Tangential Force Input for Touch Panels Using Bezel-Aligned Elastic Pillars and a Transparent Sheet

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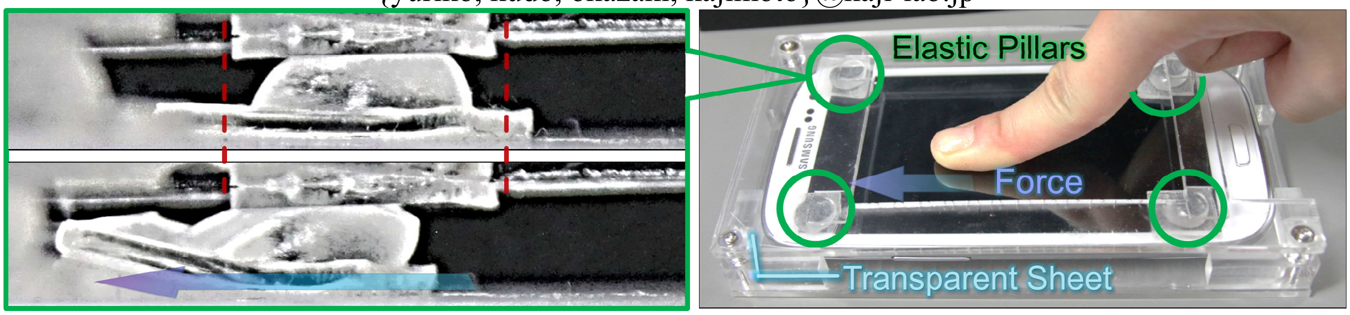

Figure 1 Appearance of the new structure enables tangential force input for touch panel

ABSTRACT
This research aims to enable tangential force input for touch panels by measuring the tangential force. The system is composed of a plastic sheet on a touch panel, urethane pillars on the panel that are aligned at the four corners of the bezel, and a case on top of the pillars. When the sheet moves with a finger, the pillars deform so that a tangential force can be obtained by measuring the movement of the finger. We evaluated the method and found that the system showed realistic force sensing accuracy in any direction. This input method will enable development of new applications for touch panels such as using any part of the touch panel surface as joysticks, or modeling virtual objects by deforming them with the fingers.

Author Keywords
bezel; shear deformation; tangential force; touch panel; elastic pillar;

ACM Classification Keywords
H.5.2. Input devices and strategies, Haptic I/O, Interaction styles

INTRODUCTION
We interact daily with portable devices using touch operation. Today's touch panels employing capacitive sensing can simultaneously detect the position and contact area of the user's fingers, and the latter information can be regarded as a pressing force. On the other hand, force sensing is limited to a vertical direction. This led us to develop a measurement scheme that can sense tangential force on the touch panel with a simple non-powered method using only a transparent gel layer [1]. This paper is a follow-up of the previous work, suggesting a new structure as shown in Figure 1, leading to more robust omnidirectional force sensing.

RELATED WORK
Harrison and Hudson placed joysticks between the display and touch panel to obtain a shear force [1]. Vlack et al. developed GelForce [3], which used transparent gel with embedded color markers and a camera. They captured displacement of the markers and obtained the force vector distribution by solving the inverse problem. These research studies realized 3 DoF force sensing on touch surfaces, but they required special electrical components such as joysticks or cameras, which limited their practical use. Heo and Lee proposed a method of distinguishing between the drag operation and tangential force by measuring the contact area (vertical force) and the speed of the touch movement [4]. The method needed no additional hardware. However, the authors mentioned they observed that the distinction between tangential force and drag operation was quite difficult to achieve, especially in the case of a forward direction.

We previously developed a measurement scheme which can sense tangential force on the touch panel using a transparent gel layer [1]. The displacement of the finger is mechanically amplified so that force sensing becomes more accurate, compared to the case without the gel layer. However, we found that there was a tradeoff between touch sensitivity and tangential force sensing accuracy, which depended on the thickness of the gel layer. This is because the thicker gel leads to greater finger movement and easier detection of the tangential force, while also leading to reduced touch sensitivity because the gel is an electrical

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insulator. In other words, vertical force sensing (that requires touch area size sensing), and tangential force sensing, were incompatible.

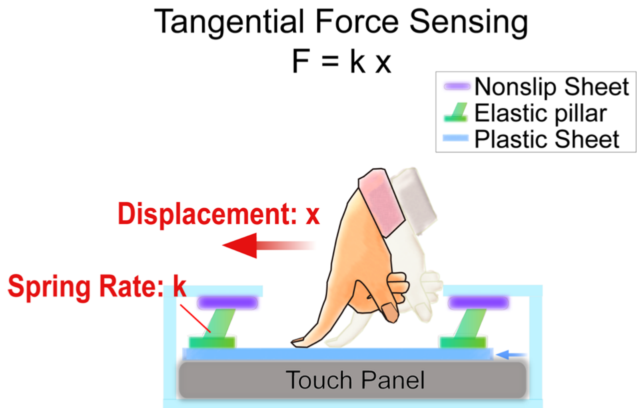

Figure 2 Components of new Structure and System for sensing tangential force

METHOD

The new structure we developed looks similar to a smart phone case (Figure 1). Elastic pillars (6mm thick urethane cushion pad, 30 ASKER C) are sandwiched between nonslip sheets attached to the reverse side of the top layer and a plastic sheet (0.2 mm thick) on a touch panel (Figure 2). Figure 2 also shows the operation of the device. Users touch the touch panel via the plastic plate. When a tangential force is applied, the elastic pillars deform with a shear strain. The maximum displacement is about 5 mm in all directions. The deformation is detected as the touch position displacement by the standard function of the touch panel. This displacement is considered to be approximately proportional to the tangential force, assuming linear elasticity.

This new structure is more durable than our previous one because there is no direct vertical pressure from the finger to the elastic body. Furthermore, the thin plate does not hinder touch sensing, which makes vertical and horizontal force sensing compatible.

EVALUATION

The evaluation system consisted of a smartphone with a capacitive touch panel (GT-I9300, SAMSUNG) mounted on a 3 DoF force sensor (DSA-03A, Tec Gihan Co., Ltd.). The participants were six laboratory members (age: 21-26, five males and a female). They were asked to place the index fingers of their dominant hands at the center of the touch panel, and to gradually increase the tangential force. We also asked them to input force from 200 gf to 1000 gf by observing the value on a PC monitor. The directions of force were front, back, right and left, and we obtained two sets of data simultaneously; the displacement of their fingers on the touch panel and the tangential force measured by the 3 DoF force sensor. The experiments on vertical force sensing were conducted with the same setup, by obtaining the change in the contact area of their fingers and the vertical force.

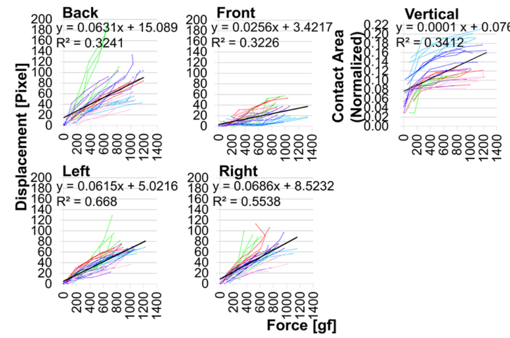

Figure 3 Relationship between the tangential forces and finger displacement or the change in the contact area

The results are shown in Figure 3. The horizontal axis is the actual force and the vertical axis is the finger displacement (tangential force case) or contact area size (vertical force case). Overall, correlation coefficients of all graphs are not high, probably because the displacement depends on each finger's softness. However, we also observe that correlation coefficients of tangential force sensing are comparable with that of vertical force sensing that has already been used in many applications in existing touch panels. We believe that this implies that we achieved 3DoF force sensing with acceptable accuracy.

CONCLUSIONS

We have proposed a new measurement scheme that can sense tangential force on the touch panel with a simple non-powered method using a soft gel layer. In this study, we suggested a new structure which replaced the gel layer with urethane pillars and a plastic sheet. It improved not only durability, but also the vertical force sensing accuracy without degrading of the tangential one. Our next step is to optimize design parameters such as elasticity of the pillars based on user study.

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