AVITRACK

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Deliverable D6.1 A
Prototype scenes tracking evaluation

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1. INTRODUCTION

This document presents the first part of the evaluation results of the AVITRACK tracking prototype. Subject of the evaluation is Motion Detection and 3D Scene Reconstruction.

Motion Detection was evaluated by pixel-wise comparison of the results and a manually detected ground truth in terms of false negatives and false positives.

3D Scene Reconstruction was evaluated by comparing trajectories with the well known patching lines of the echo-40 apron.

2. PERFORMANCE EVALUTION

2.1. OVERVIEW

The main purpose of performance evaluation on computer vision systems is:

- To compare with other algorithms
- To demonstrate the robustness and reliability of the algorithm
- To improve the algorithm from the performance evaluation results

2.2. VIDEO DATASETS

In order to be objective, the evaluation of the prototype is based on video datasets containing realistic conditions according to the following situations:

- Type of vehicles operating at the airport's apron
- Number of individuals and vehicles in the scene
- Complexity of the scene
- The detection quality of the prototype in front of shadows, reflections, illumination changes, low chromaticity information and distance between objects and cameras.

2.3. MOTION DETECTION EVALUATION

The algorithm currently used by the AVITRACK motion detection module is Colour Mean and Variance.

To evaluate motion detection performance on the prototype motion detection module three apron datasets have been chosen (**S21 – Camera 1**, **S3 – Camera 1** and **S3 – Camera 2**).

Ten reference frames are chosen from each dataset and ground truth images are created manually in those frames by examining the previous frames and looking for any motion.

These segmented objects are compared with the foreground objects detected by prototype and false positive, false negative, true positive and true negative object pixels are counted and summed up over the chosen frames and compared with each other.

The purpose of performance metrics is to characterize the success and failures of the prototype evaluated against the data produced by the ground truth.

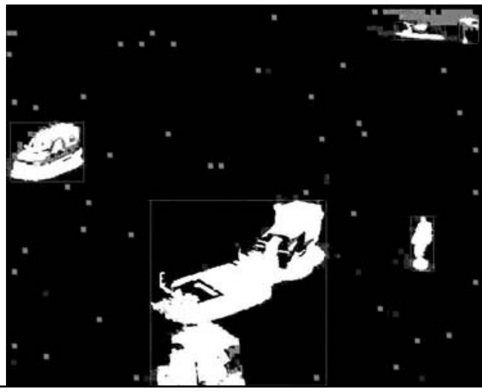
The following metrics are used to evaluate the performance of the prototype motion detector.

- Detection rate: *TP/(TP+FN)*
- Specificity: *TN/(TN+FP)*
- Accuracy: *(TN+TP)/N*
- False negative rate: *FN/(TP+FN)*
- False positive rate: *FP/(FP+TN)*

where N is the total number of pixels, TP number of true positives, TN number of true negatives, FN and FP number of false negatives and positives respectively.

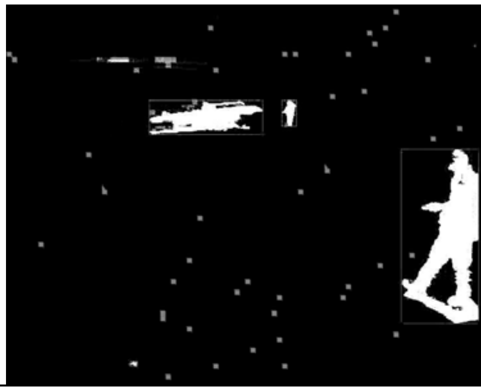
Next a reference image from each of the chosen sequences with their respective ground truth and the output of the prototype motion detector are shown.

➢ S21 Camera 7

Reference image – S21 Camera 7	Ground Truth	Prototype
		

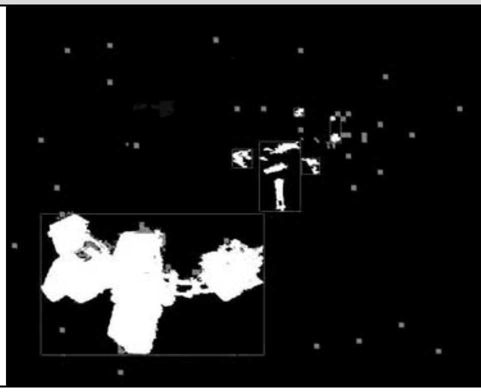
The individual segmentation quality is acceptable. The vehicle segmentation quality depends on the presence of shadows and also on the chromaticity information of the scene.

➢ S3 Camera 1

Reference image – S3 Camera 1	Ground Truth	Prototype
		

Strong shadows are detected as mobile objects and misclassified as foreground pixels as can be well seen in the frame. A ghost is presented at the top on the left side.

➢ S3 Camera 2

Reference image – S3 Camera 2	Ground Truth	Prototype
		

The loader of the frame which starts to move slowly is partially detected during few frames. Strong shadows are detected as part of the mobile objects.

➢ Conclusions

The prototype motion detector can not handle strong shadows in sequences S3-Cam 1 and S3-Cam 2 and shadows in sequence S21-Cam 7 (foggy conditions). The shadow suppression methods currently implemented are based on the use of chromaticity information.

The prototype motion detector is robust against illumination changes. In front of low chromaticity information in the scene objects are partially detected and in some cases foreground pixels are misclassified as highlighted background pixels. Holes and fragmentation are presented in objects with the same colour as background.

2.4. 3D SCENE RECONSTRUCTION EVALUATION

For the first AVITRACK prototype 3D scene reconstruction evaluation only individuals have been considered.

The consortium has chosen datasets **S27 – All Cameras** for the prototype 3D scene reconstruction evaluation. S27 datasets contain individuals walking on well known trajectories along the patching of the apron echo-40 ground. We can then compare 3D prototype data output to real data.

The following criterions have been considered to choose individual trajectories from datasets S27 – All Cameras:

- Distance between camera and individual
- Horizontal / Vertical trajectories respect to the ground patching
- Occlusions
- Reflections

➢ Performance metrics and statistics

A trajectory is defined as a sequence of positions over time. Paths are distinguished from trajectories by defining a path as a trajectory not parameterized by time.

The 3D output data of individuals defines trajectories while the lines of the apron's patching are defined by paths.

In order to evaluate the performance of the 3D scene reconstruction, the trajectories have been considered as paths. For each position of the person the shortest Euclidean distance between the point defining the position and the patching line is calculated.
The following performance statistics metrics are applied to the results:

- Mean
- Standard deviation
- Minimum
- Maximum

➢ Experimental results

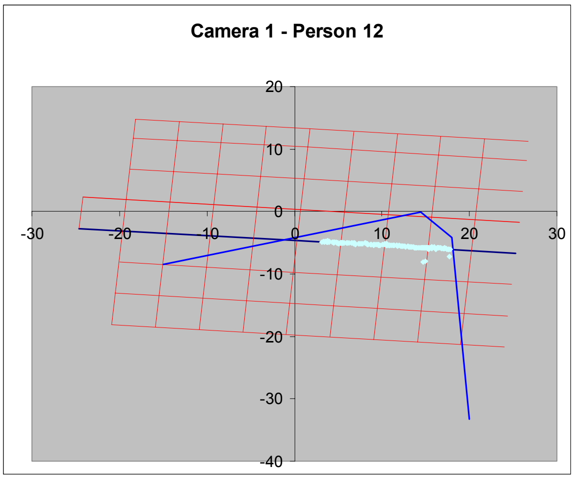


Figure 1: Example of 2D graph

Figure 1 shows an example of a 2D trajectory graph for camera 1 and person 12. The light (red) lines represent the patching lines and the dark (blue) lines represent the line which the person should follow. The light (blue) lines represent the camera field of view and the color light (turquoise) represent the person's trajectory.

➢ Conclusions

The 3D scene reconstruction accuracy depends on the distance between the camera and the object.

The output of data fusion module will contain the best camera field of view for a set of frames taken at the same instant. The best camera field of view for each time instant can be computed by the confidence measure and Appearance Ration. The data fusion output information will help to improve trajectory accuracy.

Reflections provoke errors on the reconstruction of 3D trajectories. Occlusions lead to loss of 3D data information and also provoke errors on 3D trajectory reconstruction.

Once again, the prototype 3D output data of the different cameras can be combined in order to obtain more accurate trajectories.

3. SUMMARY

This first evaluation has demonstrated the operational functionality of first tracking prototype version detecting all objects in the area, people and all the vehicles around the aircraft. The hardware design tests has proved the efficiency real time processing of the implemented algorithms.

Qualitative tests have been realized on several video sequences illustrating the capability of the prototype to process tracking on all cameras field of view, on different scene complexities considering number of individual and vehicles.

The prototype motion detector has been tested on sequences with various weather conditions, including bright sunlight and fog. Gradual illumination changes can be handled without problems.

Detailed evaluation, using metrics, points some limitations of the actual version:

- Shadows provoke undesirable situations in 3D object reconstruction and tracking as they are incorporated as part of the mobile objects.
- The low chromaticity information in the scene provokes detection errors reducing the sensitivity of the motion detector.
- Object ID and the accuracy of the 3D scene reconstruction are influenced by occlusions and reflections.

The actual AVITRACK prototype is clearly efficient and constitutes an excellent first version of the prototype.

Necessary improvements are identified. Solutions are planed to be integrated and evaluated during the next task.