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Unreal Engine Testbed for Computer Vision of Tall Lunar Tower Assembly

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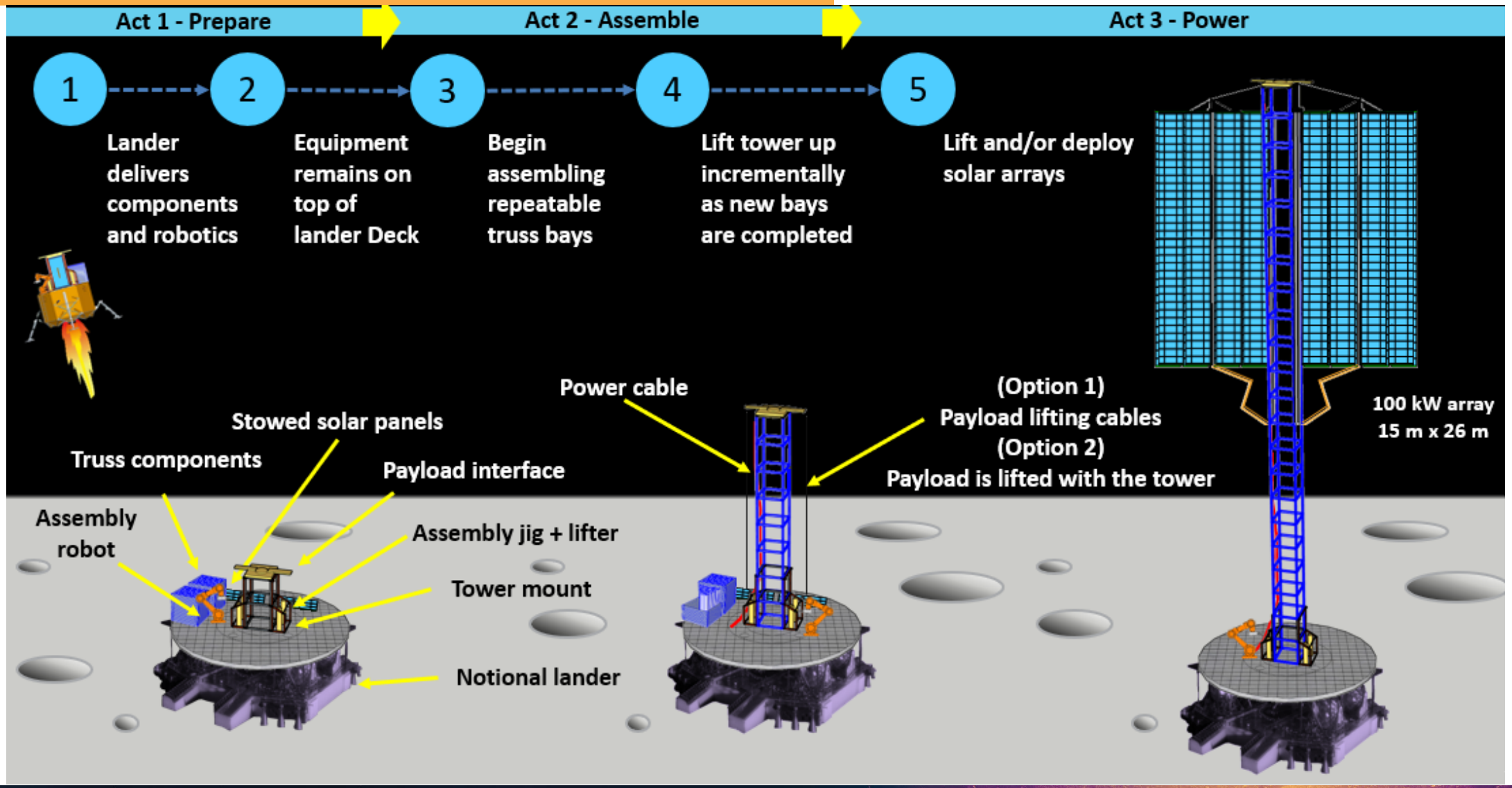
Outline

- Tall Lunar Tower (TLT) Background
- TLT Computer Vision System
- Unreal Engine 5 Lunar South Pole Lighting Testbed (UE5 Lunar-SPLIT)
- Lunar Analog Environment (LAE)
- You Only Look Once (YOLO) Object Detection Model for Robotic Assembly Inspection Cases
- Synthetic and Real Image Training Dataset Comparison
- Concluding Remarks

Tall Lunar Tower (TLT) Background



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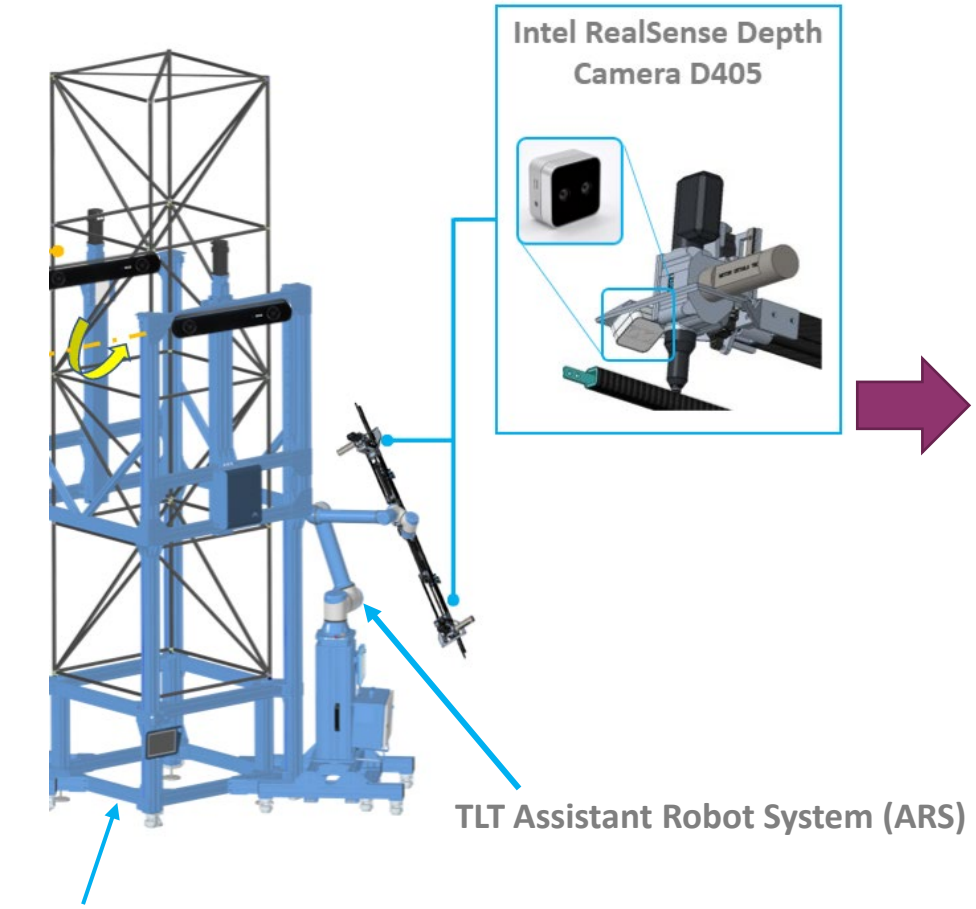
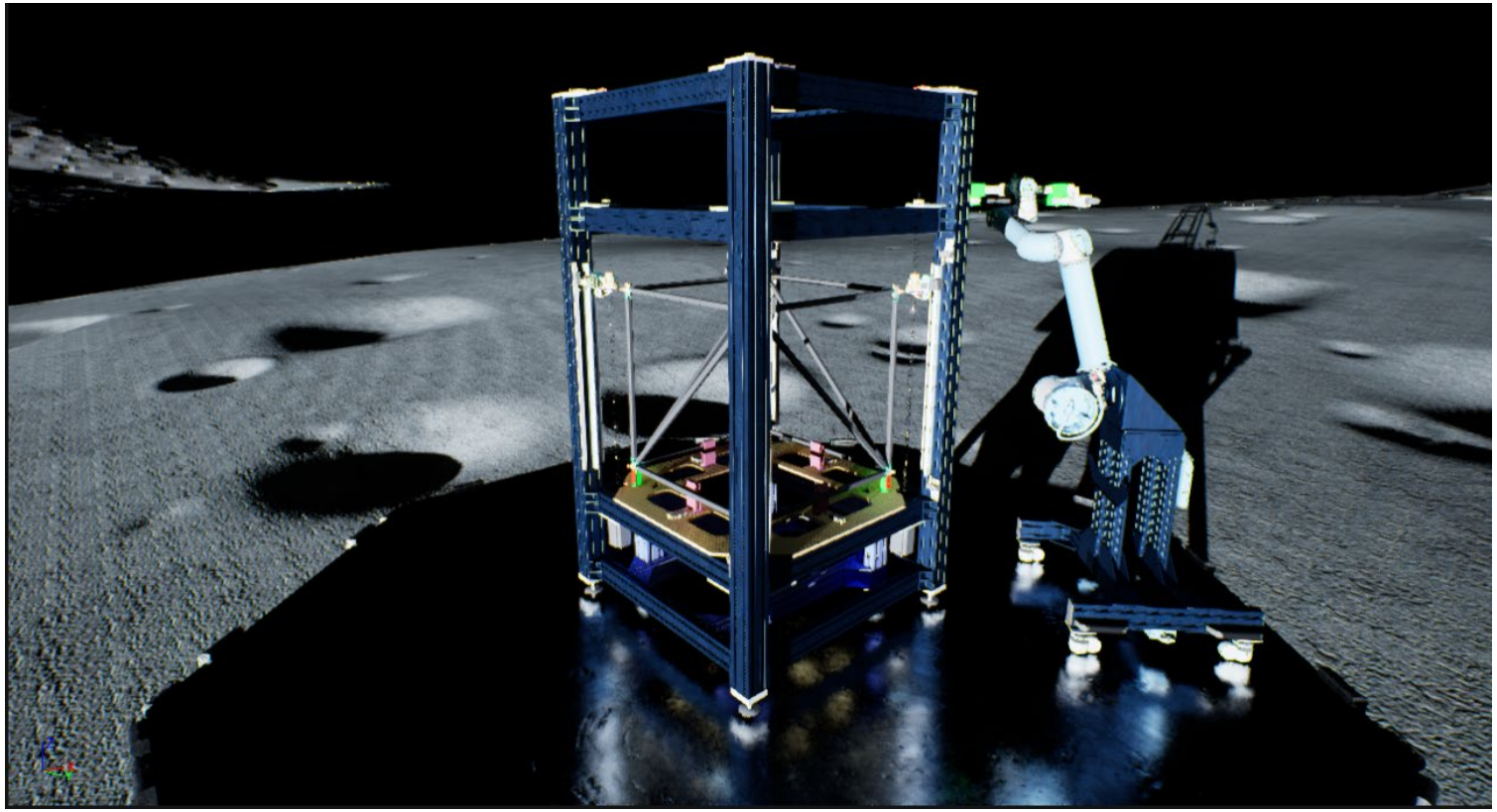
TLT Computer Vision System

TLT Computer Vision System



Unreal Engine 5* (UE5)



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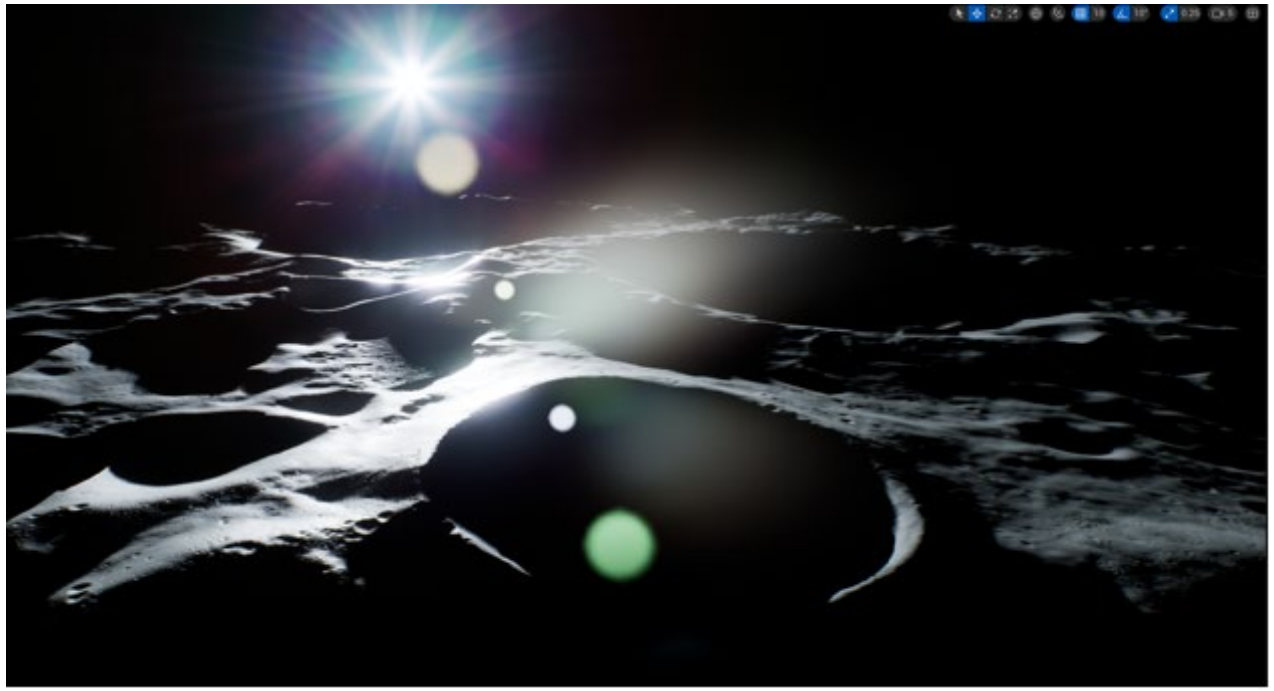
UE5 Lunar South Pole Lighting Testbed (UE5 Lunar-SPLIT)

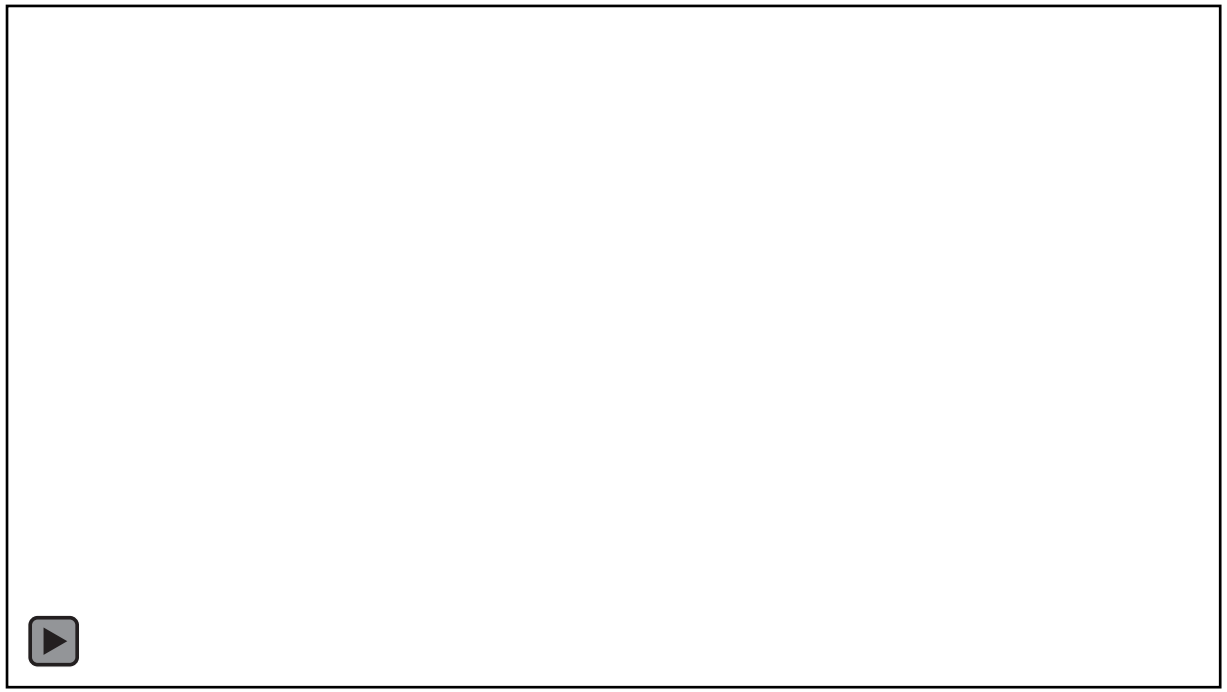
Lunar Terrain Generation

- Static mesh generated from digital elevation models (DEM) with Nanite virtualized geometry enabled



Lunar Lighting Generation

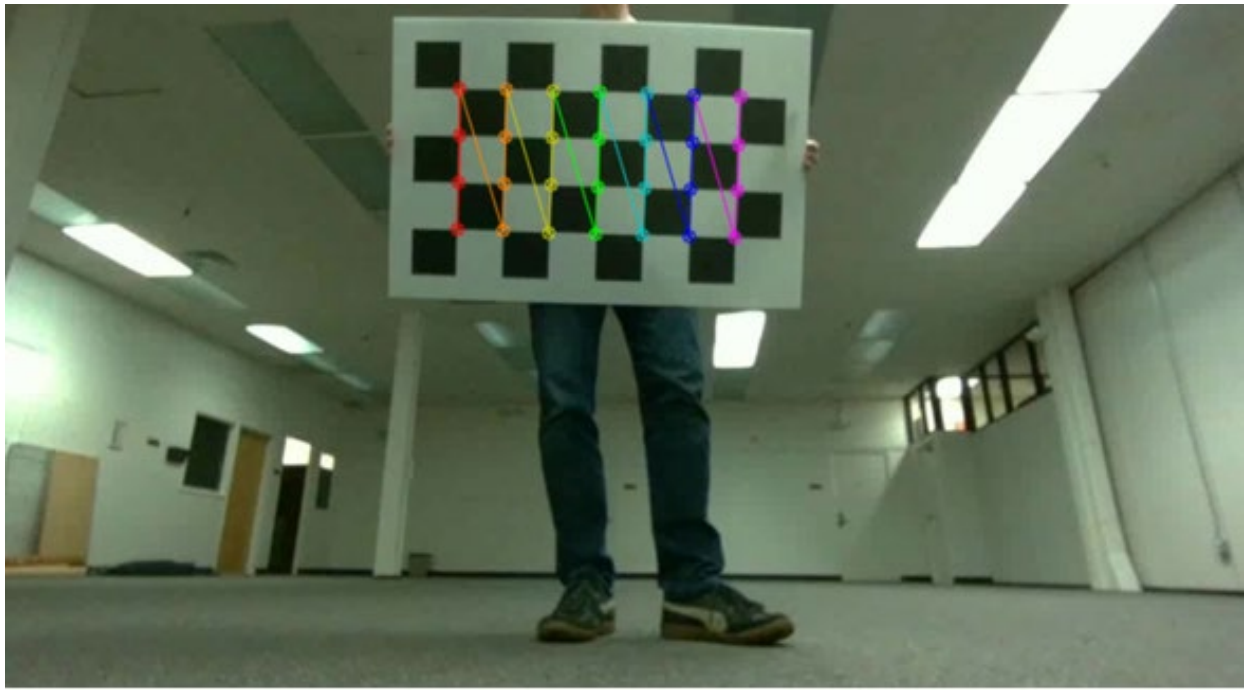
- Directional light game asset positioned by spacecraft, planet, instrument, camera-matrix, events (SPICE) ephemeris data kernels



UE5 Lunar-SPLIT (Continued)

OpenCV Camera Calibration

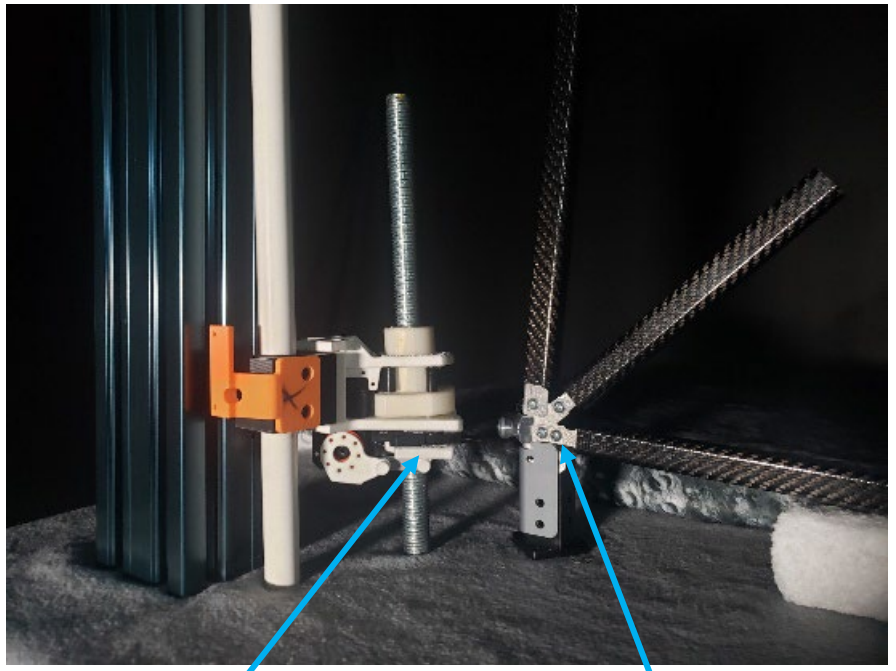
- Checkerboard D405 camera calibration -> camera properties: distortion coefficients, image centers, focal length



Len Distortion

- Generate UE5 Lens File with OpenCV camera calibration properties

Lunar Analog Environment (LAE) TLT Test Jig



Darkroom Outfitting

TLT CRS Active Gripper

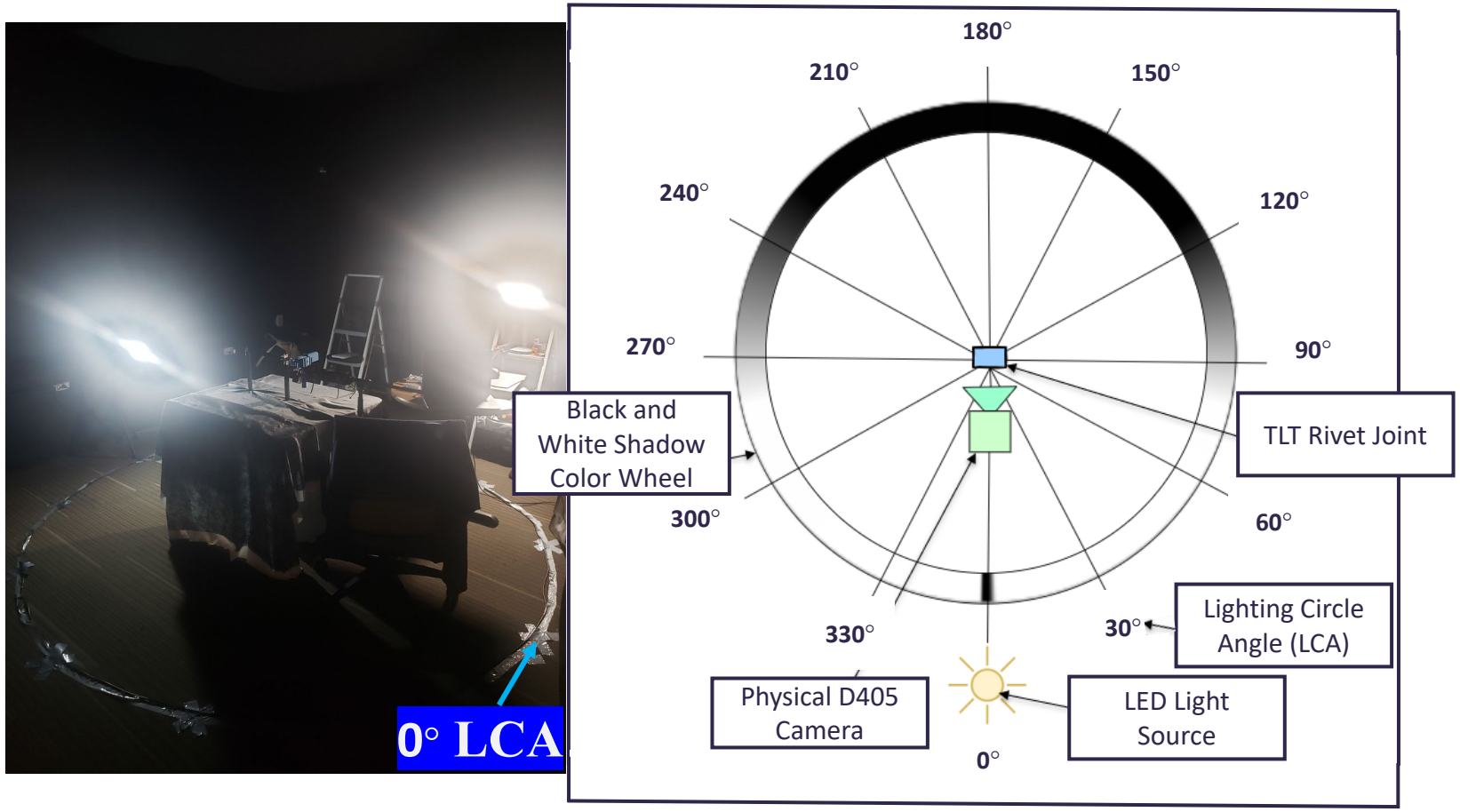
Truss Bay Corner

D405 Camera

TLT ARS Adjustable Stand

Lighting Circle Angle (LCA) Setup

12 LCA Light Positions



Four D405 Camera Angle Positions

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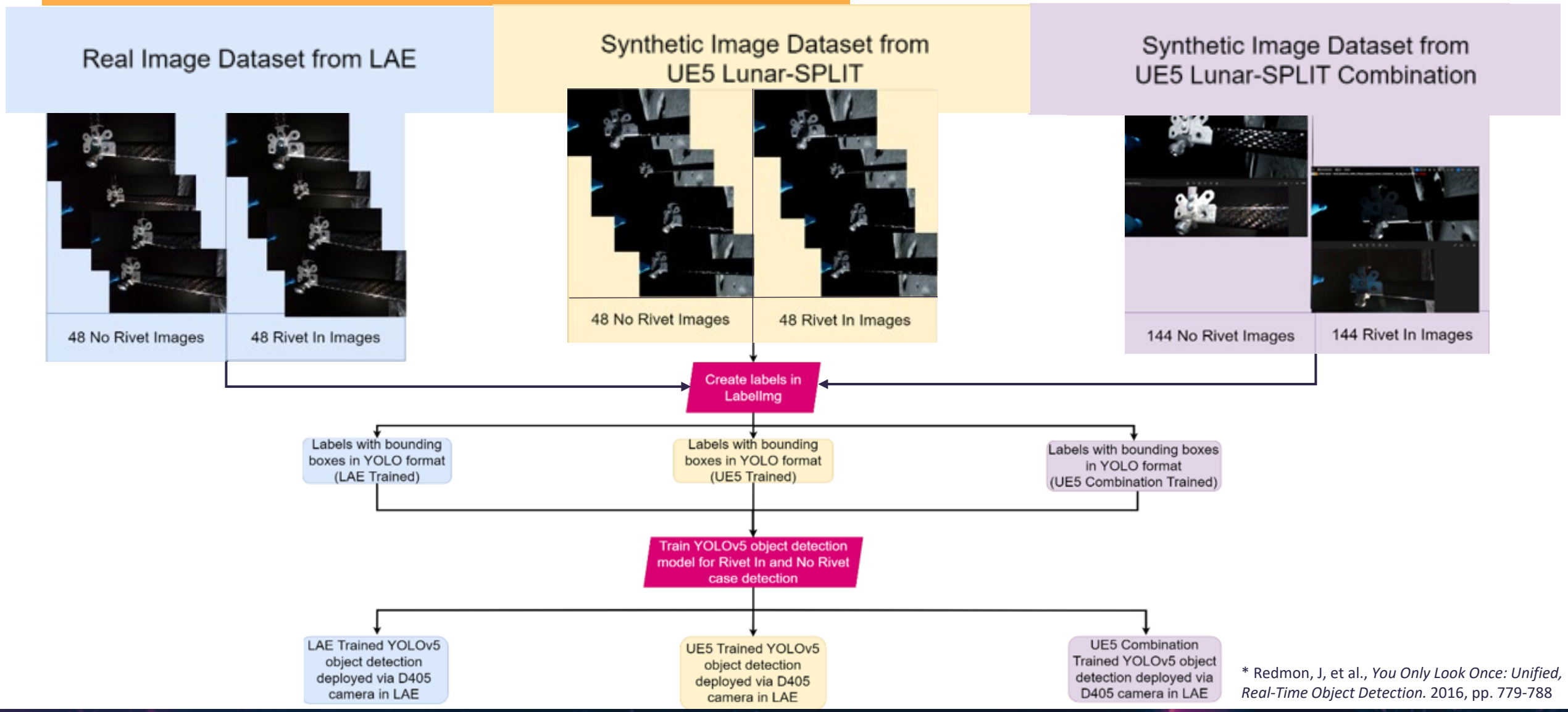
YOLO* Object Detection Model for Assembly Inspection Cases



* Redmon, J, et al., *You Only Look Once: Unified, Real-Time Object Detection.* 2016, pp. 779-788

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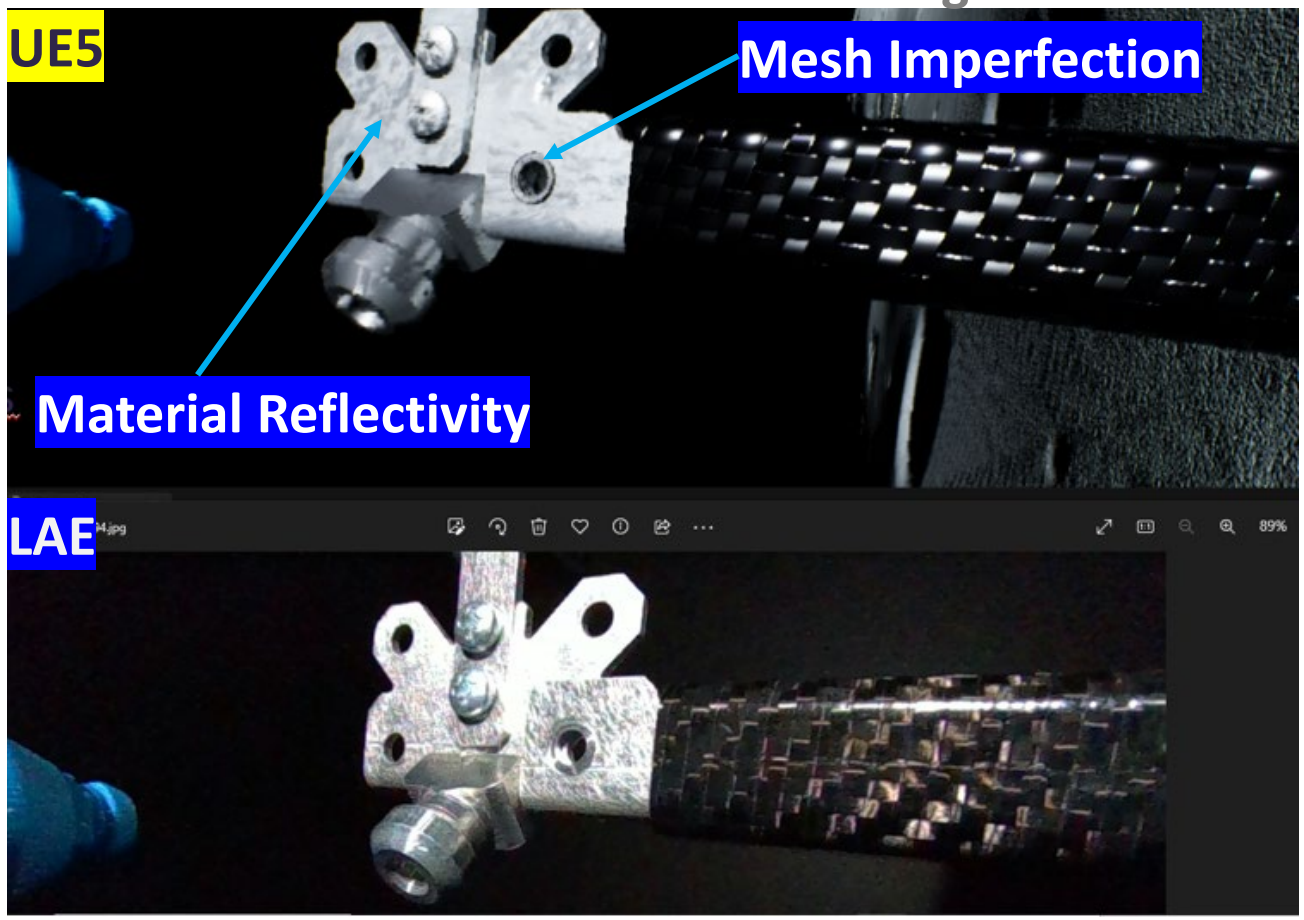
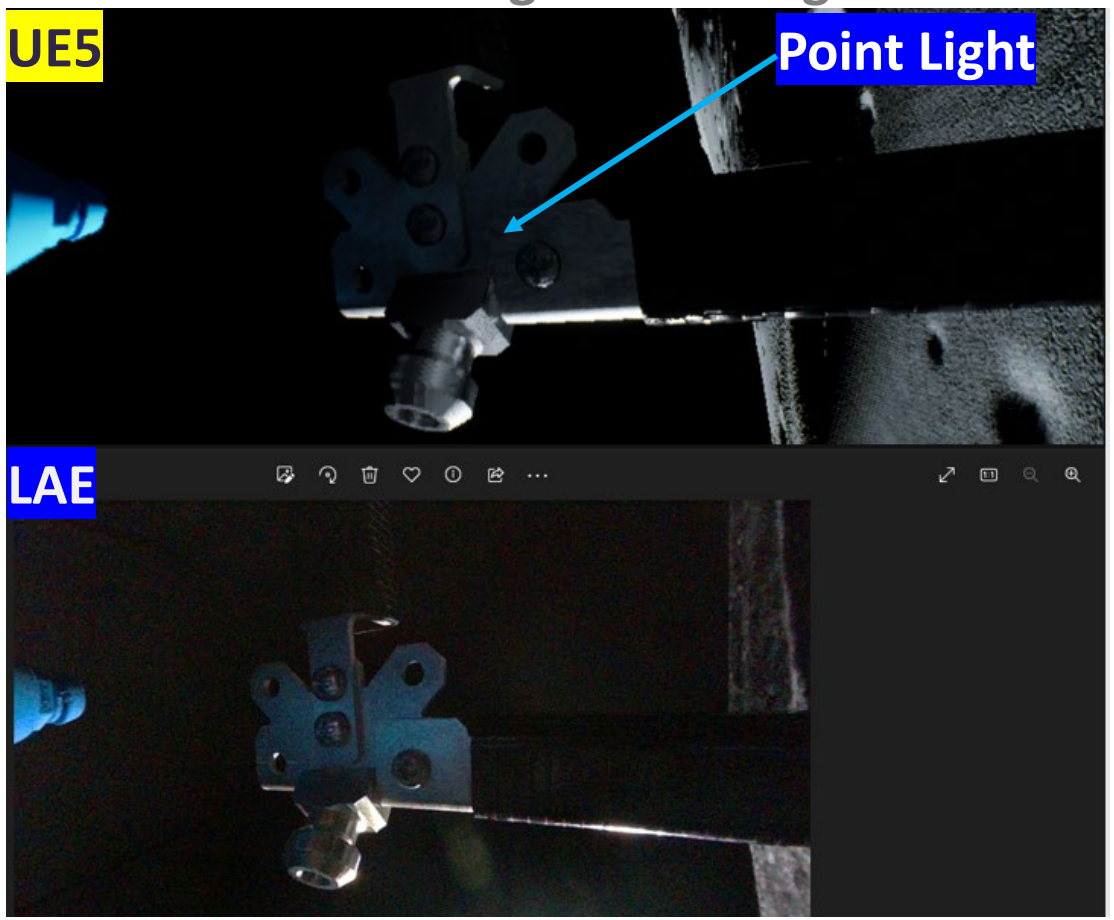
YOLO Object Detection Model for Assembly Inspection Cases

Rivet Joint Assembly Area Synthetic Image Dataset Finetuning

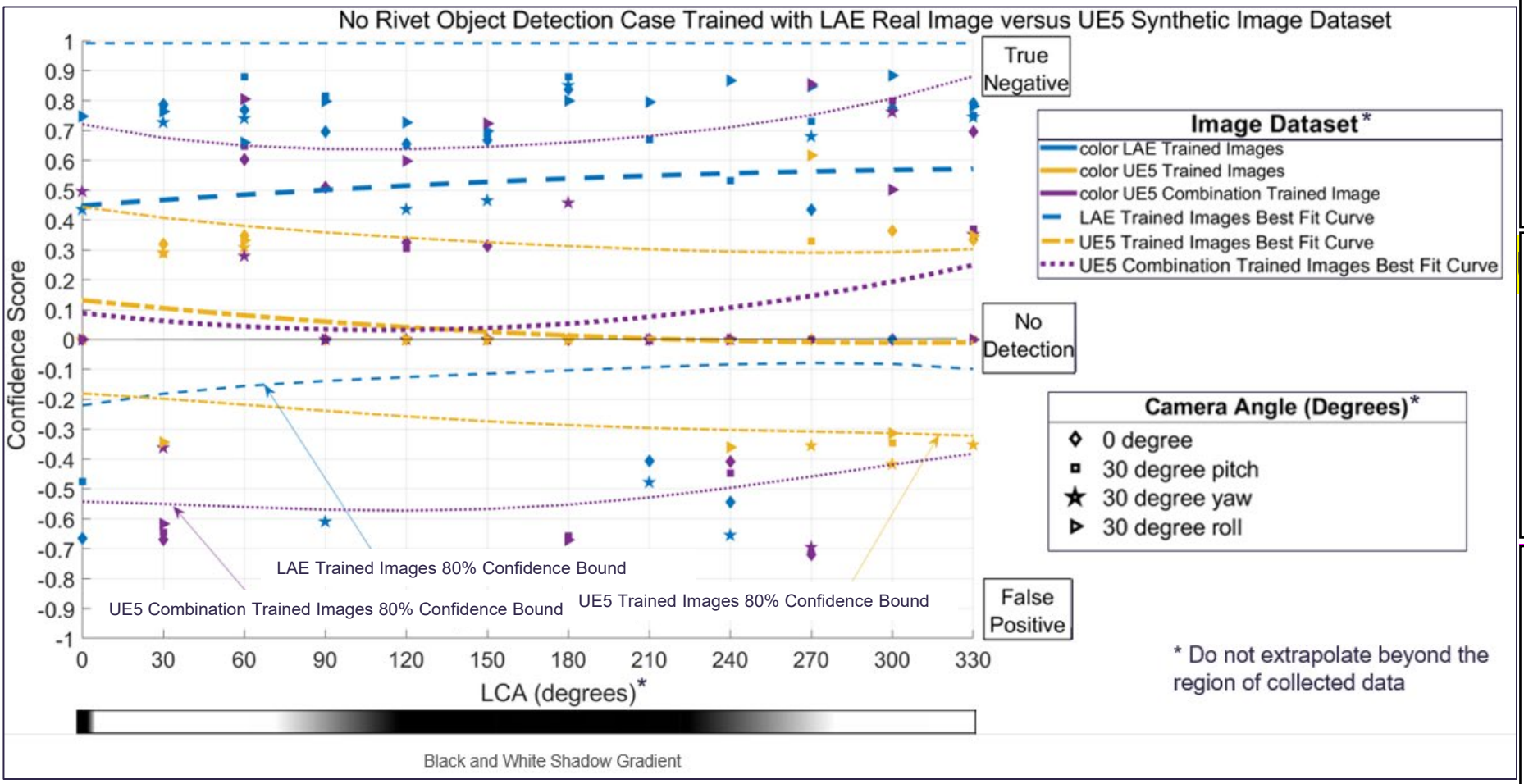
Surface Material Matching



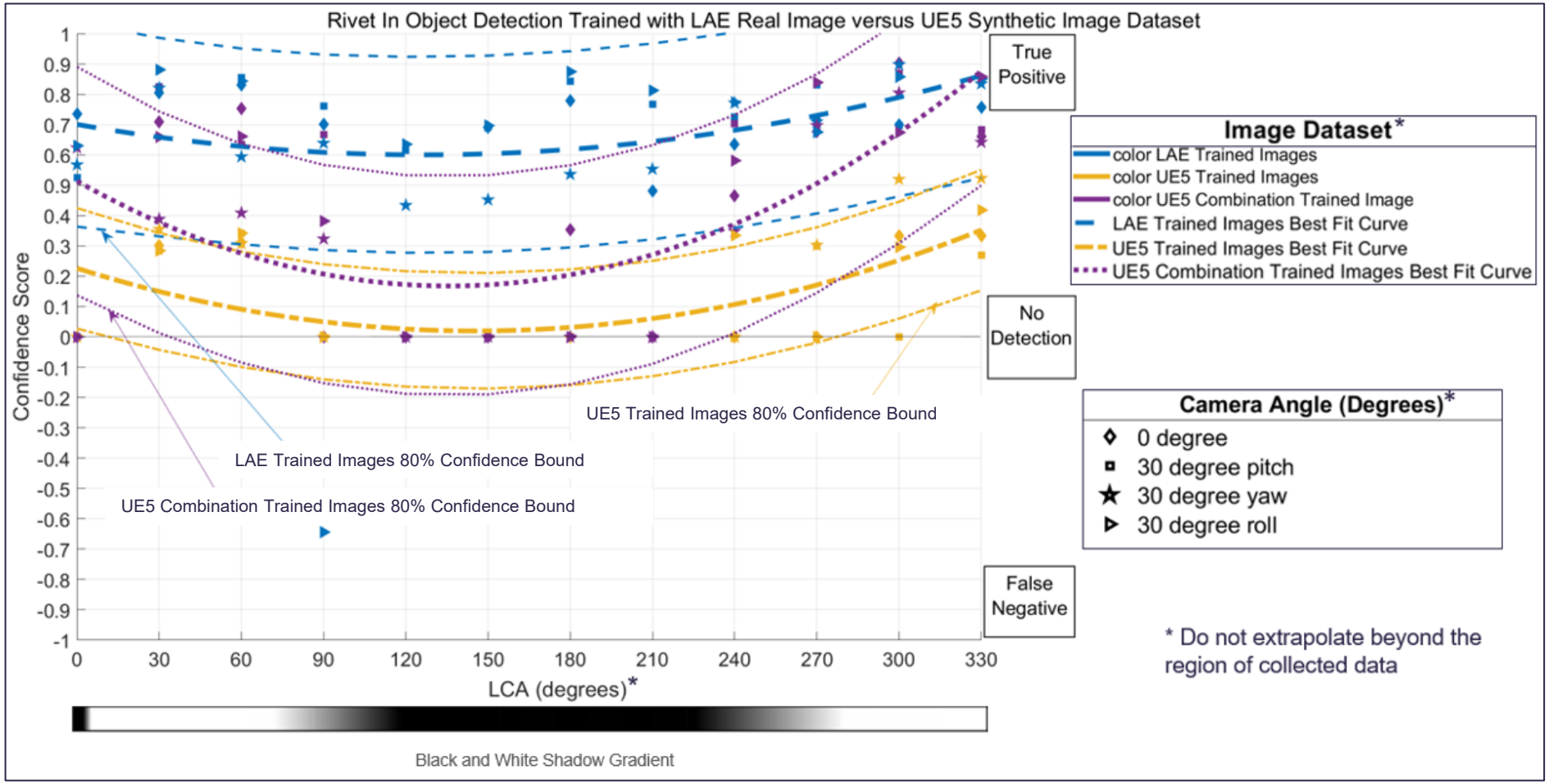
Ambient Light Matching



No Rivet Synthetic and Real Image Training Dataset Comparison



Rivet In Synthetic and Real Image Training Dataset Comparison



Concluding Remarks

- The Tall Lunar Tower (TLT) computer vision system in UE5 Lunar-SPLIT and LAE environments were presented
- Three YOLO object detection models trained with UE5 Lunar-SPLIT synthetic images and LAE real images were discussed
- Shadowing and illumination of joint assembly working area significantly affected object detection confidence scores and correct detection
- Visual fidelity of UE5 Lunar-SPLIT can be tailored for simulated objects to match real environments.
- Confidence scores from synthetic image training demonstrated that UE5 is a viable testbed for optical sensor simulations for TLT and In-Space Servicing, Assembly and Manufacturing (ISAM) applications

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