Investigation into the correlation between AI in a simulated environment and using a real low-cost UAV

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Applied Artificial Intelligence - MSC

Project Github

Aims & Objectives

AIMS:

The aim of this thesis is to gain an understanding through an investigative experimentation the effectiveness of an object detector under varying illumination conditions and altitudes on its ability to classify and detect trained targets in a simulated and real-world environment by using a camera sensor from a UAV to determine if there are any differences.

OBJECTIVES:

1. Devise an Experiment that is applicable in a simulation and the real world that utilises key "object targets" that the UAV can classify.

1. Accurately construct the Real-World experimental space within the simulation environment.

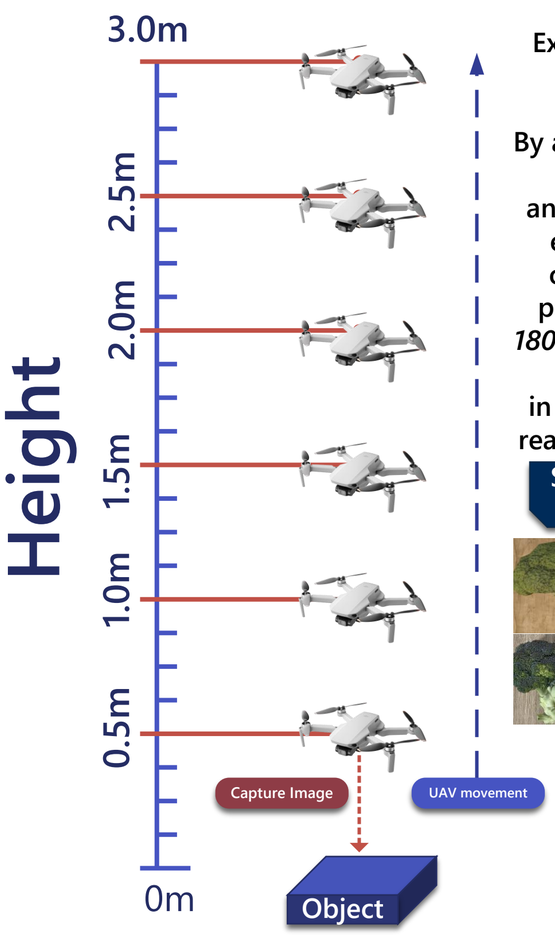
2. Synthesise & Train an AI algorithm within the realm of object detection using current methods.

3. Integrate the trained object detector algorithm into a UAV within a simulated and real-world environment.

4. Conduct both experiments within the environments to obtain valid results.

5. Evaluate results by comparing gathered data and establish reasonings using evidence behind any differences or similarities.

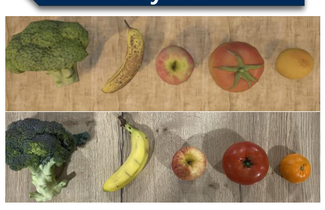
Methodology



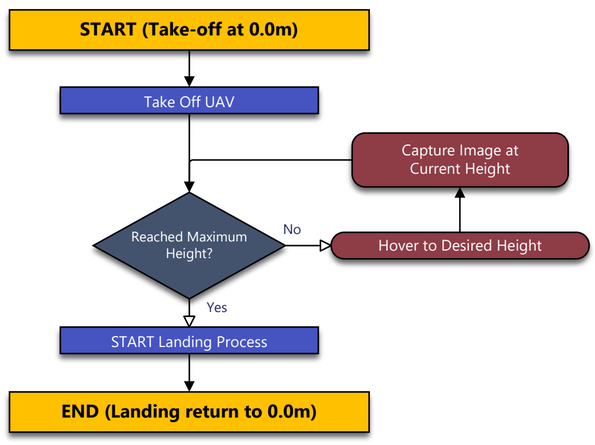
Experiment to Gather Results:

By adjusting the altitude of the UAV and illuminance of the environment, a set of experiments are performed to gather *180* images of the target objects in both simulation and real-world environment

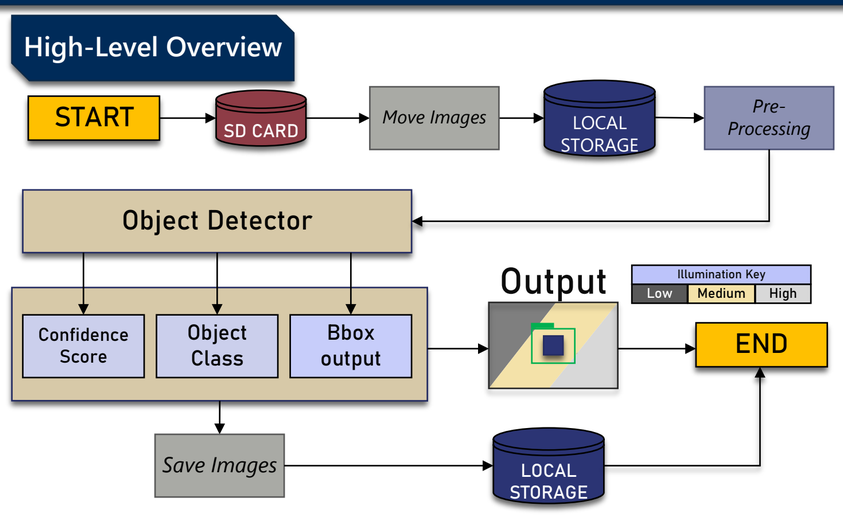
Simulated and Real Objects



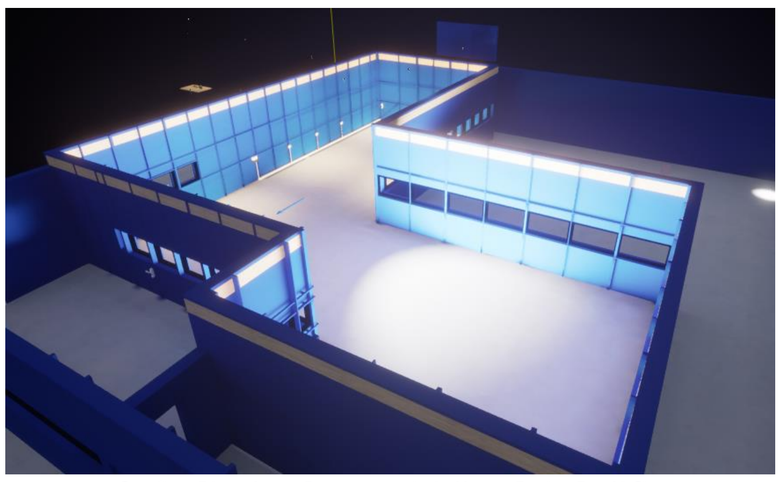
Experiment Flowchart



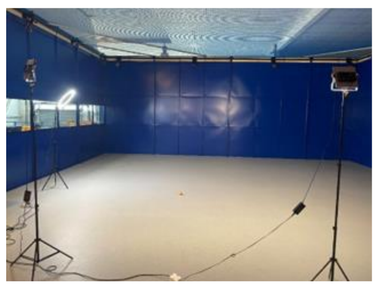
High-Level Overview



Implementation



Cranfield Flight Arena Developed within Unreal Engine For AirSim

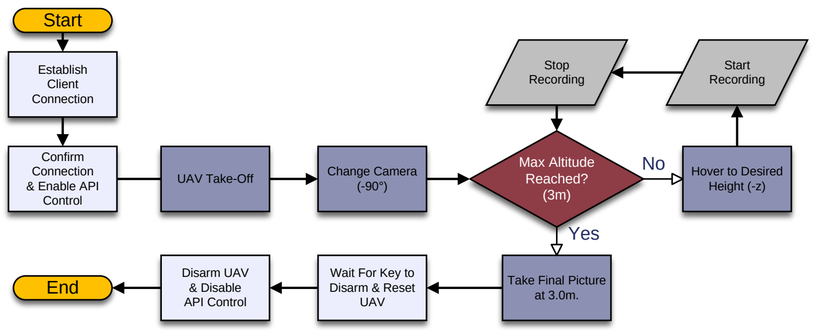


Illumination was controlled through the real would through LED Lights and Spotlights.

AirSim Altitude (-z[NED])	*Real-World Altitude (m)*
-3.05	0.5
-6.10	1.0
-8.13	1.5
-12.20	2.0
-15.25	2.5
-18.30	3.0

AirSim uses NED coordinates, which need a corresponding z value equivilence, this was found in the real-world and manipulated to work within the simulation.

AirSim Algorithm Flowchart

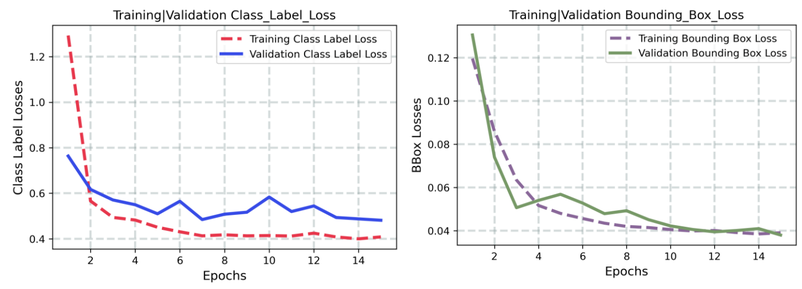


Training Algorithm Flowchart

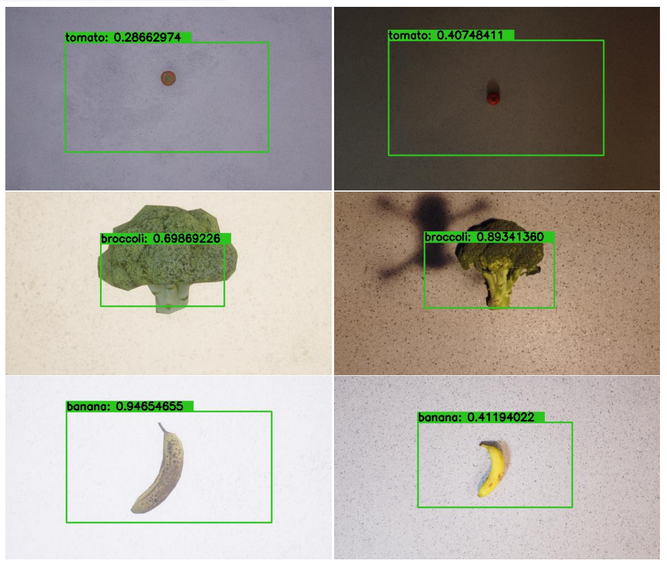
Testing Algorithm Flowchart

Results

Training Loss Curves



System Output



Classification - Metrics

		Object Classes					
Environment	Metrics	**Apple**	**Banana**	**Broccoli**	**Tomato**	**Orange**	**Average**
Real-World	Mean Accuracy	0.833	0.777	0.833	0.666	0.333	0.610
Simulator	Mean Accuracy	0.722	0.777	0.666	0.610	0.277	0.688

		Object Classes					
Environment	Metrics	**Apple**	**Banana**	**Broccoli**	**Tomato**	**Orange**	**Average**
Real-World	Mean Recall	0.833	0.777	0.775	0.660	0.333	0.595
Simulator	Mean Recall	0.667	0.777	0.607	0.590	0.333	0.675

		Object Classes					
Environment	Metrics	**Apple**	**Banana**	**Broccoli**	**Tomato**	**Orange**	**Average**
Real-World	Mean F1-Score	0.889	0.777	0.873	0.833	0.500	0.709
Simulator	Mean F1-Score	0.775	0.777	0.753	0.753	0.487	0.774

Regression - Metrics

	Table of mean IoUs				
Environment	**IoU_{Apple}**	**IoU_{Banana}**	**$IoU_{Broccoli}$**	**IoU_{Tomato}**	**IoU_{Orange}**
Real - World	**0.399**	**0.424**	**0.472**	**0.398**	**0.396**
Simulation	**0.416**	**0.427**	**0.517**	**0.406**	**0.437**

	Table of mAP at $_{IoU > 0.4}$				
Environment	**mAP_{APPLE}**	**mAP_{BANANA}**	**$mAP_{BROCCOLI}$**	**mAP_{TOMATO}**	**mAP_{ORANGE}**
Real - World	**34.1**	**54.4**	**62.1**	**26.5**	**26.3**
Simulation	**24.5**	**40.3**	**69.7**	**22.8**	**39.2**

Conclusion

Overall, through perseverance despite the limitations has provided an investigation into the correlation of an AI algorithm performing in a simulated and a real-world environment using a low-cost UAV to capture palpable results.

In terms of the object detection algorithm performing in both environments, the results correlate well, however this correlation is constricted through the model's ability to accurately predict the correct class and bounding box coordinates. The two manipulated values of altitude and illuminance do have an effect on the model's robustness although its very small.

The next step in refining the experiment would perform the experiments in a live scenario utilising a proposed system to access the closed architecture of the UAV through RTMP Streaming.