

ORIGINAL ARTICLE

Optimizing clinical workflows through a vital signs documentation extension

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ABSTRACT

Introduction: Recording vital signs is crucial in healthcare, but manual documentation is time-consuming and error-prone, taking an average of 22.5 minutes for seven patients. Delays in data entry can hinder timely clinical decisions and increase nurses' workload. Existing automated systems are often costly and require overhauling hospital records systems. **Methods:** We propose the Automated Vital Signs Documentation Extension Device (AVD-Ex), a low-cost solution compatible with existing monitors. AVD-Ex uses a camera with OpenCV and Tesseract for optical character recognition to capture readings (blood pressure, heart rate, oxygen saturation, temperature) and automatically update patient records. The pilot test involved 10 nursing students who performed routine vital signs documentation under two conditions: (1) manual entry and (2) automated entry using AVD-Ex. For each participant, the data entry time (in seconds) was recorded as the main variables of interest. Statistical analyses were conducted using paired-sample t-tests to compare performance between manual and automated documentation conditions. **Results:** AVD-Ex reduced data entry time by 60% and minimized errors compared to manual entry. **Conclusions:** These results suggest that AVD-Ex can streamline workflow, reduce documentation burden, and support quicker clinical decisions. Its compatibility with current devices avoids major reinvestment, making it a practical and scalable solution, especially in understaffed or resource-constrained settings.

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INTRODUCTION

Recording vital signs is a crucial task, which is performed at a certain time interval, throughout the hospitalization period of a patient. The task is often performed by a nurse, manually reading the vital sign monitor. This repetitive and time-consuming work can impose a burden on nursing staff, especially in hospital with large number of patients and can introduce error in data entry. On average, the estimated time to monitor and record vital signs can take five minutes and one second per patient [1]. Another study indicates that it will take another seven minutes per ten patients for further entering the handwritten observation into the electronics health record system (EHR) [2]. Overall, based on these studies, it can be deduced that it can taken an average

of 22 minutes to handle vital sign recording for 7 patients for one monitoring cycle. As such, the manual documentation alone can impose additional workload on nurses while the time can be better allocated for more crucial task such as patient care [3].

With manual data observation and entry, it imposes a possibility of error, which can be detrimental to patient care and might lead to inaccurate clinical decisions. A study by Finkelstein (2021) [4] revealed that in manual data collected in group of 30 patients, seven patients data were entered incorrectly while two patients' data were not recorded at all. Furthermore, due to the manual nature of the recording, real-time monitoring is unfeasible. This can lead to delay in clinical decision making and adversely impacting patient care. In 2019, the Ministry of Health Malaysia has released a health technology assessment report emphasizing on a system to improve early detection of clinical deterioration in patients, which culminated in development of National

Early Warning Score (NEWS) to standardized method for early detection of sudden deterioration. Therefore, having an automated system will align with this goal and improve in-ward patient care by reducing the bureaucratic burden of staff. Whilst some automated system is commercially available, this system can be costly to be implemented hospital-wide. One example of such system is ViSi mobile by Sotera Digital Health, which measure major vital signs such as blood pressure, oxygen level, electrocardiogram continuously and uploaded straightaway to hospital database [5]. However, it can be unfeasible for some hospital to replace entire system in order to obtain such real-time feature. Furthermore, it is also wasteful to let go existing working vital sign monitor. Recent advancement in optical character recognition (OCR) allows computer to decipher writing into processible text [6]. One of the earliest idea in using OCR was by Chen et al (2012) [6], which used a web-cam to record digital number. A study by Soeno et al. (2024) [4] utilized OCR technology to decipher medical personnel handwriting and vital sign monitor to speed up record keeping shown improvement in record accuracy [7]. With greater computing power and advancement in machine learning, OCR technology can capture variety of font and technically can support wide variation of system.

Our work proposed on leveraging the advancement of OCR technology to frequently record vital sign reading from existing monitor. The OCR technology will be installed on a Raspberry Pi mini computer and vital sign monitor reading will be capture by a camera module. The recorded number can then be sent to nursing station or existing databases.

METHODS

Study Design

This study adopted an experimental pilot design to evaluate the performance, efficiency, and accuracy of the proposed AVD-Ex compared to conventional manual documentation methods. The evaluation focused on workflow efficiency, error reduction, and potential improvement in data accuracy.

Participants

A total of ten nursing students from a local university nursing program participated voluntarily in this study. All participants had prior training in vital signs measurement and documentation to ensure consistency in data collection procedures. Informed consent was obtained from all participants prior to participation.

Hardware structure

The main engine of the device is the Raspberry Pi 4 model B (www.raspberrypi.com) single board computer, along with Raspberry Pi camera module (8 MP camera module V2). The Raspberry Pi and camera is then installed within a 3D-printed casing which is then connected to

a commercially-available phone holder. The holder is attached to the basket of vital sign monitor to secure it in front of the display as shown in Figure 1.



Fig. 1: AVD-Ex Vital Sign Monitor recorder

Open-source Tesseract

The open source Tesseract OCR (<https://github.com/tesseract-ocr/tesseract>) and open source computer vision tool, Open CV (<https://opencv.org/>), were installed on the Raspberry Pi 4. The image of the vital sign monitor display was captured and subsequently pre-processed using Open CV. The pre-processed images are then processed by Tesseract to detect main keywords related to the vital signs (Figure 2).



Fig. 2: The display of AVD-Ex

Data acquisition protocol

The data acquisition began by the nurses registering patient's detail by scanning patients QR code on the AVD-Ex. The device camera is then pointed towards the vital sign monitor and the nurse verified the data extracted by AVD-Ex by visually checking the vital sign monitor. The image is pre-processed using OpenCV and the run through Tesseract OCR for text recognition and extraction. The data generated by AVD-Ex are pushed to online EHR database via the application programming interface (API). The time taken for the nurse to utilize AVD-Ex as well as using manual data entry methods was

taken and compared. Four vital sign data were recorded namely blood pressure, heart rate, blood oxygen saturation (SpO₂) and body temperature.

Ethics approval

This study received ethics approval from the KPJ Clinical and Research Ethics Review Committee (CRERC), reference number KPJU/KPJRIC/GRANT/2025/01(CRGS13).

RESULTS

The AVD-Ex was capable of capturing the images of the vital sign monitor and subsequently capable to process the image as shown in Figure 3. The Tesseract OCR was successful in extracting the number accurately in the bounding box. In the preliminary testing, we compare the time taken to compute manual vital sign monitoring vs implementing AVD-Ex for 1, 7 and 10 subjects, performed by a student nurse. As shown in Figure 4, AVD-Ex consistently showed lesser time needed to record subjects’ vital sign relative to the manual approach. This time reduction was more noticeable when involving more subjects, as expected due to reduction of repetitive steps needed to use AVD-Ex. For these reasons, we can expect that automated system such as AVD-Ex can provide significant improvement or nursing workload, while amplifying existing vital sign monitor features with capability to provide higher monitoring frequency.

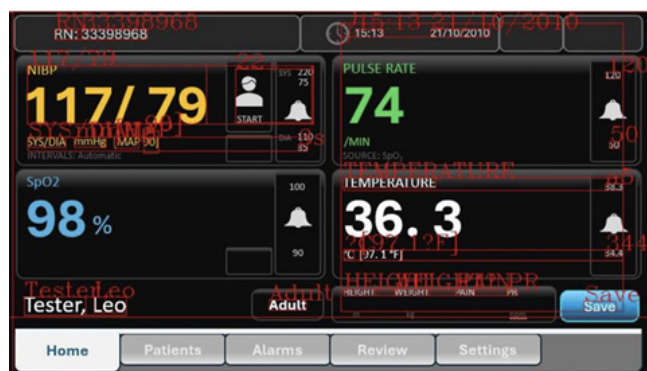


Fig. 3: The extracted reading by the OCR.

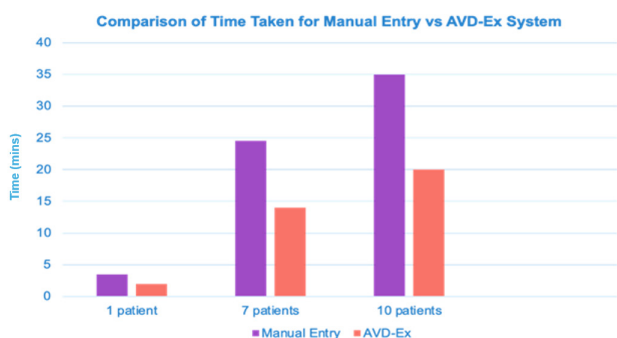


Fig. 4: Comparison of time taken for manual entry vs AVD-Ex-1

DISCUSSIONS

The automated recording feature can help to save time and reduce healthcare professionals workload, especially in large hospital systems. AVD-Ex helps healthcare professionals by skipping the process of manual data entry, as well as enabling possible remote recording of the vital signs. The system also can enhance accuracy by reducing manual data entry errors by humans. The system essentially eliminates the need for workers to be near the patients for data recording for most of the vital signs. This allows real-time updates of vital signs and enables quick decision-making by clinicians. By merging the system with signal processing tool [5, 8], several features can be extracted and healthcare professionals can be alerted if there is sudden deterioration of subjects.

While the idea of automated vital sign monitoring is not entirely new, most currently available systems are costly and require significant investment to upgrade for the entire hospital. These systems typically are embedded with automated features within the vital sign monitor itself such as the ViSi mobile system by Sotero (<https://soteradigitalhealth.com/>). This can be uneconomical as the entire vital sign need to be replaced to accommodate the new feature. A work by Wong et al. (2015)[9], motivated to reduce workload of healthcare professionals, implemented a tablet placed bedside near the vital sign monitor in order to push the data straight into a database [9]. However, the system only eliminates the need for handwritten forms, as it still relies on manual input by healthcare professionals to key in the data into the tablet. Nonetheless, the system showed a high usability score among the surveyed professionals.

The use of OCR technology has also been implemented by another study Soeno et al. (2024)[4], which compared the performance of using OCR to transcribe handwritten vital signs vs. manually re-writing into another form [7]. Similar to our findings, their study showed significant reduction in time needed to complete the task, with reduced error as well. However, the study utilized a commercial OCR technology which can be cost-prohibitive. On the other hand, our proposed system is built using open-source OCR technology with established single board computer systems, Raspberry Pi. This system can easily be improved and implemented in wider environments.

Our preliminary study has shown good potential for our developed automated vital sign monitor system or AVD-Ex. However, several limitations must be noted such as data security risk. To prevent data breach, the system must be linked to a secure wireless network and secure data server. As we also utilize a camera for recording the vital sign, care must be taken to ensure patients’ privacy is secured. The implementation of such system in wider hospital environments must be planned accordingly by

providing proper trainings.

CONCLUSIONS

We have developed an automated system to automatically record vital sign data from existing vital sign monitoring systems onto online database. The system was built using an open-source Tesseract OCR, which extracted vital sign data from the images captured by a camera placed in front of the vital sign monitor. Our preliminary study suggests that the system is capable of reducing the time need to process vital sign data of patients, relative to manual data entry. We believe the system can be capable of providing real-time vital sign data onto the database, providing a capability for quick clinical decision making. Nonetheless, a more intensive testing will be necessary before adapting the AVD-Ex into wider hospital system.

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