中文摘要

本研究以強化心臟功能、降低心血管疾病風險為出發點，開發出一套運動促進健康管理系統，幫助需要以運動來促進身體機能之人們，直覺地透過音樂節拍引導，於運動中達到所適合之心率區間，完成有效且完整的運動周期。系統主要包括三個部分：(1)生理感測裝置：此部份由感測智慧衣與生理訊號無線傳輸裝置所構成，能即時記錄使用者之心電訊號，並於運動過程中以無線通訊將心電訊號傳回運動促進平台；(2)運動促進健康管理系統：提供安靜心率、運動後心臟恢復及心肺指數體能分析等評估功能。運動促進介面則按照標準運動流程分為暖身、訓練、緩和三期，透過引導之運動節拍達到有效運動心率；(3)運動處方雲端伺服器：此系統根據使用者年齡及預先建模好之心率與運動轉速之回歸線以推算出轉速節拍引導，隨著運動次數的增加，再依此近期累積之多組運動轉速與心率數據，逐漸訓練出符合個人運動心率之回歸線，作為個人最佳的運動反饋模式。根據本研究所提出之服務模式，以受測者運動資料選擇適合訓練之回歸模型並利用不同受測者於暖身期、訓練期及緩和期之目標運動心率達成率做實驗結果的比對，並確定適合初步引導使用者之回歸模型，為此設計出四種實驗模式：(A) 心跳與運動轉速回歸模型比較：以決定係數為 97.21％、

98.09 %以及平均相對誤差絕對值為 3.12、2.06 之二次多項式回歸做為運動心率趨勢訓練模型；(B) 單一心率上升回歸模型對運動完成度之影響：以單心率回歸做三期運動完成度之觀察，扣除心率變化期之三期平均完成度為 96.14％、 77.27％、 63.27％，於訓練及緩和期結果不盡理想；(C) 心率上升及下降回歸對運動完成度之影響：以雙回規模型的方式，扣除心率變化期之三期平均完成度為 97.05％、 91.91％、 98.32 %，結果證明使用雙回歸之模式進行運動可以得到更好之結果；(D) 選擇初步運動回歸模型之精確度比較：實驗證明體能分群回歸模型之精準度較好，訓練前後之平均相對誤差絕對值上升模型為 6.37、3.84，下降模型為 5.25、3.57。

關鍵字－運動促進健康管理系統、智慧衣、生物資訊學、心率監控、運動心率趨勢

Abstract

This study proposes a Smart Fitness System that utilizes smart clothes, artificial Intelligence technology and wireless sensing technology to easily reach target heart rate during exercise. The system consists of three components. (1) Physiological Sensing Module which is comprised of smart clothes and gateways, records electrocardiography in real time and conveys the ECG data to Fitness Center Platform. (2) Fitness Center Platform which provides a service to estimate user's physical fitness and to analyze heart function base on heart recovery rate. (3) Exercise prescription Server which provides a personal exercise plan. The system will monitor user's instant heart rate and give a fit beats guidance if the heart rate does not reach the optimal heart rate. In order to validate the performance of Smart Fitness Center we proposed, we designed four experiments including (A) Regression model for exercise heart rate tendency, experiment result show that the coefficient of determination are 97.21% and 98.09%, and mean absolute percentage error are 3.12, 2.06. To prove that quadratic polynomial regression is a better way to predict the rhythm of exercise .(B) Single quadratic polynomial regression to feedback, experiment result show that the accuracy of exercise heart rate is 96.14% for warm-up state, 77.27% for training state and 63.27% for cool-down state respectively. (C) Two quadratic polynomial regressions to feedback for speed up and cool-down, experiment result show that the accuracy of exercise heart rate is 97.05% for warm-up state, 91.91% for training state and 98.32% for cool-down state respectively. They are not different in warm-up state and

training state, but single quadratic polynomial regression is worse than another way. It proves that heart rate changes cannot be mixing up speed-up state and cool-down state. (D) Initial regression model, experiment result show that the mean absolute percentage error in heart rate speed-up model and cool-down model is 5.25 and 6.37. After training, the mean absolute percentage error in heart rate speed-up model and cool-down model 3.84 and 3.57. It proves that three physical grouping models have better prediction, with calculating the mean absolute percentage error.

Keywords—smart fitness system; smart clothes; bio-sensor; heart rate monitoring; exercise heart rate tendency;