Toward a Compact Device to Interact with a Capacitive Touch Screen

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ABSTRACT

Capacitive touch screens are widely used in various products. Touch screens have an advantage that an input system and output system can be integrated into a single module. We consider this advantage could make it possible to realize a new universal interface for both human-to-machine (H2M) and machine-to-machine (M2M). For a M2M interface, some sort of method to simulate finger touching is needed. Therefore, we propose an alternative method to interact with a touch screen using two electrical approaches. Our proposal is effective in automating touch screen operations, modality conversion device for people with disabilities, and so on. We assembled a prototype to confirm the principle to control a touch screen with the electrical methods. We believe that our proposal will complement the weakness of touch screens and expand their possibility.

Author Keywords

touch screen; supportive user interface; M2M by H2M

ACM Classification Keywords

H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous

INTRODUCTION

Capacitive touch screens [3] are widely used in various products such as smart phones, digital cameras, home appliances, industrial equipments, and car consoles. Thanks to their flexibility such as easy to change their appearance (virtual buttons, on-screen keyboard, and so on), they could replace many conventional physical interface devices.

Though a touch screen can display its contents and functions corresponding to the contexts, it is still difficult to meet special needs: some constraints on fingers, further improvements on efficiency, connecting touch screens with other devices directly, and so on. Kato and et. al. proposed a method to convert simple finger movements to complex touch inputs on a touch screen just by attaching a transparent conductive film [2]. However, the research by Kato and et. al. still needs finger touching. On the other hand, touch screens have an advantage that an input system and output system can be integrated into a single module. We consider this advantage could make it possible to realize a new universal interface for both human-to-machine (H2M) and machine-to-machine (M2M).

Therefore, we propose an alternative method to interact with a touch screen without fingers (we call this interaction quasi-touch). Our approach is one methodology to realize supportive user interfaces [1]. Some test equipment manufacturers produce inspecting machines to check that a touch screen device responds correctly to touch inputs using robot hands, which needs a relatively large footprint. To solve this problem, we employed two electrical approaches to realize quasi-touch: resistance control method and capacitance sensor control method, which only need small space. This scale factor expands the potential of our alternative method significantly.

In this paper, we describe our final goal and use cases at first, then explain how quasi-touch works and a prototype as proof-of-concept. Then we conclude.

GOAL AND USE CASES

Though the key technology in this paper is how to realize quasi-touch, we would like to describe the final goal of this research. Our final goal is to develop a device which has "vision" to understand the contents of a screen and have the capability of "quasi-touch" to control a touch screen instead of fingers. It might be necessary to have some communication capability, program storage, an audio interface, and/or other I/O devices depending on the application.

Figure 1 shows the appearance of the devices. A quasi-touch unit is located in the bottom of a device (Figure 1(a)) or in the L-shaped solid ((Figure 1(b)). The next section explains how the latter can control the touch screen.

(a) Full cover type (b) L-shaped type

Figure 1. Devices to Meet Our Final Goal: (a) A quasi-touch unit and an image sensor are enclosed in the bottom. (b) A quasi-touch unit is located in L-shape unit and a camera is fixed on the edge.

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Automation
The proposed device automates touch operation sequences by associating pattern matching with touch operations (i.e. if icon A appears, then touch it). It is useful to control applications without any automation script functionality.

Remote Controller
In home appliances such as digital cameras, conventional remote controllers need special software on the main body side. The proposed device enables home appliances to be controlled remotely if those home appliances have a touch screen.

Data Importer and Exporter
Some cloud-based consumer services do not have data importing and exporting functions. The proposed device can operate any application and import data through a screen. It actively works on an application by selecting menu items and scrolling, and then recognizes data using the OCR.

Modality Conversion
The proposed device recognizes the contents on a touch screen and converts them into voice or braille. Then, it recognizes user inputs and converts them into touch inputs. Using this device, we can change ordinary products to those usable for people with disabilities. Tactile touch screens have also been studied by a lot of researchers but they must be embedded into individual products.

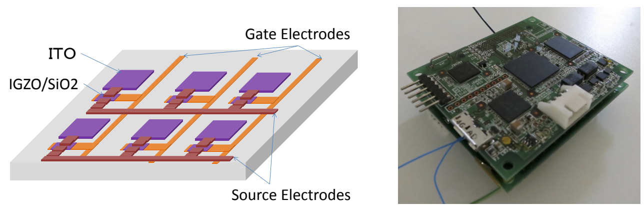
ELECTRICAL APPROACHES FOR QUASI-TOUCH
Capacitive sensing touch screens detect capacitance changes by finger touching, which causes the movements of electrical charges. To reproduce this phenomenon without real fingers, some mechanism is required.

One approach is to cause the movement of electrical charges directly on the surface by contacting semiconductor switches. We call this approach resistance control method, which is suitable for the design of Figure 1(a). Another approach is to deceive capacitive sensors by giving AC signals from the outside. By generating AC signals carefully, "touch" can be simulated at any point. It is not necessary to contact a probe physically at the point of quasi-touch. We call this approach capacitive sensor control method, which is suitable for the design of Figure 1(b).

Resistance Control Method
We used a variable resistance matrix to drain electrical charges on a specified point onto the ground. For such a matrix, we developed a semiconductor device with IGZO-TFT (Figure 2(a)) which changes resistance between 100kΩ to several G Ω. We employed ITO to form the electrical circuits on the contact surface to make the wiring of the device as short as possible in order to decrease its host capacitance.

Capacitive Sensor Control Method
Typical mutual capacitance touch screens scan the surface to detect touch points. The control IC of touch screens emits the pulses to drive switched-capacitance-filters (SCF) on the electrodes of "drive" axis sequentially and capacitive sensors measure the changes in capacitance on the "sensing" axis.

The basic principle of this method is to make the voltage of the capacitive sensors lower enough at appropriate timings by giving AC signals from the outside, because a time difference from the beginning of each scanning cycle corresponds to a position of touch. As a simplified configuration, we developed a scan sampler/signal emitter (Figure 2(b)). In input mode, it records scan signals by attaching the antenna probes on the surface. Scan signals are recorded at each point to touch in advance. Then it emits AC signals corresponding to a specified touch position with synchronizing the scanning cycle. Such an AC signal is processed (e.g. reversing phase) from the recorded one corresponding to the position.



(a) Structure of Variable Resistance Matrix (b) Scan Sampler/Signal Emitter

Figure 2. Prototype for Quasi-Touch

EXPERIMENT ON A SMART DEVICE
We assembled another prototype to automate touch operations on a smart device. This prototype consists of three antenna probes, emitters, control circuits, and an Arduino board. We attached this prototype onto iPhone 5 and confirmed that it generated quasi-touch signals at three positions, successfully invoked an application, and then went back to the home screen. Please note that the on-screen home button can be used by enabling the assistive touch option in iOS.

CONCLUSION
We proposed an alternative method to interact with a capacitive touch screen to meet special needs and extend its use to M2M interface. We believe that our proposal will complement the weakness of touch screens and expand their possibility. In the next step, we will develop the device to realize the use cases described in this paper.

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