MAGIC-Surfaces: Prototyping Location-aware Smart Building Materials

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1. Introduction

One attractive application of pervasive computing is a smart space that supports human activity through embedded computer networks and sensors. However, to provide various rich services, almost all smart spaces should have custom-made sensing devices. As a result, constructed smart spaces require high building cost. In order to reduce the cost, we believe that it is necessary to make building materials smart. From this point of view, we have researched how to make such smart building materials. As one approach to this challenge, we propose "MAGIC-Surfaces" that can provide short-range wireless network connectivity as well as location and orientation detection based on a magnetic method.

2. MAGIC-Surfaces

Figure 1 shows the system architecture of MAGIC-Surfaces. A MAGIC-Surface consists of an array of small magnetic communication devices. Each device has a microcoil and an electronic compass. The microcoil produces a magnetic field and is used as a transmitter. The electronic compass detects both the magnitude and direction of the magnetic field. Magnetic communication between the MAGIC-Surface and a movable d evice is provided by using a data modulated magnetic field.

The location and orientation of the movable device are determined based on the theory of magnetic dipoles [1][2]. By measuring outputs of three or more electronic compasses, we can determine the location and orientation of the coil based on Newton's method.

3. Experimentation

In order to proof the concept of MAGIC-Surfaces, we implemented a prototype system as shown in Figure 2. We measured the accuracy of the localization and the orientation detection. The result showed that we could determine the location of the coil with an accuracy of 5 mm and the orientation of the coil with an accuracy of 5 degrees or less. Note that we also confirmed that the level of the received signal at each electronic compass is sufficient for magnetic communication.

4. Summary

We proposed MAGIC-surfaces for the easy and low cost construction of smart spaces. Based on a magnetic method, the device can provide bi-directional communication as well as location and orientation estimation for indoor objects. An initial experimentation showed that our device could determine location and orientation with an accuracy of about 5 mm and 5 degrees, respectively.

References

[1] F. Raab, et al., "Magnetic Position and Orientation Tracking System," IEEE Transaction on Aerospace and Electronic Systems, vol. 15, no.5, 1979
[2] M. Minami, et al., "MAGIC-Surfaces: Magnetically Interfaced Surfaces for Smart Space Applications," In Adjunct Proceedings of the 3rd International Conference on Pervasive Computing (Pervasive 2005), Munich, Germany, May 2005.
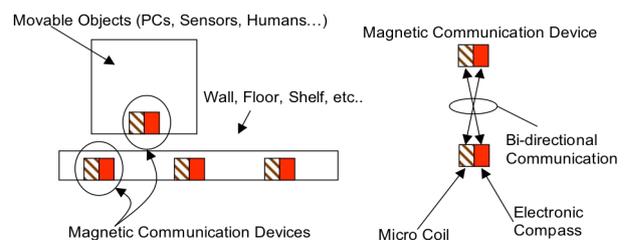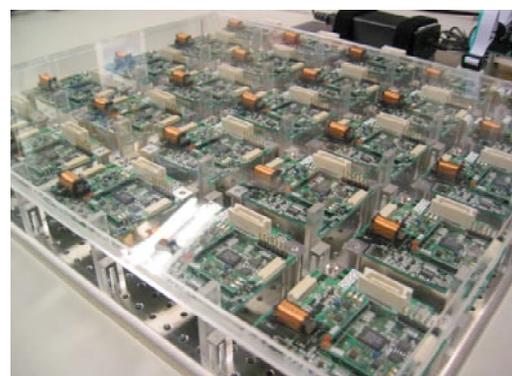

Fig. 1: System Architecture

Fig. 2: Prototype Implementation