zant

October 4-5

TINY_HACK

Turin

The first Embedded AI Vision hackathon

Focus AI

Low Power Space Debris Monitoring

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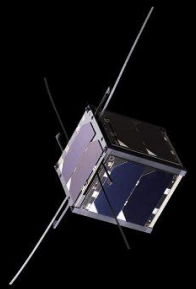
with the support of:

ARDUINO TOOLBOX Datapizza

1. Project Overview

The main objective is to tackle the issue of space debris by developing a multi-class classification model to increase debris awareness, space pollution mapping and eventually collision avoidance.

Our solution has to be low power, low cost and with a low bandwidth usage to be implemented efficiently on a cubesat.



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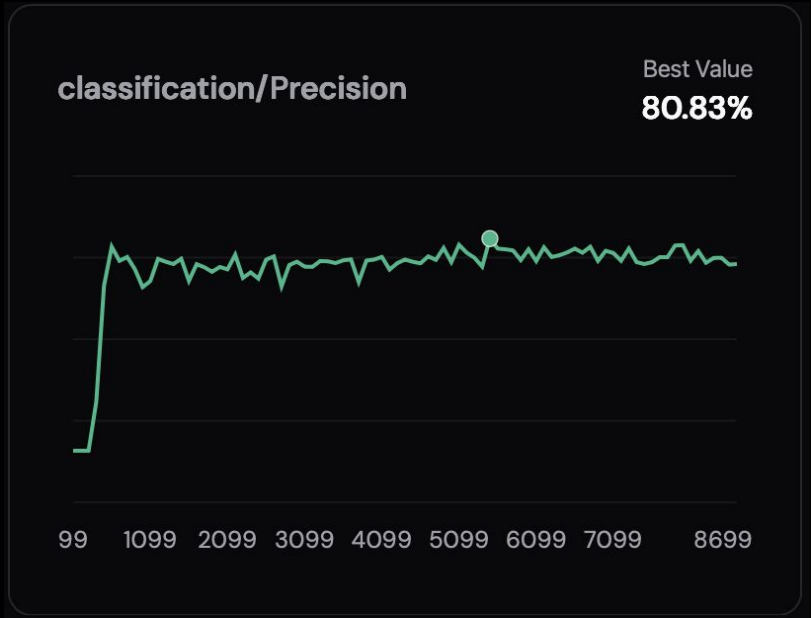
2. Dataset & Model

📊 The initial dataset was a public collection of debris and satellites images. We upgraded the dataset by artificially generating a new label required for our project.

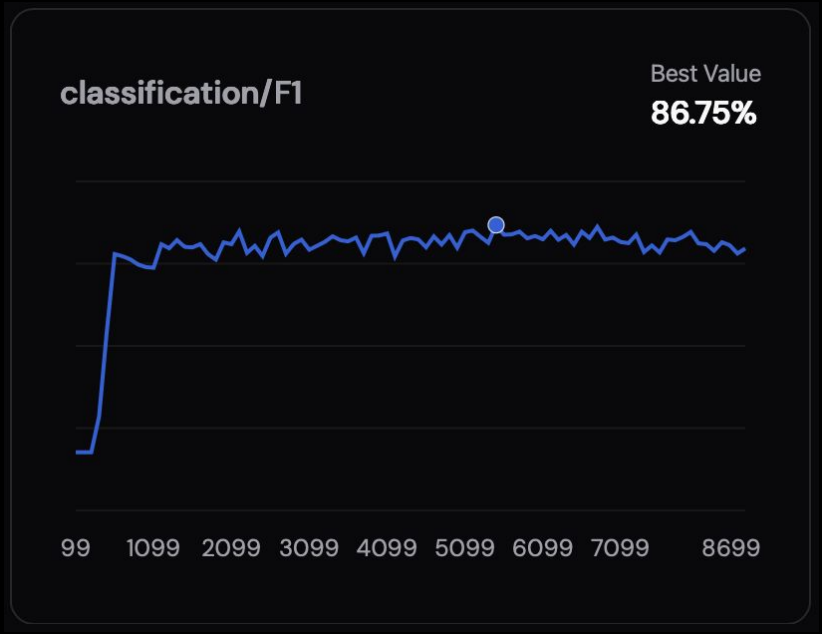
🧠 We fine tuned Focoos' Fai-cls-n-coco model on our dataset. We obtained a F1 of 0.87 on a multiclass classification task of 5 different labels.

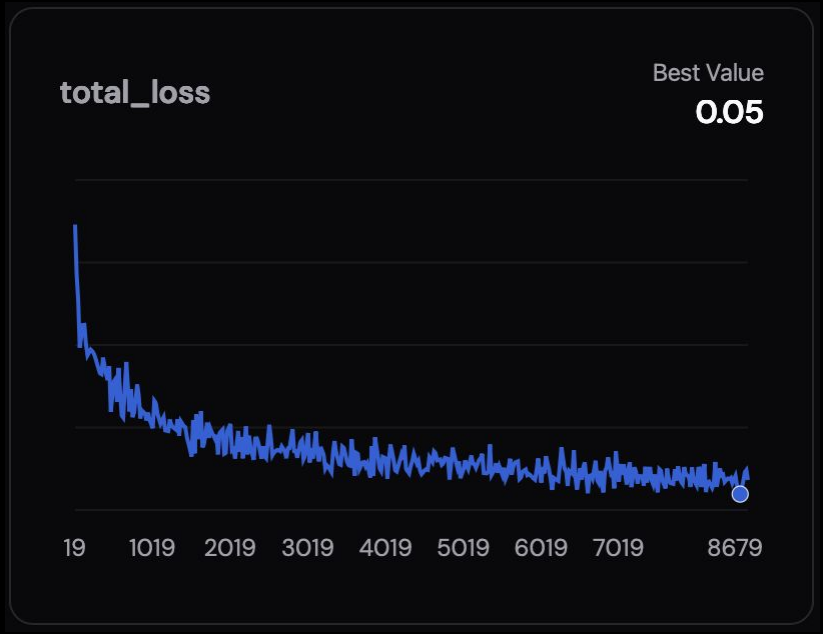
The size of the model once quantized is 349KB (int8 weights). The very small size allows to store and send camera images to the client. Due to the hypothetical low bandwidth, the image is sent only if a threshold in the logits is reached.

2b. Just Some Metrics



2c. Just Some Metrics pt.2





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3. Deployment Pipeline

🔧 In order to be more efficient, we automated every step of Z-Ant deployment of the quantized model:

- `make` to codegen, build and flash using all the optimized flags.
- `make watch` to check on the serial output.
- `make server` to build the server Docker image.

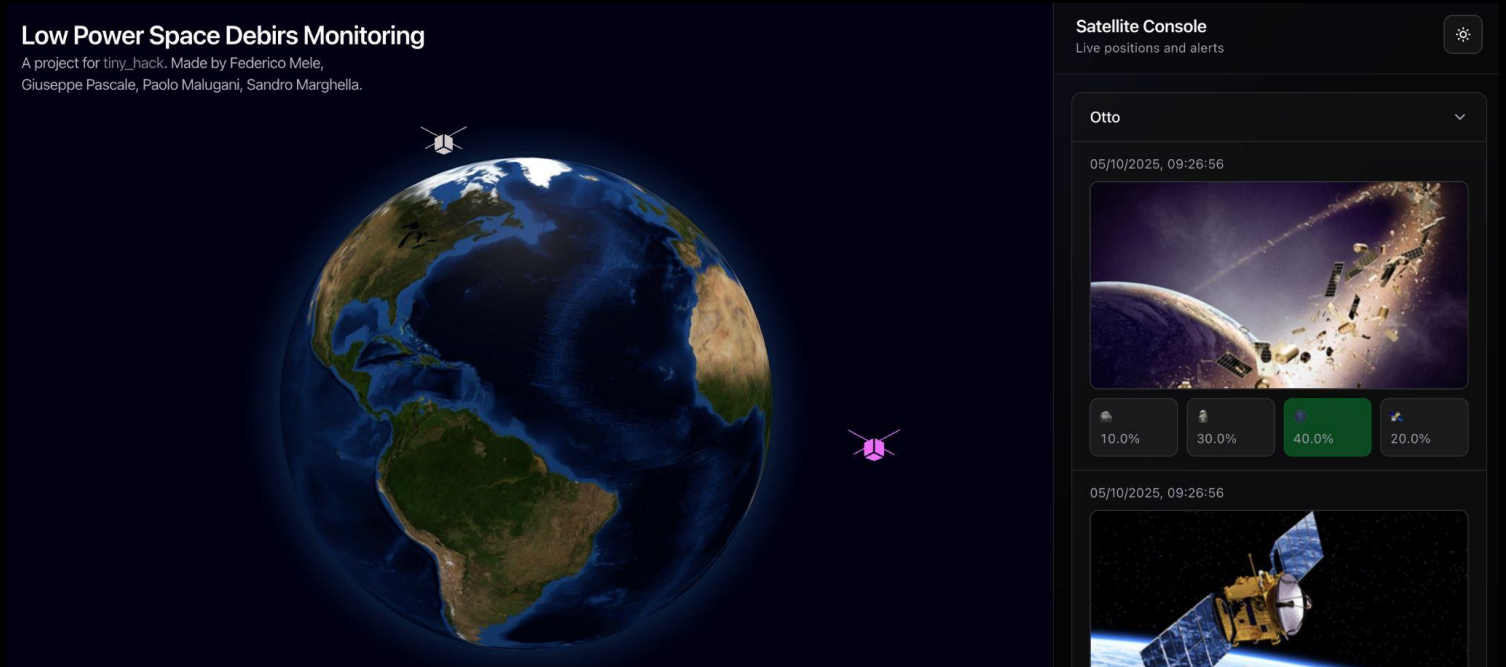
4. Central Server Model

🖥️ All the data from the Nicla gets collected by a central server on the CubeSat, that then gets relayed to the ground. This is done through:

- Serial communication between Nicla and server.
- The server backend saves the debris alerts in a database, with their respective image and its classification.
- The client retrieves the latest alarms from the dashboard, pooling the backend for data.

5. Demo & User Experience

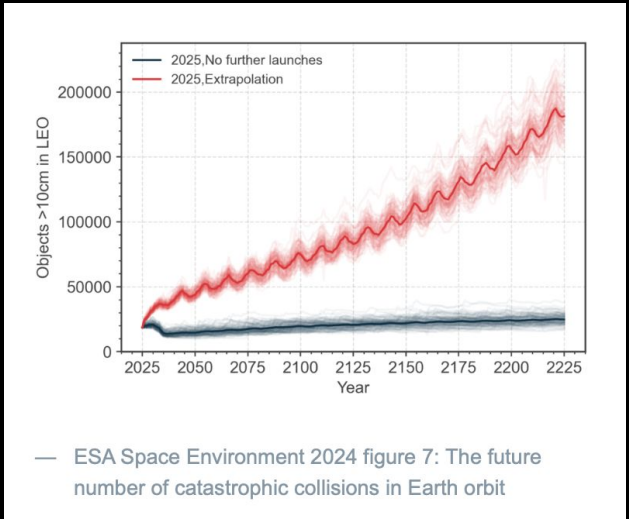
Our project comes with a convenient interface for live monitoring the detected space junk.



6. Impact & Next Steps

🚀 Our idea can be expanded by developing a distributed sensor network, making the CubeSat communicating to each other.

In the coming years, due to the ongoing space race, the amount of space debris is expected to grow significantly.



— ESA Space Environment 2024 figure 7: The future number of catastrophic collisions in Earth orbit

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That’s a wrap! 🌮

Thanks