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Design of ISO/IEEE 11073 and HL7 Framework for Driver's Health Monitoring in Vehicles

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***Abstract*—Recently, thanks to the rapid development of computer convergence technology, driver monitoring system with various bionic sensor devices has become one of the most popular forms of technology to decrease the traffic accidents. In this paper, we present the issue of exploiting the driver's bionic data monitoring system by using ISO/IEEE 11073 and HL7 standard interfaces. The proposed system is based on the client and sever model, where the client agent encodes the health related data and server manager decodes the received message from the client. In order to gather the driver's health data, the client agent activates various bionic sensors which include not only personal social information but also height, weight, body temperature, SPO2, blood pressure and etc. Every sensor device is connected by configuring the wireless sensor network which is applicable to ZigBee or Bluetooth. After the health data is gathered in the remotely located database server, it can be monitored by doctors or therapists for further investigations.**

Keywords—IEEE/ISO 11073; HL7; Driver Monitoring; Bionic Sensors

I. INTRODUCTION

The driving monitoring system is one of the-state-of-the-art technologies for providing driver's safety in vehicle environments. The most representative monitoring methods include driver's inattention, distraction, fatigue and any other bionic abnormal conditions. By adopting these monitoring systems, most vehicle accidents can be significantly reduced up to 80% since many previous research works have reported that the most common cause of the traffic accidents is driver's distraction [1][2][3]. For the detection of driver's abnormal conditions, a lot of monitoring sensors and devices are developed to investigate not only the degrees of physical conditions (e.g. heart rate, body temperature, body motions, etc) but also mental recognition (e.g. Electroencephalography (EEG), Electrooculography (EOG), etc.) [2][3][4].

Since there is gradual increment of bionic sensor data for the health monitoring purposes with various data types, the monitoring systems are also required to have standardized documentations for efficient medical information management, easier integration and exchange between physicians and hospitals.

In this regard, ISO/IEEE 11073 PHD (Patient Health Data) [5] and HL7 standards [6] have been proposed in order to support healthcare informatics interoperability and compatibility. The ISO/IEEE 11073 protocol defines all aspects of communication interoperability and messaging procedures between healthcare devices and manager devices which is usually remotely located in the external server. When the gathered health related data is needed to be exchanged between medical entities such as hospitals or other physicians, HL7 protocol specifies a number of flexible standards, guidelines, and methodologies to transmit and receive the various types of bionic data.

In order to develop and implement these standards, several related systems are proposed. In [7], the authors present the possibilities of IEEE 1451 and HL7 protocols and implement a new message format for communicating data among medical sensors and actuators. The authors in [8] present a healthcare monitoring system with hierarchical network architecture in wireless sensor networks. However, these proposed systems do not highly consider driver and vehicle environments. In this paper, in order to support driver's health data management, we design and develop a new monitoring system based on ISO/IEEE 11073 and HL7 standards.

The rest of this paper is organized as follows. In section II, we describe the proposed system architecture in detail and the gathered bionic information of the driver is presented. Finally, we conclude the paper with concluding remarks in section III.

II. PROPOSED SYSTEM

We have developed both ISO/IEEE 11073 and HL7 standard interfaces for processing the driver's health related data in vehicle environments by using various bionic sensing devices such as body temperature, blood pressure, heart rate, SPO2 and etc. The conceptual design topology is illustrated in figure 1. In this figure, we assume that the driver is equipped with tiny sensor devices and the measured bionic data from the sensors is transmitted to another embedded device via the ISO/IEEE 11073 protocol. Then, the merged data is additionally encoded into HL7 messages and relayed to the remote server located in the hospital. Finally, the server decodes the received HL7 health messages for further analysis.

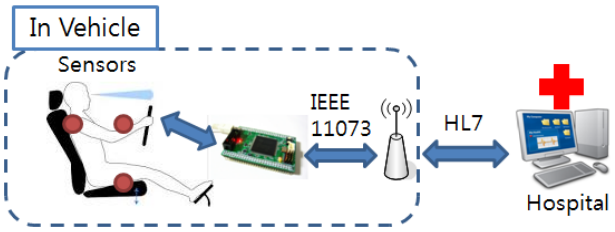

Figure 1. Conceptual topology

Figure 2 shows the detailed design layout of ISO/IEEE 11073 communication in proposed monitoring system. In this layout, the measured bionic data is transmitted to the integrated embedded device which is responsible for data aggregation through the channel access mechanism of wireless sensor network protocols such as ZigBee, Bluetooth, etc. We used Raspberry Pi platform [9] as the data aggregator and it is shown in figure 3. This platform supports Linux and the used kernel version of the developed system is 3.6.

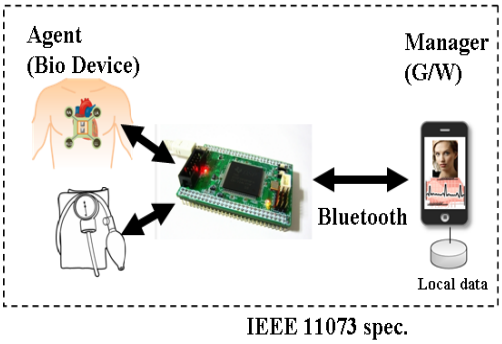

Figure 2. Layout of ISO/IEEE 11703

Figure 3. Raspberry Pi Agent device

When each bionic sensor around the driver starts to measure the health data, the aggregating device encodes the received data according to the IEEE 11073 standard which describes Associating, Configuring, Operating and Disassociating procedures.

After finishing the data aggregation, the measured data is maintained in the local database of mobile device which plays role as a gateway and manager agent for external devices and networks. We use an android based mobile phone as a gateway. Although this mobile gateway can process immediate data analysis for driver's condition, it does not provide further medical decision or diagnosis due to limited computing resources. Thus, in order to support the external communication between in-vehicle gateway and remotely located medical server, we also develop a HL7 interface based on client/server model, which is described in figure 4 and figure 5. For the compatibility of other database management software, we adopt Java platform and XML specifications. The HL7 standard basically defines user and patient admission message formats and observation message formats. Hence our proposed system also provides full compatibility with ATD_A01, ORU_R1 event messages for patient admissions and patient observation results, respectively. The ADT_A01 and ORU_R1 message structures are shown in table 1 and table 2, respectively.

Table 1. Message structure of ADT_A01

1: MSH (Message Header)
2: EVN (Event Type)
3: PID (Patient identification)
4: PD1 (patient additional demographic) optional
5: ROL (Role) optional repeating
6: NK1 (Next of kin / associated parties) optional repeating
7: PV1 (Patient visit)
8: PV2 (Patient visit - additional information) optional
9: ROL (Role) optional repeating
10: DB1 (Disability) optional repeating
...

Table 2. Message structure of ORU_R1

1: MSH (MESSAGE HEADER)
2: ORU_R01_PATIENT_RESULT (a Group object) repeating
3: DSC (CONTINUATION POINTER) optional

Once the driver's personal information (e.g. ID, name, etc.) is already registered in medical server, the measured bionic data from various sensor devices is captured and encoded into the HL7 standard message format by using the client module as shown in figure 4. The client module accepts examination date/time, height, weight, body temperature, blood pressure, heart rate, SPO2, and etc. These measured values are encapsulated in ORU_R1 messages (ORU_R01_PATIENT RESULT) as shown in table 2. Figure 5 shows the server module of the proposed HL7 interface, where the received messages are captured and decoded according to the HL7 parser. In addition, the server module also shows its status information and transmitted response messages such as acknowledgement packets. For the XML message support, the server also can provide a XML parser and the converted message is shown in figure 6.

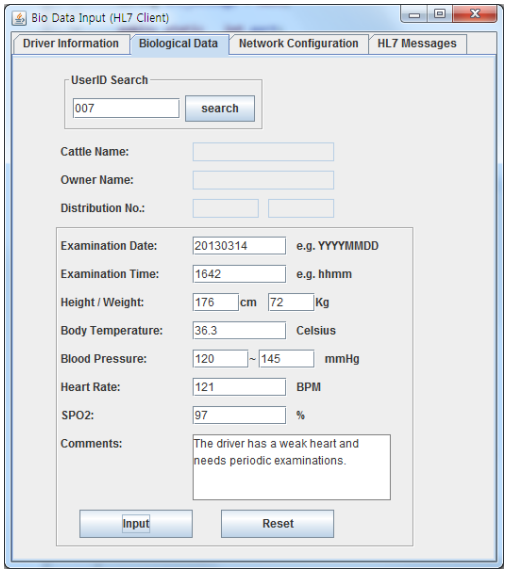

Figure 4. HL7 client module for data input

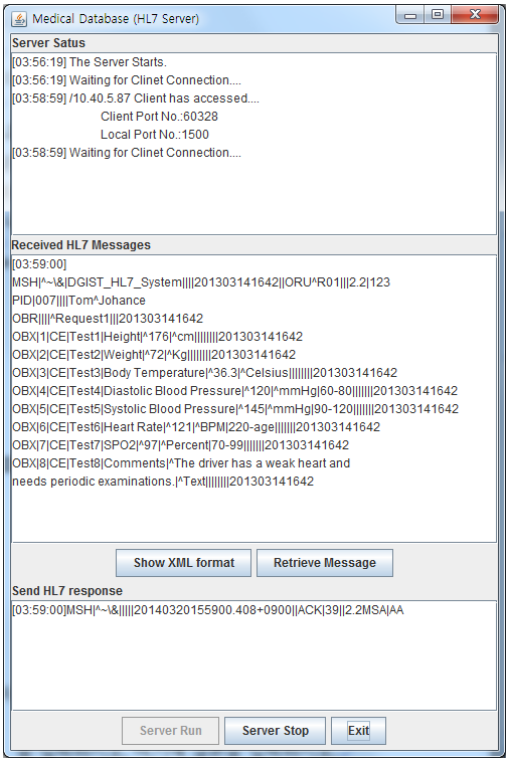

Figure 5. HL7 server module for data retrieval

III. CONCLUSION

In this paper, we design and develop a driver's bionic data monitoring system which is fully compatible with ISO/IEEE 11073 and HL7 standard protocols. The system can support various bionic sensor devices and transmit the measured data to remotely located server by using wireless networks. In addition, since the developed system support both Linux and Java platform, it can be easily adopted to not only PC environments but also any embedded devices. In future works, we plan to develop a reliable data analysis system for further medical diagnosis by improving the proposed system.

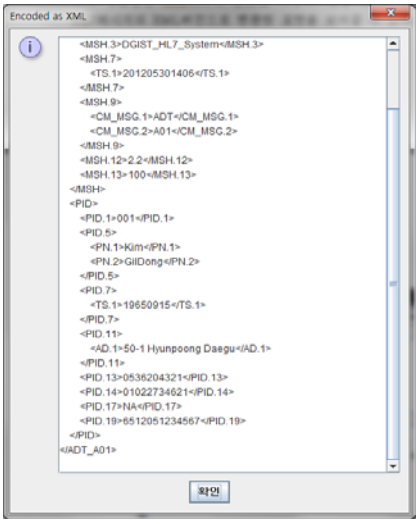

Figure 6. Converted XML messages

ACKNOWLEDGMENT

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