정전식 테블릿 기기에서의 마찰 변조 모델링

Characterizing Friction Modulation in an Electrostatic Tablet Device

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요약문

본 연구에서는 정전기 마찰 햅틱 자극을 제공하는 태블릿 기기에서의 햅틱 자극의 특성을 알아보고자 하였다. 이를 위하여 회전식 마찰계를 제작하고, 터치 펜을 이용하여 접선력과 법선력을 측정하였다. 측정 결과, 태블릿 기기에서 제공하는 정전기 마찰력의 접선력은 입력 신호의 세기와 2 차 다항식 관계가 있음을 확인할 수 있었다.

ABSTRACT

We developed a rotary tribometer for collecting force data of a tablet device with electrostatic display. Instead of human fingertip, a sensitive touch pen for scanning the surface is used to eliminate dependencies to human varying skin properties. A quadratic relationship between the input intensity and the output tangential friction force is observed.

INTRODUCTION

An electrostatic display modulates attractive friction force on human fingertip once its surface being scanned. There have been a few attempts to characterize and model this small friction force with respect to the input parameters, but in most cases a human fingertip is used to scan the surface [1, 2]. Varying human skin properties, even for the same person in the short scanning time, makes the force readings unreliable. To avoid this, we replaced fingertip with a sensitive touch pen in which its properties remain unchanged during the experimentation. We developed a rotary tribometer, as opposed to the linear ones used in [1, 2], utilizing touch pens to scan the surface and collect tangential and normal force components.

DATA COLLECTION SYSTEM

We used an electrostatic tablet (Senseg Feelscreen, Finland) and developed a rotary tribometer for force measurement. The tribometer consists of a DC motor with two symmetrical touch pens attached to its shaft and a 6 axis force/torque sensor placed under the tablet (Figure 1). A balancing beam with a counterweight on its opposite end is used to adjust the normal pressure. This design has several advantages: there is no human fingertip in the loop to avoid varying skin properties, there is no additional mechanical components for linear movement to reduce unwanted mechanical effects on the readings, and it has continuous rotation as opposed to stop and change direction modes in linear movements.

Using the SDK provided for the electrostatic tablet device, nine haptic grains can be played with intensity level between 0.0-1.0. Each haptic grain modulates a noticeable different friction on the tablet display. An Android app is developed

to display a scanning surface having multiple vertical lines (edges) aligned horizontally along the landscape orientation of the tablet. When each edge is crossed by the rotating touch pens, a haptic grain is played.

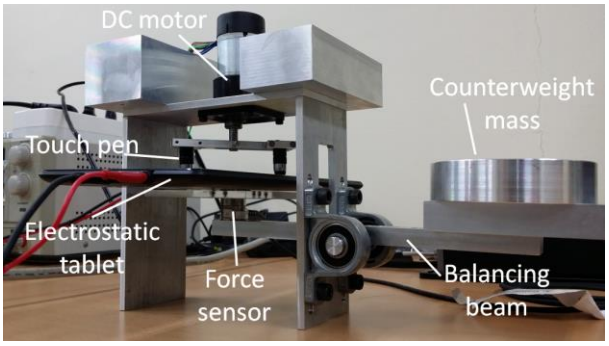

Figure 1. Rotary tribometer

For intensities between 0.1 and 1.0 with step size 0.1, the measurement is repeated and the data is sampled in 10 KHz. The resultant tangential force is calculated by $F_{XY}=\sqrt{(F_X^2+F_Y^2)}$. It can be seen that whenever an edge is crossed, a peak in tangential force signal occurred (Figure 2).

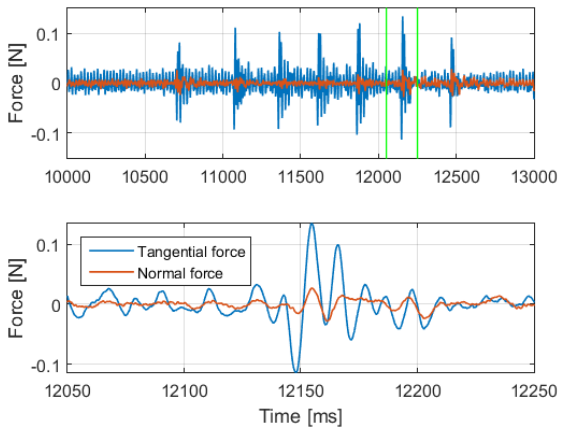

Figure 2. Example of tangential force readings.

For each intensity, the peak-to-peak changes amongst the data are extracted and then the 50 largest ones are averaged. A quadratic fit superbly relates the output force and the input intensity with the maximum of 0.25 N (Figure 3). Assuming that the actual voltage input to the electrostatic film is linearly proportional to the intensity in the SDK, this is an evidence of the classic equation ($F=\varepsilon AV^2/2d^2$) usually considered for parallel-plates condenser model.

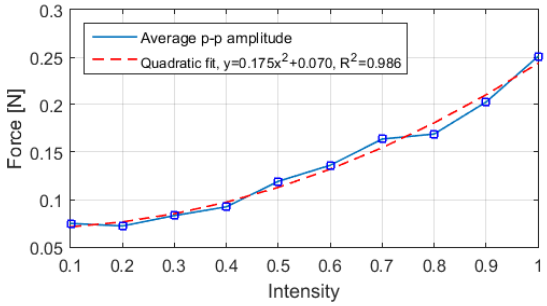

Figure 3. Quadratic fit relating output tangential friction force and input intensity.

CONCLUSION

Using a rotary tribometer, the tangential force of an electrostatic tablet is measured and a quadratic relationship between the modulated friction force and the input intensity is drawn. This step is essential for developing any application using the electorstatic tablet devices.

ACKNOWLEDGMENT

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