Research On Human Physical Characteristics of Drivers Based on Ergonomics

Huawei Xie [a], Jinzhou Su
Fujian Police College, Fuzhou 350007, China
[a] momoxhw@163.com

Abstract. Correctly identifying the driver's identity is the breakthrough in case investigation and tracing back to the source.Based on ergonomics, this study explored the relationship among man-machine-environment and their interaction rules from the perspective of human physiological and psychological characteristics, so as to achieve the purpose of optimizing the man-machine system's working efficiency.In this study, the key data acquisition elements such as car seat, control device, visual field and display device are determined under the condition of driving comfort.At the same time, the key data of drivers with different personal characteristics on the adjustment of cab layout elements under the driving comfort state were collected, and then combined with relevant theoretical knowledge of statistics, the prediction model of personal characteristics of motor vehicle drivers under the background of ergonomics was constructed.

Keywords: Ergonomics; drivers; human physical characteristics; predict; model.

1. Introduction

The identification of the driver is the fundamental guarantee for restoring the truth of the incident, avoiding the loss of public and private property and clarifying the responsibility of the accident. It is of great significance to grasp the personal characteristics of drivers and timely and accurately identify the drivers involved in traffic accidents, for the identification of accident liability, the mediation of damage compensation and the punishment of the drivers involved in traffic accidents. It is conducive to the timely and proper handling of the accident and the resolution of the conflict between the parties concerned, to protect the legitimate rights and interests of the victims to the greatest extent, so as to further improve the efficiency and quality of the public security organs.[1] This is the practice of law enforcement for the people, to build a harmonious relationship between the police and the people. It is of great significance to maintain social fairness and justice and build a harmonious society.

2. Ergonomics in the driving view

As a cross and comprehensive subject, ergonomics includes many subjects such as human biology, computer science, mechanical science and psychology.[2] It applies to a wide range of applications. It studies in a certain working environment, the relationship between people, machines and environment and the rules of action, and how to integrate work efficiency and people's comfort, safety, to create the best system efficiency of the operating environment and so on. From the human point of view, ergonomics can explore the physiological and psychological changes of occupants in the process of car use, as well as the interaction between various factors in the human-vehicle environment.

Driving posture generally refers to the posture state taken by the driver in order to complete the corresponding driving task in a specific driving environment, which is affected and restricted by many factors.[3] Due to the long time in static posture and repetitive operation posture, drivers tend to seek the most comfortable and safe operation mode, and their driving posture has a certain degree of habituation and stability. Each human body has its own unique characteristics. On the premise of comfort, by collecting the debugging data of the car seat, control device and visual field device in the driver's room, the driver's personal characteristics are summarized, so as to provide scientific theoretical analysis for the identification of the driver in the accident. In order to facilitate the study of the sitting state of drivers, the human skeleton is simplified into a two-dimensional rod-shaped model of motion chain, [4]as shown in Fig. 1.

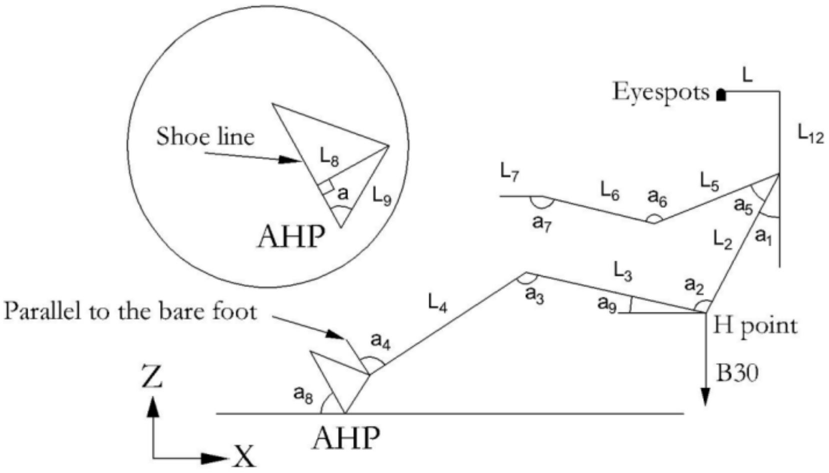

Fig.1. Two-dimensional rod-shaped mannequin

3. Preparation for the experiment

The experiment included 100 subjects, including 76 males and 24 females, who had been driving for more than a year. Young drivers are the representative types, ranging in age from 20 to 30 years old.The average height of the subjects is 168.55cm. The height distribution of the subjects basically conforms to the normal distribution. Before the experiment, inform each experimenter of the purpose and requirements of the experiment. All subjects tried to wear tight and elastic clothing, which was convenient to mark and measure their body joint parts during the experiment, and observed and recorded the posture state of the subjects according to a unified standard.

The experimental model is Englon SX7, one of Geely SUV models.The experimenter entered the experimental vehicle, adjusted the seat, rearview mirror and other layout elements according to their own state according to their usual driving habits, and placed their hands on the steering wheel naturally until they were finally in a "comfortable and natural driving state".

4. Experimental design

4.1. Experimental parameter setting and influence range

The adjustment variables of interior layout elements were selected as experimental parameters. The collected data were statistically analyzed to study the influence of drivers' driving state variables on cab experimental parameters, as shown in Table 1.

Table 1. Influence of experimental parameters on driving state variables

	Back Angle (°)	Chair Angele (°)	The seat at the far right to BOF horizontal distance (mm)	The straight-line distance from the center of the steering wheel to the far right of the seat (mm)	The Angle between the left rearview mirror and the Y-axis (°)	The Angle between the right rearview mirror and the Y-axis (°)
Range of variation	17-26	102-113	650-830	470-640	67-82	54-71
Hip Z (mm)	29	29	18	14	30	22
Hip X(mm)	53	53	80	66	52	2.5
Left knee (°)	-8	-8	4	10	-8	4
Trunk thighs Angle (°)	2	2	3	1	2	1
Lower limbs long (mm)	75	75	135	150	75	30
Eyespots Z(mm)	63	63	15	39	63	65
Eyespots Y(mm)	-7	-7	-1	2	-7	-7
Shoulder high(mm)	65	65	20	39	65	50
Left elbow Angle (°)	13	13	33	21	13	0

Rearview mirror Angle is mainly related to the position of people's eyes. In the same car, adjusting the Angle of the rear-view mirror is an important guarantee for different drivers to obtain indirect vision, so the relationship between the rear-view mirror and the position of the eye point should be analyzed.

4.2. The experimental process

According to the obtained data, the linear regression analysis was carried out for each driving state variable and the adjustment variable of cab layout element,as shown in Table 2. Thus, the influence of adjusting variables of each cab layout elements on driving state variables can be analyzed.

Table 2. Summary of coefficient of change for regression analysis

	Back Angle (°)	Chair Angele (°)	The seat at the far right to BOF horizontal distance (mm)	The straight-line distance from the center of the steering wheel to the far right of the seat (mm)	The Angle between the left rearview mirror and the Y-axis (°)	The Angle between the right rearview mirror and the Y-axis (°)
Hip Z（mm）	4.6581	4.6581	-0.0242	-0.0541	0.5311	0.6877
Hip X(mm)	8.7799	8.7799	0.615	0.2592	1.3947	1.9016
Left knee (°)	-0.5147	-0.5147	0.0161	0.1158	-0.2954	0.0118
Trunk thighs Angle (°)	0.629	0.629	0.0086	0.0162	0.0529	0.0722
Lower limbs long（mm）	12.0195	12.0195	0.9192	0.4276	4.4053	5.3227
Eyespots Z(mm)	6.1127	6.1127	0.1295	0.0637	2.0544	3.8136
Eyespots Y(mm)	-1.3335	-1.3335	0.0259	-0.0269	-0.1424	-0.279
Shoulder high(mm)	8.2552	8.2552	0.1591	0.0354	2.4510	4.5135
Left elbow Angle (°)	1.4982	1.4982	0.1160	0.0374	0.0372	0.4234

In the process of driving, according to the different driving tasks, the driver must constantly complete a variety of executive operation work, and always keep the sitting state for operation.In this process, the driver's hip position is relatively fixed and will not change greatly because of the change of driving operation.This feature of the driving operation indicates that the position of the human buttocks is only affected by the horizontal distance between the pedal and the seat.In the same driving environment, the position of the pedal is fixed and unchanged, so the position of the driver's point H mainly depends on the position state of the seat, that is, the position of point H will basically remain unchanged without changing the position state of the seat.When the seat position is fixed, the driver's lower limb posture is relatively fixed. Therefore, when studying and analyzing the influence of various layout parameters in the cab on driving state, the relationship between seat and lower limb state, steering wheel and upper limb state can be targeted to explore when the driver is in normal driving state, providing a certain research direction for experimental data analysis.

Regression equation of driving state prediction is summarized in Table 3.

Table 3 Summary of regression equations for driving state prediction.

	Male	Female
HipZ	199.2177+4.6383*Back Angle (R²=0.808016388)	219.3499+3.5419*Back Angle (R²=0.881558458)
HipX	-19.4012+0.9283*Horizontal distance to the right of the seat (R²=0.929821658)	-8.2699+0.1132*Horizontal distance to the right of the seat (R²=0.957811985)
Left knee (°)	342.6057-0.6872*HipZ+0.0278*Horizontal distance+2.23*Back Angle-0.1513*Steering distance (R²=0.906752995)	375.5991-1.0335*HipZ+0.0747*Horizontal distance+2.7883*Back Angle-0.0978*Steering distance (R²=0.895387776)
Trunk thighs Angle (°)	91.6445-0.1093*HipZ+1.1768*Back Angle+0.1137*Left knee Angle (R²=0.826967776)	81.2379-0.044*HipZ+1.1046*Back Angle+0.0788*Left knee Angle (R²=0.868765165)
Eye height in the car	①589.2479+4.4292*Steering distance -5.2167*Trunk thighs Angle+1.5605*HipZ-2.8548*Far right of seat (R²=0.82094215) ②1041.283-5.1288*Trunk thighs Angle+2.3683*Left rearview mirror+4.2097*Right rearview mirror (R²=0.819866696)	①617.494+2.6833*Steering distance -2.0165*Trunk thighs Angle+0.6459*HipZ-1.9228*Far right of seat (R²=0.875727212) ②721.5182-4.346*Trunk thighs Angle+4.3401*Left rearview mirror+5.228*Right rearview mirror (R²=0.804034076)
Eyespots Y(mm)	231.8+0.0374*Far right of seat-0.4217*HipZ (R²=0.756527346)	217.8+0.0354*Far right of seat-0.4225*HipZ (R²=0.744315814)
Shoulder high(mm)	①-194.043+2.9395*Back Angle+0.974*Eye height in the car (R²=0.925461465) ②734.8386-4.325*Trunk thighs Angle+2.7713*Left rearview mirror+4.8806*Right rearview mirror (R²=0.789886084)	①-228.46+1.9544*Back Angle+1.0419*Eye height in the car (R²=0.916813214) ②381.199-2.6318*Trunk thighs Angle+4.2989*Left rearview mirror+5.6563*Right rearview mirror (R²=0.79650382)
Elbow	93.7609+0.1293*The rightmost horizontal distance+0.0811*Steering distance-0.1863*Shoulder high+2.03755*Back Angle (R²=0.844855422)	92.7609+0.1313*The rightmost horizontal distance+0.0818*Steering distance-0.1846*Shoulder high+1.92*Back Angle (R²=0.844910734)
Lower limbs Long (mm)	406.0607-1.4433*Left knee Angle+0.9425*Horizontal distance (R²=0.899671146)	647.9923-0.8039*Left knee Angle+0.5696*Horizontal distance (R²=0.800974259)
Eye height mm)	-312.2855+0.8313*Lower limbs Long+1.1251*Eye height in the car (R²=0.95694107)	-543.718+1.2518*Lower limbs Long+0.9472*Eye height in the car (R²=0.951059056)
height(mm)	149.205+0.9851* Eye Height (R²=0.964466649)	67.78+0.6233* Eye Height (R²=0.919988257)
Height to weight ratio	36.0317+0.1712*ElbowAngela-1.4505*Back Angle-0.2602*Eyespots Y+0.1767*Left knee Angle-0.0248*height+0.1817*HipZ (R²=0.831464181)	28.5317+0.182*Elbow Angela-1.4805*Back Angle-0.2602*Eyespots Y+0.1767*Left knee Angle-0.0248*height+0.1877*HipZ (R²=0.822803916)

4.3. The experimental conclusion

The six variables are all related to the body posture during driving, among which the influence of the dorsal Angle on Hip, eye point, shoulder position and trunk thigh Angle is obvious [5], and the elbow joint Angle and knee Angle are also affected, but slightly.The Angle of rearview mirror deflection is mainly affected by the height of the eye point, and the distribution position of the shoulder can be analyzed by combining with the characteristics of human body size. After the information of H point and eye point is known, the information of shoulder position can be obtained through inverse kinematics and optimization calculation [6].

The influencing factors of driving posture state prediction include not only the parameters of cab layout, but also the size of various parts of the driver's body [7].

5. Conclusion

Through experiments, this study explored the relationship between the size of personal characteristics and seat, steering wheel and rearview mirror under comfortable driving state, and obtained the corresponding function equation by multiple factor regression analysis.By observing the driver's driving state and the Angle of the driver's seat, the experiments were further analyzed. It was found that the trunk thigh Angle ≈ the chair Angle -8°≈ the back Angle +80°, which provided convenience for further analysis of the relationship between the driving state and the adjustment variables of the cab layout element.Data analysis shows that male and female drivers have different regression analysis on driving state prediction, but the coefficient of prediction factors is relatively small. In order to improve the accuracy of the prediction effect, the driver's personal characteristics can be predicted by gender classification in the range of conditions.

Acknowledgments

This work was financially supported by the Education Department in Fujian (JAT200389).

References

[1] Yu L, SUN N Q. Discussion on the importance and methods of identifying drivers responsible for traffic accidents [J]. Journal of Xinjiang Police College, 2014, 34(02):30-33.

[2] Li Qianqian. Research on Moving Vehicle Recognition Technology in Video Surveillance [D]. Taiyuan University of Technology,2015.

[3] Chai Chunlei. Research on Ergonomic Design Technology Based on Driving Posture Prediction Model [D]. Zhejiang University, 2005.

[4] Liu Yan. Digital Man-machine Design and Evaluation Technology of Bus Interior Environment [D]. Northwestern Polytechnical University,2006.

[5] Lu Qi. Research on Ergonomic Design of Car Based on RAMSIS [D]. Wuhan University of Technology,2012.

[6] Cui Wenshi. Study on Cab Layout Optimization Based on Joint Load Posture Comfort Evaluation [D]. Jilin university,2011.

[7] Yan Wenli. Vehicle Cab Design Based on Ergonomics [D]. Xi 'a Polytechnic University,2017.