**Interaction of Automated Vehicles with other Traffic Participants**

ITSC 2015, **Workshop 14**, 15. September, Las Palmas, Gran Canaria

Organizers: Cristóbal Curio (Reutlingen University, Germany) and Christoph Stiller (KIT, Germany)

First authors are presenters, if not stated otherwise

**********

**********

Program

**********

**********

**09:00-09:15** Opening words by Cristóbal Curio and Christoph Stiller

*********

SESSION A

*********

**09:15-09:40** Jürgen Gall, "Estimating Human Pose and Activity"

University of Bonn, Institute of Computer Science III, Computer Vision Group, Germany

In this talk, I will give an overview of some recent work on pose estimation from images and recognition of activities in videos. In particular, I will address the question if human pose is needed to recognize activities in videos. In order to allow a systematic performance evaluation of an action recognition pipeline, we annotated human joints for the HMDB dataset (J-HMDB). The annotation can be used to systematically replace the output of various algorithms in an existing pipeline with ground truth data to analyze the components with the highest potential for improving the recognition accuracy. For example, is it worth to invest more time on improving low-level algorithms like optical flow, is the image location of the human performing the action important, or would knowledge about human pose be helpful? Finally, I will briefly talk about the recent project `Mapping on Demand' (http://www.ipb.uni-bonn.de/projects/MoD/). Within the project, a system that recognizes potential moving objects is implemented on an unmanned aerial vehicle for collision avoidance.

**09:40-10:05** Konrad Doll, Sebastian Köhler, Michael Goldhammer and Ulrich Brunsmann, "Pedestrian Movement Modelling and Trajectory Prediction at Urban Intersections"

University of Applied Sciences Aschaffenburg, Germany

Knowledge about the intention of pedestrians and their future trajectories offers the potential to improve quality and reliability of VRU safety systems of automated vehicles. Especially regarding motion transitions, e.g. starting, stopping or bending in, widely used methods, like Kalman filtering, can be outperformed by advanced movement models using prior knowledge. We collect high resolution movement data by a sensor setup at a public urban intersection to analyze and to model the behavior of pedestrians under realistic conditions. Our goal is to use self-learning techniques for a fast detection of motion transitions with video-based motion descriptors and SVM classification.

Furthermore, the measured tracks are used as input for continuous prediction of the future trajectory for a time horizon of 2 – 3 seconds, using implicit movement modelling by polynomial fitting and artificial neural networks.

**10:05-10:30** R. Quintero, I. Parra, D. F. Llorca and M. A. Sotelo, "Pedestrian Intention and Pose Prediction through Dynamical Models and Behaviour Classification"

University of Alcalá, Spain

Pedestrian protection systems are being included by many automobile manufacturers in their commercial vehicles. However, improving the accuracy of these systems is imperative since the difference between an effective and a non-effective intervention can depend only on a few centimeters or on a fraction of a second. In this paper, we describe a method to carry out the prediction of pedestrian locations and pose and to classify intentions up to 1 s ahead in time applying Balanced Gaussian Process Dynamical Models (B-GPDM) and näive-Bayes classifiers. These classifiers are combined in order to increase the action classification precision. The system provides accurate path predictions with mean errors of 24.4 cm, for walking trajectories, 26.67 cm, for stopping trajectories and 37.36 cm for starting trajectories, at a time horizon of 1 second.

**********

**********

Pause

**********

**********

*********

SESSION B

*********

**10:50-11:15** Antonio M. López, "Learning to See in Virtual Worlds"

Computer Vision Center (CVC) and Univ. Autònoma de Barcelona (UAB), Spain

Most promising vision-based object detection and semantic segmentation methods rely on classifiers trained with annotated samples. However, the annotation step is a human intensive and subjective task worth to be minimized. By using virtual worlds we can automatically obtain large amounts of precise and rich annotations. Thus, we face the question: can a visual model learnt in realistic virtual worlds operate successfully in real world images? Conducted experiments in some specific visual tasks show that virtual-world based training can provide excellent testing accuracy for some real-world datasets; however, it also appears the dataset shift problem for many others. Accordingly, during the last years we have explored different domain adaptation ideas for several state-of-the-art object detection and semantic segmentation approaches, especially for pedestrian detection and urban semantic segmentation. In this talk, we review this work.

**11:15-11:40** Bojan Pepik, "Beyond Bounding Boxes: Enriching the Outputs of Object Class Detectors"

Computer Vision and Multi-modal Computing group at the Max-Planck Institute for Informatics, Saarbrücken, Germany

Current object class detectors target 2D bounding box localization, encouraged by benchmarks such as Pascal VOC. While this seems suitable for the detection of individual objects, higher-level applications such as autonomous driving, would benefit from more detailed object hypotheses. In this talk I will present our work on incorporating 3D geometry, occlusion and sub-ordinate information in object class detectors. First, I will present a 3D deformable part model capturing the inherent 3-dimensional nature of objects. Then, I will present an occlusion-aware object class detection method. By explicitly modeling the appearance of the occluder and the occludee, the detector leads to significantly better performance, especially on the occluded objects. Last, I will present our work on 3D object class detection in the wild - state-of-the-art single view 3D object detection pipeline capable of detecting objects from many categories in challenging real world scenarios.

**11:40-12:05** Martin A. Giese, Albert Mukovksi, Nick Taubert, Andrea Christensen, Dominik Endres, "Learning-based Representations of Interactive Human Movements"

Section Computational Sensormotorics, University of Tübingen, Germany

Interactive human behaviors are important for different technical Applications, including computer vision and robotics. We present two learning-based approaches for the representation of human interactive behaviors. The first approach is based on unsupervised learning, representing human body movements by the combination of movement primitives. These primitives are learned from trajectories using anechoic demixing. An architecture is presented that permits the online synthesis of coordinated interactive body movements by the design of nonlinear dynamical systems that generate movements by the flexible combination of dynamic movement primitives. The second approach allows to learn hierarchical probabilistic models from interactive behaviors, exploiting a framework that is based on a combination of Gaussian process dynamical models and Gaussian Process Latent Variable models. It is demonstrated how this architecture for the online synthesis of interactive movements can be used to for the realization of an emotional interactive avatar, which can be used to study social perception in interactive contexts.

**12:05-12:30** Andreas Schulz* and Rainer Stiefelhagen**, "A Controlled Interactive Multiple Model Filter for combined Pedestrian Intention Recognition and Path Prediction"

*Robert Bosch GmbH, Chassis Systems Control, **Karlsruhe Institute of Technology, Institute for Anthropomatics and Robotics, Germany

We present a novel approach combining pedestrian intention recognition and path prediction for advanced video-based driver assistance systems. The core algorithm uses an Interacting Multiple Model Filter in combination with a Latent-dynamic Conditional Random Field model. The model integrates pedestrian dynamics and situational awareness using observations from a stereo-video system for pedestrian detection and human head pose estimation. Evaluation of our method is performed on a public available dataset addressing scenarios of lateral approaching pedestrians that might cross the road, turn into the road or stop at the curbside. During experiments, we demonstrate that the proposed approach leads to better path prediction performance in terms of a lower lateral position error compared to state-of-the-art pedestrian intention recognition and path prediction approaches. The computational costs of our approach is comparatively low and therefore can be ported easily onto a real-time system.

**********

**********

Lunch

**********

**********

*********

SESSION C

*********

**13:40-14:05** Jeff Johnson* and Christoph Stiller**, "Towards Trajectory Planning for Interacting Traffic Participants"

*Robert Bosch, Palo Alto, USA and **Institut für Mess- und Regelungstechnik KIT - Karlsruher Institut für Technologie, Germany

This contribution is concerned with trajectory planning methods for road users who must negotiate for space without direct communication. Emerging from deterministic planning methods based on minimizing a cost functional, we focus on methods that explicitly incorporate uncertainty due to sensor noise and imperfect predictions. We argue for a reasoning framework that separates the planning task into two interacting components: a maneuvre decision module that investigates the set of possible driving behaviours, and a trajectory planning module that provides the best trajectory within each maneuver class. This separation is intended to emulate the divide between higher-level human decision making, and lower-level human.

**14:05-14:30** Thomas Weisswange and Christian Görick, "Foresighted Driving Assistance Systems"

Honda Research Institute Europe GmbH, Germany

Experienced humans drive foresighted. They choose their behavior based on a prediction of most probable behaviors of other traffic participants and incorporate small adaptations the help avoid potential risks. When developing advanced driver assistance systems (ADAS) which support a driver in foresighted driving, we face the problem that many hazardous events have a very low probability of occurrence. Any system intervention should take into account user acceptability given that the related event does not occur in the end in most cases. We will present a set of systems, which first detect situations that bear a potential risk (in our example based on orientation and relation to the road), in a second step evaluate possible foresighted behaviors taking into account the spatial scene layout and its plausible temporal evolution, and finally communicate a behavior recommendation via a subtle suggestive car yaw angle change in the respective direction (“Car Gestures”).

**14:30-14:55** Tomotaka Wada, Go Nakagami, Masato Matsuoka, "New Estimation Method Adaptable for Running out by Pressure Sensor for Pedestrian-Vehicular Collision Avoidance Support System"

Kansai University, Japan

We have developed Pedestrian-Vehicular Collision Avoidance Support System (P-VCASS) in order to protect pedestrians from traffic accidents and its effectiveness has been verified. P-VCASS is a system that takes into account pedestrian’s moving situations. It gives warning to drivers of neighboring vehicles in advance if there is a possibility of collision between vehicles and pedestrians. There are pedestrians to move around. They are dangerous for vehicle drivers because they have high

probability of running out into the road suddenly. Hence, we need to take into account the presence of them. In this paper, we propose a new estimation method to adapt to running out into the road by using pressure sensor attached to sole of a pedestrian. We show the validity of the proposed system by experiments using a vehicle and a pedestrian terminal in the intersection. As a result, we show that a driver of vehicle is able to detect dangerous pedestrians quickly and accurately.

**********

**********

Pause

**********

**********

*********

SESSION D

*********

**15:15-15:40** Maximilian Schwalm, "Seamless and cooperative automated driving: A framework on understanding and predicting the functional behavior of drivers"

Ika - RWTH Aachen, Germany

When we see another car driving we automatically attribute certain skills to the driver and try to anticipate his behavior: Will he change lanes? Is he going to brake? During normal driving, we expect the driver to behave in a strategic or even "social" way - just as we would probably do. Understanding the driver´s proactive and reactive behavior especially becomes important in the context of critical situations: Which proactive decisions on vehicle guidance level provoke or foster the occurrence of a critical situation? How does this decision making process work and which role does anticipation and workload management play? Once the driver encounters a critical situation, his reactive behavior appears to be decisive: will he be able to decelerate the vehicle sufficiently? Is he reacting fast enough to avoid a collision by an evasive maneuver? Understanding this behavior is a prerequisite for predicting and modeling it. This may form a promising basis to generate "cooperative automated driving" meaning a virtual driver, who makes the right strategic decisions, normally avoiding to step down to a reactive behavior. We will propose a psychological working framework to explain behavioral adaptations to increased workload situations of drivers. Based on this deeper understanding of natural strategic resources of drivers, new concepts and challenges for the behavior and interaction of higher automated driving functions shall be discussed.

**15:40-16:05** Cristóbal Curio*,** Martin Breidt**, "Drivers' state estimation by means of robust 3D head pose estimation for enhancing perceptual scene awareness"

*Reutlingen University, Germany, **Max Planck Institute for Biological Cybernetics, Tübingen, Germany

Reliable and accurate car driver head pose estimation is an important component for the next generation of advanced driver assistance systems in automated vehicles. Such a system should not be invasive nor rely on prior training and calibration, thus being independent of the driver's identity. We report on a highly accurate system we have adapted from graphics for automotive applications and demonstrate its performance on new challenging real-world data. Our system automatically fits a statistical 3D face model to depth measurements of a driver's face, acquired with a low-end sensor. We can demonstrate improvements over state-of-the-art camera-based 2D face tracking approaches. Our system delivers a full 6-DOF pose with very little degradation from strong illumination changes or out-of-plane rotations of more than 50 degree. We discuss potential applications of this approach for enhancing driver's perceptual awareness under high work load and distraction for different degrees of automated driving based on our new object detectability concept.

**16:05-16:30** Tongtong Chen, Bin Dai*, Daxue Liu, Hao Fu, Jinze Song, "Likelihood-field-model-based Vehicle Pose Estimation with Velodyne"

National University of Defense Technology

*Presenter

Dynamic vehicle tracking is an important module for Autonomous Land Vehicle (ALV) navigation in outdoor environments. The key step for a successful tracker is to accurately estimate the pose of the vehicle. In this paper, we present a novel real-time vehicle pose estimation algorithm based on the likelihood field model built on the Velodyne LIDAR data. The likelihood field model is adopted to weight the particles, which represent the potential poses, drawn around the location of the target vehicle. Importance sampling which is speeded up with the Scaling Series algorithm, is then exploited to choose the best particle as the final vehicle's pose. The performance of the algorithm is validated on the data collected by our own ALV in various urban environments.

---

**16:30-16:45** Discussion - end of workshop

---