AI for Heart Rate Measurements for Sport Performance: A review

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AI for Heart Rate Measurements for Sport Performance: A review

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Abstract. Increasing sport performance in athletic has been a major task for coaches around the world. The ability to improve athletes' performance benefits not only the coaches but to the athletes themselves. Heart rate analysis for sport performance has been investigated for many years. Heart rate plays an important role to measure the athletes' ability to perform in sports of their choices. The heart rate information will not only aid in training the athletes according to personal abilities but it will also assist in monitoring athletes' health by reducing the chances of cardiovascular mortality risk. This paper briefly outlines the potential of Artificial Intelligence (AI) in learning information contain in human heart rate measurement for improving the athlete's sports performance.

1. Introduction

Heart rate monitoring plays important roles in as sports performance training aid. Stork [1] explains that heart rates always related to physiological limits, thus heart rate are suitable to measure athletes' performance. Wearable technologies such as smart sport watches, power and cadence meters, and heart rate monitors band are connected to training technologies has made heart rate measurement becomes easier [2]. The heart rate determines several information for athletes, it has been use to trace medical condition [3], achieve desire result in planned training [4], monitoring athlete's performance [5] and to prevent sudden cardiac death [6]. There are considerably several factors that affected the athlete's performance among those are physical, technical, tactical and psychological as shown in Figure 1. The heart measurement is apart of cardiovascular system [3].

2. Heart Rate Measurement

Heart rates (HR) is a measurement of heart beats; the state of HR depends on how many times a heart beats per minute (BPM). HR and parameters such as oxygen intake (VO2) and lactate concentration are normally used to predict individual fitness level [7].Typically, in order to improve a person aerobic fitness, it was suggested that the HR of a person during training should be consistent. The value should represent 70% of their maximum HR as the value is unique for each individual [3]. The equilibrium for HR for individual is as follows:

$$hr_{min} \leq hr\ (u,t) \leq hr_{max}\ [beats.min^{-1}] \quad (1)$$

Where;

$hr\ (u,t) = hr_{min}$ Resting Heart Rate
$hr\ (u,t) = hr_{max}$ Maximum Heart Rate
u Exercise intensity
t Time, Duration

The heart rate equilibrium has been used by few researchers to measure HR for athletes [1].

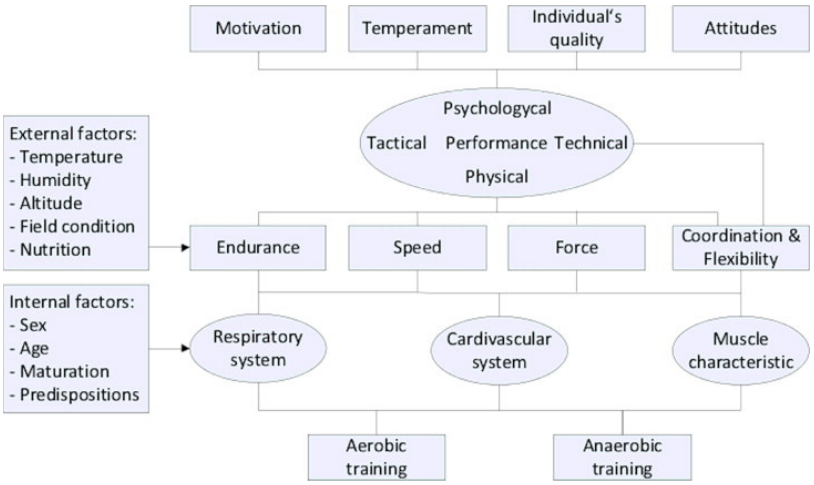

Figure 1. Key components of sports' training performance [3].

Adjunction to HR measurement, Heart rate variability (HRV) is variation in the time interval between sequential heartbeats or commonly known as R-R interval [8]. HRV allows predicting cardiovascular outcomes. Conclusively, HR, HRV and R-R interval plays important roles in reading of cardiovascular abilities during psychical activities. The conventional HR Measurement are by using index finger and middle finger on the pulse nodes such as wrist, lower neck or wind pipes. In clinical setting electrocardiograph or ECG is use as it generates a graph pattern which shows heart function where it is more reliable to calculate HRV and R-R interval.

In recent years, HR monitor is accessible commercially for normal consumer. Practical wearable device like chest electrodes band HR monitoring system, sport shoes, sports watches, HR band and head phones. All these devices provide the data is real time and viewable providing it is connected to mobile phones or personal computers. The more recent technology in wearable devices are smart clothing where it caches health information namely HR information to mobile, mobile cloud from time to time and alerted authorities if anything happens to wearer [23][24].

3. Heart Rate Variability (HRV)

Heart rate Variability (HRV) is use to monitor autonomic nervous system where it is affected by stress, cardiac diseases or pathological states [9]. ECG recording also allows researcher to study the R-R interval as it always associates with body position of athlete which affecting Blood Pressure [10]. There are 4 ways to conventionally measure HRV for analysis; The time domain methods, Frequency domain methods, Non-Linear and Rhythm patterns analysis. All these methods required analysing graph produce by electrocardiogram (ECG) [11]. Figure 2 displays R-R interval estimation from ECG graph.

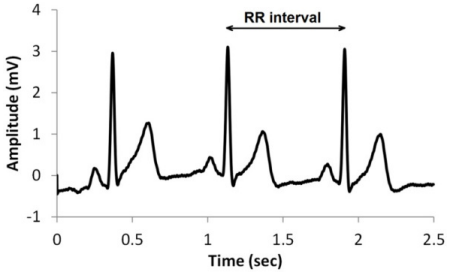

Figure 2. A typical ECG signal showing R-R Interval [25]

Figure 3 shows steps taken to measure HRV by 2 conventional methods; Time domain method and frequency methods. The ECG recorded requires 5 minutes under stable condition for frequency domain methods or 24 hours for time domain methods. The data was digitalised, edited and follow with reading of Normal to Normal (N-N) data sequence.

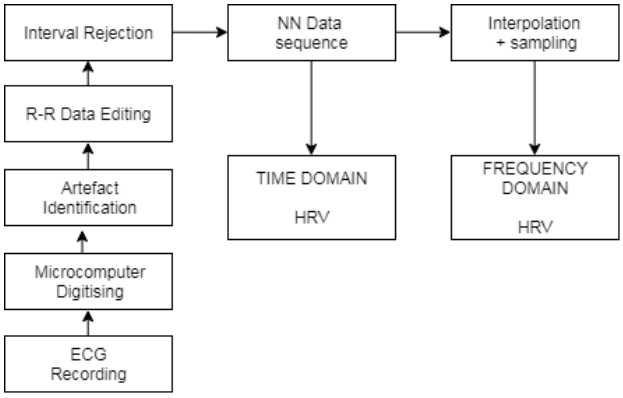

Figure 3. Steps to obtain individual ECG signal for HRV Analysis[11]

4. Artificial Intelligence and Heart Rate Measurement for Sports Performance

Artificial Intelligence (AI) is statistical application to through human machine collaboration [12]. This section briefly discusses on possibilities of information produce by learning Heart rate (HR) information by using AI. HR information plays important role in sport performance as physical activities influence the HR patterns. Thus, researchers start to predict HR rate by using Support Vector Regression [13] and Artificial Neural Network (ANN) to measure HR responses to exercises [14]. This is due to the nature of ANN where input and output data is easy to construct [15].

Xiao [22] uses Evolutionary Neural Network to model HR prediction. The HR prediction is based on physical activities data retrieved from alive HR monitor. García-García [16] uses Principle Component Analysis to calculate physical activities intensity using Multi-Axial Accelerometer and HR data. The study produces energy expenditure information and suggested that the class should be balance in order to produce maximum accuracy. The physical activities intensity is important in sport performance as it will contribute in learning the effectiveness of the training undergone.

Some researcher studies athletic aerobic endurance by controlling athlete's HR. It prevents overworking of athlete's heart. In order to control athlete's heart rate, the training was normally undertaken in controlled environment condition. Exercise machine such as treadmill, rowing, elliptical and bikes are normally use for aerobic endurance studies. For example, the automated real time HR control system during treadmill normally realised by continuously adjusting controllable variable such as treadmill speed and training programmes [17]. These methods are normally reprogrammed the

exercise machinery by using algorithm such as Non-Linear Fuzzy control [4], Fuzzy PI [18] as fuzzy is known as a simple method to map an input to an output [19].

Besides physical activities and heart rate control, HR information combine with AI are used to form training model for athletes. Adaptive Particle Swamp Optimization (APSO) are used together with HR and training duration to build their training model; it is suggested that APSO is the best method for producing high performance training model [20]. Similarly, Particle Swamp Optimization is use to generates training impulses. Training impulses is outcomes from calculating training volume in minutes and training intensity by overlooking average HR beat. The studies conclude that by using PSO and training impulse it helps improving athlete's capability after long absence from training [26]. In addition, Bat algorithm helps to expand athlete's current formation by suggesting fitness training plan [2] and Artificial Immune System was suggested to rule out athlete's preparedness for training [21]. This shows that implementation of Artificial intelligence to learn new information from HR measurement is robust and should be consider for further venture.

5. Conclusion

Section 1, 2 and 3 discuss how to obtain Heart Rate(HR) and HR variability information. The section also discusses the potentials of the HR information to enclose vital information that can be converted into elaborate information. From section for of this paper concludes there are some advantages combining HR or HRV measurement with AI, among those is;

- Predicting physical activities such as resting, sitting, running, cycling and swimming.
- Learning energy expenditure and power output produce by human body while exercising.
- Program training cardio machinery such as treadmill, stair mill, bikes to be able to control user heart beat to prevent injuries and maximizing training abilities.
- Building training models that are suitable for the condition of athletes and predict athletes' readiness for competition.

As conclusion, it is clear that HR measurement is one of the main important information that should be used to elevate athlete's abilities. Furthermore, the usage of AI improve the understanding of hidden data contain in HR measurement.

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