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Fast Hardware-Based Image Processing for Agriculture

Background & Objectives

Background:

- To produce healthy crops, a farmer must monitor the condition of their crops and react to the damage from adverse weather, pests and disease. This task is cumbersome on large farms and requires a modern technological solution.

Objectives:

- This project's goal is to design a hardware-based image-processing system that can be eventually mounted on an aerial drone and take pictures of crops as the drone flies over the fields.

Figure 1: Crop Field
Image courtesy of NaturalNews.com

Project Objectives

Requirements	Component
Hardware *(Real-time Processing)*	Terasic DE10-Nano (*Proof of concept with Raspberry Pi IV)*
Camera *(Minimum 1920x1080 resolution)*	IMX-252-C
Image Processing	OpenCV, Python, C
GPS *(Accuracy to +/- 2cm, RTK)*	C94-M8P RTK GPS
GSM	MIKROE-1298 GSM Click
Mass Storage Device	Sandisk 64GB Micro SD

Selected Design - Hardware

- Terasic DE10-Nano utilizing both an FPGA (field programmable gate array) and HPS (hard processing system). FPGA side uses Verilog coding, HPS side runs Linux kernel capable of using Python and C languages. Interconnect for FPGA-HPS allows all peripherals to run concurrently.
- FPGA allows parallel processing of tasks to increase speed and flexibility.

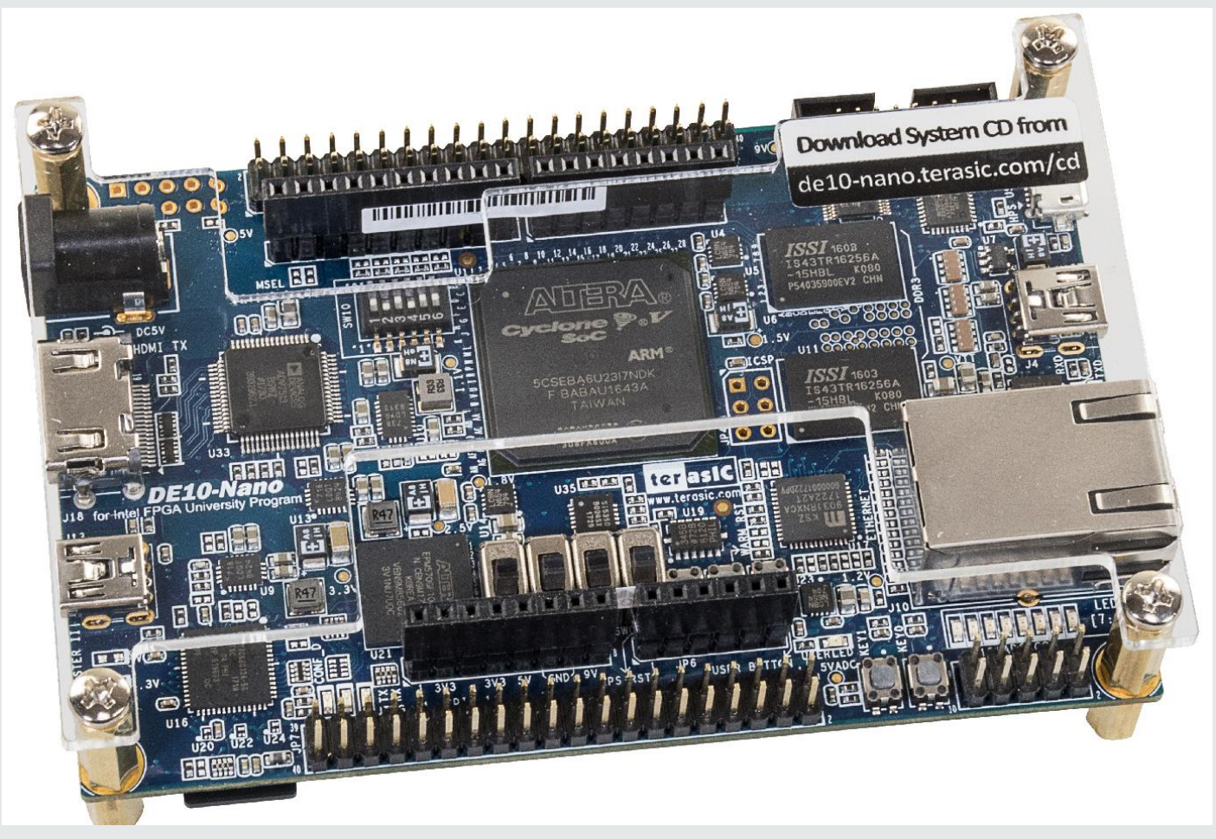

Figure 2: DE10-Nano
Image courtesy of Terasic.com

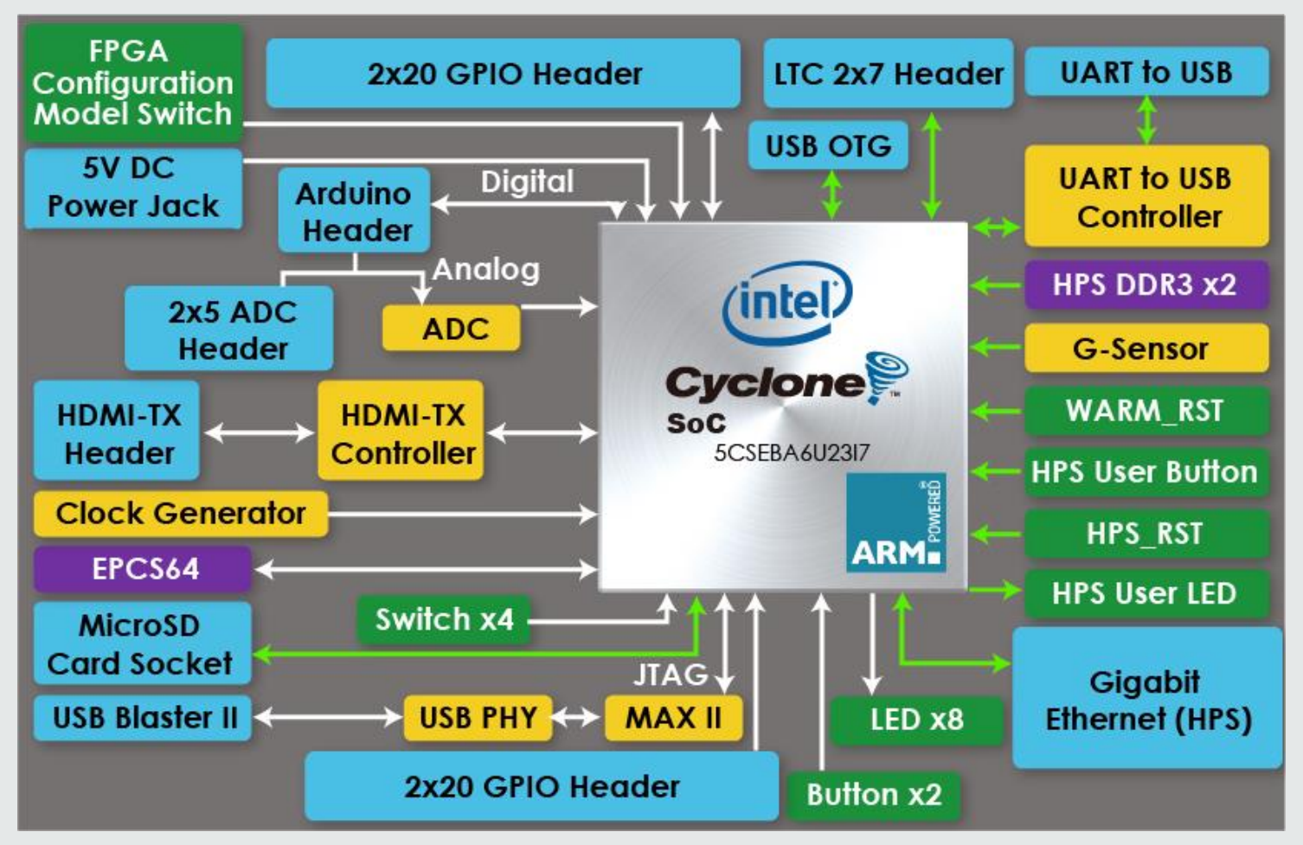

Figure 3: DE10-Nano Block Diagram
Image courtesy of Terasic.com

Selected Design - Camera

- Vision Components IMX-252-C producing a 2048x1536 image using a Global Shutter system. Connecting over a MIPI CSI-2 interface using an FPC connection. The Global Shutter is crucial as our drone will be moving and this will avoid image distortion.

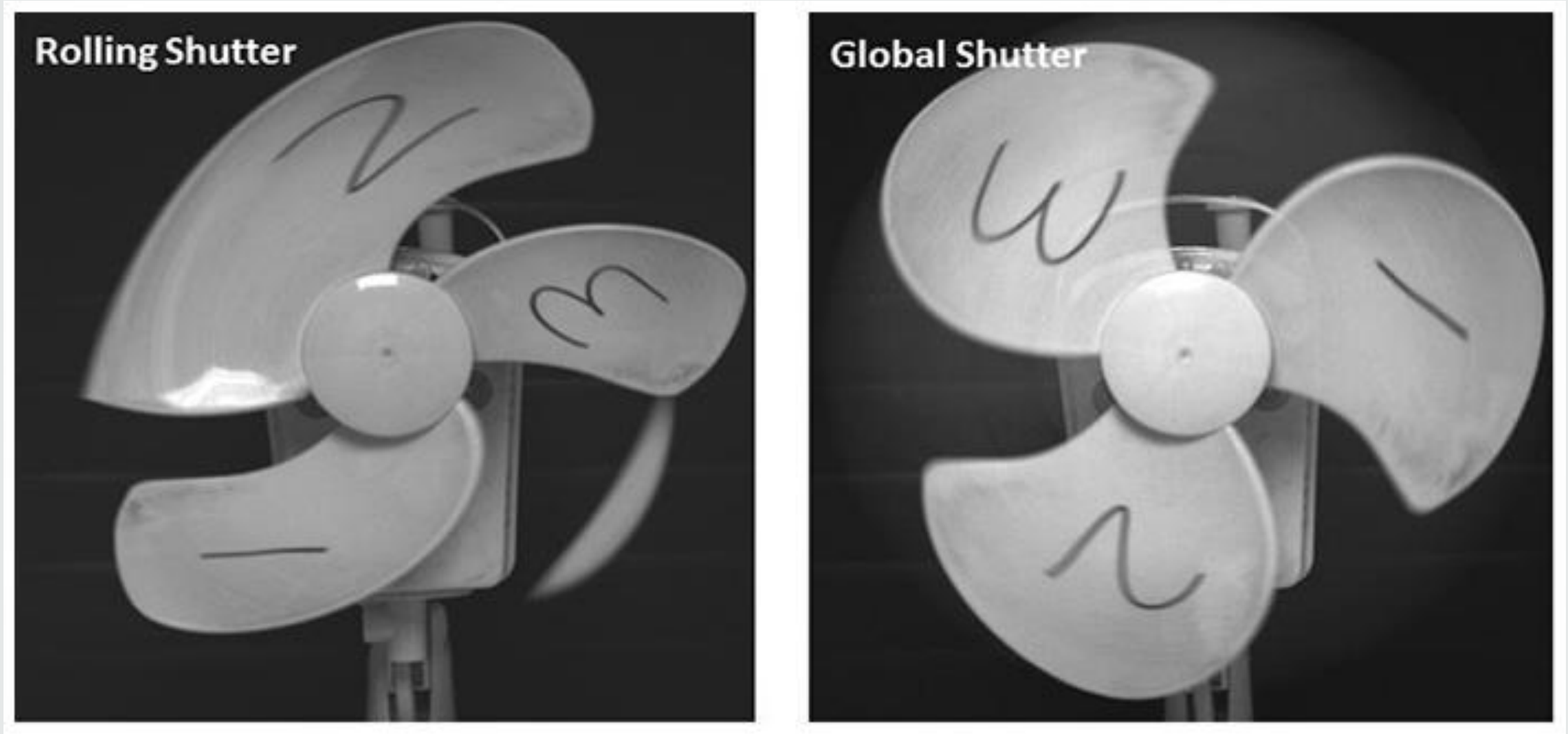

Figure 4: Rolling Shutter vs Global Shutter
Image courtesy of andor.oxinst.com

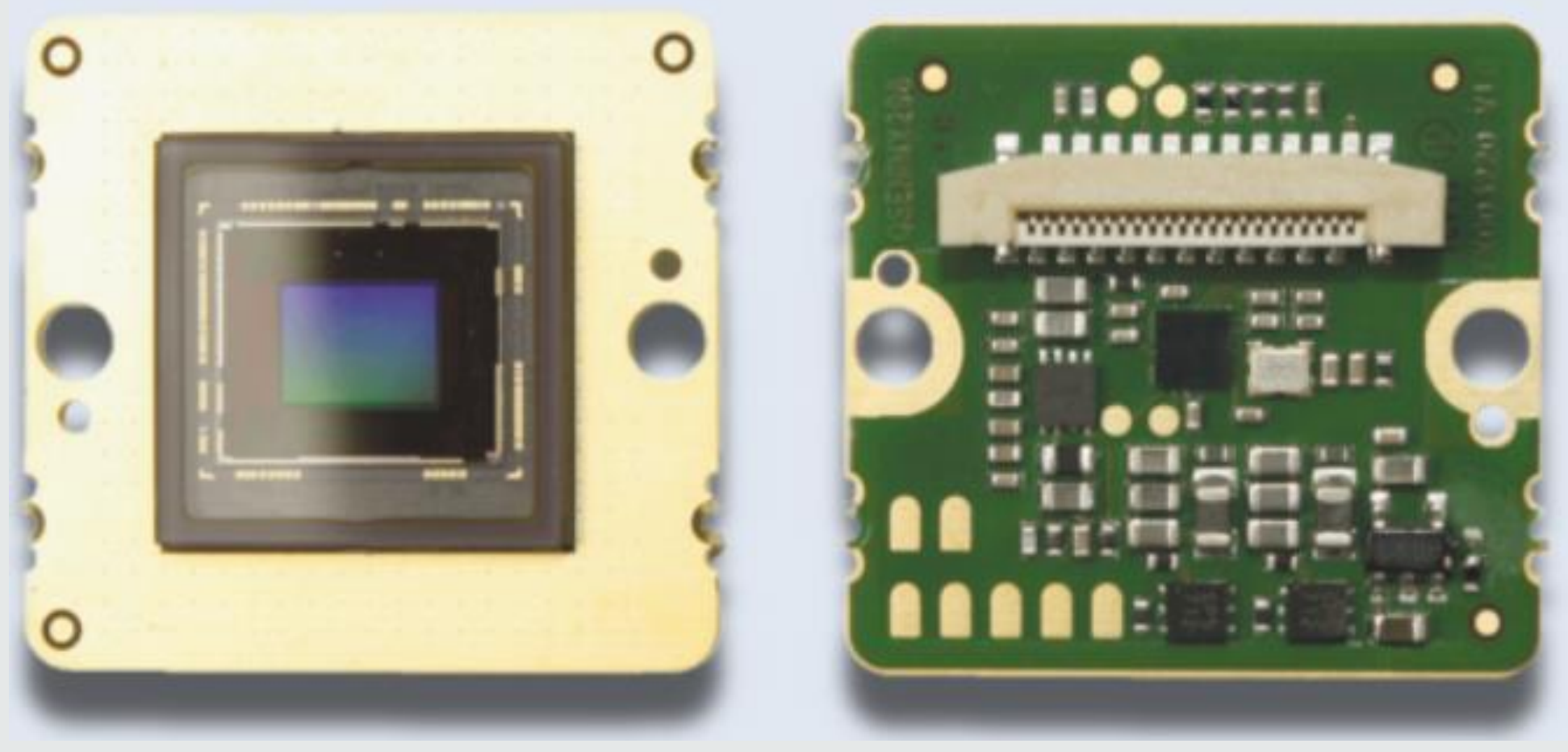

Figure 5: Camera module
Image courtesy of vision-components.com

Selected Design – Image Processing

- Using Python and OpenCV, images captured from the camera are scanned for target colours. Any problematic colours are contoured.
- Images are geotagged with the location they were captured.
- Processed images saved locally on Micro SD card for future use in building a map of the crop field.

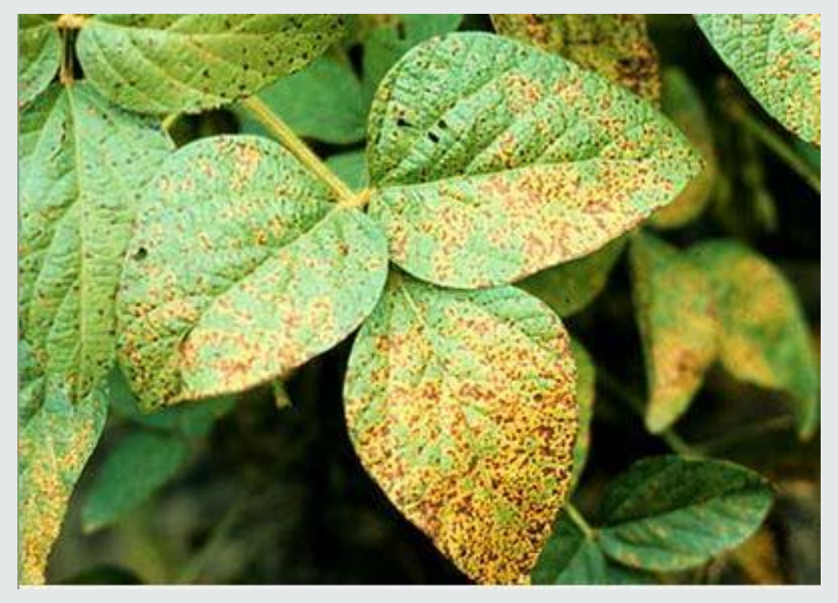

Figure 6: Problematic Plant
Image courtesy of wisc.edu

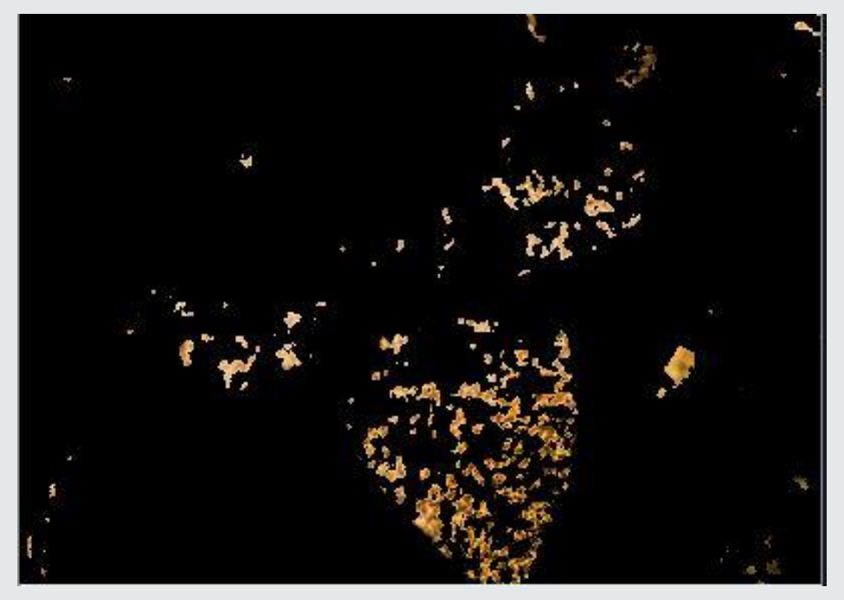

Figure 7: Mask Image

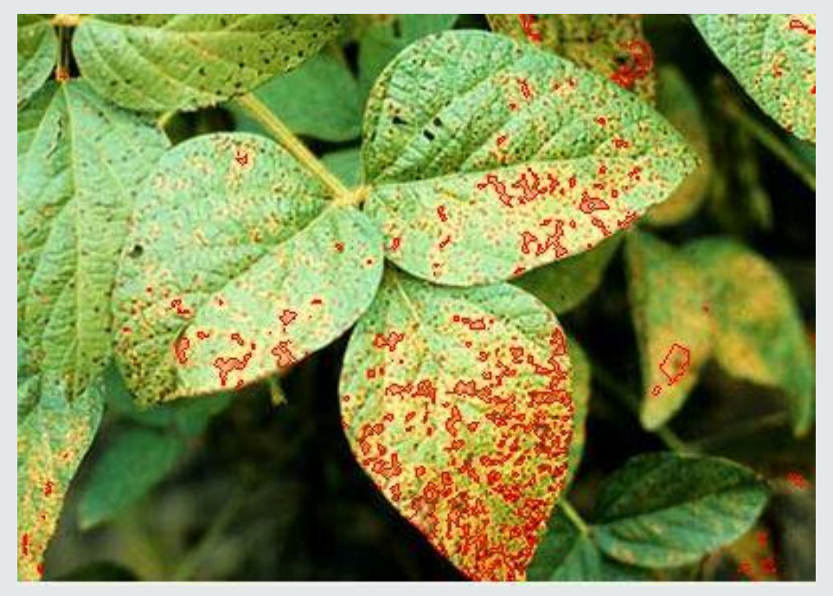

Figure 8: Contoured Image

Selected Design - GPS

- C94-M8P application boards containing high precision GNSS modules and base station/rover functionality allowing for RTK capability (Real-time kinematics)
- Transmits coordinates to the main board through a serial UART connection

Figure 9: C94-M8P Package
Image courtesy of digikey.com

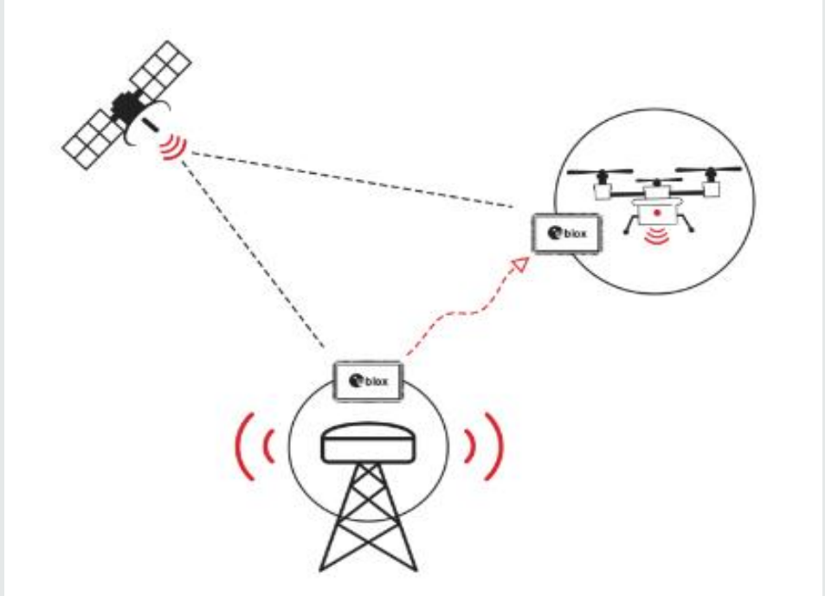

Figure 10: Base/Rover
Image courtesy of u-blox.com

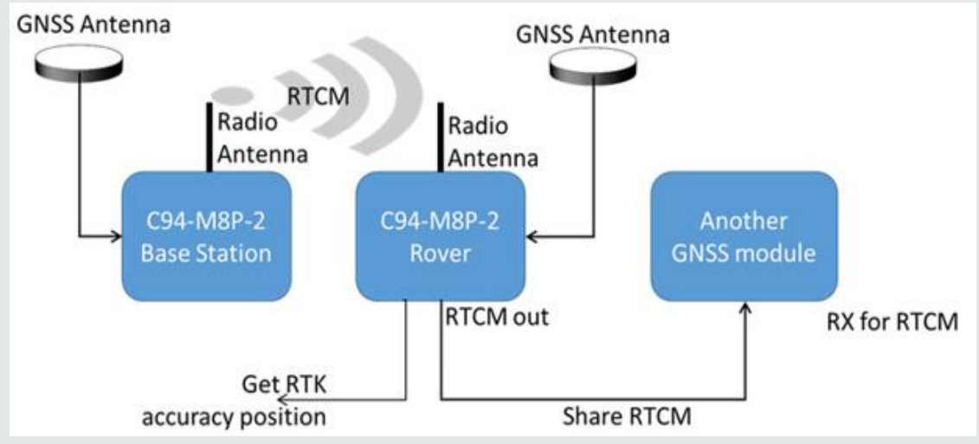

Figure 11: Data Stream
Image courtesy of u-blox.com

Project Status

- GPS coordinate retrieval is functional.
- OpenCV image processing on device saves the correct image.
- Geotagging captured image proof of concept with Raspberry Pi 4 is operational.

Conclusion & Future Work

- Image processing and geotagging has been completed using Python on a Raspberry Pi as proof of concept.
- Next task is to incorporate GSM communication with cloud-based storage or handheld device to send image data.
- Further work involves transferring the image processing code to the DE10-Nano HPS.
- Long-term goal of building a housing and mounting to an aerial drone to begin flight tests.

References

- DE10-Nano Kit – Terasic.com
- MIPI Camera Modules – Vision-components.com
- OpenCV – Opencv.org
- OpenCV Python Tutorial – Tutorialkart.com

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- Dr. Young K. Chang (Project Lead & Sponsor, Dalhousie U.)
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