

Intelligent Vehicles and Intelligent Transportation Systems at the Innovative Sensing and Intelligent Systems Research Group – Annual Summary of Publications

Miguel Ángel Sotelo

Innovative Sensing and Intelligent Systems Research Group
University of Alcalá
Spain

Abstract

The purpose of this technical report is to provide a summary and brief description of the different scientific publications carried out by the members of the Innovative Sensing and Intelligent Systems Research Group in 2014. The topics covered in the various publications deal with parking assistance systems, occupancy estimation on freeways, pedestrian path prediction, road curb detection, vehicle model recognition, and pedestrian detection in crosswalks. In the following lines, an abstract of each publication is provided.

Vehicle model recognition using geometry and appearance of car emblems from rear view images. IEEE Intelligent Transportation Systems Conference. Qingdao, China. 2014

In this paper a novel vehicle model recognition approach is presented modelling the geometry and appearance of car emblems (model, trim level, etc.) from rear view images. The proposed system is assisted by LPR and VMR modules. Thus, a generic methodology is defined to build a hierarchical structure of car-make-dependent vehicle model classifiers. The emblems location, size and variations are firstly learnt. Then, the appearance of each badge is modelled using a linear SVM binary classifier with HOG features and the outputs of each individual classifier are converted to an estimate of posterior probabilities. A specific probability is computed for each hypothesis (model) integrating the posterior probabilities of all the emblems using the geometric mean. Inference about the most probable car model is finally carried out selecting the model with the maximum probability. We evaluate this approach on a dataset composed of 342 images (910/432 for training/test) corresponding to 8 different car makes and 28 different car models (52 considering generations) achieving an overall accuracy of 93.75%.

Road curb and lanes detection for autonomous driving on urban scenarios. IEEE Intelligent Transportation Systems Conference. Qingdao, China. 2014

This paper addresses a framework for road curb and lanes detection in the context of urban autonomous driving, with particular emphasis on unmarked roads. Based on a 3D point cloud, the 3D parameters of several curb models are computed using curvature features and Conditional Random Fields (CRF). Information regarding obstacles is also computed based on the 3D point cloud, including vehicles and urban elements such as lampposts, fences, walls, etc. In addition, a gray-scale image provides the input for computing lane markings whenever they are present and visible in the scene. A high level decision-making system yields accurate

information regarding the number and location of drivable lanes, based on curbs, lane markings, and obstacles. Our algorithm can deal with curbs of different curvature and heights, from as low as 3 cm, in a range up to 20 m. The system has been successfully tested on images from the KITTI data-set in real traffic conditions, containing different number of lanes, marked and unmarked roads, as well as curbs of quite different height. Although preliminary results are promising, further research is needed in order to deal with intersection scenes where no curbs are present and lane markings are absent or misleading.

Pedestrian path prediction based on body language and action classification. IEEE Intelligent Transportation Systems Conference. Qingdao, China. 2014

Safety-related driver assistance systems are becoming main stream and nowadays many automobile manufacturers include them as standard equipment. For example, pedestrian protection systems are already available in a number of commercial vehicles. However, there is still work to do in the improvement of the accuracy of these systems since the difference between an effective and a non-effective intervention can depend on a few centimeters or on a fraction of a second. In this paper, we use the 3D pedestrian body language in order to perform accurate pedestrian path prediction by means of action classification. To carry out the prediction, we propose the use of GPDM (Gaussian Process Dynamical Models) that reduces the high dimensionality of the input vector in the 3D pose space and learns the pedestrian dynamics in a latent space. Instead of combining a reduced number of subjects in a single model that will have to deal with the stylistic variations, we propose a much more scalable approach where all the subjects are separately trained in individual models. These models will be then hierarchically separated according to their action (walking, starting, standing, and stopping) and direction of the motion. Finally, for a test sequence, the appropriate model will be selected by means of an action classification system based on the similarity of the 3D poses transitions and the joints velocities. The estimated action will constrain the models to use for the prediction, taking into account only the ones trained for that action. Experimental results show that the system has the potential to provide accurate path predictions with mean errors of 7 cm, for walking trajectories, 20 cm, for stopping trajectories and 14 cm for starting trajectories, at a time horizon of 1 s.

Stereo-based Pedestrian Detection in Crosswalks for Pedestrian Behavioral Modelling Assessment. IEEE ICINCO Conference. Vienna, Austria (2014)

In this paper, a stereo- and infrastructure-based pedestrian detection system is presented to deal with infrastructure-based pedestrian safety measurements as well as to assess pedestrian behavior modelling methods. Pedestrian detection is performed by region growing over temporal 3D density maps, which are obtained by means of stereo reconstruction and background modelling. 3D tracking allows to correlate the pedestrian position with the different pedestrian crossing regions (waiting and crossing areas). As an example of an infrastructure safety system, a blinking luminous traffic sign is switched on to warn the drivers about the presence of pedestrians in the waiting and the crossing regions. The detection system provides accurate results even for nighttime conditions: an overall detection rate of 97.43% with one false alarm every 10 minutes. In addition, the proposed approach is validated for being used in pedestrian behavior modelling, applying logistic regression to model the probability of a pedestrian to cross or wait. Some of the predictor variables are automatically obtained by using the pedestrian detection system. Other variables are still needed to be labelled using manual supervision. A sequential feature selection method showed that time-to-collision and pedestrian waiting time (both variables automatically collected) are the most significant parameters when

predicting the pedestrian intent. An overall predictive accuracy of 93.10% is obtained, which clearly validates the proposed methodology.

Pedestrian Path Prediction Using Body Language Traits. IEEE Intelligent Vehicles Symposium. Dearborn, USA (2014)

Driver Assistance Systems have achieved a high level of maturity in the latest years. As an example of that, sophisticated pedestrian protection systems are already available in a number of commercial vehicles from several OEMs. However, accurate pedestrian path prediction is needed in order to go a step further in terms of safety and reliability, since it can make the difference between effective and non-effective intervention. In this paper, we consider the three-dimensional pedestrian body language in order to perform path prediction in a probabilistic framework. For this purpose, the different body parts and joints are detected using stereo vision. We propose the use of GPDM (Gaussian Process Dynamical Models) for reducing the high dimensionality of the input feature vector (composed by joints and displacement vectors) in the 3D pose space and for learning the pedestrian dynamics in a latent space. Experimental results show that accurate path prediction can be achieved at a time horizon of $\approx 0.8s$.

Parking assistance system for leaving perpendicular parking lots: experiments in daytime/nighttime conditions. IEEE Intelligent Transportation Systems Magazine (2014)

Backing-out and heading-out maneuvers in perpendicular or angle parking lots are one of the most dangerous maneuvers, especially in cases where side parked cars block the driver view of the potential traffic flow. In this paper a new vision-based Advanced Driver Assistance System (ADAS) is proposed to automatically warn the driver in such scenarios. A monocular gray-scale camera was installed at the back-right side of a vehicle. A Finite State Machine (FSM) defined according to three CAN-Bus variables and a manual signal provided by the user is used to handle the activation/deactivation of the detection module. The proposed oncoming traffic detection module computes spatio-temporal images from a set of pre-defined scan-lines which are related to the position of the road. A novel spatio-temporal motion descriptor is proposed (STHOL) accounting the number of lines, their orientation and length of the spatio-temporal images. Some parameters of the proposed descriptor are adapted for nighttime conditions. A Bayesian framework is then used to trigger the warning signal using multivariate normal density functions. Experiments are conducted on image data captured from a vehicle parked at different locations of an urban environment, including both daytime and nighttime lighting conditions. We demonstrate that the proposed approach provides robust results maintaining processing rates close to real-time.

Editorial Introduction - Special Issue on the 2013 IEEE Intelligent Vehicles Symposium & Workshop. IEEE Intelligent Transportation Systems Magazine (2014)

The 2013 IEEE Intelligent Vehicles Symposium (IEEE-IV'13) was held in the City of Gold Coast, Australia, from 23 June to 26 June 2013. The Intelligent Vehicles Workshop sessions were also part of the Symposium and were held on 22 June 2013. The Symposium, together with its Workshops, attracted 320 paper submissions (288 submissions to the Symposium and 32 submissions to Workshops). A total of 232 papers were accepted and included in the Symposium program (206 Symposium papers and 26 Workshop papers). In recognition of the quality of its papers, the Symposium was invited to this Special Issue of the ITS Magazine. After the

Symposium, eight symposium and workshop papers were initially invited to this Special Issue based on the scores obtained and comments received from the IEEE-IV'13 Reviewers, and the Best Paper Award Committee members. The authors of each of those eight papers were requested to submit extended versions of their papers within the given time frame. Seven symposium and workshop papers were then received and all underwent a rigorous review and revision process conducted by the Special Issue Editors and their reviewers. Finally, five papers met the paper review criteria within the given time frame as set by the Magazine Publisher. These five papers are therefore included in this special issue and are co-authored by researchers from Australia, Germany and Spain.

Lightweight Occupancy Estimation on Freeways Using Extended Floating Car Data. *Journal of Intelligent Transportation Systems* (2014).

Advanced traffic management systems rely heavily on technology to perform accurate estimations of the current state of the traffic as well as its short-term evolution. The objectives are improving traffic flow and enhancing road safety. Their success is based on accurate monitoring of two key variables, specifically speed and occupancy. The latter of the two has, to date, received significantly less attention from the scientific community. In this work we present a lightweight method to perform “on-line” occupancy estimation. We first propose three occupancy measurements calculated from data collected by a floating car: vehicle count, percentage of stop time, and headway. We then extend these discrete values to a continuous estimation of occupancy in space and time. The proposed estimators are based on a pairwise linear regression of each of the previously calculated measurements over certain references obtained from other floating cars or magnetic loop detectors. The method has been calibrated and validated under real traffic conditions and data. Despite the ease of implementation, the method is able to reproduce the occupancy values generated by the actual loop detectors, achieving promising results, with estimation errors down to 6.52%, even before multivehicle systems are considered.

In the references section, we provide not only the references to the technical papers published in 2014, but also a bunch of previous publications by members of our research group that constitute the basis for the research that we conduct at present.

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