Master Thesis

Generating Synthetic Data for Object Detection using a 3D Model of the Target Environment

Keywords: Deep Learning, Object Detection, Synthetic Data, Simulation-Reality Gap

Tamara R. Dieter
Hochschule Darmstadt, FBI &
German Aerospace Center (DLR)
tamara.dieter@h-da.de

Prof. Dr. Andreas Weinmann
Hochschule Darmstadt, FBMN
andreas.weinmann@h-da.de

Date: 18/10/2022

Motivation

The lack of publicly available data, the cost intensity, and the high time expenditure associated with acquiring labeled data are leading to the increasing use of synthetic data when training *deep neural networks (DNN)* for diverse *computer vison (CV)* tasks (e.g., drone detection). Data generation methods range from fairly simple techniques, such as *domain randomization*, to game engine-based simulations in three-dimensional environments (e.g., via Unreal Engine). Despite their popularity, the discrepancy between simulation and reality (also known as *simulation-reality gap*) is a non-negligible and controversial issue of ongoing research. Therefore, the development of generation techniques for synthetic data, as well as the evaluation and quantification of their benefits and limitations are important research topics.

Figure 1: Drone detection example based on real data (top) and the corresponding 3D model of the target environment.

Objective & Method

The objective of this work is the analysis of the applicability of synthetic data for DL-based object detection derived from a three-dimensional replica of the target environment. This includes the game engine-based generation of synthetic data, the investigation of the existence and extent of the simulation-reality gap, and the adaption of simulation parameters to complete real data in the most efficient way for our application domain. This work is based on existing preliminary work, upon which further aspects will be explored.

Work Content

- Enhancement of the 3D model of the target domain (e.g., w.r.t. vegetation, lightning, weather conditions, or seasonal effects)
- Game engine-based simulations and generation of synthetic data
- Training state-of-the-art object detection models using different training strategies
- Evaluation of the usability and quality of the generated synthetic data (esp. regarding the simulation-reality gap) / comparison with existing approaches

Requirements

- Currently enrolled as a Master student in computer science, mathematics, optical engineering or similar major
- Experience in working with Unreal or Unity (or something comparable), experience with *Microsoft AirSim* advantageous but not required
- Interest in deep learning, image processing, and object detection
- Basic Python skills (ideally w.r.t. deep learning applications, e.g., *Pytorch* or *Tensorflow*)