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# A Static Tamil Sign Language Recognition System

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**Abstract**: Sign language recognition is a very challenging research area. In this paper, a system to recognize static gestures representing Tamil words has been proposed. The recognition of human gestures and facial expressions in image sequences is an important and challenging problem that enables a host of human-computer interaction applications. In this work a new view for recognizing sign language has been proposed. Most researches on continuous sign language recognition were done with frames obtained by processing the videos with regular/equal interval. If a system developed is strong enough for processing the static gestures then it would be the finest system to process the frames obtained while processing the continuous gestures. This work contains three phases of work. First phase is preprocessing, in which the obtained images are processed through the steps like resize, gray conversion, filtering for reducing the distortion and Black and White conversion. Black and white image is taken purposely so that shape descriptors can be applied to extract the required features. Region-based analysis exploits both boundary and interior pixels of an object. Solidity, Perimeter, Convex area, Major axis length, Minor axis length, Eccentricity, Orientation are some of the shape descriptors used as features in this work. Proximal Support Vector Machine classifier has been considered for classification which provides a good result with less computation time for larger datasets. The features derived are used to train the binary classifier first, secondly the testing images has been introduced for classification. Since, we handled a binary classifier we performed a one-versus-all kind of classification. A The proposed Sign Language Recognition System is able to recognize images with 91% accuracy.

**Keywords**: Sign Language recognition, Shape Descriptors, Machine learning, Proximal Support Vector Machine

## I. INTRODUCTION

Sign language as a kind of gestures is one of the most natural means of exchanging information for most deaf people. Sign language recognition has emerged as one of the most important research areas in the field of human-computer interaction. With the widespread use of computers in modern society, traditional human–computer interaction (HCI) technologies based on mouse and keyboard show their increasing limitations. Thus, research on multimodal HCI is becoming more and more important in real life. Sign language recognition (SLR), as one of the important research areas of HCI, has spawned more and more interest in HCI society.

Motion is intimately tied with our behaviour; we move when we communicate through facial expressions and gestures. The estimation and explanation of this sort of human motion is a challenging problem with diverse applications in human-computer interaction, medicine, robotics, animation, video databases, and surveillance etc.

The goal of SLR is to provide an efficient and accurate mechanism to transcribe sign language into text or speech so that “dialog communication” between the deaf and hearing society can come true. From a user’s point of view, the most natural way to interact with a computer would be through a speech and gesture interface. Thus, research on sign language and gesture recognition is likely to provide a shift paradigm from point-and-click user interface to a natural language dialog-and-spoken command-based interface.

In addition, it has many other applications such as providing a “speaking aid” for deaf-mute people by integrating SLR and speech synthesis modules into a digital glove, controlling the motion of a human avatar in a virtual environment via hand gesture recognition, multimodal user interface in virtual reality (VR) system and having a learning demonstration for the robot.

The use of hand gesture [1, 2] is an active area of research in the vision community, mainly for the purpose of sign language recognition and Human-Computer Interaction (HCI). A gesture is spatio-temporal pattern which may be static, dynamic or both. Static morphs of the hands are called postures and hand movements are called gestures. The goal of gesture interpretation is to push the advanced human-machine communication to bring the performance of human-machine interaction close to human-human interaction. Unlike general gestures, sign language is highly structured so that it provides an appealing test bed for new ideas and algorithms before they are applied to gesture recognition.

Human gestures constitute a space of motion expressed by the body, face, and/or hands. Among a variety of gestures, the hand gesture is the most expressive and the most frequently used one. In this work, we define a gesture as a meaningful part of the hand motion to

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communicate with a computer. The interaction using hand gestures has been studied as an alternative form of human-computer interface by a number of researchers.

For signer-independent SLR [3], there are two difficulties: (1) the model convergence difficulty caused by noticeable distinctions among different people signs. For a robust signer-independent recognition model, the training data must be collected from different signers. This makes the training data very massive. Since different people vary their hand shape size, body size, operation habit, rhythm, and so on, the noticeable distinctions between the data of the same sign due to different signers are almost larger than sign variations due to the change in the sign identity. (2) The lack of effective features extracted from different signers' data. Unlike speech recognition in which every speech feature has been profoundly explored, the research on the feature extraction of SLR is still in its infancy. How to effectively extract common features from different signers is a more challenging problem that needs to be solved.

There are two main directions in sign language recognition. One is using data gloves and other is visual approach. Instrumented glove approach simplifies the recognition but complicates the hardware. Also it is expensive and less user friendly. On the other hand, vision based approach [1] is most suitable, user friendly and affordable. So, it is widely used. Hence, a vision based approach is used to recognize signs of Tamil Sign Language.

Every country and state has its own and developing sign language. There are different sign languages all over the world such as American Sign Language (ASL), British Sign Language (BSL), French Sign Language, Australian Sign Language, Indian Sign Language (ISL), etc. All these sign languages were developed independently. There is no unique way in which such recognition can be formalized. In the same way, Tamil Sign Language is developing for Tamil deaf community. This paper tries to provide a solution for this community in which it recognizes a set of hand gestures which will be ultimately rendered as spoken words. Each hand gesture corresponds to a word in Tamil Sign Language.

The major challenges that SLR faces now are developing methods that solve signer-independent continuous sign problems [3, 4, 5]. Signer independence is highly desirable since it allows a system to be used straight out of the box and it allows the system to be built for the signer who is not known beforehand. The ability to recognize signer-independent and continuous sign language [4], without the introduction of artificial pause, has a profound influence on the naturalness of the human–computer interface.

The task of locating meaningful patterns from a stream of input signal is called pattern spotting. Gesture spotting is an instance of pattern spotting where it is critical to locate the start point and the end point of a gesture pattern. It has been regarded as a highly difficult task mainly due to two aspects of signal characteristics: segmentation ambiguity and spatio-temporal variability.

In this work static hand and facial gestures has been taken for processing. Tamil sign hand gestures are collected from a specially aided person which are shown in Fig. 1. are some of the static gestures. The collected signs are of different shape, scale and brightness. Since the continuous SLR is the only remedy for the deaf-dumb community to communicate with normal people and so far to develop a continuous SLR many researchers has processed the continuous gestures by splitting it into isolated signs, so if a system has been developed to recognize the complete dataset of isolated signs in perfect then it would be simplest work to develop a continuous SLR which is an idea lying behind of this work.

Fig. 1 A collection of static gesture images

## II. PROPOSED WORK

Signs vary from person to person so; it is very significant for the researchers of sign language recognition to develop a system which recognizes the sign of deaf/dumb person is a very challenging task. Various factors like color, angle, and position of hand disturb the perfect recognition of the signs.

The main objective of this work is to develop a Tamil sign language recognition system for deaf-dumb people using image processing techniques. In the proposed method, single right hand palm image, two handed Tamil sign gestures and also hand with facial gestures are taken to process. This work contains three phases of work. First phase is preprocessing, in which the obtained images are processed through the steps like resize, gray conversion, filtering for reducing the distortion and Black and White conversion. Second phase is feature extraction, in order to extract the necessary feature vectors from the output obtained at the pre-processing phase, Shape Descriptor/Moment Descriptor (MD) [6, 7] has been selected. Moment Descriptor is one of the well-known methods of shape matching. MD has been used when a region based analysis of the object is performed. Finally, Proximal Support Vector Machine (PSVM) [8] classifier is

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used to recognize the signs from trained set of hand gestures.

In the proposed work an image processing techniques are handled in a way to get a better classification result. Factors affecting the recognition result are eliminated by selecting a right set of features. Features are the decisive key for this sign language recognition application. In this work an image processing technique has been presented and designed for recognizing the signs of Tamil language for deaf-dumb/dumb persons. It perfectly recognizes the Tamil sign language by comparing the sample images of different persons with previously available standard set of images.

The recognition of human gestures and facial expressions in image sequences is an important and challenging problem that enables a host of human-computer interaction applications. In the proposed work a new view for recognizing sign language has been proposed. Most researches on continuous sign language recognition were done with frames obtained by processing the videos with regular/equal interval. If a system developed is strong enough for processing the static gestures then it would be the finest system to process the frames obtained while processing the continuous gestures.

## III. System Methodology

A vision based analysis is used in the present work. Vision based analysis, is based on the way human beings perceive information about their surroundings, yet it is probably the most difficult to implement in a satisfactory way. Several different approaches have been tested so far.

• One is to build a three-dimensional model of the human hand. The model is matched to images of the hand by one or more cameras, and parameters corresponding to palm orientation and joint angles are estimated. These parameters are then used to perform gesture classification.

• Second one to capture the image using a camera then extract some features and those features are used as input in a classification algorithm for classification.

In this work we have used second method for modeling the system. The block diagram shown in Fig. 2. describes the steps involved in the project.

The system model includes four stages like,

1. Input image
2. Preprocessing
3. Feature extraction
4. Classification

All these four stages are discussed briefly in the way how the hand gesture images are handled at that stages can be seen further.

### *A. Image acquisition*

A collection of 40 static hand images as well as hand images with facial gestures are taken by using USB connected camera. Since a vision based analysis has been performed, a certain limitations are followed such as black background and fixed distance between the signer and the background and also between the signer and the camera.

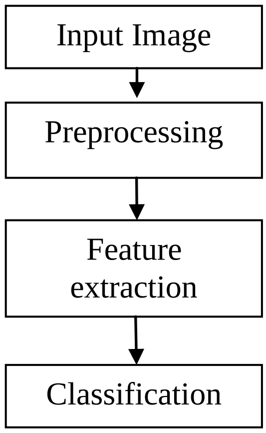


Fig. 2 System Overview

Each image holds an unique sign represents a Tamil word. The resolution of grabbed image is too large (for clarity) to process so that the image is cropped to reduce the size and so finally got an image of size 480×640. For fast processing of images at various stages captured images are then resized to a resolution of 200×200 which is given as input to the next stage of the project.

### *B. Preprocessing*

Preprocessing is very much required task to be done in sign language recognition system. Preprocessing is applied to images before extracting features from hand images. Preprocessing consists of two steps

- Segmentation
- Gaussian filtering

Segmentation is done to convert gray scale image into binary image so that we can have only two object in image one is hand and other is background. After converting gray scale image into binary image we have to make sure that there is no noise in image so we use Gaussian filter technique.

A very good segmentation is needed to select adequate threshold of gray level to extract hand from background *.i.e.* there is no part of hand should have background and background also shouldn't have any part of hand.

If we take close look into the segmented image sometime we find that the segmentation is not perfectly done. Background may have some 1s which is known as background noise and hand gesture may have some 0s that is known as gesture noise. A Gaussian filtering approach has been applied to obtain a smooth, closed, and complete contour of a gesture.

A Gaussian filter (also known as Gaussian smoothing) is the result of blurring an image by a Gaussian function. It is a widely used effect in graphics software, typically to reduce image noise and reduce detail. Gaussian blur has the effect of reducing the image's high-frequency components; a Gaussian blur is thus a low pass filter.

The desired output at the preprocessing stage is Black and White (BW) image which is obtained by using some of the image processing techniques like RGB to gray

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conversion, filtering and thresholding. The first stage result is shown in Fig. 3.

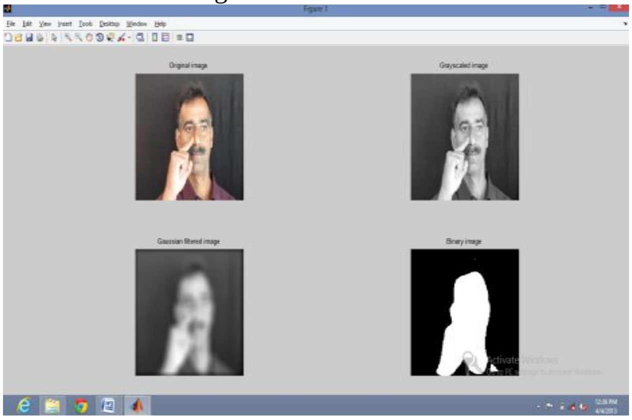

Fig. 3 Preprocessing stage

*C. Feature extraction*

In this work shape descriptors have been handled which are used when a region based analysis of the object is performed. In region based techniques, all the pixels within a shape are taken into account to obtain the shape representation. Common region based methods use moment descriptors to describe the shape. Because moments combine information across an entire object rather than providing information just at a single boundary point, they capture some of the global properties missing from many pure contour-based representations: overall orientation, elongation, etc.

Region-based analysis [6, 7] exploits both boundary and interior pixels of an object. Solidity, Perimeter, Convex area, Major axis length, Minor axis length, Eccentricity, Orientation are some of the shape descriptors used as features in this work. These shape descriptors are more robust to noise and distortions. Region-based analysis are invariant to translation, rotation and scale. They are also computationally simple. Let us review the features handled in this work.

*1) Solidity*: Scalar specifying the proportion of the pixels in the convex hull that are also in the region. In simple terms density in mass per unit volume. But in two dimensional image objects this can be defined as the ratio between the area and convex area of the same object:

$$Solidity = \frac{Area}{Convex\ area}$$

For a solid object or cell, this value is 1, while the value is lower for an object having a rough perimeter or an object which has holes in it.

***2)*** *Perimeter:* Perimeter is an important feature of an object. Contour based features which ignore the interior of a shape, depend on finding the perimeter or boundary points of the object. Scalar specifying the distance around the boundary of the region. It is computed by calculating the distance between each adjoining pair of pixels around the border of the region. If the image contains discontiguous regions, region props returns unexpected results.

***3)*** *Convex Area:* Scalar that specifies the number of pixels in 'Convex Image'. This property is supported only for 2-D input label matrices. Convex Image is a binary image (logical) that specifies the convex hull, with all pixels within the hull filled in (i.e., set to on). The image is the size of the bounding box of the region. This property is supported only for 2-D input label matrices.

*4) Eccentricity:* Eccentricity is the ratio between the length of the short axis to the long axis as defined in the following equation.

$$Eccentricity = \frac{Minor\ length\ axis}{Major\ length\ axis}$$

The value of eccentricity is between 0 and 1. (0 and 1 are degenerate cases; an ellipse whose eccentricity is 0 is actually a circle, while an ellipse whose eccentricity is 1 is a line segment.) Eccentricity is also called ellipticity with respect to minor axis and major axis of the ellipse. If the major axis gets longer, eccentricity gets higher. This property is supported only for 2-D input label matrices.

5) *Major Axis Length:* Scalar specifying the length (in pixels) of the major axis of the ellipse that has the same normalized second central moments as the region. This property is supported only for 2-D input label matrices.

6) *Minor Axis Length:* Scalar specifying the length (in pixels) of the minor axis of the ellipse that has the same normalized second central moments as the region. This property is supported only for 2-D input label matrices.

Major and minor axes are the simplest of all features but yet important. They give essential information of an object such as elongation, eccentricity etc. They are also used to find other features like elliptic variance. The major axis points are the two points in an object where the object is more elongated and where the straight line drawn between these two points is the longest. Major axis points are calculated by all possible combinations of perimeter pixels where the line is the longest

7) *Orientation:* Scalar specifying the angle (in degrees ranging from -90 to 90 degrees) between the x-axis and the major axis of the ellipse that has the same second-moments as the region. This property is supported only for 2-D input label matrices.

*D. Classification*

The support vector machine (SVM) has performed successfully in many real-world problems. The SVM is attractive in its ability to condense the information contained in the training set and to find a decision surface determined by certain points in the training se. For multiclass problems [9], the computation can be very challenging even for moderately sized datasets if the number of classes *k* is large. Proximal support vector machines (PSVM) were recently introduced as a variant of SVM [10] for binary classifications which has been handled in this work.

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Standard support vector machines (SVMs), which are powerful tools for data classification, classify 2-category points by assigning them to one of two disjoint half spaces in either the original input space of the problem for linear classifiers, or in a higher dimensional feature space for nonlinear classifiers. Recently much simpler classifier, the proximal support vector machine (PSVM) [8, 11], were implemented. In proximal support vector classification two parallel planes are generated such that each plane is closest to one of two datasets to be classified and the two planes are as far apart as possible. However, it is much faster to train a PSVM classifier by simply solving a system of linear equations.

Extensions of the PSVM multiclass problems [12, 13, 14] have been considered based on the one-versus-rest scheme. The main idea here is to solve $k$ binary classification problems by separating one class from the rest, then construct the decision rule according to the maximal output. This approach has been considered in this work for classifying images belonging to different set of classes. We first review the standard SVM and then move to the PSVM.

*1) Standard SVM Classifier:* The idea of a support vector machine is to construct a decision surface in the form of a hyper plane that separates or set apart the datasets of two classes in such a way that the margin of separation between the two classes is maximized. In case of the nonlinearly separable dataset, input data are projected into another high dimensional feature space with the help of kernel function which made the data separable in that space. After that SVM finds a linear separating hyper plane in this higher dimensional space having the maximal margin. The decision surface is linear in the high dimensional feature space but it is nonlinear in input space. The parameters of the solution or optimal hyper plane are derived from the optimization of the cost function subjected to inequality constraints.

The standard SVM algorithm aims to find an optimal hyper plane $w.x + b = 0$ and use this hyper plane to separate the positive and negative data. The classifier can be written as:

$$f(x) = \begin{cases} +1, & if\ w.x + b \geq 0 \\ -1, & if\ w.x + b \leq 0 \end{cases}$$

The separating hyper plane is determined by two parameters $w$ and $b$ . The objective of the SVM training algorithm is to find $w$ and $b$ from the information in the training data.

$$\min \frac{1}{2} \left|\left|w\right|\right|^2 + C \sum_i \xi_i \qquad (1)$$

$$\text{s.t. } \forall i, y_i(w.x_i + b) + \xi_i \geq 1 ,$$

$$\xi_i \geq 0$$

The first term $\left|\left|w\right|\right|^2$ controls the margin between the positive and negative data. $\xi$ represents the training error of the $i^{th}$ training example. Minimizing the objective function of (1) means minimizing the training errors and maximizing the margin simultaneously. $C$ is a parameter that controls the tradeoff between the training errors and the margin.

The optimization problem (1) can be converted to a standard Quadratic Programming problem. Many efficient methods have been proposed to solve this problem on large scale data.

*2) Proximal SVM Classifier:* The proximal SVM also uses a hyperplane $w.x + b = 0$ as the separating surface between positive and negative training examples. But the parameter $w$ and $b$ are determined by solving the following problem.

$$\min \frac{1}{2} (\left|\left|w\right|\right|^2 + b^2) + C \sum_i \xi_i{}^2 \qquad (2)$$

$$\text{s.t. } \forall i, y_i(w.x_i + b) + \xi_i \geq 1$$

The main difference between standard SVM (1) and proximal SVM (2) is the constraints. Standard SVM employs an inequality constraint whereas proximal SVM employs an equality constraint. We can see that standard SVM only considers points on the wrong side of $w.x_i + b = 1$ and $w.x_i + b = -1$ as training errors.

However, in proximal SVM, all the points not located on the two planes are treated as training errors. In this case the value of training error $\xi_i$ in (2) may be positive or negative. The second part of the objective function in (2) uses a squared loss function $\sum_i \xi_i{}^2$ instead of $\sum_i \xi_i$ to capture this new notion of error. The proximal SVM made these modifications mainly for efficiency consideration. This modification, even though very simple, changes the nature of optimization problem significantly.

## IV. System Methodology

The system for recognizing a set of Tamil sign words has been developed by using MATLAB R2010a which is processed in a Windows 8 Operating system. MATLAB, which stands for **MAT**rix **LAB**oratory, is a state-of-the-art mathematical software package, which is used extensively in both academia and industry. It is an interactive program for numerical computation and data visualization, which along with its programming capabilities provides a very useful tool for almost all areas of science and engineering. MATLAB is one of the finest and efficient tool for any signaling and image processing related applications.

The recognition of human gestures and facial expressions in image sequences is an important and challenging problem that enables a host of human-computer interaction applications. In this work a new view for recognizing sign language has been proposed. Most researches on continuous sign language recognition were done with frames obtained by processing the videos with regular/equal interval. If a system developed is strong enough for processing the static gestures then it would be the finest system to process the frames obtained while processing the continuous gestures.

The collected signs are of different shape, scale and brightness. Signs vary from person to person so; it is very

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significant for the researchers of sign language recognition to develop a system which recognizes the sign of deaf/dumb person is a very challenging task. Various factors like color, angle, and position of hand disturb the perfect recognition of the signs. Factors affecting the recognition result are eliminated by selecting a right set of features. Features are the decisive key for this sign language recognition application. BW image is taken purposely so that shape descriptors can be applied to extract the following features like solidity, perimeter, convex area, eccentricity, major axis length, minor axis length and orientation.

All the features mentioned above are interrelated with one another. For example, to measure the eccentricity we need the major axis and minor axis length values so that each feature depends on one another only for the corresponding image and does not depends on feature of other images. But in some cases the features like solidity are found to have mere closer values for all set of images eventhough it does not affect the system performance anyhow. The features obtained for the binary image of Fig. 3. is shown in Fig. 4.

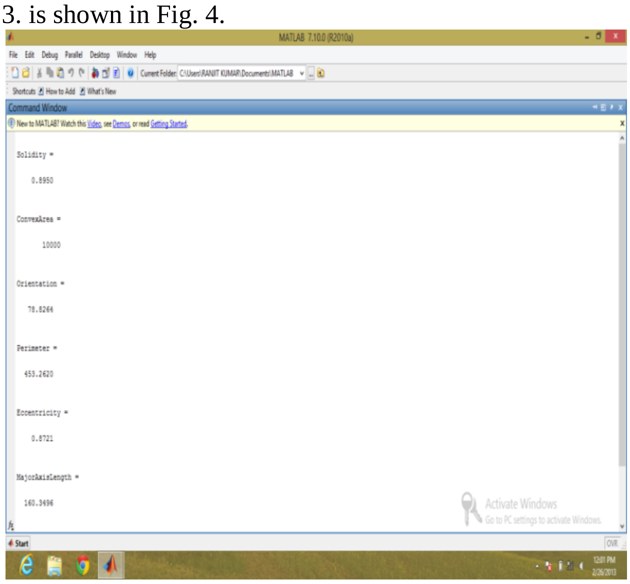


Fig. 4. Features extracted from the binary image

The extracted features of all trained set of images are grouped together as a matrix and each row of matrix represents the feature set of individual image of training group. The same is carried out for the testing dataset.

PSVM classifier is a machine learning classifier so, initially the classifier is trained (made to learn) with training dataset and when newly applicable (testing data) data are given to the classifier it has to classify with prediction to which class it belongs to.

In PSVM the data of interest is classified based on the separating parallel planes. In proximal support vector classification two parallel planes are generated such that each plane is closest to one of two datasets to be classified and the two planes are as far apart as possible. However, it is much faster to train a PSVM classifier by simply solving a system of linear equations. One of the result obtained by using the proposed classification technique (PSVM) is shown in Fig. 5.

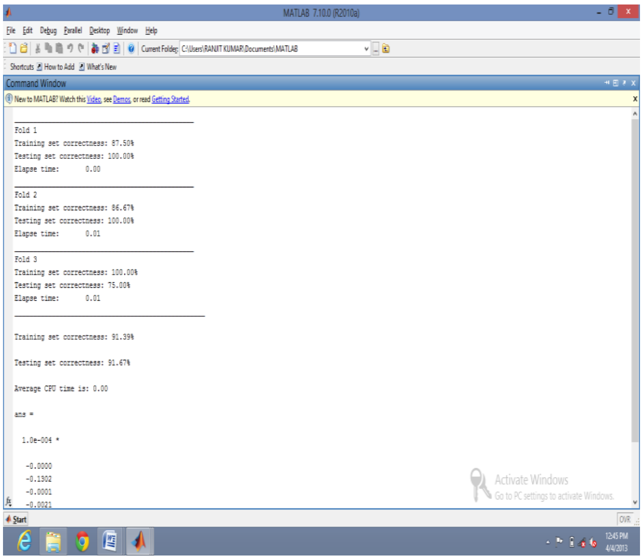


Figure 5. Classifier result.

## V. CONCLUSION AND FUTURE WORK

Sign language recognition is a wide area of research. The aim of this work is to develop a Tamil sign language recognition system for deaf-dumb people. In this project, an image processing technique has been presented and designed for recognizing the signs of Tamil language for deaf-dumb persons. In this work more data has been collected and processed. Instead of taking only static hand gestures additionally hand with facial gestures are taken. So, a large set of data are processed with extracted features called moment descriptors which are classified by using the Proximal Support Vector Machine classifiers. The results of the classification technique is evaluated and found that Proximal Support Vector Machine works as well with 91% accuracy. The work presented in this paper recognizes static signs only. In future, the work can be extended to recognize the dynamic signs of Tamil Sign Language. Now, the system deals with images with, uniform background, but it could be made background independent.

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