인체 체액에 대한 임베디드 진단 시스템의 설계

김 원[†]

요 약

노령 인구가 늘어가는 나라일수록 다가오는 u-health 사회를 준비하는 것은 중요한 문제로 대두되고 있다. U-health 기술은 장소와 시간에 구애받지 않고 노인들의 건강을 관리하는 일을 도울 수 있는데, 그 이유는 유비쿼터스 기술은 그 핵심 개념을 건강 관리 문제와 결합할 수 있기 때문이다. 이 연구에서는 u-health 시대에 대비하여 인체 체액에 대한 자동화된 진단 시스템을 구성할 수 있는 설계 방법을 제안한다. 구체적으로 이 시스템은 임베디드 시스템, 빛 발생 시스템, 광 감지 시스템으로 이루어지는데, 화학적 시료 패드에 조사되는 빛으로부터 분산되는 빛을 분석하며 구체적 질병에 따라 미리 정의된 색상 값에 의하여 다양한 질병을 진단하는 기능을 한다. 제안된 시스템은 실제 하드웨어로 구현되었으며 95%의 신뢰성으로 정확하게 측정할 수 있는 성능을 보인다.

주제어 : 자동화 진단, 임베디드 시스템, 광학 시스템, U-health

Design of An Embedded Diagnosis System for Human Body Fluid

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ABSTRACT

It becomes important for the countries with ageing populations to prepare coming u-health societies. Surely, the technology of u-health will help the elderly everywhere and everytime because the key concept is based on the combination of the ubiquitous and healthcare technology. In this paper, a design scheme is proposed to construct an automated diagnosis system of body fluid for u-health. Specifically, the system is comprised of embedded system, light generating system and photo sensing system. The system analyzes the diffused lights from the chemical reagent pads under LED lights and diagnoses a variety of diseases according to the predefined color values on specific diseases. As a result, the system is implemented as a hardware and shows the measurement accuracy of 95% in reliability.

Keywords : Automated Diagnosis, Embedded System, Optical System, U-health

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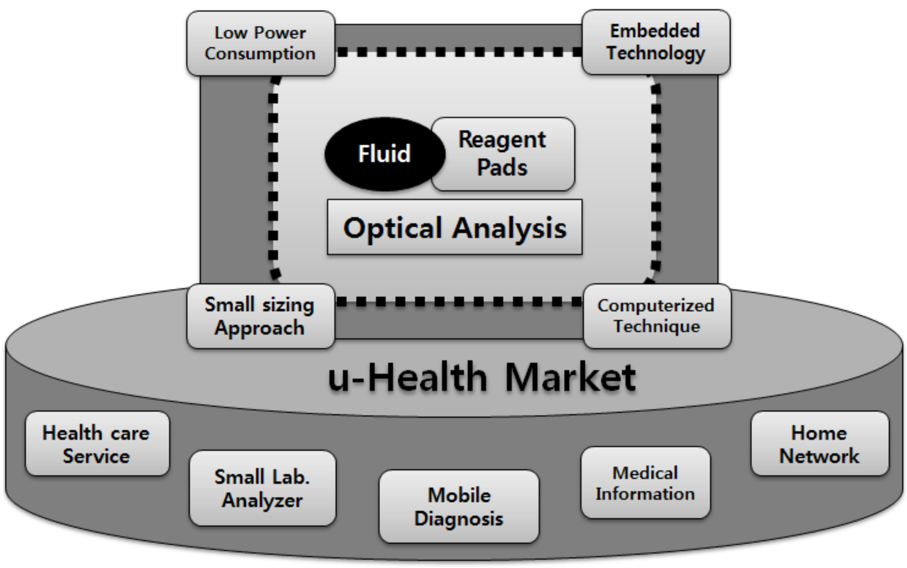
논문접수: 2012년 11월 05일, 심사완료: 2012년 11월 19일, 게재확정: 2012년 11월 24일

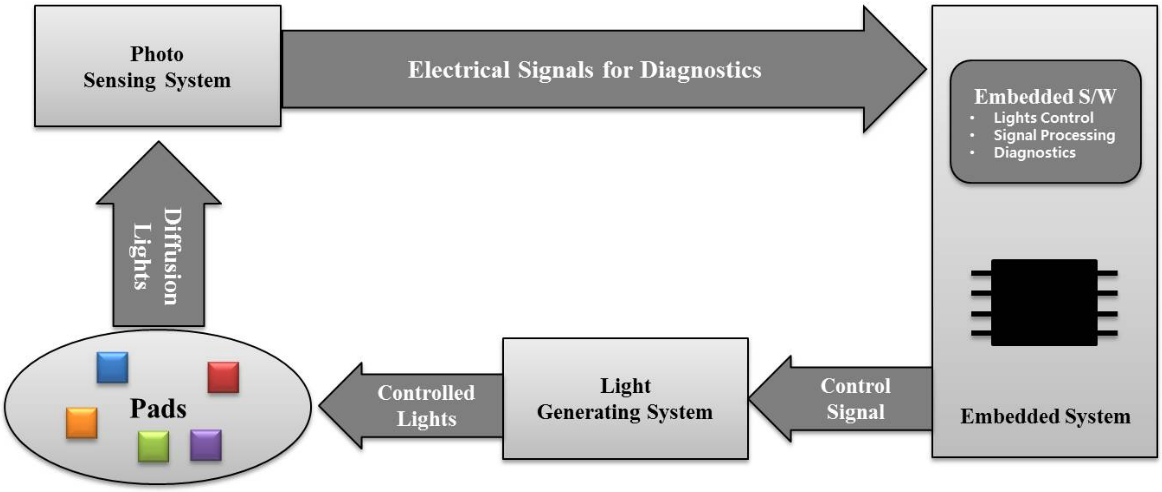
1. Introduction

It becomes important for the countries with ageing populations to prepare coming *u-health* societies. Surely, the technology of u-health will help the elderly everywhere and everytime because the key concept is based on the combination of the ubiquitous and healthcare technology. Networking is one of the essential technologies which can solidify the groundwork for the construction of u-health society. For this reason, Zhang et al. proposed *U-Care* which deals with a health care network for the elderly[1]. Recently, Korea is one of the challenging countries to develop the u-health technology because the ageing populations are now growing in the country. The environment for u-health was studied[2], a u-health monitoring system was proposed by using a *Nintendo* game machine[3], and a wireless sensor network based wearable smart shirt was proposed for ubiquitous activity monitoring[4]. Meanwhile, a u-health expert system was proposed with a statistical neural network because the machine intelligence is important to make the ubiquitous devices work independently on its own intelligence in everywhere[5]. To cover the mobile problem in u-health technology, a mobile u-health system was proposed as service application[6]. In the daily life equipment, non-intrusive sensors were studied to monitor physiological signals for the u-health application[7]. As the elderly has a tendency to spend most of times in home, a u-health smart home was studied[8]. USN(*ubiquitous sensor network*) is an fundamental technology for u-health, as it is easily found that a letter '*u*' gives the original concept for USN and u-health simultaneously. Kim et al. studied a USN system for fire prevention for a wide range application[9]. Meanwhile a ubiquitous service model was proposed as a more flexible diagnosis method by using CDSS(Clinical Data Supporting System) technique[10]. Recently, a cyber physical system was proposed for silver towns as an aging-friendly telemedicine system[11].

In this paper a design concept will be discussed to configure the computerized diagnosis system of body fluid for u-health. As illustrated in Fig. 1, the study deals with the optical analysis technique for on chemical



<Fig. 1> Effects of Computerized optical diagnosis device



<Fig. 2> Conceptual design of the proposed system in overall

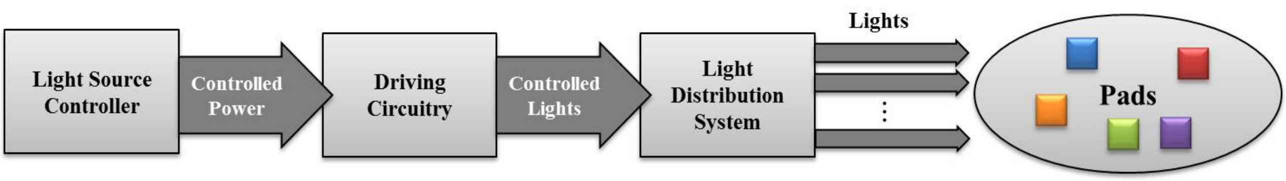
reagent pad for human fluid. If the system consumes lower power in smaller size by embedded technology, a computerized mobile diagnosis can be implemented easily and this will make the u-health world come early.

2. Design of the Computerized Diagnosis System

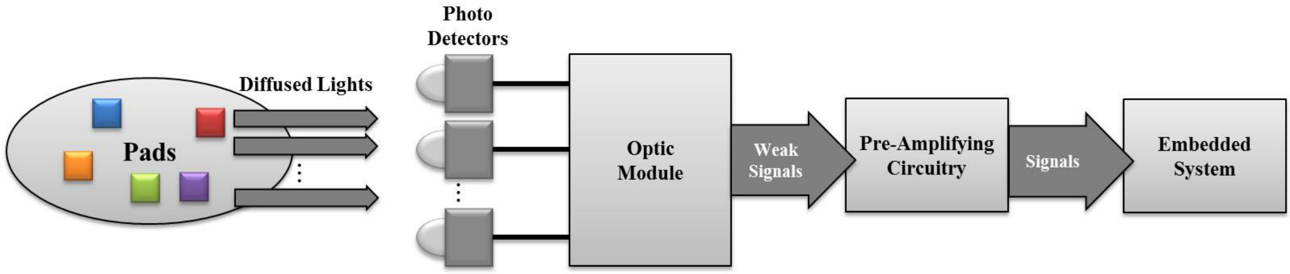
Overall design concept is proposed to configure the computerized diagnosis system of body fluid for u-health as illustrated in Fig. 2. There are 3 major systems in the computerized diagnosis system such as light generating system, photo sensing system and embedded system. When light is generated in controlled intensity onto chemically activated reagent pads, diffused lights are delivered through air to photo sensing system. The photo sensing system changes the diffused lights to corresponding electrical signals and finally the embedded system will measure the electrical signals with AD converters inside. System ability to measure the diffused lights from the chemical reagent pads under the LED lights can give chances to diagnose a variety of diseases according to the predefined color values describing specific diseases for pads.

In light generating system, under the control of the embedded system, a light source controller is adjusting relevant resisters to control the currents of the driving circuitry in which power-type transistors are operating to support the currents for LED circuits as illustrated in Fig. 3. As a result, the controlled lights in the embedded system are delivered to the chemical pads on strips.

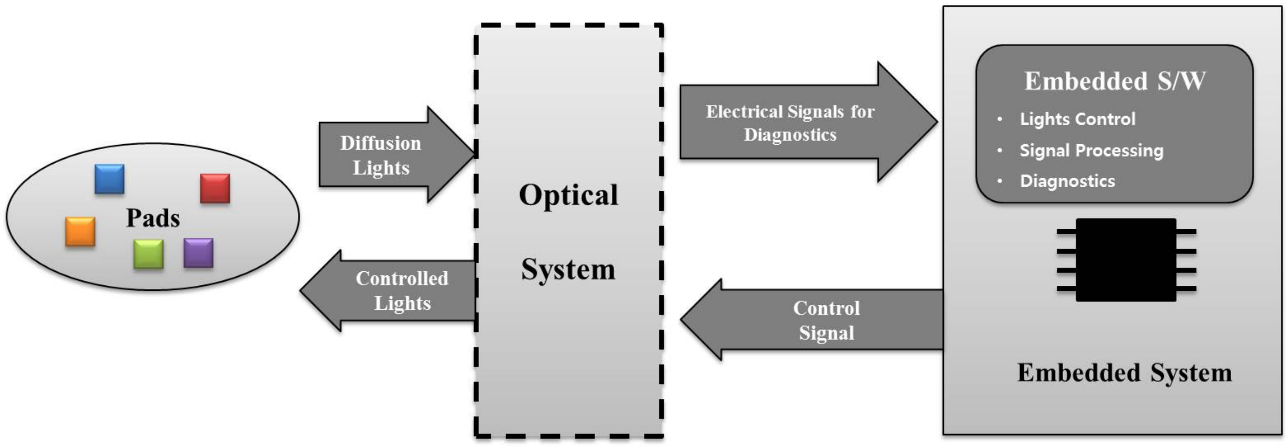
In photo sensing system, there are photo detectors which are generally color photo diodes. The diodes will change the diffused lights to corresponding electrical signals according to light intensities and finally the embedded system can measure the electrical signals with AD converters as illustrated in



<Fig. 3> Conceptual design of the light generating system



<Fig. 4> Conceptual design of the photo sensing system



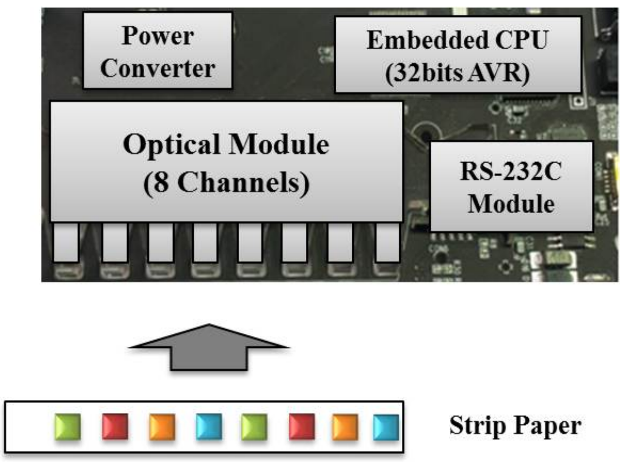
<Fig. 5> Conceptual design of the embedded system

Fig. 4.

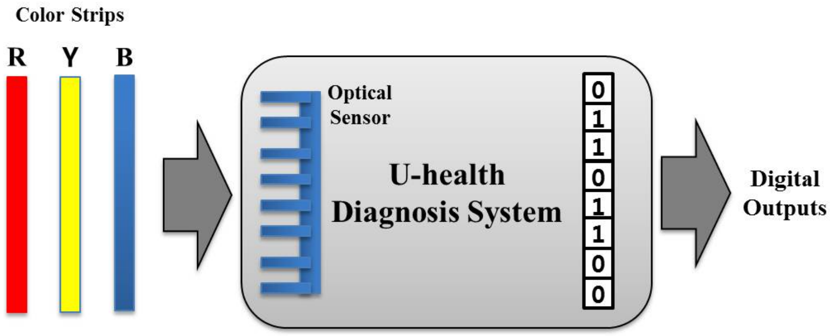
Embedded system illustrated in Fig. 5 contains an embedded software which controls light intensity, and processes the signals from AD converter through photo-diodes, and diagnoses a variety of diseases according to the predefined color values describing specific diseases. In the next Chapter, implementation issues are discussed for the proposed design results.

3. Implementation of the Proposed Design

Proposed design is implemented in a hardware as illustrated in Fig. 6. In the figure, a high-performance 32bit Atmel AVR system is applied to PCB-type circuitry as embedded system, as discussed in Chapter 2, which also supports low-power consumption. Optical module is comprised of the light generating system and the photo sensing system already explained in Chapter 2. The system supports 8 optical channels and there is a pair of an LED and a photo diode device for each channel. The system measures the diffused lights from the



<Fig. 6> Implemented hardware for the proposed system



<Fig. 7> Testing concept of measurement accuracy

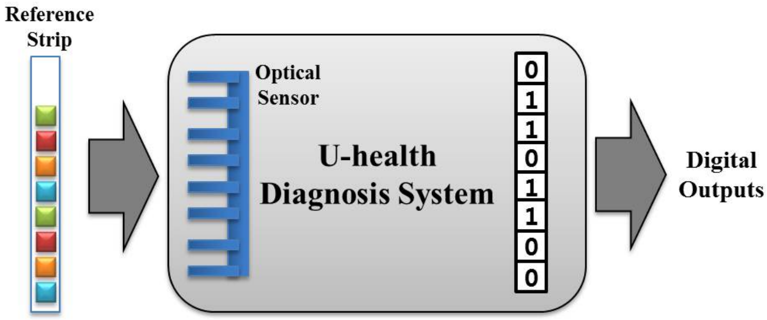
chemical reagent pads under LED lights and gives the chance to diagnose a variety of diseases according to the predefined color values on specific diseases. RS-232C module is prepared to communicate with a host computer for debugging and data processing.

4. Experimental Results

Two questions arise before applying the implemented system to real world. First, does the system exactly measure color values through each optical channel? Second, can the computerized system accurately diagnose diseases in considering any predefined color-coded diagnosing reference table? The first question is relevant to measurement accuracy while the second is related to diagnosis accuracy.

To deal with the measurement accuracy problem, three kinds of uni-colored strip such as R, Y, B are prepared and inserted into the optical sensor part as illustrated in Fig. 7. Because color reference values can be obtained for R, Y, B before testing, the measurement accuracy can be measured by comparing current reading color values with corresponding reference values for a specific color strip, which is one of R, Y, B strips. As a result, the measurement accuracy shows 95% in average. In optical availability, 8 channels are prepared for reagent pads. Low-power consumption technique enable for the system to endure about 7 days in power-on state. Finally, 500 cases of diagnosis information can be saved in memory block as summarized in Table 1.

For the case of diagnosis accuracy, current reading color values are compared with the predefined reference values of a specific disease for a specific reference color strip as illustrated



<Fig. 8> Testing concept of diagnosis accuracy

<Table 1> Overall system performance

Evaluation Items	Performance
Measurement Accuracy	95%
Optical Channels	8 Channels
Power-on Endurance Time	7 Days
Diagnosis Data Memorizing Size	500 Cases

in Fig. 8. For this, the reference color strip can be prepared by dipping it to the liquid which is a mixture of predefined chemical solutions. In this study a liquid is prepared as a reference in 50 RBC/ul for hemoglobinuria. As a result, the diagnosis accuracy measures 90% in accuracy.

For the comparison with the recent research, the diagnosis accuracy of the proposed system is compared with the result of CDSS-based system which is based on the clinical data supporting system[10]. The accuracy in the proposed system is higher than the CDSS-based system as summarized in Table 2.

5. Conclusions

In this study, a design scheme is proposed to construct a computerized diagnosis system of body fluid for u-health. The system is comprised of embedded system, light generating system and photo sensing system. The system measures the diffused lights from the chemical reagent pads under LED lights and diagnose a variety of diseases according to the predefined color values on specific diseases. The system is implemented as a real hardware and shows the measurement accuracy of 95% in reliability.

<Table 2> Comparison of diagnosis performance

Evaluation Item	CDSS-based System	Proposed System
Average diagnosis Accuracy	70%	90%

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