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應用創新感測融合定位技術之新一代非接觸新生兒智慧感測系統

Innovative Sensor-fusion Localization Technique Applied on Contactless Neonatal Smart Sensing System

隊伍名稱｜救救新生兒 Rescue Newborn
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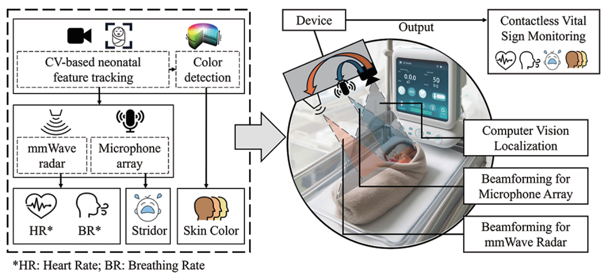
成功大學生物醫學工程博士，現為成功大學生物醫學工程系教授。曾獲得旺宏金矽獎評審團鑽石大賞、最佳指導教授及最佳創意獎；中華工程教育學會IEET教學獎；臺灣機電工程國際學會年輕機電工程科技學者獎等獎項。

研究領域

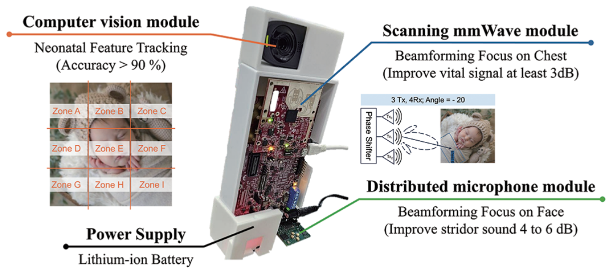
多年來在生醫系統整合、生醫訊號處理、數位醫療以及醫療機械人領域進行研究。分析醫療場域實際存在痛點進行系統開發，並連結產學界優勢進行合作。杜翌群教授的數位醫療與機械人實驗室鄰近數個醫學中心，藉由此優勢進行生醫系統臨床驗證，進而實際改善目標族群生活品質。

作品摘要

在高齡化及少子化的趨勢下，全球對新生兒的照護意識逐年上升；再加上臺灣34歲以上的高齡孕婦逐年增加，各大醫院對於高齡產婦與早產兒的照護更是主要工作之一；但新生兒死亡率過高的問題，臺灣仍相當嚴重。根據統計數據，2022年臺灣新生兒死亡率高於經濟合作暨發展組織所統計的各國平均值，臺灣為日本的2.7倍、韓國的1.6倍；如何提升新生兒的照護品質，是臨床很重要的課題。本作品與成大醫院婦產科陳柏帆醫師、新生兒科朱蔚穎醫師討論後，將目前新生兒照護的臨床問題統整，包含：（1）接觸式新生兒的生理量測感測貼片常造成皮膚傷害，且不易固定導致訊號不穩定。（2）新生兒的呼吸頻率及呼吸音是相當重要的臨床判讀資訊，但目前尚無可長時紀錄與分析的工具。（3）新生兒的臨床照護壓力大，希望有可以長時間監控之提醒工具，降低醫護壓力。有鑑於此，本作品提出應用創新感測融合定位技術之新一代非接觸式新生兒智慧感測系統，可針對包裹毛巾的新生兒進行生理參數長時的資料收集與評估，參數包含新生兒的心率、呼吸、哭聲以及體表顏色，如圖一所示。本作品提出的系統可以分成兩部分，第1部分是先藉由AI影像分析出新生兒全身、臉部及胸腔3個位置，以作為非接觸感測的基礎。第2部分再透過掃描式毫米波陣列模組針對胸腔位置掃描，藉此取得心率與呼吸資訊；波束成型的麥克風陣列模組則鎖定新生兒臉部的位置， 藉此取得哭聲等相關生理參數。這樣的設計可大幅降低傳統非接觸式感測不穩定的缺點，能夠用於協助改善目前新生兒照護流程並降低臨床壓力。本團隊打造雛型品Rescue N具備三大模組， 如圖二所示。其中，電腦視覺模組可辨識及追蹤新生兒特徵，準確率高於90%，掃描式毫米波陣列天線模組可提高目標生理訊號至少3dB，分佈式麥克風陣列模組則可以提高目標聲音4至6dB。完成功能性驗證後，本團隊將與成大醫院婦產科以及新生兒科合作，進行新生兒臨床場域驗證並使用臨床接觸式量測方法進行準確率驗證，進而提高非接觸式量測模組的臨床實用性。



圖一 系統使用情境。



圖二 Rescue N 模組功能及規格。

Abstract

Recently, according to statistics, the birth rate of developed and partial developing countries gradually declines, influencing the survival rate of neonate which has become a global issue. After discussing with our clinical consultants, we listed the three existing pain points in neonatal clinical procedures. (1) Over a quarter of repeatedly tearing and sticking sensor patches, cause neonatal skin injury; (2) clinical consultants determined breathing frequency and stridor sound as judgement criteria of acute respiratory distress syndrome (ARDS), but most medical device only measures oxygen saturation; (3) Lacking professional neonatal personnel and immediacy of neonatal vital feedback. Through these three pain points, we therefore focus on neonates wrapped in swaddling blanket to propose two-stage sensor fusion technique for contactless neonatal smart vital monitoring system. In the first stage, system utilize computer-vision to process neonatal feature localization and real-time object tracking. In second stage, with various feature position, scanned by millimeter wave module and dual-layer microphone array module process beamforming algorithm focused on target direction measuring vital signs, including the heart rate (HR), breathing rate (BR), wailing sound and skin color changes. Moreover, we collaborated with local medical centers to process clinical trial for validation of contactless vital measurement module. With validated contactless sensing module, we integrate Internet of Things (IoT) technology for update of neonatal vital sign feedback, which can assist neonatal personnels in providing vital sign feedback to doctors in hospital during referral. Proposed contactless neonatal smart vital sign monitoring system helped neonatal clinical procedure for the reduction of sensor patches usage, increasing the judgement efficiency in ARDS and immediacy of vital sign feedback in emergency referral, further enhancing survival rate of neonates.

Our team proposed contactless neonatal vital sign monitoring system named N Care, includes three main modules: CV based neonatal feature tracking module, scanning mmWave array antenna module and dual-layer distributed microphone array module. N Care processed vital sign monitor with two stages. In first stage, CV module localize the neonatal features, achieved an accuracy more than 90%. In second stage, scanning mmWave module focused on chest feature monitoring HR and BR, improving signal reception at least 3 dB; distributed microphone module focused on facial feature monitoring stridor and other sound signal, improving target sound 4 to 6 dB.

Our team has collaborated with medical center to process clinical trial for validation of contactless vital measurement module, as shown in Fig. 3. Firstly, we collected the neonatal image dataset in delivery room and newborn baby room for Neonatal Feature Recognition AI Model training and validation. Secondly, for validation of mmWave and microphone module, we utilized sensor modules to measure HR, BR and sound signals of neonates in newborn baby room, simultaneously using sensor patches and physiological monitor to measure same signal as reference.

Main target audience of this project is the related personnels in the neonatal care and clinical area, especially nurses in baby room and intermediate care nursery, who needs to take care several infants simultaneously. With the proposed system, not only can nurses enhance the efficiency of neonatal care process, but also is able to increase the immediacy and accuracy of ARDS judgement, further reducing neonatal mortality rate. For promoting more convenience and safer neonatal care process, our team expect proposed device to be reimbursed by health insurance. Because health insurance for infants is usually not available for first 90 days of their life, most of Maternity Insurance and Newborn Baby Health Insurance cover the expense of the mother and neonates for up to 60 days after delivery, which included hospitalization costs, specialized care costs, and among other neonatal services. However, most related insurances do not cover or only cover partial of Neonatal Intensive Care Unit (NICU) fee.

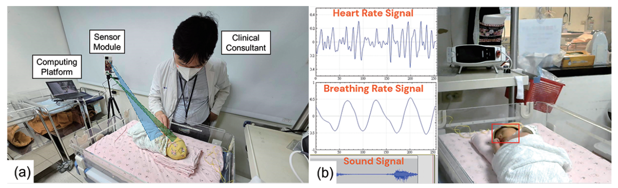


Fig. 3 (a) clinical validation setup. (b) actual measurement result.