are consists mainly on a STM32F4–Discovery development board attached to an extension board.
- The extension board was developed in such a way that it contains all the necessary electronic components needed to steer the satellite.
- A Bluetooth and Wifi modules are available for communicating with the satellite.

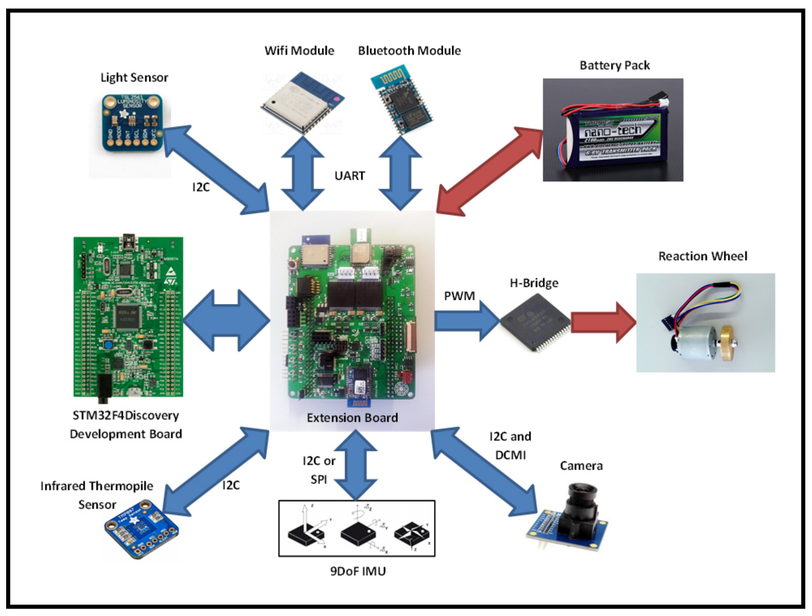

Figure 2: The Floating Satellite (FloatSat) system

Operation of the Float-Sat

There are 5 modes of operation of the Float–Sat: **1. Deployment**, **2. Motor–Speed Controller**, **3. Velocity Controller**, **4. Position Controller**, **5. Mission Mode**.
Two most of important modes are depicted below:

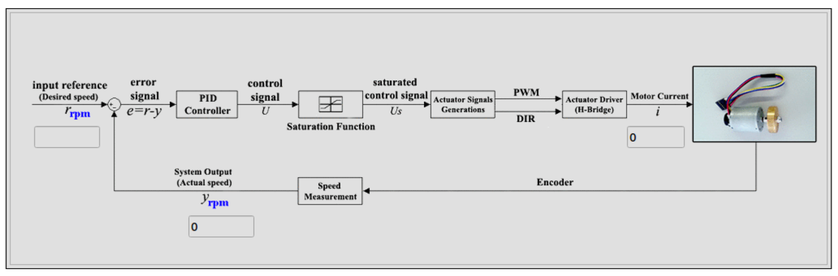

Figure 3: Motor Speed Controller

The motor–speed controller is designed as depicted in figure 3. In the velocity mode a cascade controller is used where the first controller is the velocity controller which calculates the motor speed in rotation per minute (rpm) to rotate the Float–Sat with the desired velocity. This means that the output of the first controller is the required motor speed (RPM) to attain the desired velocity of the Float–Sat, this velocity controller of the Float–Sat is shown in figure 4.

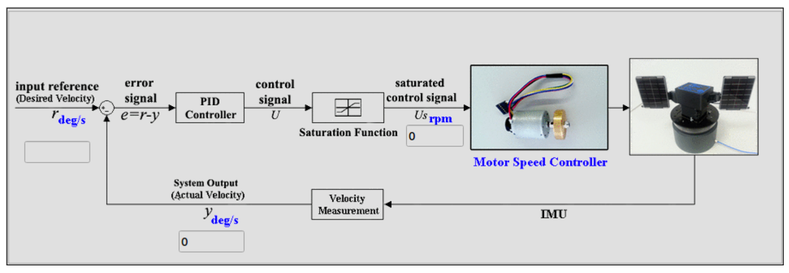

Figure 4: Velocity Controller

Software Architecture of Float-Sat

All of the functions of the Float–Sat are supervised under a specially developed Real–Time Object Oriented Dependable Operating System (RODOS).RODOS is jointly developed by the Central Core Avionics department of German Aerospace Center and Chair of Aerospace Information Technology University of Wuerzburg Germany. It is specifically developed for aerospace applications as it has minimal footprint and it is also very well suited for the applications which demand high dependability. It is used in 10 satellites which are already in the orbit

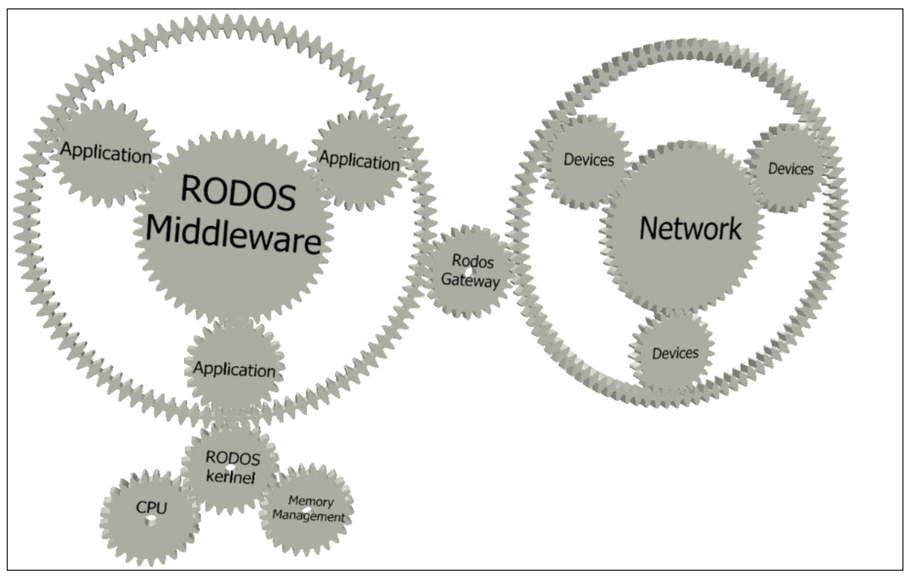

Figure 5: Structure of RODOS

Ground Station

Information exchange between the Float–Sat and the Ground–Station takes place via Middleware mechanism of the RODOS using the WIFI protocol. RODOS on the Float–Sat transmits the telemetry with its message interface using the UDP socket over the WIFI network. Ground–station is implemented in Linux using the QT Library.

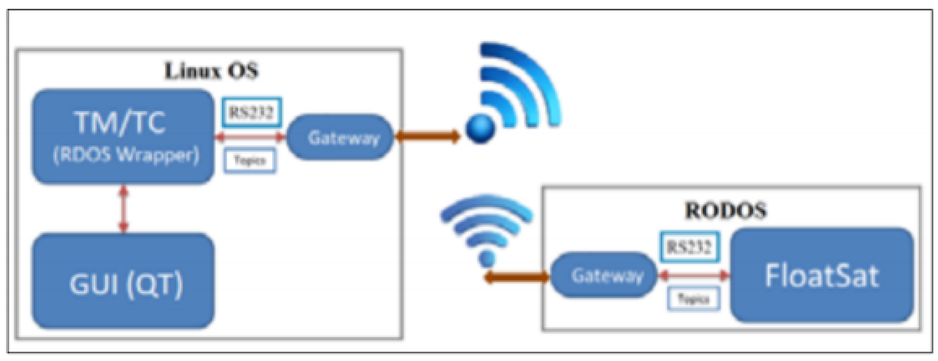

Figure 6: Communication between Float–Sat and Ground Station.

Missions of the Float–Sat

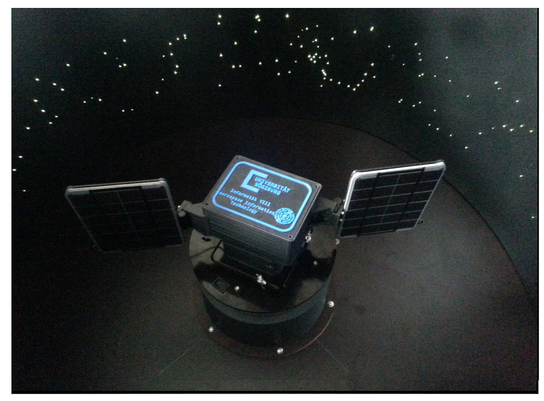

Figure 7: Star Tracking using FloatSat

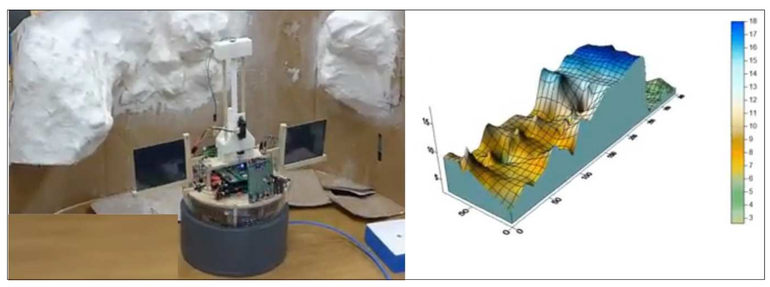

Figure 8: Three dimensional scanning of an Analogues surface of a Planet

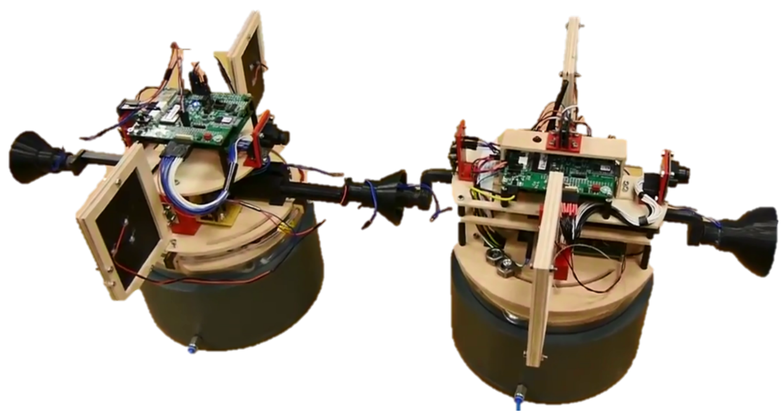

Figure 9: Display of Docking between two Float–Sats

Conclusion & Future Work

- Float-Sat was tested on an air–bearing platform which resulted in in a very smooth and stable floating with the adjustment of the weights.
- The Float–Sat's platform is being actively used to train bachelor and master's students to write different control Algorithms for a spacecraft and perform diverse missions.
- The current Float-Sat is a 1-dimensional satellite simulator, The next step of the research is the development of a three dimensional space vehicle simulator.