Stage Oriented Design of an Intersection Management System Based on Laser Scanner Data

Gustavo Velasco-Hernandez, Eduardo Caicedo-Bravo

Universidad del Valle

velasco.gustavo@correounivalle.edu.co, eduardo.caicedo@correounivalle.edu.co

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Abstract

In this work is described a stage-oriented design of an intersection management system based on a laser scanner sensor. After an introduction of the use of laser scanners in traffic monitoring, four stages are defined in the process flow of such a systems: preprocessing, feature analysis, pattern recognition and situation assesment. Then, an example implementation using a laser scanner dataset is presented.

1 Introduction

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2 Stages Definition

In the designing of an IMS, there are four main stages that have to be performed from the data source to final output: preprocessing, feature analysis, pattern recognition and situation assessment.

The aim of the first stage is to extract data of interest from the raw sensor information, using filtering and background subtraction techniques to get the foreground of the scene, remove noise and irrelevant data. Spatio-temporal alignment of data is also performed in this stage. In the second stage, the objective is to identify elements within the foreground and extract relevant features of them. The third stage receives the set of features from the previous stage and performs recognition and classification tasks. Also, tracking and prediction of objects' state is performed based on historic information. In the fourth stage, object behaviour and inter-objects interaction are analysed to identify context and detect situation or events of interest.

The output of the fourth stage could be delivered to an optional fifth stage of decision and control, to a human operator, or to a traffic agent or institution, to take immediate actions on traffic control, issue traffic tickets, warn drivers about possible incidents or improve transportation policies in a long-term basis. In figure 1, previously described stages are depicted, and also is shown how the data volume is reduced while data meaning increases in the last stages.

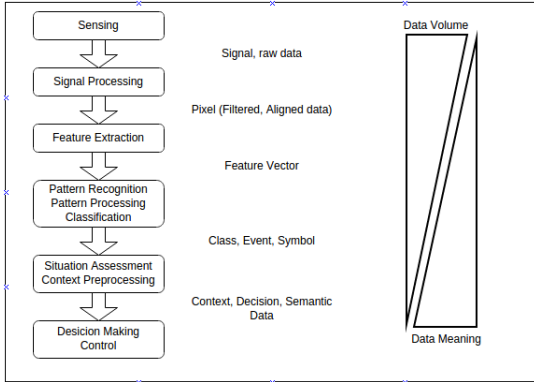Different tasks could be performed in each afore-

Figure 1: Dataflow through processing stages in an IMS.

mentioned stages, as is referred in figure 2. Below there is a description of common concepts and techniques associated with each of these tasks.
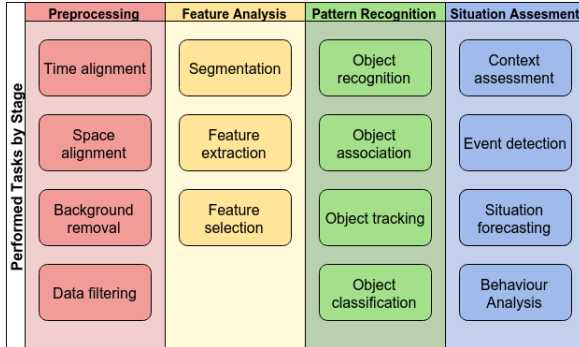

Figure 2: Processing stages and tasks performed.

2.1 Preprocessing

In the preprocessing stage raw data from sensor is received and the purpose is to enhance this data through filtering noise, removing outliers and discarding corrupted data. Also, in order to extract meaningful information, background removal techniques are applied in this stage. For doing this, a background model should be generated. One typical approach to generate a background model is to use a threshold to determine if certain measure corresponds to background or foreground. This threshold is computed based on a peak value found in histogram of the measure within a time window. Another approach consist in describe the data using a probability distribution function, using maximum likelihood estimation, commonly of a gaussian model.

Sometimes, the threshold technique is enough for modeling static backgrounds like walls, buildings or ground. But in other cases, it could be found a non-stable background, for example, when there exist moving vegetation or object borders, and a mixture of models may retrieve a better representation of the data instead.

2.2 Feature Analysis

After obtaining the foreground of the scene, it is needed to extract relevant points that could represent objects of interest. Clustering is used to group points that belong to the same object, specially algorithms where estimated number of cluster is not needed.

2.3 Pattern Recognition

2.4 Situation Assesment

3 Laser-based System Implementation

3.1 Dataset

The dataset used for this work was provided by POSS research group and was used for [2]. The dataset consist of ten minutes of laser scanner raw data from six sensors arranged horizontally over an intersection near Peking University. Background model and calibration data for each laser scanner is also provided. Additionally, dataset contains trajectory info of objects in the scene, generated by their algorithm.

3.2 Preprocessing

As mentioned before, the dataset provides a background model for each laser scanner. This model was

generated using a histogram of each sampling angle of scanning, then a peak is found indicating a motionless object, considered as background. With the peak values at all sampling angles the background model is obtained. Now, when a new frame comes from the laser scanner, the measure at certain angle is compared with the peak value associated with that angle. If the difference is larger than a given threshold, the measured value is considered to belong to a moving object at the intersection.

3.3 Feature Analysis

With the set of points marked as foreground, clustering is performed to identify the set of points belonging to the same object. The algorithm used in this implementation is DBSCAN, which stands for Density-Based Spatial Clustering of Applications with Noise. This algorithm does not need an estimated number of clusters as input, instead of this, it requires only two parameters: a minimum number of points per cluster, m, and a neighbourhood measure, ϵ. A detailed description of the algorithm, can be found in [1].

3.4 Pattern Recognition

3.5 Situation Assesment

4 Results

5 Conclusions and Future Work

References

[1] Martin Ester, Hans-peter Kriegel, and Xiaowei Xu. A Density-Based Algorithm for Discovering Clusters in Large Spatial Databases with Noise.

[2] Huijing Zhao, Jinshi Cui, and Hongbin Zha. Sensing an Intersection Using a Network of Laser Scanners and Video Cameras. *IEEE Intelligent Transportation Systems Magazine*, pages 31–37, 2009.