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# Position Estimation and Smooth Tracking With a Fuzzy-Logic-Based Adaptive Strong Tracking Kalman Filter for Capacitive Touch Panels

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TOUCH panel technology, which is based on resistive, capacitive, acoustic-wave, and infrared methods, has been widely commercialized in mobile phones, digital cameras, navigation systems, TVs, and tablet PCs. The capacitive touch panel (CTP) has attracted significant interest and achieved considerable penetration of the consumer electronic product market in recent years owing to its sensitivity, excellent durability, and multi touch functionality [3]. However, the CTP is easily affected by noise produced by finger trembling, environmental magnetic interference, or manufacturing process variation, leading to the inaccurate prediction of touch positions and a zigzag output. Therefore, this paper presents a novel algorithm implemented in a CTP system and provides reliable real-time tracking ability and estimates the touched position with satisfactory precision. Fig. 1(a) shows the CTP system, which consisting of a controller system, a 7in projected CTP, an MCU, a sensor IC, and an interface board. A laptop computer receives data from the USB interface board when a touching event occurs. The proposed method is implemented to estimate accurately the touched position on a display panel. Fig. 1(b) shows a block diagram of the hardware system for the CTP. This work proposes a fuzzy-logic-based adaptive strong tracking KF (FLASTKF) method to increase the accuracy of determination of the trajectory and yield smooth tracking trajectory at all speeds. Experimental results demonstrate that the proposed method can reduce the impact of unstable measurement noise, especially at low speed. Fig. 2 shows the smoothness values obtained using MAF, KF, STKF, and the proposed method are better than that obtained using the raw data without a filter. The MAF eliminates only the high-frequency noise, yielding a less smooth trajectory than those obtained using KF, STKF, and the proposed method. This figure also reveals that using the KF-based methods can reduce the effect of noise when the form of the noise is unknown in the raw data includes Gaussian white noise. The proposed method yields a favorably smooth trajectory when the variation of measurement noise is eliminated. Fig. 3 compares the aforementioned methods with a nonlinear trajectory, based on calculated tracking errors at a speed of 45 (cm/s). Based on the measurements, the trajectories that are obtained using the MAF and KF methods do not match the reference trajectory, but exhibit a sever tracking error. The trajectory that is obtained using the STKF method does not track the reference trajectory very closely. The trajectory that is obtained using the proposed FLASTKF method almost matches the reference trajectory. Additionally, this method yields a smaller tracking error than those obtained using the MAF, KF, and STKF methods. Therefore, the experimental results demonstrate that the proposed method can reduce the impact of unstable measurement noise, increasing the smoothness of the obtained trajectory.

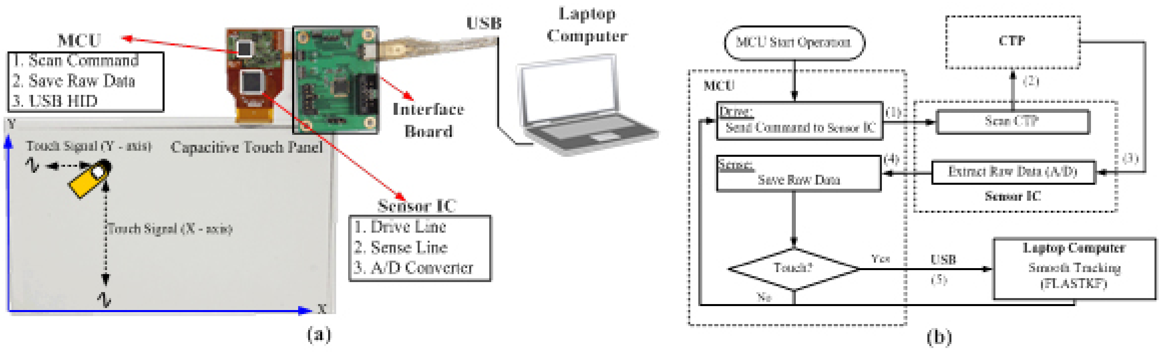


Fig. 1. (a) Photograph of the experimental CTP system. (b) Block diagram of the CTP system.

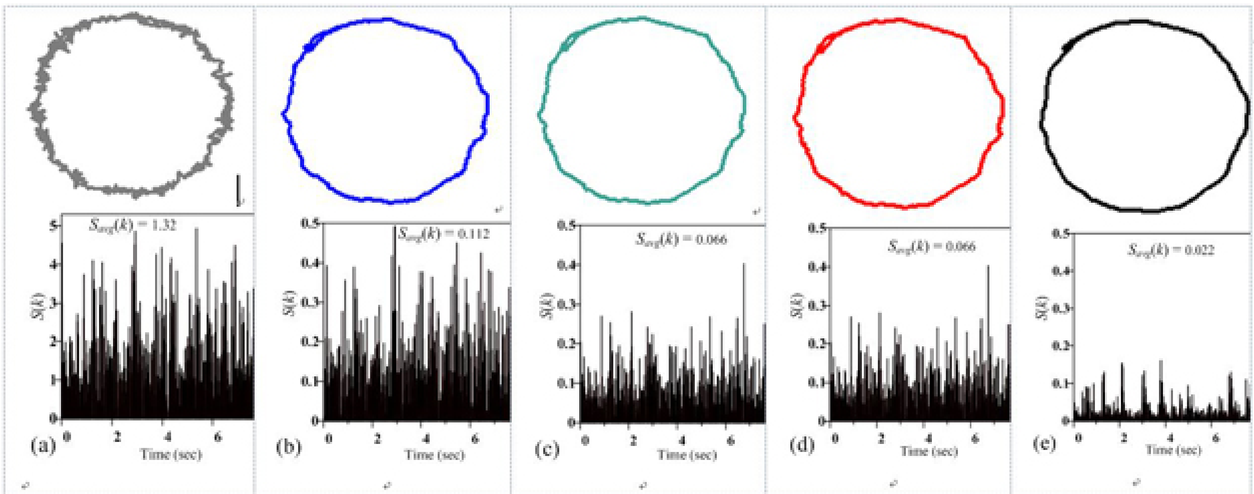


Fig. 2. Comparison of smooth trajectories and S(k) associated with circular motion determined by various methods. (a) Raw data. (b) MAF method. (c) KF method. (d) STKF method. (e) FLASTKF method.

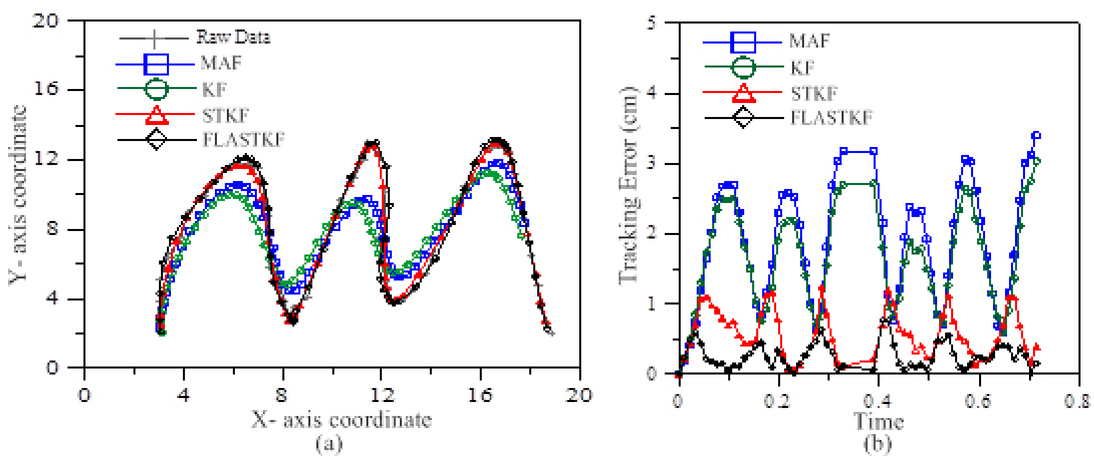


Fig. 3. (a) Nonlinear movement at 45 (cm/s) on CTP. (b) Comparison of errors of tracking trajectory in nonlinear movement at 45 (cm/s).

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