A method for estimating the potential of the physiological and emotional characteristics of a driver in a changing traffic situation using the ADES information system

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Abstract. Road traffic accidents are one of the problems of organizing road safety. According to statistics, every fifth road traffic accident in Russia occurs due to the unsatisfactory condition of streets and roads. The driver must react quickly to changes in the traffic situation while driving. Analysis of the human factor and identification of patterns in the driver's behavior on the road remains an urgent issue. This article is devoted to the design of an information system that helps to assess the emotional and psychophysiological state of the driver, for further forecasting his actions on the road. The method of processing the research results using the Wilcoxon test is presented.

1. Introduction

The road transport industry is actively developing. There are more and more cars on the roads, which provokes the appearance of road defects. While driving, the driver must quickly respond to the appearance of holes in front of the hood, potholes, roadbed subsidence, deviations of the manhole cover, etc. It is especially difficult to identify them in the dark and winter conditions. Therefore, checking such driver characteristics as reaction time, attentiveness, concentration is highly relevant.

The structure of the flow itself is currently changing [1]. Different levels of autonomy of vehicles appear on the roads, making their own adjustments to the driver's behavior on the roads. The structure of cars becomes more complex, there are many electronic elements that, on the one hand, help the driver, on the other, they require a sequence of actions, for the implementation of which it is necessary to perform the actions without errors. In this regard, it is necessary to assess not only the driving experience, but also the condition and mood of the driver. Therefore, it becomes necessary to classify driver behavior on the road and develop methods for monitoring and assessing dangerous driving [2]. Emotional state largely influences driving style, concentration and decision-making time, so it is important to find a correlation between the behavior and state of the driver during driving. Such analysis can greatly assist in predicting the road behavior of fully autonomous vehicles. Thus, the development of system that helps to assess the emotional and psychophysiological state of the driver is relevant.
2. Description of the development environment for game components

The developed information system (IS) Analyzer of Driver Emotional State (ADES) has a client-server architecture similar to work [3]. The main feature of the IS is a testing model using gaming technologies created with Unity.

Unity is a cross-platform computer game development environment developed by the American company Unity Technologies [4]. Unity lets you create applications that run on over 25 different platforms, including personal computers, game consoles, mobile devices, web applications and more. The main advantages of Unity are the presence of a visual development environment, cross-platform support and a modular component system.

The Unity editor has a simple Drag & Drop interface that is easy to customize, consisting of various windows, so you can debug the game right in the editor. The engine uses C# to write scripts. Unity also supports solid and tissue physics. The editor has an object inheritance system; child objects will repeat all changes to the position, rotation, and scale of the parent object. Scripts in the editor are attached to objects as separate components.

When importing a texture into Unity, you can generate an alpha-channel, mip-levels, normal-map, light-map, a reflection map, but you cannot attach a texture directly to the model - a material will be created to which a shader will be assigned, and then the material will be attached to the model. The Unity Editor supports writing and editing shaders. The Unity editor has a component for creating animations, but animations can also be pre-created in the 3D editor and imported with the model, and then split into files.

3. Filling the information system

Unity is a multi-platform 3D and 2D game development tool. This engine provides a fast and flexible way to port your application to almost any popular operating system. The developed information system ADES consists of 7 games aimed at determining the physiological characteristics of the driver:

- Test game for reaction and concentration.
  The task is to keep the red square within the playing field for as long as possible and not collide with obstacles. Output data: number of attempts and elapsed time.
- Reaction speed.
  The test game is designed to determine a simple reaction speed. The task is to press the button in the minimum amount of time when the screen color changes.
- Mindfulness and memory.
  The "Matrix" test game is designed to test and train visual memory. The task is to open all pairs of pictures hidden behind a blue background in the shortest possible time. The goal of the "Matrix" game is to find identical images under the buttons, remembering the desired color and location of the button it needs.
- Test game "Ball" to test a simple reaction.
  The game implements a dynamic drop of objects from the top of the screen. The player needs to collect all the balls, trying not to make mistakes. In addition to the "ball" object, other round objects fall from above.
- Test game "Difficult reaction".
  To determine the difficult reaction of the driver, a game was created, the goal of which is to drive as far as possible and score the most points. The game contains objects that help the player and hinder the achievement of the goal. In the game, depending on the objects caught, the speed of the game, the direction, the level of health changes.
- Test game for switching and distribution of attention.
  The game "Switching and Distribution of Attention" is to correctly determine the shape and the location (complex reaction) of a figure in a minimum amount of time by pressing a button (simple reaction). Description of the game: the screen of the driver's device is divided into two parts, in which random figures will appear; the driver must choose the side of the screen on which there is no figure in the minimum time; the game ends after 60 seconds. During the game, the program calculates the correct and incorrect answers, as well as the average response time, this data is displayed on the screen, and is written into variables and stored in the database for further processing.
- Test game for coordination and concentration.

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The game "Connect the dots without taking your hands off" is to connect the black and red squares with a line in the labyrinth in the minimum amount of time without taking your hand off. The game ends if the player loses (goes out of the screen, the line crosses itself, touches the walls of the maze) or wins.

4. Analysis of the obtained results of the ADES system
The developed information system ADES displays the results of all games in one window. It is enough to select a game from the drop-down list and the statistics of all the results of passing games will be displayed on the screen. If a sufficient number of games have been played (more than 10 playthroughs), then the system displays the trend of change in the progress rates (Figure 1).

![Figure 1. Results of passing the game "Switching and distribution of attention".](image)

All game results are stored in a database, from where they can be downloaded. The uploaded data can be presented in the form of table 1.

| Date       | Time   | Place | Device | State | Mood     | Correct clicks (pcs.) | Wrong clicks (pcs.) | Average response time (s) |
|------------|--------|-------|--------|-------|----------|------------------------|---------------------|---------------------------|
| 15.08.2020 | 8:26   | Home  | Computer | Sleepy | Suppressed | 33                     | 22                  | 1.070423                  |
| 20.08.2020 | 8:30   | Home  | Computer | Vigorous | Merry     | 13                     | 15                  | 0.7373057                 |
| 21.08.2020 | 11:01  | Home  | Computer | Emotional | Merry     | 331                    | 2                   | 1.538989                  |
| 22.08.2020 | 11:47  | Home  | Computer | Vigorous | Unstable  | 307                    | 46                  | 0.5493248                 |
| 23.08.2020 | 12:55  | Home  | Computer | Irritated | Merry     | 306                    | 4                   | 0.5493248                 |
| 24.08.2020 | 14:11  | Home  | Computer | Vigorous | Cheerful  | 307                    | 5                   | 0.5626769                 |
| 25.08.2020 | 16:08  | Home  | Computer | Tired   | Cheerful  | 307                    | 3                   | 0.5435227                 |
| 26.08.2020 | 17:16  | Home  | Computer | Sleepy  | Suppressed | 306                    | 6                   | 0.5392932                 |
| 28.08.2020 | 23:48  | Home  | Computer | Tired   | Merry     | 309                    | 6                   | 0.5247977                 |
| 20.08.2020 | 22:00  | Home  | Computer | Vigorous | Merry     | 304                    | 3                   | 0.5363936                 |
| 23.08.2020 | 00:08  | Home  | Computer | Vigorous | Depressive | 307                    | 5                   | 0.5363282                 |
| 22.08.2020 | 25:27  | Home  | Computer | Vigorous | Merry     | 306                    | 5                   | 0.5498408                 |
| 23.08.2020 | 27:35  | Home  | Computer | Vigorous | Sorrowing | 305                    | 3                   | 0.5527318                 |
| 24.08.2020 | 29:33  | Home  | Computer | Tired   | Depressive | 305                    | 7                   | 0.5229787                 |
| 25.08.2020 | 00:45  | Home  | Computer | Irritated | Merry     | 303                    | 3                   | 0.527375                  |
| 26.08.2020 | 21:11  | Home  | Computer | Vigorous | Merry     | 302                    | 1                   | 0.5809607                 |
| 27.08.2020 | 23:57  | Home  | Computer | Tired   | Unstable  | 300                    | 3                   | 0.5831292                 |
| 28.08.2020 | 22:48  | Home  | Computer | Tired   | Merry     | 309                    | 6                   | 0.5247977                 |

Table 1. Fragment of test results and data processing.

The results of tests using gaming technologies are processed using statistical analysis. The Wilcoxon test was used as a statistical processing method [5].

Three different pairs of emotional states of drivers were considered: “depressive” + “calm”, “depressive” + “smiling” and “smiling” + “calm”. For three pairs, the dependence of the number of correct answers, as well as the reaction time of the subject on his emotional state, was tested. Checking the dependence of the test results on the physiological state was considered in work [6].
Table 2 Calculation of Wilsonson's criterion for the dependence of correct answers

| Name                  | Value          |
|-----------------------|----------------|
| Emotional condition   | Depressive     | Smiling      | Calm          |
| Condition             | A              | B            | C             |
| Selection size $n_i$  | 123            | 135          | 229           |
| Variation series      | $N_1=n_1+n_2=258$ | $N_2=n_2+n_3=364$ | $N_3=n_1+n_3=352$ |

For $N_1$

Hypothesis $H_0$: The number of correct answers does not depend on whether the experiment participant is in state A or in state B

- $W_{observed} = 21706$
- $W_{lower} = 20212$
- $W_{upper} = 23207$

Conclusion: Confirmation of the hypothesis $H_0$: The number of correct answers does not depend on whether the participant is in state A or in state B

Hypothesis $H_1$: The number of correct answers depend on whether the experiment participant is in state A or in state B

For $N_2$

Hypothesis $H_0$: The number of correct answers does not depend on whether the experiment participant is in state B or in state C

- $W_{observed} = 16507$
- $W_{lower} = 14943$
- $W_{upper} = 16913$

Conclusion: Confirmation of the hypothesis $H_0$: The number of correct answers does not depend on whether the participant is in state B or in state C

Hypothesis $H_1$: The number of correct answers depend on whether the experiment participant is in state B or in state C

For $N_3$

Hypothesis $H_0$: The number of correct answers does not depend on whether the experiment participant is in state A or in state C

- $W_{observed} = 23459$
- $W_{lower} = 23042$
- $W_{upper} = 26233$

Conclusion: Confirmation of the hypothesis $H_0$: The number of correct answers does not depend on whether the participant is in state B or in state C

Hypothesis $H_1$: The number of correct answers depend on whether the experiment participant is in state A or in state C

To check the dependence of the response time on the state, a similar calculation was carried out. Hypothesis $H_2$ was assumed - the dependence of the reaction time on the emotional state; hypothesis $H_3$ was chosen as a competing hypothesis - the absence of the dependence of the driver's reaction time on the emotional state. Processing the results of the experiment and testing hypotheses $H_0$ and $H_2$ in Table 3.
Table 3. Summary table with results.

| Confirmation of hypothesis $H_0$ for a pair of states | Confirmation of hypothesis $H_2$ for a pair of states |
|-------------------------------------------------------|-------------------------------------------------------|
| $N_1$ | $N_2$ | $N_3$ | $N_1$ | $N_2$ | $N_3$ |
| +    | +    | +    | +    | +    | +    |

5. Conclusion

A methodology for testing a driver using gaming technologies to determine emotional and physiological states is presented. The presented studies have shown that the emotional state of the driver affects the reaction time and the total number of responses. On average, the ratio of the number of correct answers to all remains unchanged. These studies can be used in the training of drivers before entering a real road, as well as in studies of the influence of road situations on the condition and characteristics of the driver.

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