3D Stylus and Pressure Sensing System for Capacitive Touch Panel

Chih-Lung Lin, Chia-Sheng Li, Yi-Ming Chang and Chia-Che Hung
Department of Electrical Engineering, National Cheng Kung University, Tainan 701-01, Taiwan, R. O. C.
Alvin Lin
Cando Technology Center, Cando., Hsinchu Industrial Park, Hsinchu 30351, Taiwan, R.O.C.

***Abstract*-- This work presents a new simple passive 3D stylus for capacitive touch panels that detects the x,y-directional position and z-directional strength using a peak calibration algorithm. The proposed algorithm can successfully detect the touch information while eliminating noise, ultimately leading smoother and faster tracking. Analysis results of an experiment on a touch panel demonstrate the effectiveness of the proposed stylus system.**

I. INTRODUCTION

Touch panels are extremely popular due to the intuitive ability of humans to interact with machines, especially in consumer electronics products. Capacitive touch panels (CTPs) are adopted more frequently than other techniques in a wide variety of products due to their robustness and low cost. Both Finger-touch, and to a lesser degree, Pen-touch, cab be used as input interfaces for CTPs, for which multi-touch is easily achieved by changing the sensing method [1].

However, human writing is an action in 3D space. The information contains the touch position (x,y) and the strength (z), combining to form an unique stroke. If the panel can detect touch pressures, the strokes are easily reconstructed and can produce many creative applications. However, the noise and the quantization error significantly affect the accuracy of both the touch position and strength of CTPs, causing zigzag output. Several papers have attempted to resolve these interferences in order to ensure a smooth track and reduce the noise effects [2].

Traditional handwriting technologies, including electro-magnetic resonance pens, utilize pressure sensing on its active stylus with a battery. Despite its high accuracy, a finger can not operate the panel. Recently, modifications to the CTP structure have been proposed to effectively conquer the above constraint. However, the hardware for these adaptations, such as pens with pressure sensors and ADC modules [3], or touch panels embedded with an additional force sensing layer [4], is complex and expensive.

This work presents a new 3D passive stylus and relative algorithm using peak calibration to enable traditional CTPs to detect touch pressure without the constraints of increasing hardware costs or the necessity of a power source for the stylus. Some applications were also proposed to ensure the usability of this algorithm.

II. TOUCH PANEL CONFIGURATION

The touch panel system consists of the following: (1) single layer capacitive touch panel, 10” (2) sensor ICs: Tango S32, (3) micro-controller unit (MCU): Silicon Labs F349, (4) USB interface. The whole structure is mounted on the display of EeePC to confirm the accuracy of the results (Fig. 1).

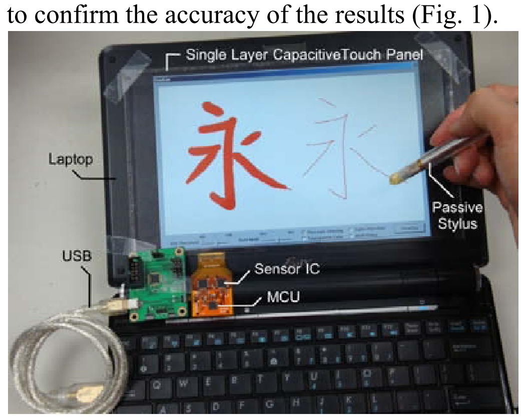

Fig. 1. Photograph of the experimental touch panel system mounted on EeePC laptop.

The MCU sends commands to the Sensor IC in order to drive the panel of an Axis-intersect type. The voltage level changes when touched, allowing for the position of each touch. Since the Axis-intersect sensing method is constraints in terms of ghost points in multi-touch operations, the MT-scan method replaces a single-scan method in order to judge the position of the intended touch point. Finally, the touch positions are transmitted to a computer through a USB human interface device (HID). The smooth algorithms using Kalman filter [5], [6] are verified through visual C++ to perform a real-time process of the proposed algorithm.

III. PASSIVE STYLUS AND PRESSURE SENSING PRINCIPLE

In order to accomplish pressure sensitive stylus, materials and physical principles are taken into consideration. Consisting of conductive materials, including the head and the body, the passive stylus is designed to maintain current paths to flow from a panel to the human body. The stylus head comprises “wood pulp cotton”, a soft material. Additionally, the stylus body is composed of “galvanized iron”, thus making conductive. Notably, a pressure sensor on the stylus does not need to be implemented since the pressure sensing is of passive-type. Thus, although no battery is needed, the shape of the head must be designed as an inverse triangle, as shown in Fig. 2.

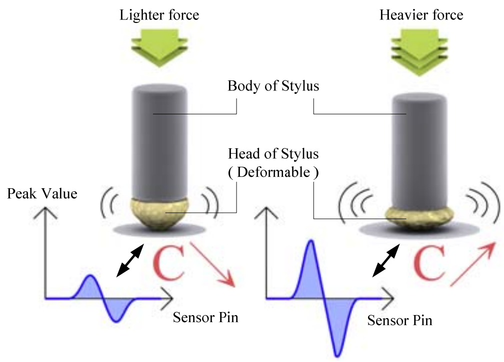

Fig. 2. Relationship between pressure and a sensed value.

The contact area is proportional to the touch pressure if the contact material is deformable. Due to the principle of parallel plates model: $C = \frac{\varepsilon A}{d}$, a larger area implies a larger coupling capacitance. Also, the distance decreases with the applied force, incurring a greater change in capacitance. Since CTPs sense the capacitance value by voltage coupling, the amount of coupling is related to physical force. This is the main idea of pressure sense. Finger touch operates based on this concept.

IV. Experiment Result

A. Peak calibration

In the experiment as shown in Fig. 3, the peak calibration algorithm is first implemented into the touch panel system. The peak values of each pin are summed up to represent the force of the touch. A harder touch implies a higher captured peak value, explaining why the procedure can detect the difference between harder and lighter touch.

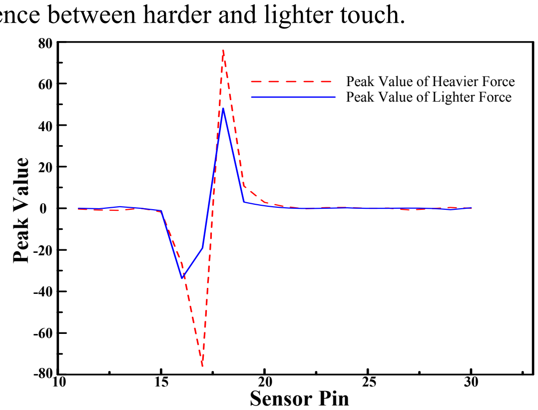

Fig. 3. Peak calibration results under different touch forces.

B. Strokes reconstruction

Pressure signals are used in many applications. The most common use is painting. To reconstruct this action, pressure signals are plotted as a dot with a specific diameter in its current location, as shown in Fig. 4(a). This is the result of the absence of a smooth algorithm. Fig. 4(b) shows the strokes with smoother transition at the edge by applying Kalman Filter. Fig. 4(c) shows the corresponding pressure signal of the same stroke over time, in which a comparison can be seen explicitly.

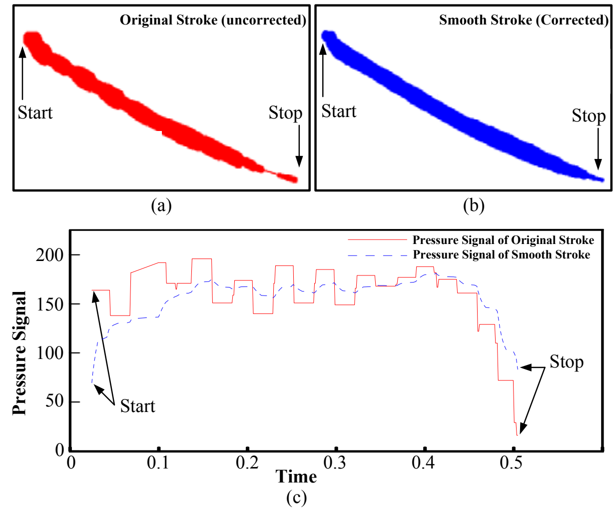

Fig. 4. Reconstruction of strokes with and without Kalman filter. (a) Original pressure signal. (b) Smooth pressure signal. (c) Comparison chart between the original pressure signal and a smooth pressure signal.

V. Conclusion

This work demonstrates the feasibility of implementing pressure sensing capability on traditional CTPs simply by using a peak calibration algorithm and the uniquely designed stylus. Moreover, using a smooth algorithm improves the robustness of this pressure sensing, making it highly promising for commercial product applications.

Acknowledgment

The authors would like to thank both the National Science Council of the Republic of China, Taiwan (Contact No. NSC 100-2221-E-006-046-), as well as funds from receiving the First Grand Prize, 11th GOLDEN Silicon Awards, MXIC International Co., Ltd, Taiwan (July, 2011).

Reference

[1] Z. K. Ho, C. Y. Lee, "Simple Single-Layer Multi-Touch Projected Capacitive Touch Panel," *SID Symposium Digest*, vol. 32, pp. 447-450, 2009
[2] C. L. Lin, Y. M. Chang, "Kalman Filter Smooth Tracking Based on Multi-Touch for Capacitive Panel," *SID Symposium Digest*, P-198, pp. 1845-1847, 2011
[3] H. Li, Y. Wei, "Late-News Paper: Multitouch Pixilated Force Sensing Touch Screen," *SID Symposium Digest*, vol. 32, pp. 455-458, 2009
[4] C. Wen and C. H. Huang, "A Paperless Fax Machine with A Single-Touch Panel," *IEEE Transactions on Consumer Electronics*, vol. 54, no. 4, 2008
[5] D. J. Jwo and S. H. Wang, "Adaptive Fuzzy Strong Tracking Extended Kalman Filtering for GPS Navigation," *IEEE Sensors Journal*, vol. 7, no. 5, pp. 778-789, 2007.
[6] W. T. Lin and D. C. Chang, "Adaptive Carrier Synchronization Using Decision-Aided Kalman Filtering Algorithms," *IEEE Transactions on Consumer Electronics*, vol. 53, no. 4, 2007