TOUCH SCREEN TECHNOLOGY BASED ON ACOUSTIC PULSE LOCALIZATION

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ABSTRACT: In modern world touch screens are widely used as input interfaces. Most popular technologies such as capacitive touch screens and resistive touch screens require specially treated surfaces, which make them expensive and less suitable for larger screens. In this paper, a low cost acoustic pulse localization system based on the speed of the sound wave is presented.. Unlike surface acoustic wave technology, only the acoustic wave created by the touch is used, making it more energy efficient and compact. An added advantage is its possibility to convert surfaces of many homogeneous materials to touch screens by the placement of several piezoelectric sensors.
KEYWORDS: Acoustic touch screen, pulse localization, Microcontroller based touch surface.

1. INTRODUCTION

The ease of use and the vast range of possible gestures have made touch screens popular in modern equipments [S+08]. Capacitive touch screens and resistive touch screens are the most common touch screen technologies. Other technologies include infrared, surface acoustic wave (SAW) [L+10], Optical Imaging or a variation of them. These technologies require specially prepared dedicated surfaces [AM02], [Lee06], which increase the cost per unit area and limit the range of possible applications. In this research, time difference of arrival (TDOA) is used to determine the location of touch. This can be used upon many homogenous surfaces and can easily be scaled.
Speed of sound in a solid is determined by the physical properties of the material and is practically invariant in homogeneous materials [R+07]. A touch or a hit by a finger creates an acoustic wave, which travels to all directions radiating from the point of impact. Impact sensors located at different locations of the touch screen surface detect this wave. The time of arrival of wave for each sensor differs due to the difference in distances. By comparing the signals with each other this shift is calculated and is used to calculate the location of the touch. By carrying out an initial calibration with known locations, requirement to know the real speed of the sound wave can be eliminated [W+03].

2. IMPLEMENTATION

Initial experimentation was conducted for a two dimensional glass surface using two piezoelectric sensors. Glass had a height, width and a thickness of respectively $200.0 \pm 0.1 \times 10^{-3}$ m, $70.0 \pm 0.1 \times 10^{-3}$ m, $0.5 \pm 0.1 \times 10^{-3}$ m. The two piezoelectric sensors were attached to the ends of the glass using the silicone sealant. The signals picked from these sensors were separately amplified using a LF 355N IC based, operational amplifiers circuit. Gains of the op-amps were set to make the output optimum for 5 V. These signals were fed in to the Analogue to Digital Converter (ADC) of the Arduino-Uno board, which converted the voltages to numerical values. ADC could only detect positive voltages. But the Piezoelectric sensors produced both positive and negative voltage swings [R+02]. To compensate for this, equilibrium voltage was shifted to 2.5 V. Therefore when no signal is present, 2.5 V is maintained at the ADC. Resolution of the conversion was reduced to 5 bits in order to increase the sampling rate [OB10]. Average sample delay was estimated to be 200 µS.
A threshold value for noise was chosen empirically. When the voltage difference between the input signal and the equilibrium was larger than the noise threshold, in any of the piezoelectric sensors, next 100 data points from both sensors were recorded in separate arrays.
By comparing the pattern between the two arrays it was possible to determine the shift between the signals. Leading array identified the sensor, which was closest to the point of touch, and the amount of shift determined the distance ratio between point of touch and the two sensors. In the initial execution, Arduino requested the user to touch certain locations and these data was used to calculate the speed of sound in the material. After the calibration, it was possible for the program to determine the location of touch.

3. RESULTS

A test was carried out by tapping 40 different points each 6 times. Distance between two adjacent tapping points were 5.0± 0.1 x 10^{-3} m. Fig 1 shows the relationship between the displacements of touch point measured from the left edge and the calculated length. A linear relationship was observed among above parameters with a gradient of 0.99 and intercept of -0.02. RMSE of location was 4.06.

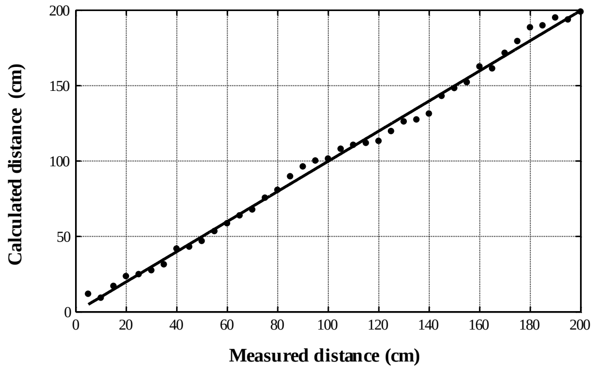

Fig. 1. Calculated length from left edge Vs. Measured length from left edge

The linear relationship agrees with the theory and provides evidence of feasibility of this method. At the later stage, it is expected to auto calibrate and presents the results as a function of displacement.

4. CONCLUSIONS

It was concluded that it is possible to determine the location of touch on a homogeneous material using the wave arrival time difference in two locations. Low cost piezoelectric sensors and microcontroller can be used to practically implement the system.

5. FUTURE WORK

This is an ongoing research and it is expected to extend localization to 2D localization based on TDOA. Possibility of using other homogenous materials and feasibility of creating an underwater touch screen is also considered.

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