MART – MUSIC ASSISTED RUN TRAINER

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ABSTRACT

This demonstration paper describes our smartphone app called MART – music assisted run trainer. The goal of MART is to assist users to jog easily and pleasantly. Users can select one of the two modes in MART: the free-running mode and the cardio-training mode. In the free-running mode, the system estimates the user's step frequency and modifies the music in time-scale so that it plays in a tempo closed to user's step frequency. The user's step frequency is computed via the smartphone's tri-axial accelerometer signal. In the cardio-training mode, the user is asked to run to a certain speed so that the heart rate stays in a specific range. The music tempo accelerates if the current heart rate is too low and vice versa.

1. INTRODUCTION

Based on an online survey on 1000 U.S. adult runners, 87% of them like to listen to some audios to keep them motivated while jogging, and 78% of these runners listen to music [1]. Research shows that listening to music with slightly increasing tempos can decrease track athletes' running time [2], and people tend to feel pleased when the music tempo is closed to the jogger's step frequency [3]. Music tempo is often associated with jogger's step frequency. The rhythmic paces performed by joggers are believed to synchronize with the rhythmic structure of the music [4]. Several commercial products and past studies use this property to build automatic music selection systems for joggers [3][5][6]. There are also Hockman's system [7] and D-Jogger [8] that synchronize the music tempo with a jogger's steps by time-scaling the music using phase vocoder. However, both systems run on a PC, which might not be suitable for outdoor jogging.

In this demonstration paper, we present a smartphone app for jogging music playback: MART – music assisted run trainer. Since this app runs on a smartphone, it is suited for outdoor jogging. Users can select one of the two modes in MART: the free-running mode and the cardio-training mode. In the free-running mode, the user runs at his or her own pace. The system estimates the user's step frequency and modifies the music in time-scale so that the music tempo is in accordance with the user's step frequency. In the cardio-training mode, the user is asked to run to maintain the heart rate to a certain range. The music tempo is adjusted to maintain the user's heart rate to a specific range. More details are given in the following sections.

2. MART SYSTEM DESCRIPTION

This section describes the two modes in MART. Figure 1 shows the MART interface. MART is currently only implemented for iOS devices and has been tested on iPhone4s and iPod Touch 5. HR-Kit Plus [9] is used as the heart rate monitor, a device that is worn around the chest and the heart rate information is sent to the iOS device via Bluetooth. All the parameters can be modified online in the Option screen (Figure 1.d shows the default parameter setting). For the time being, we only use songs with constant tempos for the demonstration purpose.

2.1 Free-Running Mode

The free-running mode consists of three modules: step frequency estimation, music tempo selection, and time-scale modification of music. When the app is started by the user, the smartphone's built-in tri-axial accelerometer sensor starts to capture acceleration data. The step frequency estimation module uses these data to estimate the current and historic step frequency. For each step frequency update, the music tempo selection module decides if there is a need of tempo change. If the need is positive, the last module modifies the music in time-scale.

In the step frequency estimation module, we apply a beat tracking method proposed by Wu [10] on the square root of sum of squares of the 3-dimensional acceleration data to find the time stamp of each step. This computed step time is used to estimate the step frequency (measured in steps per minute or SPM) which is computed as the average step frequency in the past k seconds.

In the music tempo selection module, the design here is similar to the Masahiro's system [3]. The design philosophy is that, since the user's step frequency might not be totally stable, we want to avoid frequent change of the music tempo. The major difference between this tempo selection method and Masahiro's method is that, this module is only executed once for every update in step frequency, i.e. once for a window hope size (1.5s in default setting) instead of once for every step (0.4 seconds for 150 SPM). This reduces the computational load and is more suitable for computation on a handheld device.

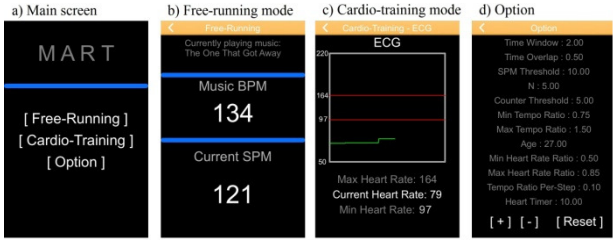

Figure 1. MART interface.

The last module is executed either when there is a request of tempo change in the current song, or when the current song is about to end and the next song is to be prepared. An implementation [11] of the WSOLA algorithm [12] is used to perform the time-scale modification of music so that the music can be "stretched" or "compressed" in time-scale without changing the pitch of original music. We empirically set the time-scaling factor to be between 0.75 and 1.5 to avoid "unmelodious" music tempo as it might be too slow or too fast. In addition, in order to reduce the extent in the change of tempo so that the perceived difference between the original and the modified music is minimized, the time-scaling factor that is closest to 1 is chosen such that the ratio between the modified tempo and the user's step frequency is either ½, 1, or 2. These ratios would help the jogger step his or her feet right on the beat.

2.2 Cardio-Training Mode

In the cardio-training mode, the user's pace is guided by the music tempo in order to maintain the heart rate in the desired range (as shown in Figure 1.c). The desired heart rate range is determined by a high and a low percentages of the maximum heart rate. The maximum heart rate is estimated as (220-age). In the example shown in Figure 1.c and d, these percentages (shown as min and max heart rate ratio) are set to 50% and 85%, as recommended by the American College of Sports Medicine [13]. If the user's heart rate is below the minimum heart rate, MART issues an speedup message and increases the music tempo so that the user is notified to run faster and thus increase his/her heart rate and vice versa. The required step frequency estimation and time-scale modification of music techniques are the same as described in subsection 2.1.

3. CONCLUSIONS AND FUTURE WORK

In this paper, we described the research issues involved in developing a smartphone app MART for assisting users to jog easily and pleasantly through music. In the future, we will need to conduct a larger scale of experiment on step frequency estimation. A full-scale usability test is also required to examine the effectiveness of the system.

4. REFERENCES

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