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Comprehensive Survey of Performance of Techniques for Hand Gesture Recognition System for Sign Languages

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ABSTRACT

Hand Gesture Recognition System (HGRS) used for human-computer interaction. HGRS is having phases which are applied on captured image. The image is passes through phases like Hand Detection, Region of Extraction, Feature Extraction, Feature Matching, Pattern Recognition. There are many algorithms and techniques used for the phases in HGRS. There are various techniques used to improve the performance of HGRS in feature extraction and feature matching. This comprehensive study of techniques used for feature extraction and feature matching will elaborate performance of these techniques for various purpose in HGRS. For the various phases in HGRS, different algorithms can be used for feature extraction and feature matching like K-nearest neighbor, Support Vector Machine, BOF and SIFT, etc. The performances of the various existing algorithms is discussed.

Keywords: HGRS, SVM, Histogram, BOF, DSL, ISL, ASL, SIFT, K-nearest neighbor, PCA.

I. INTRODUCTION

Hand Gesture Recognition System (HGRS) for sign languages is used for human computer interaction for deaf and dump people. The image is captures as input and processes it by feature extraction and matched with training dataset by feature matching. HGRS requires image processing in complex background like changing lighting conditions and other challenges. There are different sign languages present for different languages like ISL for Indian sign language, ASL for American sign languages, DSL for Devnagari sign languages. Various gesture recognition techniques are important in enhancing performance of HGRS systems for recognition of sign languages. Further sections emphasizes on several existing techniques in HGRS for sign languages and performance study of techniques in HGRS for sign languages.

In HGRS, there can be single-handed as well as double handed static hand gesture recognition. The Indian Sign Language can have single handed and double handed gestures with static as well as dynamic gestures. Whereas, other standard sign languages which uses single handed static gestures for representing the alphabet. The use of complex nature of the gestured sign aplhabets in the Indian Sign Language, single-handed and double-handed gestures categorizes separately. The algorithm proposed that uses HOG features of an image and classifies it using a Support Vector Machine classifier algorithm. Multi-feature static HGRS contians classifiers such as k-Nearest neighbor, Nearest Mean Classifier and Naive Bayes classifier for recognition of Indian Sign Language alphabets and numbers. The fusion of Multi-feature descriptor have high recognition rate of 99.61% [5].

Fingerprint feature extraction method in HGRS recognizes 32 signs of South Indian Language (SIL) with 98.125% accuracy[6]. HGRS includes phases like image capturing, pre-processing, extraction of region, feature extraction and feature matching for recognition.

II. TECHNIQUES

In Hand Gesture Recognition System (HGRS) there are phases like impage capturing and pre-processing, region of interest extraction, feature extraction, feature matching and pattern recognition.These phases are used to achieve the expected result.

A. Image Capturing

The image is captured with the camera in which color is a robust feature. Image capturing is done with the different color space methods. It is not good to changing lighting conditions and background. The constant image size used for the processing, then computation time will be very high.

B. Image pre-processing

Once image captured with camera, the primary phase includes with pre-processing. In this phase, skin detection done by normalizing it and produces gray threshold which results into binary image. Median filtering is used to reduce the noise. It is more effective than convolution because it reduces noise and preserve the edges simultaneously. Gaussian filter applied to filter the image. It uses the morphological operations for filtering the image, which closes the binary image and closes the dilation operation once done with erosion by using structuring element. In HGRS, the combination of Haar-like and Histogram of Oriented Gradients (HOG) features used for pre-processing of image.With new Haar-like features resort it resolves Haar-like problem for high false positive error rate in hand posture. The hybrid method can recognize and processed the hand gesture with 93.5% accuracy[10].

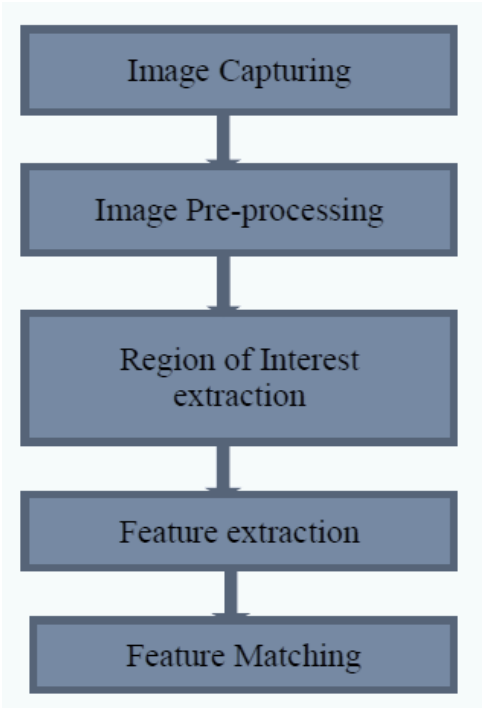

Figure 1. Hand Gesture Recognition System for sign languages

C. Region of Interest Extraction

Binary image is calculated by using bwlebel and regionprops to find bounding box for white pixels of captured image of hand. Then imcrop is used to extract the region of interest (ROI) from captured image. Edge detection is also extracted from image using Sobel method which finds edges using the Sobel. It approximately get the derivative edges at the points where the gradient of captured binary image is maximum. BLOB used for region of extraction which accomplishes appriximately 96% accuracy. In real-time it gives 95% accuracy with complex background for Indian sign languages(ISL) and achieves 90.19% accuracy for ASL[2].

D. Feature Extraction

Features extracted from images and forms feature vector for training dataset images stored in database .

Histogram used as a feature extracted in static HGRS applied for recognition of numbers and alphabets.

HGRS used to recognize the hand gestures with recognition rate of 93.1%[1]. Fingertip feature extraction used to get the features with accurate positions of fingertips. The fingertips can be tracked in the real-time system with an accuracy of 95% . Convex hull used in this system which incorporate to recognize 24 American signs. It accomplishes the recognition speed of 60 frames/second with precision of 97.1%[2] .

E. Feature Matching

Feature matching is calculated by using Euclidian distance. Euclidian distance is used with feature vector of captured image and feature vector of each stored training data image is calculated using Euclidian distance formula. In this system, template matching algorithms are applied for identifying SIL. System is able to match the160 test images with 320 training dataset images and achieves the accuracy of 98.125%[2]. System comprised of phases like image pre-processing, feature extraction, skin segmentation, and features classification. This system works in real-time and complex background conditions for hand gestures and gains the recognition rate of 93.1%.

F. Pattern Recognition

In last phase of HGRS, Patterns are recognized by using Principal Component Analysis (PCA) used in recognition of features. Feature vectors are provided to train Support Vector Machine (SVM) for recognition of features with recognition rate of 97.73%[11]. Vision-based real-time HGRS provides the classification of features by using SVM algorithm with an accuracy of

93.4%. With Advanced Neural Network (ANN) in HGRS used to identify hand gestures using muscle activity. System recognizes 6 arm gestures achieves the success rate of 97.5%. Real-time system recognizes 10 gestures by using Bag of Features (BOF) with K-Means Scale Invariant Feature (SIFT) whereas SVM algorithm achieves highest recognition rate of 96.23% in complex and dynamic background.

III. PERFORMANCE ANALYSIS OF TECHNIQUES

For sign languages, Feature Recognition is done with bag of features and Support Vector Machine Algorithm. Methods used like Skin Color Segmentation , Distance Distribution features, Color marker to grid the images[8]. For Rotation invariant gesture image, a technique is principal component of hand gestures is with vertical axes. Localized contour sequence (LCS) based feature is used to classify the hand gestures. K-means radial basis function neural network is used for classification of hand[9]. There are three phases canny algorithm for Edge detection, Clipping used to avoid the unnecessary portion after edge detection, Boundary tracing for the final image and the highlighted fingertips on detection[10]. In HGRS, hand detection is first phase where system enables finger touch interaction on planar surfaces uses good camera and skin-detection accuracy with 96.9% with the 40-cm projector distance [8]. HGRS comprises Continuous Adaptive Mean Shift (CAMSHIFT)algorithm to track skin color after ultimate process promotes detection rate of 93.4% [9]. Recognition system entails infrared camera to capture videos of moving objects. System uses Gaussian Mixture Model (GMM) followed by morphological median filtering operation to remove noise in the background subtracted image. Indoor environment system fulfils an average identification rate of 97.73% [10].In HGRS the usage of combination of Haar-like and Histogram of Oriented Gradients (HOG) features. Additionally, some new Haar-like features resort to resolve main Haar-like problem specifically high false positive error rate in hand posture perception. The system confirmed that hybrid method can recognize hand gesture with 93.5%accuracy. Novel approach is integrated to detect pointing vector in 2D space of a room. Points in hand contour utilized for the fingertip are discovered in convex hull and contour with precision of 94%.

It uses the Principal of Curvature Based Region and Wavelet Packet Decomposition and classifies gestures with using the SVM algorithm. The accuracy is getting from this technique is 91.2% for static gestures with complex environment and 86.3% for dynamic gestures with complex environment. Whereas, a technique to recognize the fingerprint gestures in the Indian Sign Language, with use of Artificial Neural Networks and Fourier Descriptors as shape descriptors[4] and get the results with the accuracy of 91.11%. Also, by using Zernike moments and minimum Euclidean distance classifier we are able to recognize 19 of these gestures with an accuracy of 97.22%[5]. Fingertips can be detected using Harris Corner Detectors and the final classification can performed using PCA by which we can achieve the accuracy of 94% for 34 gestures. In order to achieve better performance than achieved from classifications based on a single feature, multiple features have been used together. Some algorithms based on multiple feature with SVM classification for recognizing with the fusion of HOG and SIFT features[6]. Some other feature of fusion technique which combines shape and color and employs the Bag of Words model[7].

IV. RESULTS AND DISCUSSION

In HGRS to recognize the sign languages, there are various techniques used. The performance of these techniques are analyzed on the basis of lighting conditions, background and other conditions of the image taken. Performances of the different techniques will be discussed in detail.

1) HGRS by using BOF, SVM techniques, we can have 96.23% recognition rate, highest recognition time can be 0.017 frames per Second with different lighting condition in complex background.
2) Whereas, SVM, HuInvariant Moment are used in HGRS, time for recognition is 0.1333 frames/second and the recognitionrate of 96.2% in complex background. Real-time HGRS with inertia features and Moment techniques requires recognition rate 96.1 % and recognition time 0.066667 Frames/Second.
3) HGRS with Neural Model requires the lowest recognition rate of 76.1 % incomplex background.K-Nearest Correlated Neighbors performed on the complete set of gestures using HOG features with accuracy of 78.84%. For the

same classification technique applied on SIFT features, an accuracy of 80% achieved.

Table 1. Performances of HGRS Techniques

Techniques	Accuracy	Recognition Time
Haar Wavelet Representation	94.89%	0.4
SVM, Body-Face Centered	93.4%	Not disclosed
BOF, SVM	96.23%	0.017
Centroid of BLOB	90.19%	0.7
Real-Time based on inertia feature & Hu Moment	96.1%	0.066667
K-nearest neighbor, HOG, SIFT	78.84%	Not disclosed
Histogram	87.82%	0.5
Histogram, Skin detection method	93.1%	0.5

V. CONCLUSION

We have studied multiple techniques to recognize hand gestures and sign languages .It is presented on the basis of fragmentation, feature extraction, feature matching used in HGRS.A comprehensive study of performances of various HGRS techniques presented and observations has been drawn from the study. These observations will be very helpful for further research on sign languages in hand gesture recognition system and researchers can put the more additional work from this survey in this domain of sign languages for improving the recognition rate.

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