Monitoring Safety and Security from Below

—*Sensing a person's presence using RFID*—

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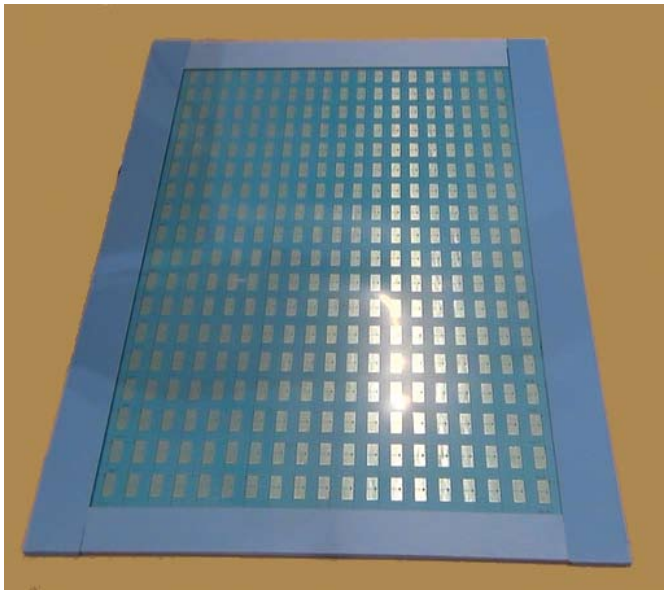
1. Introduction

The aging of populations is currently a worldwide trend. In countries belonging to the Organisation for Economic Co-operation and Development (OECD), the average of the old age support rate, which is the ratio of those in a population aged 20–64 (working age) to those aged 65 and over, has been predicted* to decrease from 4.2 to 2.1 between 2008 and 2050. Reducing the resulting burden on those of the working age is an urgent issue. Watching over the elderly all day long imposes a particularly high burden. Therefore, information and communication technology (ICT) for social care and safety monitoring is becoming more and more essential.

In terms of monitoring people, many approaches based on video camera analysis have been proposed, including intruder detection in a restricted area, trajectory extraction of a shopper in a store, safety monitoring for elderly people, and others. However, there are problems with the video-based approach. A camera has blind spots where persons cannot be seen due to being hidden by other persons or obstacles. For example, a child in a crowd of adults can hardly be seen from a camera. Moreover, camera usage is strictly restricted due to privacy issues in some locations such as restrooms and hospital rooms.

Unlike a video camera, which watches you from above, we propose monitoring safety and security from below. We have developed a practical sheet-type sensor to realize this idea and mitigate the problems facing the video-based approach.

Figure 1: Developed sheet-type sensor. RFID tags are aligned in a grid as sensor nodes.



2. Features of the proposed sheet-type sensor

Monitoring persons without video cameras can be achieved by detecting the footprints of individuals who stand on a sheet-type sensor installed on the floor. This solves the privacy problem because it senses only footprints within several centimeters above the floor. It also becomes possible to detect the existence of persons correctly even in a crowded situation because feet never overlap each other.

Conventionally, sheet-type sensors have not been practical, for two reasons. One, it is too expensive for conventional sheet-type

Figure 2: Sheet-type sensor covered with ordinary vinyl flooring material.

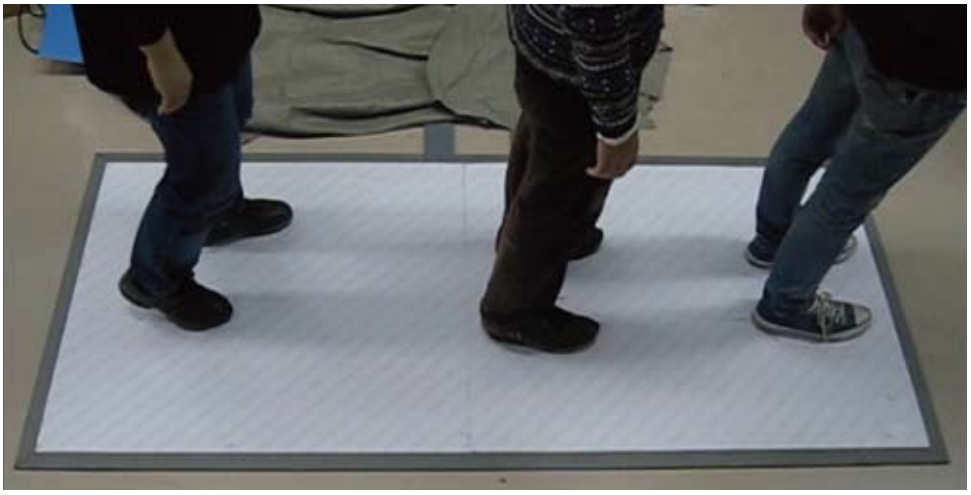
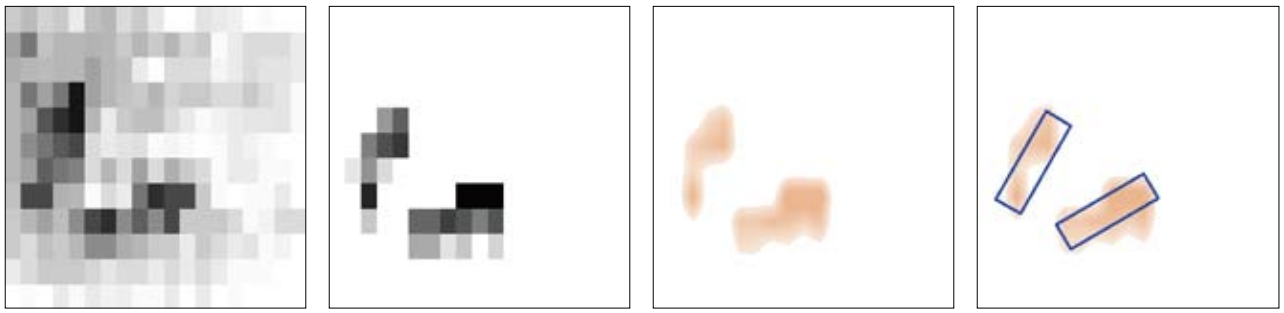


Figure 3: Data flow in footprint detection processing.



(a) Sensor output (b) Normalized data (c) Restored shape (d) Detected footprints

sensors such as an array of pressure sensors to be spread all over the floor, and two, the sensors are not stiff enough to withstand the load of the cane or heels of a walking person.

Our proposed sheet-type sensor can be used practically for the following two reasons: (1) production cost can be minimized by utilizing inexpensive radio frequency identifier (RFID) tags as sensor nodes, as shown in Figure 1, and (2) practical endurance can be achieved by installing sensors beneath ordinary flooring materials with normal stiffness while still maintaining radio wave detection, as shown in Figure 2.

The new sheet-type sensor has a simple composition: RFID readers, wires as antennas, and passive RFID tags as sensor nodes. The RFID reader activates the passive RFID tags and receives signals from each tag through the antenna. The signal strength of a tag changes when an object with high dielectric constants (such as a foot) comes close to the tag due to increased parasitic inductance or stray capacitance. By analyzing the signal changes of all tags, the existence of a foot on the tags can be detected.

3. Person presence sensing system

We also developed a person presence sensing system with our new sensor to identify the shape and direction of footprints. We apply signal and image processing techniques to solve the two primary weak points of the sensor, which are; variation of signal strength and low spatial resolution.

Figures 3(a)–(d) show an example of the data flow in the footprint detection processing.

The output signal strength of the sensor when two feet are on the sheet is visualized in Figure 3(a). It is quite difficult even for human eyes to recognize the existence of the two feet because of the variation of signal strength caused by the nature of the radio waves and the low resolution of the sheet-type sensor. By normalizing the variability of the signal strength, the sensor output can be corrected, as shown in Figure 3(b). Then it becomes possible to restore the footprint shapes, as shown in Figure 3(c), by applying spatial interpolation with the relationship between signal strength and the cover ratio of the object over the tag. Finally, each footprint can be extracted along with its direction, as shown in Figure 3(d). In this way, persons walking over the sensor can be monitored without any privacy issues because individuals cannot be identified only from the footprint shapes.

4. Future work

We argue that perceiving a person's presence while maintaining privacy is becoming increasingly important for people to live comfortably in both the public and private spheres. Our proposed sheet-type sensor is a type of technology that fulfills this requirement, and from now we intend to perform further experiments on its practical use.

* http://www.oecd.org/berlin/47570029.pdf

Cover Art

Fuji sanjurokkei Zoshigaya Fujimi chaya
(The Teahouse with the View of Mt. Fuji at Zoshigaya, from the series 36 Views of Mt. Fuji.)

Utagawa Hiroshige (1797-1858)

Woodblock print:
Courtesy of Sakai Kokodo Gallery