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OBJECTIFYING DISCOMFORT SEAT MEASUREMENT FOR NEXT GENERATION TRUCK DRIVER'S SEAT

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ABSTRACT - Comfort is an attribute that today's drivers demand more and more. Seat is one of the important features of vehicle and there is the place where the professional driver spends most of their time. According to 'European Union Legislation for Drivers and Promote', the weekly driving time for truck drivers shall not exceed 56 hours. Assuming eight week vacation and one more for holiday, the truck driver is spending around 2408 hours driving time per year. Truck seat, which are in contact with truck occupants, play an important role in improving the comfort and work environment of a driver. The perceived comfort of humans in a given environment can be classified as a subjective assessment, because it is possible to find a considerable variation in responses of different people to the same situation. Nevertheless, the factors on which the opinions of people on (dis)comfort level are physical variables such as pressure, temperature and heart rate. The main research objective is to investigate "How to improve the truck seat comfort objectively?" The paper describes the state-of-the-art objective measurement techniques in seat development and an intelligent system is proposed for the next generation truck driver's seat.

INTRODUCTION

Many truck drivers nowadays spend a significant proportion of their time travelling and there is an increasing demand for comfort. There are various reasons for continuing to try to improve driving comfort conditions in vehicles. A good ambience results in better performance by the driver, improving the road safety. Truck manufacturers recognize comfort as one of the major selling point, as it is thought to play an important role for buyers as well. The seat comfort can be distinguished themselves from competitors. In addition, employers are getting interested in comfortable equipment for their employees in order to create a healthy and stimulating working environment.

Drivers of commercial vehicles, particularly heavy trucks, are required to drive long and sometimes irregular hours. In America, the driving limit for truck drivers, as defined by the Federal Highway Administration Hours-of Service (HOS) regulations, is 10 hours [1]. Commercial trucks are unique in that they are specifically designed to transport heavy loads over long distances, where for the trucks; high priority has been given to durability and functional efficiency. On the contrary, automobiles are made to comfortably accommodate passengers over relatively shorter distances [2]. The personal vehicles are emphasized in the factors such as riding comfort, handling, technology and appearance are of high importance in vehicle market. The different requirements of commercial trucks and personal automobiles have led to separate directions in design. Therefore the truck driver's seat plays an important role to position the

driver to perform the task of driving, meet the safety requirements, and fulfill the drivers comfort needs. The paper describes the objective measurement methods that are used for the development of comfortable seat, and proposes an intelligent system that enable the assessment of seat comfort for the development of next generation truck driver's seat.

COMFORT AND DISCOMFORT IN VEHICLE SEAT

The Cambridge Advanced Learner's Dictionary defines comfort as a pleasant feeling of being relaxed and free from pain. Hertzberg [3] describes comfort as absence of discomfort. The term "seat comfort" is typically used to define the short-term effect of a seat the human body [4]. Comfort is a generic and subjective feeling that is difficult to measure, interpret, and related to human physiological homeostasis and psychological well being [5]. Generally, comfort issues not under debate by researchers are [6]: (1) comfort is a construct of a subjectively-defined personal nature; (2) comfort is affected by factors of various nature (physical, physiological, psychological); and (3) comfort is a reaction to the environment.

The concepts of comfort and discomfort in sitting are under debate. There is no widely accepted definition, although it is beyond dispute that comfort and discomfort are feelings or emotions that are subjective in nature [6]. Seating discomfort has been examined from a number of different perspectives. The problem with evaluating comfort in regards to pressure or any other factor is that, comfort is subjective and not easy to quantify. Seating discomfort varies from subject to subject and depends on the task at hand. Comfort, however, is a vague concept and subjective in nature. It is generally defined as lack of discomfort [7].

For example, truck drivers require sitting for long periods of time approximately eight hours. The extended period of sitting includes higher risk of back problems, numbness and discomfort in the buttocks due to too high surface pressure under the thighs [8]. The study by Adler et al. [9] shows that the driver posture is not static and changes over time. Posture changes and continuous motion are strategies of the driver to avoid mechanical load and ischemia of tissue, which has been identified as one main reason for discomfort. Discomfort feelings, as described by Helander and Zhang [10], is affected by biomechanical factors and fatigue. Zhang [11] presented a model that illustrates the interaction of comfort and discomfort as shown in Fig. 1. Transition from discomfort to comfort and vice versa are possible in the intersection of the axes. Hence, if discomfort is increased, such as with a longer time within task and fatigue, comfort will decrease. Its means that good biomechanics may not increase the level of comfort, it is likely that poor biomechanics turns comfort into discomfort.

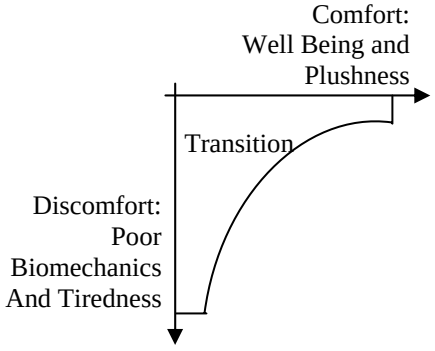

Figure1: Hypothetical Model of Discomfort and comfort [11]

OBJECTIVE MEASUREMENT METHODS FOR TRUCK SEAT DISCOMFORT

The design of truck driver's seating for improved driving discomfort is one of the primary goals for truck seat manufacturers. Comfort measurement is difficult because of such factors as user subjectivity, occupant anthropometry, seat geometry, and amount of time spent sitting [12]. A great deal of research has been performed in recent years to find objective measures for predicting seat comfort perception. Some of the proposed objective measures include vibration, interface pressure, and muscle activity. These objective measures are correlated with subjective data to determine the relative effects of each measure related to comfort [13]. Research has shown that some of the main factors that affect seating comfort are seat-interface pressure distribution, whole-body vibration and pressure change rate [14].

A vast majority of objective measures used for evaluating comfort and discomfort. From the literature search, the objective measurement methods for seat such as pressure distribution, posture, computer-aided design (CAD), computer-aided engineering (CAE), temperature, humidity, vibration, electromyography (EMG), and adrenaline. Fig. 2 shows an overview of different objective measurement methods for seat comfort and discomfort.

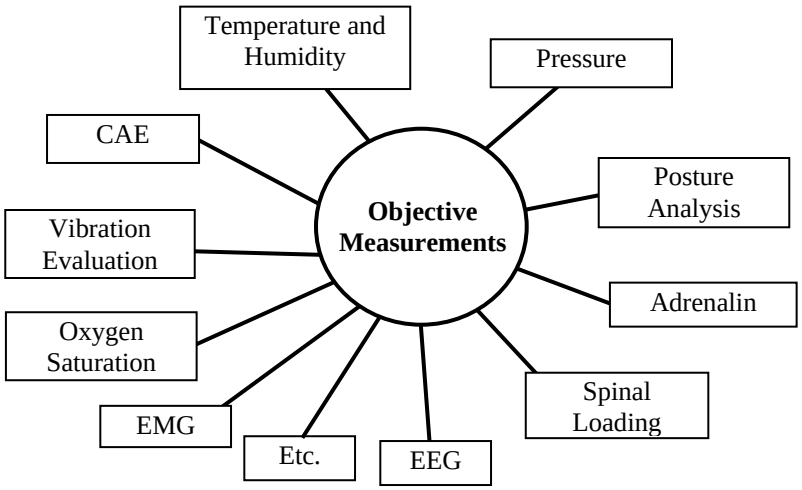

Figure 2: Overview of different objective measurement methods for seat comfort and discomfort

Pressure Measurement

The pressure distribution method is the most common method that used by researchers to measure seat comfort objectively. Several researchers have measured the pressure at the human-seat interface using electronic sensors (capacitive, resistive, strain gauge), pneumatic and electro-pneumatic. However, the visco-elastic behavior at the interface is completely altered by the sensors used [15]. Andreoni et al. [16] used Tekscan pressure mat to gather cushion and backrest pressure data during static conditions and real driving activity. Figure 3 shows the various pressure measurement techniques that used in the seat development.

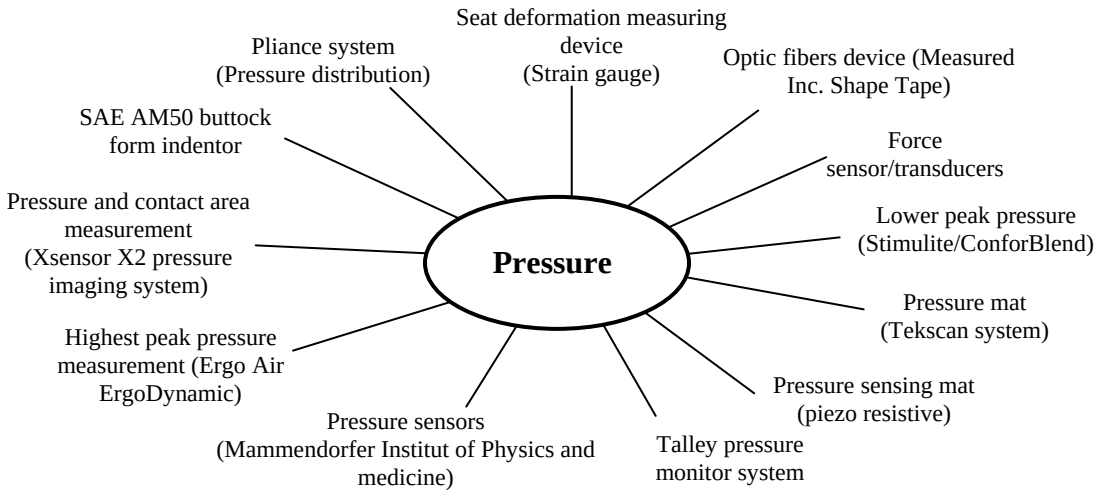

Figure 3: Various pressure measurement techniques

Posture Analysis

The automotive industry strongly encourages research in the field of objective comfort assessment, especially dedicated to the seat and the related postures [17, 18]. Driver posture is one of the most important issues to be considered in the vehicle design process [19] regarding not only the car and the user [20, 21] but also the experimental conditions. Figure 4 shows the different objective measurement techniques for posture analysis.

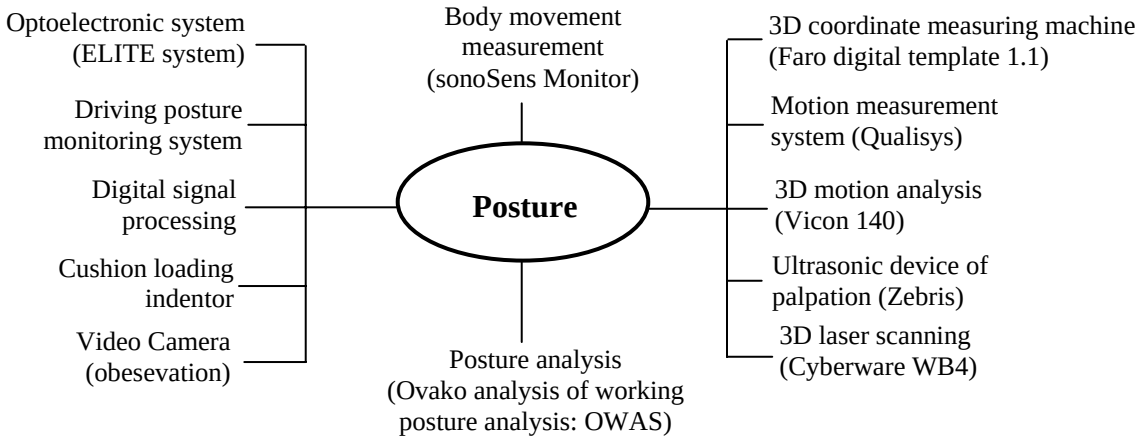

Figure 4: Objective measurement techniques for posture analysis

Vibration

A major portion of the vibrations experienced by the occupants of an automobile enters the body through the seat [22]. Whole-body vibrations, which are vertical vibrations, tend to affect the human body the most. These vibrations are transmitted to the buttocks and back of the occupant along the vertebral axis via the base and back of the seat [23]. Figure 5 shows the objective measurement methods in vibration analysis.

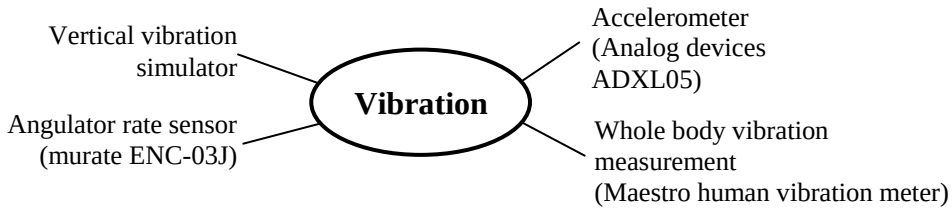

Figure 5: the objective measurement methods for vibration analysis

Temperature and Humidity

Thermal comfort is an important aspect to be considered in the ergonomics evaluation of the driver seats, which are significant interfaces between man and machine in autos. Determining thermal comfort in vehicle is a complex task, because thermal comfort involves the interaction of many variables and automobiles are susceptible to temporal fluctuations in their thermal environments [24]. As shown in Figure 6, air speed, air temperature, humidity and mean radiant temperature are used to determine the temperature and humidity of the seat objectively.

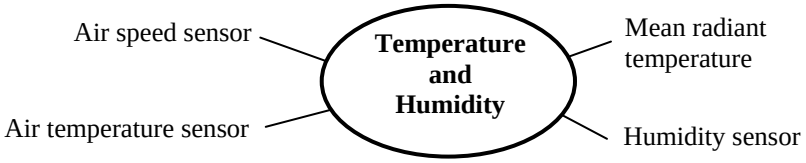

Figure 6: The objective measurement methods for temperature and humidity

Computer Aided Engineering

Due to the advancement of the computer system, computer-aided engineering (CAE) is used to support scientists and engineers in tasks such as simulation, analysis, design, manufacture, planning, diagnosis and repair. The use of CAE could facilitate the seat development process. In the early stages of the design process a new design can be tested for its degree of comfort by computer simulations with models of the human and the seat. This allows manufacturers to speed up the design process of a new seat or interior and reduce costs. Figure 7 shows some CAE techniques that used to measure the seat objectively.

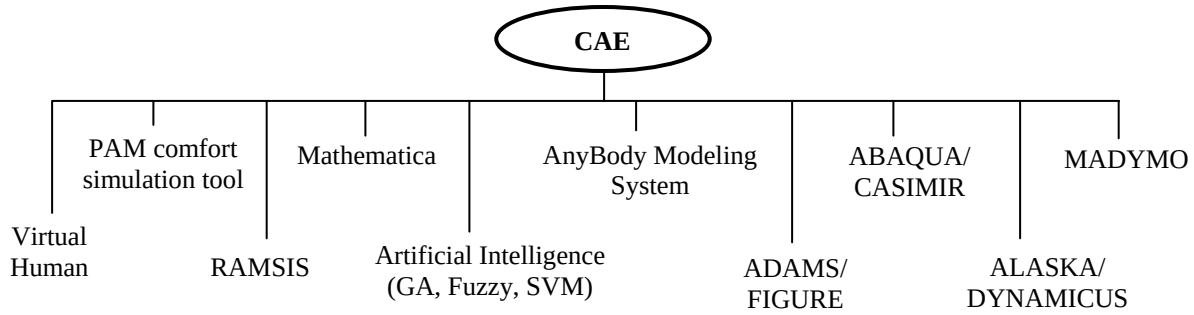

Figure 7: CAE techniques for seat development

Physiology

Biological parameters such as heart rate, muscle, and urine can be used to measure the seat comfort objectively. The biological parameters are based on human body physiological or orthopedic phenomenon. For example, electromyography (EMG) signals is used to measure the myoelectrical activity of muscles, adrenaline in the urine can be used to measure the human stress level, and oxygen saturation is used to check the human discomfort. Figure 8 shows the various objective measurement methods for physiological analysis.

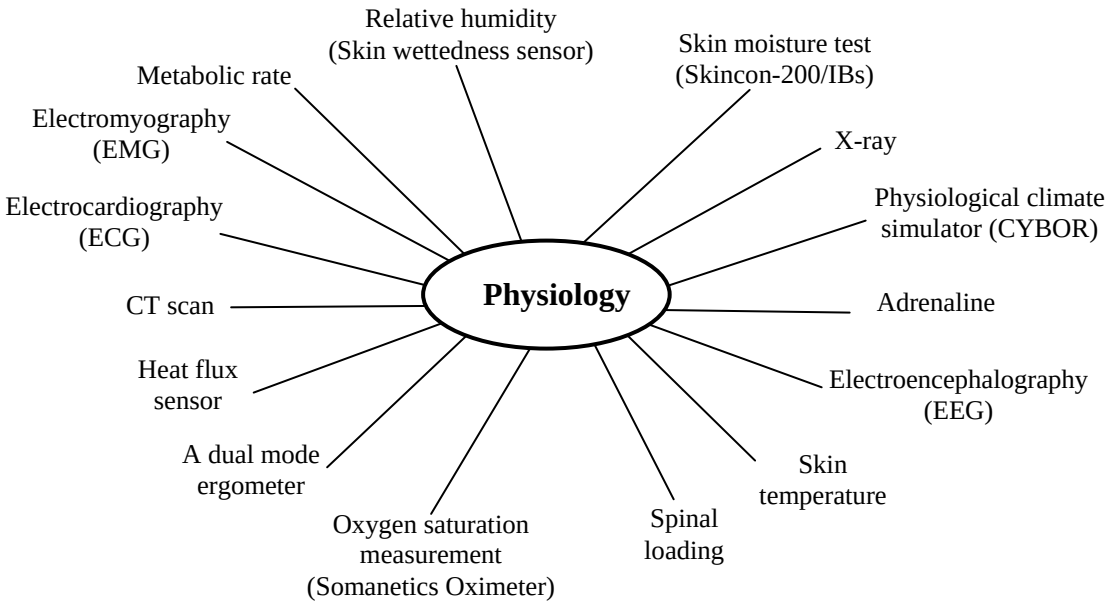

Figure 8: Various objective measurement methods for physiological analysis

PROPOSED INTELLIGENT SEAT SYSTEM FOR TRUCK DRIVER

An intelligent system is proposed to improve the comfort of truck driver's seat as shown in Figure 9. The truck driver's seat will be equipped with multiple sensors. The sensors will detect the driver condition such as physiology, movement and posture. The data from the sensors will be input to central processing unit (CPU). The artificial intelligence software will be used to support the CPU to diagnose and evaluate the input data. In addition, the data will be input to truck driver's sitting database. The database is used to record sitting condition of the truck driver and adjust the seat according to the driver preferred sitting position. The output from the system is the actuators. The actuators will change the seat condition such as shape, softness, and contour.

CONCLUSION

In this paper, we have described the objective measurement techniques that used to measure the driver sitting (dis)comfort objectively and proposed an intelligent seat system for truck driver. The literature findings shown that pressure measurement methods is the favorite among the seat developers or researchers. The method of pressure measurement would provide seat developers/researchers with rapid, easily quantifiable data, which can indicates the sitting areas which were contributing to seat (dis)comfort at an early stage in the design process. It will also

help in the development of intelligent seat system for truck driver. Besides, posture measurement methods also can also be used to detect the posture change of truck driver effectively. The frequent change of posture can indicate that driver is not comfortable. For the physiological measurements, obtaining human body data is a good way to measure the human discomfort objectively as well. The objective measurement of truck driver's discomfort should be approached by the measurement of pressure, posture and physiological at the truck driver's seat. Our aim is to reduce the current truck driver's seat discomfort especially for long haul truck drivers.

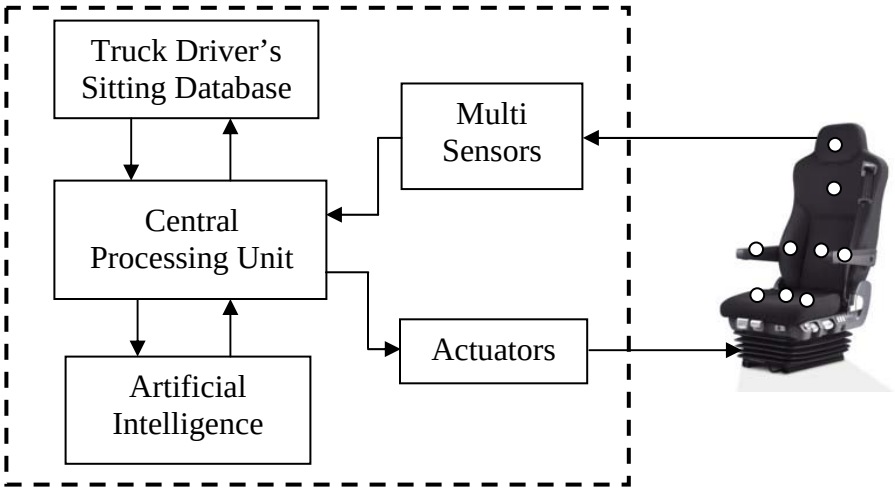

Figure 9: Proposed intelligent truck seat system

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