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Bio-feedback Based In-flight Music System Design to Promote Heart Health

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Abstract. For a long-haul flight passenger, if he/she is an adult, his/her normal heart rate should be 60 -100 beats per minute. However, the combination of long flight duration, dehydration and reduced oxygen availability etc. flying factors may cause his/her heart beating out of the normal range for a long time which endangers his/her heart health. In this paper, we present a new bio-feedback based music system to promote the passenger's heart health with his/her preferred music. If the passenger's heart rate is higher than the normal heart rate, the system recommends his/her preferred calm music to the passenger to transfer his/her heart rate back to normal; If the passenger's heart rate is lower than the normal heart rate, the system recommends his/her preferred upbeat music to uplift his/her heart rate back to normal; if the passenger's heart rate is normal, the system recommends the passenger preferred music to keep his/her heart rate at normal.

Keywords: In-flight music system, bio-feedback, heart rate adjustment, music recommendation.

1. Introduction

For a child (age 6-15), his/her normal heart rate should be 70-100 beats per minute. For an adult (age 18 and over), his/her normal heart rate should be 60-100 beats per minute. However, the unusual long-haul flight cabin environment may cause the passenger's heart rate beating out of the normal range for a long time which poses serious heart health risks to the passenger [1]. In this paper, we present a new bio-feedback based music system for healthy air travels. Based on the passenger's current heart rate and the target normal heart rate, if the passenger's heart rate is higher than the normal heart rate, the system recommends his/her preferred calm music to the passenger to transfer his/her heart rate back to normal; if the passenger's heart rate is lower than the normal heart rate, the system recommends his/her preferred upbeat music to uplift his/her heart rate back to normal; if the passenger's heart rate is normal, the system recommends the passenger preferred music to keep his/her heart rate at normal.

The rest of this paper is organized as follows. Related works which include the current in-flight music systems and research on relations between the music tempo & heart rate are investigated in section 2. After that, our new biofeedback-based in-flight music system design for healthy air travels is introduced in section 3. Conclusions and future works are presented in Section 4.

2. Related Works

In this section, first, the current in-flight music systems are investigated and their limitations are discussed. Then, the current research on relations between the heart rate and music tempo is investigated.

2.1. Current In-flight Music Systems

In-flight entertainment systems which refer to entertainment systems available to aircraft passengers during air travel are commonly installed on long-haul flights to increase passengers' comfort level. The entertainment services usually include audio, video, games, in-flight email, internet access and ever-

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increasing digital entertainment options. Liu investigated the current installed in-flight entertainment systems in the aircrafts of airlines of Lufthansa, Air France, British Airways, American Airlines, Delta Airlines, and Japan Airlines which are top airlines in Europe, North America and Asia from Total Scheduled Passengers point of view [2] [3]. All the in-flight entertainment systems provide in-flight music service. All of them are implemented based on the pre-set concept of what customer likes and requires as a homogeneous passenger group that has similar tastes and desires. They present the same interface and music contents to each passenger. If the user wants to get desired music services during air travel for recreation, he/she needs to interact with the in-flight entertainment system by means of touch screen, etc. to browse and select the desired music from provided options (refer to figure1). However, if the available choices are many and/or the passenger himself/herself is not familiar with the service category structure, and/or the interaction design is poor, the passenger tends to get disoriented and not manage to find the most appealing music; if the available choices are limited (for example, most airlines we investigated only provide several music albums during air travel), the chance for the passenger to find desired music services is slim. What is more, due to different kinds of music may lead the listener to different bio states; it is possible that the user selected music may lead him/her to difficult bio states. Under these circumstances, the current in-flight music systems do not contribute to improve the passenger's health level, on the contrary, to some extends, it exacerbates the situation.

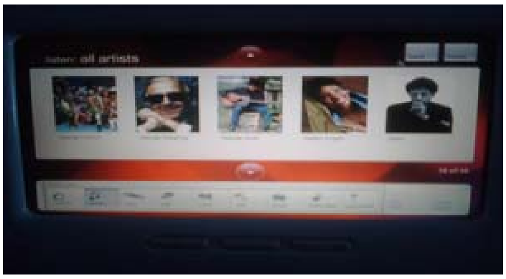

Fig. 1: Interface of the in-flight music system [4]

2.2. Current Research on Relations Between Heart Rate and Music Tempo

To my best knowledge, there are few literatures about relations between the heart beat and music tempo. Peter Sleight found that listening to music with a slow or meditative tempo has a relaxing effect on people, slowing breathing and heart rate. Listening to faster music with a more upbeat tempo has the opposite effect - speeding up respiration and heart rate [5]. However, there is a long literature involving the use of music for reducing the user's psychological stress. Researches have show that heart rates can be used as an indicator of stress. For example, Nancy found that during the exam and when their graded exams were returned to them, most students' heart rates increase substantially [6]. Taelman reported that a person's heart rate is significantly faster when he is in mental stress than at rest [7].

Miluk-Kolasa et al. showed that music was one of the relaxing adjuncts in modulating the ascent of autonomic responses to negative stress [8]. Knight and Rickard revealed that relaxing music attenuated blood pressure and heart rate after a stressful task; moreover, the level of subjective anxiety was reduced after the presentation of relaxing music. The tempo of the music being listened to appears to be an important parameter here [9]. Steelman 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 [10]. White and Shaw reported similar results and argued that tempos slower than the average human's heart rate (40 to 60 beats per minute) induce suspense, while tempos of 60 beats per minute with a low pitch are most soothing [11]. Stratton and Zalanowski 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 [12]. Iwanaga found that people prefer music with tempo ranging from 70 to 100 per minute which is similar to that of adults' heart rate within normal daily situations [13].

3. Bio-feedback Based In-flight Music System Design to Promote Heart Health

In this section, we start by introducing a desired usage scenario of our bio-feedback based in-flight music system, and then, we present a healthy heart state model; after that, how to described music and the user's music preference are discussed; finally, the bio-feedback based in-flight music system which mediates between the passenger's heart rate state, music, and user's music preference to enable the passenger's heart to beat within the normal range is presented.

3.1. In-flight Music System Usage Scenario

Mr. John Doe is a frequent air traveler; he always travels with Airline SEAT. In order to get "added value" from Airline SEAT, he applies to be a golden club member of Airline SEAT. He fills in a golden club member application form which contains his date of birth and preferred genres of music etc. information and submits it to Airline SEAT. After Airline SEAT receives his application form and approves, Mr. John Doe's personal data is input into Airline SEAT's in-flight entertainment system database by Airline SEAT's system administrator. Next time, when Mr. John Doe checks in at Airline SEAT's check-in desk, the staff of Airline SEAT will make a personalized connection between Mr. John Doe's in-seat entertainment interface and the on-board entertainment server to enable him to get personalized music service.

During air travels, Mr. John Doe's heart rate data is used as an indication of his heart health by the music system. As an adult (age 18 and over), Mr. John Doe's normal heart rate is 60-100 beats per minutes. During the flying, if Mr. John Doe feels uncomfortable and his heart rate is high, then the system will recommend him a music playlist which can transfer Mr. John Doe back to the normal state. We assume that after some time, Mr. John's heart rate back to normal, if Mr. John Doe still likes to enjoy the music, the system will recommend him personalized music which can keep his heart rate at normal range; if Mr. John Doe feels depressed and his/her heart rate is low during flying, then the system will recommend a music playlist which can uplift Mr. John Doe back to the normal state.

3.2. Heart Rate Model

Heart rate is a measure of the number of heart beats per minute [14]. For a child (age 6-15), his/her normal heart rate at rest is 70-100 beats per minute. For an adult (age 18 and over), his/her normal heart rate at rest is 60-100 beats per minute. Then for each age group, we can model three heart rate states: high (100-220), normal (60-100 or 70-100) and low (60-0 or 70-0).

3.3. Music Description

A piece of music can be described by a set of attribute/value pairs. It can be expressed formally by an ordered vector $E_m = ((a_{m1}, v_{m1}), (a_{m2}, v_{m2}), ...(a_{mn}, v_{mn}))$ where (a_{mn}, v_{mn}) is the n^{th} attribute/value pair. Each attribute/value pair describes one aspect of the music. Some attributes contain information mainly for user preferred music recommendation/selection (e.g. title, artist, recording company). Some attributes address the nature of the piece of music (e.g., tempo, rhythm).

3.4. User's Music Preference

The information of a user which can reflect his/her music NRDs (Needs Requirements and Desires) is called a user music preference model [15] [16]. Rentfrow found that when people discuss their music preferences they tend to do so first at the level of genres and to lesser extent subgenres and only later step up to broader terms (e.g., loud) or down to specific artists (e.g., Van Halen) or songs (e.g., "Running with the Devil") [17]. Thus, the genre is the optimal level at which to start our investigations of music preferences.

3.5. Bio-feedback Based In-flight Music System Architecture Design and Implementation

Figure 2 presents the state chart of our bio-feedback based in-flight music system. In the figure, the target state of the heart rate is normal. If the passenger's heart rate is in the low state, then, his/her preferred genre of music with tempos between 120 and 100 is recommended to uplift him/her; if the passenger's heart rate is in the high state, his/her preferred genre of music with tempos between 60 and 80 is recommended to calm him/her; if the passenger's heart rate is in the normal state, his/her preferred genre of music with tempos between 70-100 is recommended.

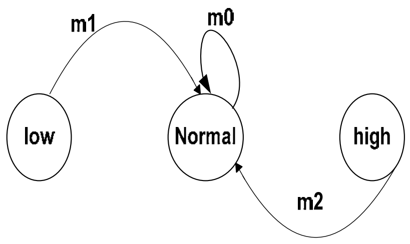

Fig. 2: Transition graph for the heart rate state

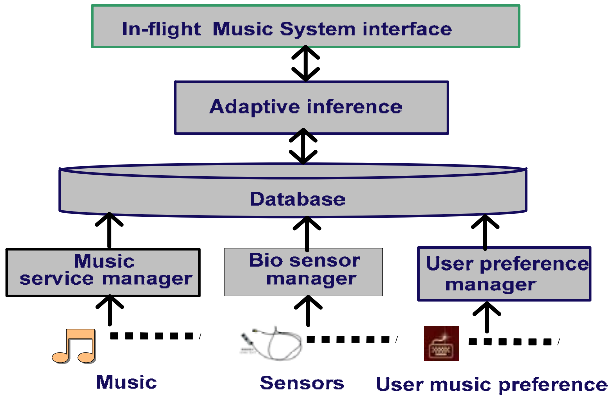

Fig. 3: The architecture of the in-flight music system

Figure 3 shows the main components that make up our bio-feedback based in-flight music system. The whole architecture is divided into five abstraction levels from the functionality point of view. The lowest level is the resource level which contains the music, heart rate bio sensors and user music preference. The second layer is the resource manager layer which includes the music service manager, bio signal manager and user music preference manager. The music manager is responsible for music registration, un-registration, etc functions. The bio signal manager collects and models signals from bio sensors and stores them in the database. The user music preference manager collects and updates the user's music preference information. The third layer is the database layer which constitutes by a database. It acts not only as a data repository, but also enables the layers and the components in the layers loosely coupled. This increases the flexibility of the whole architecture. For example, replacing or updating components in the resource manager layer does not affect the architecture performance unless data structures they store in the database changed. The fourth layer is the adaptive control unit layer which includes adaptive inference component. It is used to mediate between the music, heart rate state and available music to recommend personalized music to transfer the passenger from the current state to the target state. The fifth layer is the interface layer. The passenger interacts with the in-flight music system interface to get music services.

The in-flight music system is implemented with web-based browse/server architecture. For each passenger, there is an in-seat computer which monitor is a touch screen. These computers are connected to a central server. The passenger can browse the in-flight music system via the in-seat touch screen. Figure 4 is a screen print of our integrated music manager, user preference manger, and music streaming server. Figure 5 is a screen print of the music system interface. In the figure, a music playlist is recommended to the passenger according to his/her current heart rate state.

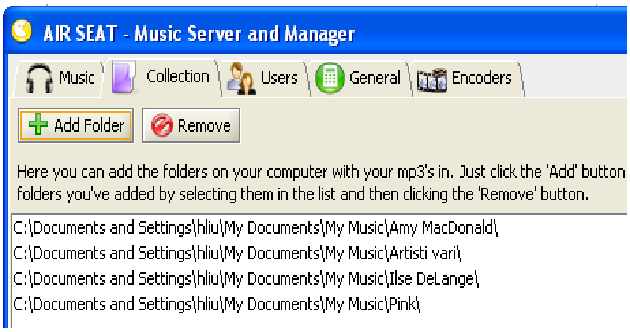

Fig. 4: User preference manager and music server

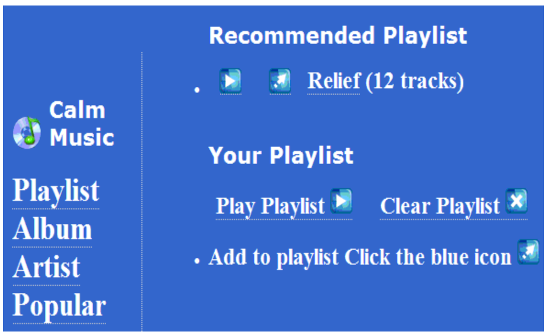

Fig. 5: Music system interface

4. Conclusion

In-flight music systems play an important role in improving passengers' comfort level during air travels. Today, the current in-flight music systems have made significant progress in providing music service with user friendly interface, interaction mode and ever increasing music options, etc. However, despite all these advances, the current in-flight music systems surveyed in this paper still have much room to improve to enable healthy air travels. In this paper, we present a new biofeedback based in-flight music system for healthy air travels. Compared to the current in-flight music system, it can regulate the passenger's heart rate at the target state with user preferred genre of music. We have already implemented our bio-feedback based in-flight music system. In the coming months, we plan to do the real world test to validate and improve our in-flight music system.

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6. References

[1] World Health Organization. Travel by air: health considerations. Retrieved March 1, 2008 from World Health Organization's Web site: http://whqlibdoc.who.int/publications/2005/9241580364_chap2.pdf.

[2] H. Liu. State of Art of In-flight Entertainment Systems and Office Work Infra structure. Deliverable 4.1 of European project Smart tEchnologies for stress free Air Travel, Technical university of Eindhoven, 2006.

[3] WATS. World Air Transport Statistics Special 50th Edition, International Air Transport Association, 2006.

[4] Flickr. In-flight system music interface, retrieved May 1, 2008 from Flickr's Web site: http://flickr.com/photos/johnny_n/2420423678/

[5] L. Bernardi, C. Porta, P. Sleight. Cardiovascular, cerebrovascular, and respiratory changes induced by different types of music in musicians and non-musicians: the importance of silence. Heart (British Cardiac Society). 04/2006; 92(4):445-52.

[6] L. Nancy Elwess and F. Daniel Vogt. Heart Rate and Stress in a College Setting. Bioscience, Volume 31(4) December 2005: 20-23.

[7] J. Taelman, S. Vandeput, A. Spaepen and S. Van Huffel. Influence of Mental Stress on Heart Rate and Heart Rate Variability. J. Vander Sloten, P. Verdonck, M. Nyssen, J. Haueisen (Eds.): ECIFMBE 2008, IFMBE Proceedings 22, pp. 1366–1369, 2008.

[8] B. Miluk-Kolasa, M. Matejek and R. Stupnicki. The Effects of Music Listening on Changes in Selected Physiological Parameters in Adult Pre-surgical Patients. Journal of Music Therapy, 1996, 33, pp 208–218.

[9] WEJ. Knight and NS. Rickard. Relaxing Music Prevents Stress-induced Increases in Subjective Anxiety, Systolic Blood Pressure, and Heart Rate in Healthy, Males and Females'. Journal of Music Therapy, 2001, 38(4), pp. 254–72.

[10] VM. Steelman. Relaxing to the beat: music therapy in perioperative nursing. Today's OR Nurse, 1991, Vol. 13, pp.18-22.

[11] J. White and C. Shaw. Music therapy: a means of reducing anxiety in the myocardial infarction patient. Wisconsin Medical Journal, 1991, July, 90(7), pp. 434-437.

[12] VN. Stratton and AH. Zalanowski. The Relationship between Music, Degree of Liking, and Self-Reported Relaxation. Journal of Music Therapy, 1984 21(4): 184–92.

[13] M. Iwanaga. Relationship between heart rate and preference for tempo of music. Percept Mot Skills, 1995 Oct, 81(2):435-40.

[14] Wiki. Heart rate. Retrieved July 1, 2008 from Wiki's Web site: http://en.wikipedia.org/wiki/Heart_rate.

[15] B. Salem, M. Rauterberg. Multiple User Profile Merging (MUPE): Key Challenges for Environment Awareness. Lecture Notes in Computer Science, 2004, vol. 4161, pp. 103-116.

[16] H. Liu, B. Salem, M. Rauterberg. Adaptive User Preference Modelling and Its Application to In-flight Entertainment. In: Proceedings of 3rd International Conference on Digital Interactive Media in Entertainment and Arts, ACM ISBN: 978-1-60558-248-1, pp. 289-294.

[17] P. J. Rentfrow, S. D. Gosling. The do re mi's of everyday life: The structure and personality correlates of music preferences. Journal of Personality and Social Psychology, 2003, 84, 1236-1256.