# Development of an Internet of Things System for Measuring the Direction of Use of Body Pressure Dispersion Cushions using Radio Frequency Identifier

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Abstract: Pressure ulcer prevention guidelines recommend repositioning within 4 hours. For encouraging implementation, IoT technology was used to design a pressure distribution cushion with an embedded radio frequency identifier (RFID) tag and a prototype Android smartphone application to read the tag. As a result of the RFID tag reading experiment, 83% without blanket and 13% with blanket could read the correct posture successfully. In addition, the position was correctly read by the system. With this prototype, the body position could be detected appropriately.

## 1 INTRODUCTION

Prevention of pressure ulcers as part of long-term nursing care is extremely important in ensuring the quality of life of the elderly. It has various precautionary measures; one of them is pressure dispersal, which is crucial. Pressure ulcer prevention guidelines recommend that postural change be performed every 4 hours or less (The Japanese Society of Pressure Ulcers Guideline Revision Committee, 2016).

For the proper distribution of body pressure, the date and time of the postural change and the person performing the postural change should be recorded as accurately as possible. The use of ICT to prevent pressure ulcers has been extensively investigated. Several studies perform the following: (1) Detecting pressure ulcer risk factors using electronic medical record data and communicating them to nurses (Park, 2019) (Davidson, 2019), (2) Gathering information on pressure ulcer occurrence and using it as an index for quality evaluation.

In recent years, with the spread of machine learning, research integrating (1) and (2) have been attempted (Cramer, 2019). Thus, pressure ulcer prevention based on data is progressing.

Meanwhile, only few research use such information technology for body pressure distribution, which is a more basic means of preventing pressure ulcers. The reason is that postural variance is excessively analogous and requires less ICT participation.

Therefore, from the viewpoint of the Internet of things (IoT), we report on the development of a system that implants an IC chip in a postural change cushion and enables detection and recording of the postural position.

## 2 METHODS

### 2.1 Aim for Development

We aimed to develop this system to be able to automatically record the position, date, and time of the position change, and the nurse who performed the position change. Hence, we have developed a postural change cushion with an embedded IC chip.

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### 2.2 Design of the Body Pressure Partial Pressure Cushion

The body pressure distribution mattress has a structure in which a scapula is lifted to distribute the weight of a patient. The angle at which the scapula is lifted is 30°, so the cross section of the mattress is a right triangle of 30°-60°–90°.

Therefore, we could specify whether the patient was in the right or in the left lateral position according to the base of the right triangle, which is either above, or below the body. To specify such position, we assigned a function in radio frequency identifier (RFID).

The performance and position of the RFID tag were designed so as not to affect the abovementioned positional relationship.

### 2.3 Design of the Position Detection System

The information system for reading the body pressure dispersion cushion with the RFID tag was designed for Android.

At present, according to reviews in other clinical fields, many mobile terminals used for observing symptoms are for Android smartphones (Choi, 2018). Hence, the environment used by the authors for design was Android, and the software used for reading the IC chip was a highly versatile middleware.

### 2.4 Method for Evaluating the Prototype of This System

For this prototype of the body pressure dispersion cushion and the body position detection system, we constructed a sleeping environment virtually. The validity of reading the IC chip and the absence of malfunction were verified.

Considering that this verification is performed in a virtual environment, government approval based on the Pharmaceutical Machinery Act or approval of the ethics committee at the university is unnecessary.

## 3 RESULTS

### 3.1 Outline of the Newly Developed Body Pressure Dispersion Cushion and Body Position Detection System

The body pressure dispersion cushion was made of urethane sponge, and its length was 40 cm. The cross section was a right triangle, with the hypotenuse at the bottom. RFID tags were attached to both ends of the cross section. This RFID tag measured 22 mm in diameter and 0.6 mm in thickness (Figure 1).

The format of the RFID tag is NTAG213, which is a 13.56 MHz-band passive tag. An RFID tag of this standard has an effective distance of 10 cm, with 144 bytes of user memory.

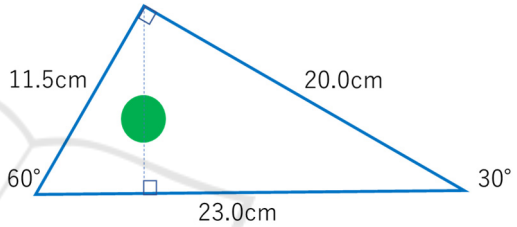


Figure 1: Cross section of the body pressure dispersion cushion (circle in the center represents the RFID tag).

The reading system employs a general-purpose RFID tag reading system that runs on an Android smartphone; when a user touches a tag attached to a cushion, the body position is displayed in a pop-up (Figure 2).

### 3.2 Reading Result of the RFID Tag Attached to the Cushion

We placed the humanoid model in the right lateral recumbent position and inserted a body pressure dispersion cushion equipped with an RFID tag to maintain this posture.

In this environment, the RFID tag on the head (written information: postural change to the right recumbent position) was read in an environment without a blanket. Consequently, 25 out of 30 trials (83%) were correctly read.

When a similar reading test was performed with a blanket placed on the humanoid model, reading was successful only four times (13%) and failed 26 times (87%).

In both situations with and without a blanket, the RFID tag placed on the foot (written information: repositioning to the left lateral position) was never read by mistake (Table 1).

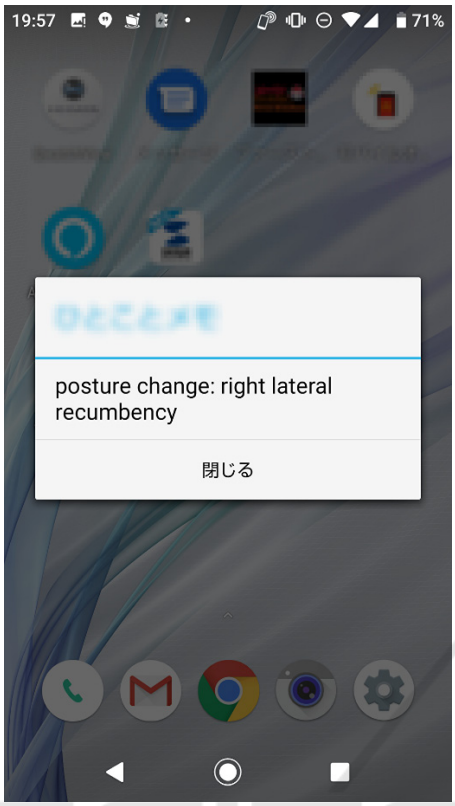


Figure 2: Pop-up screen when reading an RFID tag attached to a cushion with Android smartphone.

Table 1: Success rate of reading an RFID tag attached to a cushion (number of trials: 30).

| | Head side tag | Foot side tag |
|---|---|---|
| Without blanket | 25 (83%) | 0 (0%) |
| With blanket | 4 (13%) | 0 (0%) |

# 4 DISCUSSION

## 4.1 Availability of the Position Detection System

This system is the first to record postural change using IoT technology for postural dispersal cushions among bedridden patients.

In a virtual environment experiment using a humanoid model, reading can be possibly correct 80% of the time in an environment without blankets. This percentage may be insufficient, but at least, false readings may not occur in general.

Conversely, when a blanket was used, the reading success rate decreased to approximately 10%. Peeling off the blanket is indispensable to perform the repositioning; however, this reading success rate is appropriate for a system that records the proper performance of repositioning.

Next, the validity of the RFID tag is considered. Regarding NTAG213 (ISO14443 type-A) used this time, related literature cannot be found in PubMed. Therefore, comparing it with other cases is difficult, but it is still appropriate because of the absence of false reading of RFID in this experiment. Given that the effective distance of NTAG213 is approximately 100 mm, the tag of the foot is not read when reading the tag of the head.

According to a previous study of pressure ulcer prevention using IoT technology, a device can detect excessive body pressure by attaching it at the center of a wheelchair (Tavares C, 2019).

I have no intention to deny such a sophisticated body pressure detection tool. However, extremely simple tools, such as those proposed herein, are also useful, and we suggest that they will be used for pressure ulcer prevention.

## 4.2 Considerations for Implementing a Posture Detection System

This system is the first to record postural change using the IoT technology for postural dispersal cushions in bedridden patients.

In this experiment, we only developed a postural change cushion equipped with an RFID tag, and we verified the effectiveness of reading by using a general-purpose software. To implement this system in an electronic medical record system or the like, we need to consider a message format.

Thus, we will discuss the message format by using the Master of Nursing terms certified by the Ministry of Health, Labor, and Welfare of Japan. This master consists of nursing observation and nursing action, both of which have the expressions “right side supine” and “left side supine.”

In any case, the information to be written to the RFID tag is either “right side supine” or “left side supine,” and this master can express it with one code. Therefore, in this study, we leave judgment on whether to use the Master of Nursing observation or nursing action. Hence, writing a code that specifies left and right on the RFID chip is necessary, so that it can be used for three-point authentication (Figure 3).

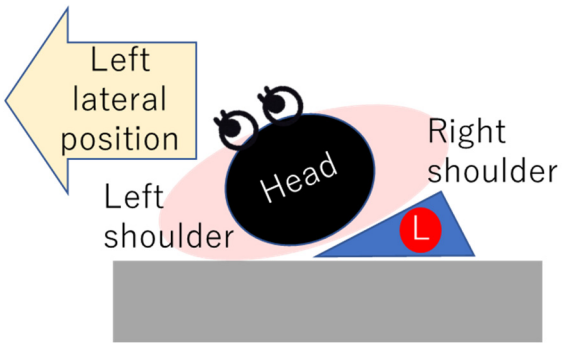


Figure 3: Image of an RFID tag with left side-lying information (L symbol).

## 5 CONCLUSIONS

In this study, a prototype of a postural change cushion and a reading system using the IoT technology were developed to accurately record postural changes necessary for pressure ulcer prevention.

By devising the effective range of the RFID tag, we verified that constructing a system that enables position detection is possible. The developed system can also be applied to other nursing situations. For example, the date, and time of changing clothes can be recorded by attaching an RFID tag to a hospital garment. We will continue to consider various uses.

This model has been registered as a utility model in Japan (registration number:3225058) by Japan Patent Office.

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