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An Accelerometer-Based Digital Pen with a Trajectory Recognition Algorithm for Handwritten Digit and Gesture Recognition

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Explosive growth of miniaturization technologies in electronic circuits and components has greatly decreased the dimension and weight of consumer electronic products, such as smart phones and handheld computers, and thus made them more handy and convenient. Due to the rapid development of computer technology, human-computer interaction (HCI) techniques [1-2] have become an indispensable component in our daily life. Recently, an attractive alternative, a portable device embedded with inertial sensors, has been proposed to sense the activities of human and to capture their motion trajectory information from accelerations for recognizing gestures or handwriting [3] . This paper presents an accelerometer-based digital pen and its associated trajectory recognition algorithm for handwritten digit and gesture trajectory recognition applications. The digital pen consists of a triaxial accelerometer, a microcontroller, and an RF wireless transmission module for sensing and collecting accelerations of handwriting and gesture trajectories. The dimension of the pen-type circuit board is 14 cm × 2 cm × 1.5 cm as shown in Fig. 1. The schematic diagram of the pen-type portable device is shown in Fig. 2. Users can use the pen to write digits or make hand gestures, and the accelerations of hand motions measured by the accelerometer are wirelessly transmitted to a computer for online trajectory recognition. The proposed trajectory recognition algorithm shown in Fig. 3 composes of the procedures of acceleration acquisition, signal preprocessing, feature generation, feature selection, and feature extraction. The algorithm is capable of translating time-series acceleration signals into important feature vectors. The algorithm first extracts the time- and frequency-domain features from the acceleration signals, and then further identifies the most important features by a hybrid method: kernel-based class separability (KBCS) [4] for selecting significant features, and linear discriminant analysis (LDA) [5] for reducing the dimension of features. The reduced features are sent to a trained probabilistic neural network (PNN) for recognition. In the experiments, we used 2D handwriting digits and 3D hand gestures to validate the effectiveness of the proposed device and algorithm. The overall handwritten digit recognition rate was 98% and the gesture recognition rate was 98.75%. These results demonstrate the feasibility of using the digital pen with the proposed algorithm as a novel alternative of HCI devices.

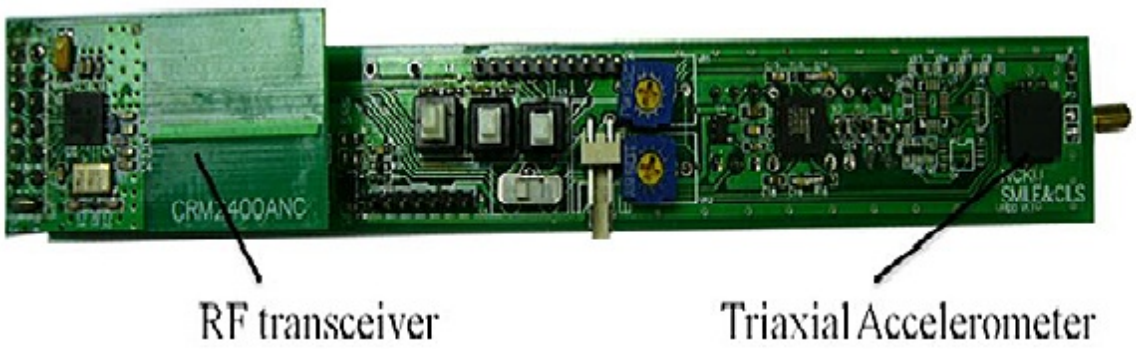

Fig. 1. The circuit board of the digital pen.

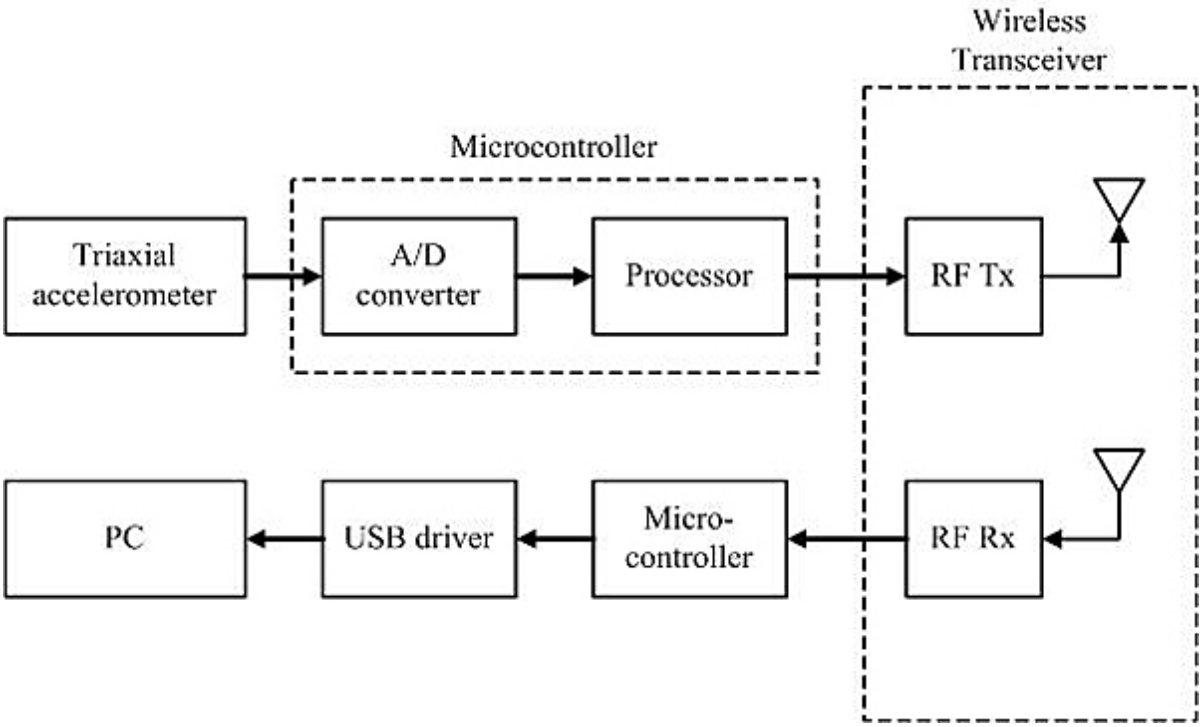

Fig. 2 The schematic diagram of the digital pen module.

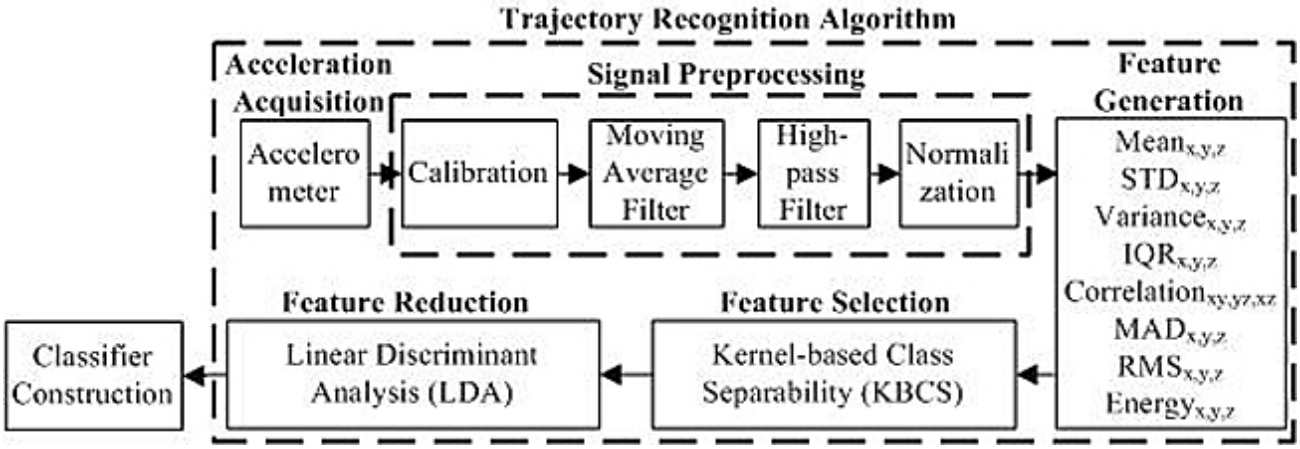

Fig. 3 Block diagram of the trajectory recognition algorithm.

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