

## OVERVIEW

In this section, we describe how we measure the intensity of gestures based on research from exercise science and then how we calculate the training intensity of the game.

### Gesture Intensity

In exercise science, heart rate is commonly used as a metric to evaluate the intensity level of a certain exercise [1]. The corresponded intensity  $I_i$  for each exercise can be converted based on their heart rates (i.e.,  $HR_{max}$ ,  $HR_{avg}$ ,  $HR_{rest}$ ) calculated by the Karvonen formula [2].

$$HR_{avg} = (HR_{max} - HR_{rest})I_i + HR_{rest} \quad (1)$$

$$I_i = \frac{HR_{avg} - HR_{rest}}{HR_{max} - HR_{rest}} \quad (2)$$

Where  $I_i \in [0,1]$ ;  $HR_{max} = 220 - age$ ;  $HR_{avg}$  is the average HR measured during the exercise;  $HR_{rest}$  is the rest HR of the user.

To get the intensity  $I_i$  and corresponding heart rate  $HR_i$ , we conducted the following pilot study with a similar approach in [3]:

- First, a level consisting of an infinite number of gestures with gesture type  $Ges_i$  is provided.
- Ten healthy university students (5 females) whose age ranged from 22 to 28 were recruited to play each level for about 5 minutes. None of them were athletes.
- The experiment run over several days for each participant to mitigate any effects due to tiredness.
- We designed and tested 10 gestures for each version; the version and the gestures were counterbalanced.
- Duration  $D_i$  (in seconds) associated with gesture type  $Ges_i$  was calculated as the average time participants take to finish each gesture of that type.

### Exergame Intensity Evaluation

To get the corresponding intensity level of each exergame, we used the following formula:

$$AvgI_{game} = \sum_{n=1}^6 P_n \times I_{(n)} \times c \quad (3)$$

Where  $AvgI_{game}$  is the intensity level of the corresponding game.  $P_n$  is the probability of triggering each gesture  $Ges_i$  which we have set it as  $\frac{1}{6}$ .  $I_{(n)}$  is the intensity level when doing the gesture  $Ges_i$ , which had been measured in the pilot study. Coefficient  $c$  can be calculated by  $\frac{D_i}{2.5}$  where 2.5s is the allowed action time we set for Experiment 1.

Our calculation results show that the intensities for standing and seated exergames are 31.1% and 30.1%, respectively. The six selected gestures led to a similar intensity level for both the standing and seated exergames.

## REFERENCE

1. Levine BD. VO2max: what do we know, and what do we still need to know? J Physiol 2008 Jan 1;586(1):25–34. [doi: 10.1113/jphysiol.2007.147629]
2. Karvonen J, Vuorimaa T. Heart Rate and Exercise Intensity During Sports Activities. Sports Medicine 1988 May 1;5(5):303–311. [doi: 10.2165/00007256-198805050-00002]
3. Xie B, Zhang Y, Huang H, Ogawa E, You T, Yu L-F. Exercise Intensity-Driven Level Design. IEEE Trans Visual Comput Graphics 2018 Apr;24(4):1661–1670. [doi: 10.1109/TVCG.2018.2793618]