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STATIC HAND GESTURES CONTROLLED BY ELECTRONIC DEVICES USING SVM

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ABSTRACT In order to receive information people repeat same mouse and keyboard actions, inducing waste of time and inconvenience. To improve these situations we have proposed a system in which user can interact with system by using hand gesture. Communication through gestures has been used since early ages not only by physically challenged persons but nowadays for many other applications. As most predominantly hand is use to perform gestures, Hand Gesture Recognition have been widely accepted for numerous applications such as human computer interactions, robotics, sign language recognition, etc. This paper focuses on bare hand gesture recognition system by proposing a scheme using a database-driven hand gesture recognition based upon skin color model approach and thresholding approach along with an effective template matching with can be effectively used for human robotics applications and similar other applications.. Initially, hand region is segmented by applying skin color model in YCbCr color space. In the next stage Otsu thresholding is applied to separate foreground and background. Finally, template based matching technique is developed using Principal Component Analysis (PCA) for recognition. The system is tested with the controlled and uncontrolled database and shows 80% accuracy with controlled database and 74.43% with low brightness images.

1.INTRODUCTION

Gestures are the movement of any body part used to convey the meaningful information. Communication through gestures has been widely used by humans to express their thoughts and feelings. Gestures recognition refers to the process of identifying gestures performed by human so that machine can perform the corresponding action .Gestures have been classified in two categories static and dynamic[16]. Static gestures refer to still body posture and dynamic refers to movement of body part. Gestures can be performed with any body part like head , face, arms, hands, etc. but most predominately we use hand to perform gesture like we wave hand to say 'good bye'. Hand gestures have been widely used for many applications[like human – computer interaction (HCI), robotics, sign language, human machine interaction, TV interaction etc. With the advancement of technology, human robot interaction (HRI) has become an emerging field in recent years. Hand gestures can be effectively used to give commands to the robot which in turn can be employed in large number of applications. Now-a-days, human robot interaction using hand gestures has widely been used in medical sciences[15]. But still challenges regarding robustness and

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efficiency are to be considered. Hand Gestures Recognition techniques have been divided into two categories[13] Sensor based and Vision Based recognition. Sensor based recognition collects the gesture data by using one or more different types of sensors. These sensors are attached to hand which record to get the position of the hand and then collected data is analyzed for gesture recognition. Data glove[1][2] is an example of sensor based gesture recognition. Other sensors used were Wii controller, EMG sensors, accelerometer sensors, etc. Sensor based recognition has certain limitations. First of all it requires a proper hardware setup which is very expensive. Secondly, it hinders the natural movement of the hand. So to overcome the limitation of sensor based recognition vision based techniques came into existence.

Vision based techniques [1]uses one or cameras to capture the hand images. Various type of cameras used for capturing image can be stereo cameras, monocular cameras, fish eye cameras, time- of –flight cameras, infrared cameras, etc.

Vision based techniques uses various image processing algorithms to get hand posture and movement of hand. Some vision based techniques uses colored markers to get the position of hand. But the vision based recognition also has some limitations that it is affected by illumination changes and cluttered backgrounds.

Vision based techniques are further divided into two categories – 3D model based and Appearance base recognition. Model based approaches uses 3D hand model to search kinematics parameters by comparing 2D projection of 3D hand image and input frame. 3D model are further divided into volumetric 3D recognition [10] and skeleton 3D recognition. Because of the complexity of 3D model it is not preferred.

Appearance based techniques are based on extracting features from the visual appearance of the image and compare it with already defined templates. Various features that can be extracted from the image can be shape based features[4] that can be geometric or nongeometric. Geometric features include- position of fingertips, location of palm, centroid[8], orientation[3], direction[7],etc. Non- geometric features includes color[9], silhouette and textures, contour, `edges, image moments, Fourier descriptors[10][23], Eigen vectors[21], etc. Some techniques uses skin color model[14] to extract skin colored pixels. Other techniques HOG features[5], SIFT features, etc. Appearance based technique is preferred over model based technique because of the complexity of the model based techniques.

The basic step of hand gesture recognition is to localize and segment the hand from the image. Various techniques are available for hand segmentation. The most popular and simplest technique is skin color model[7][14] which is used to get the skin pixels in the image but it has some limitations that skin color of different person can vary and background image can also contain the skin pixels.

Other techniques are thresholding which divides the image into two regions foreground and background based on color, depth[6][10][12], etc. Some researcher uses background subtraction[9][11] for segmenting the hand.

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In our approach keeping in view the limitation and simplicity of skin color model we will combine it with thresholding for hand segmentation. Skin color segmentation [25] can beapplied on any color space-RGB, HSV, YCbCr, YUV, etc. Every color space has its own benefits. We will use YCbCr color space for skin color segmentation. For gesture recognition HMM[3][8], SVM[18][8][23],Nearest Neighbor classifier[10], neural network[17][14], PCA[21],finite state machine (FSM)[22] etc. In our approach vision based hand gesture recognition technique is proposed using a database-driven approach based upon skin color model and thresholding along with an effective template matching using PCA which will use for controlling robotics hand in surgical applications and many other similar applications.

2.EXISTING SYSTEM

The recognition problem is solved through a matching process in which the segmented hand is compared with all the Images in the database. In this paper a novel approach for vision based hand gesture recognition is proposed by using both principal component analysis (PCA) and projection method for feature extraction. We conclude with future abilities. One of the main goals of Hand Gesture Recognition is to identify hand gestures and classify them as accurately as possible. For systems to be successfully implemented, it is critical that their performance is known. To date the performance of most algorithms has only been reported on identification tasks, which imply that characterization on identification tasks holds for verification [1][2]. In this paper will discuss an approach for man-machine interaction [3] using a video camera to interpret the American one-handed sign language alphabet and number gestures. *Sign languages:* Sign languages are the natural communication media of hearing-impaired people all over the world [4]. Sign languages are well-structured languages with a phonology, morphology, syntax and grammar. They are different from spoken languages, but serving the same function. The aim in SLR is to reach a large-vocabulary recognition system which would ease the communication of the hearing impaired people with other people or with computers.

3.PROPOSED SYSTEM

In this section we will discuss our proposed methodology step by step.

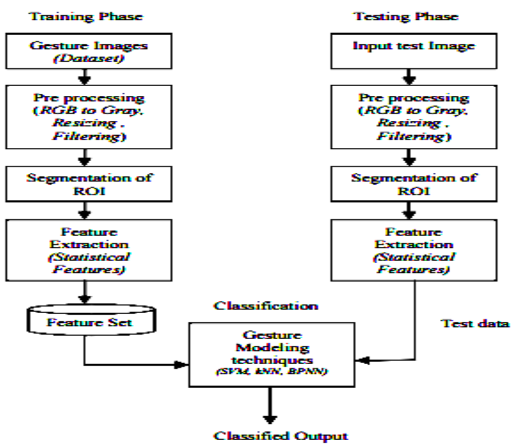

Fig. 2 Flow Diagram of proposed Methodology

Image Acquisition:

Images are acquired using the 13 megapixel real-aperture camera in controlled background as well as by varying the lightning conditions.

Hand Segmentation: The main and basic step in hand gesture recognition is to segment the hand from the whole image so that it can be utilized for recognition. In our proposed color skin color segmentation is applied to segment the hand. As skin color of different person can vary and background image can also contain the skin pixels so after skin color model Otsu Thresholding is applied to remove the background

Conversion from RGB to YCbCr:

The proposed skin color segmentation in applied to YCbCr color space. So first of all RGB color space is converted to YCbCr color space. Y represents the luminance and Cb and Cr represents chrominance. The RGB color space is converted to YCbCr color space using the following equation:

$$Y = 0.299R + 0.587G + 0.114$$
$$Cb = (B - Y) * 0.564 + 128$$
$$Cr = (R - Y) * 0.713 + 1$$
………(1)

Skin Color Segmentation:

The skin color segmentation is used to classify the pixel as skin pixel or non-skin pixel. As or hand is connected component made of skin pixels we will get the hand after skin color segmentation. Steps for skin color segmentation:

1. The first step in skin color segmentation to specify the range for the skin pixels in YCbCr color space.

$$[R_{Cb}, R_{Cb}'] = [77, 127] \ \&$$
$$[R_{Cr}, R_{Cr}'] = [133, 173]$$
…………(2)

2. Find the pixels (p) that are in the range defined above:is lower and upper bound for Cb component.

$$R_{Cb} \leq Pixel\ value(Cb(i,j)) \leq R_{Cb}'$$
$$R_{Cr} \leq Pixel\ value(Cr(i,j)) \leq R_{Cr}'$$
……..(3)

3. Summation of all the pixels in the above step belongs to Region of interest i.e hand.

$$ROI = \sum p(i,j)$$
………..(4)

After Skin color segmentation we will the hand but may be some other pixels in the background also. To remove that background pixels we will use Otsu Thresholding.

Otsu Thresholding:

Thresholding is used to separate the object from its background by assigning pixel to either background or foreground based on threshold value.

In our proposed system hand is in foreground. Otsu threshold is a global thresholding method which chooses threshold that minimizes within class variance.

1. Calculating threshold value: In MATLAB there is a function Gray threshes (I) which calculate global threshold value using Otsu Threshold. TH = gray thresh (I)

2. Convert Image pixel values into binary value according to THR. Then

$$g(i,j) = \begin{cases} 1 \ \ if\ p(i,j) \geq T \\ 0, \ \ otherwise \end{cases}$$
………..(5)

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Gesture Recognition

One of the important technique of recognition is template matching in which a template to recognize is available and is compared with already stored template. In our approach PCA method for feature extraction and matching is used. Principal Component Analysis: PCA is used to reduce the dimensionality of the image while preserving much of the information. It is the powerful tool for analyzing the data by identifying patterns in the dataset and reduces the dimensions of the dataset such that maximum variance in the original data is visible in reduced data. PCA was invented by Karl Pearson in 1901. It works by converting set of correlated variables to linearly uncorrelated variable called principal components. Principal components are calculated by computing Eigen vectors of covariance matrix obtained from the group of hand images. The highest M eigenvectors contains the maximum variance in the original data. These principal components are orthogonal to each other and the first component is in the direction of greatest variance.

K-Nearest Neighbor Classifier

In pattern recognition, the K-nearest neighbor algorithm (K-NN) may be a wide used classifier for classifying objects supported nearest coaching examples within the feature area. The k-nearest neighbor formula is that the simplest classifier of all machine learning algorithms. During this classifier image is assessed by a majority vote of its neighbors. In KNN classifier the Euclidian distance between the testing image feature and every coaching image feature is set to make a distance matrix. The summation worth of distance matrix is calculable and sorted in increasing order .The first K components are elect and majority category worth is set for classifying the image accurately.**:** KNN algorithm is used for classification in this research because it is the simplest machine learning algorithm and it is very easy to implement. It is a technique based on the closest training samples in the feature space. When the test sample is given, the distance between the test sample and all the training samples are first calculated using Euclidean distance. Then, the 'k' nearest neighbours which have minimum distance are determined. Once the nearest neighbours are found, the test sample is classified according to the majority votes of the nearest neighbours. k-NN Training involves storing the input feature vectors and their corresponding labels. In the testing phase, the unlabelled query image is simply assigned to the label of its k nearest neighbours. The k-NN classification process is shown in Fig. 4. for different values of k.

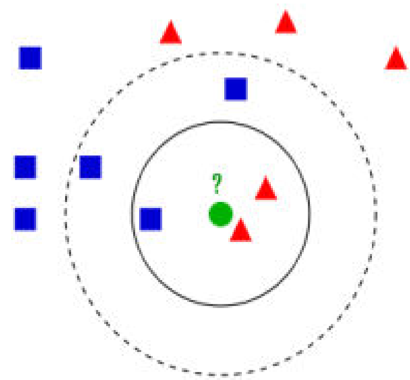

Fig 4 knn Classifier

Typically, the test data is classified based on the majority labels of its k nearest neighbours. For k=1, the class label of test image is assigned as the class of its nearest object If there are only two classes, k must be an odd integer. For multiclass classification, ties occur even though k is an odd integer. The Euclidean distance 'd' between the training feature vector X=(x1,x2, ……xn) and the test feature vector Y= (y1,y2,…..yn) of fixed length is calculated using the following equation.

$$d = \sqrt{(x_1 - y_1)^2 + (x_2 - y_2)^2 \dots . (x_n - y_n)^2}$$

The accuracy of k-NN classifier is found by choosing different values of k. We obtained the better classification accuracy of 76% at k=5. If the value of k is increased further, there is no significant improvement in the performance.

SVM

In machine learning, **support vector machines** are supervised learning models with associated learning algorithms that analyze data used for classification and regression analysis In addition to performing linear classification, SVMs can efficiently perform a non-linear classification using what is called the kernel trick, implicitly mapping their inputs into high-dimensional feature spaces.When data are not labeled, supervised learning is not possible, and an unsupervised learning approach is required, which attempts to find natural clustering of the data to groups, and then map new data to these formed groups. The clustering algorithm which provides an improvement to the support vector machines is called **support vector clustering** and is often used in industrial applications either when data is not labeled or when only some data is labeled as a preprocessing for a classification pass More formally, a support vector machine constructs a hyper plane or set of hyper planes in a high- or infinite-dimensional space, which can be used for classification, regression, or other tasks. Intuitively, a good separation is achieved by the hyperplane that has the largest distance to the nearest training-data point of any class (so-called functional margin), since in general the larger the margin the lower the generalization of the classifier.

Mathematical Model for SVM: The PCA approach has 2 stages: Training and Testing stage. In the training stage the Eigen space in established using training images of hand gestures and these images are mapped to the Eigen space. In the testing stage the image to be tested is mapped to same Eigen space and is classified using distance classifier.

ALGORITHM FOR SVM

Training Stage*:* Calculation of Eigen vectors:

1. Obtain the database containing N training images of dimensions M×M : $I_1, I_2, I_3, \dots \dots, \dots I_N$.
2. Convert these N images into vectors Z_i ,N of dimension M^2 .
3. Obtain mean image vector $\Psi = \frac{1}{N}\sum_{i=1}^{N} Z_i$
4. Obtain the difference image by subtracting the mean image vector from the training image.$\Phi_i = Z_i - \Psi$
5. Obtain the covariance Matrix C having dimensions $M^2 \times M^2$

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$$C = \frac{1}{N}\Phi_n\Phi_i^T = AA^T$$

A=[$\Phi_1, \Phi_2, \Phi_3, \ldots \ldots, .. \Phi_N$.] dimension $M^2 \times N$

6. Compute the Eigen vectors$V$ of AA^T As the dimensions of AA^T $M^2 \times M^2$are very large so computation of eigenvectors is impractical.
7. Obtain Eigen vectors u_i of AA^T [dimensions N × N. AA^T has M^2 Eigen vectors and Eigen values. AA^T has N Eigen vectors and Eigen values
8. Obtain the best N eigenvectors of AA^T by following equation.

u_i= AA^TTake only V Eigen vectors corresponding to V largest Eigen values

4 APLLICATIONS OF PROPOSED SYSTEM

Neuroscience

A variant of principal components analysis is used in neuroscience to identify the specific properties of a stimulus that increase a neuron's probability of generating an action potential. This technique is known as spike-triggered covariance analysis. In a typical application an experimenter presents a white noise process as a stimulus (usually either as a sensory input to a test subject, or as a current injected directly into the neuron) and records a train of action potentials, or spikes, produced by the neuron as a result. Presumably, certain features of the stimulus make the neuron more likely to spike. In order to extract these features, the experimenter calculates the covariance matrix of the spike-triggered ensemble, the set of all stimuli (defined and discredited over a finite time window, typically on the order of 100 ms) that immediately preceded a spike. The eigenvectors of the difference between the spike-triggered covariance matrix and the covariance matrix of the prior stimulus ensemble (the set of all stimuli, defined over the same length time window) then indicate the directions in the space of stimuli along which the variance of the spike-triggered ensemble differed the most from that of the prior stimulus ensemble. Specifically, the eigenvectors with the largest positive eigen values correspond to the directions along which the variance of the spike-triggered ensemble showed the largest positive change compared to the variance of the prior. Since these were the directions in which varying the stimulus led to a spike, they are often good approximations of the sought after relevant stimulus features.In neuroscience, PCA is also used to discern the identity of a neuron from the shape of its action potential. Spike sorting is an important procedure because extracellular recording techniques often pick up signals from more than one neuron. In spike sorting, one first uses PCA to reduce the dimensionality of the space of action potential waveforms, and then performs clustering analysis to associate specific action potentials with individual neurons. PCA as a dimension reduction technique is particularly suited to detect coordinated activities of large neuronal ensembles. It has been used in determining collective variables, i.e. order parameters, during phase transitions in the brain.[30]

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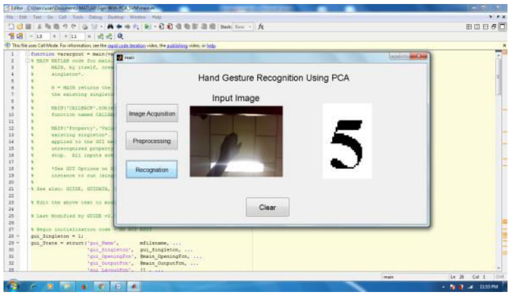
RESULTS



CONCLUSIONS

In this paper the hand gesture recognition system is developed using skin color model, Otsu thresholding and Advanced PCA(SVM). The system is tested in controlled background and indifferent lightning conditions. The database collected in the ideal conditions has proved to be the most efficient database in terms of accuracy and gives 80% accuracy and when the lightning conditions are changed the accuracy decreases as compare to the previous one. The system shows 74.43% with low brightness images.The hand images have been obtained for the purpose of human computer interactions for the operation theatre robots, which must understand the hand language in order to take the actions. Our research empowers the medical experts to pass the instruction to the robotic hands remotely to add the accuracy in the operations. But the proposed model is not capable of working with the images containing hands of other than skin color. The proposed model does not evaluate the images clicked in other light colors where the hand gestures has been clicked and the model work only with static gesture .In future the system can be upgraded to support dynamic gestures and an application for controlling medical operations can be developed using the system.

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