ROAD RECOGNITION IN MATLAB ENVIROMENT

V. Šimák, J. Hrbček

Department of Control and Information Systems, Faculty of Electrical Engineering, University of Žilina, Univerzitná 8215/1, 01026 Žilina, Slovak Republic

Abstract

This paper deals with a road recognition system. The work presented in this paper has been carried out during author's study stay at the Automation Technology Laboratory of the Helsinki University of Technology (TKK).

1 Basic of road recognition

Road recognition in images is a very complex task.

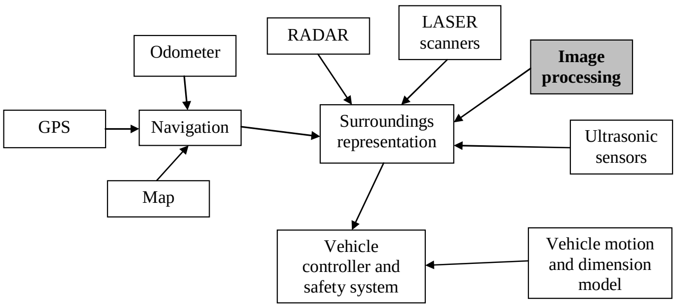

Figure 1: Image processing used in vehicle control

The basic principle of all recognition algorithms is comparison between image and model. Some constraints by creation of model are also needed because nowadays computers have not adequate computing power to animal or human brains which are able to easy perform this task. The constraints are following:

- Road has constant width along all its length.
- Image taken by the camera is ideally perspective projection of the scene.
- Ambient scene illumination (without any significant shadows).

Some conditions for analysis are also needed because of ability to analyze the scene.

- Road cannot have the same hue as ambient.
- Algorithm described below is up to certain level noise resistant, but is not resistant to shades angle-wise shade projected on the road (e.g. trees, streetlights… etc.).
- Road is lighter than surroundings.

2 Description of the analysis

- Loading image from file.
- Identification of image resolution.
- Cutting of not important parts of image (engine bonnet and scenery above horizon).
- Selecting 5 rows of the image in 1/6, 2/6, 3/6, 4/6 and 5/6 of image height.
- Comparing these rows with ideal road width using cross-covariance (1) utilizing Matlab

command xcov.

$$\mathrm{cov}(X,Y)=\frac{1}{n}\sum_{i=1}^{n}(X_i-E(X)).(Y_i-E(Y)) \quad where \quad E(X)=\frac{1}{n}\sum_{i=1}^{n}X_i \quad and \quad E(Y)=\frac{1}{n}\sum_{i=1}^{n}Y_i \qquad (1)$$

- Finding maxima of the cross-covariance and projecting it to the image width.
- Rotating coordinate system of selected points about 90 degrees, because during approximation y=f(x) is vertical line hard to approximate.
- Polynomial approximation of selected points.
- Rotating coordinate system of selected points and approximation line back about -90 degrees.
- Plotting coordinates of road middle and selected points into the image.

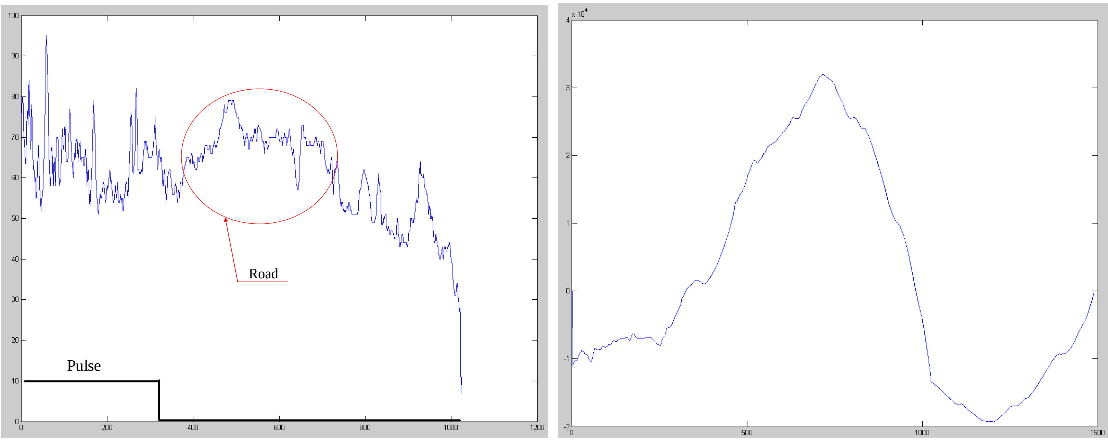

Figure 2: Image row and cross-covariance result between this row and pulse of same width as road on image

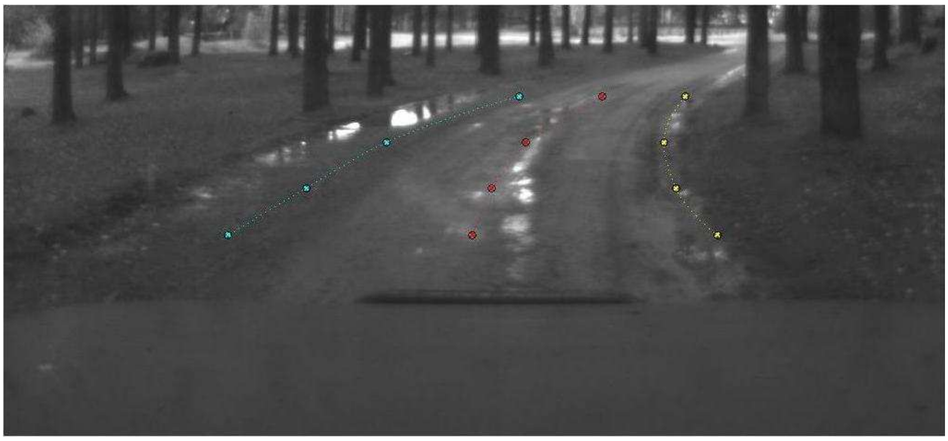

Figure 3: Interpolated result of searching road in image

3 Cross-covariance improvement

The cross-covariance looks like to be a very strong tool in image processing. Unfortunately, it takes a lot of computing power because the mean values are calculated in every shift between pulse and image row. Therefore I used following constraint (see below) that allows me to save the computing time.

- Number of shifts between pulse and image row is reduced from *n* to *n-s-1* where
  - *n* is image width (pixel)
  - *s* is pulse width (pixel)

This constraint causes that both *E(x)* and *E(y)* from formula (1) are constant during whole cross-covariance function computing. This simplifying allows me to reduce cross-covariance calculation to calculation of first cross-covariance (2) and following calculation of changes (3) see Figure 4.

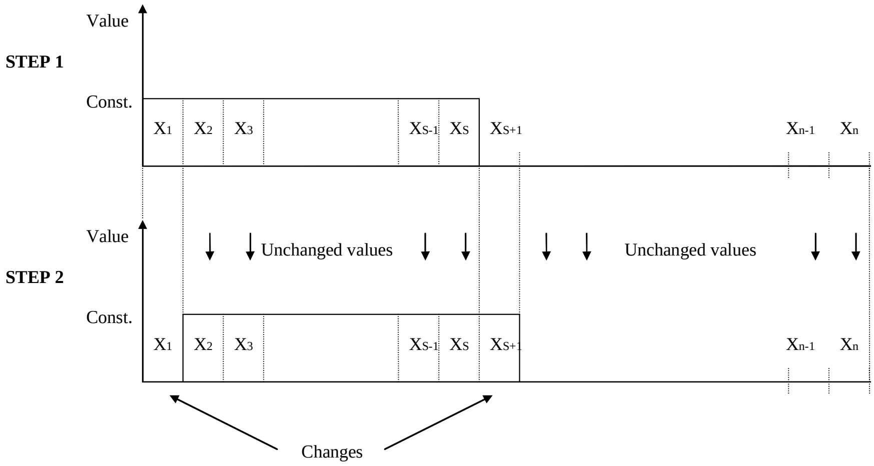

Figure 4: Calculation of cross-covariance

$$\operatorname{cov}_1(X,Y)=\frac{1}{n}\sum_{i=1}^{n}\left(X_i-E(X)\right).\left(Y_i-E(Y)\right) \tag{2}$$

$$\begin{aligned}\operatorname{cov}_{m+1}(X,Y)&=\operatorname{cov}_m(X,Y)\\&-\left(\left(const.-E(X)\right).\left(Y_m-E(Y)\right)\right)-\left(\left(0-E(X)\right).\left(Y_{m+s}-E(Y)\right)\right)\\&+\left(\left(0-E(X)\right).\left(Y_m-E(Y)\right)\right)+\left(\left(const.-E(X)\right).\left(Y_{m+s}-E(Y)\right)\right)\end{aligned} \tag{3}$$

$$where \quad m=1,2,\ldots,n-s \quad and \quad const. \quad is \quad pulse \quad amplitude$$

4 Conclusion

This approach is more reliable than other methods like tresholding and Hough transformation, in most cases it is successful. The cross-covariance is the solution for cases when the surface is not Lambertian (wet mud and plashy ground) and tresholding will give wrong results (see Figure 3). In some cases this approach fails but the cases are very difficult to analyze (for example track parallel to the road caused by heavy vehicle) and in cases where is near to no color difference between road and forest. This paper shows only a small part of vehicle control problem. The complexity of vehicle control is huge and can be solved in several PhD theses as you can see in Figure 1. Improvement of cross covariance described in chapter 3 can save more than 99% of computing power by horizontal image resolution 1024 columns and pulse width 350 pixels.

5 References

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Ing. Vojtech Šimák, PhD.
Department of Control and Information Systems, Faculty of Electrical Engineering, University of Žilina

Ing. Jozef Hrbček, PhD.
Department of Control and Information Systems, Faculty of Electrical Engineering, University of Žilina