A SOFTWARE TOOL FOR THE VISUALIZATION AND ANNOTATION OF NATURALISTIC DRIVING DATA STORED IN RELATIONAL DATABASES

Holger Lietz, Matthias J. Henning, Tibor Petzoldt, Josef F. Krems, Gerd Wanielik
Chemnitz University of Technology
I-FAS, Interdisziplinäres Zentrum für Fahrerassistenzsysteme, 09107 Chemnitz
{holger.lietz@etit,matthias.henning@psychologie,tibor.petzoldt@psychologie}.tu-chemnitz.de

ABSTRACT: This contribution describes a customisable software tool that can display recorded data from Naturalistic Driving Studies (NDS) or Field Operational Tests (FOTs) on a virtual dashboard. Its advantage is the possibility of displaying video data and data from other automotive sensors, which are stored in relational databases, simultaneously. Furthermore, it supports the analysis and annotation of recorded data. To assess its appropriateness for NDS or FOT data, first data analysis campaigns have been conducted on the lane-change behaviour using UMTRIs data set from the Road Departure Crash Warning System FOT.

1 OBJECTIVE

Within the last decade, many Naturalistic Driving Studies (NDS) and Field Operational Tests (FOT) have been conducted by automobile industry and traffic research institutes. In contrast to small-scaled studies with few participants and short project runtime, it is not efficient any more to store the recorded sensor and video data in an ordinary file system for a larger study. For NDS or FOT with hundreds of participants, such as the 100-Car driving study [1] or the ongoing second Strategic Highway Research Program (SHRP2 [2]), recorded data must be searchable and stored in a well-structured database system. For this reason, leading traffic research institutes like the Virginia Tech Transport Institute (VTTI) or the University of Michigan Transportation Research Institute (UMTRI) transfer the data into relational database systems to simplify the data analysis. However, with a standard database client, merging video and sensor data is really clumsy and a playback of the recorded traffic scenarios is usually not supported. The alternative is to connect other commercial software products to a database. However, these products are limited in displaying driving data appropriately and in writing annotated data back to databases.

In this contribution, we present a software tool that fulfils the requirements of NDS and FOTs. It is part of the FAT ("Forschungsvereinigung Automobiltechnik e.V.") and BASt ("Bundesanstalt fuer Strassenwesen" in Germany) funded project "Methodical Aspects of Naturalistic Driving Studies and Field Operational Tests".

2 METHOD

2.1 Data material

To develop and test the tool, a data subset from the 'Road Departure Crash Warning System Field Operational Test' [4] (RDCW) was acquired. This data set contains the baseline drive (the first six days) for the RDCW project in the greater Detroit area, where the Advanced Driver Assistant Systems (Curve Speed Warning and Lane Departure Warning) were still switched off. Therefore, although the dataset was recorded as part of an FOT, the dataset itself can be considered as an example of naturalistic driving data. Data from 18 drivers (10 females, 8 males) with a mean age of 45 years were included.

To fulfill the requirements of a 'realistic' analysis, the focus laid on lane change maneuvers on limited access roads. Altogether, the database included 917 lane changes of this type, 428 to the left and 489 to the right.

Alternatively to the RDCW data, a data set from the project "Methodical Aspects of Naturalistic Driving Studies and Field Operational Tests" [5] was employed for testing the software tool. This data set contains data from five test drives with an overall distance of 540km. It was originally used for testing a data acquisition system under different environmental conditions. In this scenario, the test vehicle was equipped with cameras and different automotive sensors. Four video streams, vehicle speed, yaw-rate, brake pressure and the lateral and longitudinal acceleration were captured during the test drives. This data material is not FOT or NDS data in the proper meaning, but similar to these kinds of studies.

2.2 The Data Analysis Tool

The NDS Data Analyser can replay both video and sensor data, recorded in a NDS or FOT, on a graphical dashboard. It supports the data analyst in a way that not only complete trips can be replayed but also parts of trips, selected scenarios at given events, combinations of trips from different drivers, combination of trips from different geographical areas, etc.

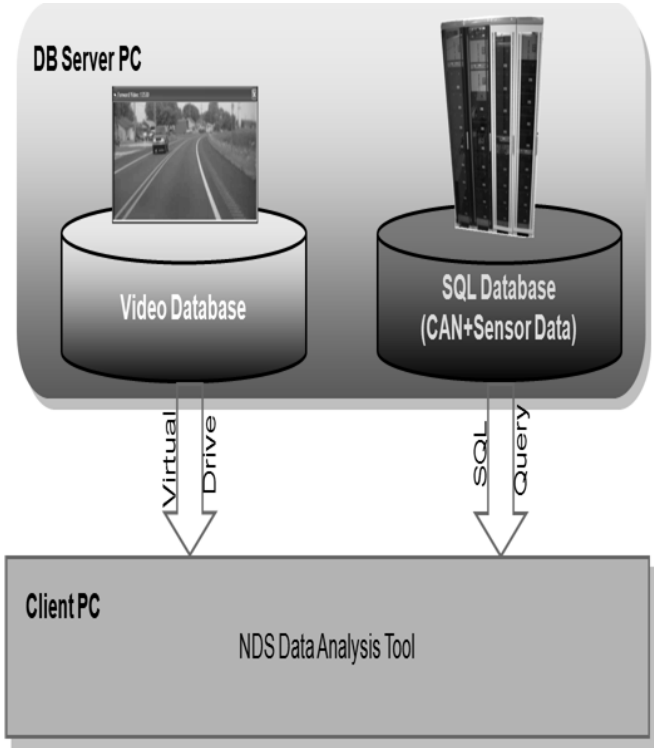

Figure 1: Data Structure

This software assumes the following database architecture (see Figure 1): Data from internal and external sensors except video data have to be stored in a relational database (usually

some form of SQL). Video streams from different cameras have to be stored separately in the common Audio Video Interleave (.AVI) files. The connection between videos and the remaining sensor data are links to the video file name and frame number within the tables of the SQL database.

For displaying recorded data of a FOT or NDS, a SQL query to the relational database is started. If the query results contain certain columns of interest, e.g. video file names, a replay of the data is possible. The playback can be in forward direction and in reverse direction with different speeds. Currently, the following display elements are supported: Four video channels, LED indicators, a 2D-graph, a gauge and horizontal and vertical slides (see Figure 2). The user can define the names of the columns that fit to the display elements.

Furthermore, the NDS Data Analyser supports the manual and automatic annotation of the recorded data (see Figure 3). This means that dedicated events, which cannot be detected by a sensor, may be annotated afterwards by a data analyst or by pre-defined rules. The manual annotation of data can be conducted for single events or for permanent states. During the annotation process, the recorded scenario is replayed. The data analyst can use mouse or

keyboard to set the labels. The labeling scheme can be customized. The entries of the labeling scheme consist of name of the label, the value (which is the representation in the database), and a hotkey for the user interface. After having finished the data annotation, the labels can be exported to a Comma Separated Values (CSV) file or appended to the table in the relational database.

Figure 2: Screen Shot NDS Data Analyser

The NDS Data Analyser is not limited to a certain database system and uses only conventional file formats for videos and for data exchange. It supports different database management systems and offers customized user interfaces. Therefore, it can be applied to analyse data from different naturalistic driving studies and field operational tests.

3 PROTOTYPICAL ANALYSIS

Two main tasks of a prototype analysis were conducted; play-back of video and sensor data at the same time to get an idea of the developing of the sensor data and code video back into the database.

3.1 Displaying time-lines of sensor data

We focused our analysis starting at the last ten seconds before a lane change. The database was queried for the respective events using the NDS Data Analyser's interface. To illustrate the typical time-course of a lane change for selected sensors, like steering wheel, accelerator pedal, brake pedal, longitudinal acceleration, and lateral acceleration, queries were limited to those relevant data channels. Figure 3 illustrates the distance to lead vehicles starting ten seconds before crossing the left lane edge, measured by the right-hand front radar.

Figure 3: Screen Shot Data Annotation

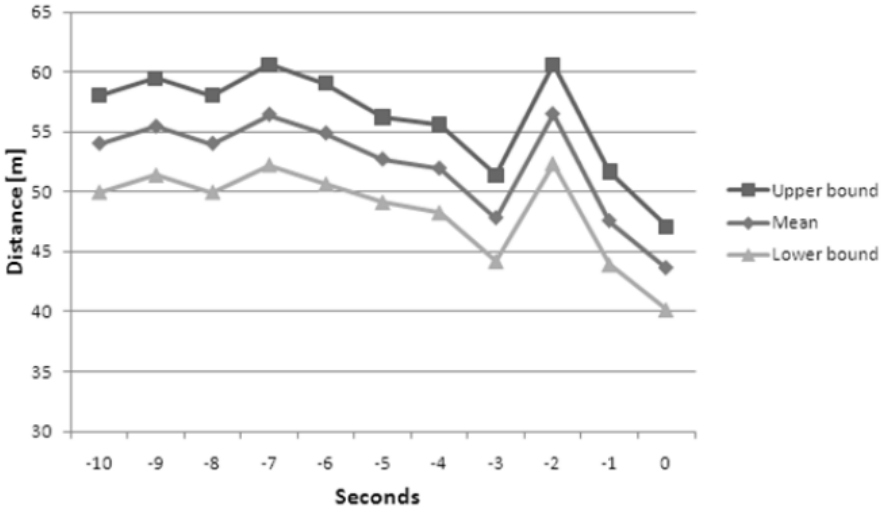

Figure 4: Distance to the leading car, starting 10 seconds before crossing the left line, measured by the right-hand front radar (Mean, upper, and lower bound of the 95% confidence interval)

As Figure 4 shows, there is a peak in distances to the lead vehicle at around two seconds before lane changing. This seems to be an anomaly in the evolution of the data over time. To get some insight into possible reasons for this anomaly, a further step in the analysis is to display these situations visually.

In the presented case, a hypothesis was that the peak is from fast lane changes with no traffic in the adjacent lanes and a very slow leading vehicle. This peak seems to be a truncated curve due to distance-limitations in the radar-system.

3.2 Review of video data and labeling of situations

In a first step, we used the NDS Data Analyser's capabilities to have the respective video sequences replayed for the lane change events. To test our hypothesis that the properties of the surrounding traffic are responsible for the unusual peak observed in the numerical data, the situations were labeled accordingly. Traffic density and speed of vehicles on the adjacent lanes were assessed qualitatively by reviewing the videos and coded using the developed tool. The coding was done in a binary way: no relevant rearward-traffic vs. relevant rearward-traffic, and was done exemplary for a selected number of lane changes. The labels were then written back into the database and the displaying of the time course (3.1) was accomplished again for both traffic-conditions (no rearward traffic vs. rearward traffic). The results showed a flatter curve two seconds before lane changing for the condition with rearward traffic.

4 CONCLUSIONS

The prototype analysis supports our claim that the introduced software tool is able to work with large-scaled databases and video material synchronously. Our tests with different data sets showed that it fulfils all requirements to display, analyse, and annotate large-scale NDS and FOT data in an appropriate and sophisticated way. Due its support of common file types like CSV and AVI, the data analysis can easily combined with other analysis tools. The next step is to apply it to other data sets, like the field study of [3].

5 ACKNOWLEDGEMENTS

This publication is based on parts of the research project carried out at the request of the Federal Ministry for Transport, Construction and Town Planning, represented by the Federal Highway Research Institute, under research project No. 82.0351/2008/. The authors are solely responsible for the content.

The authors would like to thank the FAT (Forschungsvereinigung Automobiltechnik e.V.) and the BASt (Bundesanstalt fuer Strassenwesen) for their financial support of the development of the Data Analysis Tool. Thanks are due to Winfried Koenig, Friedrich Preisser, Christhard Gelau and Joerg Bakker for the helpful discussions.

6 REFERENCES

[1] Dingus, T. A., Klauer, S. G., Neale, V. L., Petersen, A., Lee, S. E., Sudweeks, J., et al.: 'The 100-Car Naturalistic Driving Study, Phase II (Results of the 100-Car Field Experiment)'. DOT HS 810 593. National Highway Traffic Safety Administration, 2006.

[2] Fitch, G. M., and Hankey, J. M.: 'Global Perspectives on the Use of Naturalistic Driving Data to Improve Highway Safety'. Human Factors and Ergonomics Society Annual Meeting Proceedings, 52, 2008. pp.1880-1882.

[3] Henning, M.J., Georgeon, O., Wynn, T. and Krems, J.F.: 'Modeling driver behaviour in order to infer the intention to change lanes', in Brusque, C. (Ed.), 'Proceedings of the European Conference on Human Interface Design for Intelligent Transport Systems'. Lyon: Humanist Publications, 2008.

[4] LeBlanc, D., Sayer, J., Winkler, C., Ervin, R., Bogard, S., Devonshire, J., et al.: 'Road Departure Crash Warning System Field Operational Test: Methodology and Results'. Ann Arbor: UMTRI, 2006.

[5] Mosebach, H., Lietz, H., Schomerus, J., Petzoldt, T., Baumann, M., Henning, M.J., et al: 'Methodische und technische Aspekte einer Naturalistic Driving Study', Final Report (Not published yet), 2010.