An Agreeable Evaluation Method for Vehicle Dashboard Considering Drivers’ Eye Movement Information

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Keywords: Acceptance evaluation, Vehicle dashboard, Human-machine interaction.

Abstract. Internal cause analysis for human-computer interaction in the process of cognition, that the introduction of eye tracking technology to carry out the pilot of on-board instrument acceptance evaluation research. Select fixation time and scanning time, fixation point number, the data as an indicator to measure, put forward the calculation method of visual searching and information processing efficiency to measure the acceptance level by automotive instrumentation, and the internal differences of automotive instrument graphical analysis eye movement method is applied to evaluate two vehicle instrument of acceptance level, the result has a good degree of differentiation, the evaluation method is verified the practicability and effectiveness.

Introduction
Automotive instrument device is an integral part of automotive, and is an important information exchange interface for information exchange between drivers and vehicles. More importantly, it’s the vehicle running condition monitoring and fault alarm intelligent devices. Drivers obtain information by focusing on the instrument, therefore, how to observe the instrument and get the information accurately and conveniently is the key to evaluate the design of the vehicle instrument and the relationship between man and machine.

Currently car manufacturers evaluate the acceptability of vehicle instrument is mainly based on subjective assessments by using the questionnaires. Traditional evaluate methods have the many problems.

F. Bellotti and others put forward user self-configuring vehicle virtual instrument, it can change the layout of the instrument according to the actual driving conditions, and thus the display interface is flexible. For security it can provide an integrate, open and coordinate channels for any form of visual information. Michael K. Allio and others proposed a specially designed vehicle instrument for tracking the key performance parameters, clarify the actual monitor strategy of the dashboard; balanced management team design a more humane acceptable multidimensional instrument pointer and other factors; using simple metrics standards; provide maximum spatial layout of the dashboard; committed to establish a more mature and humane vehicle instrument configuration in performance evaluation and measurement .aspects of a system to achieve.

In this paper, we established a set of standardized field test methods of car dashboard design. And test two different vehicle models, using eye-tracking technology to capture the eye movement regulations between the process of watching the front road and the dash board. Dealing with the eye movement parameters such as fixation time, saccade time, and other eye movement, then using intuitive graphic to analyze the divers’ acceptance of different vehicle instrument. Providing more effectively objective basis and theory support for the vehicle instrument design.

Consider the Eye Movement Information Onboard Instruments Accepted Evaluation Strategy

Evaluation Strategy
Instrument information acceptance assessment strategies generally consider these factors of HMI system: easy to learn, efficiency, fault tolerance, easy to remember and subjective satisfaction. This paper concentrates mainly on skilled driver, they’re more familiar with dashboard and have good
operations skills, so the opportunity of making error is small, they also have strong learning ability, so easy to learn, fault-tolerance and other factors can be ignored. Therefore, this paper mainly measured the acceptance of the dashboard by evaluating the operating efficiency, and divide the assessment strategy into two categories

1) Searching efficiency evaluation
Searching speed S
It’s the reciprocal of Th (Th: fixation time on dashboard during the driver starting the task to finish the task)

\[ S = \frac{1}{T_h} \]  

(1)
Ignore the dimension of the calculation result, the longer fixation time, the smaller the searching speed and lower searching efficiency.

2) Processing efficiency evaluation
In order to analysis the driver's internal interaction cognitive factors on dashboard, it needs to study the user’s eye movement characters from the perspective of information process. The evaluation strategy includes cohesion, directness and difficulty these three aspects:
- Process cohesion C
  Cohesion degree to represent the degree of concentrate in process:
  \[ C = \frac{N_{AOI}}{N_2} \]  
  (2)
  There \( N_{AOI} \) is the number of interesting area and components of UI. Generally one AOI need at least one fixation point to process, but sometimes people can also use the edge of the eyeball fovea to obtain information, so a fixation point can process several AOI, thus the value of C can be less than 1 and more than 1.
  - Process difficulty D
  Related research shows that the longer the duration of fixation, the harder the process is, user spend longer time to interpret the representations of UI elements, the more time-consuming. On this basis, calculating all of the valid time of the fixation point: \( T_e \).
  \[ D = \frac{T_e}{N_{AOI}} \]  
  (3)
  Ignore the dimension of the calculation result, the longer fixation time, the harder the process.
- The degree of process directness I
  Visual captured objects typically attract user’s fixation points at the most beginning, if the UI element that the task needs have been included in these objects, it will undoubtedly speed up the user’s positioning process of the target. Use the degree of process directness I to express this concept, it can be formal definite.
  \[ I = \begin{cases} 0 & (U_{AOI} \cap OU = \emptyset) \\ 1 & \text{else} \end{cases} \]  
  (4)
  where \( U_{AOI} \) is task required UI region of interest, OU is assembly of visual captured elements

Car Meter Accepted Valuation

Experiment Preparation
Although there are some deviations on the operating time of the task and user experience, the relative cognitive assessment based on internal factors is still valid. In this paper, the experimental material is two cars (model 1 and model 2), they have different types of instrument panel layout. Experiment equipment is Smart Eye Pro eye tracker from Sweden’ Smart Eye AB company, Smart Eye Pro provides a remote eye tracking system, it can measure three-dimensional images that constituted by head and line of sight with high accuracy and full frame rate. Sampling rate is 60Hz, system lag typically <50 ms, 6 DOF head tracking, accuracy: 0.5 degrees of rotation, movement <1 mm, 3 DOF visual tracking, accuracy: under ideal conditions 0.15 to 0.5 degrees (depending on the gaze angle range).
Test Drivers

A total of three users, three skilled men drivers between the ages of 28-35, more than one year of driving experience, have been driven more than five thousand kilometers.

Experiment Scene

Experimental task are here: First, (next stop standstill) watch the calibration 10 meters front then watch the speedometer. Second, watch the calibration 15 meters front then watch the speedometer. Third, watch the calibration 20 meters front then watch the speedometer. Fourth, watch the calibration 10 meters front then watch the tachometer. Fifth, watch the calibration 15 meters front then watch the tachometer. Sixth, watch the calibration 20 meters front then watch the tachometer. Schematic diagrams are as follows:

![Schematic Diagram](image1.png)  
![Schematic Diagram](image2.png)

Figure 1. Scene demarcate schematic.  
Figure 2. Task procedure schematic.

Experimental Procedure

(1) Parking the car and installing eye tracker. As fig 3 (a) and3 (b) shows:

(2) Following the sitting habit of drivers to build head models through eye tracker, to get the demarcating parameter between eye tracker and particular driver between. Manual calibrate model and test the accuracy. As fig 3 (c) and fig3 (d) shows:

![Images](image3.png)

Figure 3.

(3) Measuring the three camera’s locations to determine the origin of the world Coordinate system. And calibrate the front scene camera’s coordinate position etc. And establish data and scenes camera video files folder for storage and called. As figure 3 (e) and figure 3 (f) shows:

Experiment Data Collect and Process

Data collect: Figure 4 (a) (b) (c) (d) respectively record three different drivers respectively use two cars (model 1 and model 2) to complete the different tasks (in parking and stationary state):

① Watch the calibration 10 meters front then watch the speedometer. ② Watch the calibration 15 meters front then watch the speedometer. ③ Watch the calibration 20 meters front then watch the speedometer; ④ Watch the calibration 10 meters front then watch the tachometer. ⑤ Watch the calibration 15 meters front then watch the tachometer. ⑥ Watch the calibration 20 meters front then watch the tachometer. Use eye tracker to collect eye movement parameters of all those section above such as the driver's average gaze time and average saccade time.
Figure 4.

Data process: ① Use the MATLAB software to do graphic analysis about the average data obtained, compare the average fixation time and saccade time of different types of dashboard, analysis the advantages and disadvantages of the dashboard design. ② Put the eye movement measurement parameters obtained into accepting assessment formula to obtain the search efficiency and the processing efficiency, and then do exemplified analysis & specific applications. Considering the other drivers’ different efficiency of using two different types of cars’ dashboards to complete the different tasks, do t-test (p <0.05) to the results to verify the validity of the assessment method.

Focusing time of watching demarcate point at different distance are as shown in Figure 5 (a) (b) as follows:

Figure 5.

Due to space limits, this paper selects one driver’s eye movement data, take task 1 (watch the calibration 10 meters front then watch the speedometer) for example to illustrate the specific application of the assessment method. Put the parameters’ value above into the formula (1) - (4) to do calculation, can obtain assessment results and are shown in Table 1.

![Table 1](image)

Similarly, considering the other drivers’ different efficiency of using two different types of cars’ dashboards to complete the different tasks, do t-test (p <0.05), it is founded that in task 1, task 2 and task 3, search efficiency of car model 1 is higher than the model 2, but the processing efficiency is lower than model 2; In task 4, task 5 and task 6, search efficiency of model 2 is higher than model 1, but processing efficiency is lower than model 1.

In addition, using a 5-point interval scales to do assessment (let the drivers subjectively score the cognitive and operation satisfaction of the dashboard), with the result of the assessment has highly consistency with the result of the eye movement assessment method, deviation is less than 20%, it shows that the assessment method has a certain value.
Conclusion

This paper makes a series of assessment methods about driver’s acceptance of dashboard based on the established eye movement evaluation indicators and strategies. Through real vehicle experiment, this paper does graphic analysis about the driver’s average fixation time and saccade time of different cars and different dashboard. Also, it takes an example of putting the eye movement parameters that have been obtained from the real vehicle experiment into the assessment strategy equations and obtain S,C,D,I. Here gives the conclusion:

(a) From the aspect of focusing time, the speedometer is significantly longer than the tachometer, so it is necessary to consider the type of scale, number design, pointer shapes, colors and other design factors.

(b) When watching the different speedometers and tachometers of the two models, the average saccade time of the model 1 is shorter than the model 2. When watching the different speedometers of the two models the average fixation time of model 1 is shorter than the other but when watching the tachometer the fixation time of model 2 is shorter than model.

(c) From the aspect of searching efficiency S, that the model 1 is faster than model 2, drivers can obtain the useful information from the dashboard easier in model 1.

(d) From the aspect of processing efficiency, cohesion of model 2 is larger, indicating that there are other UI elements interfere the user, so the attention is distracted and efficiency is reduced.

(e) From the view of process difficulty D, model 1 is harder than model 2, drivers consider more on model 1.

(f) From the perspective of process directness, tasks needed UI region of interest and the visual captured elements assembly at the beginning has no intersection, it is need to be considered that whether there is target information in driver’s habitual search area.

Vehicle model 1 is relatively better than model 2.

Next step, analysis of the visual acceptance and the information getting easiness of dashboard will be done, and then a more complete assessment model will be established.

References


