Node Self–Localization in the ”Two–Dimensional Communication” Networks

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1 Introduction

Our group has proposed the Two–Dimensional Communication sheet (2DC sheet) [Shinoda et al. 2007] for ubiquitous communication. On the 2DC sheet, ubiquitous nodes can communicate with each other and acquire electricity anywhere on the sheet without any direct electrical connections to it. The sheet structure is simple and the power and signal are transmitted with microwaves. Thus, this technology achieves wireless and batteryless ubiquitous infrastructures.

Here, in this paper, we propose a method to identify the positions and orientations of the nodes distributed on the 2DC sheet. The detection is based on the measurement of the electric field on the sheet surface. Our localization function makes it easy to install and maintain sensor nodes in a large network. In addition, it provides location–specific functions to various network devices placed on the sheet.

2 Approach

Our method was inspired by a pen–positioning system by Anoto [Anoto]. Anoto's pen identifies its position on a special paper by capturing the fine pattern printed on the paper with an optical device embedded into the pen. The printed pattern at each location is unique so that the pen can identify the location. We use electric field patterns as the location signs.

The 2DC sheet has three layers. Two conductive layers sandwich the dielectric layer. Microwaves for communication and power supply can propagate in the dielectric layer. The top conductive layer has a meshed structure which forms an evanescent wave immediately above the surface of the sheet. Thus, sensor nodes on the sheet can communicate and acquire electricity through the proximal connection to this evanescent wave. The two–dimensional amplitude pattern of the evanescent wave depends on the mesh shape of the top conductive layer. In our new design, the mesh structure has two types of elementary patterns (blocks) that express on bit information, and multiple contiguous blocks represent Cartesian coordinate values. An electric field sensor attached to a node measures the location–specific evanescent pattern and determines its position and orientation.

One of the features of our method is self–localization. This means our method needs no external devices like cameras. With only an electric field sensor attached to a node and a small modification to the existing 2DC sheet, the nodes can easily obtain precise position to an accuracy of 1 mm. In addition, thin obstacles like a piece of paper can be placed between the 2DC sheet and the sensor node.

3 Conclusion and Future Work

This paper proposed a novel method for node self–localization in the Two–Dimensional Communication networks.

Based on our approach, we have designed the effective code on the 2DC sheet using two types of elementary patterns which represents

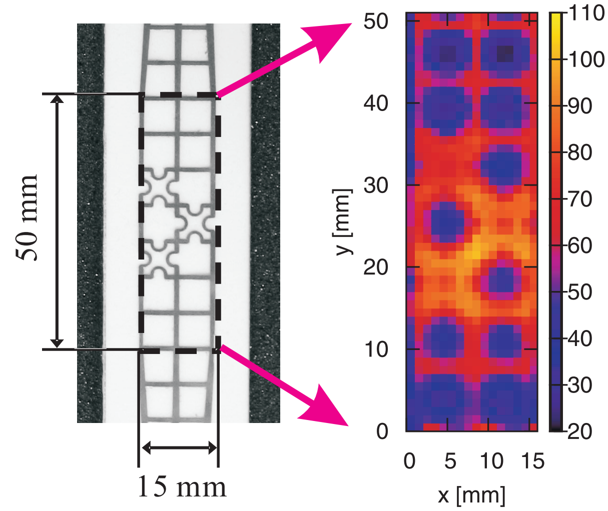

Figure 1: The setup and result of the fundamental experiment are shown. The left side picture is the prototype 2DC sheet. It includes both marked and plain blocks. In the measurement area shown in the picture, we measured the vertical component of electric field 1 mm above the sheet surface with a 1 mm interval. The result is plotted on the right side. The pattern of marked and plain blocks is clearly represented. The result suggests that we can also detect the position code pattern on a 2DC sheet with a practical electric field sensor.

one bit of information. The simulation results suggest that the modulation of the electric field above the 2DC sheet is effective enough to be measured, and the influence to the communication and power supply properties caused by this modification of the 2DC sheet is negligible. Furthermore, we succeeded in reading the desired electric field pattern using the sensor and 2DC sheet implemented for the fundamental experiments.

Based on these results, we are currently developing a prototype model. In the future, we will try to build sensor network systems in order to confirm the usability of the proposed model. In addition, we will also implement location–based applications using the feature that the node obtains the power, signal and position simultaneously.

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