Tool Description

WP6 - Modelling & Simulation Tool

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The Modelling and Simulation Tool provides a convenient system for generating high-fidelity synthetic air-operations datasets including environment selection, drone physics simulation and weather effects (e.g., wind, fog). The Tool utilizes 3D modelling environments, allows trajectory edition or waypoint selection, implementation of drone physics behaviour and supports multiple sensor configurations such as monocular or stereoscopic camera systems.

The first version of the tool uses Blender. It is a 3D open-source modelling and rendering engine applied for synthetic dataset generation. It supports loading of several data formats, supports animations, simulations and it is highly configurable. One of the advantages is the ability to render photorealistic images using Cycles render. Blender supports rendering into multiple cameras as well as configuring the parameters of cameras such as focal length or radial distortion. Cameras are connected to the 3D model of the UAV. After that, the centre of mass is animated in such a way as to simulate a fly-through of the city. The Blender provides tools for precise trajectory modelling and the trajectory can be exported to the external file using scripts. The exported trajectory data of the generated synthetic dataset is important for the evaluation of the accuracy of the trajectory estimation algorithm which uses the generated images as an input and the exported trajectory as a ground truth.

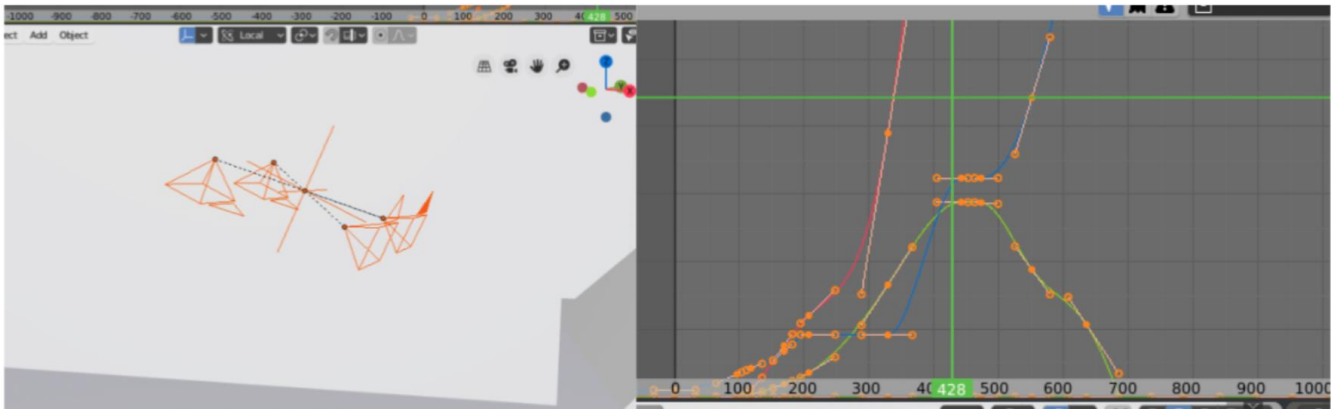

Figure 1: Model of the camera system (left) and planning of the trajectory (right)

Blender supports rendering using CPU, Cuda, and OpenCL or combinations of CPU+Cuda or CPU+OpenCL. The hybrid rendering that uses both CPU and GPUs is however not optimal. Blender renders only one frame in parallel and it is not feasible to render two frames in parallel. It is possible to start two instances of Blender, but it is not convenient, and it introduces other problems. If hybrid rendering is used, all devices work on the same frame, and it often occurs that the GPU(s) waits on the CPU. The rendering using Blender is the biggest bottleneck in the tool, after any change in environment or settings the dataset needs to be re-rendered, which can take a significant amount of time, depending on the resolution, number of cameras on UAV and desired framerate.

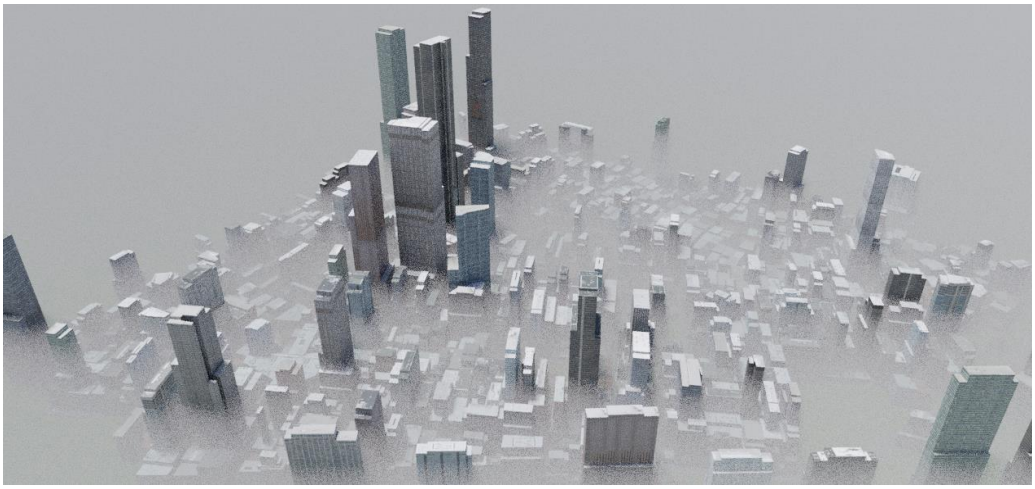

Figure 2: Simulated weather effect - fog

The alternate version of the Modelling and Simulation tool is being developed on the Unity engine. Unity3D has a powerful renderer, can support high-fidelity 3D environments, and provides a 3D physics simulation toolkit. Various Models of UAVs can be imported to the project and the movement is specified by direct inputs or by navigation goals. Especially the latter movement input provides a way to define an operating trajectory and the physical system will provide commands for the UAV, creating a more natural fly-through.

1.1.1.1 V cycle coverage

The Modelling and Simulation tool can be utilized for the design of sensor configurations of the UAV, generating, and observing visual data in such configurations. Trajectory estimation algorithms can be tested and evaluated by processing the datasets and comparing the estimated trajectory with ground truth. The impact of external forces such as fog and wind on the quality of the estimated trajectory can be investigated by setting various weather conditions in the Modelling tool.

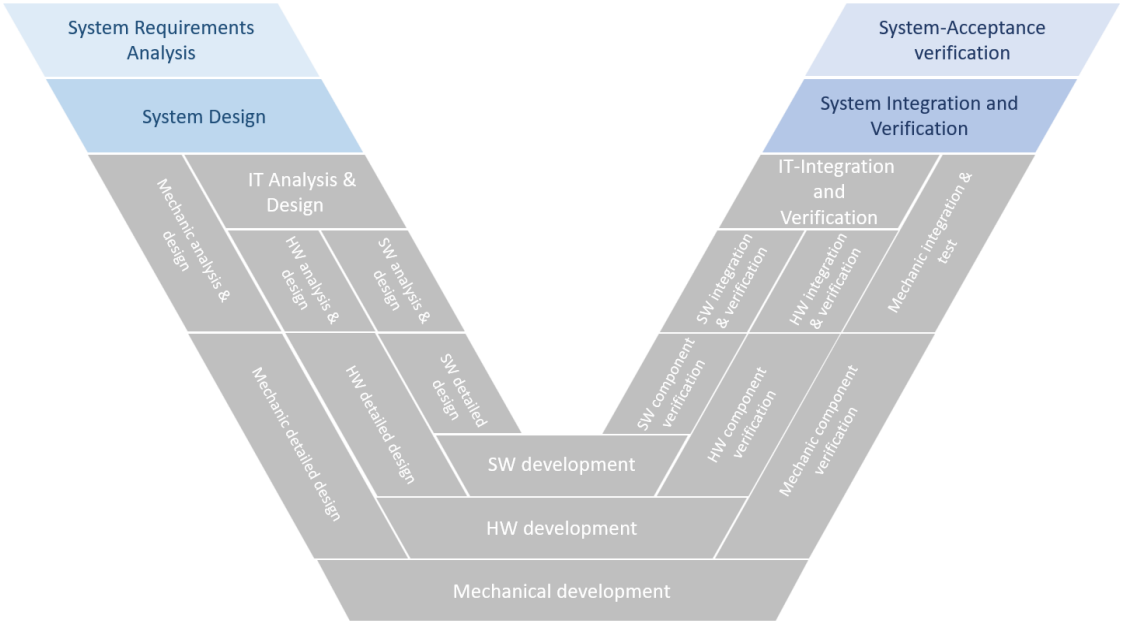

Figure 3: Scope of Modelling & Simulation Tool in the V-cycle

This tool has designed interoperability with BUT *Mission design and optimization* tool (Figure 4). This tool can be also integrated with other tools using a sequence of 6DOF poses.

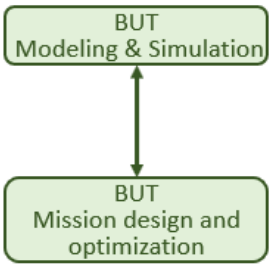

Figure 4: Modelling & Simulation Tool interoperability

1.1.1.2 Evaluation metrics

Table 1: Requirements and evaluation metrics for Modelling & Simulation Tool

ID	Requirement description
UC4-DTC-01	The tool shall provide high fidelity representation of dynamic models.

1.1.1.3 Assessment of metrics vs requirements

The goal of the requirement UC-DTC-01 is to provide high fidelity representation of the dynamic model. To simulate the visual data from UAV sensors the Simulation and Modelling tool can be used while designing the sensor configuration (positions and orientations of the cameras on the UAV body). The tool's options allow to create different camera configurations including their poses and intrinsic parameters (focal length, radial distortion) and generate images or videos of specified flight operations to evaluate the overlap between the cameras and coverage of the environment. This allows for a speed-up in UAV design without the need for physical construction to gain an insight into its reconnaissance capabilities.

Several camera configurations were tested, and the simulated datasets were evaluated by a trajectory estimation algorithm. The generated data contained 3D models of ground, street-level geometry, and buildings. The reconstruction algorithm was able to use the features from the images for successful trajectory estimation as it would using real data. The generated synthetic datasets can be also used to evaluate the accuracy and robustness of visual-based trajectory reconstruction and visual odometry algorithms. This enables the co-design of the UAVs and movement estimation algorithms in different weather conditions and sensor configurations without the need for real-data acquirement, saving time and resources.