Quantitative Analysis Of Facial Palsy

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DECLARATION

We hereby declare that this submission is our own work and that, to the best of our knowledge and belief, it contains no material previously published or written by another person nor material which has been accepted for the award of any other degree or diploma of the university or other institute of higher learning, except where due acknowledgment has been made in the text.

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CERTIFICATE

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SUMMARY

Quantitative assessment of facial function is challenging, and subjective grading scales such as House–Brackmann, Sunnybrook, and eFACE have well-recognized limitations. Machine learning (ML) approaches to facial landmark localization carry great clinical potential as they enable high-throughput automated quantification of relevant facial metrics from photographs and videos. However, the translation from research settings to clinical application still requires important improvements. To develop a novel ML algorithm for fast and accurate localization of facial landmarks in photographs of facial palsy patients and utilize this technology as part of an automated computer-aided diagnosis system.Portrait photographs of 8 expressions obtained from 200 facial palsy patients and 10 healthy participants were manually annotated by localizing 68 facial landmarks in each photograph and by 3 trained clinicians using a custom graphical user interface. A novel ML model for automated facial landmark localization was trained using this disease-specific database. Algorithm accuracy was compared with manual markings and the output of a model trained using a larger database consisting only of healthy subjects. In this study we demonstrated that ML approaches can provide objective, automatic, and accurate facial measurements in photographs of patients suffering from facial palsy, so that these methods have the potential of disrupting the current clinical practice for diagnosis and assessment of the condition. However, our results demonstrated that publicly available models, trained with databases of healthy subjects, provide significantly worse landmark localization accuracy when applied to photographs of patients. We also demonstrated that by retraining the facial landmark localization model using a small number of photographs from a disease-specific clinical database, it is possible to significantly improve the facial landmark localization accuracy in this patient population. The standardized recording conditions (pose, illumination, expression, and background) of photographs in the clinical database likely explain the observed high accuracy of the model, despite use of a relatively small training data set. These results supported our hypothesis that a novel model for facial landmark localization trained using disease-specific photographs would demonstrate improved tracking accuracy when presented with faces of patients with the condition, in comparison with the model trained using a much larger database of normal subjects.

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1. **SVM** - Support Vector Machine
2. **CNN** - Convolutional Neural Network
3. **FPA** - Facial Paralysis
4. **PIE** - pose, illumination, and expression
5. **TSM** - Tree Structured Model
6. **H-B** - House-Brackmann
7. **LFPW** - Labeled Face Parts in the Wild

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Chapter 1 Introduction -

1.1 General Introduction

Bell's palsy is an acute idiopathic peripheral facial nerve paralysis of sudden onset and accounts for approximately 75% of acute facial nerve paralysis. Facial nerve paralysis has been known since ancient times by the Egyptians, Greeks, Romans, Incas, and other native cultures. The first medical studies of the disease should be attributed to Avicenna. He was the first to record the differences between central and peripheral facial paralysis.

Although the name of Sir Charles Bell, who published his findings in 1821, is usually associated with this condition, there are two papers, one published by Niclaus A. Friedrich in 1798 and the other by Richard Powell in 1813, whose observation of onset, physical findings, natural history, and recovery preceded those of Charles Bell. Acute idiopathic peripheral facial palsy is a common disease with an annual incidence of 15–30 per 100,000 population. Most patients recover completely, but about 15–30% are reported to be left with different degrees of sequelae. There are many possible causes of Bell's palsy, but still the aetiology remains obscure. The term Bell's palsy should be restricted to idiopathic facial palsy. Various reasons account for the scanty information on the incidence of Bell's palsy. Different specialties are involved in the management of patients with Bell's palsy; patients do not look for treatment as the condition is painless and frequently limited, or of short duration.

Facial paralysis (FP, also known as peripheral facial nerve paralysis) occurs on one or both sides of the face when the cranial nerve is injured. Such an injured nerve, being originally responsible for several functions in the face, is not able to control muscles for normal facial motions. Therefore, facial asymmetry would commonly appear in FP patients that cause significant inconveniences to their daily life (e.g., work and social communication). Timely and effective treatment of FP can alleviate the facial disfigurement, where an objective diagnosis of FP plays an important role in the whole procedure of treatment.

1.2 Problem Statement

Spontaneous idiopathic facial nerve (Bell's) palsy leaves residual hemifacial weakness in 29% which is severe and disfiguring in over half of these cases. Right now there is no robust method or device which measures the severity of facial paralysis or even tells the difference between the facial landmark points of Facial Palsy patients. Therefore, a proper method is needed such that we can detect the Facial Palsy and analyze it, and provide proper diagnosis to the disease.

1.3 Significance/Novelty of the problem

It may represent a reasonable facial grading option across disciplines in the future that will help the doctors and therapists to early detect and provide the suitable treatment to the patients, such that they can recover from this disease as soon as possible.

1.4 Brief Description of the Solution Approach

We employed a popular approach for automatic facial landmark localization in facial photographs known as cascade of regression trees. Specifically, we employed the algorithm proposed by Kazemi and Sullivan, which provides accurate facial landmark localization results under multitude of pose, illumination, and expression (PIE) conditions and can process medical images in just a few hundred milliseconds without the use of graphical processing units or other specialized hardware. Implementation of this algorithm for facial landmark localization is readily available in open source ML libraries such as OpenCV and Dlib. These implementations were trained using an open source data set comprising nearly 270 images which have 50% healthy faces and 50% of those who are suffering from facial palsy. From the Intelligent Behavior Understanding Group (iBUG). Model training has been performed by manually annotating a set of facial landmarks in each photograph using the 68-point Carnegie Mellon University multiple pose, illumination, and expression (multi-PIE) database approach. Manually annotated landmarks outlined the superior border of the brow, the free margin of the upper and lower eyelids, the nasal midline, the nasal base, the mucosal edge and vermilion–cutaneous junction of the upper and lower lips, and the lower two-thirds of the face. After landmark extraction we used SVM and Logistic Regression to detect palsy in the face. We have done data analysis and visualization of data is done through Matplotlib.

1.5 Comparison of existing approaches to the problem framed

Earlier there were not so good approaches for doing the facial landmarking and analyzing the important facial features which help in detecting the facial palsy easily, but our solution helps in easily detecting the palsy through the plotting of important facial features, and applying the traditional machine learning algorithms like Logistic Regression and Support Vector Machine.

Chapter 2 Literature Survey-

2.1 Summary of papers studied

[A] ***Efficient quantitative assessment of facial paralysis using iris segmentation and active contour-based key points detection with hybrid classifier :-***

Due to time consuming traditional methods for detection of facial palsy, it is difficult for therapists to start working on the rehabilitation process of the patients.

Authors proposed a solution based on a machine learning model (and provided accuracies of different classification methods) which detects type and severity of the facial palsy by using iris segmentation , facial symmetry and important landmarks on the face of patients.

Preprocessing : Face dimension alignment, removal of anything except face, noise removal, contrast enhancement (using median filtering) and conversion to grayscale.

Model combining of Localized Active Contour and optimized Daugman's algorithm is used for extraction of facial key points (landmarks) and iris.

Symmetry score of face is calculated using a ratio between landmarks extracted from both sides of the face.

A hybrid of logistic regression and rule based classifier is used for determining healthy and unhealthy subjects.

[B] ***Binarized Convolutional Landmark Localizers for Human Pose Estimation and Face Alignment with Limited Resources :-***

Through this paper authors propose a parallel and multiscale residual architecture for face alignment and estimation of human pose (landmark localization), which will be suitable for cases with limited computational resources while retaining performance of CNN.

Models were trained using Imagenet classification using binary CNN and RMSprop. For training of 3D-face alignment, randomly augmented images with flipping and rotation

between -40 to 40 degrees is taken and trained for nearly 55 epochs.

For training of human pose estimation a similar method is used for nearly 100 epochs. Torch7 is used for implementation of the models.

[C] ***A Fully Global Approach to Image Segmentation via Coupled Curve Evolution Equations :-***

Through this paper authors propose a universal approach for segmentation of images which have a known number of regions which can be differentiated using certain characteristics.

Coupled Curve Evolution(CCE) is used in the approach. CCE is derived from the principle of separating the values of statistics maximally, within the background subject and curves.

Some advanced mathematical constraints were put in place to extend the application of this model to a larger class of images.

[D] ***Automatic recognition of facial movement for paralyzed face :-***

Authors propose a machine learning based hybrid model to recognize different patterns of facial movements and evaluate severity/degree of facial nerve paralysis.

Hybrid of Active Shape Models and Local Binary Patterns (ASMLBP) is used. Preprocessing:Active Shape Model is used for locating facial landmarks like pupils, nose, lips etc.

Preprocessing: Length of pupils is scaled to 68 pixels, forehead is scaled to 85 pixels and then image is cropped to 138x196 rectangle.

ASM is used to locate 68 key points on the face. LBP is used to extract the movement features of eight regions on the face.

[E] ***Detecting Visually Observable Disease Symptoms from Faces :-***

Authors proposed a machine learning based approach to detect facial anomalies and classify them into multiple visible facial disease categories to reduce the possible medical reasons of the abnormality.

Preprocessing : Colour space was converted from RGB to CIELAB with two channels

(A & B).

Feature Extraction : Active shape models with 194 landmarks are used to extract facial features like eyes, lips etc.

Anomaly Detection : Anomaly is detected using the statistical data collected from training dataset.

[F] ***Convolutional Experts Network for Facial Landmark Detection :-***

In this paper the authors have proposed an algorithm called Convolutional Experts Constrained Local Model (CE-CLM) which is the better method for facial landmark detection, as earlier facial landmarking was being done by Constrained Local Model methods.

First of all the region of interest (ROI) is taken out from the input image, and the region of interest is the 2D image of size n*n, after that the ROI is convolved with a contrast normalizing convolutional layer with shape 500x11x11, basically it stretches the range of intensity values, after that the output is convolved with the Rectified Linear Unit neurons layer of 200x1x1. Now there is a convolutional layer of Mixture of Experts which is of size 100x1x1 which uses sigmoid activation function and at last we get a response map, and it is non-negative.

The model was trained with the help of Helen training set and LFPW, after that results were calculated on the basis of size normalized median per image error, and it was tested for two image variations i.e frontal and profile, and in both the cases this model showed the best results.

[G] ***Deep Geodesic Learning for Segmentation and Anatomical Landmarking :-***

In this paper the authors have proposed the deep geodesic learning technique to do the segmentation in the mandible region and also identifying the 9 landmarks in that region and marking it in the geodesic space.

Segmentation Network – An algorithm is proposed for the segmentation of the mandible region, which is based on DenseNET also known as Tiramisu. There are actually two paths in this network the first is Downsampling and the other is Upsampling. So first the input is sliced and it is convolved (3*3), after that we have dense network blocks for down

transition and after that we have dense network blocks for up transition and then at the last convolution (1*1) is done again.

Geodesic Learning of Landmarks – Displacement maps which are also called heat maps are generated for x,y and z axes, which are created using Euclidean metric, and to map it to a Geodesic space using Geodesic Distance Transform.

Localization of closely spaced landmarks- Here the landmark locations of the mandible region are identified, LSTM network is used here. First of all the landmarks are classified and then LSTM network helps to plot 9 landmark points of the mandible region. The deep networks were trained for 50 patients CBCT scans, each patient's scan included 512 slices therefore total images were 25600 to train the system.

[H] ***Context-Guided Fully Convolutional Networks for Joint Craniomaxillofacial Bone Segmentation and Landmark Digitization :-***

In this paper the author has proposed the method of bone segmentation and landmark digitization, with the help of full convolutional networks.

First of all the input is a CBCT image, in this we apply a fully convolutional network with an architecture of U-Net in two stages. In the first stage, the important step is to capture the spatial information from the image. So after this stage we get a displacement maps for all the three axes i.e x,y and z, and after this in the second stage of FCN the input data will be the original image and the displacement maps which we have generated in the previous stage, and the output of this stage is the segmentation maps and landmark heatmaps. Overall we can say that our system contains two subnetworks, FCN1 and FCN2. After that the training of FCN1 and FCN2 are done together.

[I] ***Bell's Palsy - A Prospective Study :-***

This article helps to understand what actually Bell's palsy(facial paralysis) is and how it occurs. It has also discussed some experimental treatment techniques and its effects. The main objective of this paper is to discuss Bell's palsy, symptoms and recovered rate.

Bell's palsy is actually a facial nerve paralysis, it's a common disease which occurs to 15-30 people per 100,000 population. Most parents recover from this disease only 15-20% are not able to recover fully. The main and common symptoms were they feel pain before the attack, their hearing power gets less and also their taste sensation gets affected. Almost 80%

of the people got fully recovered from this disease while the others required some follow up period.

[J] ***Automatic Facial Paralysis Assessment via Computational Image Analysis:-***

In this paper the authors have proposed an automatic technique to assess the grade of facial paralysis i.e Bell's palsy, they have used data collected from the LSCI device, and three learning methods are used i.e NN, SVM and K-NN to quantify the data.

In this study first of all facial blood flow measured images are taken with the help of LSCI technology of the Bell's palsy patient. After that the 3D face is also constructed with the help facial colour image and Surrey face model with the help of reconstruction algorithm. After that the facial landmarking is done, so that we can perform facial blood image segmentation. So next we get the landmark points of the face, and with the help of camera matrix and surrey face model we get the segmented image of the facial blood image segmentation, which represents in which segments how much blood is flowing. After that the quantitative analysis is being done with the help of K-NN, SVM and NN classifiers. These classifiers help us to divide the patients into two categories i.e left side paralysis and right side paralysis. And then the average blood flow is calculated for all the regions which gives the HB Score classifier.

[K] ***Deep Hierarchical Network with Line Segment Learning for Quantitative Analysis of Facial Palsy:-***

In this work, the author tries to extract features from the images provided in the dataset and to detect the severity level of the Facial Palsy. We implemented three algorithms dependent on each other to generate the results. Used computer Vision to extract important features from the image and then implemented a DarkNet Deep Hierarchical Network Model to get the region with deformity in the face.

The detailed Methodology is discussed as follows: There are three main stages of detecting the facial palsy region- FACE DETECTION, FACIAL LANDMARK LOCALIZATION, DETECTION OF FACIAL PALSY REGION

a) FACE DETECTION: The face detector is built over YOLO2. In this we detect the facial region and crop the region of the face in a 11x11 matrix of values with each cell associated with 2 bounding boxes for prediction, and only one class (face) is considered.

b) FACIAL LANDMARK LOCALIZATION: We are using the VGG-16 to detect the line segments or the main informative points over the whole face. The line segments are obtained by connecting the neighbouring landmarks in each training image, generating a target line segment map for learning.

c) DETECTION OF FACIAL PALSY REGION: The facial palsy region detector takes the facial image combined with the facial line segment image as input and delivers the local palsy image in the output.

[L] ***WIDER FACE: A Face Detection Benchmark:-***

In this work, the author detects faces of the people irrespective of the situation the user is in. It can be attributed to different pose, scale, facial expression, occlusion, and lighting condition. Author shows an example of using WIDER FACE through proposing a multi-scale two-stage cascade framework, which uses divide and conquer strategy to deal with large scale variations. A set of convolutional networks with various sizes of input are trained to deal with faces with a specific range of scale.

To detect a wider face, the author proposes a multi scale two-stage cascade framework and employ a divide and conquer strategy. Specifically, it trains a set with the face detectors. The first stage generates a multi-scale proposal from a fully CNN network. The second stage is a multi-task CNN network that generates face and non-face prediction of the candidate window obtained from the first stage.

[M] ***Deep Face Recognition:-***

In this work, the author extracts the face either for the single photograph or from a set of faces tracked in a video. The main used methodologies are CNN.

Consider three architectures based on the A, B, and D architectures. The CNN architecture A is given in full detail in Table 3. It comprises 11 blocks, each containing a linear operator followed by one or more non-linearities such as ReLU and max pooling. The first eight such blocks are said to be convolutional as the linear operator is a bank of linear

filters (linear convolution). The input to all networks is a face image of size 224x224 with the average face image (computed from the training set) subtracted – this is critical for the stability of the optimisation algorithm.

[N] ***Regressive Tree Structured Model for Facial Landmark Localization:-***

In this work, the author developed a Regression Tree model for facial landmark localization points. The Tree Structured Model(TSM) is proven effective for solving face detection, pose estimation and landmark localization in an unified model. The authors developed a Regressive Tree Structure model(RTSM) to improve the run time speed and localization accuracy.

The RTSM is composed of a coarse TSM (c-TSM), a refined TSM(r-TSM) and a BSVR(bilateral Support Vector Machine). The c-TSM is designed for fast detection of face candidates which is further processed by r-TSM for locating landmarks and pose estimation. The landmarks considered in the r-TSM are a partial set of those in the original TSM. The rest of the dense set of landmarks are estimated using the forward BSVR instead of the time-consuming part-based model. The BSVR is trained on the shape model with dense landmarks only and without considering appearance features, resulting in a fast landmark detector.

[O] ***A Smartphone-Based Automatic Diagnosis System for Facial Nerve Palsy:-***

In this work, the author describes a smartphone based automatic diagnosis System for facial nerve palsy. To classify facial nerve palsy, we used Linear Discriminant Analysis(LDA), Support Vector Machine(SVM) and Leave-One-Out Cross Validation(LOOCV) with 36 subjects. The clinical assessment system of facial nerve palsy is an important tool for diagnosing, monitoring and treating facial nerve palsy. The House-Brackmann (H-B) scale is a widely accepted system that grades the facial function from normal (grade 1) to total paralysis (grade 6) [1]. The disadvantage of the H-B scale is its subjective assessment characteristics, which are not reliable and vary among clinicians.

The detailed Methodology is discussed as follows:

a) Data Acquisition: In this step we record the people and collect the data as described under the database heading and store it at a single place.

b) Feature Extraction: The asymmetric index was calculated using the displacement of shape point sets that correspond to the eye-brows and mouth regions while the participants performed facial movements. To extract the asymmetric index, the forehead and eye regions were used based on the H-B scale and heuristic approach.

c) Subjects: A total of 36 volunteers participated in the study. Of these, 23 subjects suffered from facial nerve palsy and 13 were normal subjects without facial disorders.

[P] ***Automatic Grading of Palsy using Asymmetrical facial features:-***

In this paper the authors suggested to use facial landmarks that will be tracked by a regression model. Then normal and palsy images are classified using a support vector machine. The authors also suggested to use smile as another measure to detect facial palsy level.
The detailed methodology is discussed as follows:-

Preprocessing:-Authors performed preprocessing that involves facial images to be aligned in upright position. All the color images are converted to gray scale images to remove unwanted color. Face images are converted to 200x200 pixels with 100 pixels distance.

Data Augmentation:- We have generated 5 types of facial palsy level for the original image including mid,moderate,moderately-severe,severe and total paralysis which helps in training our CNN. Author also uses discriminator to differentiate between samples from model and training data. So the model generates 5 different images for a particular image with different palsy levels.

Feature Learning:- In this 2 CNN and a pretrained CNN called VGG-16 is used. CNN 1 and CNN 2 consists of 2 convolutional layers while VGG-16 is used for classifying palsy grades. In this we apply input face image to CNN 1 and its mirror image to CNN 2 and then the resultant images from two CNN's are then applied to VGG-16 so as to classify images into that five levels of palsy.

Classification : After the whole process CNN classifies the given face image into one of the 5 levels of facial palsy. Softmax layer of VGG-16 classify image.

[Q] ***An ensemble of regression tree based facial features extraction for efficient facial palsy classification:-***

In this authors suggested a robust approach to efficiently evaluate facial paralysis and its classification. Here the regression trees method is also used to extract features from images efficiently. Facial landmark features are calculated to find the quality of facial paralysis.
The detailed methodology is discussed as follows:-

Preprocessing: Here we are using still images as input to our classification model and we are also normalizing the facial images to reduce complications. Images are converted to a resolution of 960x720 pixels.

Feature Extraction: We preprocess the image and facial features are extracted using facial landmarks and there should be a total 68 points that covers eyes,eyebrows and mouth. Histogram of Oriented Gradients is used for facial features extraction along with image pyramid. It takes an image as input and gives us output as a feature vector.

Ensemble of Regression Trees: Regression trees are used to estimate positions of facial landmarks by making positions around face pixels. There is no use of feature extraction here.
Classification: Here we are using Regularized Logistic Regression(RLR) for classification of facial palsy levels. Determining whether it is peripheral palsy or central palsy.

[R] ***Automatic Face Paralysis Evaluation Augmented by Cascaded Encoder Network Structure:-***

In this paper a deep neural network is used for facial paralysis analysis. Encoder structure is used to determine facial symmetry features. Training scheme is also used for efficiently utilizing insufficient face images.
The detailed methodology is discussed as follows:-

Model Overview: Mode utilizes an intermediate model that extracts facial features. Training method of this model produces latent features that contain higher level information regarding facial features segmentation. Cascaded strategy is performed which in turn enhances the performance of facial paralysis segmentation.
Facial feature segmentation: In this the encoder extracts a set of feature maps for semantic information and the classifier thus transforms into pixel-by-pixel images. For extraction of facial attributes facial segmentation model is used.Fully Convolutional network is used to extract spatial features of images.

Facial Paralysis Evaluation: For the process of facial paralysis evaluation data is processed through cascaded encoded structure. First encoder extracts spatial features and second encoder is used to measure paralysis features on the basis of spatial features which we have

obtained from encoder first. VGG-16 is used in encoder second and House-Brackmann grading system is used to depict six levels of facial paralysis.

Training Model: Firstly, the face segmentation model is trained with the help of a mixture of training data which includes both normal faces and paralysed faces. We have a total of 25k facial images and 12k paralysis images. Our ⅔ data is used in the training part and ⅙ part goes for the testing part. During the second stage model is trained using only paralysis dataset. After the training part is done we make a grading model for giving grade level to different paralysis level.Evaluation metrics are calculated which includes true positive,true negative, false positive, false negative.

[S] ***Facial Component extraction using Segmentation Method on Face Recognition System:-***

In this paper authors are doing face detection from facial images using skin color model. Author is extracting facial components from facial image in the region of eyes, nose,mouth. Detailed methodology is discussed as follows:-

Preprocessing: Luminosity level is decreased from facial images to reduce lighting effects and unwanted noise.RGB color images are converted to YCbCr images. Low pass filter is used on YCbCr images to reduce unwanted noise. Cb and Cr values are converted to row vectors with the help of reshape function.

Face cropping Process: Firstly we are separating the skin part of the face from other body parts like arms,legs so as to get better results from our model. Whole area of the face is determined with the help of equation **E=C-H** where E is Euler number, C is related component number and H is hole number in relation. We are cropping facial images in a symmetric manner so as to achieve better results. Coordinates are used to make a boundary along the face and make a rectangle and that rectangle is used to crop the original image.

Extraction and Measuring Distances: Face image is divided into three parts: face,eyes and mouth regions. Then distances are calculated between left eye and right eye, right eye and mouth, left eye and mouth, right eye and nose, left eye and nose and other also. After dividing the face image into various parts then extraction takes place. Eyes are extracted by forming a map on eyes and similarly for mouth also. Nose extraction is done by forming a triangle with sides including distance of left eye and right eye, left eye and nose, right eye and nose. Distance is measured in individual components and results are made. Correspondingly eigenvalues and eigenvectors are obtained which gave us the result of facial images.

[T] ***Bell's Palsy:-***

In this there is a better understanding of what is facial paralysis and what are the causes and its effects and it also describes the basic functional classification system and rehabilitation approach for recovery of persons with facial paralysis.

Facial nerve palsy can be diagnosed resulting in dropping of eye brow, dropping of lips area. There is an inability to close the mouth whenever saliva runs out from mouth. House - Brackmann facial nerve grading system is used for nerve disorders and overall facial function dividing face paralysis into 6 levels like 1. Normal 2. Mild Dysfunction 3. Moderate Dysfunction 4. Moderately severe dysfunction 5. Severe Dysfunction 6. Complete Paralysis. Several regions' scales of face image are considered using the Yanagihara system.

[U] ***Face Detection using ADABOOSTED SVM-based component classifier:-***

In this paper the authors have used AdaBoost in combination with the Support Vector Machine for the Face Detection Task. Since AdaBoost is used to increase the accuracy of any algorithm, therefore authors tried it on the SVM model to check how much accuracy they are able to attain in the Face Detection. Finally they have found that their approach is more better than previously applied AdaBoost approaches.

First of all boost based learning is used to construct the classifier. On the training samples, AdaBoost is used to maintain a probability distribution. With the help of AdaBoost we are improving the weak classifiers, we are giving greater weights to weak learners with lower errors and with the help of AdaBoost we will control the accuracy of each weak learner in the SVM. The basic algorithm which is used is that first of all the weight of training samples are initialized and then for all the samples each we perform ComponentLearn algorithm to train the classifier and then we calculate the training error after that the weight of the component classifier is set and then the weights of training sample is updated

[V] ***Face Detection with Effective Feature Extraction:-***

In this paper the author has proposed that features other than Haar like features can also be used to train a face detector, as earlier only Haar-like features were used to train the face detectors. The features which the author has proposed have more performance improvement than the Haar-like features.

Basically in the paper the author has proposed some facial features which take less time for extraction and has a great impact on the classifier, i.e. it has high discriminative power. The simple edge descriptors are based on HOG and LBP features which are proven to give excellent results. The rectangular feature can be denoted by a tuple where tuple contains x and y position of the top corner of the block and width and height of the block. And in the block, the change of pixel intensities is considered.

[W] **A two-step learning method for detecting landmarks on faces different domains:-**

In this paper the author has tried to reduce the high demand of large volume annotated data for the detection of the landmarks. And they have proved that their method performs better than the other techniques. Author has applied and tested his technique on the human and animal faces.

This is a two-step learning process with supervised and unsupervised steps. In the first step the unlabelled images get encoded with the face features using the encoder network, after that we create a vector of all the features and then we pass it through the network of decoder and generate the output. And in the second step instead of passing it through the decoder we pass it through the supervised method that is regression. The encoder has five convolution layers, and all the input images were of size 32*32.

[X] ***An Introduction to Logistic Regression Analysis and Reporting*:-**

The author has showcased the preferred patter for the application of the logistics method and it has also shown an example of logistic regression.

The author has showcased that Logistic regression can be applied wherever Binary Classification or Multi class classification is required, we need to have one dependent

variable and there can be many independent variables, such we get an equation which decides the value of the independent variable.

[Y] ***Binary Logistic Regression Analysis in Assessment and Identifying Factors That Influence Students' Academic Achievement*:-**

In this paper the author is trying to identify the major factors which influence the student academic achievements, and there were many factors such as choice of department, peer pressure, study time and many more that were significant in predicting whether a student is ok in academic achievements or not.

The dependent variable of this study is "academic achievements" which has two possibilities i.e. 1 for ok status and 1 for not ok status. The predictor variables consider: age of student, parents' educational background, securing first choice of department, availability of textbooks and references, environmental factor, study habit, place of residence before joining university, peer influence, study time outside class, amount of money received from family, arranging study time and good life later on.

[Z] ***Bell's Palsy: A Prospective Study Department of Maxillofacial Surgery*:-**

In this paper the author describes the research conducted on a small group of patients who have complained about the symptoms of facial palsy.

The detailed methodology is as follows:

the specific objectives are as follows:

(i) To determine the grade of the attack at onset

(ii)To identify the various associated symptoms

(iii)To identify the percentage of completely recovered and incompletely recovered patients.

The doctors used several parameters to identify the grade of the severity of facial palsy and the associated symptoms with it.

[AA] ***Bell's palsy: Physical therapy and surface electromyography biofeedback:-***

In this paper the author describes the research conducted on patients who complained about facial palsy. This paper also describes the grading system of facial palsy about the level of palsy a person has and its acute symptoms and cures.

Bell's palsy if diagnosed upon abrupt onset of impaired facial expressions due to unilateral facial weakness of all facial nerve branches, dry eye, if saliva runs out of the mouth, the inability to close or wink the eye or close the mouth, to droop the brow or the corner of the mouth.

Different facial grading scales have been developed and can be divided mainly into two categories, gross scales and regionally weighted or unweighted scales. In addition to these two main categories, specific scales also exist. The House-Brackmann scale (HBS) is the most commonly used grading system for facial nerve disorders and categorizing of overall facial function. The scale has six grades, or scores, where I = normal function and VI = complete paralysis

[AB] ***Facial Landmark Localization: past, present and future:-***

In this paper the author describes the technologies and dataset used to obtain the facial landmarks in the past, and present. And what will be the techniques used in the future to detect the landmark features.

The main reason behind this are the countless applications where face landmarking plays arguably the important role are facial expression analysis. face animation, 3D face reconstruction, registration. Expression understanding: Facial expressions form a visual channel for emotions and nonverbal messages, and they have a role in supporting the spoken communication. Face registration: Face registration is the single most important factor affecting face recognition performance. Face recognition: Face recognition schemes typically

locate the eye region and then extract holistic features from the windows centered on various regions of interest.

Appearance-based approaches: the authors present a method based on a combination of Support Vector Regression and Markov Random Fields to drastically reduce the time needed to search for a point's location and increase the accuracy and robustness of the algorithm. Using Markov Random Fields allows us to constrain the search space by exploiting the constellations that facial points can form.

Model-based approaches: proposed a unified model for face detection, pose estimation, and landmark estimation in real-world, cluttered images. this model is based on a mixture of trees with a shared pool of parts; the authors model every facial landmark as a part and use global mixtures to capture topological changes due to viewpoint and show that tree structured models are surprisingly effective at capturing global elastic deformation, while being easy to optimize unlike dense graph structures .

[AC] ***A Landmark Paper in Face Recognition:-***

The effects of the number of landmarks on the mean localization error and the recognition performance are studied. Two landmarking methods are explored and compared for that purpose: (1) the Most Likely-Landmark Locator (MLLL), based on maximizing the likelihood ratio and (2) Viola-Jones detection. The MLLL has been trained for locating 17 landmarks.

Most Likely Landmark Location: MLLL treats landmark finding as a two-class classification problem: a location in an image is either the landmark or it is not. The texture values in a region surrounding a landmark are the features for the classification. For each location in the ROI the likelihood ratio-for that location to be the landmark- is calculated. The most likely location, i.e. the one with the highest score, is taken to be the landmark.

Viola-Jones based landmark localization: The second method for landmark localization is the Viola-Jones detector, which uses a combination of Haar-like features to represent the texture information in an image. We developed detectors for 5 landmarks: two eyes (size 28 × 14), one nose (size 28 × 14), and two mouth corners (size 20×20). Only 5 of the 17 landmarks have been chosen for the Viola-Jones based method, because the other

landmarks did not result in fast and compact cascades for detection. For simplicity, the face region is first detected as a ROI for the localization landmarks in face.

[AD] ***Annotated Facial Landmarks in the Wild: A Large-scale, Real-world Database for Facial Landmark Localization:-***

No adequate databases exist that provide a sufficient number of annotated facial landmarks. The databases are either limited to frontal views, provide only a small number of annotated images or have been acquired under controlled conditions. Hence, we introduce a novel database overcoming these limitations: Annotated Facial Landmarks in the Wild (AFLW). AFLW provides a large-scale collection of images gathered from Flickr, exhibiting a large variety in face appearance (e.g., pose, expression, ethnicity, age, gender) as well as general imaging and environmental conditions.

Face recognition is an intrinsic part of human visual perception.The significance of face recognition for humans is reflected by the variety of applications of computational face recognition. Thus, face recognition is also one of the core tasks in computer vision. The main motivation for the Annotated Facial Landmarks in the Wild (AFLW) database is the need for a multi-view, real-world face database for facial feature localization. The images of our database are collected on Flickr exhibiting a large variety in pose, lightning, expression, ethnicity, age, gender, clothing, hairstyles, general imaging and environmental conditions. Further, the database offers various backgrounds and many other parameters. A wide range of images related to face relevant tags were gathered and manually processed.

[AE] ***Application of Logistic Regression in the Study of Students' Performance Level:-***

Authors proposed a solution of binary logistic regression on the dataset of students of university. Analysis of the results of examination of students is obtained.

Firstly the dataset is divided into two categories of credits with less than 30 and more than 30 credits. Assumptions are made regarding hypothesis which is null hypothesis and alternate hypothesis. Logistic regression is performed while taking an amount of credits as independent variable and gender, location as dependent variable. We apply correlation analysis to find out the significant correlation between students and other variables.

[AF] ***Using regression analysis to establish the relationship between home environment and reading achievement:-***

Through this paper authors propose a regression analysis approach to study the relationship between home environment factors and reading achievement.

Firstly data is treated for missing values and data is screened for outliers. Descriptive statistics is applied for all variables in our dataset.After applying statistics skewness is checked for each variable and histograms were obtained for variables whose skewness is greater than 1.

[AG] ***Bell's palsy: a summary of current evidence and referral algorithm:-***

Through this paper authors propose about Bell Palsy. Bell palsy leaves residual hemifacial weakness in 29% patients which is severe.

Facial nerve paralysis was reviewed and components were considered with respect to preclinical and clinical evidence.Search strategy is performed with the help of Cochrane Handbook for systematic reviews.After the search strategy is performed the studies were checked to check on aspects of diagnosis and prognosis.

[AH] ***Analysis of Support Vector Machine Classification:-***

Authors propose study regarding support vector machines. In this paper 1-norm soft margin classifier is analyzed.

After the preprocessing of data is done the data is processed through a binary classifier and data is divided into two units. Misclassification error is calculated for the data with the help of Baye rule in probability. Mercer Kernel is applied and reproducing kernel hilbert space is applied. Soft margin classifier is applied and the generalization error is calculated.After applying soft margin classifier the offset is calculated.

[AI] ***Support Vector Machine Classification of Microarray Data:-***

Authors propose a support vector machine approach to predict cancer morphologies and treatment success.

Here confidence intervals are introduced to reject points at which the classifier is not confident enough.SVM is trained on a dataset and confidence intervals are calculated.

Leave one out estimator is used on training data and feature selection is also performed by minimizing standard SVM and diagonal matrix.

[AJ] ***Face Detection, Bounding Box Aggregation and Pose Estimation for Robust Facial Landmark Localisation in the Wild:-***

Through this paper, the authors propose a robust framework for face detection and localisation of landmarks on human faces. The proposed framework has four stages comprising a bounding box for faces, pose estimation, image preprocessing and two proprietary and two CNN based open sourced face detectors.
There are mainly four stages in this framework:

Face Detection: It uses four different face detectors two open sourced (CNN and MTCNN based) and two proprietary detectors.

Bounding Box Aggregation: For less false positives it is used, by extracting the desired part from the image.

Pose Estimation: Profile and Semi frontal images are processed separately which are output from the previous stage.

Landmark Localization: Pre trained CSR model is used to extract 68 landmarks from the frontal images or 39 from side profile images.

[AK] ***A study on multiple linear regression analysis:-***

By this paper authors demonstrate an analysis of regression and how multiple independent variables affect dependent variables.

Availability of lost data was checked using frequency analysis. Then multivariate normality, linearity, freedom from extreme values, and multilinear relations were analyzed.

For assumption on multivariate linearity, a matrix of scatter diagrams was generated.

[AL] ***Automated objective and marker-free facial grading using photographs of patients with facial palsy.***

Through this paper authors proposed an automated, objective, fast and simple classification system for grading and detecting facial palsy in patients through images.

A marker-free, novel, fast and automated method for unilateral facial grading was developed based on support vector machines and certain discriminative facial image features. Using features of a trained AAM and Action Units (AU), predicted from it.

Automated grading of all photographs according to House Brackmann grading scale (HB), Sunnybrook grading system (SB), and Stennert index (SI)

[AM] ***Toward a Universal, Automated Facial Measurement Tool in Facial Reanimation:-***

Through this paper authors proposed a highly quantitative facial function measuring tool that yields accurate, objective measures of facial position in significantly less time and with more efficiency than existing methods.

50 Individuals underwent facial movement analysis using photoshop based measurements. Comparisons between individuals with normal facial conditions and patients with facial paralysis condition were made to learn the sensitivity to abnormal movements.

[AN] ***Emerging vs Time-Tested Methods of Facial Grading Among Patients With Facial Paralysis:-***

This paper proposes a method to establish the correlation between the scores on the two most common grading scales among patients with facial paralysis and to compare the reliability of these two scales.

Two independent physical therapists evaluated patients using both the eFACE and the Sunnybrook FGS.

Scores were then compared and the correlation coefficient of Spearman rank was calculated.

Among the total scores and each of the 3 subscores, including static, dynamic, and synkinesis scores.

Chapter 3 Requirement Analysis and Solution Approach

3.1 Overall description of project

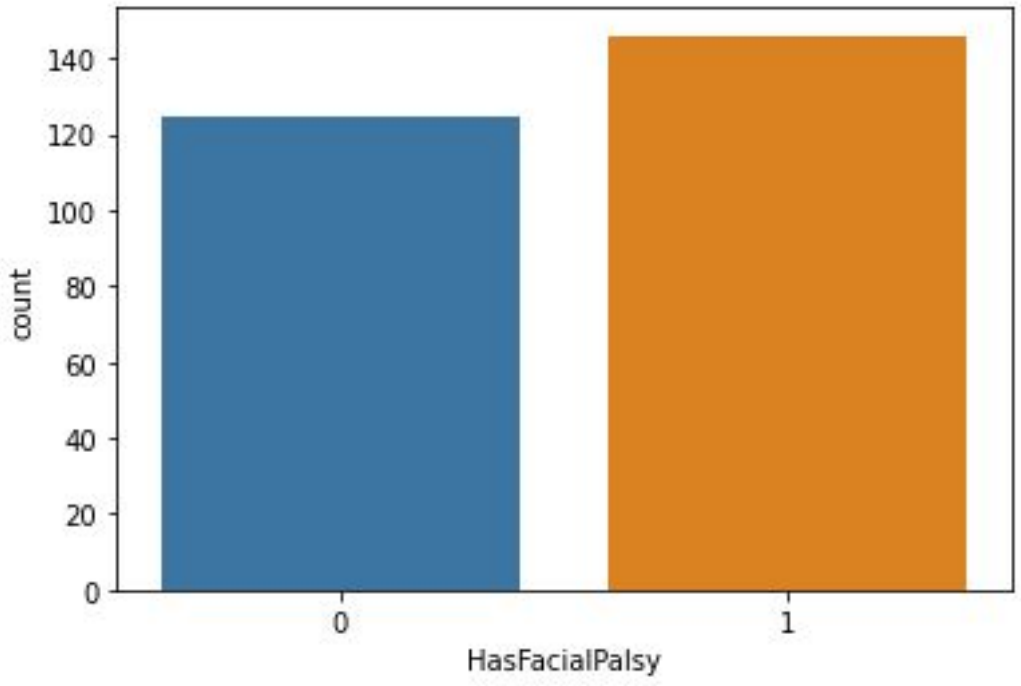


Figure 1:- Distribution of dataset between patients and healthy people

A novel ML model for automated facial landmark localization was trained using the disease-specific database. Algorithm accuracy was compared with manual markings and the output of a model trained using a larger database consisting only of healthy subjects. After that we collected the data of all the patients in the excel, and we applied Logistic Regression which helps in binary classification and multi class classification and parallely we also applied SVM to check the accuracy of the model. We also did the data analysis to generate a report of the major facial features which helps in detecting the Facial Palsy.

3.2 Requirement Analysis -

- To get the facial landmark points for the provided dataset
- Get the excel file of the facial landmark points of the dataset

- Data visualisation of the major facial landmark points
- Getting the accuracy of the Logistic Regression and SVM model
- View the facial landmark points

3.3 Solution Approach -

	UniqueIdentifier	BrowHeightDevAbs	BrowHeightDevPer	PalpebralFissureHeightDevAbs	PalpebralFissureHeightDevPer	CommisureExcursionDevAbs	Commi
0	False	False	False	False	False	False	
1	False	False	False	False	False	False	
2	False	False	False	False	False	False	
3	False	False	False	False	False	False	
4	False	False	False	False	False	False	
...	...	...	...	...	...	...	
266	False	False	False	False	False	False	
267	False	False	False	False	False	False	
268	False	False	False	False	False	False	
269	False	False	False	False	False	False	
270	False	False	False	False	False	False	

271 rows × 8 columns

Figure 2 :- Dataset post data cleaning

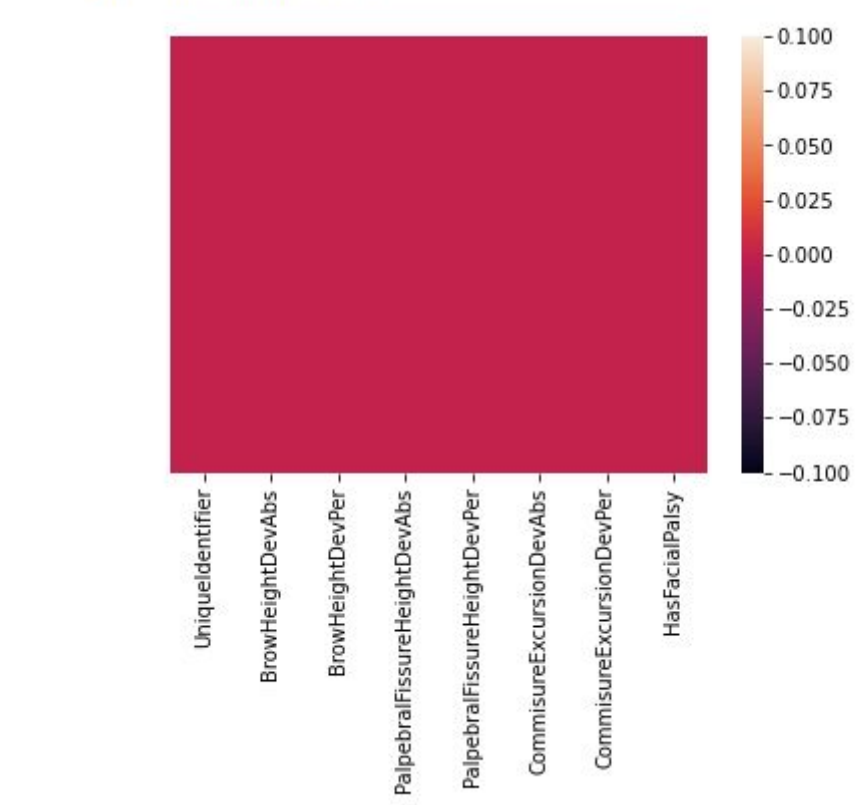


Figure 3:- Heatmap of data post data cleaning

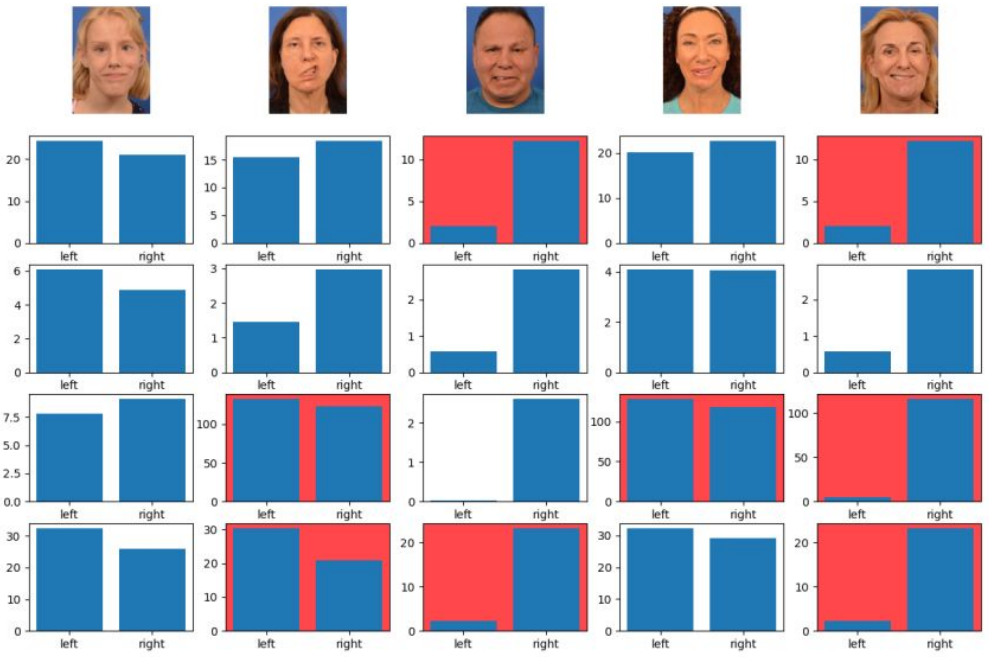


Figure 4:- Data visualisation of the major facial landmarks

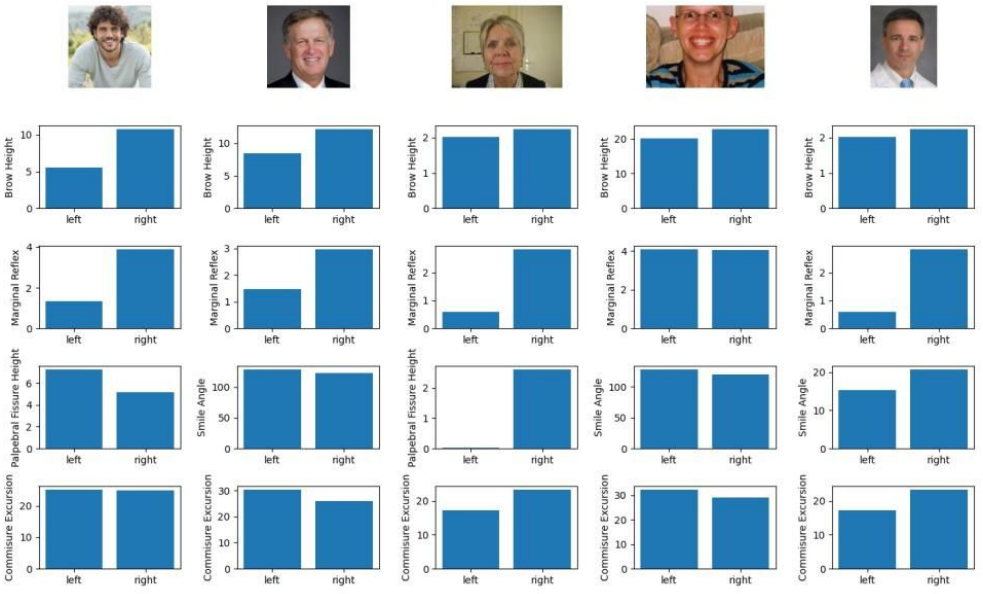


Figure 5:- Examples of automated facial metrics

Presented measures include eyebrow height (vertical distance from the midpupillary point to the superior border of the brow), palpebral fissure height (vertical distance between central

portions of upper and lower lid margins), and commissure excursion (distance from the facial midline at the lower lip vermilion junction to the oral commissure)

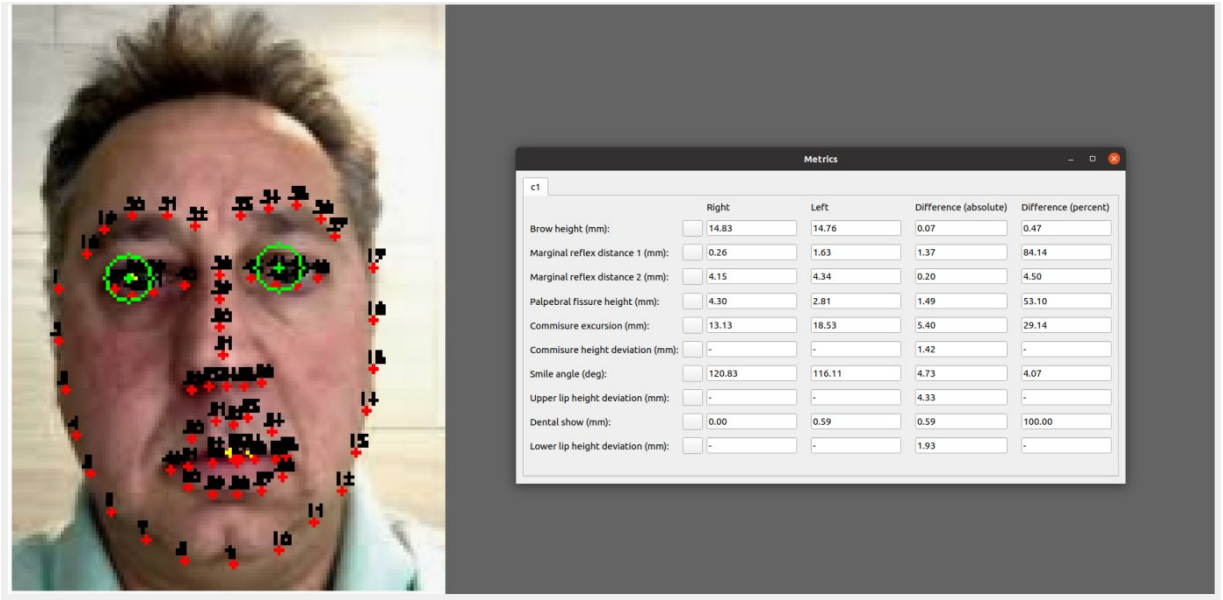


Figure 6 :- Facial landmarking and their respective coordinates of a healthy patient

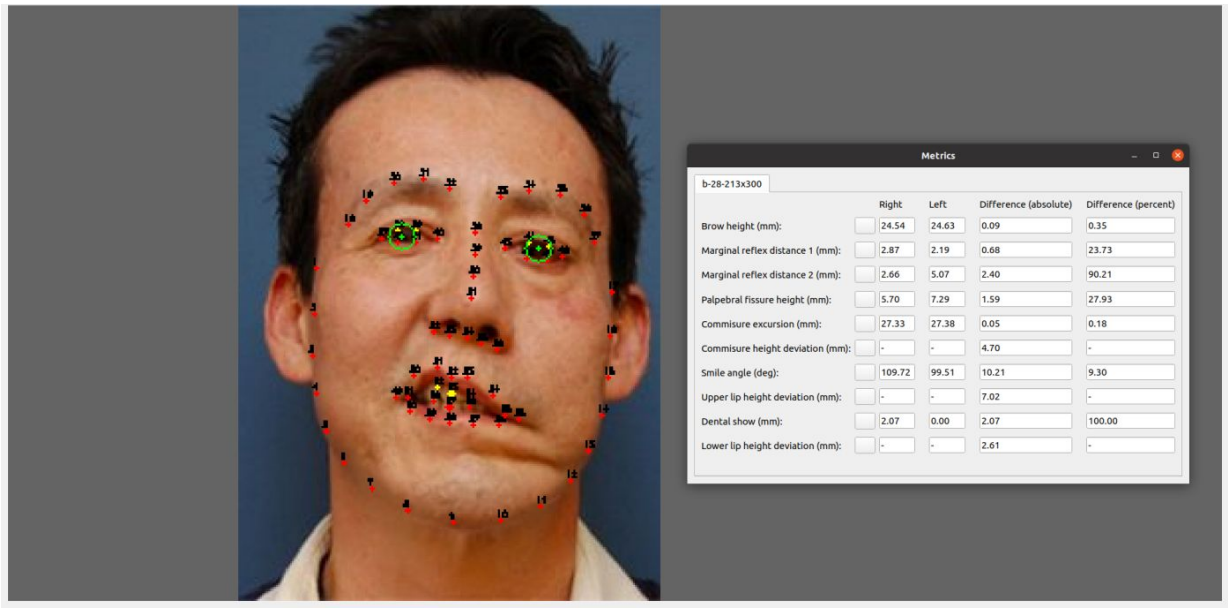


Figure 7 :- Facial landmarking and their respective coordinates of a Bell's palsy patient

Machine learning (ML)-based computer vision algorithms enable rapid and fully automated tracking of facial displacements from digital images and videos recorded under typical conditions with consumer-grade cameras. Such facial landmark detection algorithms are

usually trained using databases of manually annotated facial photographs. Once trained, these ML algorithms can predict the position of facial landmarks in a new photograph without human intervention, with high accuracy. ML algorithms for facial landmark localization are increasingly being used to study facial palsy, Parkinson disease,stroke, amyotrophic lateral sclerosis, and dementia. Owing to their training using predominantly normal subjects, current ML models for facial landmark recognition may be biased against patients, and demonstrate inadequate accuracy when presented with faces of patients with neuromuscular disease impacting facial movements and expression. Herein, we hypothesize that training a ML model for facial landmark localization with facial photographs from a disease-specific clinical database will demonstrate improved tracking accuracy when presented with faces of patients with the condition, in comparison with the model trained using a much larger database of normal subjects.

We employed a popular approach for automatic facial landmark localization in facial photographs known as cascade of regression trees. Specifically, we employed the algorithm proposed by Kazemi and Sullivan, which provides accurate facial landmark localization results under multitude of pose, illumination, and expression (PIE) conditions and can process medical images in just a few hundred milliseconds without the use of graphical processing units or other specialized hardware. Implementation of this algorithm for facial landmark localization is readily available in open source ML libraries such as OpenCV and Dlib. These implementations were trained using an open source data set comprising nearly 270 images which have 50% healthy faces and 50% of those who are suffering from facial palsy. From the Intelligent Behavior Understanding Group (iBUG). Model training has been performed by manually annotating a set of facial landmarks in each photograph using the 68-point Carnegie Mellon University multiple pose, illumination, and expression (multi-PIE) database approach. Manually annotated landmarks outlined the superior border of the brow, the free margin of the upper and lower eyelids, the nasal midline, the nasal base, the mucosal edge and vermilion–cutaneous junction of the upper and lower lips, and the lower two-thirds of the face. After landmark extraction we used SVM and Logistic Regression to detect palsy in the face. We have done data analysis and visualization of data is done through Matplotlib.
Modules Used -

- Matplotlib
- Pandas
- OpenCV

- Dlib
- Sklearn
- Numpy
- Scipy
- PyQt5
- Openpyxl

Chapter 4 Modeling and Implementation Details

4.1 Design Diagrams

4.1.1 Use Case Diagram

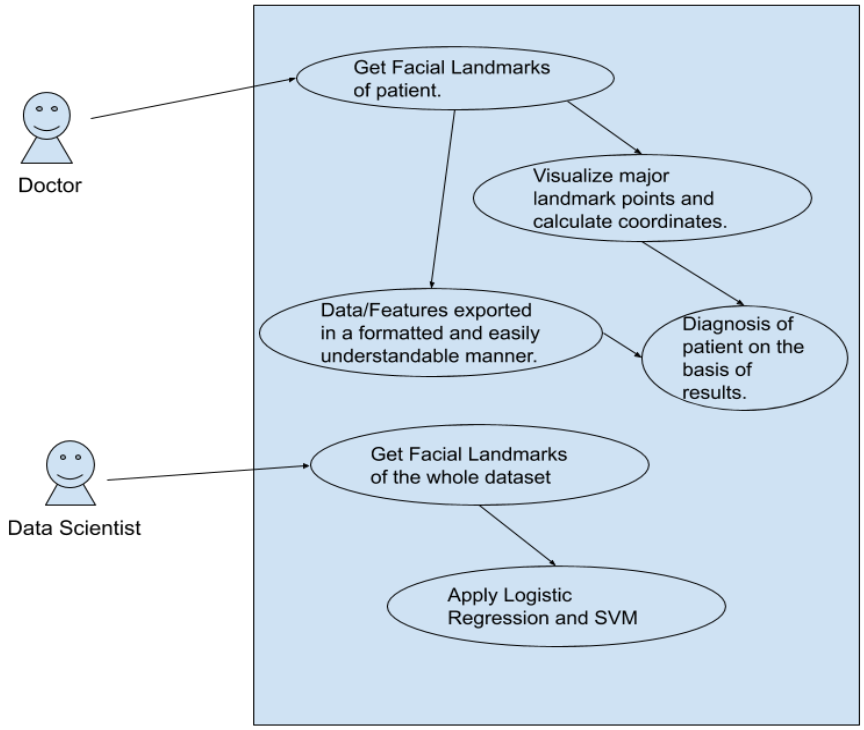


Figure 8:- Use Case Diagram

4.1.2 Control Flow Diagram

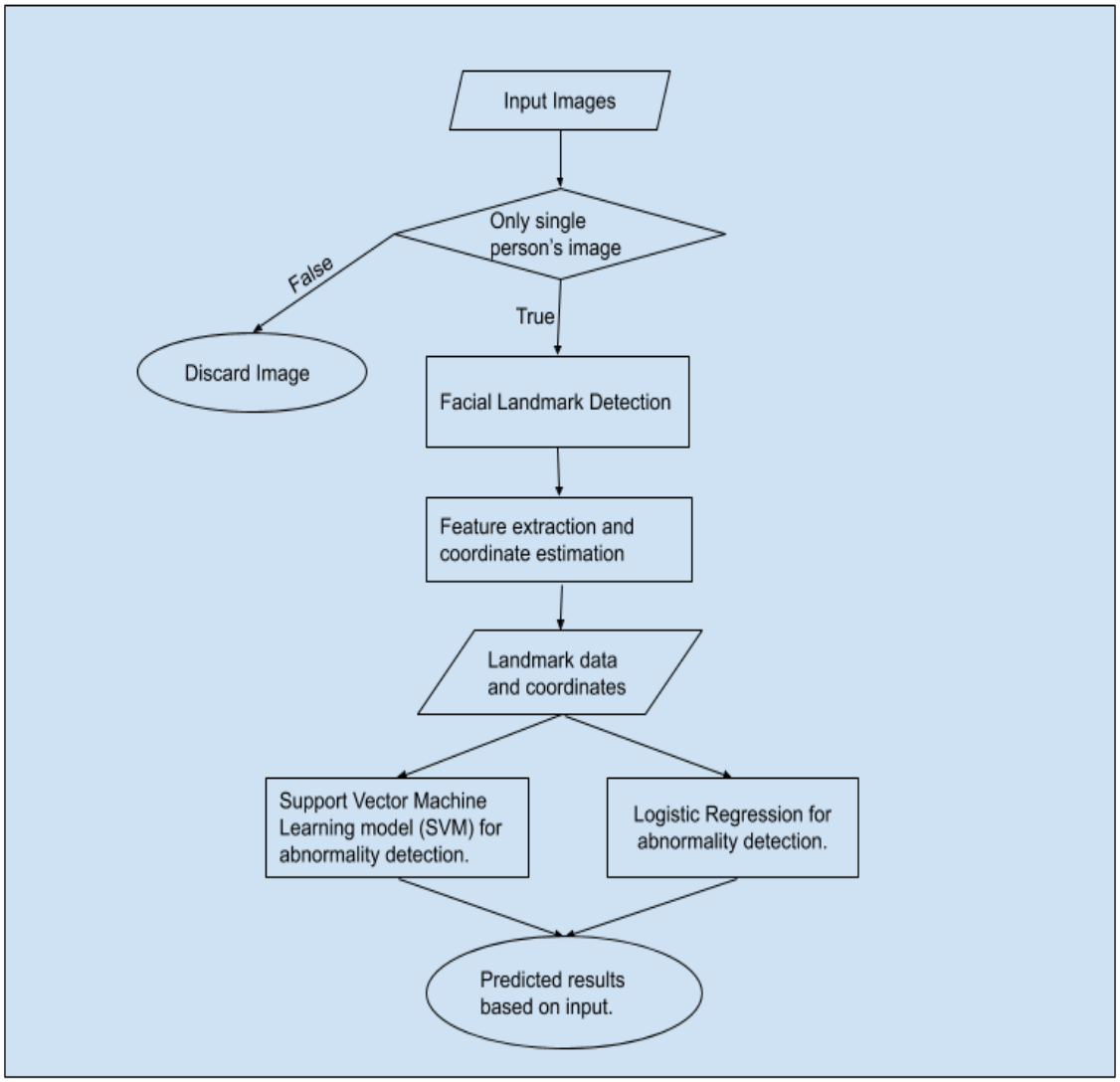


Figure 9:- Control Flow Diagram

4.1.3 Activity Diagram

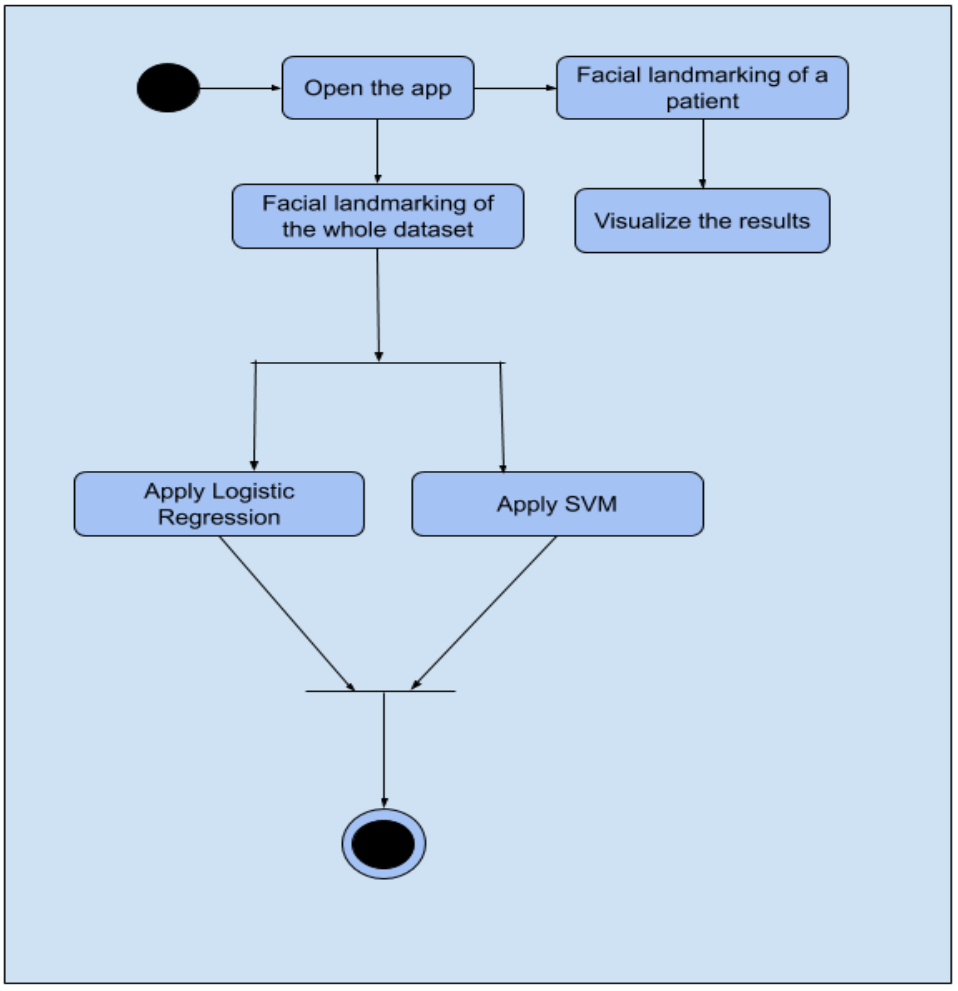


Figure 10:- Activity Diagram

4.2 Implementation details and issue

With the help of OpenCv and Dlib modules we are first of all recoginizing the face and then adding the landmarks with the help of cascading regression. The user can generate the facial landmarks of a particular patient or for a particular dataset. He can also save the details of patients in a csv file, and then visualize it so that he can get the idea what all parameters are there which are responsible. For the whole dataset, we can save the landmarks in a csv file to get the whole dataset and then clean it accordingly. In the database we tested we majorly found three major facial landmarks which were significant in detecting the facial

palsy, the three major landmarks were “Brow Height”, “Palpebral Fissure Height” and “Commissure Excursion”, we added both deviation and percentage in the database. And then we applied the two strong traditional algorithms for classification i.e Logistic Regression and Support Vector Machine, for doing the classification between a patient and a healthy person. We cleaned the data first of all, i.e. we replaced the null values with the average value and then after that we got the final database, and we applied both the algorithms.

During the above mentioned process some of the major problems we faced were regarding preprocessing of the dataset and training of the models on low end devices. Training and testing alone took more than 60 hours of computational time with such a small dataset.

Still after these shortcomings we were able to get the precision and accuracy of both the models around 70-75%.

4.3 Risk Analysis and Mitigation

Table 1: Risk Analysis

Risk_ID	Classification	Description of Risk	Risk Area	Impact
Risk_1	Design	The possibility of low accuracy as we are using traditional machine learning algorithms.	Performance	High (H)
Risk_2	Engineering Specialties	The project scope demands maximum possible reliability on the predicted outcomes, as the lives of patients are at risk	Reliability	Medium (M)
Risk_3	Requirements	Risk of availability of complete, robust and reliable dataset with proper labels for training our models	Completeness	Low (L)

Table 2:Risk Area Wise Total Weighting Factor

S.no	Risk Area	Weights (In + Out)	Total Weights	Priority
1	Performance	9+3+3+1	16	1
2	Budget	9+3+1	13	2
3	Hardware constraints	9+3+1	13	3
4	Reliability	9+3	12	4
5	Requirements	3+1	4	5

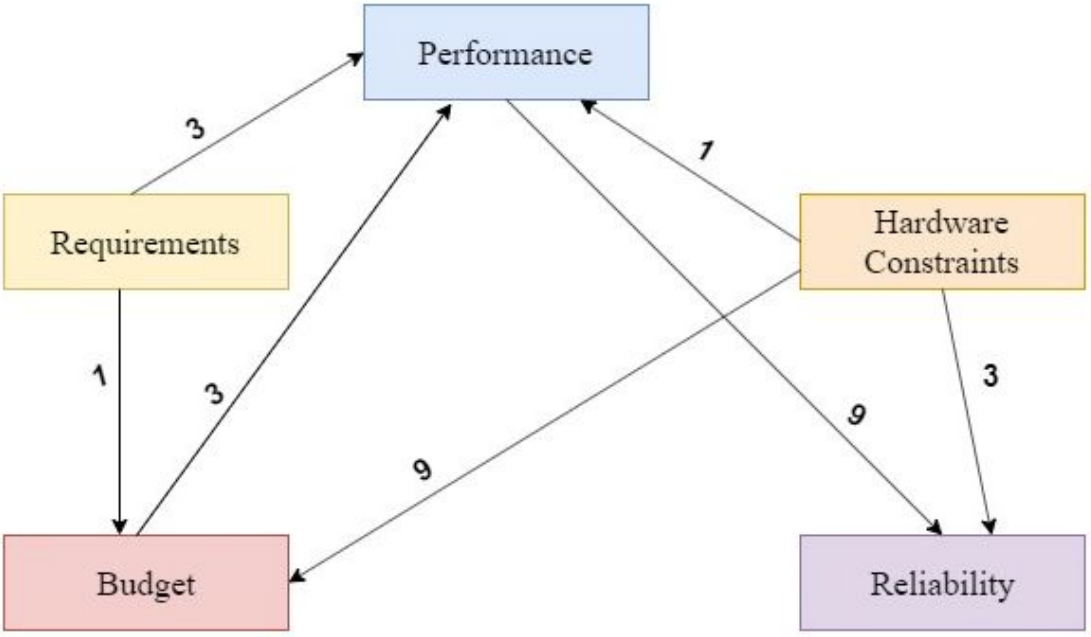


Fig. 11 Weighted Interrelationship Graph

Chapter 5 Testing

Software testing is an important phase in the software development life cycle as it verifies and validates the system under test i.e. whether it works as expected and satisfies the stakeholders' needs. With respect to the text extraction system also, testing & evaluation is significant; as it is important to test the system before deployment. In order to assess the system output, appropriate quality assessment techniques should be adopted for determining the system performance in comparison to the benchmark level or with the quality of the previous version or with similar kinds of different products**.**

5.1 Testing Plan

First of all we tested the facial landmarks with the few images whose landmarking we had already stored, we checked the deviation of each point. For the algorithms we splitted our dataset into training and testing dataset, the ratio was 7:3. We tested the model with the help of a 30% dataset.

5.2 Component decomposition and type of testing required

The objectives behind the testing of our developed model are:

- Evaluation of Parameters of the developed system
- Calculating accuracy
- Speed of the model
- Evaluation of Complexity in colored images
- User Level Testing

Table 3:- Types of Testing

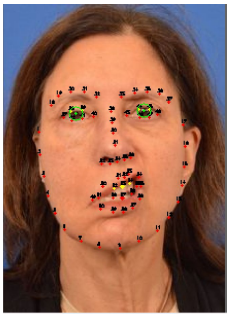
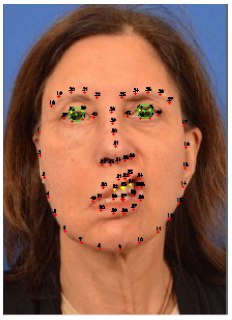
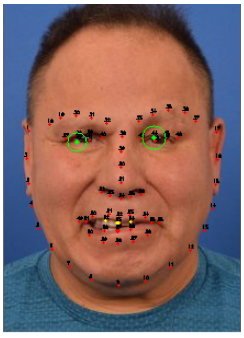
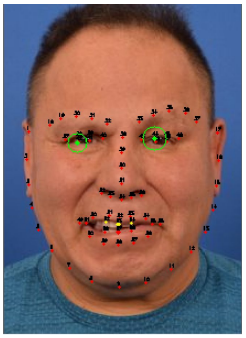
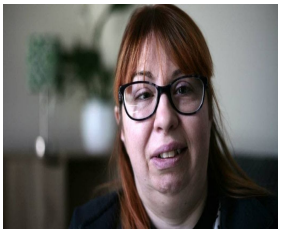
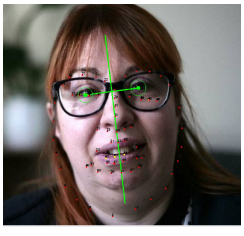
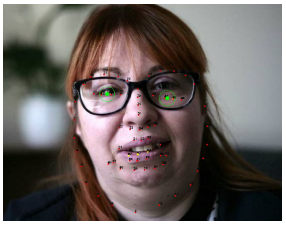
Type of test	Explanation	Software component
Requirement Testing	Validation checks were made to ensure that hardware and software specifications meet the minimum	Anaconda/Google Colab

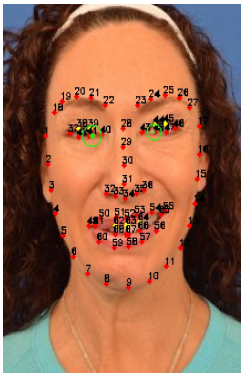
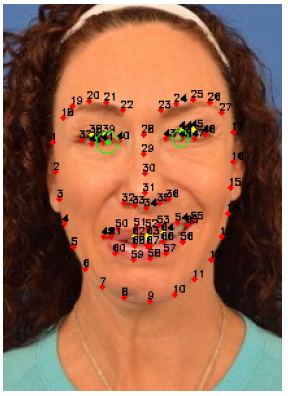
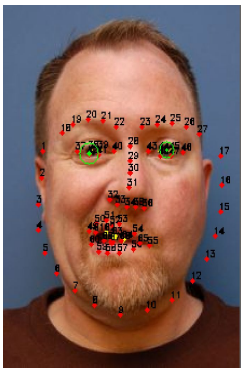
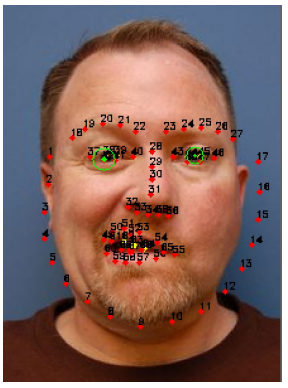
	requirements. Certain libraries such as SimpleITK were required to be specially installed and the minimum CPU/GPU requirements for our architecture were also checked.	
Performance Testing	Performance testing is the process of determining the speed, accuracy, and consistency of the proposed model. This was achieved by creating, training, and testing the whole U-net based deep learning network, experimenting with varied training methodologies. We were able to achieve a dice coefficient of 0.9815, 0.9844, 0.9804, 0.9954 on the test set of HGG-1, HGG-2, HGG-3, and LGG-1 respectively.	Anaconda/Google Colab
Experimental Testing	Our model was checked against various experimental tests to fine-tune the hyperparameters in order to ensure the best results. Hardware specification was improved and the number of epochs was increased to improve the dice coefficient of training, validation, and testing sets. The U-net based deep learning network was experimented with different learning rates and training methodologies.	Anaconda/Google Colab
Unit Testing	The purpose is to validate that each unit of the software performs as	Anaconda/Google Colab

	designed. The output of the steps within data preprocessing and the result of tumor segmentation was randomly tested in order to ensure valid and consistent results.	

5.3 List all test cases

Table No:- 4 List of all test cases

Input ID	Input Image	Expected Output	Predicted Output	Status
Test Case 1				Pass
Test Case 2				Pass
Test Case 3				Fail

Test Case 4				Pass
Test Case 5				Fail

5.4 Limitations of the solution

There are several limitations with the facial landmark localization model described herein. The database comprises patient photographs from a single center and reflects its demographics. The database includes more female ($N = 135$) than male ($N = 65$) patients, and its racial demographic is mostly white ($N = 160$), with small representation of minorities, including Hispanic ($N = 15$), Asian ($N = 14$), and black ($N = 11$). In addition, the database comprises more middle-aged adults (age group = (24, 64] years, $N = 142$) than younger adults (age group = (18, 25] years, $N = 12$), older adults (age group = 64+ years, $N = 41$), and children (age group = (0, 18] years, $N = 5$). Other sources of model bias such as the presence of facial hair were not assessed. Nonsymmetric distribution of patient demographics might lead to prediction error bias; for example, the model might demonstrate higher performance among adult middle-aged white women as they comprised the largest cohort of the training data set. The model is further limited in that recording conditions (PIE) were specific to our clinical center. Although patient pose (requiring frontal view of face with

neutral roll, tilt, and yaw) and expression may be readily standardized across clinical centers, illumination conditions are more challenging to standardize and their impact on model accuracy has yet to be assessed. Further work will seek to expand the training data set to include patient photographs from multiple clinical centers to improve model accuracy across a wider range of patient demographics and disease severities. The facial landmark localization model was applied only to patient photographs of eight fixed facial expressions. Future study will seek to assess the performance of this model for dynamic tracking of facial landmarks during expression from videos of patients with unilateral facial palsy.

Chapter 6 Findings, Conclusion, and Future Work

6.1 Findings

We were able to find the landmark coordinates of the face, then track out important facial features which were significant to predict whether the patient has facial palsy or not. We are also storing the coordinates in the CSV file, so that it can act as a tool to the doctor such he can also analyse the data and find the important points which can help him to give some treatment measures to the patient.

6.2 Conclusion

We introduced the first manually annotated database of standardized PIE photographs among patients with unilateral facial palsy. Using this data set, we demonstrated that a ML model for automatic facial landmark localization in this patient population outperforms a model trained using a much larger data set of healthy subjects. We demonstrated the clinical utility of this approach in the quantification of facial palsy disease severity from database photographs and characterized an open-access software tool that facilitates rapid calculation of relevant facial metrics in this patient population. After applying Logistic regression and SVM on our dataset accuracy of 82 % is achieved.

6.3 Future Work

In future we have planned to provide a robust grading system to our project, so that we can provide a suitable grade score and also recommend the proper treatment measures to the doctor. And more than that we can get more data of the patient in the form of CT scan and even we can get the Facial Blood Loss image data from LSCI so that we can get more accurate grades and predict concrete treatment measures.

For the purpose of our study, a dataset containing a wide range of diversities of symptoms with roughly equal amounts of each is required for testing; similar data scar- city challenge is also faced by many other studies on image recognition-based diagnosis. We address this problem by using semi-supervised anomaly detection which produced promising results. Given the diversity, imbalance, and noise in the dataset, as well as a simple methodology, the statistical results we achieved in this study confirm the promise of our approach and future possibilities. However, semi-supervised learning also restrained the performance. Algorithms for medical usages often require high recall with relatively high precision, which is still beyond the overall summary statistics of our current methods. There are other semi-supervised anomaly detection mechanisms that could be used . We investigated Gaussian Model-Based detecting mechanism in our preliminary study; applying other semi-supervised anomaly detection models on our variants should result in similar performance. We plan to improve the performance of our algorithm in future work.

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Experience

- **Google Summer of Code - Oppia** — Remote
  Student Developer (Full-time) — *May 2019 - Sep 2019*
  - **Completed the Project**: Asking students why they picked a particular answer, a feature for Oppia's lesson player to allow students to explain why they picked a particular answer.
  - **Project Overview**: http://tiny.cc/GSoCProjectOverview
- **Oppia** — Remote
  Core Team Member (Part-time) — *Feb 2019 - Oct 2019*
  - **Contributed to Frontend and Backend**: Successfully merged 30+ pull requests
  - **Member of Various Teams**: Dev Workflow, Bug Fixing, Contributors Onboarding, Release Team
- **CampK12** — Remote
  Coding Instructor (Part-time) — *Jan 2020 - June 2020*
  - **Taught Python Language, Machine Learning, MIT App Inventor**: For more than 500+ hours
  - **Impact**: Course has been taken by 100+ students so far

Education

- **Jaypee Institute of Information Technology** — Noida, India
  Bachelor of Technology - Computer Science; GPA: 8.6/10 — *July 2017 - Present*
  Courses: *Data Structures & Algorithms, Software Engineering, Operating Systems, Networking, Databases*
- **Little Scholars** — Kashipur, India
  Intermediate - 93.2% — *2016*
- **Little Scholars** — Kashipur, India
  High School - 10.0/10.0 — *2014*

Skills Summary

- **Languages**: Python, C++, C, SQL, JavaScript(familiar)
- **Tools**: Git, MySQL, GitHub
- **Platforms**: Linux, Windows
- **Soft Skills**: Leadership, Critical Thinking, Public Speaking, Time Management

Projects

- **KHOJ (Web Development, Machine Learning)**: A platform to prevent human trafficking, find someone lost during natural disasters or large gatherings and identifying dead bodies.Tech: Python, Django, HTML, CSS
- **ASKING STUDENTS WHY THEY PICKED A PARTICULAR ANSWER (Web Development)**: (GSoC'19 Project) A feature to the lesson player that allows students to explain how they arrived at a (wrong) answer. Tech: Angular JS, Python, Web2py, Protractor
- **LIBRARY SYSTEM (Web Development)**: A library management system, where library can update books available for borrow, student can hold the book for 30 mins and student can see all the books he had borrowed. Tech: PHP, HTML, CSS, JavaScript, MySQL
- **GET IT REGISTERED (GUI Application)**: A platform for college hubs to register student for their workshops and send mail to all the students in few clicks. Tech: Python, Tkinter

Workshops, Talk and Webinars

- **Python and C++ Workshops**: in JIIT Noida (2018 & 2019)
- **Introduction to Open Source and GSoC**: Mody University, JSS Noida, BVP Delhi, GDG Gwalior (2020)

Honors and Awards

- Letter of Appreciation - IC3 Conference
- Winner at Atlas Hack, Top 5/200 NEC Ideathon
- 376/15622 Codeforces Round 667
- 231/13965 Codeforces Round 640
- 168/4215 Codechef May Cook-Off Div2

Position of Responsibility

- **Chairperson at IEEE Student Branch JIIT Noida** — Noida, India
  Organised events, conducted technical workshops and lectures. — *July 2019 - July 2020*
- **Coordinator at Open Source Developers Community** — Noida, India
  Conducted meetups on different technologies and programs like GSoC, Outreachy, etc. — *July 2019 - July 2020*

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Education

- **Jaypee Institute of Information Technology** — Noida, India
  Bachelor of Technology - Computer Science; GPA: 8.0 — *July 2017 - Present*
  Courses: *Data Structures & Algorithms, Operating Systems, Software Engineering, Networking, Databases*
- **Mother Teresa Public Sr. Sec. School** — Balotra, India
  Sr. Secondary (RBSE Board); Percentage: 87.80% — *July 2017*
- **Shanti Niketan Sr. Sec. School** — Balotra, India
  Secondary (RBSE Board); Percentage: 90.17% — *July 2015*

Skills Summary

- **Languages**: Python, C/C++, PHP, JavaScript, SQL
- **Tools**: GIT, MySQL, Github
- **Platforms**: Linux, Web, Windows, Arduino, Raspberry
- **Soft Skills**: Event Management, Public Speaking, Time Management

Experience

- **Microcontroller based Systems & Robotics Hub - JIIT** — Remote
  Organizer — *July 2019 - Present*
  - **Autonomous Robotics Workshop**: Managed & taught about building LFR with Arduino, Sensors etc.
  - **Manual Robotics Workshop**: Managed & taught about building Manual Robot with Gears, Motors etc.
  - **Impact**: Several participants displayed projects in conferences and hackathons.
- **Freelancing** — Remote
  Freelancer — *June 2020*
  - **Project** : Developed an optimized interactive GUI software to visualize, store & manupulate output of different Electronic Hardware Lab components to run on Raspberry-Pi Touch Display.
  - **Tech**: Python, Tkinter, Serial communication APIs

Projects

- **KHOJ (Web Development, Machine Learning)**: A platform to prevent human trafficking, find lost person during natural disasters or large human gatherings and identifying dead bodies. Tech: Python, OpenCV, Django, HTML, CSS
- **Quizzing Portal (Web Development)**: Fully functional quizzing portal with registration system and time constraint based Quiz hosting with User role management. Tech: PHP, JS, HTML, CSS
- **The Fitness Box (Web Development)**: A fitness related E-Commerce and Content Sharing Platform. Tech: PHP, MySQL, JS, AJAX, HTML, CSS
- **Flight Navigating and Alerting system (Data Structure)**: Flight's real time navigation and alerting system. Tech: DS: K-D Tree, C++, Python, API-OpenSKI
- **Hand gesture to Text and Speech Conversion system(Hardware)**: Project to convert different hand gestures into text and speech for specially abled people. Tech: Arduino, Bluetooth, LDR-Sensors, TTS-Application

Honors and Awards

- Letter of Appreciation - ICSC Conference.
- Top 5/200 NEC Ideathon.
- Rated 4 Star on Codechef.
- Secured (65/1865)th position in Codechef 2019 Cookoff.
- Secured Below 100 position individually out of more than thousand teams multiple times(csictf, rgbCTF, redpwn-ctf etc.) in Capture the Flags (Cyber Security).

Volunteer Experience

- **Coordinator at Microcontroller based Systems & Robotics Hub-JIIT** — Noida, India
  Conducted workshops & hands-on session on building Autonomous and Manual Robots — *July 2019 - Present*
- **Mentored Project Exhibition at IC3 Conference** — Noida, India
  Mentored participants to build awesome software and hardware projects. — *Jan 2020*

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SKILLS

PROGRAMMING

• Python3 • Javascript

LIBRARIES AND FRAMEWORK

• React Native • Firebase

Familiar -

• React JS • C++ • GIT

• MYSQL • Postman

PUBLICATIONS

• POWER RANK – AN INTERACTIVE WEB PAGE RANKING ALGORITHM UNDER REVIEW

Dated:- Feb-2020

ACHIEVEMENTS

• GOT SELECTED UNDER THE **MEITY PROGRAM** IN AN INCUBATION PROGRAM.

• PARTICIPATED IN IC3 CONFERENCE.

PROFILE

I am a dedicated, hardworking and proactive Computer Science Engineer with a strong background in design, and integration with intuitive problem -solving skills. Proficient in PYTHON, JAVASCRIPT. Passionate about implementing and launching new projects. Ability to translate business requirements into technical solutions. Looking to start the career as an entry-level software engineer with a reputed firm driven by technology.

WORK EXPERIENCE

BLOOD DONATION APP | SUMMER INTERNSHIP | May 2020 - July 2020

• Tech Stack : React Native, Firebase

TAILOR UNCLE - DELIVERY APP | REACT NATIVE | Dec 2019 - Jan 2020

• Tech Stack : React Native, Firebase

TSF FOUNDATION | PHP PROJECT | April 2019-June 2019

• Tech Stack: PHP, HTML5

SKIRON GAMING | WORDPRESS | Nov 2018 - Jan 2019

• Tech Stack: Wordpress,HTML, CSS3

PERSONAL PROJECTS

ML BASED HUMAN IDENTIFICATION USING GAIT PATTERN AND COMPUTER VISION | Jan 2020 - May 2020

• Tech Stack: ML models, Python3

WEB PAGE RANKING ALGORITHM |Jul 2019 – Dec 2019

• Tech Stack: Python3, HTML, Javascript,

BEST ROUTE | Aug 2018

• Tech Stack: C++, Graph Algorithms

EDUCATION

JAYPEE INSTITUTE OF INFORMATION TECHNOLOGY, NOIDA

B.TECH IN COMPUTER SCIENCE | 2017 - Present

Aggregate **CGPA: 7.7/10.0**

ST. JAMES SR. SEC. SCHOOL| CBSE | HARDOI, INDIA

Intermediate: 85% | 2016

High School: 90% | 2014

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Education

- **Jaypee Institute of Information Technology** — Noida, India
  Bachelor of Technology in Computer Science; GPA: 7.7 — *July 2017 – Present*
- **Innocent Hearts School** — Jalandhar, India
  Intermediate - 87% — *2017*
- **S.D. Model School** — Jalandhar, India
  High School - 92.8% — *2015*

Skills

- **Languages**: Javascript, C++, Python
- **Libraries & Frameworks**: React, Bootstrap
- **Tools**: MySQL, Git

Experience

- **FarziEngineer** — Remote
  Web Developer (Intern) — *Jan 2020 - July 2020*
  - **Completed the project**: Developed an ERP System from scratch, a platform to list all the inventory items,sales and purchases of client. Any number of customers,suppliers,products can be added and graphs are plotted using Chart JS

Projects

- **ERP System**: A platform to list all the inventory items,sales and purchases of client.Any number of customers,suppliers,products can be added.
  Graphs are plotted using ChartJS to depict sales and purchases of client on daily,weekly and monthly basis.For every sale and purchase invoice is generated.
  Tech:- ReactJS, JS, CSS, Bootstrap, ChartJS
- **Library System**: A Library Management System where library can update the books available for borrow and can see all the books he had borrowed.
  Tech:- PHP, HTML, CSS, JS, AJAX, SQL
- **Weather App**: A platform to find out weather of any city in the world, Temperature,Humidity and description of weather is shown and Data is gathered from openweathermap API.
  Tech:- ReactJS, HTML, CSS
- **Tic-Tac-Toe Game**: Basic game made using ReactJS. We can play against computer. Moves of computer are randomly generated and whenever any player wins the game stops there.
  Tech:- ReactJS, CSS

Achievments

- Letter of Appreciation - ICSC Conference
- Won 1st prize in Make your Masterpiece in CyberSrishti(JIIT)

Position Of Responsibility

- **Creativity and Innovation Cell In Electronics(JIIT)**: Digital Head

Certificates

- **FarziEngineer**: Web Developer (Intern)
- **Hackerrank**: Problem Solving