中文摘要

隨著全球人口高齡化及少子化，使得幼老的照護成為首要議題，雖政府積極提出相關政策，但照護人力不足的問題仍未得到改善，因此本研究秉持以科技輔助照護的理念，針對醫院、居家、社區以及機構型的健康照護需求，提出以穿戴式裝置搭配使用智慧衣以及低功耗藍芽技術的物聯網整合架構，主要由前端穿戴式生理訊號監控裝置，中端藍芽訊號介接及處理平台，以及後端健康照護服務相關應用系統所組成。

於本研究中開發三項系統，分別為(1)即時監控系統：接收使用者生理資訊如心電圖、呼吸、血氧濃度、步數以及睡眠品質等，並提供緊急求救以及原地停留時間過久、如廁過久、夜間離床以及接近警戒區等異常事件通報功能。(2)健康照護系統：將生理量測結果紀錄以圖形化數據呈現、異常事件警示以及統計分析報表匯出等應用。(3)關懷服務通知系統：當使用者生理量測異常或有緊急事件發生時，即時將訊息推播至 APP、Email 及簡訊等訊息接收管道，並於系統排程時間主動發送衛教訊息以及相關問卷調查，提供更多元化的健康照護服務。

此外，本研究進行三項演算法準確度實驗，(1) R 波偵側演算法與 MIT-BIH 資料庫數據比對結果顯示兩者 RRI 的相關性為 0.97452。(2)

呼吸訊號提取演算法與市售呼吸綁帶比較，10 名受測者平均呼吸次數差異 <1.5 次。(3)血氧濃度值計算方法準確度與市售血氧濃度量測產品量測值比較，平均誤差皆小於 2%。以上實驗，證明本研究穿戴式裝置生理訊號量測方法準確度。

最後，為驗證本研究所提出的系統架構及服務模式可行性，已將系統實際建置於 2 處機構型場域，分別為啟智照護機構及護理之家，以及 5 戶居家型場域，皆已上線使用約 3 個月，系統功能皆達成場域預期目標，系統使用率分別為 72.44%、98.94%，以及 44.66%。統計期間在啟智照護機構部分，共發生 477 次異常，其中生理量測異常 363 次，事件異常 114 次，護理之家部分，共發生 913 次停留過久異常，而在居家型場域部分，共發生 439 次異常，其中緊急求救 24 次，事件異常 415 次。場域中發現停留過久、如廁過久及夜間離床異常事件誤報問題，系統未來可透過增加個人化的參數條件設定以及警戒閥值來減少事件誤報發生率。透過系統之導入，除了建立一套完整異常事件通報機制，且持續收集生理數據進行統計分析，以圖形化介面呈現數據結果給照護人員參考，於此，不僅能有效減少照護人員紙筆作業時間，降低人力負擔，並能給予更為個人化之服務，進而提升整體照護品質。

關鍵字－穿戴式裝置、智慧衣、健康照護系統、低功耗藍芽、物聯網、關懷服務通知系統

Abstract

With the aging and declining population of the world, caring for the elderly and child has become a top priority issues. Although the government has actively proposed relevant policies, the problem of over lack of manpower in long-term care has not been improved. Therefore, this study adheres to the concept of technology-assisted care for hospital, home, community and institutional health care needs. This thesis proposes the IoT integration architecture with wearable devices, smart clothes and Bluetooth Low Energy (BLE) technology. The proposed system architecture including wearable devices to monitor user's physiological signal in front-end, Bluetooth signal processing platform in mid-range, and a back-end health care service related application system.

Three systems were developed: (1) Real-time monitoring system: Receives physiological data such as electrocardiogram, respiration, blood oxygen concentration, steps, and sleep quality, and providing real-time abnormal event notification service. Such as emergency call, sit for too long, long toilet time, getting up at night and entering the warning area. (2) Health care system: Provides functions such as recording physiological measurement results, display data in a graphical interface, warning when abnormal events happen, and export statistical analysis report. (3) Care service notification system: When the system detects abnormal vital signs or an emergency event happened, the message will be immediately sent to caregivers' APP, Email or SMS. Moreover, the health education message and relevant questionnaires are actively sent during the system scheduling

time to provide more diversified health care services.

In addition, this study conducted three experiments to verify the accuracy of the physiological signal measurement method. (1) R-peak detection algorithm in comparison with the MIT-BIH database shows the correlation of RRI between the two is 0.97452. (2) Respiratory signal extraction algorithm compared with the respiratory bandage, the average respiratory rate difference of 10 subjects is less than 1.5 bpm. (3) Blood oxygen saturation calculation results show that the average error compared with the measured blood oxygen saturation and the commercially available blood oxygen saturation measurement product is less than 2%.

Finally, to verify the feasibility of the system architecture and service model proposed in this study, the system is actually built in 2 institutional fields, special education care center and nursing home, and 5 home-type fields. The system has been online for about 3 months, and all the functions achieved the expected target of the field. The system utilization rates were 72.44%, 98.94%, and 44.66%, respectively. During the statistical period, happened 477 abnormal events in special education care center, including 363 physiological abnormal and 114 other abnormal events. In the nursing home, there were 913 abnormal events for siting too long, and in the home-type field, 439 abnormal events occurred, including 24 emergency calls and 415 other abnormal events. The problem of false alarms on abnormal events happened in the fields such as sit for too long, long toilet time and getting up at night is found. In the future, the system can reduce the false alarm rate by giving the personalized parameter setting and warning

threshold. Through the introduction of the system, a complete abnormal event notification mechanism has been established. The system continuously collecting physiological data for statistical analysis, and presented the results in graphical interface for caregiver to reference. Thereby not only can effectively reduce the time caregivers spend on paperwork, but also they can provide personalized care services in order to improve overall care quality.

Keywords—Wearable Device; Smart Clothes; Health Care System; Bluetooth Low Energy; Internet of Things; Care Service Notification System