Identification of Driver Distraction in Automotive Environments

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Abstract: To identify times of unawareness of a driver in an automotive environment, in terms of not looking for the traffic, we suggest to rate operation elements according to the value of complexity of the secondary tasks they are used with. The median complexity rating is presented as an efficient predictor for this task.

1 Introduction

Many accidents in traffic can be ascribed to mistakes by the driver (Statistisches Bundesamt 2006) and often fatigue and unawareness are reasons for this. Especially the growing number of infotainment devices and control elements that are available for the driver are reasons for unawareness. Using these devices drivers sometimes do not use the possibility to interrupt the tasks and are several seconds not aware of the traffic situation. Systems that could identify or even predict these situations to warn the driver or to direct the driver's attention to the traffic could result in a great reduction of traffic accidents. We introduce a system using the complexity of interaction activity of a driver with the in-build infotainment, communication and control elements to make an assumption of the state of distraction.

2 Related Work

Much work has been done to identify the state of fatigue (Fletcher et al. 2003) and in some cars assistant systems are already in serial-production. Less work, however, has been done to identify inattention. Some systems use assistants for lane change measurement to warn the driver if he is going to leave the lane unintentionally (Polychronopoulos et al. 2005). Other work has been done by using an inbuilt camera system that monitors the gaze direction of the driver (Markkula et al. 2005). Because customers may not want cameras that observe them such systems seem not appropriate for this task.

Most related to our approach is the work of (Torkkola et al. 2007) who did use primary task parameters like steering wheel angle and the position of the accelerator pedal to detect inattention.

We present a camera free method that estimates the potential distraction of the operation elements used with secondary tasks by the driver on a five item scale where one means low distraction and five means high distraction which could cause problems in keeping the speed and the distance to other cars. We make the assumption that high complexity might result in high distraction if the driver is not taking the possibility to interrupt the secondary task. In the following chapters we describe the user study that was conducted and the statistical analysis we performed. Furthermore we present and discuss the results.

3 Method

First data was recorded in a user study. The data was divided into a training dataset and a test dataset. The training dataset was then statistically analyzed.

3.1 User study

The training and test datasets to be used for this work were recorded in a user study with 23 trial runs performed by 6 people who were all familiar with the car. During each run 31 secondary tasks were performed and after each task the complexity level was rated by the trial subject as well as the supervisor according to table 1.

Data from the CAN was recorded with 20 Hz and preprocessed during the trials by a Simulink model that combined buttons, switches and levers to logical operation elements.

Rating	Description for trial subject
1	The task can be performed blindly and there is no problem keeping the speed or the distance.
2	The task requires little attention and the distance and the speed need to be checked infrequently.
3	The task requires some attention and the distance and the speed need to be checked frequently.
4	The task requires some attention and the distance and the speed need to be corrected infrequently.
5	The task requires some attention and the distance and the speed need to be corrected frequently.

Table 1 : Complexity levels of the test subject.

3.2 Analysis

The ratings of the trial subjects were used as ground truth for the data. For prediction, however, four different types of data were compared. For both the rates of the trial subjects and the rates of the supervisor the data was used in two ways, with the original data that takes into account the length of the interaction duration of each operation element, and with simplified data that only uses unique items.

For each task the rates of the trial subjects and respectively the rates of the supervisor were assigned to the operation elements used in that task and summarized over all subjects and all tasks (see figure 1).

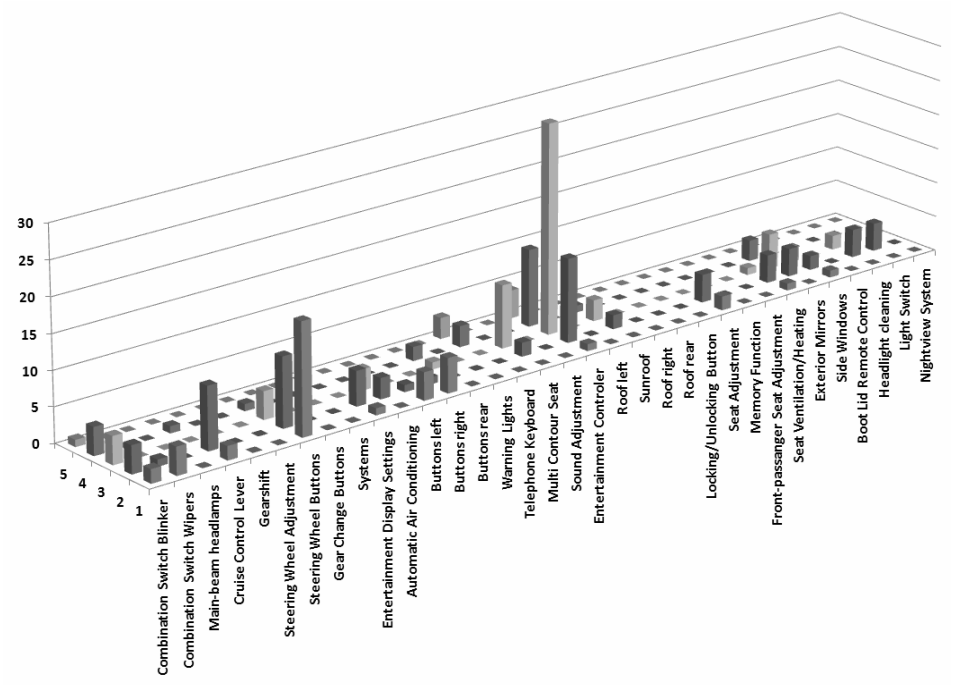

Fig. 1 : Summarized occurrences of rates by the trial subjects for each operation element over all subjects and all tasks reduced to unique items.

Furthermore the median as predictor and the quartiles as measure for the variation were computed for these summarized occurrences (see figure 2).

	Combination Switch Blinker	Combination Switch Wipers	Cruise Control Lever	Steering Wheel Buttons	Entertainment Display Settings	Automatic Air Conditioning	Buttons left	Buttons right	Buttons rear	Telephone Keyboard	Multi Contour Seat	Entertainment Controler	Sunroof	Seat Adjustment	Seat Ventilation/Heating	Exterior Mirrors	Side Windows	Headlight cleaning	Light Switch	average
25% quantile	2	1	1	1	2	2	1	1	2	4	3	2	2	1	1	2	1	1	1	1
median	3	1	1	1	3	2	1	1	2	5	3	3	2	2	1	3	2	2	2	2
75% quantile	3	1	2	2	3	3	1	1	4	5	4	4	3	2	2	3	2	2	2	3

Fig. 2 : Median and quartiles of the summarized occurrences of rates by the trial subjects for each used operation element over all subjects and tasks reduced to unique items.

4 Median rating of complexity as predictor

The performance of the median complexity rating as predictor for unawareness of the driver compared with the rates given by the trial subjects as ground truth will be presented and discussed in the following. Six of the 23 trial runs were chosen randomly as test dataset. For both the original and the simplified data the number of correct predictions, the percentage of correct predictions and, with the assumption that the five item distraction scale is equidistant, the mean square error is computed. Furthermore the performance for each operation element is presented.

4.1 Overall performance

The best performance is given by the median complexity rating of the reduced data to unique items (figure 3) with a correctness of 50%. It has a 12%-points higher performance than the median with the original data and is with 4%-points only slightly worse than the quality of the ratings of the supervisor to the ratings of the trial subject. In contrast the best constant predictor (constant value 2) has a correctness of 34%. The mean square error of 0.68 is 0.12 points better than the mean square error of the simplified data and 0.08 points worse than the mean square error of the supervisor ratings. The performance on the 6 trials from the test dataset varies from 63% correctness to 41% correctness and a mean square error from 0.47 to 0.97.

	TS 1	TS 2	TS 3	TS4	TS 5	TS6	total
number of operations	34	33	39	37	38	39	
number correct to driver	13	20	14	18	23	17	
% correct to driver	0.41	0.63	0.41	0.50	0.61	0.44	0.50
MSE to driver	0.97	0.56	0.68	0.75	0.47	0.64	0.68
number correct supervisor to driver	21	15	21	13	22	22	
% correct supervisor to driver	0.66	0.47	0.62	0.36	0.58	0.56	0.54
MSE supervisor to driver	0.34	0.53	0.82	1.06	0.42	0.44	0.60

Fig. 3 : The performance of the median predictor with the simplified data compared to the rates of the trial subjects for six trial runs of the test dataset.

4.2 Performance of operation elements

In figure 4 the performance of the median complexity rating predictor of the simplified data according to the operation elements is presented. It can be seen that there are four operation elements that are predicted with a correctness of more than 80%, these are "Combination Switch Blinker", "Buttons left", "Buttons right" and "Multi Contour Seat". Nine operation elements are predicted with correctness between 40% and 70%, among these also the operation element with the highest complexity value of 4, "Telephone Keypad". Three operation elements are predicted with less than 30%.

	Combination Switch Blinker	Combination Switch Wipers	Cruise Control Lever	Steering Wheel Buttons	Entertainment Display Settings	Automatic Air Conditioning	Buttons left	Buttons right	Buttons rear	Telephone Keyboard	Multi Contour Seat	Entertainment Controler	Sunroof	Seat Adjustment	Seat Ventilation/Heating	Exterior Mirrors	Side Windows	Headlight cleaning	Light Switch
1	2	4	2	16	1	0	4	5	0	0	0	1	0	2	1	0	1	0	0
2	4	1	9	10	5	3	1	1	0	0	2	12	2	4	4	4	2	4	4
3	4	0	0	4	0	3	0	0	1	0	9	30	3	0	1	5	2	2	2
4	4	0	1	1	0	0	0	0	2	3	0	11	1	0	0	3	0	0	0
5	1	0	0	0	0	0	0	0	0	3	0	4	0	0	0	0	0	0	0
prediction	3	1	2	2	3	3	1	1	3	4	3	3	3	2	1	3	2	2	2
number correct	4	4	9	10	0	3	4	5	1	3	9	30	3	4	1	5	2	4	4
number incorrect	11	1	3	21	6	3	1	1	2	3	2	28	3	2	5	7	3	2	2
% correct	0.27	0.80	0.75	0.32	0.00	0.50	0.80	0.83	0.33	0.50	0.82	0.52	0.50	0.67	0.17	0.42	0.40	0.67	0.67
% incorrect	0.73	0.20	0.25	0.68	1.00	0.50	0.20	0.17	0.67	0.50	0.18	0.48	0.50	0.33	0.83	0.58	0.60	0.33	0.33
MSE	1.33	0.20	0.50	0.77	1.50	0.50	0.20	0.17	0.67	0.50	0.18	0.74	0.50	0.33	1.33	0.58	0.60	0.33	0.33

Fig. 4 : The performance of the median predictor with the simplified data listed for all operation elements used. Four operation elements are predicted with >80% correctness, only one with <15%.

5 Discussion and Future Work

Since there are a few operation elements that are either used very infrequently "Seat Ventilation/Heating" or for several task with different complexity ratings "Entertainment Controller" these results are not sufficient, yet. The performance of the median complexity predictor of the simplified data should be tested with a greater test dataset to verify the results and more trial runs have to be performed to increase the prediction for frequently used operation elements with high variance like the Entertainment Controller, which is used both for highly complex tasks like navigation and for tasks with low complexity like changing of radio channels.

Furthermore the values for the operation elements predicted with the median predictor from the simplified data should be used as lookup table in a Simulink model together with other analysis to improve the distraction estimation of drivers while performing secondary tasks.

6 References

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