Structure and ground plane extraction from optical flow

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The DIPLECS project

The DIPLECS project entails the design of a cognitive system capable of learning and adapting to everyday situations, with particular application to driving scenarios. One of the goals of the project is to use computer vision, and especially optical flow information, as a tool for analysing inputs from different operating environments (e.g. road surface, non-navigable regions, obstacles).
A mobile platform has been constructed, which is used for demonstrating our developed approaches to learning. It is based on a standard RC car platform, fitted with a camera and an on-board mechanism for recording images, control signals and sensor readings. See Fig. 1.

For more information about the DIPLECS project, see http://www.diplecs.eu/

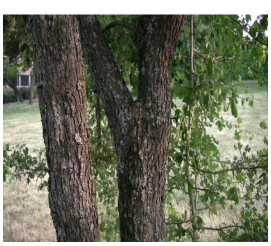
Fig. 1 The RC car platform developed for the requirements of the DIPLECS project.

Structure from motion

We have developed a robust, context dependent feature tracker that can be used for analysis of different environmental cues (see Fig. 2). It is composed of:

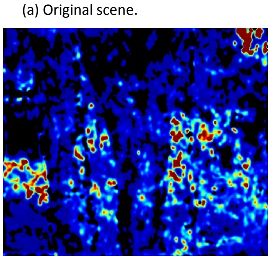
- A standard KLT **region tracking** algorithm, used in both directions (track-retrack) to reject any inconsistent point trajectories early into the tracking process [1].
- A **learning step** that uses a histogram of oriented gradients (HOGs) descriptor to train a classifier and select appropriate regions to track. The classifier can be trained on a specific environment and thus outperform traditional generic methods based on the Harris measure [2].

Training the classifier requires ground truth data. We have investigated the use of advanced rendering techniques for generation of ground truth motion fields from synthetic images [3].

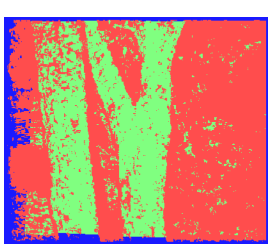


(a) Original scene.

Fig. 2 Comparison between Harris and HOG-based approaches. In the former, points will be generated on regions of high probability (red) which as we can see are mostly on small objects (leaves) that undergo non-rigid motion and thus not good for tracking or ego-motion estimation. In the latter case, areas of high probability (green) outline rigid objects (trunk) very well and are used for training the classifier.



(b) Generated Harris energy.



(c) HOG based ground truth.

Ground plane extraction

If we know the location and boundary of the ground plane then we can establish the position of our vehicle and determine a path through the world. For extracting the ground plane, we devised a simple yet effective algorithm where a robust plane fit is determined from the 3D world points using RANSAC. Any points that are beyond some distance threshold from the plane are classified as outlying obstacles and assigned a probability value. This leads to a "confidence" density map of where the road surface is in the 2D view (see Fig. 3).

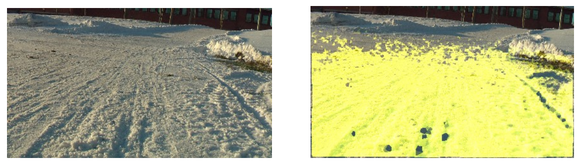


Fig. 3 On the left a typical frame captured with the RC car. On the right the superimposed ground plane density map in yellow.

Obstacle detection in 2D and 3D

We have also explored the probabilistic extraction of planar patches in 3D using geometric and intensity information [4] as a way of segmenting distinct, generic objects in the scene. Under typical conditions, our method is an effective and efficient tool, which can be used to augment the existing obstacle detection we have developed. Some characteristic examples can be seen in Fig. 4.

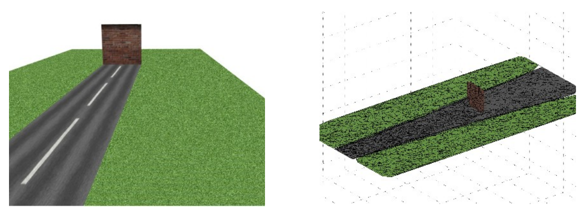
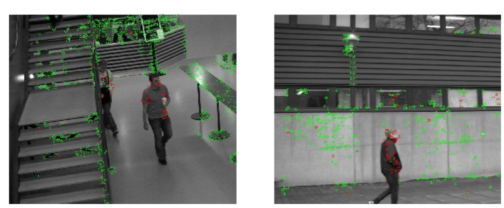


Fig. 4 A synthetic 2D view of a path (left) and the extracted planar patches in 3D (right).

We have also carried out some work on detection of motion outliers, that is, objects (2D image points) that although move in a consistent manner do not obey the rigid world assumption. These points are very likely to correspond to moving obstacles in the scene. Our method [5] uses the geometry of 6 points in a scene to infer groups of such motion outliers, and appropriately segment them from other stationary points. Typical results are shown in Fig. 5.

Fig. 5 Detection of motion outlier points (red) within a static scene that obeys the rigid world assumption (green).



References

[1] J. Hedborg et al. **Fast and Accurate Structure and Motion Estimation**. ISVC 2009
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