Development of Smart System for Neck Comfort during Air Travel

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***Abstract*—Technology has changed significantly over the years. As a result, consumer expectations, in terms of performance, have risen. In Western society, the comfort of products has developed into important issue. Air travels, especially long distance, expose passengers a number of factors that may cause both physiological and psychological discomfort. Passenger comfort is clearly a main factor in user's acceptance of transportation systems. In order to reduce the stress in air travel, an intelligent system is proposed to integrate into the aircraft passenger seat. The paper describes the development of smart neck support system that will improve the aircraft passenger comfort. We conducted experiments in the aircraft cabin simulator to validate smart neck support system. Surface electromyography is used to measure the sternocleidomastoid stress. The results showed that smart neck support system able to reduce sternocleidomastoid stress adaptively.**

Keywords-smart system; neck support; air travel; experiment

I. INTRODUCTION

Air travel is becoming increasingly more accessible to people both through the availability of cheap flights and because the airlines are now able to cater for individuals of all ages and disabilities. Health problems may arise due to anxiety and unfamiliarity with airport departure procedures prior to flying, whilst during the flight, problems may arise as a result of the food served on board, differences in the environmental conditions inside the cabin (pressure, ventilation, relative humidity, noise and vibration), the risk of cross-infection from fellow passengers, seat position, posture adopted and duration of the flight. These can be further compounded by changes in time zones and meal times, which may continue to affect an individual's health long after arrival at the final destination [1]. Travel by air, especially long distance, is not a natural activity for human. Many people experience some degree of physiological and psychological discomfort and even stress during flying. Excessive stress may cause the passenger to become aggressive, over-reaction, and even endanger the passenger's health [2,3]. A number of health problems can affect flying passengers.

Comfort is an attribute that today's passenger demand more and more. The aircraft passenger comfort depends on different features and the environment during air travel. Seat comfort is a subjective issue because it is the customer who makes the final determination and customer evaluations are based on their opinions having experienced the seat [4]. The aircraft passenger seat has an important role to play in fulfilling the passenger comfort expectations. The seat is one of the important features of the vehicle and is the place where the passenger spends most of time during air travel. The aviation industry is highly competitive and therefore airlines try to maximize the number of seats [5]. Often this results in a very limited amount of seating space for passengers, especially in economy class [6]. In this paper, we describe aircraft sitting comfort and discomfort and propose an intelligent system to improve the aircraft passenger neck comfort during air travel.

II. AIRCRAFT SEAT

Seat is one of the important elements for the passenger comfort. Different seat aspects have to be seen and taken into account in the comfort model. In charter and economy class the two least satisfactory characteristics are 'seat comfort' and 'leg room' [1].

The Civil Aviation Authority (CAA) is the regulatory body for the safety guidelines for aircraft seat spacing. The guidelines are set with safety, not comfort, in mind and relate to robustness of aircraft seats at the time of a crash and the ease of passenger evacuation in the event of an emergency [1]. There are three kinds of seat position in the aircrafts, such as window, corridor and isolated. For passengers seated in the central position of three or more seat row, the feeling of being surrounded is one of the worst aspects of economy air travel.

InNova [7] was created a seat design called the bubble. The innovation of the design is to relocate the hand baggage to underneath the seat, therefore eliminating the need for overhead bins; this in turns increase the passenger's perception of space by reducing the tunnel effect. B/E Aerospace developed the moving set called ICON seating [8]. The moving seat surface allows the passenger to adopt multiple postures, including back and side sleep. Side support wings on the seat bottom can be adjusted to provide leg support in a side sleep posture. ICON seating allows passenger in full control of comfort and personal space.

Lantal Textiles from Switzerland was developed the pneumatic cushions comfort system for aircraft seat. The new system is replaced conventional foams with air-filled chambers. Passenger can adjust the pneumatic pressure of the seat to suit their personal preferences, from firm when seated upright and medium when relaxing to soft in the fully flat position [9].

III. Sitting Comfort And Discomfort

The Cambridge Advanced Learner's Dictionary defines comfort as a pleasant feeling of being relaxed and free from pain. Hertzberg [10] 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 [11]. Comfort is a generic and subjective feeling that is difficult to measure, interpret, and related to human physiological homeostasis and psychological well being [12]. Generally, comfort issues not under debate by researchers are [10]: (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 [13]. 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. Comfort, however, is a vague concept and subjective in nature. It is generally defined as lack of discomfort [14].

Discomfort feelings, as described by Helander and Zhang [15], is affected by biomechanical factors and fatigue. 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 increase. Its means that good biomechanics may not increase the level of comfort, it is likely that poor biomechanics turns comfort into discomfort.

IV. Framework of Smart Neck Support System

The intelligent neck support system is developed to reduce sternocleidomastoid (SCM) muscle stress during air travel. The developed system is designed for economy class aircraft passenger seat. Fig. 1 presents the framework for neck support system. The framework is commenced by detecting the passenger's head posture. Air pressure sensor is embedded in the seat to detect the head posture of the passenger. Subsequently, information of the head posture is sent back to the smart control module. The smart control module functions by (1) supporting passenger head based on current head posture; and (2) changing the head rotation angle of passenger to reduce the neck muscle stress adaptively. The smart control module would detect the low activity of passenger, once the passenger is in contact with airbag for more than one minute, the system will activate. The system will move the passenger head facing front and reduce the SCM muscle stress, since the head that facing front is the most comfort position [16].

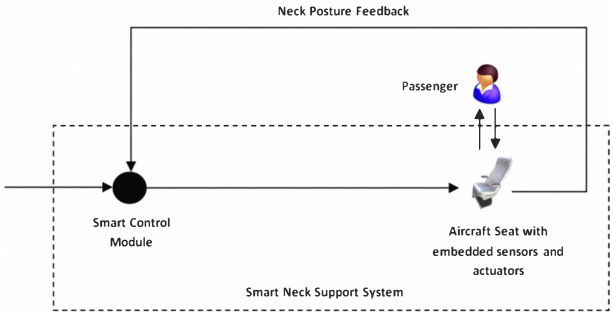

Figure 1. Smart neck support system framework.

V. State Transition of Smart Neck Support System

Fig. 2 shows the state transition diagram that used to describe the behavior of the smart neck support system. The state transition diagram describes the possible states of airbag as events occur. Each state inter-related to each other. For example, when the passenger head in contact with head cushion and the system sense the presence of the passenger (p2), state 1 (S1) will transit to state 2 (S2). If the passenger head turn to right and in contact with right airbag for t time, condition 2 (p2) will change to condition 3 (p3). Subsequently, state 2 (S2) will transit to state 3 (S3). Similarly, if the passenger head turn to left and in contact with left airbag for t time (p4), state 2 (S2) will transit to state 4 (S4). If the passenger left the system, all state will transit to state 1 (S1) and become condition one (P1).

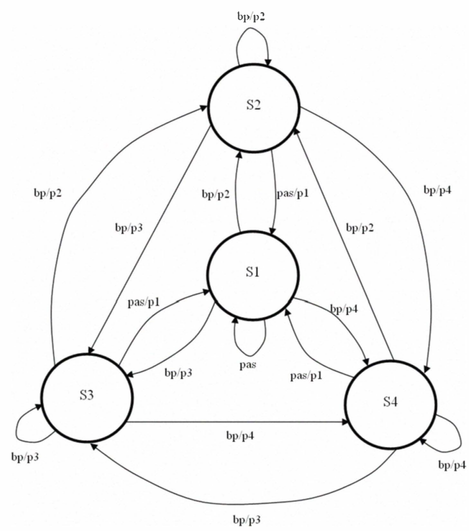

Figure 2. State transition diagram for smart neck support system.

VI. AIR PRESSURE MODEL

An air pressure detection model was developed. The objective of the developed air pressure detection model is to detect the passenger head position by using airbag system. The developed model takes into account the passenger head posture while computing differences in air pressure in the airbag. The proposed model is recorded both increase and decrease of air pressure in airbag. The actuator is not activated when the recording of air pressure take into place. It is because the air that flows into airbag or exhaust from the airbag is interfering the current air pressure value. The model can be easily modified to take into account any variation in the air pressure during implementation. For example, if the passenger head is away from the supported airbag, the current air pressure in the airbag will change. The series of air pressure recorded is relative to the passenger head posture.

Let,
$P_{current}$ = current air pressure after t time
$P_{recorded}$ = recorded air pressure when passenger in touch with airbag for t time
n_1 = value for upper threshold
n_2 = value for lower threshold

A measurements of time comprise, t = n seconds.

P_{airbag} is the comparison between current air pressure and recorded air pressure. P_{airbag} is defined as

$$P_{airbag} = P_{recorded} + (P_{recorded} - P_{current}) \quad (1)$$

VII. PROTOTYPE OF SMART NECK SUPPORT SYSTEM

The final prototype setup as showed in Fig. 3 is a neck support system that contains two airbag with sensor and actuator connected.

Figure 3. The smart neck support prototype.

VIII. VALIDATION OF SMART NECK SUPPORT SYSTEM

The smart neck support system was validated with three participants in the aircraft cabin simulator. The one hour experiment was conducted at the simulation lab, main building, Eindhoven University of Technology. Surface electromyography is used to validate the smart neck support system based on the SCM muscle stress. Fig. 4 shows the experiment in action.

Figure 4. The validation experiment in aircraft cabin simulator.

Table I shows the mean ratings and standard deviation of normalized EMG value from the experiment. As referring to Table 6.11, it is showed that the mean scores of normalized EMG value for after supported by smart neck support system (M = 2.817, SD = 2.130) is lower than the mean scores of normalized EMG value for before supported by smart neck support system (M = 3.029, SD = 2.312). The result proved that the smart neck support system able to reduce the SCM muscle stress and improve the seating comfort.

TABLE I. MEANS (M) AND STANDARD DEVIATIONS (SD) OF NORMALIZED EMG VALUE FOR TWO ACTIVITIES

Activity	M	SD
Before supported	3.029	2.312
After supported	2.817	2.130

IX. CONCLUSION

In this paper, we have described an intelligent system to improve the neck comfort during air travel and examined how it may be applied to improve the passenger comfort level. Firstly, we described the aircraft seat which included the current development of aircraft seat. Next, we described the sitting comfort and discomfort in general. Then, we described the development of smart neck support system. To validate the developed intelligent system, an experiment was conducted in the aircraft cabin simulator. The experimental result showed that the developed smart neck support system able to reduce the SCM muscle adaptively. As a conclusion, smart neck support system able to improve current aircraft passenger's neck comfort especially during long haul flight.

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