Tool Description

WP6 - Big Data Analytics Tool

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The custom tool proposed by BUT to address UC4 consists of an algorithm combining Computer Vision analysis and Big Data to effectively provide per-pixel segmentation of drone-captured scenes. The tool consists of a Deep Neural Network trained on multiclass pre-annotated data and tuned to evaluate quickly on HD video captured by a flying drone mounted with an RGB camera.

The classes for which the model specializes are shown in the following table:

Table 1: Recognized object classes

Tree	Rocks	Dog	Fence
Grass	Water	Car	Fence-pole
Other vegetation	Paved area	Bicycle	Window
Dirt	Pool	Roof	Door
Gravel	Person	Wall	Obstacle

To make the proposed tool widely applicable to a range of scenes, camera resolutions, and video capture height-from-ground (AGL), the method is trained with the Semantic Drone Dataset in a multi-scale setting. This way, the U-Net for per-pixel segmentation can provide accurate analysis of the scene independently of pixel-to-scene measurement variations in the range of 1cm per pixel to 50cm per pixel.

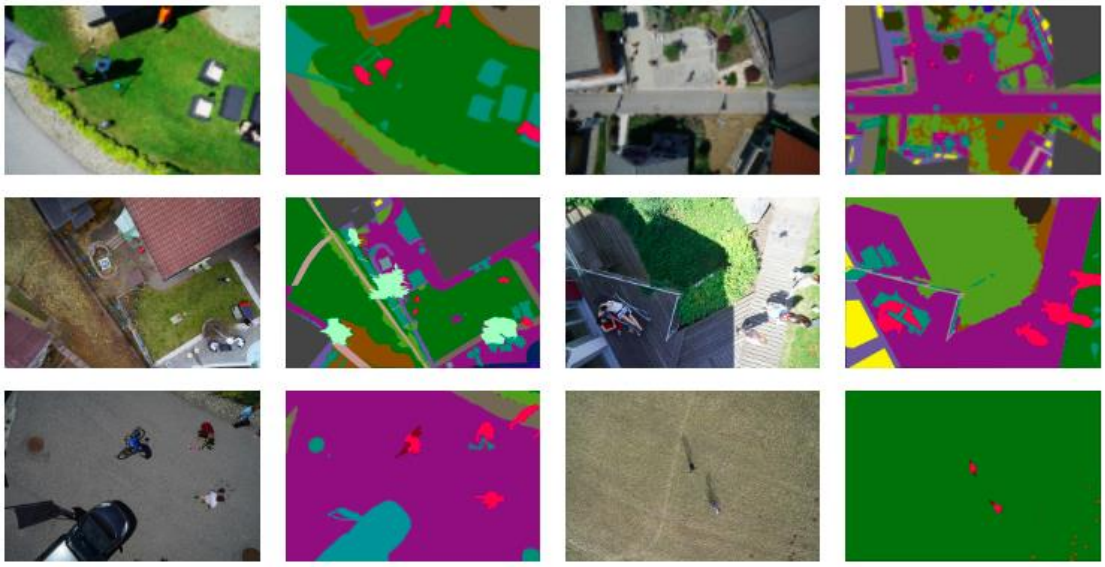

Figure 1: Scenes of various resolutions are compared for a visual assessment of variability and precision in pre-annotated data.

The custom tool is a complex Big Data analytics system for object detection, classification, and segmentation utilising custom raw data as well as annotated external datasets. By utilising a deep segmentation network trained on the Semantic Drone Dataset, the tool enables the processing of Big Data in the form of raw video from drones and associated metadata. For any given scene, the information is aggregated, fed into the training pipeline, and leads to the creation of a segmentation model.

By providing per-pixel class information, the outputs can be aggregated to an image-wide or scene-wide categorization, enabling further information extrapolation from the data. The tool consists of object detection, extraction of objects from video/images, storage of the images and processing of a database of the objects, (semi) automatic annotation of the object database, and analytics/machine learning sub-tools for processing of the database (AdaBoost/WaldBoost and/or Random Forests and/or CNN based tools, etc.).

Thanks to an efficient strategy for storage, retrieval, and modelling, the provided system has the following benefits:

- Big Data in the form of high-definition videos from drones
- The tool input is a series of video frames and semantic drone telemetry
- The input is optionally augmented with sparse metadata annotations, including class ID and scale (computed from drone altitude)
- Pre-trained classes
- A training tool capable of runtime configuration to enable training of new relevant classes found in the data, given samples images, telemetry, and annotations

1.1.1.1 V cycle coverage

The utilisation of the tool greatly benefits the V-cycle steps associated with this work package. Namely, the steps leading to SW development preparation, SW development, and Integration and validation are addressed as described below.

System Requirements Analysis – Understanding of the scenes to be captured is supported by an analysis of existing datasets, and requirements. See the following figure for a range of examples:

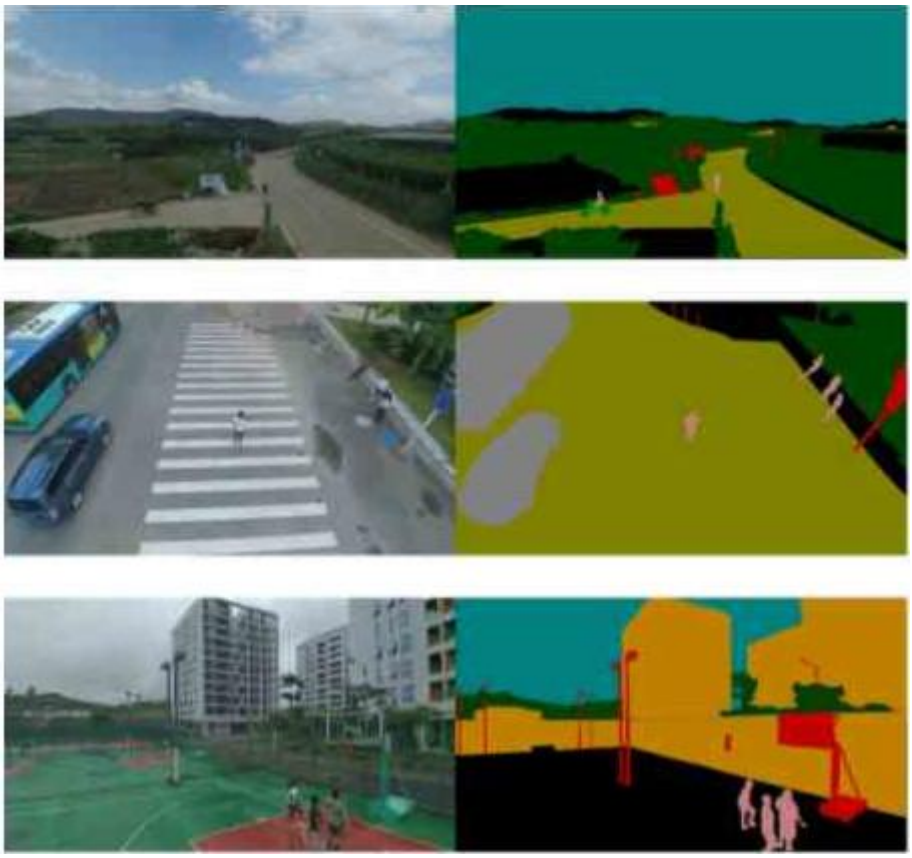

Figure 2: Example of various supported scenes.

System Design – The design of the system stems from the complexities associated with sensing, control, and capture. Issues to be addressed are data streams, flow, and capture settings (ex.: angle, speed, FPS), as well as camera parameters and requirements with respect to weather conditions.

IT Analysis & Design – The captured data and infrastructure defines how the software should be designed, and how it should be integrated into the solutions provided. Therefore, an understanding of the data, segmentation classes, and data flow requirements defines how the IT should be analysed and designed. An appropriate design consideration is a multi-level integration, such as that made possible by the Feature Pyramid Network (FPN):

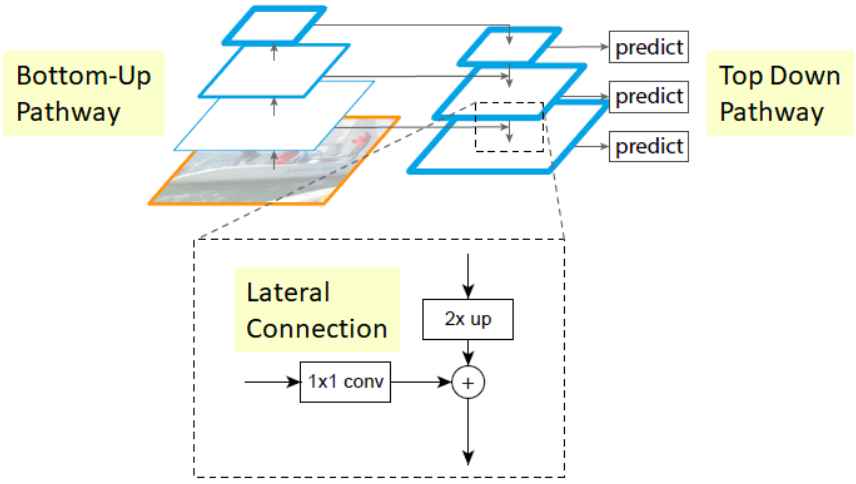

Figure 3: Feature Pyramid Network diagram.

SW Development – This portion of the process is critical, but well-prepared for by preparation steps undertaken before. The selected Big Data architecture and Computer Vision components need to be developed so that the system is trained on pre-annotated data is compatible with evaluation procedures for quality assessment and can be deployed for applications on raw captured data from drones involved in this work.

IT-Integration and Verification – As the developed method is prepared for testing, it can be verified with cross-validation on pre-annotated data, as well as held-out scenes. Integration is not critical for training but must be performed for drone imagery processing.

System Integration and Verification – By taking imagery from the drone, the developed method can be integrated into the data flow, and domain experts are to be approached with the task of stability and accuracy verification of predicted segmentation.

System-Acceptance verification – The level of unification and simplification provided by the solution is assessed by measuring how much it simplifies the desired data capture and processing flow. Furthermore, the data analysis capabilities are assessed by considering the ability to detect different object classes from new videos/images. These classes are outlined above in a table in section design.

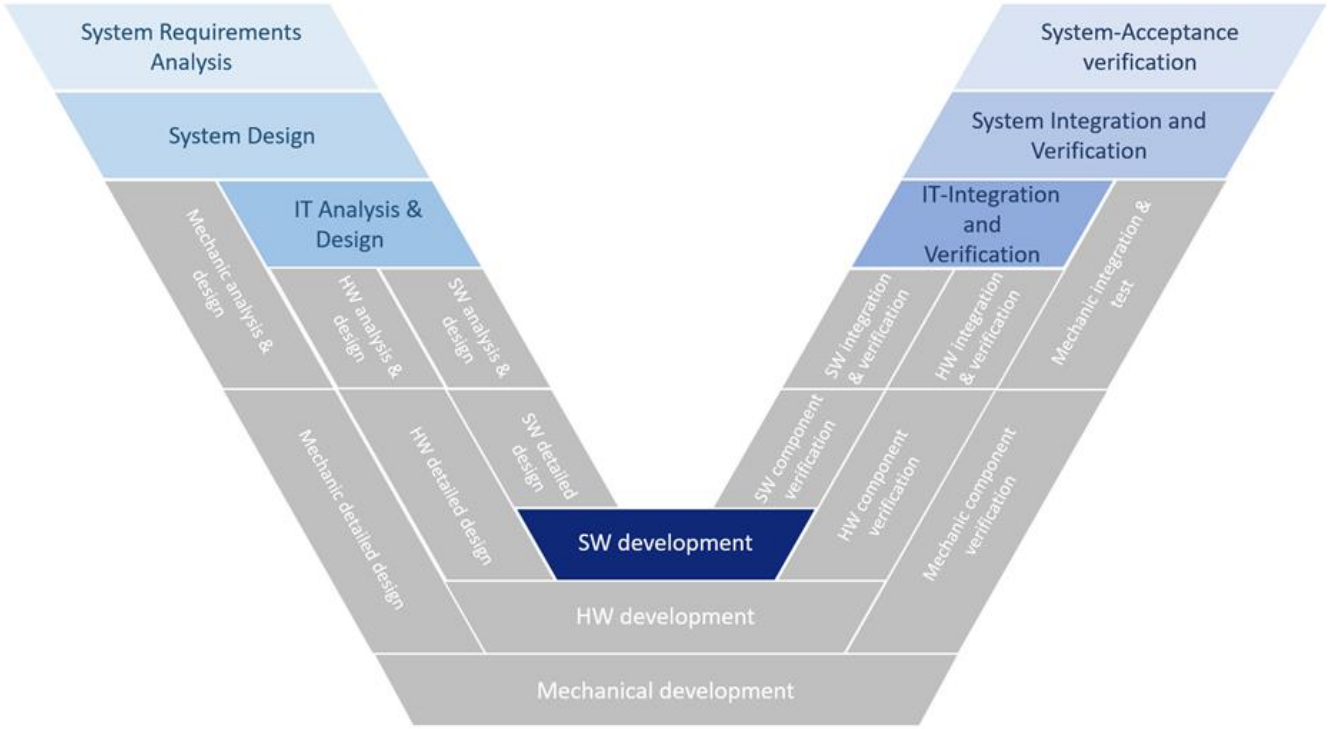

Figure 4: Scope of Big Data Analytics Tool in the V-cycle

1.1.1.2 Evaluation metrics

Table 2: Requirements and evaluation metrics for Big Data analytics tool

ID	Requirement description
UC4-DTC-60	The tool shall provide data analysis capabilities. It shall be possible to detect different objects from video/images.
UC4-DTC-61	The Big Data Analysis tool should unify and simplify the processing of acquired data.

There is no planned interoperability with other tools, but this tool processes videos and metadata, which allows low-effort integration of this tool.

1.1.1.3 Assessment of metrics vs requirements

Metrics addressing the level of completion of UC4-DTC-60 are outlined above, and they practically consist of:

- Cross-validation on training labelled imagery
- Stability tests as evaluated by domain experts
- Accuracy assessment as performed by domain experts on captured drone data

Conversely, metrics addressing the level of completion of UC4-DTC-61 focus on the level of integration of Data Flow with respect to expert user time savings. Therefore, these consist of

- Comparison of annotation pipeline with vs. without the Big Data Analysis tool
- Throughput test of the developed solution