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Web-Based Intravenous Fluid Treatment Monitoring Platform in Nursing Station

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Abstract

Background: Intravenous fluid treatment is the most common way to take care of inpatients. Because of the global pandemic, the number of inpatients is increasing rapidly, leading to constant demand in the contactless system.
Purpose: In this article, we suggest a web-based intravenous fluid treatment monitoring platform in the nursing station to unburden the medical staff's workload.

Keywords

biomedical engineering, evidence-based medicine/surgery, ergonomics and/or human factors study

Introduction

During a global pandemic, there were constant demands on contactless system, especially in medical fields.[1] Meanwhile, 90% of nurses are extremely concerned due to their heavy workloads.[2] Generally, most medical staff rounds ward to check many things, including status of intravenous (IV) fluid treatment which is reported as 17.71% portion in medical staff's workload.[3] However, it takes time and effort to look at each patient in person. Moreover, the ratio of accident about IV fluid treatment is over 69.7% including case of infusion rate and infusion volume which takes portion of 29.8% and 26.5% each.[3]

To lessen medical staff's repetitive work, to prevent accidents, automated system and remote monitoring system is in need.[4] Therefore, this paper suggests web-based remote monitoring and control platform. To monitor infusion rate, deep learning-based computer vision is used. Images of fluid chamber are used as input data to identify whether drop is fallen or not. Linear actuator is used to control infusion rate. Optical sensors are used to check backflow of blood. All checklists about IV fluid treatment are streamed via server to web which can monitor each patient and control the rate of fluid infusion in nursing station.

Methods

Figure 1 shows the entire process of the integrated monitoring system. The proposed system is composed of measuring part, control part, sensing part, and integrated web monitoring environment. With the webpage from nursing station, it is available to monitor the patient's infusion status and handle work remotely without going directly to ward.

Measuring Part

The measurement part monitors the infusion chamber with a camera attached to the raspberry pi and measures the infusion rate and the infusion volume through deep learning. It is designed to operate in night by infrared dimming No InfraRed (NoIR) camera module. For deep learning, a You Look Only Once (YOLO) model, which showed excellent performance in detection, was used.[5]

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Information about drops was detected from the chamber that can be calculated to remaining volume and remaining time of the fluid treatment are returned to the nursing station in real time.

Control Part

The system is configured so that medical staff can remotely adjust the infusion rate based on the infusion

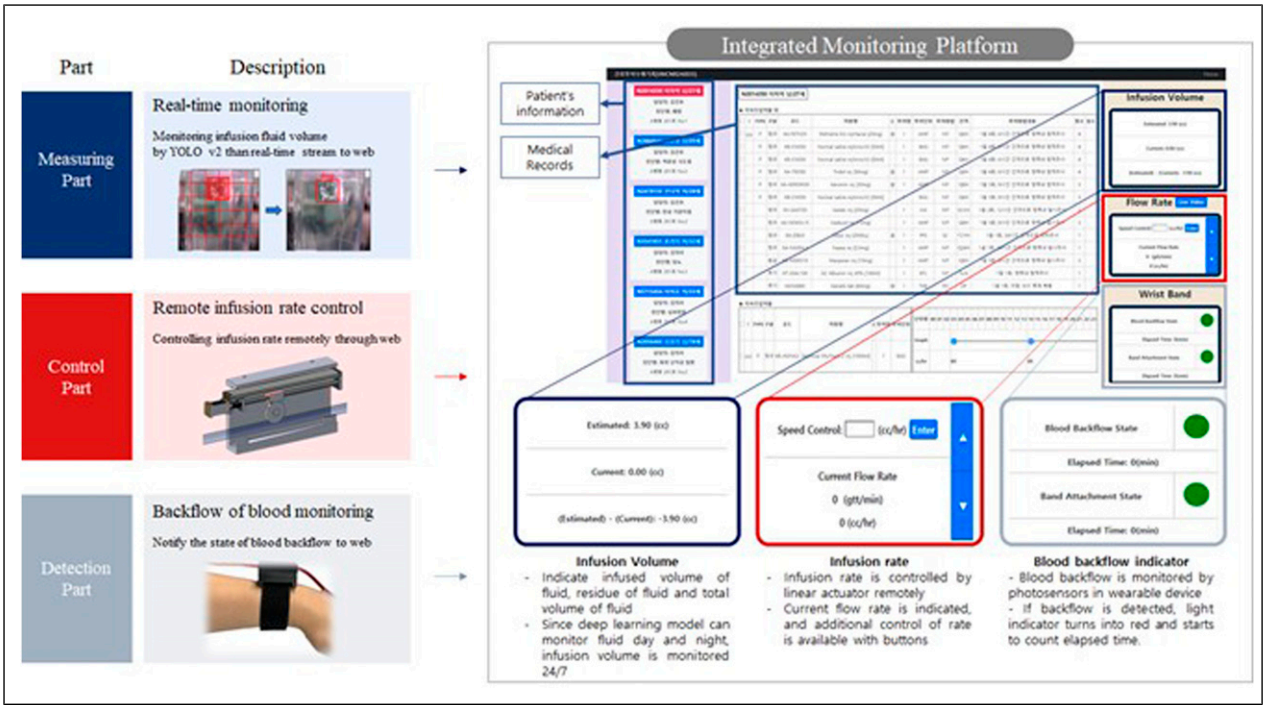

Figure 1. Abbreviated description of the platform design.

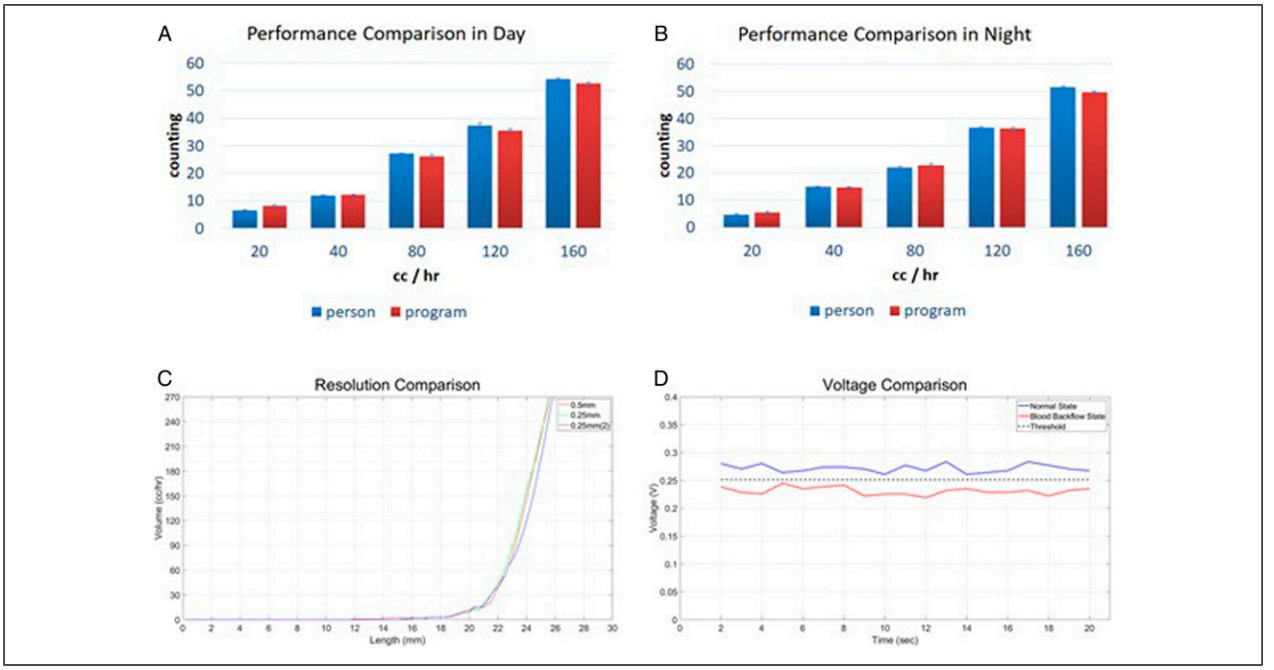

Figure 2. Experiment results. (a) Performance of deep learning model in day (b) performance of deep learning model in night (c) result of resolution comparison of control part (d) result of voltage comparison of detecting part.

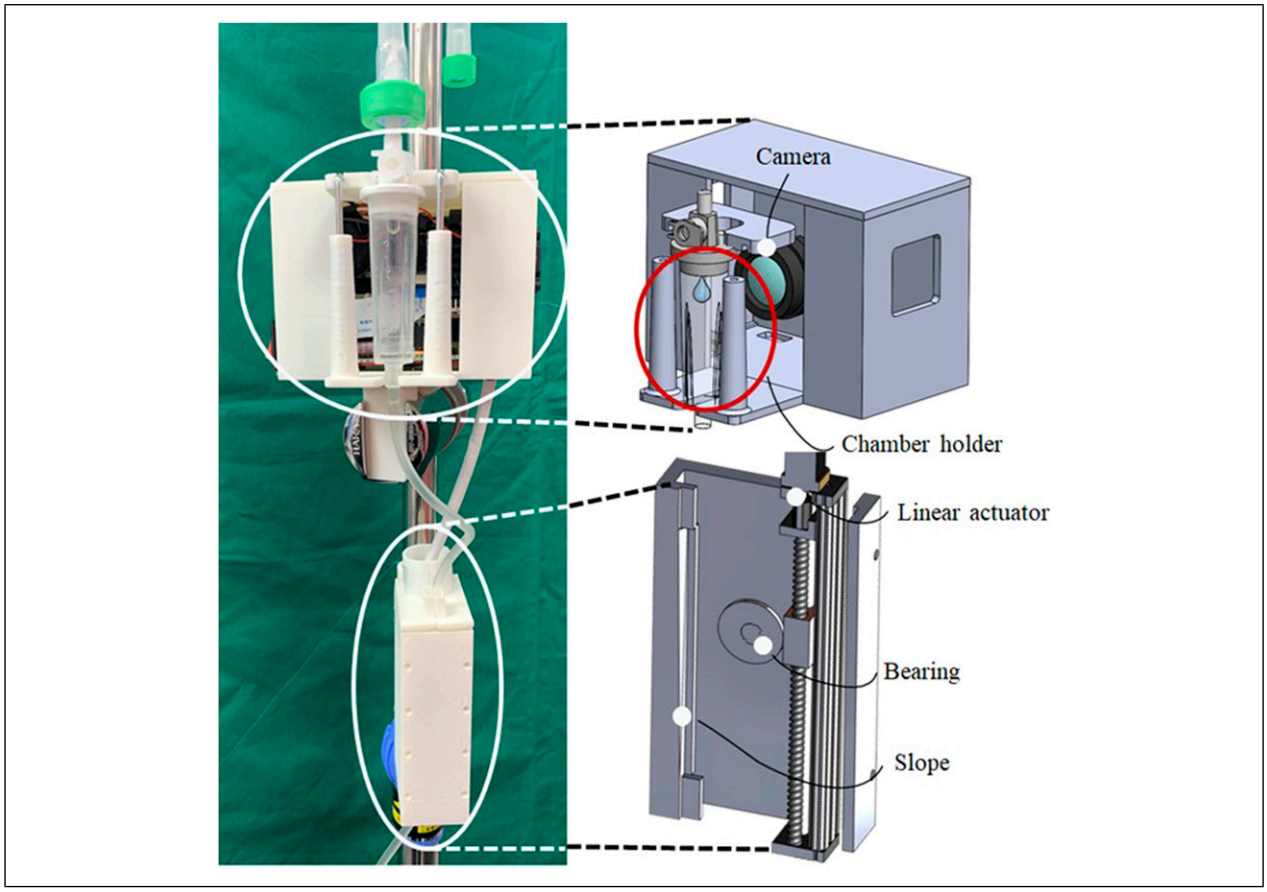

Figure 3. Design and manufactured device.

parameter value. The system is composed with linear actuators, ball bearings, and algorithms are configured to use limit switches to prevent motor's breakaway from lane. If speed value is input into web browser, a correspondence process using the database was designed. Therefore, the infusion rate could be changed in real time by compressing the infusion tube by linear actuator.

Detection Part

The system was designed using white Light Emitting Diode (LED)s and Near InfraRed (NIR) Photodiodes to monitor backflow during infusion treatment. Red blood cells have absorption spectrum of 650–750 nm wavelength range, which absorbs light in the same wavelength range among visible light spectra emitted from white LEDs. Therefore, the current decreases as the amount of light received in the 720 nm photodiode decreases. The algorithm was configured to generate a signal by the Micro Controller Unit (MCU)'s timer interrupt when the received current value becomes less than a certain threshold than transmitting to Raspberry Pi through Bluetooth. With the control unit, a correspondence process was designed to monitor backflow of blood could be transmitted in real time.

Result

In order to clarify the performance of this system, we took the experiment about how measurement is accurate, regulating of fluid is detailed, and detecting backflow is exact. To confirm the performance of measurement, experiment is done 10 times with each different five infusion rate. In day, correlation coefficient r showed .9960 ($P <$ .0001) while .9976 ($P <$ .0001) in night. To measure resolution of linear actuator, we measured in step of .5 mm once and .25 mm twice. We found that concordance rate of variation is similar to each graph. To classify whether blood is flowed backward or not, voltage threshold is set on 25 mV.

Figure 2 shows every result of each part. Through every experiment, each part showed prominent results which can be used in practical medical field.

Conclusion and Discussion

Current nursing system to check status of fluid treatment in person could burden medical staffs, especially in pandemic. Therefore, in this paper, remote monitoring system based on web is suggested. Figure 3 is image of

the designed and manufactured device. This device with developed web environment is expected to unburden medical staff's workload and could prevent inevitable medical accidents while IV treatment.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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