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Forward Scattering Radar for Automatic Vehicle Classification

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The need for accurate vehicle classification for road traffic applications is becoming more important and demanding. Planners require information about the types and numbers of vehicles along different roads; and if possible traffic data should be collected without the need for extensive installations. Statistical data collection, vehicle categorisation for traffic legislation and regulation, automatic tolling, safety studies, tunnel clearance verification, road and bridge design are some application examples. The main design requirements for a modern tool include: high probability of correct vehicle classification; a flexible classification scheme allowing the number of classes to be altered; high system performance and robustness to weather conditions; ease of installation; low system and maintenance costs as well as low weight and size.

Most of the existing automatic classification systems, based on inductive loop detectors, laser sensors, video cameras and radar sensors, do not

fully satisfy all of the above design requirements. This leaves the field open for further research.

In addition to these existing systems, this project develops another approach for vehicle classification, which is based on the effect of the forward scattering radar (FSR) phenomena. This method shows that a unique signature for the specific vehicle shape can be obtained. This forms the main basis behind vehicle classification, which is achieved through the analysis of this unique signature. By comparing its' signature with signatures stored in a database the vehicle can be effectively classified. The main feature of the FSR method is the high resolution attained along the vehicle trajectory, which is determined by the ratio of a wavelength to the target's path within forward scattering region. The hardware development for the FSR is simple and low cost. The proposed system operates at low RF band, which is robust to weather and other external conditions. Figure 1 depicts 2 examples of a typical road vehicle and its corresponding real signature in frequency domain, as well as a 3-D diagram for the classification.

The specific objectives for the project are:

- To investigate the feasibility of the forward scattering radar system for target imaging in application to target classification, in particular road vehicles.
- To propose major technical solutions for a new target imaging method.



1 – Honda Civic



2 – Ford Mondeo

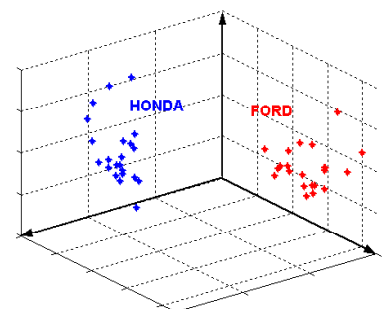
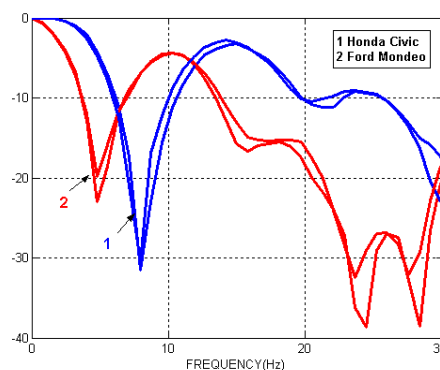


Figure 1: Experimental Result. The result shows a clear visible difference and high level of stability

- To classify and recognise road vehicles by using forward scattering radar system.

Figure 2 illustrates the system block diagram, which comprises of two major parts: the simple hardware that requires minimum power consumption (the sensor itself) and the software (classification algorithm). The received signal diffracted from the vehicle serves as a vehicle signature. This is the input to the classification system. Only the Doppler component of the received spectrum is used for vehicle classification. To extract the Doppler component, the signal is down-converted to the possible Doppler frequency range.

To perform vehicle classification, each vehicle is characterised by its feature vector. This is produced in the pre-processing block, which may perform various processes in the vehicle spectrum. The classification system, in general, consists of two phases, the training and the recognition phase. The aim of the training phase is to extract a model characterising each vehicle category. This is obtained from experimental training data. Each

vehicle category has a set of feature vectors.

In the recognition phase, we are given a feature vector of an unknown vehicle. Based on the models obtained in the training phase, the category of the unknown vehicle is estimated. The spectral feature vector, as obtained from the pre-processing block, is of a high-dimension and the features are highly correlated. Principal Component Analysis (PCA) was employed as a means of reducing the dimensionality of the spectral feature vector. Using PCA, often only the first few principal components are necessary to represent the information contained within the data. The relationships in the data can then be identified by plotting the data in a coordinate system defined by the principal components.

The project will produce the following deliverables:

- A design of an automatic vehicle classification radar system.
- A low cost, robust to any weather conditions vehicle classification system which is easy to install.

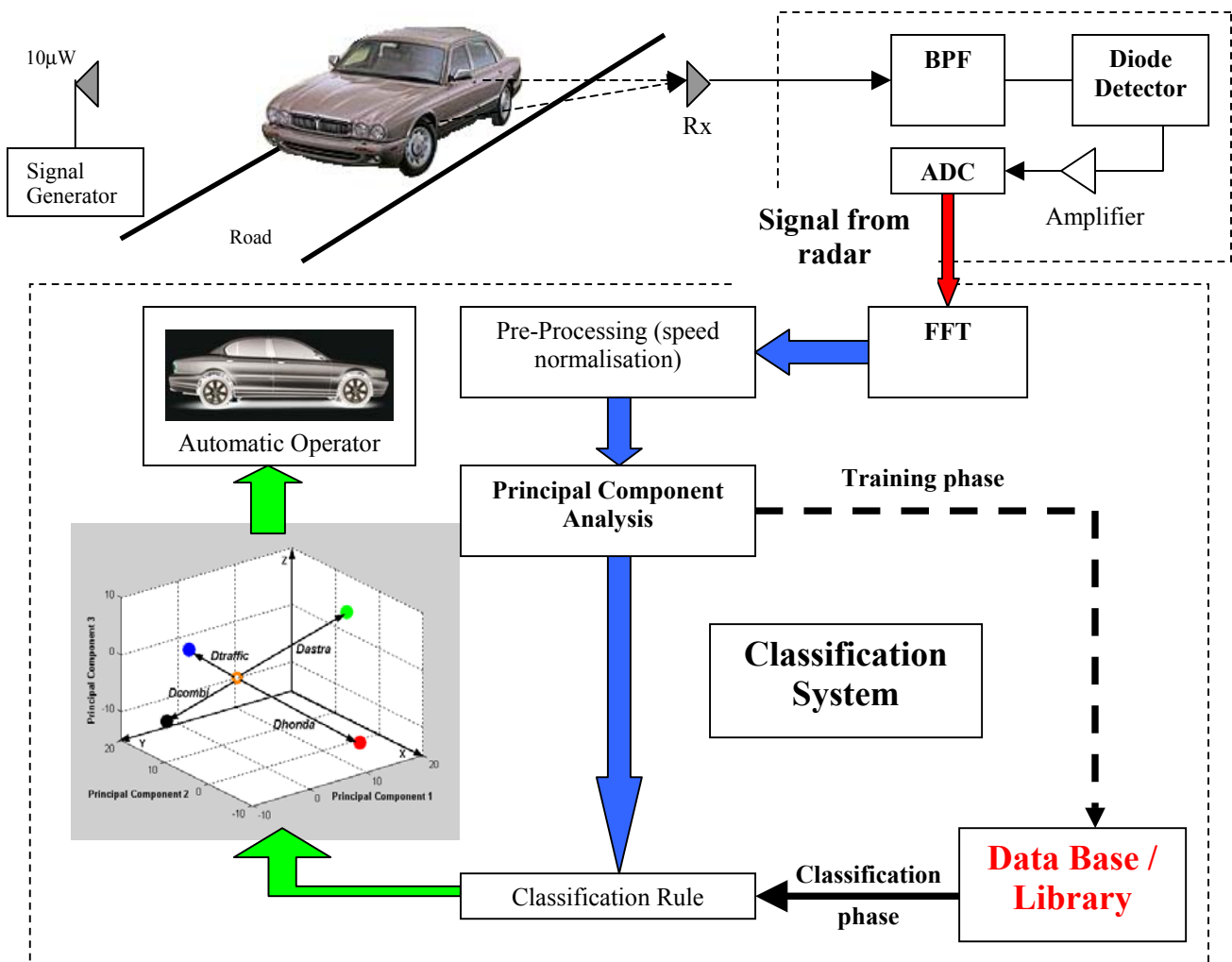


Figure 2: System Block Diagram