USING SYSTEMATIC DATA FLOW WITH HELP OF HAND GESTURE BASED DIGIT RECOGNITION

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Abstract

Recognition of static hand gestures in our daily plays an important role in human-computer interaction. Hand gesture recognition has been a challenging task now days so a lot of research topic has been going on due to its increased demands in human computer interaction. Since Hand gestures have been the most natural communication medium among human being, so this facilitate efficient human computer interaction in many electronics gazettes . This has led us to take up this task of hand gesture recognition. In this paper different hand gestures are recognized and no of fingers are counted. Recognition process INVOLVES steps like feature extraction, features reduction and classification. To make the recognition process robust against varying illumination we used lighting compensation method along with YCbCr model.

Keywords– *Gobar, Virtual, Gesture, Glove, Multidirectional.*

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1. INTRODUCTION

Researchers have found variety of ways to interaction with machines such as giving command by voice , keyboard, touch screen, joystick and so on. Lots of research has been done for the detection and recognition of hand gestures.

Since Hand gestures have been the most natural communication medium among human being, so this allows human computer interaction in many electronics gazettes. This research field has achieved a lot of attention due to its applications and usefulness in interactive human-machine interaction and virtual environments. Such devices have become familiar but it limits the speed of the communication between the users and the computers a lot of current works related to hand gesture interfacing techniques has been used in machine learning.

1.1 Human Computer Interface System

Many input and output devices have been developed over the period of time with the purpose of simplifying the communication between human and computers .The two techniques are **glove-based method** and **vision-based technique**.

1.1.1 Glove-Based Method

In Glove-based gesture interfaces necessitate the user to wear a device, and generally carry a weight of cables that connect the device to a computer. The position of the human body like angles, rotation and movement need to be sensed.While the glove-based system needs the user to wear a glove or attach sensors on the skin to give the commands necessary for the computer.

Fig 1.1: glove based hand gesture [34]

1.1.2 Vision-Based Technique

Many vision-based techniques have been developed for locating and recognizing gestures. This approach is another way of gesture recognition. It requires a camera for capturing the input from user. It is a natural way of gathering a human-computer gesture interface. But it has limitations.

Fig1.2: vision based technique [35]

Gesture recognition process involves features extraction based on which classifier classifies gesture w.r.t. their individual classes. Many special devices have been designed and used for human-computer interaction. But gestures are strong means of communication among the human. Different approaches have been proposed for computer vision system to understand gestures. Recognition systems play important role in fields like biometrics, telemedicine and Human-Computer Interaction.

Gestures are an important form of human interaction in the man and machine interfaces and interpersonally.

Gesture is a form of communication which is used to convey information among people. Hand gestures are used sometimes for verbal communication like pointing to someone or something. But to recognize the gestures and its meaning being used in HCI, it's a big challenge.

Hence a lot of research has been done to understand the gestures. One can directly use their hands in hand gesture recognition in HCI. In this project, we are recognizing five different hand gestures. The process should be working in varying illumination conditions. To achieve this we adopted an adaptive skin colour model which consists of two parts
- Lighting compensation method
- Skin color model.

Among all possible combinations we used reference white +YCbCr skin colour model for segmentation of hand in different lighting conditions.

The proposed method is a step towards developing a system with less complexity and high accuracy. So we used gabor based feature vector for classification. We used 15 gabor filters with three scales and 5 orientations for extraction of features from the input hand image. These filter responses are then used for classification but due to high dimensionality we have to use PCA (Principal component analysis) for dimension reduction. These features are then used for classification for 5 different hand gestures using one vs. all strategy SVM (Support Vector Machine).The results are also compared with classification using Euclidean distance.

1.2 Gesture Based Applications

Gesture based applications are widely classified into two types on the basis of their uses:

Multidirectional control and a symbolic language

1.2.1 3D Design

Computer aided design (CAD) is a Human computer interaction which gives a stage to interpret and control 3-D inputs might be the gestures. Controlling 3d inputs with a mouse is a period expending undertaking as the assignment includes a confounded methodology of decaying a six degree opportunity errand into no less than three successive two degree tasks.mit has thought of the 3draw innovation that uses a pen installed in polhemus gadget to track the pen position and introduction in 3d.a 3 space sensor is inserted in an even palette, speaking to the plane in which the articles rest .The CAD model is moved synchronously with the clients gesture developments and items can in this manner be turned and made an interpretation of so as to view them from all sides as they are continuously made and modified[35].

1.2.2 Tele Presence

There may advancement the need of manual operations in cases like framework Failure, emergency hostile conditions or difficult to reach remote ranges .It is not workable for people as operators to be physically present close to the machines. Tele presence is that zone of engineering which intends to give physical operation help and maps the operator's arm to the mechanical arm to do the essential undertakings [34].

1.2.3 Sign Language

Sign languages are the most crude and common manifestation of languages, which could be dated again to as promptly as the coming of the human advancement, when the first speculations of sign languages showed up ever. It has begun even before the development of spoken languages. From that point forward the sign dialect has advanced and been received as an indispensable some piece of our everyday correspondence process. Presently, sign languages are, no doubt utilized widely as a part of worldwide sign utilization of hard of hearing and idiotic, in the realm of sports, for religious practices and additionally at work places.

1.2.4 Virtual Reality

This is connected to computer-simulated surroundings that can recreate physical vicinity in spots in this present reality, and in addition in fictional universes. Most present virtual reality environments are basically visual encounters, showed either on a computer screen or through exceptional stereoscopic presentations. There are additionally a few reproductions incorporate extra tactile data, for example, sound through speakers or earphones. Some progressive, haptic frameworks now incorporate material data, by and large known as power criticism, in restorative and gaming provisions [35].

1.3 Objective

Human computer interaction is the most preparing field of research. The main objective of our research is to correctly detect and recognize five different hand gestures. In order to achieve this following processes are carried out in a systematic manner. The processes are as follows:
1) To extract features and reduce its dimension. For this following process are carried out:
(i) To make the recognition illumination invariant using Adaptive skin colour model
(ii) To reduce the dimension of the feature vector using PCA (Principal Component Analysis)
(iii) To classify the different hand gestures using Euclidean and Cosine distance

2) To classify different hand gestures using Support Vector Machine (SVM).

1.4 Database

In today's times, laptops are presented with high quality Webcam embedded in it. But we used iball external USB webcam which captures better quality of image and would have been nice if we have got a camera which has night vision system in it so that it can have proper view and calibration of the images. The colour component of the images can be varied by varying the light focused on it, so we have to take proper care while using it. The USB webcam used is shown below:


Fig1.3: USB CAMERA

A database has been created taking 100 images of each of five different hand gesture of only one User using the camera. Among these, 30% of them are used for training and remaining 70% for testing. The input image taken is a colour image of size 480*640.The images are taken under varying illumination conditions. The five different hand gestures used in our project for recognition are shown below:

Fig1.4: Five Hand Gestures

1.5 Overview
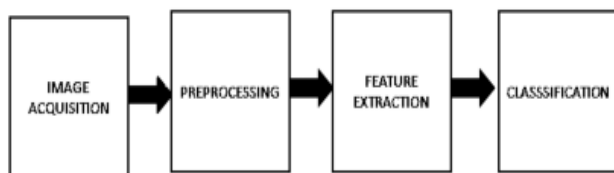
Fig 1.5: Block diagram of hand gesture recognition system [14]

Chapter 1 of the thesis explains about human computer interface. Next a brief insight is provided about hand gestures detection and recognition. Finally the literature survey and objective are presented in a lucid and simple manner.

Chapter2: This section contains feature extraction and reduction which uses gabor filter concept to extract features and followed by reducing the high dimensionality of data by principle component analysis methods. Results of these experiment has been recorded.

In addition to the feature extraction and reduction, different classification methods like Euclidian distance (EUD) and cosine angle distance (CAD) have been implemented.

Chapter 3: Support vector machine (SVM) classifier is used here to classify each count of figure to different classes. Here radial basis function (RBF) kernel is used for non – linear classification. Classification Results has been recorded.

Chapter 4: This section contains conclusion of the overall experiment and compares the results that has been obtained by different classification method. Different possible future works that can be developed using this project has been suggested.

2. FEATURE EXTRACTION AND FEATURE REDUCTION

This section describes the method of collecting images, pre-processing the raw image and extracting features from it. The pre processing stage contains illumination invariant algorithm and used skin colour model i.e YCbCr model. The features extracted are gabor based features which have large dimension. So we used PCA (Principal Component Analysis) for feature dimensionality reduction. Later, two classification methods of Euclidean distance and Cosine distance for hand gestures are described and results are shown.

2.1 Methodology

2.1.1 Pre Processing

Hand Segmentation

The color image obtained from the usb camera is a 3 channel image which is composed of Red (0-255), Green (0-255), and Blue (0-255).The input RGB image used in this project is shown in fig 2.1
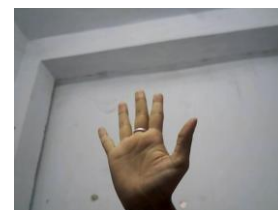
Fig 2.1: Input RGB image

The image preprocessing technique is developed to achieve robustness against lighting changes.

So we used a scheme to achieve it.

Adaptive Skin-Color Model Switching Method (ASSM)

A combination of skin colour model and lighting compensation is adaptively selected in this method which we used in our project. This method contains the possible combinations of the three skin color models, i.e., the YCbCr model, Soriano's and the Gaussian mixture model along with three methods of lighting compensation, i.e., reference white, modified retference white ,and gray world .In our method, first lighting compensation is applied and then the skin-color model is used. The input image of size 480*640 is resized to 60*80 for efficient computation. Here we have used Reference white lighting compensation+YCbCr model for hand segmentation.

Reference White Lighting Compensation

In this method, the top 5% of intensity values of the image are regarded as the reference white but the condition is that the number of those pixels shoul be sufficiently large .In our project we assumed it should be >100 pixels. The Red, Green, and Blue components of the input color image are adjusted in such a way that the average intensity value of the above mentioned pixels is scaled linearly to 255. Lets assume i € [l, 255] be the top 5% intensity levels and fi be the no of pixels of that in the image.

YCbCr Skin Color Model

This color space represents each color also with 3 numbers. The Y component signifies the intensity of the light. The Cr and Cb components signify the red and blue component intensities s of light relative to its green component. This color space exploits the properties of the human eye. Light intensity change affects our human eye more while the hue changes affect less. To minimize the information content, the Cb and Cr components are stored with less accuracy content than the intensity component. This colour space is used by the JPEG format to reject insignificant information. This is a form of color spaces which can be used as part of the color image .This model does not depend on luma (brightness) as compared to RGB, therefore can show better performance in varying lighting. In our implementation a pixel is classified as skin pixel if

$67 \leq Cb \leq 137$
$133 \leq Cr \leq 173$

Where Y represents intensity
Cb-intensity of blue w.r.t green component
Cr-intensity of red w.r.t green component

Two hand gestures at different varying illumination has been shown in fig.2.2.1 and fig.2.2.2 respectively.

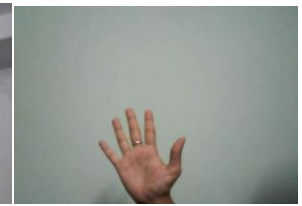**Fig 2.2.1** input image 1   **Fig 2.2.2:** input image 2

The Cb value of one of the skin pixel is 106 and Cr value is 145.

The Cb value of one of the skin pixel is 113 and Cr value is 144.

As we can see the two images are taken under different lighting conditions but above mentioned model can properly binaries both images.

Principle of Gabor Filters

Gabor filters represent important visual properties, such as orientation selectivity, spatial locality and spatial frequency properties. Hence we chose Gabor features to represent our hand gestures. Gabor filter is used as a wavelet transform approach .These filters are used for features detection which can be used for different angles and scales.

Spatial frequency bandwidth is found as λ / σ. Generally, researchers use five scales and eight orientations in a gabor filter bank where the input image is convolved with these 40 Gabor filters. But we convolved the input images with 15 filters to reduce the complexity. As per the function defined above the higher value of standard deviation makes the image blur so we used only three scales to reduce the complexity and also to get good results. It is a linear filter which can be used for edge detection.

2.2 Feature Extraction

Feature extraction is an important pre-processing step in machine learning and pattern recognition problems. This develops new features from the original features, while the feature selection returns a proper subset of the original features. Feature extraction simplifies the amount of data we require for describing a huge data set accurately. When we perform analysis of complex huge data a major problem arises from the no. of variables we have used. Working with a large no of variables generally requires a huge amount of memory and computational power or may be we require an algorithm for classification that can overfit the training samples. Extracting features is generally used for constructing different combinations of the variables to overcome these problems while using the data with sufficient and good accuracy. Gabor based images are used as feature vectors. The input binary image is convolved with 15 gabor filters to give rise to a feature vector giving rise to a dimension of 60*80*15 for only one image.

2.3 Feature Dimensionality Reduction

The feature vector extracted through gabor filter is large (60*80*15*30) for 30 users. Hence to reduce its dimension we used PCA (Principal Component Analysis).

The PCA method is quite popular in reduction of dimensions as it finds a set of orthonormal vectors in the data space, by maximizing the data variance and mapping the data onto a lower dimensional subspace spanned by these vectors, which are called principal components. PCA is better than linear discriminant analysis (LDA) method, especially for the cases where few training samples are used.

Dimensionality reduction just transforms the high-dimensional data into efficient, meaningful representation of reduced dimension. PCA provides data which has no redundancy as Gabor filter wavelet.

Working Principle of PCA

It is a statistical procedure which uses orthogonal transformation to transform a number of observations of correlated variables into a set of linearly uncorrelated values called as principal components.

The transformation is done in such a way that the first principal component has the maximum variance and each succeeding component has the largest variance under the condition that it is orthogonal to the previous components.

Lets consider a dataset of M images containing p variables of information where N(w*h) is the no of pixels in the image. At first, we calculate the mean i.e. the global mean image of the training set. Then the empirical mean is found along each dimension. The empirical mean vector is subtracted from each observation. The covariance matrix is found from the resultant matrix as covariance identifies data redundancy between data sets. The covariance of a set is found by the multiplication of it with its transpose. If X is a set, its covariance set will be $C=X*X^T$.

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$$V^{-1}CV=D \qquad\qquad .....2.4$$

Where D is the diagonal matrix containing the eigen values of matrix C. This diagonal matrix of eigen values contains the significant information of the matrix and thus gives a meaningful representation of the data. The eigen values and eigen vectors are then sorted in decreasing order such as [λ_1 λ_2 $\lambda_{3...}$ λ_p] where [$\lambda_{1>}$ $\lambda_{2>}$ $\lambda_{3...>}\lambda_p$] Now a desired set of feature vectors of dimension($<$p) is chosen for our purpose. At last the feature vector of an image is acquired by projecting X onto the PCA subspace. This feature vector is of the desired reduced dimension.

2.4 Classification Using Euclidean distance and Cosine distance

The reduced feature vector after using PCA(Principal Component Analysis) is classified using two methods:-
(i)Euclidean Distance
(ii)Cosine Distance

(i) Euclidean Distance:- It is just the ordinary distance between two data points. In this method we need to measure the distance between the test image and the training image in database. The smaller the distance the higher the proximity. Thus the class which has the smallest distance with the test image is classified as that class. As we have 30 training images we would measure the test image distance with all the 30 image features for each class. We have assumed a threshold in 16 the distance below which the image is taken to be classified. We assumed a threshold of 0.0005 in our project. The one with the maximum no of classifications is considered finally as the class.

(ii) Cosine Distance:- Cosine Distance:- It is a similarity measure between two vectors of an inner product space which measures the cosine angle between them. In this method judgment is done on orientation. The cosine 0 degree is 1 which means they are similar vectors while the cosine90 degree is 0 which means they have zero similarity. So, similarity is defined as

$$\text{Cosine}(\theta)= \frac{a.b}{2||a|.|b||}.$$

2.5 Results

Segmentation Result

Segmentation in our proposed hand gesture recognition system is done by illumination invariant algorithm. This algorithm treats the segmentation of a RGB image of size 480*640 pixels into a binary image of size 60*80 pixels as a classification problem in which the two classes (in this case, hand and background) are generated from the set of pixels.

Illumination Invariant Result

The result of the use of the illumination invariant algorithm is shown below in fig 2.3

Fig 2.3: image under two different lighting conditions and its output binary image respectively

As we can see the two input images are taken under different lighting conditions but due to the proposed adaptive skin colour model both images are segmented properly.

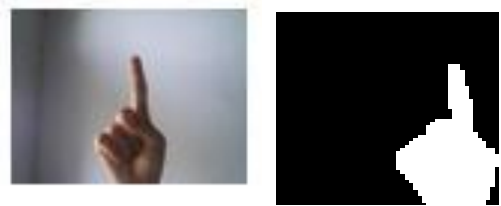**Fig 2.4.1** Unsegmented gesture A   **Fig 2.4.2** Segmented gesture A

Fig 2.4.3 Unsegmented gesture B   **Fig 2.4.4** Segmented gesture B

Fig 2.4.5 Unsegmented gesture C   **Fig 2.4.6** segmented gesture C

Fig 2.4.7 Unsegmented gesture D   **Fig 2.4.8** segmented gesture D

Fig 2.4.9 Unsegmented gesture E   **Fig 2.4.10** segmented gesture E

Gabor Based Feature image

The input binary images are convolved with 15 local gabor filters to give 15 gabor based featured image. The results of different scales and orientations are shown below:

Input Image

Fig 2.5 : Input binary image

The resultant gabor filtered images for the above input binary image is shown below in fig 2.6

$\sigma=1$

$\sigma=2$

$\sigma=3$

Fig 2.6: Gabor filtered images with three scales(1,2,3)

Classification Result

Using the Euclidean distance measures, we classified five different hand gestures by measuring the distance between test image and the training images. The distance of the test image is measured with 30 images of the training set. The accuracy of the above classification method is shown in the table below:

Table 1: Confusion Matrix for classification using Euclidean distance

Classified as (in percentage)	one	two	three	four	five
one	47	4	0	11	8
Two	0	60	2	3	5
three	1	6	62	1	0
four	2	0	0	65	3
five	7	0	0	0	63

Using the Cosine similarity measures, we classified five different hand gestures by measuring the distance between test image and the training images. The accuracy of the above classification method is shown in the table below:

Table 2: Confusion Matrix for classification using Cosine distance

Classified as (in percentage)	one	two	three	four	five
one	45	4	0	12	9
Two	0	62	2	2	4
three	0	7	63	0	0
four	3	0	3	64	0
five	8	0	0	0	62

2.6 Conclusion

In this section we extracted features from the binary images by convolving with 15 gabor filters and then this feature vector of high dimension is reduced by using PCA(Principal Component Analysis) for computational efficiency. Here we also used classifiers like Euclidean distance and Cosine distance for classification which gave accuracy of 84.86% and 84.57% respectively.

3. DIGIT RECOGNITION

3.1 Classifier

Machine learning is well-known as subfield of artificial intelligence. Through machine learning techniques we can develop methods enabling a computer to learn. Over the time period there are so many techniques that have been developed for machine learning.

SVM(Support Vector Machine) has been firstly introduced by Vapnik and has gained popularity because of its exiting feature of giving better empirical performance. SVM(Support Vector Machine) is a classification and regression technique which uses machine learning theory for maximizing the accuracy of prediction.

In this project we used the binary classifier SVM(Support Vector Machine) for classification of different hand gestures. SVM is a supervised learning method. Basically, SVM is a linear classifier that maximizes the distance between the decision lines.SVM uses kernels for non-linear data transformation like linear, Gaussian, rbf etc.

The objective of using SVM is to divide the given data into two distinct categories and then to get hyper plane which separates the given classes. It is a binary classifier classifying only two categories at one time. Support vectors are those samples which lie close to the decision hyperplane of an SVM, and thus are the most important data in determining the optimum location of the decision hyperplane. One SVM classifier looks for an optimal hyperplane which maximizes the margins of decision boundaries to ensure that the worst-case errors are minimized, known as ''structural risk minimization (SRM).''
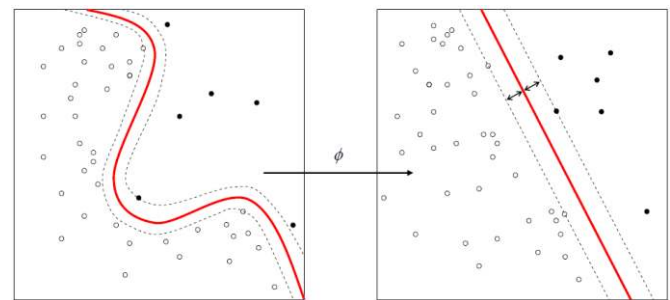
Fig 3.2: Kernel Machine[33]

SVM can use both linear and non-linear kernels for classification.

SVMStruct is the structure which contains information about the trained SVM classifier in the following way:

Support vectors-the matrix of data points where each row corresponds to a support vector in the normalized data space.

Bias - Intercept of the hyper plane which separates the two groups in the normalized data space.

Kernel Function-The function that maps the training data into kernel space.

Group Names-These are numerical, categorical and logical vector or a cell vector of strings where each row represents a class label. It specifies the group identifiers for each data group.

Here we have used "rbf" network for classification.

3.2 Methodology

The collected images were divided into two categories such as training set and testing set containing 30% and 70% of the images respectively.

3.2.1 Training

Features were extracted from image of each hand gesture using 15 local gabor filters and fed to the SVM training process. As discussed earlier, the features of different classes are clustered together for training of binary classes using the svmstruct framework as shown below:
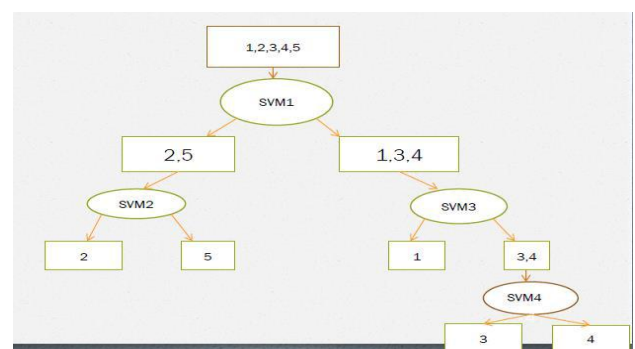
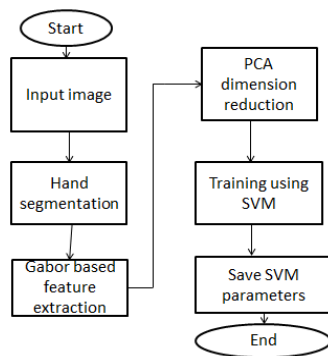**Fig 3.3:** Illustration of SVMStruct framework

Fig 3.5: Flow Diagram for Testing Phase

3.3 Results

The five different hand gestures was recognized using SVM(Support Vector Machine).The accuracy of the algorithm was assessed by using the testing set. Table I represents the confusion matrix of classification using SVM.

Table 3: Confusion Matrix for classification using SVM

Classified as (In percentage)	one	two	three	four	five
One	56	0	3	8	3
Two	0	63	2	0	5
Three	0	3	66	1	0
Four	0	1	1	67	1
Five	3	0	0	0	67

As we can see we get an overall accuracy of about 90.86% in the classification of five different hand gestures. The class "one finger" is classified as 80% while class "two finger" and class "three finger" being classified as 90% and 94.29% respectively. The class "four finger" and "five finger" are being classified as 95.71% and 94.29%. From the table we can see the class "one finger" is not so well classified and is misclassified as "four finger".

3.4 Conclusion

This section uses a binary classifier SVM for classification .In our project we used "rbf" kernel for classification due to which the accuracy improved. The classification accuracy is also compared with the other classifiers used in the previous section and found to be better than those two. The overall accuracy is found to be 90.86% using SVM of gabor based features.

4. CONCLUSION AND FUTURE WORK

4.1 Conclusion

In the recent years a lot of research has been done on hand gesture recognition. The aim of this project was to develop a hand gesture based digit recognition system. We have also shown here that the system can be classified using SVM. The performance of SVM was also compared with two other methods-(i) Euclidean distance and (ii) Cosine distance and the accuracy was found to be improved. It is seen that gabor based feature is found to be very important feature which

helped in classification as it conveys important information about orientation selection, spatial locality and spatial frequency properties. The use of PCA (Principal Component Analysis) helped in reduction of feature dimension for computational efficiency and reducing complexity. The overall accuracy rate of using SVM is 90.586% while the former two gave an accuracy of 84.86% and 84.57% respectively.

4.2 Future Work

This project can be further developed and implemented in surveillance bot and Industrial robots supported hand-robot interaction by interfacing this software based system with the hardware.

The planned methodology adopted is user- friendly and eliminates intrusion and facilitates motion management of robots mistreatment finger signals, which is supplement solely to language within the sense of communication.

The planned technique is anticipated to supply effective and implementable solutions for not just about industrial robots, however conjointly for higher intelligence embedding robots like humanoids. This can also be used to monitor a bot from a remote area where line of sight is not required using wireless communication techniques. As only one user is considered for training this ensures security purposes which can also be enhanced for a few others.

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