Adaptive Framework and User Preference Modeling for Economy Class Aircraft Passenger Seat

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Abstract— **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. Air travels, especially for long haul, may cause both physiological and psychological discomfort to passenger. Passenger comfort is clearly a main factor in user's acceptance of transportation systems. The paper presents an adaptive framework and user preference model for economy class aircraft passenger seat. The adaptive framework is based on the passenger's current and target sitting comfort states to reduce the sitting discomfort. The system uses a seat feedback system to regulate the passenger sitting comfort. The user preference model is used for personalized seat service delivery systems.**

Keywords-adaptive framework, user preference, economy class airacraft passenger seat

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. Air travels, especially for long haul, may cause both physiological and psychological discomfort to passenger. 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, 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 passenger to become aggressive, over-reaction, and even endanger the passenger's health [2]

[3]. A number of health problems can affect aircraft passengers.

Comfort is an attribute that today's passenger demand. 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. 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 in which passenger spends most of their time during air travel.

User preference was suggested as an improvement for a variety of applications, such as the delivery of personalized services for an aware environment [5] [6]. According to the study by Pawn [7] [8], user preference involves not only user's evolving long-term commitment to certain categories of service, but also use's instantaneous service requirement which depend on context of use. The user's instantaneous service requirement is subordinated to the user's long term service preference.

In this paper, we present an adaptive economy class aircraft seat framework and adaptive user preference modeling for air travel. The adaptive framework integrates the concepts of context adaptive systems, user profiling, and methods of using in-flight systems to reduce passenger's sitting discomfort. An adaptive user preference represented by a two layer tree with dynamic changeable structures. The top layer of tree is used for modeling user's hierarchical static service preference. The lower layer of the tree is used for modeling user's dynamic service preference which depends on context of sitting posture. The application of sensor for adaptive aircraft passenger seat system was described as well.

The paper is organized as follows: Section 2 describes the adaptive framework and Section 3 describes adaptive user preference. Subsequently, architecture of adaptive body back support system follows in Section 4 and scenario of the

developed system presented in Section 5. Section 6 describes the sitting posture detection. The paper is concluded in Section 7.

II. ADAPTIVE FRAMEWORK

Figure 1 present the economy class aircraft seat adaptive framework. As shown in figure, the framework starts by setting the passenger's target sitting comfortable states. Then, the system observing the current passenger's sitting posture preference that he/she wishes to control. The action creates an internal representation of the passenger's posture situation. After that, the adaptive inference engine will determine (1) whether the passenger is in the target state or not; and (2) if the passenger is not in the target state then optimized sitting services are recommended based on user sitting preference. The passenger is an adaptive system, when he/she feel sitting discomfort, he/she will try to change the sitting posture until he/she fell comfort. The action from passenger creates an internal representation of the sitting services. During this process, the passenger's physical and psychological states may influenced by the set of variables which is called disturbance [9]. The change in the passenger's physical or psychological states is again perceived by the system, and this again trigger the adaptation sitting process. User's sitting preference depends on the context of use.
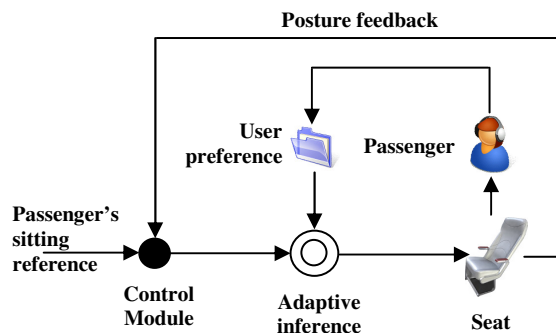

Figure 1. An adaptive economy class aircraft seat framework.

III. ADAPTIVE USER PREFERENCE

An adaptive user preference model is represented by a two layer tree with dynamic changeable structures. The top layer of the tree is used for modeling user's hierarchical static sitting preference. The lower layer of the tree is used for modeling user's dynamic service preference which depends on context of use. The tree is dynamically constructed by the formal relation definitions among nodes. It combines the current hierarchical tree and rule-based language user preference modeling approaches' advantages while overcomes their shortcomings.

For example, context of use Po_n is defined as a categorization of the actual situation under which the service is delivered by the system. It is expressed formally as an ordered vector $S_m = (p_1, p_2, \ldots p_n)$ where p_{mn} is n^{th} category of the actual pressure situation under which the service is delivered by the system.

An optimized action list to transfer the passenger from the current physical state S_i to the target S_m can be computed with the Bellman equation:

$$v(Po_i) = \max_{a \in A} \{ F(po_i, po_i) + r \sum_{s_j \in S} P_a(s_i, s_j) v(s_j) \}$$

Where r is the reduce rate and satisfied $0 < r \leq 1$. For the passenger to transfer from current state s_i to the target state s_m with minimum intermediate states r could be turned smaller or r could be turned toward 1.

A user preference model is shown in Figure 2. There are two layers of the model, where one model is used to model user's sitting preference, and the other is used to model user's real time sitting preferences which depends on context of use. In the user static sitting preference, the sitting can be refined into posture. Posture can be further refined into posture 1, posture 2, etc. As refer to Figure 2, Posture 1 can be assumed as air pressure and passenger. The user preference item (position,(air pressure,0.1) subordinates to his/her sitting preference and can be further refined into sub-preference items. In Figure 2, one of its sub-preference item is ((sideway, position), (air pressure, 0.1), (passenger 1)), where (sideway, position) is one of the context of sitting.
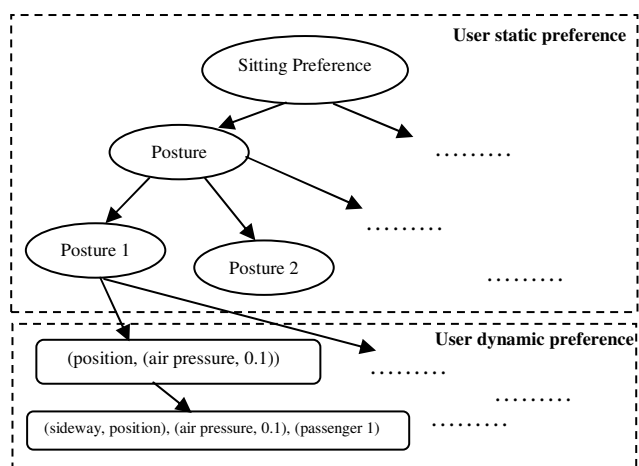

Figure 2. A user preference model

IV. ARCHITECTURE OF ADAPTIVE BODY BACK SUPPORT SYSTEM

Figure 3 shows the architecture of adaptive aircraft passenger seat system. The passenger seat is embedded with sensors. The sensors are designed to detect the passenger condition such as temperature and posture. The output from sensors is input to central processor and database. The central processor is the core component of the system where it is used to mediate between sensors and actuators. The algorithm for the system is to: (1) provide passenger sitting position and support adaptively; (2) provide better sitting support and propose solution according to passenger's preferred sitting condition. The database is used to record sitting behavior and condition of passenger. The output from the system is the actuator. The actuators will change the seat condition such as shape, softness, and contour. For

example, when passenger feels discomfort during sleeping, he/she will change the sitting posture frequently; the inference engine will get the preferred seat condition list, select best seat condition according to passenger current sitting posture and change the seat condition to reduce passenger's discomfort.
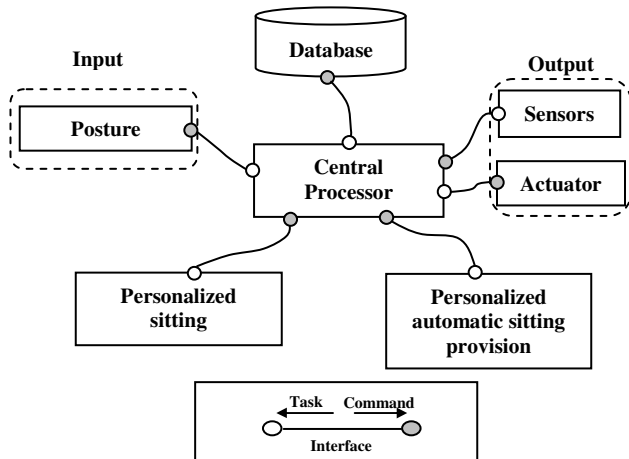

Figure 3. Architecture for the adaptive economy class aircraft passenger seat system.

V. SCENARIO

In this section, a scenario is presented to describe the developed system. During the long haul flight, Mr. Robert is sitting between two passengers in the economy class section. In this sitting location, he will share the hand rest with other passenger. After few hours, he starts to sleep. During sleeping, he feels discomfort at his upper body especially neck and shoulder. Then, he changed his sitting posture frequently in order to get the best sitting position and try to reduce the discomfort feeling. With the sensors that embedded in the seat hand rest and back rest, the system detects Mr. Robert's condition and posture. The system adjusts the seat based on his preferred sitting condition and support Mr. Robert upper body to reduce the discomfort feeling.

VI. SITTING POSTURE DETECTION

To understand the sitting posture of aircraft passenger, observation method was used. The observation is conducted in a long haul flight from Amsterdam, the Netherlands to Kuala Lumpur, Malaysia. The duration of the trip was 12 hours. The researcher documented the activity of the passengers in his visual range. There were 15 subjects, 8 female and 7 male selected in the observation. . The age of subjects was between 19 to 62 years old. The average age was 28 years old.

Based on the observation results, 7 different sitting postures were identified. Observation in a long haul flight established a ground protocol on sitting behavior of aircraft

passenger. Figure 4 shows the observed sitting posture of aircraft passenger.

(a) Neutral position

(b) Slide down (without pillow)

(c) Slide down (with pillow)

(d) Sideway position (left)

(e) Sideway position (right)

(f) Sideway position (Left- with pillow)

(g) Sideway position (right- with pillow)

(h) Sideway position (Right- with hand)

(i) Sideway position (Left- with hand)

(j) Turned torso (Left- no pillow)

(k) Turned torso (Right- no pillow)

(l) Turned torso (Left- with pillow)

(m) Turned torso (Right- with pillow)

(n) Turned torso (Left- head perpendicular to back rest)

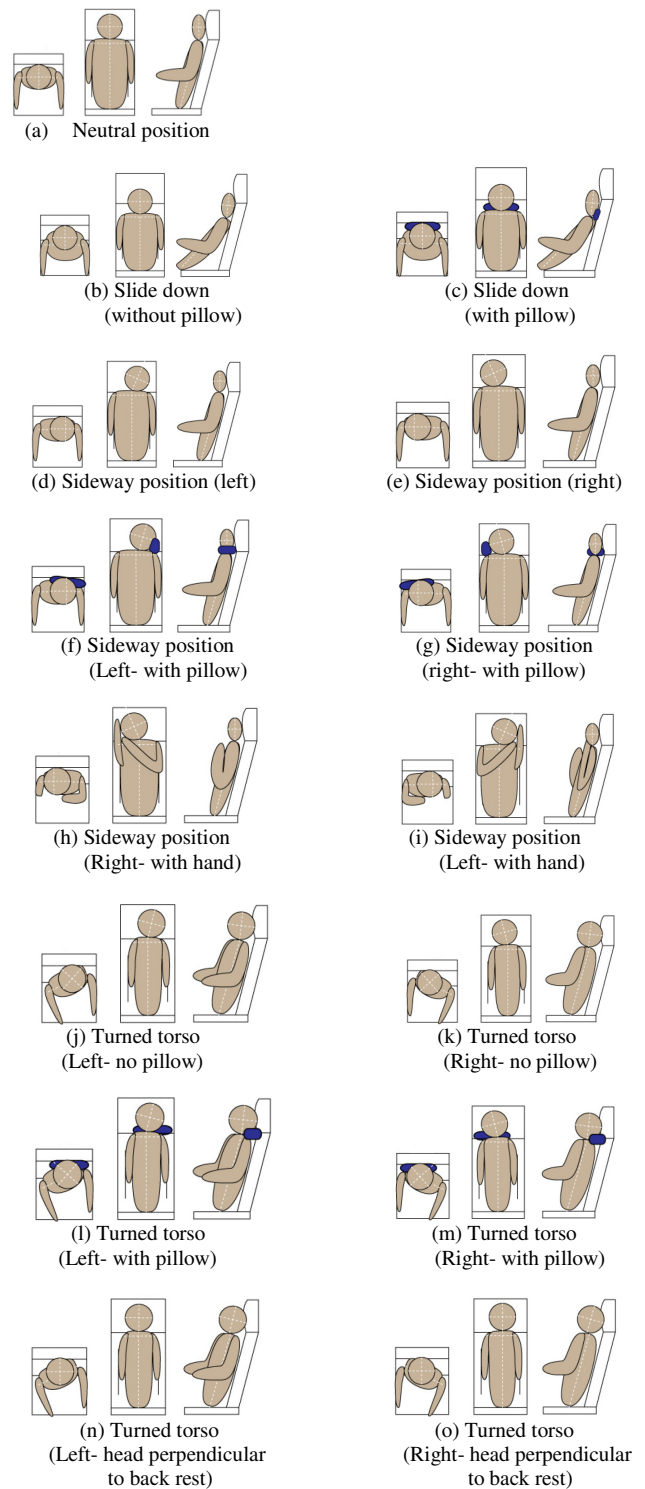(o) Turned torso (Right- head perpendicular to back rest)

Figure 4. The sitting positions while sleeping protocol.

After that, an experiment was conducted to measure and validate the sitting posture. The experiment was implemented in the aircraft cabin simulator. The experiment was conducted for each individual separately. Before the experiment, the participant was briefed with the experiment procedure and regulation. The participant sat in the prepared seat, interpreted the 10 sitting positions from the protocol for 30 seconds. The experiment was started when the participant confirmed in the correct sitting position. Each position was measured with Max and microcontroller. Force sensitive resistor (FSR) was used for the posture detection.

Twelve participants, 4 female and 8 male, participated in the experiment. The age range of participant was between 22 to 25 years old, with an average of 24 years old. Their average height is 1.82 m.

During the experiment, the sitting position with turned torso, with head facing the seat in front was the most comfortable sitting position for participants. The sitting position with head tilted with hand supporting between neck and head was criticized by many participants. For freedom for personal sleeping preferences, it is the most preferable sleeping position among the participants. During the experiment, most of participants turned their torso slightly up to perpendicular towards the backrest as well as leaning to their side of their face (with or without pillow) against the headrest. The sensors provided the needed data input to adaptive aircraft seat system.

VII. CONCLUSIONS

The aircraft passenger seat plays an important role in providing sitting comfort. The current aircraft passenger seat has some improvement to reduce the aircraft passenger body discomfort such as side support and head side support. Despite all the improvement, there still have some room to increase the aircraft passenger sitting comfort. In this paper, we have described the adaptive framework and user preference model of adaptive body back support for economy class aircraft passenger seat. The adaptive body back support system can adapt to passenger sitting posture by context aware and personalized sitting service. Based on the passenger sitting behavior, it can learn and adapt to the passenger's preferences. For the future work, experiment will be conducted to analyze and validate the system.

REFERENCES

[1] G. Brundrett, "Comfort and health in commercial aircraft: a literature review," *The* Journal of The Royal Society for the Promotion of Health, vol. 121, no. 1, pp. 29-37, 2001.

[2] S. Kalogeropoulos, "Sky rage," Flight Safety Australia, July 1998, pp. 36-37.

[3] World Health Organization, "Travel by air: health considerations," Retrieved from World Health Organization's Web site: http://whqlibdoc. who.int/publications/ 2005/9241580364_chap2.pdf, March 2007.

[4] V.A. Runkle, "Benchmarking seat comfort," SAE Technical Paper, No. 940217, 1994.

[5] R. Oppermann, "From user-adaptive to context-adaptive information systems," I-com 3, pp. 4-14.

[6] C. Bartneck, A. Masuoka, A., T. Takahashi, and T. Fukaya, "The learning experience with electronic museum guides," Psychology of Aesthetics, Creativity and the Arts, vol. 0, no. 1, pp. 18-25, 2006.

[7] S. Pawn, "Music and choice: adaptive systems and multimodal interaction," PhD thesis, Technical University of Eindhoven.

[8] S. Pawn and B. Eggen, "Realization and user evaluation of an automatic playlist generator," Journal of New Music Research, vol. 32, no. 2, pp. 179-192, 2003.

[9] W.R. Ashby, Introduction to Cybernetics. Chapman & Hall, London, 1956.