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AIRSF: A New Entertainment Adaptive Framework for Stress Free Air Travels

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ABSTRACT
In this paper, we present a new entertainment adaptive framework AIRSF for stress free air travels. Based on the passenger's current and target comfort states, user entertainment preference, and context of use, the system uses a Markov decision process to recommend context-aware and personalized stress reduction entertainment to transfer the passenger from the current state to the target comfort state with the minimum time cost if he/she is stressed, or keep the passenger at comfort state with context-aware and personalized non stress induction entertainment if the passenger is not stressed. Compared to the current in-flight entertainment framework, it can regulate the passenger's physical and psychological states to comfort states with context-aware and personalized stress reduction entertainment; Compared to the current entertainment stress reduction methods, it uses a linear bio feedback system to regulate the user to comfort state with context-aware and personalized entertainment recommendation.

Categories and Subject Descriptors
H.1.2 [**Models and Principles**]: User/Machine Systems – *Human factors, Human information processing.*

General Terms
Design, Human Factors.

Keywords
Adaptive framework, context-awareness, in-flight entertainment.

1. INTRODUCTION
Travel by air, especially long distance, is not a natural activity for humans. Many people experience some degree of physiological and psychological discomfort and even stress when flying [1]. Many airlines have realized the potential of the on-board entertainment in improvement of customers' comfort level. However, the current installed and commercially available in-flight entertainment systems do not explore how the entertainment services can be used to reduce the passenger's negative stress systematically and intelligently; also, these entertainment systems are built based on preset concept what customer likes and requires a homogeneous passenger group that has similar tastes and desires [2]. They present the same user entertainment interface and contents to each passenger. If the user wants to get personalized entertainment services, he/she needs to interact with systems to get desired entertainment services from provided options. Regularly if the available choices are many and the interaction design is poor, the passenger tends to get disoriented and not manage to find the most appealing entertainment services.

In this paper, we present a new entertainment adaptive framework AIRSF for stress free air travels. It integrates the concepts of context adaptive systems, user profiling, and methods of using entertainment services to reduce the user's negative stresses into a linear feedback control system. In case of the linear feedback system, a control loop, including the passenger's physical and psychological state modeling, an adaptive inference for entertainment adaptation strategies, user entertainment preference learning etc. components, is arranged in such a fashion as to try to regulate the passenger's physical and psychological states to comfort states with context-aware and personalized stress reduction entertainment. What is more, based on the passenger's bio and explicit feedbacks, it can learn and adapt to the passenger's entertainment preferences.

This paper is organized as follows: In section 2 the new entertainment adaptive framework for stress free air travels is presented. And then a case study is given in section 3. Finally, in section 4 the main conclusion is drawn and the future work is discussed.

2. AIRSF: A NEW ENTERTAINMENT ADAPTIVE FRAMEWORK for STRESS FREE AIR TRAVELS
Figure 1 present our new in-flight entertainment adaptive framework AIRSF. In the figure, the framework starts by setting the passenger's target physical and psychological comfortable states. Then, the system begins observing the passenger's current physical and psychological states (modeled on the passenger's bio feedback signals) that it wishes to control. This step of perception creates an internal representation of the passenger's physical and psychological situation. After that, depending on the difference between the target and the current real physical or psychological state, the adaptive inference component in the framework must 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 entertainment services are recommended based on user

preference, context of use and available entertainment contents etc. information to transfer the passenger from the current state to the target state with the minimum time cost. The passenger himself/herself is an adaptive system; his/her perception creates an internal representation of the entertainment service. This perception affects the passenger's physical and psychological states. During this process, the passenger's physical and psychological states may also influenced by the set of variables which in the control system called disturbances [3]. The change in the passenger's physical or psychological states is again perceived by the system, and this again triggers the adaptation process we have described, thus closing the control loop. User's entertainment preference depends on the context of use. In figure 1, if the framework recommends entertainment services that the passenger does not like, he/she may reject the recommended services and select desired entertainment himself/herself or just shut down the system. By mining on interactions between the passenger and the system, the framework can automatically learn and adapt to the passenger's preferences, thus the more the passenger uses the in-flight entertainment system, the more context-aware and personalized entertainment services can be recommended to the passenger. In the following sub sections, we describe the components of the framework in detail.

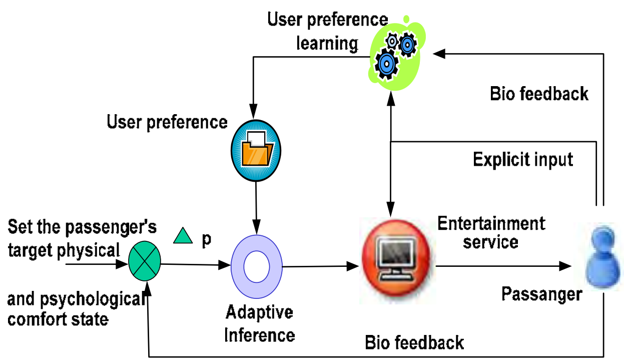

Figure 1. AIRSF: a new entertainment adaptive framework for stress free air travels

2.1 Describing Entertainment

An entertainment service can be described by a set of attribute/value pairs. It can be expressed formally by an ordered vector $E_m = ((a_{m1}, v_{m1}), (a_{m2}, v_{m2}), \ldots\ldots (a_{mn}, v_{mn}))$ where (a_{mn}, v_{mn}) is the n^{th} attribute/value pair. In this paper, for simplicity reasons, we represent E_m as $E_m = (v_{m1}, v_{m2}, \ldots\ldots v_{mn})$ since E_m is an ordered vector. For example, each piece of music can be described by a set of attribute /value pairs. Each attribute/value pair describes one aspect of the music (e.g. artist/frank, tempo/60).

2.2 Describing Context of Use

Context of use is a categorization of the actual situation under which the service is delivered by the system. As shown by figure 2, one category of the actual situation may be aggregated by several sensors' datum. Context of use can be expressed formally as an ordered vector $S_m = (v_{m1}, v_{m2}, \ldots\ldots v_{mn})$ where v_{mn} is n^{th} category of the actual situation under which the service is delivered by the system.

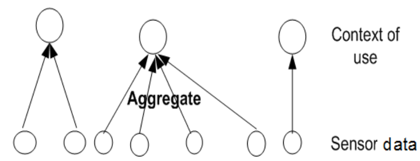

Figure 2. Context of use

2.3 Describing User Preference

The information of a user which can reflect his/her NRDs (Needs Requirements and Desires) on the preferred system behaviors is called a user preference model [4]. A detailed user preference model has been formally defined for the new entertainment adaptive framework in [5]. In this model, user preference is modeled by a two-layer tree with dynamic changeable structures. The top layer of the tree is used for modeling user's long term entertainment service preference. Each node represents user's long term evolving commitment to certain categories of entertainment service. The lower layer of the tree is used for modeling user spontaneous entertainment service requirement which depends on context of use. Each node relates one context of use to one or more desired entertainment service requirements. The tree is dynamically constructed by the formal "subordination" or "refinement" or "composition" relations among nodes. For simplicity reasons, in this paper we only introduce a piece of user dynamic preference item P_m definition: P_m is defined as $(S_m, W_m * E_m)$ where $W_m * E_m$ is defined as $(W_{m1} * V_{m1}, W_{m2} * V_{m2}, \ldots\ldots W_{mn} * V_{mn})$, W_m is the traditional VSM (Vector space model) to describe the attributes with different weighting schemes where $\sum_{i=1}^{n} W_{mi} = 1$.

2.4 User Preference Learning

The passenger's feedbacks to the recommended/self selected entertainment services need to be logged for user preference learning. In this sub section, we first define a data structure for user feedback logging, and then give a strategy for user feedback information logging.

A piece of user feedback information is formally expressed by an ordered vector $D_m = (s_m, e_m, a, t)$ where s_m is the context of use, e_m is the entertainment service which is recommended by the system or self selected by the passenger, a is the passenger's attitude towards the recommended entertainment service, if the user declined the recommendation, its value is 0, otherwise its value is 1, T is the time mark.

Each time there is a value change of s_m, e_m, or a, one piece of user feedback information is produced and stored in a database file.

Based on the logging information, the user preference learning component can learn pieces of user dynamic preference items and build a user entertainment preference tree [5]; Also, the user preference learning component needs to mine on the user feedback log file to get entertainment service effects on the passenger's internal physical and psychological state change, thus enabling optimization of entertainment service recommendation. A piece of entertainment service effect information is formally expressed by an ordered vector $D_m = (s_m, e_m, t_m, f_m)$ where s_m is the context of use, e_m is one category of entertainment services which share the same effect of transferring the passenger from one state to another, t_m depicts the passenger's physical or psychological state transferring from one to another, it can be further refined with an ordered vector (t_{mx}, t_{my}) where t_{mx} is the passenger's state before he/she enjoys the entertainment services, t_{my} is the passenger's transferred state after he/she enjoyed the entertainment services and t_{my} is not equal to t_{mx}, f_m is the cost of transferring the passenger state from t_{mx} to t_{my}. It may be the time cost of transferring the passenger state from one to another.

2.5 Adaptive Inference

Adaptive inference is the central part of the new entertainment adaptive framework. It needs to recommend optimized entertainment services mix to transfer the passenger from the current state to the target comfort state with the minimum time cost if he/she is stressed, or recommend non stress induction entertainment to keep the passenger at comfort state if he/she is not stressed.

Markov decision processes [6] provide a mathematical framework for modeling decision-making in situations where outcomes are partly random and partly under the control of the decision maker. So Markov decision processes are a perfect substitute of traditional PID controllers for a bio feedback control systems where subjectives are users.

A few definitions need to be given to use a Markov decision process to optimize entertainment service recommendation to transfer the passenger from the current stress state to the target comfort state with minimum time cost.

Definition 1: A passenger's physical or psychological state space can be formally expressed as $S = \{s_{1,} s_2 ... s_{m,} ... s_n\}$ where $1 \le m \le n$ and s_m is one of his/her possible physical or psychological states.

Definition 2: Adaptive inference action space A is formally expressed as $A = \{a_{1,} a_2 ... a_{m,} ... a_n\}$ where $1 \le m \le n$ and a_m is one category of entertainment services (actions) which could transfer the passenger's physical or psychological state from one to another.

Definition 3: A transition probability function $P_a(s_i, s_j)$ is defined as the probability that action a in state s_i at time t will lead to state s_j at time $t+1$. It can be formally represented as $P_a(s_i, s_j) = \Pr(s_{t+1} = s_j \mid s_t = s_i, a_t = a)$.

Definition 4: $R_a(s_i, s_j)$ is defined as the time reward $T_{i\,j}$ received after a transition to state s_j from state s_i with transition probability $P_a(s_i, s_j)$. $T_{i\,j}$ equals $-f_m$ where f_m is the time cost of transferring the passenger state from s_i to s_j defined in sub section 2.4.

Definition 5: A transition probability matrix P is defined as

$$P = \begin{pmatrix} P_{11} & \cdots & P_{1n} \\ \vdots & \ddots & \vdots \\ P_{n1} & \cdots & P_{nn} \end{pmatrix} \quad \text{where}$$

$P_{i\,j} = P_a(s_i, s_j) = \Pr(s_{t+1} = s_j \mid s_t = s_i, a_t = a)$.

Based on the above definitions, an optimized action list (entertainment services) to transfer the passenger from the current physical or psychological state s_i to the target s_m with the minimum time cost can be computed with the Bellman equation: $v(s_i) = \max_{a \in A} \{R_a(s_i, s_i) + r \sum_{s_j \in S} P_a(s_i, s_j) v(s_j)\}$

where r is the discount rate and satisfies $0 < r \le 1$. If we want the passenger to transfer from current state s_i to the target state s_m with minimum intermediate states, r could be tuned smaller. Otherwise r could be tuned towards 1.

3. CASE STUDY

There is a long literature involving the use of music for reducing the user's stress. Steelman [7] looked at a number of studies of music's effect on relaxation where tempo was varied and concluded that tempos of 60 to 80 beats per minute reduce the stress response and induce relaxation, while tempos between 100 and 120 beats per minute stimulate the sympathetic nervous system. Stratton and Zalanowski [8] conducted experiments and found that preference, familiarity or past experiences with the music have an overriding effect on positive behavior change than other types of music. In this section, we showcase the features of our framework by a case study of stress reduction with context-aware and personalized music provision.

In the following case study, the passenger's heart rate data is used as an indication of his/her psychological stress during air travel. For a child (age 6-15), his/her normal heart rate at rest is 70-100 beats per minutes. For an adult (age 18 and over), his/her normal heart rate at rest is 60-100 beats per minutes. Then for each age group, there are three psychological states: high (100-220), normal (60-100 or 70-100) and low (60-0 or 70-0). The target state is the normal state. We assume that there are seven categories of music $a1, a2, ...a7$ acting as actions (music). Each of them can transfer the passenger from one state to another (see figure 8).

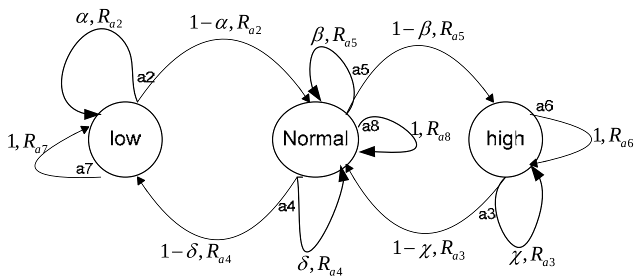

Figure 3. Transition graph

For a passenger, the system starts by recommending stress reduction music according to an expert knowledge to the passenger if he/she is stressed. During this process, the system logs the passenger's feedbacks on the recommended/self selected music. Then, after the passenger has used the in-flight entertainment system for several times, the system can learn and build the passenger's preference tree, the music effects on the passenger (rewards), the probability of categories of music transferring the passenger from one state to another. Finally, the passenger's personalized parameters in figure 3 are completed.

During the flying, if the passenger is stressed and his/her heart rate is high, then the system decides that the best action to get the maximum reward at the current context of use is a_{33} (a_{33} is a sub categories of music of $a1, a2, ...a7$) to transfer the passenger state from high to low with the minimum time cost according to the Bellman equation introduced in section 2. The system acquires a_{33} by searching the user preference tree with the current context of use which is the passenger is at rest and the state is high. Then, we assume that after some time the passenger's heart rate goes back to normal, then according to Bellman equation, the system decides that the best action to get the maximum reward at the current context of use is a_{83}. The system acquires a_{83} by searching the user preference tree with the current context of use which is the passenger is at rest and state is normal.

The more time a passenger spent on board of an airline's craft, the better user preference can be built based on the mining of his/her past behaviors. Thus the more personalized services can be recommended by the system and the more "unnecessary" dialogues between the system and the user can be avoided.

4. CONCLUSION

In-flight entertainment systems play an important role in improving passengers' comfort level. The current in-flight entertainment systems have made significant progresses to improve the passenger's comfort level by providing user friendly interfaces, ever increasing entertainment options, etc. However, despite all these advances, they still have much room to improve to increase the passenger's satisfaction level. In this paper, we present a new entertainment adaptive framework AIRSF for stress free air travels. Compared to the current in-flight entertainment framework, it can regulate the passenger's physical and psychological states to (at) comfort states with the minimum time cost by context-aware and personalized entertainment service provision. What is more, based on the passenger's bio and explicit feedbacks, it can learn and adapt to the passenger's preferences. After the introduction of the framework in detail, we use a case study to showcase our framework's ideas and validate its claimed advantages.

In the future, we planned to do the real world test to validate and improve our framework.

5. ACKNOWLEDGMENTS

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