2014 IEEE 17th International Conference on
Intelligent Transportation Systems (ITSC)
October 8-11, 2014. Qingdao, China

The Ko-PER Intersection Laserscanner and Video Dataset (Extended Abstract)

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Abstract— **Public intersections are due to their complexity challenging locations for drivers. Therefore the german joint project Ko-PER - which is part of the project initiative Ko-FAS has equipped a public intersection with several laserscanners and video cameras to generate a comprehensive dynamic model of the ongoing traffic. Results of the intersection perception can be communicated to equipped vehicles by wireless communication. This contribution wants to share a dataset of the Ko-PER intersection to the research community for further research in the field of multi-object detection and tracking. Therefor the dataset consists of sensor data from the laserscanners network and cameras as well as reference data and object labels. With that dataset, we aim to stimulate further research in this area.**

I. Introduction

Intersections are accident black spots. Therefore driver assistance is needed in this areas. The aim of this publication is to introduce a laserscanner and video camera dataset gathered at a public urban intersection to the ITS community to promote further research in the field of road user detection, classification, and tracking. Additionally the dataset provides reference data facilitating the evaluation and benchmarking of algorithms. Since the intersection perception system (ISP) has been designed and installed within the joint project Ko-PER [1], the development of algorithms to perceive the road users at the intersection was one major aim of the project. In [2] and [3] the video and laserscanner based object recognition and tracking algorithms including evaluation with reference data are presented.

II. Related Work

Several intersection perception systems (IPS) were developed in research projects addressing intersection collision avoidance applications in the recent years. In the United States of America, the Cooperative Intersection Collision Avoidance Systems-Stop Sign Assist (CICAS-SSA) program, made use of radar sensors and laserscanners to acquire road user data at rural intersections, [4], [5]. The used sensors were mounted at street level. In Europe the SafeSpot subproject INFRASENS involved laserscanners, cameras and RFID-systems to detect road users in urban areas, [6]. The laserscanners were mounted at street level, too, which made the IPS prone to occlusions caused by nearby passing pedestrians. This drawback was solved in Intersafe2 by mounting laserscanners on higher top-view-positions, [7]. This concept was adopted within the Ko-PER project. Due to the changed mounting position the appearance of the data changed, as well. This made the development of new object extraction algorithms necessary, [8]. In comparison to Intersafe2, Ko-PER extended the IPS by low- and high resolution cameras, to gather further classification information and information about vulnerable road users, e.g a pedestrian intending to cross the street, [9], [3].

Within the recent research programes IPSs are used to provide a solid information base for intersection collision avoidance systems, see e.g. [4], [7], [10]. In addition IPSs are very useful to gather sufficient naturalistic driving data for parameter determination in the development process of intersection sited driver assistance applications. Using an IPS for Cooperative Awareness in combination with car-to-X (C2X) communication and localization techniques, solves the availability problem of sufficient communicated information at equipped intersections.

III. Dataset

The perceived public intersection is a four-way crossing located in Aschaffenburg, Germany (Fig. 1(b)). Its main road features two straight ahead lanes and a separate left-turn lane for each direction. The branch roads have one lane per direction and a left-turn lane on one side. Additionally, the main road has a separate bicycle lane and the intersection is surrounded by sidewalks on all except one side. A detailed description of the intersection perception system is given in [11]. The intersection is observed by 14 SICK LD-MRS 8-layer research laserscanners and eight monochrome CCD cameras (Baumer TXG-04) with different viewpoints. The sensors are installed at infrastructure components like lamp posts and traffic lights and are mounted at least 5m above the ground. The mounting position as well as the field of view (FOV) of each sensor have been simulated according to [12]. The dataset can be downloaded from `www.uni-ulm.de/in/mrm/forschung/datensaetze.html` and features the content below

A. Content

The dataset comprises: raw laserscanner data, undistorted camera images, reference data of selected vehicles, and object labels. While the object labels are provided for `Sequence1` with a duration of 6:28 minutes, reference data for two cars performing a right turn and a straight ahead maneuver is included in `Sequence2` and `Sequence3`. Laserscanner measurements and camera images are provided for all sequences.

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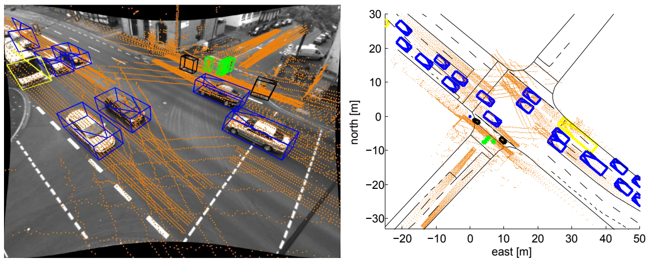

(a) (b)

Fig. 1. (a) Image of SK_1, projected laserscanner measurements, and object labels. (b) Laserscanner data and object labels. Blue boxes represent cars, green boxes represent pedestrians, yellow boxes represent trucks, and black boxes represent bikes.

B. Laserscanner and Camera Data

Four laserscanners cover the central intersection widespreaded, two scanners observe the sidewalks along the main road, and eight sensors observe three egresses of the intersection. The laserscanners synchronously operate with a frequency of 12.5 Hz. Since they scan their environment within 80 ms, not all measurements are acquired to the same time. This has to be considered by using the provided timestamps.

The cameras are monochrome cameras with a resolution of 656×494 pixels and a Pentax H416 lens with focal length of 4.2 mm. To fulfill data protection restrictions, only two of the eight cameras are included in the dataset. For these two cameras it is guaranteed that no personal data is gathered. An example image is shown in Fig. 1(a). The optical axis of the included cameras form an angle of approx. 180 degrees to reduce the risk of occlusions. The operation frequency of the cameras is 25 Hz. All laser and camera sensors are triggered in hardware thus, each measurement is associated with a timestamp which corresponds to the acquisition time of the measurement (UTC).

Additionaly a highly accurate map is provided in the form of a *Matlab* `Figure` in the east, north, up (ENU) coordinate system and comprises the $[x, y]$ position of lane markings and street boundaries.

C. Object Labels and Reference Data

For `Sequence1` a set of object labels is provided. This is generated by manually inspecting the sensor data of each sensor for each time step, including map information. During the labeling process, a box was placed around each object in different frames. The position and dimensions were adjusted by considering all available information: each camera view, the laser information and the map. Between two labeled frames, the poses of the objects were interpolated. Each labeled object includes a unique track id and an object class. Thus, the labeled data is sufficient to evaluate environment perception methods including multi-object tracking and classification algorithms. In Fig. 1(a) and 1(b), one frame of labeled data is shown.

The reference data of the vehicles has been acquired by a real-time kinematic global positioning system (RTKGPS) with inertial measurement unit. Providing only reference data which features a highly accurate status and has been validated using the digital map of the intersection, guarantees a position accuracy better 0.15 m. Thus, the reference data is sufficient to evaluate environment perception methods. The reference data is referred to the center point of the cars' front bumper on street level.

IV. Conclusion

In order to provide access to sensor data of the unique Ko-PER intersection, we prepared a dataset of three sequences of laserscanner and camera data. For two of the sequences highly accurate reference data of one car in each case is available. One sequence comes with object labels of several hundred road users including differenct object classes. The sequences are highly suitable to develop and evaluate tracking algorithms. With this dataset, we aim to stimulate further research in this area.

ACKNOWLEDGMENT

This work results from the joint project Ko-PER - which is part of the project initiative Ko-FAS - and has been funded by the German Bundesministerium für Wirtschaft und Technologie (Federal Ministry of Economics and Technology) under grant number 19S9022G.

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