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## SEEING BEYOND

Validating a CNN-based Pose Estimation System
for Relative Navigation with an Uncooperative
Spacecraft on Myriad X

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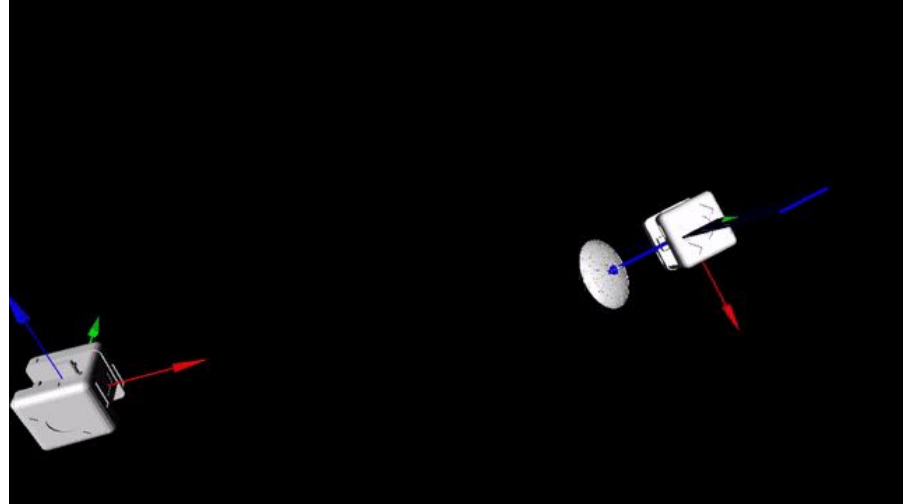UBOTICA™
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# Contents

- Background & motivation

- The pose estimation model

- The Myriad X VPU

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# Background & motivation

- CNN based approach for pose estimation of an uncooperative spacecraft.
- Promising results obtained on GPU.



https://spectrum.ieee.org/space-junk-astrobee

# Background & motivation

- Pose HRNet applied to uncooperative spacecraft.
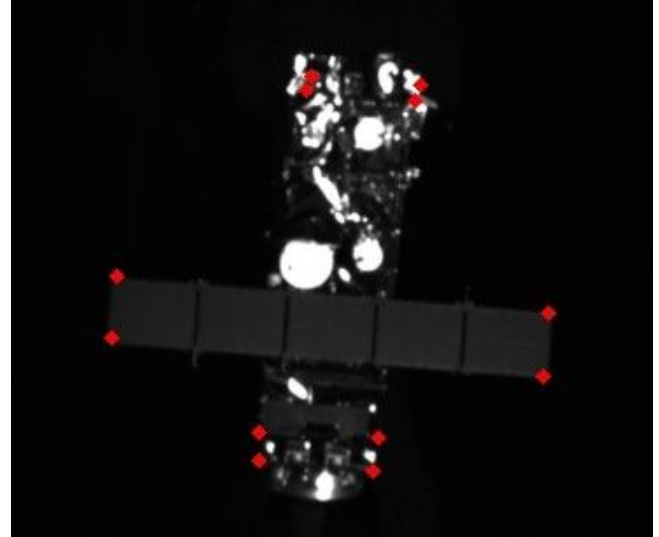- Promising results obtained on GPU.



Image courtesy of ESA

# Background & motivation

- Myriad Vision Processing Unit (VPU).
- CogniSAT CubeSat board.
- Representative hardware for small satellites.



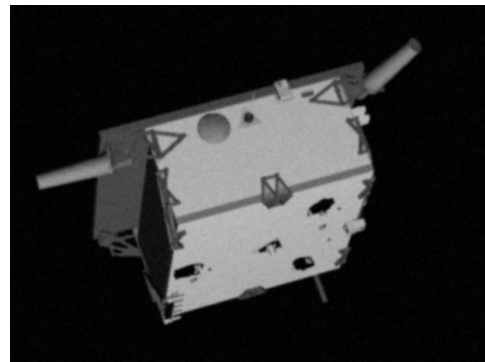Image courtesy of Ubotica Technologies



Image courtesy of Intel

Copyright © Ubotica

# Dataset

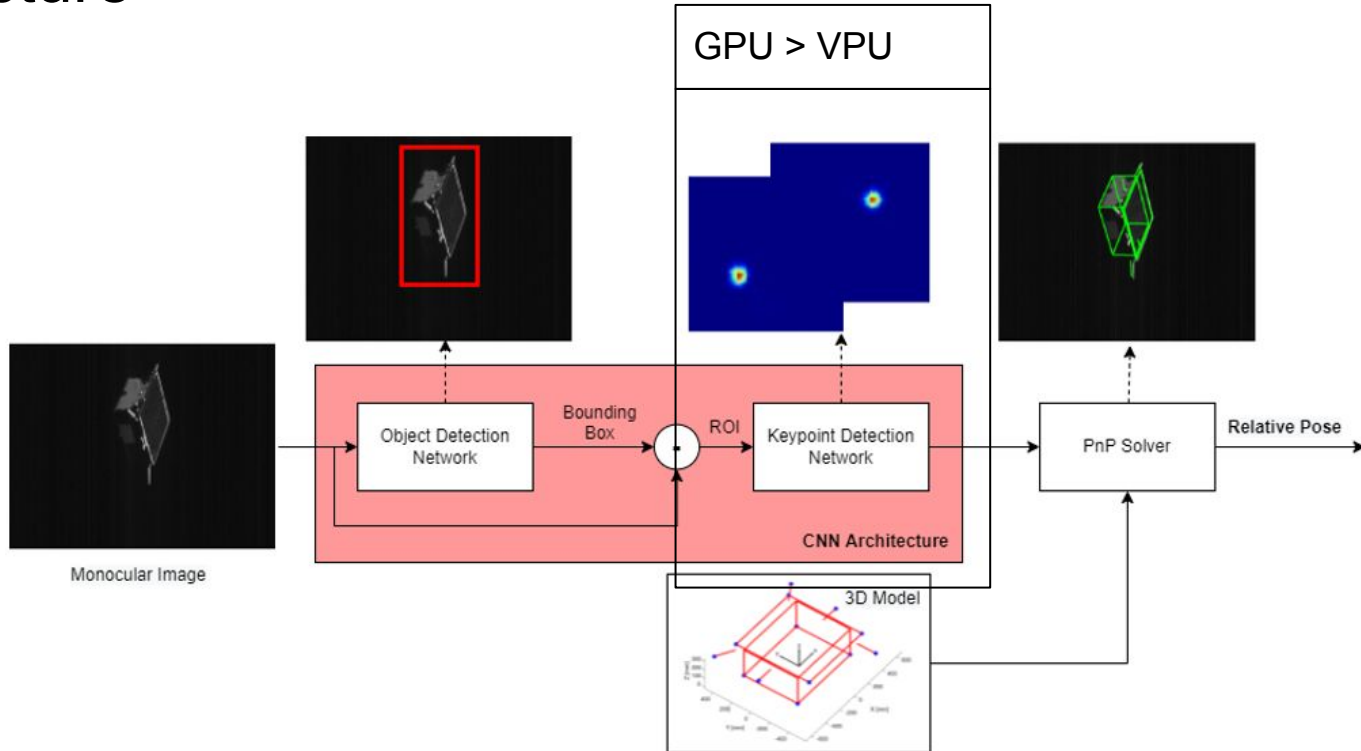| Dataset | Synthetic | lightbox | sunlamp |
|---------|-----------|----------|---------|
| Train | 47,966 (80% Noise Pipeline) (50% Light Augmentation) | - | - |
| Validation | 11,994 (80% Noise Pipeline) (50% Light Augmentation) | - | - |
| Test | - | 6,740 | 2,791 |



Example synthetic image



Example lightbox image



Example sunlamp image

# Architecture

# The Myriad X

- 2 Neural Compute Engines
- 1.5 W nominal power draw
- 16 SHAVE processor cores
- Up to 4 TOPS
- Software reconfigurable
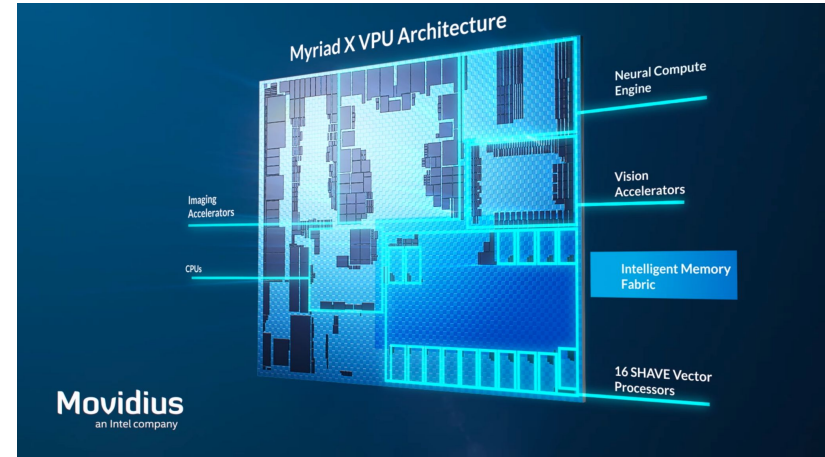- Half-precision floating point
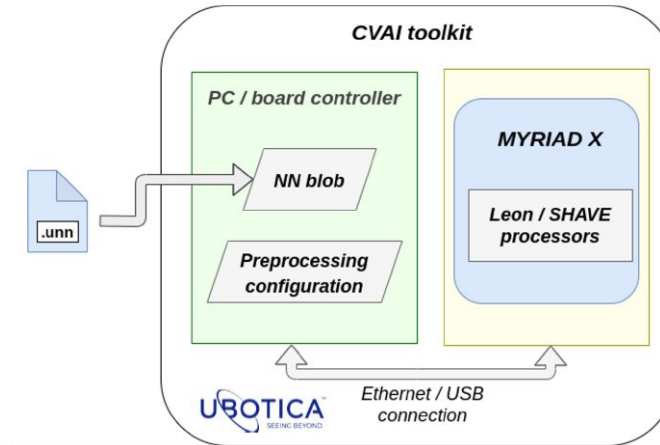


Image courtesy of Intel Movidius

# Porting the models to MyriadX

# Results

- 5x inference per Watt
- Comparable performance

| | Mean Inference Time [ms] | High Accuracy | Medium Accuracy | Low Accuracy |
|---|---|---|---|---|
| lightbox | | | | |
| GPU | 68.7 | 30% | 59% | 71% |
| Myriad X | 125.2 | 29% | 59% | 71% |
| sunlamp | | | | |
| GPU | 73.8 | 12% | 40% | 58% |
| Myriad X | 125.2 | 12% | 40% | 58% |

# Discussion

- Large pose errors in < 0.01% of inference samples.
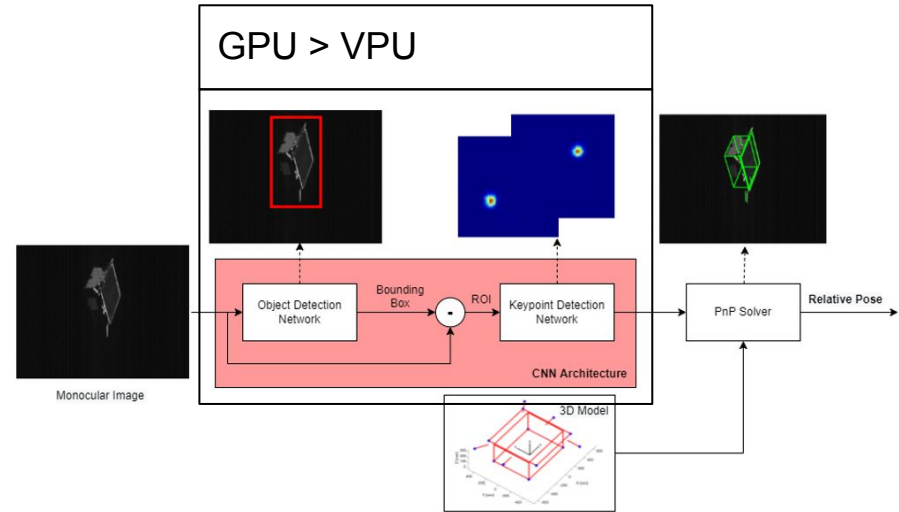- Quantization aware training.
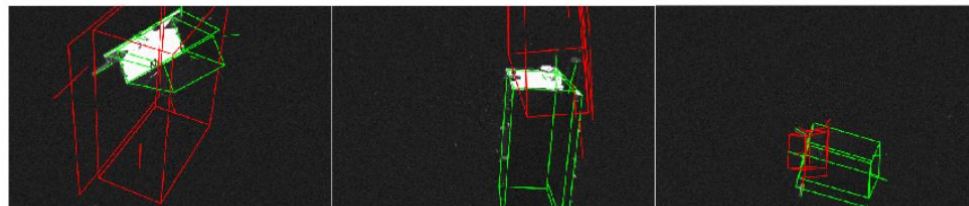


(a) lightbox
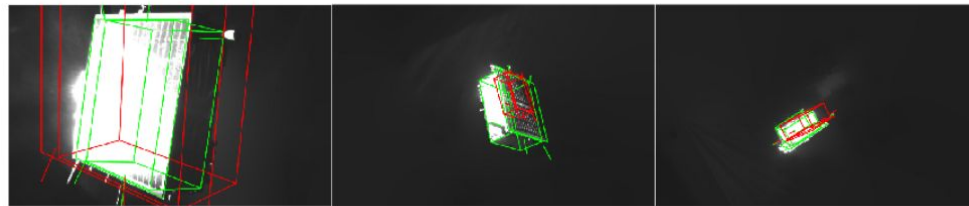
(b) sunlamp

# Conclusions

- Comparable performance at better inference per Watt.
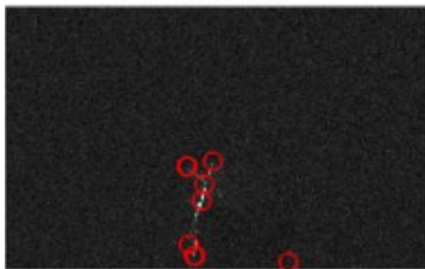- Full flow validated
- Myriad X in orbit

# Thank you for your attention!
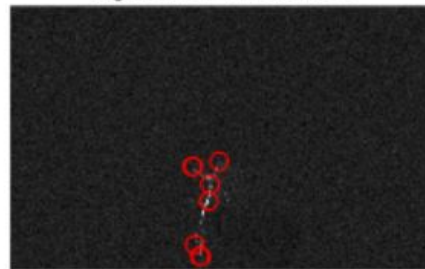
Any questions?

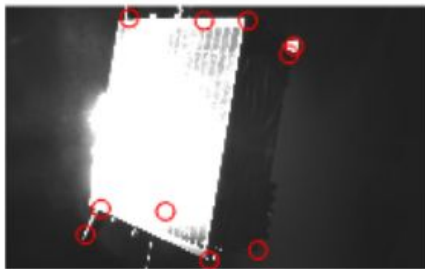✉ Tom.Hendrix@ubotica.com

# Backup 1

**GPU Inference**     **Myriad X Inference**

(a) lightbox

**GPU Inference**     **Myriad X Inference**

(b) sunlamp