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Air Writing: Gesture Recognition using Ultrasound Sensors and Grid-Eye Infrared Array Sensors

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Abstract - *Human gesture recognition has been one of the hottest research topics for quite a long time. Many gesture recognition algorithms or systems using other cameras and sensors have been proposed. In this paper we explore the possibility of detecting hand gesture using ultrasound sensors and infrared array sensors. The ultrasound sensors gives an output value which increase as the hand moves away from the sensor. To recognize gestures regardless of motion speed, the proposed method utilizes the data collected from the sensors which is fed as input to an artificial neural network.An accuracy of 83 percent accuracy. (Size 10 & Italic , cambria font)*

Key Words: (Size 10 & Bold) Key word1, Key word2, Key word3, etc (Minimum 5 to 8 key words)…

1. INTRODUCTION

The methods with which humans have been interacting with computers have travelled a long way, from keyboards to touch-screen interfaces. In the last decade, the reign of computer keyboards faced a challenge with the advent of new technologies like gesture recognition and speech recognition to take the human-computer interaction to a next level. Gestures are an integral part of human communication used to express a variety of feelings and thoughts. Communication via gestures is something beyond moving fingers or hands; it is a reasonable and noticeable dialect in which motions assume and vital part[3]. Gesture Recognition is a versatile and intuitive way of developing more natural and human centered forms of human computer interaction. Over the past few years, gesture recognition has made its debut in entertainment and gaming markets.

This ability to sense our interaction without direct physical engagement with computer systems or input devices is now a growing trend. In recognition of this fact, it has now become common for computers to use gestures as a mode of interaction with the system. Gestures can be characterized based on four different aspects: shape, motion, position and orientation. Therefore, all gesture recognition approaches try to approach the problem by concentrating on one or more of the above four aspects [1]. Gesture recognition is classed into a pair of main categories: vision based mostly and detector based. The disadvantage of vision based totally techniques includes advanced algorithms for process. Another challenge in image and video method includes varied lighting conditions, backgrounds and field of scan constraints and occlusion. The detector based totally technique provides larger quality.

In this work, we explore the possibility of using ultrasound sensors and Panasonic Infrared Grid Eye Sensor for tracking gestures. The ultrasound sensor transmits an inaudible tone that is reflected by a hand in motion, in proximity. The Grid Eye sensor is a 8x8 pixel infrared array sensor. The sensor offers digital output for thermal presence, direction and temperature values, which is used to trigger the ultrasound sensor. Hand movements are captured by the two ultrasound sensors placed at right angles and digital output from the two sensors are recorded. Data for gestures of two letters are collected. An artificial neural network was modelled with bagging to classify the two sets of letters for which it was trained.

II. RELATED WORKS

Hand-based gesture recognition is one of the hottest research fields, since it is of great significance in designing artificially intelligent human computer interfaces. Prior studies have shown that gesture recognition is of great scope in the future as it can act as a human computer interface, which includes Infrared Camera Based Hand Gesture Space Touch System Implementation of Smart Device Environment[1] by Yang Keun Ahn, Kwang Soon Choi, Young Choong Park and Kwang-Mo Jung, Algorithm for Gesture Recognition Using an IR-UWB Radar Sensor[2] by Nan Ren, Xuanjun Quan and Sung Ho Cho.[1] proposes a method in which the system tracks the tip of a finger and space touch hand gesture using an infrared camera in a smart device environment. This method estimates the tip of a finger using a curvaturebased ellipse fitting algorithm and is verified using a ellipse fitting rectangular area of some fixed value whereas [2] puts forward a system in which an algorithm for human gesture recognition using an impulse radio ultra wide band sensor of extremely wide bandwidth is used for the detection of moving objects.

Smart gloves for hand gesture recognition using sign language to speech conversion system[3] by Albert Mayan J, Dr.B.Bharathi, Challapalli Vishal, Chidipothu Vishnu Vardhan Subrahmanyam develops a system using flex sensors and mem sensors which is more flexible and accurate for measuring hand gesture. For each hand motion made, an indication is shaped by the sensors appreciate the hand sign the controller coordinates the motion with pre-stored inputs. Glove based gesture recognition system[4] by Maria Eugenia Cabrera, Juan Manuel Bogado, Leonardo Fermin, Raul Acuna, Dimitar Ralev uses flex sensors and three accelerometers for getting inputs from the users which is then preprocessed and fed into the neural networks which

classify the input hand gesture into one among the possible hand gestures. The system uses the accelerometer to gather information about wrist rotation which adds to the precision of the model. The noise reduction or smoothing methods like Gaussian smoothing and binarization of images from the camera makes the process slower in case of [1] whereas acceptance of signals having the threshold value eliminates the need of background separation in case of [2] which analyzes the direction change and frontal surface area of hand towards radar sensor to propose 6 different gestures. Method [2] has an upper hand over [1] as it involves the usage of no camera as the usage of a camera is posed as a disadvantage, considering the questions on privacy and as it features high range resolution, good penetrability, lower power consumption etc. The main disadvantage of [3] and [4] obviously is the usage of an extra wearable device making it less user friendly in spite of the fact that system modelled in [4] can be scaled based on tuning the number of neurons in the neural network used in the system.

III. PROPOSED METHOD

The system comprises of two ultrasonic pair of transmitter and a receiver. The transmitter transmits an inaudible tone that is reflected by a hand in motion, in proximity. The reflected tone undergoes a frequency shift due to Doppler Effect. This amount of shift is dependent on the velocity of hand. The receiver captures the frequency shifted signals and the sensor outputs a value equivalent to the distance between the object and sensor. One ultrasonic pair captures the motion in vertical direction and the other captures the motion in horizontal direction. The data from the sensor is read by the Raspberry Pi system and is passed to the gesture recognition program.

The Grid-Eye sensor is used to trigger the ultrasound sensor to the ON state so as to capture the gestures. The ultrasound sensor captures the data as long as the GridEye sensor is active. The Grid-Eye sensor consists of an array of 64 infrared sensors which is arranged in itself as an 8*8 array. It continuously emits and receives infrared signals that detect absolute temperatures by infrared radiation. GridEYE is able

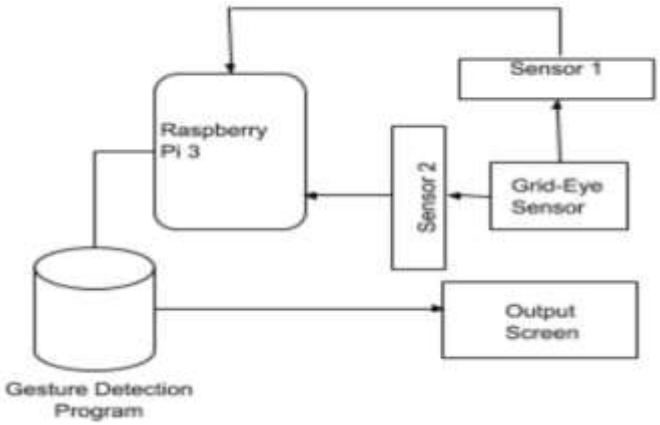

Fig. 1. Block Diagram of Experimental setup

Initial Data	36.8,35.8,34.0,33.8,33.3,31.0,32.1,33.2,33.9,34.2,35.1
Direction	Down,Down,Down,Down,Down,Down,Up,Up,Up,Up,Up
Features Extracted	(Avg. Down,Avg. Up,Up-Down,Down-Up)=>(34.11,33.7,1,0)

Fig. 2. Processing of data collected from sensors

to provide thermal images by measuring actual temperature and tem perature gradients. The movement of fingers is detected by change in the temperature data given by the sensor.

The output from the sensors are the distances to the obstacle(hand). Each data values are converted into DOWN or UP values based whether the next data point is less or greater than the current one. From the resulting data, same motions appearing consecutively are removed. From this data, the average of all upward motions, average of all downward motions, number of UP to DOWN transitions and DOWN to UP transitions are extracted which forms the features for the Neural Network for predicting the letter.
A dataset comprising of 545 samples for two letters was used to train the multilayer neural network. A 4 layer neural network was modelled having 6 input nodes in the input layer. The two hidden layers consists of 10 and 3 nodes respectively. The activation function used between input layer and hidden layer is tanh and logistic function was used between hidden and output layer. The neural network was trained on the training data using back-propagation algorithm for weight updation and learning rate was fixed at 0.001. Stochastic gradient-based optimizer was employed and maximum epoch limit was fixed to 1000. The training dataset is divided into 5 sets of random samples picked with replacement from the dataset. Each set has a maximum limit of 290 samples. Five back-propagation neural networks were modelled on each of the sets and the actual prediction was made on averaging the sum of predictions of the models.

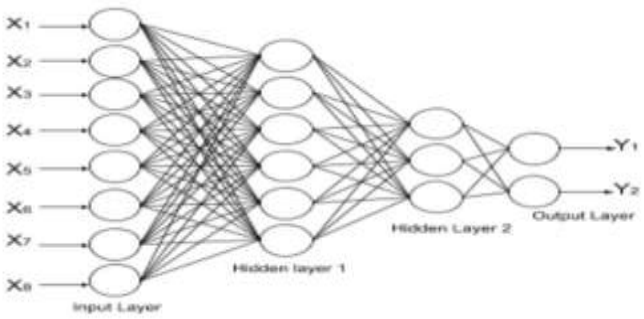

Fig. 3. Artificial Neural Network Model for Gesture Recognition

IV. EXPERIMENTAL RESULTS

The gesture recognition using ultrasonic waves is found to be accurate and reliable. The method was tested against two English letters - "L" and "V". The methodology for testing comprised of movement of single hand only. The confusion matrix in Figure.3 summarizes the performance of the model used. It shows that the system correctly classified 42 inputs of L and 32 of V correctly. The system classified 25 of the inputs incorrectly on the sample dataset provided leading to an accuracy of 83%.

Actual\Predicted	Predicted - L	Predicted -V
Actual letter- L	341	37
Actual letter- V	55	112

Fig. 4. Confusion Matrix

V. CONCLUSIONS AND FUTURE SCOPE

In this paper an integrated system using ultrasound sensors and grid-eye infrared array sensors is used to detect gestures. Our proposed method detects gestures irrespective of the speed of motion. The data from these sensors is fed to an artificial Neural Network to detect the letters. The model predicted the letters with an accuracy of 83%. This process greatly reduces the computation time as compared to the other related works that rely on image processing techniques. This work can be further extended to detect multiple hand gesture movements and words.

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