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LIVING SUPPORT SYSTEM CONSISTING OF IC CARD INTERFACE AND EMBEDDED SYSTEM

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Abstract. *This paper proposes a living support system consisting of an IC card interface and an embedded system. Our daily lives feature many electronic and information devices that make our lives simple and convenient. However, the handicapped and elderly are unable to use and operate such devices because of the numerous buttons and keys that characterize their respective controllers. Therefore, the interfaces of these devices should be simplified to provide easy access for the elderly and handicapped; several researchers and engineers have attempted to address this issue. In this study, we develop and propose an interface that controls and manages these devices using only IC cards. The study discusses the concept behind the driver software used for the reader and the microcomputer developed as part of this study; the processing speed of IC card detection is also evaluated. Finally, demonstrations are conducted to verify the efficacy of the IC card system for consumer devices.*
Keywords: IC card interface, Embedded system, FeliCa, Living support, Interrupt

1. **Introduction.** Many electronic and information devices such as vehicles, cell phones, and washing machines are available on the consumer market; these devices have made our day to day lives smart and convenient [1]. Most of the functions of these devices are realized by software programs running on microcomputers, which are known as "embedded systems" or "embedded technology". Further, such embedded systems are widely used and implemented in a large number of consumer devices [2]. Although the daily lives of most people have been dramatically improved by such devices, because of a lack of familiarity with such devices and difficulties caused by the existing interface characteristics, including the large number of buttons, elderly and handicapped people are unable to properly utilize and gain benefit from them.

An equally innovative technology in our daily lives is the IC card with a magnetic stripe and integrated circuit [3]. Until now, it has been introduced and spread as a means of identification for cash and credit card payments, and several NFC technologies are now dramatically progressing and evolving to become more convenient with the incorporation of integrated circuits and antennas [4]. For this reason, many scientists and engineers have focused on the IC/smart card and embedded technology, with a number of interfaces that take advantage of these having been proposed. In particular, the numbers of elderly single people and couples are now increasing, giving rise to the need for an interface that can be used easily and safely in a person's daily life. Therefore, there is a need to simplify the interfaces in order to ensure easy access for the elderly and handicapped.

Du and Tang proposed a web-based multi-level smart card that is characterized by being a single instance shared by all the users on a campus [5]. This method is superior in terms of the administration costs, in comparison with a conventional server/client system, and is also realized by using only a single instance. However, the system requires the design of a complex architecture. Therefore, the authors proposed that the system be developed as an embedded system, because such a system can be developed cheaply while providing high reliability. In contrast with conventional PC applications, there are numerous advantages of embedded systems, including their high reliability, low weight, low power consumption, and low cost. Therefore, we employ and use an embedded system, wherein the IC card serves as the remote controller and the embedded system handles the administration via network connections.

Feng et al. discussed the introduction of an IC card system to the student administration function of a university [6], and made a comparison with several kinds of standards in terms of the benefits provided. They discussed and investigated the comparisons in their paper. However, they did not introduce or construct an actual system or state whether they would further develop it after publication. The authors recognized the need for actual system development, in a way that would conform to any kind of standard.

The IC card has both confidential and non-confidential storage areas. The confidential area is administered by the FeliCa system developed by SONY Corporation, while the non-confidential area can be operated by individual vendors and users [7]. The most aggressive point of our proposed system is that the IC cards can be "smart", in that the electrical and information devices can learn and remember the final status and statics information in the memory of the IC card [8]. The authors focused on the reason for the need for control, such as the possession of intelligence. However, the control is not discussed in this paper as it will constitute the next step of our research.

Therefore, we are proposing a "living support system", which consists of an IC card interface and embedded system to implement intelligence, to assist the elderly and handicapped when operating consumer devices. The proposed system can safely control and administer consumer devices via network connections using only an IC card. First of all, we set out to implement a software driver between the microcomputer and the IC card reader. Therefore, first, we design and build the fundamental system of the IC card driver software, and subsequently, discuss the processing speed of the IC card detections of the system in practice.

The remainder of this paper is organized as follows. In Section 2, the concepts and ideas of the proposed system are discussed. In Section 3, we develop and implement the fundamental system for the IC card interface. Next, we discuss the processing speed of IC card detection and demonstrate the efficacy of the IC card system in controlling a television in Sections 4 and 5, respectively. Finally, concluding remarks and future work are discussed in Section 6.

2. Proposed Living Support System Consisting of an IC Card and Embedded System.

The elderly and handicapped face several challenges when operating consumer devices because of their lack of familiarity with the interfaces of devices such as TVs, air conditioners, and the keyboards of computers. Furthermore, they also face difficulties in the event of disasters such as earthquakes and large fires because they are unable to switch off devices in a timely manner. Therefore, in this study, the authors set out to improve the comfort and safety of the daily lives of the elderly and handicapped through their proposed living support system, which consists of an IC card interface that serves as a simple, remote controller and an embedded system for administrating the devices in a room and a house via network connections. Figure 1 shows the concept and outline of the living support system consisting of an IC card interface and an embedded system. The system has a microcomputer and an IC card reader; the microcomputer administers

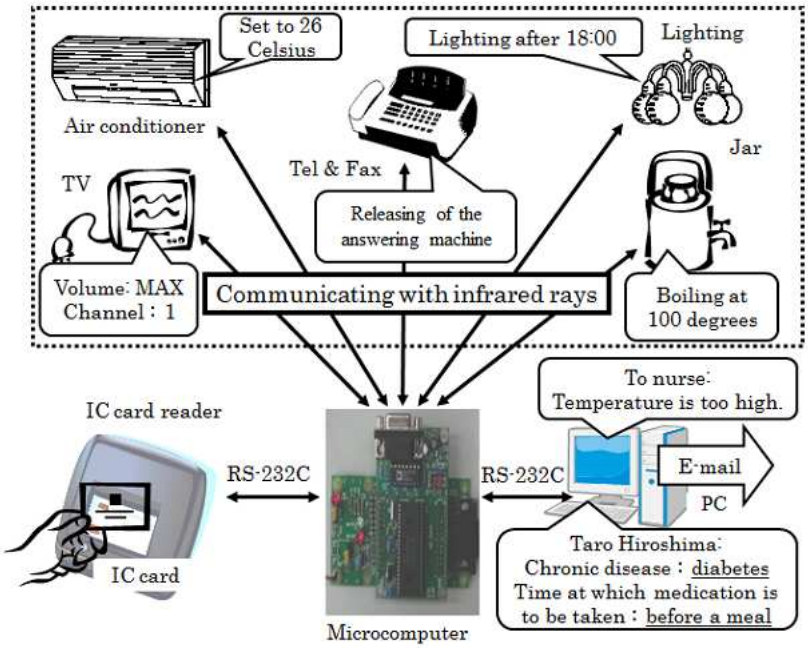
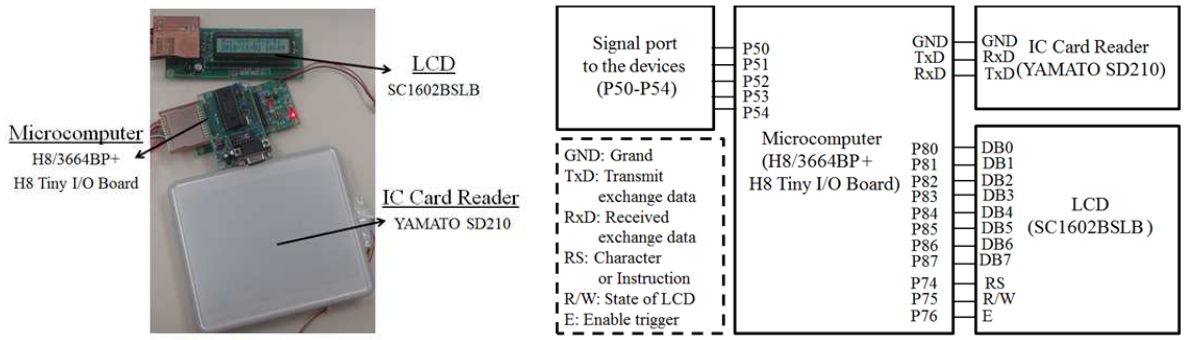


FIGURE 1. Proposed living support system consisting of IC card and embedded technology

and controls the devices and the IC card reader. In addition, for the IC card, we employ a FeliCa unit, produced by Sony Corporation and which is one of the most popular IC cards in the world, including Japan. However, the system can also accept other types of IC cards including Mifare. In the following, we discuss the system procedure required for IC card detection. First, the system initiates the connection between the microcomputer and the IC card reader when they are switched on; operation information and instruction data, such as the card ID in the memory of the microcomputer are compared with those in the IC card using the reader. Once the IC card is identified through the card ID, the system executes the instructions for controlling the devices. In addition, the system administers the safety and preferred living conditions in a house in the event of a disaster or an emergency; that is, the system executes the "turn off" instruction for all connected devices during disasters such as earthquakes, and large fires [9]. To further assist the user, the system implements an emergency function during a disaster, whereby an emergency status is sent to the user's family or career via e-mail [9]. In addition, the user's target devices become smart devices through the proposed method, as they are modified to recognize or identify a user through his/her card.

3. **Fundamental System for IC Card Reader and LCD Monitor.** As the first step towards developing a living support system, the authors designed the hardware layout for the proposed system consisting of a reader and an LCD monitor. Figure 2(a) shows an overview of the hardware components of the system, which consists of a microcomputer, reader, and LCD. The LCD indicates the card detection status such as the date, card name, and detection time. The microcomputer used in this study is Renesas Electronics H8/3664DIP [10], which is connected to the consumer devices through a tiny I/O board, which was procured from Akizuki Denshi, Japan [11]. Figure 2(b) shows the relationship between the I/O ports of the microcomputer. The IC card reader connected to the microcomputer is a YAMATO SD210 with an RS-232C interface, produced by Yamato Denshi Kogyo, Japan. The reader is typically intended for consumer PCs; therefore, to connect it to the microcomputer, we use RS-232C ports. Further, the SC1602BSLB LCD monitor,



(a) Overview of the fundamental system (b) Relationship of the I/O ports on the microcomputer

FIGURE 2. Relationship of microcomputer and IC card interface

produced by Oaks Electronics Corporation, Ltd., is connected to P8, and the controllers of the target devices are connected to P5 [12].

Next, the authors developed the driver for the microcomputer and the IC card reader; the driver is coded by C and built using the high-performance embedded workshop (HEW), which is produced by Renesas Electronics [13]. HEW consists of integration software, such as an editor, compiler, and monitor debugger, for the instruments of the embedded system.

In the following, we elaborate on the detailed system process. First, the system prepares the initial settings, stored in memory, for detecting the card instantly when the user switches on the microcomputer. Next, the system status is set to the card detection phase, which involves frequently running the card detection process with polling instructions. Finally, when the reader detects the card, the status is changed to the instruction phase, and the card number is identified based on the information in the memory of the microcomputer. And, the microcomputer executes the instructions, specific to the card, for each device through the P5 port that is connected to the target devices' wireless or radio controllers. The controllers used are universal remotes, which can store IR signal patterns in their memory; however, because of the presence of buttons and keys, and the connections through relay circuits, improvements are necessary to assist the target users. After implementing the necessary improvements, each device can be controlled easily through the proposed system. Figure 3 shows a demonstration of card detection; although the system is not connected to the target devices in this demonstration, the detection ability of the system is confirmed through the LCD monitors. Accordingly, the authors verified the efficacy of the driver software and confirmed that it operated in a way similar to that of PCs.

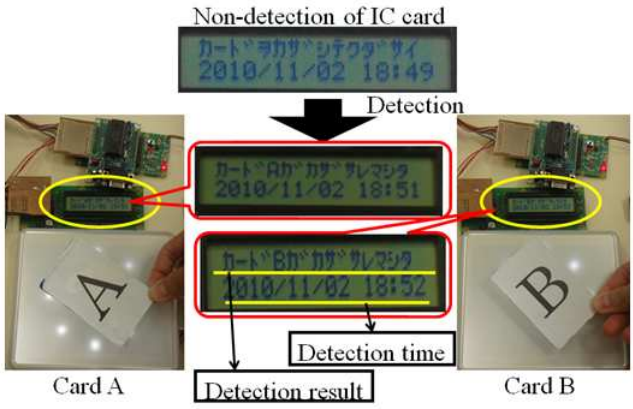


FIGURE 3. Demonstration of IC card detection

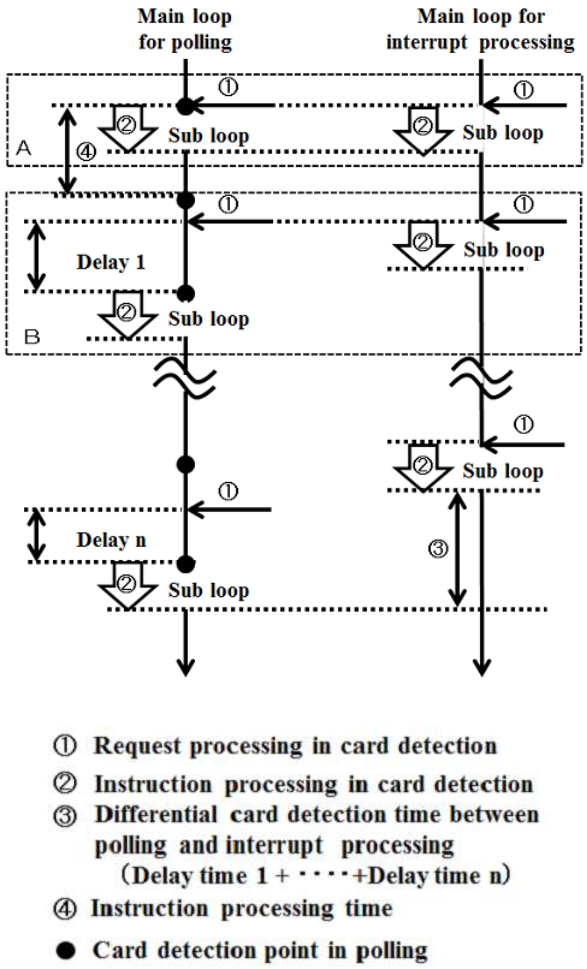


FIGURE 4. Comparison of processing method

4. **Improving the Processing Speed of IC Card Detection.** In the previous section, the authors demonstrated the efficacy of the fundamental system for IC card detection. The driver software implements polling for the card detection procedure because of its simplicity. It is expected that the processing speed can be enhanced by employing interrupt processing. Therefore, we compared the performance of the polling and interrupt processing to determine the better processing method. The difference in performance is examined to evaluate the efficacy. Figure 4 compares the performance of the polling and interrupt processing; the left-hand section is shown the polling while the right-hand section is shown the interrupt processing. In polling, the request process part of the card detection is called when the instruction request is received by the reader; however, the process does not begin during the card detection stage in polling processing. On the other hand, the instruction process in the interrupt processing is executed soon after the request process is received by the microcomputer. The processing speed is reduced when the number of lines of code in the software program is substantial; further, the delay in the polling also increases. As a result, the difference in polling and interrupt processing increases proportionally. The following times are measured to evaluate the differences.

- Card detection time
- Instruction processing time

Table 1 shows the instruction processing time for polling. The number of lines of code was minimal in the programs used in this experiment. Therefore, the improvement in the interrupt processing is only marginal. The card detection time is recorded from the

TABLE 1. Instruction processing time for polling

	Instruction process time [ms]
LED	0.015
LCD	1.700

TABLE 2. Card detection time

	Time [ms]	
	LED	LCD
Polling	48.0	1580.0
Interrupt	47.5	1540.0
Differential	0.5	40.0

start of card detection by the reader until the end of the instruction process by the microcomputer. Table 2 lists the card detection time when the difference calculated is the total of each delay. The time required for a system using LEDs is about 50 ms, while that for a system with an LCD is about 1,600 ms, regardless of the method. However, the instruction settings between them require much more time to send and receive frequent communications [12]. As shown in Table 2, the time required is improved because of the interrupt processing; therefore, the system can work faster through the adoption of this processing. Although it is only little improvement, the benefit is dramatically contributing the complex operations when the system orders and administrates the many devices as slaves.

5. **Demonstration of IC Card Operation.** Finally, to verify the efficacy of the proposed method, we demonstrate the IC card operation for a universal remote used to operate a TV. The instructions for controlling the television are stored in the memory of the microcomputer; this information is fetched when matched against the appropriate card ID and instructions. Figure 5 shows a demonstration of the IC card operation when controlling the television. In the demonstration, the ID is obtained for the card, and matched against the card ID in the memory. Next, the instructions related to the card ID are called and executed. Using this process, the television conforms to the instructions and operates correctly, as shown in Figure 5.

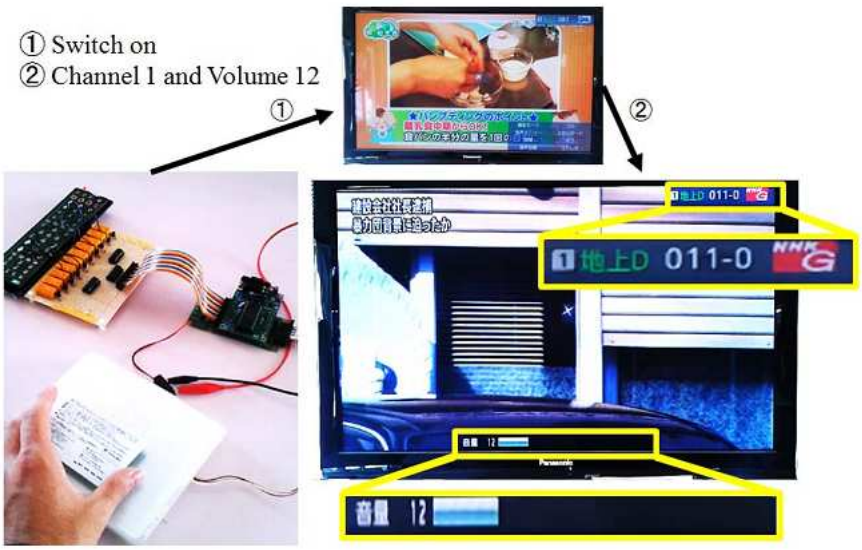


FIGURE 5. Demonstration of IC card operation

6. **Conclusions and Future Work.** In this study, we proposed and developed a living support system consisting of an IC card interface and embedded system to assist the elderly and handicapped. Moreover, we discussed the concept of the proposed system in detail. Through experiments, the efficacy of the proposed system is verified and it is confirmed that the system can identify a specific card and execute related card instructions. Further, we also improved the processing speed of card detection by replacing simple polling processing with interrupt processing. In the future, we plan to build a practical system for living spaces such as houses.

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