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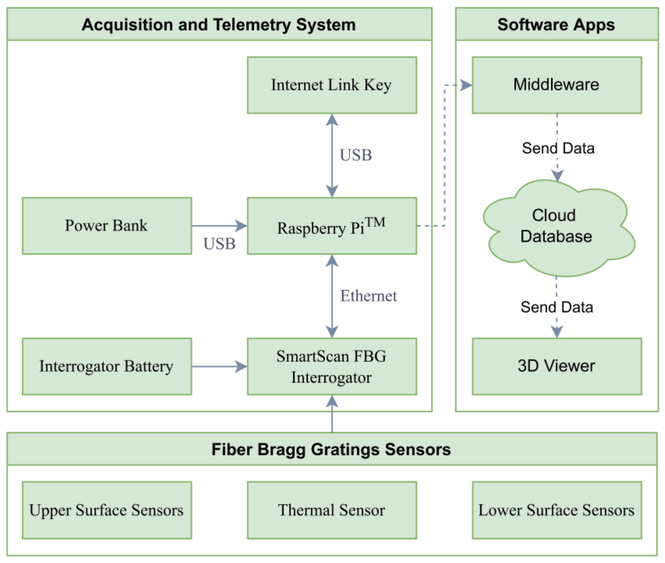
Near Real-Time Visualization of Fiber Bragg Grating Sensor Values Through Desktop Applications and Augmented Reality

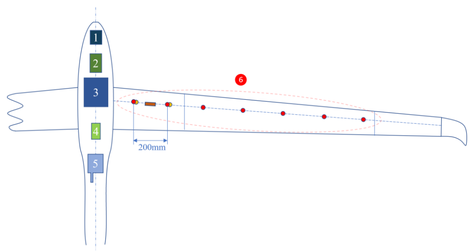
INTRODUCTION

Fiber Bragg Gratings (FBG) sensors are an innovative technology for aerospace. One of their most challenging feature is their cross-sensitivity to different physical parameters. In this work a FBG sensors network is placed on a flying test bench called Anubi. A system of data acquisition and communication is developed in order to perform on ground data visualization in near real time and in augmented reality.

Optical fiber → **Optical sensors** → **Sensitivity to strategic parameters** → ***OBJECTIVE: Optical sensors integration in aerospace systems***

Advantages of optical sensors for aerospace applications
Low cost, low weight and low size of the cable
Immunity to electromagnetic disturbances
Possibility of having numerous embedded sensors in the same communication line
High sensitivity
Lack of sparks, chemical inertia and electrical passivity

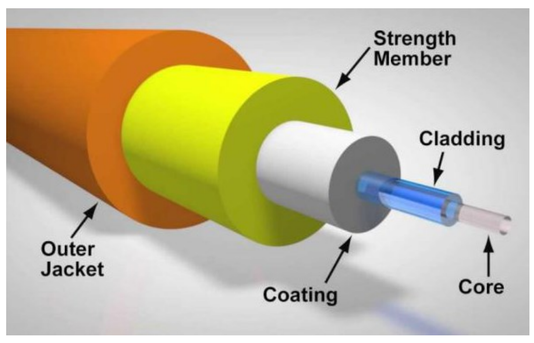




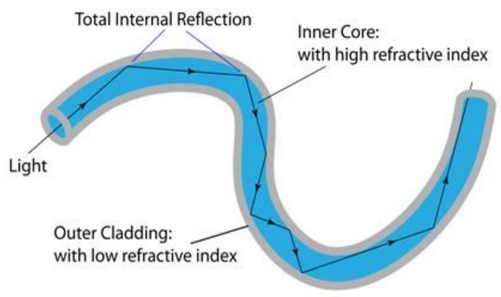
1. Flight Electronics
2. Interrogator battery
3. Interrogator
4. USB power bank
5. Raspberry Pi
6. FBG sensors

OPTICAL FIBER AND FBG

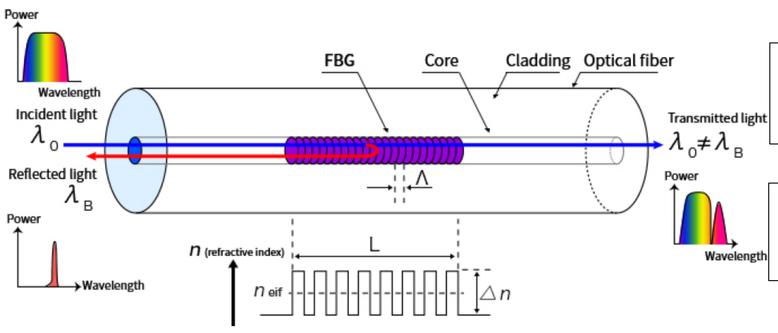
The **optical fiber** is a mixed glass and polymeric material composed by several concentric layers. Its main feature is the ability of conducting a light signal inside itself, thanks to a mechanism of multiple reflections, according to the Law of Snell.



Law of Snell $n_1 sen\vartheta_1 = n_2 sen\vartheta_2$



The **Fiber Bragg Grating** sensor is a trait of FBG in which a *periodical remodulation* is imposed to the core's refractive index. This structures reflects a specific frequency of the light, which depends on the grating pitch. Thus, a variation of the reflected wavelength is always related with an induced mechanical strain generated by an external parameter.



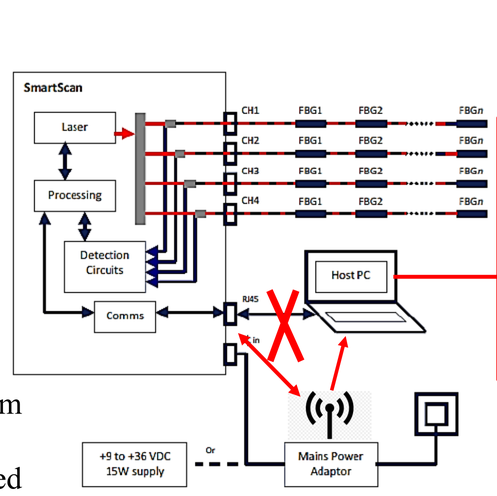
Bragg frequency:
$$\lambda_B = 2n_{eff}\Lambda$$

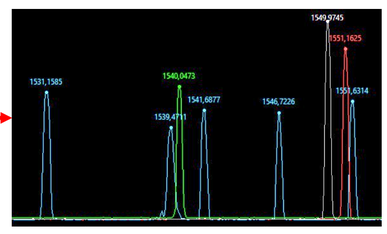
General FBG response
$$\Delta\lambda_B/\lambda_B = K_\varepsilon \Delta\varepsilon + K_T \Delta T$$

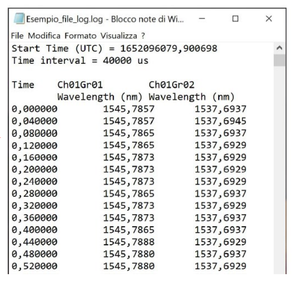
OPTICAL DATA ACQUISITION SYSTEM

Smart Scan Interrogator

- Sending laser beam to the sensors.
- Detecting reflected wavelength.
- Communicating data to host PC.



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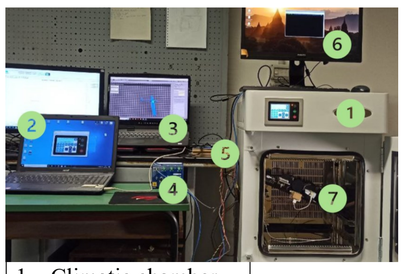
File Modifica Formato Visualizza ?
Start Time (UTC) = 1652096079,900698
Time interval = 40000 us

Time	Ch01Gr01 Wavelength (nm)	Ch01Gr02 Wavelength (nm)
0,000000	1545,7857	1537,6937
0,040000	1545,7857	1537,6945
0,080000	1545,7865	1537,6937
0,120000	1545,7865	1537,6929
0,160000	1545,7873	1537,6929
0,200000	1545,7873	1537,6929
0,240000	1545,7873	1537,6929
0,280000	1545,7865	1537,6937
0,320000	1545,7873	1537,6929
0,360000	1545,7873	1537,6937
0,400000	1545,7865	1537,6937
0,440000	1545,7888	1537,6929
0,480000	1545,7880	1537,6937
0,520000	1545,7880	1537,6929

EXPERIMENTAL SETUP



1. Climatic chamber
2. Monitor for (1)
3. Viewer
4. Interrogator
5. Raspberry Pi
6. Monitor for (5)
7. Sample

1. Interrogator
2. Raspberry Pi
3. Internet Key
4. Action cam

TEST CAMPAIGN

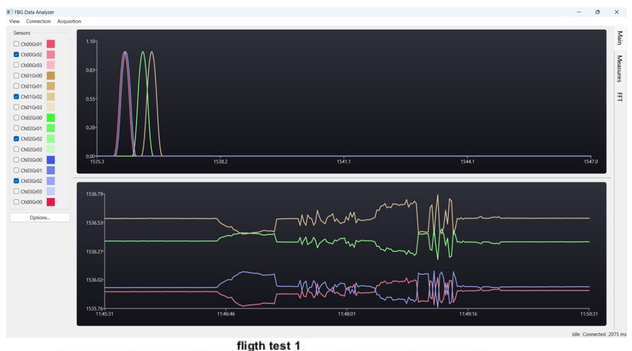
The test campaign is based on five different steps, covering the activities from laboratory tests, sensors calibration and software definition to the flight phase and data visualization in augmented reality.

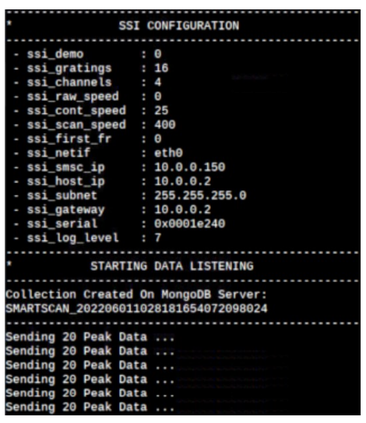
1. **Software development.** Data acquisition and storage, graphical interface.
2. **Laboratory tests.** Physical sensors calibration and software features verification.
3. **Flying test bench integration.** Assembly in the model aircraft.
4. **Flight test bench.** Test with model in flight.
5. **Data analysis.** Physical interpretation of FBG data.

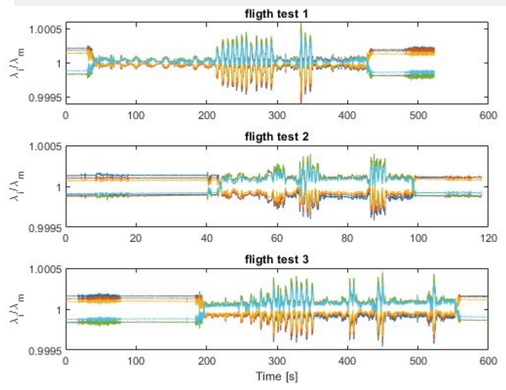
RESULTS

Results can be divided into 3 main aspects:

1. Data acquisition and storage.
2. Graphical software validation.
3. Data visualization.
4. Physical post processing of FBG data.







CONCLUSIONS

This work discussed the implementation of an open-source system capable of transmitting, storing, and displaying model aircraft data in near real-time. The core of the system is a Raspberry Pi™ 3 Model B+, which reads data from an onboard FBG interrogator and transmits them to a MongoDB® database. A 3D Viewer program is used to create user-friendly visualization of the data. This system can also be used to monitor multiple model aircraft at the same time and it can support human operator by showing near real time data in augmented reality.

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