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Onboard AI for fire smoke detection

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Introduction

Small or Cube satellites carrying advanced EO sensors capturing multi of hyperspectral imagery, have limited capacities to store and downlink these large raw imagery data to the ground. This research tackles the challenge of on-board AI processing of hyperspectral imagery for fire smoke detection for the upcoming Kanyini Hyperscout-2 Mission – using an emulation system.

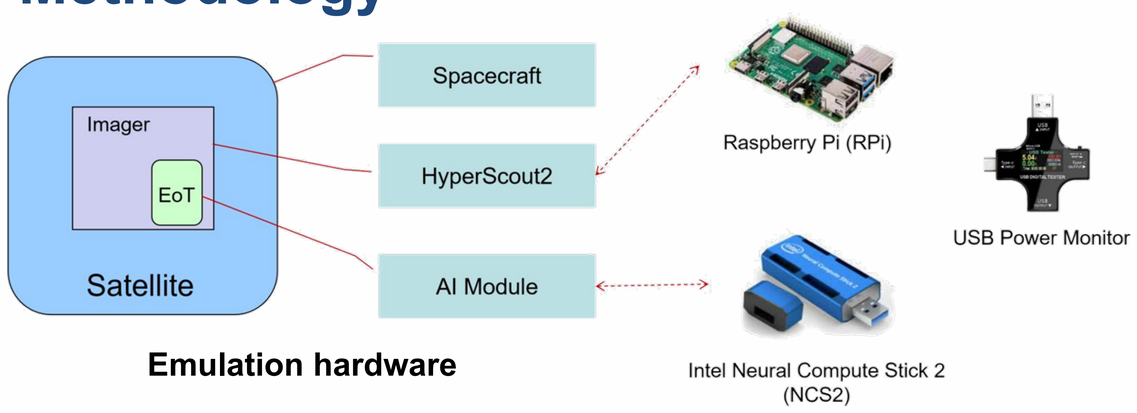
Research aims

Built emulation system for Kanyini Hyperscout-2 Mission;

Develop lightweight AI onboard fire smoke detection;

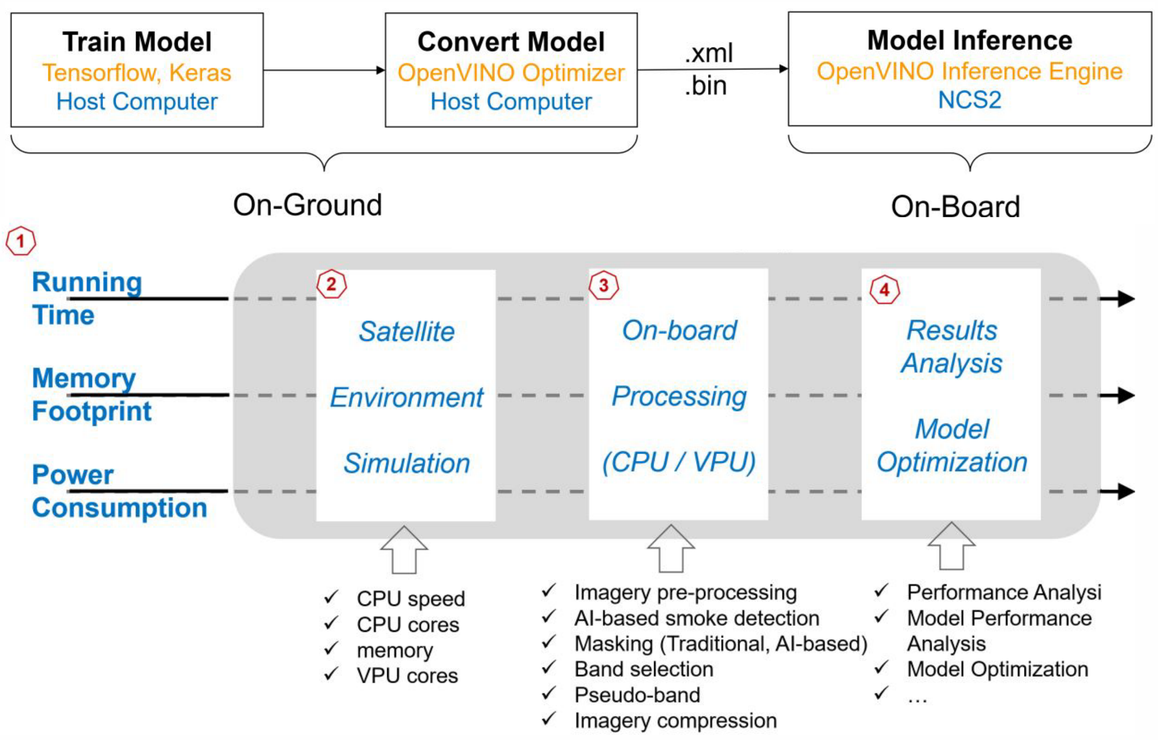
Conduct performance testing for onboard processing tasks

Methodology



Emulation hardware

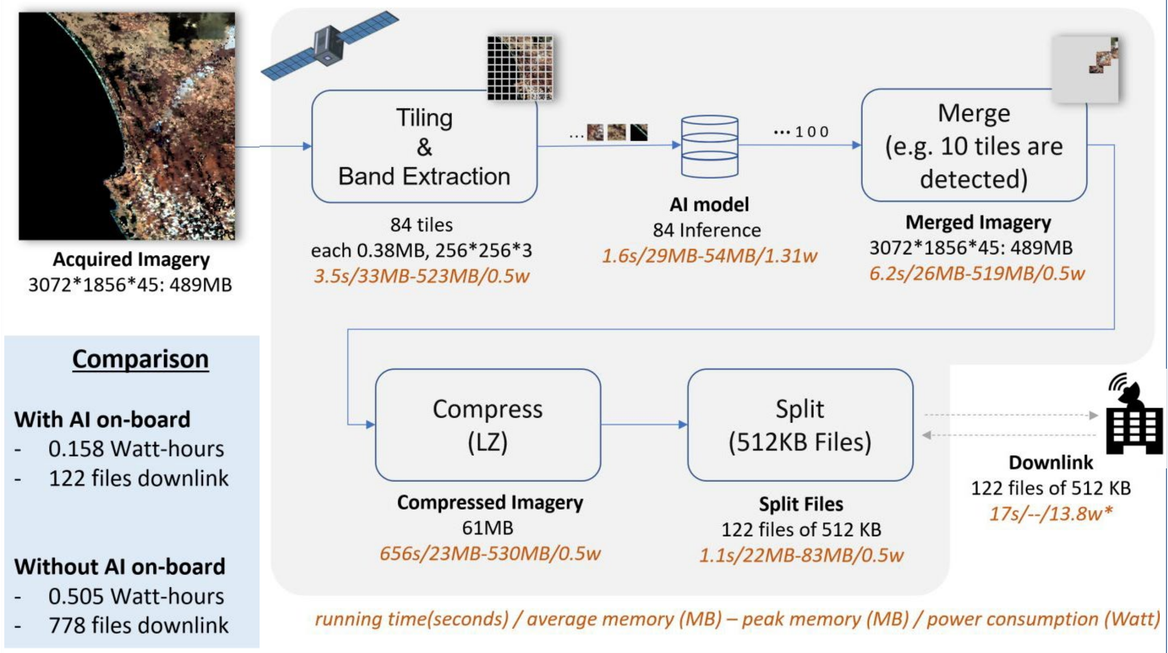
Our approach utilizes modified and resampled VIIRS imagery data over historical fire events that emulates spectral, spatial, and radiometric resolution of HyperScout-2 imagery. A light-weight AI model (VIB_SD) for fire smoke detection (Zhao et.al 2022) has been developed and trained using 800 smoke and 800 non-smoke tiles with 3, 4 or 5 selected bands. On-Ground vs On-Board performance tests were conducted as shown below.



AI model and performance pipeline

Results

Taking a 2019 fire event in South Australia as a case study for our performance tests, we compared AI on-ground with AI On-Board investigating running time, memory footprint and power consumption of various onboard processes including tiling, band extraction, AI inference, image merging, compressing and file splitting.



Simulated onboard smoke detection process

Experimental results indicated that AI onboard for fire smoke detection outperforms the AI on-ground alternative. AI onboard significantly reduces the data downlink volume to just 16% of its original size, resulting in a 69% decrease in energy consumption. In addition, AI onboard detects fire smoke 500 times faster than AI on-ground.

	AI On-ground	AI On-board	Performance Gain
Detection Time (Seconds)	2571	5	504 times faster
Energy Consumption (Watt-hours)	0.505	0.158	69% less
Data Size (MB)	388	61	84% smaller

Once Kanyini is launched, we plan to stepwise update our AI onboard model using HyperScout-2 imagery captured over wildfires or prescribed burns. Our light-weight AI approach can also be adapted to other CubeSat missions and sensors as well as to other applications, such as landslides, floods or LULC change detection.

References

Zhao, L.; Liu, J.; Peters, S.; Li, J.; Oliver, S.; Mueller, N. Investigating the Impact of Using IR Bands on Early Fire Smoke Detection from Landsat Imagery with a Lightweight CNN Model. Remote Sensing 2022, 14, 3047.

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