HIGH ACCURACY STEREOVISION SYSTEM FOR FAR DISTANCE OBSTACLE DETECTION

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Aims

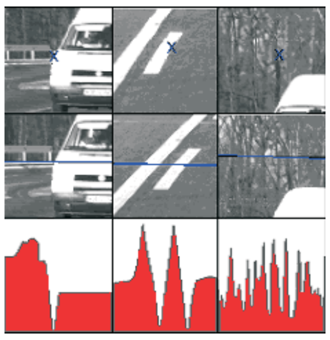
- Real time obstacle detection in real and variate traffic scenarios
- Far distance, high speed obstacle detection
- 3D position measurement accuracy comparable to an active sensor
- Data richness specific to a vision sensor

Method Highlights

- Real-time, general configuration stereovision on high resolution images.
- Most important prerequisite: the high-accuracy, far distance camera calibration.
- The general-purpose 3D point map serves as input to a point-grouping algorithm that compensates for the point density variation with the distance.
- Model-based tracking serves as grouping refinement and speed estimator.
- The output is described in the form of cuboids having position, size and speed.

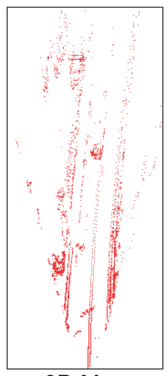
Extracting 3D Information by Stereovision

Edges detection as feature selector



a b c

- The selected left image features are searched in for their right image correspondents along the epipolar lines.
- Only the matches where the similarity function has a clear minimum (a) are kept
- Repetitive patterns (b) or fuzzy vegetation patterns (c) are filtered out.
- Sub-pixel interpolation of the result is performed.
- The 3D point map is obtained using the general stereo geometry and the camera parameters obtained through an accurate long-distance calibration



3D Map

Grouping the 3D Points into Objects

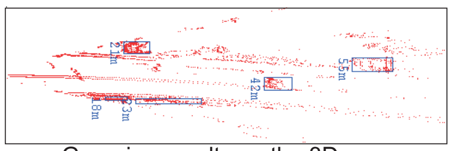
The first step is to bring the 3D points in a transformed space that compensates for the variation of point density with the distance.

$$row \quad \log_{1\,\frac{k}{f}} \frac{z}{z_{\min}} \qquad col \quad X\, f\, \frac{1}{Z}\, k$$

Compressed space

Labeling in the compressed space

- In the compressed space the elevated 3D points can be grouped directly by labeling.
- The objects are formed by taking the original 3D points corresponding to each label, and creating the cuboidal envelope.



Grouping results on the 3D map

Grouping results on the left image

Tracking

- Used to estimate the dynamic behavior of the objects, but it is also a grouping refinement method.
- Position, size and speed are filtered through the equations of the Kalman filter.
- Supplementary validations are imposed on the results: a minimum and maximum size, consistency from one frame to another.
- Smaller objects can be joined in a bigger one if they have similar trajectories.

Results

The system has been proven functional in a large variety of traffic scenarios: two way roads (a,d), urban roads (b), highways (c). The maximum guaranteed detection distance is 100 m and the maximum tested relative speed of the obstacles is 200 km/h (d). The distance measurement error is in the neighborhood of 30 cm at 50 m, and increases to 2.5 m at 100 m. The processing rate is 10 fps on a standard 1 GHz P3.

a

b

c

d

Extensions

- Improvement of the stereo reconstruction: special handling of the repetitive patterns (disambiguate instead of reject); reconstruction of the horizontal lines
- Lane detection: the general-purpose 3D point map may form the input for a 3D lane detection algorithm. A lane detection module can also help the obstacle detection by providing a more accurate means of selecting the points above the road plane, by providing search regions, etc.
- Specific object detection: the system's ability to detect any object can be used to transform it in a specialized object detector: vehicle detector, pedestrian detector, road sign detector. The objects are already having size, position and speed, making the subsequent classification much easier.

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