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Wheel Chair Motion Control Based On Hand Gesture Recognition

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Abstract: The wheelchair is an important way of transfer for handicapped and aged people. A natural human interface based on hand gesture to control the wheelchair motion. In this paper, the accelerations of a hand in motion in three perpendicular directions are detected by a MEMS accelerometer and transmitted to a PC via Bluetooth wireless protocol. An automatic gesture segmentation algorithm is developed to identify individual gestures in a sequence and the Hidden Markov Model(HMM) is used for the hand gesture model training. After this, the trained gesture model and Bayes method are combined to recognize the gestures from the sensing data sequences. When the gesture information is transferred into the corresponding wheelchair motion, S-Curve function is adopted to connect the velocities of the neigh boring motions. This would insure the wheelchair's motion to be smoothed. Simulations showed the effectiveness of recognition method and smoothed motion of intelligent wheelchair under control.

Keywords: Intelligent wheelchair, MEMS, Accelerometer, HMM, S-Curve.

I. INTRODUCTION

Many researchers have been developing intelligent wheelchairs due to the increasing requirement of safer and more comfortable wheelchairs[1],such as Wheelesley, NavChair, SIAMO, Rolland, MAid and so on. Conventional wheelchairs consist of buttons, joystick to carry out various control tasks. With this method, the user needs to be sufficiently agile to reach and operate them. While some of them, especially for the elderly, cannot manipulate the wheelchair with a lack of force or slow response. Intelligent wheelchair is proposed to improve it. Human interface of intelligent wheelchair for easy operation is one of the most popular research issues. As an alternative to the joystick control, various input interface such as head movement[2],Hand Gesture[3], voice controller[4], chin controller, Electromyogram (EMG)[5] or Electroencephalogram(EEG)[6] signal controller are developed to improve manipulability, safety and comfortableness.

For hand gesture recognition system, there are mainly two existing types, i.e., camera-based and MEMS based[12][13]. As the human interface to control wheelchair's motion, camera-based hand gesture recognition is more applied[3][7]. While compared to the camera-based recognition system, MEMS system can measure physical quantities(acceleration, angular velocity, local magnetic field) which are directly related to the motion of the body part where they are placed with being internally referenced and immune to interference and shadowing. Thus our recognition system is implemented based on inertial measurement unit with a MEMS acceleration sensor.

Various statistical and machine learning methods can potentially be utilized for training and recognizing gestures[8][9][10].In this paper, we propose an automatic gesture segmentation method to identify individual gestures in a sequence and utilize the Hidden Markov Model(HMM)method which is a well-known method for recognizing patterns with spatial and temporal variation and Bayes method to train and recognize the indicated gestures. After the recognition of the gestures, the control commands are determined by the corresponding gesture. To avoid the discontinous curvature of the velocity at the joint point between two consecutive motions, we adopt the S-curve function to smooth the velocities. Simulations showed the recognition method was effective and the wheelchair's motion could be well controlled and smoothed.

II. METHODOLOGY

In this proposed system, MEMS sensors are used to control the wheel chair movement from one place without much movement. For this, the control section consists of a MEMS sensor connected to a microcontroller and a RF transmitter. The device and wheel chair section consists of a RF receiver with relays. MEMS sensors produce different analog values for different orientation. These values are converted into digital values by the microcontroller and transmitted via RF transmitter to the devices. The

set up will have a switch to the control the wheelchair. Commands like start, stop, left, right, forward and reverse are provided to the wheel chair when the switch is pressed and MEMS sensor is tilted. These values are received by the RF receiver in devices and wheel chair and the corresponding relay is triggered for motor movement of wheel chair. LCD is used to display the commands sent from the control section.

III. SENSOR DESCRIPTION

The sensing system utilized in our experiments for hand gesture data collection is shown in Fig.1 and is essentially a
MEMS 3-axes acceleration sensing chip integrated with Micro Control Unit (MCU) and Bluetooth wireless data chips. The algorithms described in this paper are implemented and run on a PC.

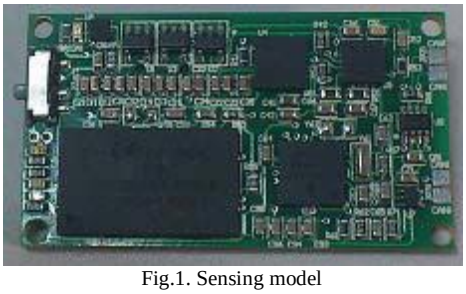
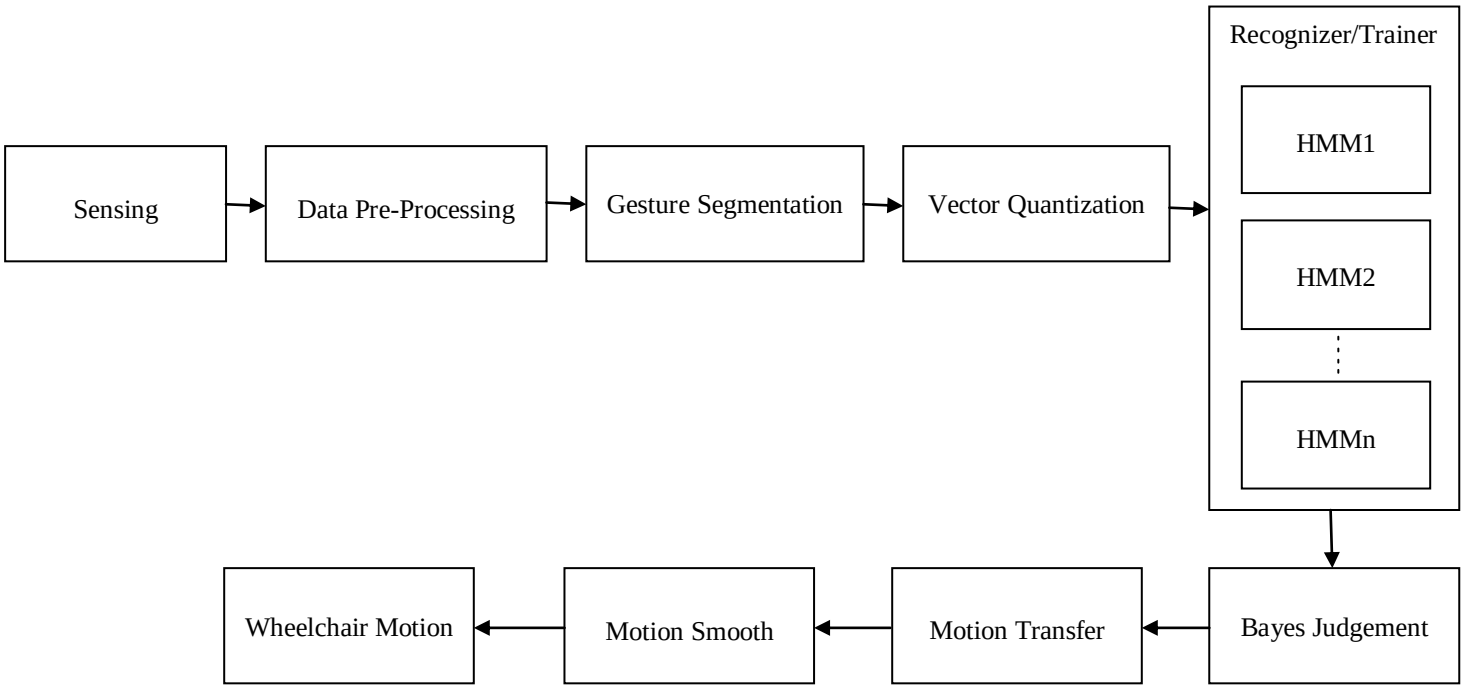


Fig.1. Sensing model

IV. SYSTEM WORK FLOW



When the sensing system is switched on, the accelerations in three perpendicular directions are detected by the MEMS sensors and transmitted to a PC via Bluetooth protocol. The sampled gesture sequence data then go through data preprocessing model which filters the environment noise and gravity interference. Then the data sequences are segmented and quantized into 1-D vector. In training phase, the segmented gesture sequences are utilized to train the HMM models. In recognizing phase, the trained HMM model and Bayes method are combined to recognize the gestures from the segmented sample data. Subsequently the motion command is determined by the corresponding recognized gesture. When the motion command is transferred into the wheelchair's motion, S-Curve function is utilized to smooth the velocities between two consecutive motions for the purpose of motion stability. The work flow of the system is shown in Fig.2.

V. GESTURE RECOGNITION

A .Data Acquisition and Pre-processing: To collect reliable hand gesture data for the sensing system, the gesture should be performed as indicated and there

should exist time interval between two gestures so that the segmentation program can separate the gesture sequence correctly. Raw data received from the sensors are pre-processed during the data acquisition stage as follows:

1) Slide average filter to filter the high frequency noises which introduced by the environment.

2) Hamming band-pass filter with the band between 10Hz to 40Hz to filter the gravity interference and only reserve the main gesture motion, as shown in Fig.3.

3) The sensor data are normalized to unify the different amplitude of gestures.

B. Segmentation: When the pre-processed data stream arrives to the computer, it passes through a segmentation module which identifies the beginning and the end of gestures. Now most segmentation is button-based, which means that the user needs to sign the beginning and the end of the gesture by pushing a button.

C. Vector Quantization: The vector quantization is used to convert the three dimensional sensor data into one dimensional prototype vectors. The collection of the prototype vectors is called a codebook. In our experiments the size of the codebook is selected empirically to be eight. Vector quantization is done using k-means algorithm [11].

D. HMM training: In our system the HMM is initialized for every gesture and then optimized by the Baum-Welch algorithm. We utilized an ergodic topology for the HMM training. In the case of gesture recognition from acceleration signals, both ergodic and left-to-right models have been reported as giving similar results[8]. The number of states in each model is set to be five.

VI. CONCLUSIONS

In this paper we utilize the acceleration data to recognize the hand gestures and then transfer the gesture information which indicates certain motion commands into the wheelchair's smooth motions. It's a try to realize the natural interaction for the older and handicapped with the wheelchair through the hand gestures. On the algorithm of hand gesture recognition, we proposed a real-time gesture segmentation method based on the distance principle which could segment the gesture sequences out of the sensing data automatically. And then we utilized the trained HMM and Bayes method to judge the gestures online. On the motion control method of wheel chair, to avoid the unsmoothed velocities between two consecutive motions, we adopted the S-curve function to realize the continuous curvature of the velocities. Simulation showed the effectiveness of the recognition method and the
realization of the wheelchair's smoothed motion under control. While there still exists a lot of work to do, such as adaptive parameter determination during the gesture segmentation, real wheelchair control under gesture recognition, et al. In the future work, we will focus on these problems and do more experiments to improve and verify the method in real environment further.

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