

# VISVESVARAYA TECHNOLOGICAL UNIVERSITY

Jnana Sangama, Belagavi – 590018, Karnataka, India



## A PROJECT REPORT

On

**“Sign Language Interpreter using Deep Learning”**

A Dissertation Submitted in partial fulfilment of the requirement for the degree of

**BACHELOR OF ENGINEERING**

In

**COMPUTER SCIENCE & ENGINEERING**

Submitted by

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**RAJIV GANDHI INSTITUTE OF TECHNOLOGY**

Cholanagar, R.T. Nagar Post, Bengaluru-560032

**2021-2022**

# RAJIV GANDHI INSTITUTE OF TECHNOLOGY

(Affiliated to Visvesvaraya Technological University)

Cholanagar, R.T. Nagar Post, Bengaluru-560032

## Department of Computer Science & Engineering



### CERTIFICATE

#### Phase- II

This is to certify that the Project Report titled “**Sign Language Interpreter using Deep Learning**” is a bonafide work carried out by **Ms. Bahaduri Prachiti Jagdish (USN 1RG17CS009)**, **Mr. Mohammed Azim (USN 1RG17CS030)**, **Mr. Mohammed Touseef (USN 1RG17CS031)** and **Mr. Prajwal B Mani (USN 1RG17CS037)** in partial fulfillment for the award of **Bachelor of Engineering in Computer Science and Engineering** under **Visvesvaraya Technological University, Belgavi**, during the year **2021 – 2022**. It is certified that all corrections/suggestions given for Internal Assessment have been incorporated in the report. This project report has been approved as it satisfies the academic requirements in respect of project work Phase – II (17CSP85) prescribed for the said degree.

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## **DECLARATION**

We hereby declare that the project work entitled **“Sign Language Interpreter using Deep Learning”** submitted to the **Visvesvaraya Technological University, Belgavi** during the academic year **2021 – 2022**, is record of an original work done by us under the guidance of **Mrs. Pushplata Dubey**, Asst. Professor, Department of Computer Science and Engineering, RGIT, Bengaluru in the partial fulfilment of requirements for the award of the degree of **Bachelor of Engineering in Computer Science & Engineering**. The results embodied in this project have not been submitted to any other University or Institute for award of any degree or diploma.

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# ACKNOWLEDGEMENT

We take this opportunity to thank our college **Rajiv Gandhi Institute of Technology, Bengaluru** for providing us with an opportunity to carry out this project work.

We express our gratitude to **Dr. Nagaraj A M**, Principal, RGIT, Bengaluru and to **Dr. D G Anand**, Rector, RGIT, Bengaluru for providing the resources and support without which the completion of this project would have been a difficult task.

We extend our sincere thanks to **Mrs. Arudra A**, Associate Professor and Head, Department of Computer Science and Engineering, RGIT, Bengaluru, for being a pillar of support and encouraging us in the face of all adversities.

We would like to acknowledge the through guidance and support extended towards us by **Mrs. Pushplata Dubey**, Assistant Professor, Dept of CSE, RGIT, Bengaluru and project coordinators **Mrs. Geetha Pawar** , Assistant Professor, Dept of CSE, RGIT, Bengaluru and **Mrs. Rajani Kodagali**, Assistant Professor, Dept of CSE, RGIT, Bengaluru. Their incessant encouragement and valuable technical support have been of immense help. Their guidance gave us the environment to enhance our knowledge and skills and to reach the pinnacle with sheer determination, dedication and hard work.

We also want to extend our thanks to the entire faculty and support staff of the Department of Computer Science and Engineering, RGIT, Bengaluru, who have encouraged us throughout the course of the Bachelor's Degree.

We want to thank our family for always being there with full support and for providing us with a safe haven to conduct and complete our project. We are ever grateful to them for helping us in these stressful times.

Lastly, we want to acknowledge all the helpful insights given to us by all our friends during the course of this project.

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# **ABSTRACT**

Speech Impairment is a disability, which affects an individual's ability to communicate using speech and hearing. This brings about the difficulty for both the sign and non - sign language speakers to communicate with each other. With recent advances in deep learning and computer vision, the focus of our project is to create a vision of an end to end Convolutional Neural Network that will be trained on the ASL(American Sign Language) dataset then modeled on robust architectures like GoogLeNet/MobileNet architecture and deploy it on an android application so that it will have more accessibility and provides an ease of use, thus aiding communication between signers and non-signers. It is a challenging and interesting problem that if solved will bring a leap in social and technological aspects alike.

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# INTRODUCTION

# Chapter 1

## INTRODUCTION

### 1.1 Introduction:

Interpreting is a translational activity in which one produces a first and final translation on the basis of a one-time exposure to an expression in a source language. The most common two modes of interpreting are simultaneous interpreting, which is done at the time of the exposure to the source language, and consecutive interpreting, which is done at breaks to this exposure. Language interpretation is defined by the International Standards Organization (ISO). It states that rendering a spoken or signed message into another spoken or signed language, preserving the register and meaning of the source language content. To do so we make use of ASL, which is American Sign Language. American Sign Language is a language that uses hand signs, facial expressions, and body postures to communicate ideas. American Sign Language not only connects the people to those who are deaf but also it serves as a membership card into a linguistic subculture of our society that not everyone is privileged to enjoy. The statistics presented by the International Standard Organization (ISO) show that over 5% of the world's population or 466 million people has disabling hearing loss. And it is expected to rise to 900 million by the year 2050 which is double as compared to the current statistics.

A sign language interpreter must accurately convey messages between two different languages. An interpreter is available for both hearing and deaf individuals. The act of interpreting occurs when a hearing person speaks, and an interpreter renders the speaker's meaning into sign language, or other forms used by the deaf party(ies). The interpreting also happens in reverse, when a deaf person signs, an interpreter renders the meaning expressed in the signs into the oral language for the hearing party, which is sometimes referred to as voice interpreting or voicing. The current statistics estimate that the actual people who are benefited from hearing aid, are only 17% of the total population while the remaining 83% of the people are suffering from the need and use of hea

### **1.1.1 Deep Learning**

Deep learning (also known as deep structured learning) is part of a broader family of machine learning methods based on artificial neural networks with representation learning. Learning can be supervised, semi-supervised or unsupervised.

Deep-learning architectures such as deep neural networks, deep belief networks, recurrent neural networks and convolutional neural networks have been applied to fields including computer vision, machine vision, speech recognition, natural language processing, audio recognition, social network filtering, machine translation, bioinformatics, drug design, medical image analysis, material inspection and board game programs, where they have produced results comparable to and in some cases surpassing human expert performance.

Artificial neural networks (ANNs) were inspired by information processing and distributed communication nodes in biological systems. ANNs have various differences from biological brains. Specifically, neural networks tend to be static and symbolic, while the biological brain of most living organisms is dynamic (plastic) and analog.

## **1.2 Scope**

ASL interpreters work in a large variety of environments, including medical, legal, educational, mental health, vocational, and other environments. Interpreting is often viewed as a practice profession which requires careful judgement of interpersonal and environmental factors as well as expertise in the skills of the profession itself. Degree programs in ASL Interpreting are available at colleges, universities, and technical schools across the country, ranging from associate degrees to master's degrees. In addition, interpreters work with mentors, attend workshops, and get certifications to become more adept, gain experience, and open additional career opportunities. Other interpreters are Children Of Deaf Adults (CODAs) and are typically exposed to ASL and Deaf culture at a young age, giving them an advantage over later learners. In recent years, much research has gone into discerning whether ASL interpreters have access to adequate, specialized, real-world training and career support systems to ensure success and protect against interpreter burnout. Many studies note interpreter reports of frustration with training that proved inadequate to deal with real-world problems, and a lack of professional support. To prevent interpreter burnouts, there are many alternatives ranging from the same human intervention process which costs 100 dollars per hour to interpreting hand gloves which cost 40,000 dollars per pair.

## **1.3 Motivation**

Communication is one of the basic requirements for survival in society. Deaf and dumb people communicate among themselves using sign language but normal people find it difficult to understand their language. Extensive work has been done on American sign language recognition but Indian sign language differs significantly from American sign language. ISL uses two hands for communicating (20 out of 26) whereas ASL uses single hand for communicating. Using both hands often leads to obscurity of features due to overlapping of hands. In addition to this, lack of datasets along with variance in sign language with locality has resulted in restrained efforts in ISL gesture detection. Our project aims at taking the basic step in bridging the communication gap between normal people and deaf and dumb people using Indian sign language. Effective extension of this project to words and common expressions may not only make the deaf and dumb people communicate faster and easier with outer world, but also provide a boost in developing autonomous systems for understanding and aiding them.

## **1.4 Problem Identification**

According to the projection of data it is expected to rise to 900 million by 2050 that is double the current stats. Over 5% of the world's population which is almost 466 million people has disabling hearing loss. Studies reveal that deaf people are around twice as likely to suffer from psychological problems such as depression and anxiety. Hearing loss can affect a person in three main ways firstly, fewer educational and job opportunities due to impaired communication. Social withdrawal due to reduced access to services and difficulties communicating with others emotional problems caused by a drop in self-esteem and confidence.

## **1.5 Objectives**

1. Create a robust android application that aids in communication for deaf people.
2. Use deep learning with transfer learning techniques to build a neural network model that as to ability to learn pattern in video and classify the images.
3. An error correction model for identifying the pattern mismatch and correcting it for the audio or text input format.
4. To build a model that has higher accuracy with less bias and overfitting problems.
5. To enhance the model to classify at least 20 classes or more.

### 1.5.1 Existing systems

There has been much research on the sign language domain. Some of them are traditional ones while some of them are advanced mechanics like sensor gloves. Therefore, these conventional mechanisms cannot effectively deal with the ever-evolving technologies.

#### 1. TRADITIONAL – BASED APPROACH

A sign language interpreter is a person trained in translating between a spoken and a signed language. This usually means someone who interprets what is being said and signs it for someone who can't hear, but understands the sign. The interpreter of course will also interpret and speak the words which convey the meaning of whatever the signing person signs, so that the hearing person can “hear” what is being signed.

#### 2. GLOVE – BASED APPROACH

The signers are required to wear a sensor glove or a coloured glove. The task will be simplified during segmentation process by wearing glove.

#### Disadvantages

- Lack of availability of the interpreter for that moment.
- The gloves based approach is that the signer has to wear the sensor hardware along with the glove during the operation of the system.
- The cost of traditional based approach will vary from 100 to 200 dollars/hrs and for gloves based approach its costs around 40,000 dollars / pair.



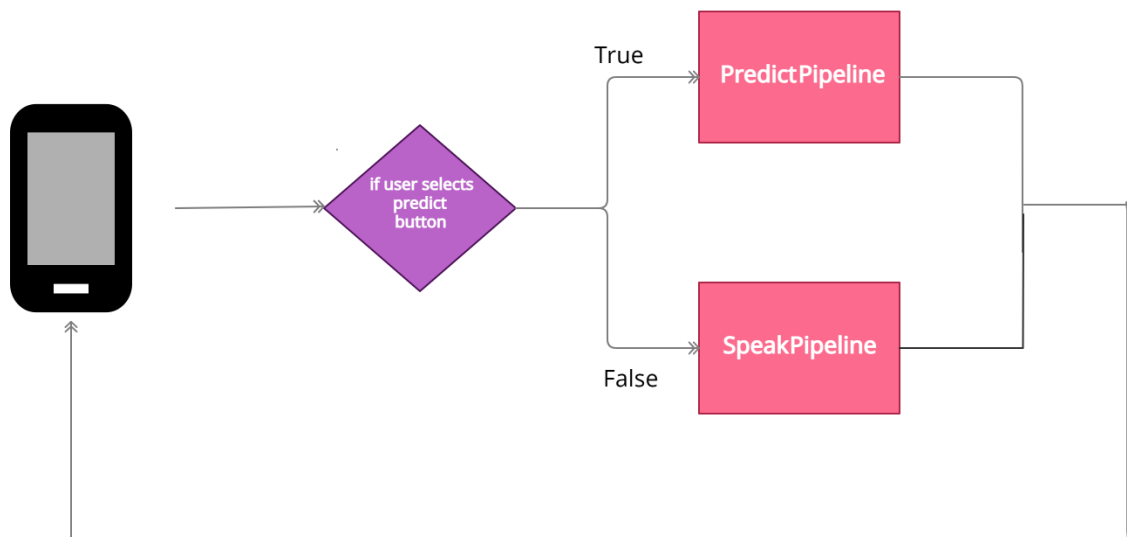
**Fig. 1.1: Traditional – based Approach**



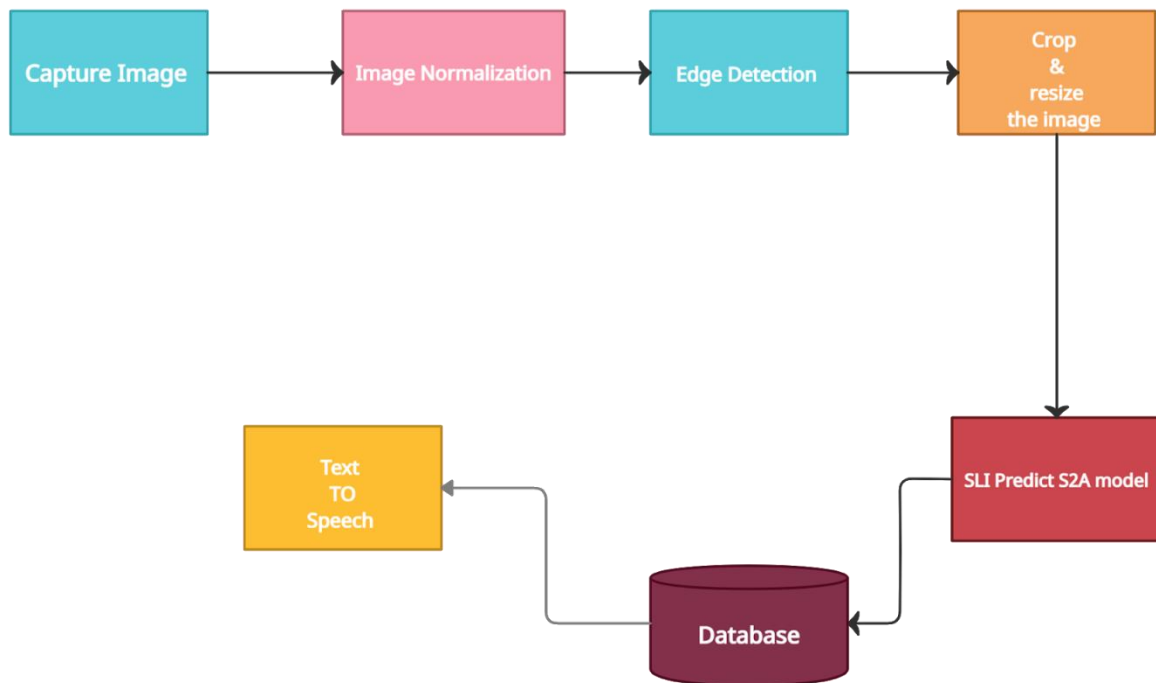
**Fig. 1.2: Glove – based Approach**

### 1.5.2 Proposed system

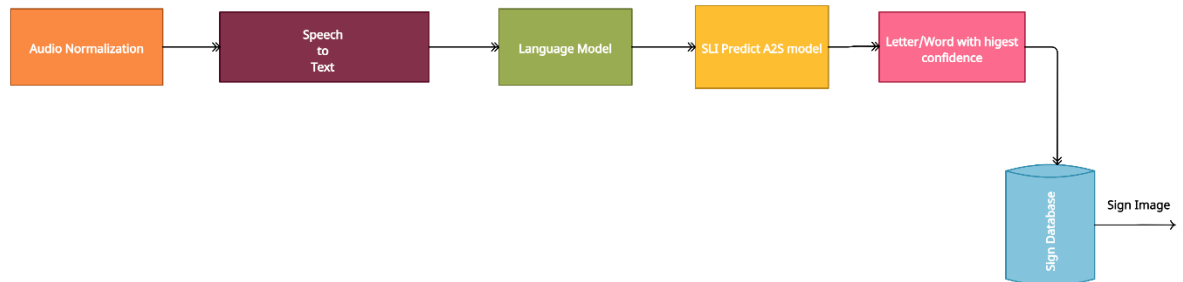
We have introduced a refined approach using advanced deep learning techniques that is flexible to use by any mobile users. In this presentation, we propose an architecture to detect signs. Image pre-processing makes the existing data and input data normalized. The pipeline allows us to automate machine learning workflow. Transfer learnings make it easy to make the models to learn even small details that are hard to capture in a small network. Kivy gives us an advantages overview by giving us a docile structure to compile to any version of the mobile app.



**Fig. 1.3: The Architecture of Sign Language Interpreter**



**Fig. 1.4: Predict Pipeline Architecture**



**Fig. 1.5: Speak Pipeline Architecture**

### Advantages

- Considerably better accuracy compared to the previous models.
- Considerably less requirement of raw computation and Storage space requirements.
- Usage of Neural network model leads to less human intervention.

# **OUTCOME OF PROJECT**



## Chapter 2

### OUTCOME OF THE PROJECT

Sign Language Interpreter will be able to predict the sign waved by the user and converts that into sound or text vice versa. So far the systems that have been developed give less accuracy and slower results with only shallow networks. The model that has been used in our project will be able to detect with improved accuracy. We will achieve the following results:

1. **UI Interface to access model functionalities:** A flexible UI with a good look and feel with a design that is self-explanatory.
2. **Improved accuracy:** By building a deeper network that model learns and minimizes more parameter that is optimal for our problem
3. **Dynamic Tracing:** By allowing users to dynamical trace would add an advantage when the app is deployed in the real-time
4. **Continuous integration pipelines that enable model redeployment:** Pipelines helps us to automate the machine learning workflows which helps us to reduce time on the surface level.

# LITERATURE SURVEY

## **Chapter 3**

### **LITERATURE SURVEY**

A literature survey or a literature review in a project report is that section which shows the various analyses and research made in the field of interest and the results already published, taking into account the various parameters of the project and the extent of the project. It is the most important part of a report as it gives a direction in the area of research. It helps to set a goal for analysis thus giving a problem statement. A literature review is both a summary and explanation of the complete and current state of knowledge on a limited topic as found in academic books and journal articles. Literature survey is a text of a scholarly paper, which includes the current knowledge including substantive findings, as well as theoretical and methodological contributions to a particular topic. And in general, a literature survey guides or helps the researcher to define/find out/identify a problem. The purpose of a literature survey is to: Place each work in the context of its contribution to understanding the research problem being studied. Describes the relationship of each work to the others under consideration. Identify new ways to interpret prior research. Literature of knowledge has a function to teach. It means that literature gives particular values, messages, and themes to the readers. The final function of literature is that literature relieve human either writers or readers from the pressure of emotions. Literature also functions to contribute values of human lives. It provides an excellent starting point for researchers beginning to do research in a new area by forcing them to summarize, evaluate, and compare original research.

As the technology progresses, the internet is now commonly used on PCs, tablets, and smartphones. This generates a huge amount of data, especially textual data. It has become impossible to manually analyze all the data for a specific purpose. New research directions have emerged from automatic data analysis like automatic emotion analysis. Emotion analysis has attracted researchers' attention because of its applications in different fields. Components such as behavior, voice, posture, vocal intensity, and emotion intensity of the a person depicting the emotion, when combined, helps in measuring and recognizing various emotions.

## NumPy CNN Android : A Library for Straightforward Implementation of Convolutional Neural Networks for Android Devices

**Table 3.1: NumPy CNN Android : A Library for Straightforward Implementation of Convolutional Neural Networks for Android Devices**

Name of the paper	Authors	Year	Features	Advantages	Disadvantages
NumPy CNN Android : A Library for Straightforward Implementation of Convolutional Neural Networks for Android Devices	Ahmed Fawzy Gad	2019	AlexNet , VGGNet and GoogLeNet are examples of CNN architecture s trained with the ImageNet dataset.	The process of creating a CNN model working on mobile devices is straight forward as the trained model is compatible with them without any in-between transformation steps. Mean error across the samples used is 0.5113.	The weakness of the proposed library is its computational time.

**Authors :** Ahmed Fawzy Gad

A new open source library called NumPyCNNAndroid is proposed that minimizes the overhead of building and running convolutional neural networks on Android devices. The library is written in Python 3. It uses Kivy for building the application interface and Numerical Python for building the network itself. The library supports the most common layers. Compared to the widely known deep learning libraries, NumPyCNNAndroid avoids the extra overhead of making the network suitable for running on mobile devices. The experimental results validate the correctness of the library implementation by comparing results from both the proposed library and TensorFlow based on mean absolute error.

## Deep Learning for American Sign Language Fingerspelling Recognition System

**Table 3.2: Deep Learning for American Sign Language Fingerspelling Recognition System**

Name of the paper	Authors	Year	Features	Advantages	Disadvantages
Deep Learning for American Sign Language Fingerspelling Recognition System	Huy B.D Nguyen, Hung Ngoc Do	2019	Histograms of Oriented Gradients(HOG) and Local Binary Pattern(LBP), Moore Neighbourhood algorithm, SIFT algorithm	The combinations of HOG, LBP features and multi-kernel multi-class VM acts as a good standalone Feature extractor, better result can be obtained than using an end-to-end CNN architecture.	The validation accuracy of the CNN-SVM model is lower than that of HOG-LBP-SVM model, it has a better chance to counter overfitting.

**Authors** - Huy B.D Nguyen, Hung Ngoc Do

Sign language has always been a major tool for communication among people with disabilities. In this paper, a sign language fingerspelling alphabet identification system would be developed by using image processing technique, supervised machine learning and deep learning. In particular, 24 alphabetical symbols are presented by several combinations of static gestures (excluding 2 motion gestures J and Z). Histogram of Oriented Gradients (HOG) and Local Binary Pattern (LBP) features of each gesture will be extracted from training images. Then Multiclass Support Vector Machines (SVMs) will be applied to train these extracted data. Also, an end-to-end Convolutional Neural Network (CNN) architecture will be applied to the training dataset for comparison. After that, a further combination of CNN as feature descriptor and SVM produces an acceptable result. The Massey Dataset is implemented in the training and testing phases of the whole system.

## American Sign Language Video Hand Gestures Recognition using Deep Neural Networks

**Table 3.3: American Sign Language Video Hand Gestures Recognition using Deep Neural Networks**

Name of the paper	Authors	Year	Features	Advantages	Disadvantages
American Sign Language Video Hand Gestures Recognition using Deep Neural Networks	Shivashankara S & Srinath S	2019	Speeded Up Robust Features(SURF), Zernike Moment(ZM), Discrete Cosine Transform(DCT), Radon Features	Due to advance preprocessing the PVGR has an average accuracy of 96.43 Overall, the recognition rate obtained is better comparing with the state of art techniques.	It is noticed that, due to the gestures captured in low illumination night time, there is a bit of loss of recognition rate.

**Authors :** Shivashankara S & Srinath S

In this paper an effort has been placed to translate / recognize some of the video based hand gestures of American Sign Language (ASL) into human and / or machine readable English text using deep neural networks. Initially, the recognition process is carried out by fetching the input video gestures. In the recognition process of the proposed algorithm, for background elimination and foreground detection, the Gaussian Mixture Model (GMM) is used. The basic preprocessing operations are used for better segmentation of the video gestures. The various feature extraction techniques like, Speeded Up Robust Features (SURF), Zernike Moment (ZM), Discrete Cosine Transform (DCT), Radon Features (RF), and R, G, B levels are used to extract the hand features from frames of the video gestures. The extracted video hand gesture features are used for classification and recognition process in forthcoming stage. For classification and followed by recognition, the Deep Neural Networks (stacked autoencoder) is used. This video hand gesture recognition system can be used as tool for filling the communication gap between the normal and hearing impaired people. As a result of this proposed ASL video hand gesture recognition (VHGR), an average recognition rate of 96.43% is achieved. This is the better and motivational performance compared to state of art techniques.

## American Sign Language Recognition using Deep Learning and Computer Vision

**Table 3.4: American Sign Language Recognition using Deep Learning and Computer Vision**

<b>Name of the paper</b>	<b>Authors</b>	<b>Year</b>	<b>Features</b>	<b>Advantages</b>	<b>Disadvantages</b>
American Sign Language Recognition using Deep Learning and Computer Vision	Kshitij Bantupalli & Ying Xie	2018	Use of Inception net, a CNN for recognizing spatial features. then use a RNN to train on temporal features. The dataset used is the American Sign Language Dataset.	Softmax layer gives more accuracy than the pool layer	One of the problems the model faced is with facial features and skin tones. While testing with different skin tones, the model dropped accuracy if it hadn't been trained on a certain skin tone and was made to predict it.

**Authors :** Kshitij Bantupalli & Ying Xie

Speech impairment is a disability which affects an individuals ability to communicate using speech and hearing. People who are affected by this use other media of communication such as sign language. Although sign language is ubiquitous in recent times, there remains a challenge for non-sign language speakers to communicate with sign language speakers or signers. With recent advances in deep learning and computer vision there has been promising progress in the fields of motion and gesture recognition using deep learning and computer vision-based techniques. The focus of this work is to create a vision- based application which offers sign language translation to text thus aiding communication between signers and non-signers. The proposed model takes video sequences and extracts temporal and spatial features from them. We then use Inception, a CNN (Convolutional Neural Network) for recognizing spatial features. We then use a RNN (Recurrent Neural Network) to train on temporal features. The dataset used is the American Sign Language Dataset.

## American Sign Language Character Recognition using Convolutional Neural Network

**Table 3.5: American Sign Language Character Recognition using Convolutional Neural Network**

Name of the paper	Authors	Year	Features	Advantages	Disadvantages
American Sign Language Character Recognition using Convolutional Neural Network	Sarfaraz Masood, Manish Chandra Thuwal, Adhyan Srivastava	2018	Convolutional Neural Network Model, Image Preprocessing and VGG16 Model	The Convolutional Neural Network provides a remarkable accuracy in identifying the sign language characters including alphabets and numerals.	Even though the accuracy is high but the percentage of misclassification is more than expected

**Authors :** Sarfaraz Masood, Manish Chandra Thuwal, Adhyan Srivastava

Inability to speak is considered to be a true disability. People with this disability use different modes to communicate with others, there are number of methods available for their communication one such common method of communication is sign language. Developing sign language application for deaf people can be very important, as they'll be able to communicate easily with even those who don't understand sign language. This work aims at taking the basic step in bridging the communication gap between normal people and deaf and dumb people using sign language. The image dataset consists of 2524 ASL gestures. The accuracy of the model obtained using Convolution Neural Network was 96%.



## Optimization of Transfer Learning for Sign Language Recognition Targeting Mobile Platform

**Table 3.6: Optimization of Transfer Learning for Sign Language Recognition Targeting Mobile Platform**

Name of the paper	Authors	Year	Features	Advantages	Disadvantages
Optimization of Transfer Learning for Sign Language Recognition Targeting Mobile Platform	Dhruv Rath	2018	Convolutional Neural Network(CNN) on ImageNet, two pre-trained models, Inception V3 model and MobileNets open-source models for comparison purposes.	Both mobile net and inception gives us an accuracy more than 95% irrespective of there parameters difference	Model can't predict sentences due to lack of Natural Language Processing(NLP) and other sentences construction techniques.

**Authors :** Dhruv Rath

The target of this research is to experiment, iterate and recommend a system that is successful in recognition of American Sign Language(ASL). It is a challenging as well as an interesting problem that if solved will bring a leap in social and technological aspects alike. In this paper, we propose a real-time recognizer of ASL based on a mobile platform, so that it will have more accessibility and provides an ease of use. The technique implemented is Transfer Learning of new data of Hand gestures for alphabets in ASL to be modelled on various pre-trained high- end models and optimize the best model to run on a mobile platform considering the various limitations of the same during optimization. The data used consists of 27,455 images of 24 alphabets of ASL. The optimized model when ran over a memory-efficient mobile application, provides an accuracy of 95.03% of accurate recognition with an average recognition time of 2.42 seconds. This method ensures considerable discrimination in accuracy and recognition time than the previous research.

## **A Deep Learning Based Video Classification System Using Multimodality Correlation Approach**

**Table 3.7: A Deep Learning Based Video Classification System Using Multimodality Correlation Approach**

<b>Name of the paper</b>	<b>Authors</b>	<b>Year</b>	<b>Features</b>	<b>Advantages</b>	<b>Disadvantages</b>
A Deep Learning Based Video Classification System Using Multimodality Correlation Approach	Junghoon Lee, Youngsan Koh and Jihoon Yang	2017	Image feature vector extraction, Audio feature vector extraction, Normalization of feature vectors	Method of normalizing each modality to a unit vector so that it can be effectively integrated at the integration stage of the multimodality.	Unit vector normalization should be done to get the required accuracy.

**Authors :** Junghoon Lee, Youngsan Koh and Jihoon Yang

In this paper, we propose a video event classification system that classifies video events using the correlation of images and sounds extracted from one video. The proposed system has better classification performance than other systems using single modality.

## Hand Gesture Recognition Using Deep Learning

**Table 3.8: Hand Gesture Recognition Using Deep Learning**

<b>Name of the paper</b>	<b>Authors</b>	<b>Year</b>	<b>Features</b>	<b>Advantages</b>	<b>Disadvantages</b>
Hand Gesture Recognition Using Deep Learning	Soeb Hussain and Rupal Saxena	2017	Transfer Learning : VGG16 architecture	The accuracy is far better than video based standard network alexnet by scoring 93.09%	The method was made robust by avoiding skin color segmentation, blob detection, skin area cropping and centroid extraction for unidirectional dynamic gestures.

**Authors :** Soeb Hussain and Rupal Saxena

In order to offer new possibilities to interact with machine and to design more natural and more intuitive interactions with computing machines, our research aims at the automatic interpretation of gestures based on computer vision. In this paper, we propose a technique which commands computer using six static and eight dynamic hand gestures. The three main steps are: hand shape recognition, tracing of detected hand (if dynamic), and converting the data into the required command. Experiments show 93.09% accuracy.

## Real-time American Sign Language Recognition with Convolutional Neural Networks

**Table 3.9: Real-time American Sign Language Recognition with Convolutional Neural Networks**

Name of the paper	Authors	Year	Features	Advantages	Disadvantages
Real-time American Sign Language Recognition with Convolutional Neural Networks	Brandon Garcia & Sigberto Alarcon Viesca (Stanford University Stanford, CA)	2016	A deep learning framework, in order to develop, test, and run our CNN specifically, they used Berkeley Vision and Learning Center's GoogLeNet pre-trained on the 2012 ILSVRC dataset.	Produce effective accuracy with the letters a-e without any image pre-processing	The lack of variation in our datasets, the validation accuracies we observed during training were not directly reproducible upon testing on the web application.

**Authors :** Brandon Garcia & Sigberto Alarcon Viesca (Stanford University Stanford, CA)

A real-time sign language translator is an important milestone in facilitating communication between the deaf community and the general public. We hereby present the development and implementation of an American Sign Language (ASL) fingerspelling translator based on a convolutional neural network. We utilize a pre-trained GoogLeNet architecture trained on the ILSVRC2012 dataset, as well as the Surrey University and Massey University ASL datasets in order to apply transfer learning [this](#) task. We produced a robust model that consistently classifies letters a-e correctly with first-time users and another that correctly classifies letters a-k in a majority of cases. Given the limitations of the datasets and the encouraging results achieved, we are confident that with further research and more data, we can produce a fully generalizable translator for all ASL letters.

## Deaf Talk using 3D Animated Sign Language

**Table 3.10: Deaf Talk using 3D Animated Sign Language**

Name of the paper	Authors	Year	Features	Advantages	Disadvantages
Deaf Talk using 3D Animated Sign Language	Mateen Ahmed, Mujtaba Idrees, Zain ul Abideen, Rafia Mumtaz, Sana Khalique	2016	With Microsoft's Kinect in the market, especially for hands, used the depth sensor of Kinect to recognize around thousand phrases from ASL and this recognition is based on the hidden Markov model (HMM), also focused on Kinect base hand gestures recognition.	The system provides dual mode of communication so it has been categorized into two independent modules with 84% accuracy	This does not solve the communication problem, as natural language speakers don't understand sign language hence there exists a communication gap between these two communities.

**Authors :** Mateen Ahmed, Mujtaba Idrees, Zain ul Abideen, Rafia Mumtaz, Sana Khalique

This paper describes a neoteric approach to bridge the communication gap between deaf people and normal human beings. In any community there exists such group of disable people who face severe difficulties in communication due to their speech and hearing impairments. Such people use various gestures and symbols to talk and receive their messages and this mode of communication is called sign language. Yet the communication problem doesn't end here, as natural language speakers don't understand sign language resulting in a communication gap. Towards such ends there is a need to develop a system which can act as an interpreter for sign language speakers and a translator for natural language speakers. For this purpose, a software based solution has been developed in this research by exploiting the latest technologies from Microsoft i.e. Kinect for windows V2. The proposed system is dubbed as Deaf Talk, and it acts as a sign language interpreter and translator to provide a dual mode of communication between sign language speakers and natural language speakers. The dual mode of communication has following independent modules (1) Sign/Gesture to speech conversion (2) Speech to sign language conversion. In sign to speech conversion module, the person with speech inhibition has to place himself within Kinect's field of view (FOV) and then performs the sign language gestures. The system receives the performed gestures through Kinect sensor and then comprehends those gestures by comparing them with the trained

gestures already stored in the database. Once the gesture is determined, it is mapped to the keyword corresponding to that gesture. The keywords are then sent to text to speech conversion module, which speaks or plays the sentence for natural language speaker. In contrast to sign to speech conversion, the speech to sign language conversion module translates the spoken language to sign language. In this case, the normal person places himself in the Kinect sensor's FOV and speaks in his native language (English for this case). The system then converts it into text using speech to text API. The keywords are then mapped to their corresponding pre-stored animated gestures and then animations are played on the screen for the spoken sentence. In this way the disable person can visualize the spoken sentence, translated into a 3D animated sign language. The accuracy of Deaf Talk is 87 percent for speech to sign language conversion and 84 percent for sign language to speech conversion.

# **SYSTEM REQUIREMENTS**

## Chapter 4

# SYSTEM REQUIREMENTS

To be used efficiently, all computer software needs certain hardware components or other software resources to be present on a computer these prerequisites are known as system requirements. System requirements are the configuration that a system must have in order for a hardware or software application to run smoothly and efficiently. Failure to meet these requirements can result in installation problems or performance problems. The former may prevent a device or application from getting installed, whereas the latter may cause a product to malfunction or perform below expectation or even to hang or crash. System requirements are also known as minimum system requirements. System requirements only tell what system must have and what it must allow users to do. The system requirements are of two types:

- Hardware Requirements
- Software Requirements

### 4.1 Hardware Requirements

The most common set of requirements defined by any operating system or software application is the physical computer resources, also known as hardware.

For Typical Operating System (Windows 10)

For Developement

- Intel Core i3 3rd gen processor or later.
- 8GB RAM & 500GB disk space
- A good GPU supported with CUDNN
- I/O devices
- Any external or inbuilt camera with minimum pixel resolution 200 x 200 (300pi or 1501pi) 4-megapixel cameras and up.

For Deloyment

An Android Smartphone with data connectivity and camera.

### 4.2 Software Requirements:

The Software requirements deal with defining software resource requirements and prerequisites that need to be installed on a computer to provide optimal functioning of an application.



Front end: Android Studio

Minimum Api level: 19(kitkat)

### 4.3 Hardware Requirement Specification

Above mentioned requirements are minimum. Practically I shall recommend the following:

1. Minimum 2-GHz processor
  2. RAM 4 GB
  3. Hard disk available space minimum of 100 GB
- **CUDNN :** The NVIDIA CUDA® Deep Neural Network library (cuDNN) is a GPU-accelerated library of primitives for deep neural networks. cuDNN provides highly tuned implementations for standard routines such as forward and backward convolution, pooling, normalization, and activation layers.
  - **Android Smartphone:** A smartphone is a portable device that combines mobile telephone and computing functions into one unit. They are distinguished from feature phones by their stronger hardware capabilities and extensive mobile operating systems, which facilitate wider software, internet (including web browsing over mobile broadband), and multimedia functionality (including music, video, cameras, and gaming), alongside core phone functions such as voice calls and text messaging.
  - **Intel® Core™ Processors - The Powerful Processor:**

Intel Core processors first came to the desktop in mid-2006, replacing the Pentium line that had previously comprised Intel's high-end processors. The Core “i” names are primarily “high level” categorizations that help differentiate processors within a given generation.
  - **GPU:** A graphics processing unit (GPU) is a specialized, [electronic circuit](#) designed to rapidly manipulate and alter [memory](#) to accelerate the creation of [images](#) in a [frame buffer](#) intended for output to a [display device](#). GPU will help us to train the models faster without using CPU resources.
  - **I/O devices:** To view and input data to the application.
  - **RAM:** RAM, also known as random access memory is vital for any system to function.
  - **Minimum RAM requirements for our system:** 8 GB
  - **Camera:** Most importantly you need a camera that can do 30 fps - that means 30 frames per second. Any less than 24 frames per second and your hands will be blurry.
  - **HardDisk:** Minimum requirements for disk capacity is 500GB.

## 4.4 Software Requirement Specification

- **Front End : Android Studio :** Android Studio is the official integrated development environment (IDE) for Google's Android operating system, built on JetBrains' IntelliJ IDEA software and designed specifically for Android development. It is available for download on Windows, macOS and Linux based operating systems or as a subscription-based service in 2020. It is a replacement for the Eclipse Android Development Tools (E-ADT) as the primary IDE for native Android application development.

The following features are provided in the current stable version:

- Gradle-based build support
  - Android-specific refactoring and quick fixes
  - Lint tools to catch performance, usability, version compatibility and other problems
  - ProGuard integration and app-signing capabilities
  - Template-based wizards to create common Android designs and components
  - A rich layout editor that allows users to drag-and-drop UI components, option to preview layouts on multiple screen configurations
  - Support for building Android Wear apps
  - Built-in support for Google Cloud Platform, enabling integration with Firebase Cloud Messaging (Earlier 'Google Cloud Messaging') and Google App Engine
  - Android Virtual Device (Emulator) to run and debug apps in the Android studio.
- 
- **Minimum Api level: 19(kitkat) :** The development of Android started in 2003 by Android, Inc., which was purchased by Google in 2005. There were at least two internal releases of the software inside Google and the OHA before the beta version was released. The beta was released on November 5, 2007, while the software development kits (SDK) was released on November 12, 2007. Several public beta versions of the SDK were released. These releases were done through software emulation as physical devices did not exist to test the operating system.

# ANDROID VERSIONS AND THEIR RELEASE DATES



**Figure 4.6: Android Versions and their release dates**

- Ubuntu : deploying .apk using Android Studio:** You can create a package for android using the python-for-android project. This page explains how to download and use it directly on your own machine (see Packaging with python-for-android) or use the Buildozer tool to automate the entire process. You can also see Packaging your application for the Kivy Launcher to run kivy programs without compiling them. Kivy applications can be released on an Android market such as the Play store, with a few extra steps to create a fully signed APK. The Kivy project includes tools for accessing Android APIs to accomplish vibration, sensor access, texting etc. These, along with information on debugging on the device, are documented at the main Android page.
- Video & image processing: Open CV, scikit-image:** Processing a video means, performing operations on the video frame by frame. Frames are nothing but just the particular instance of the video in a single point of time. We may have multiple frames even in a single second. Frames can be treated as similar to an image

## 1. Adaptive Threshold

By using this technique we can apply thresholding on small regions of the frame. So the collective value will be different for the whole frame.

## 2. Smoothing

Smoothing a video means removing the sharpness of the video and providing a blurriness to the video. There are various methods for smoothing such as `cv2.GaussianBlur()`, `cv2.medianBlur()`, `cv2.bilateralFilter()`. For our purpose, we are going to use `cv2.GaussianBlur()`.

### **3. Edge Detection**

Edge detection is a useful technique to detect the edges of surfaces and objects in the video. Edge detection involves the following steps:

- Noise reduction
- Gradient calculation
- Non-maximum suppression
- Double threshold
- Edge tracking by hysteresis

### **4. Bitwise Operations**

Bitwise operations are useful to mask different frames of a video together.

Bitwise operations are just like we have studied in the classroom such as AND, OR, NOT, XOR.

## **Neural Network Modeling:Tensorflow(tf.lite), Keras, Pytorch**

- **Tensor flow**

There are multiple changes in TensorFlow 2.0 to make TensorFlow users more productive. TensorFlow 2.0 removes redundant APIs, makes APIs more consistent (Unified RNNs, Unified Optimizers), and better integrates with the Python runtime with Eager execution. Many RFCs have explained the changes that have gone into making TensorFlow 2.0. This guide presents a vision for what development in TensorFlow 2.0 should look like. It's assumed you have some familiarity with TensorFlow 1.x.

- **Keras**

Keras is an API designed for human beings, not machines. Keras follows best practices for reducing cognitive load: it offers consistent & simple APIs, it minimizes the number of user actions required for common use cases, and it provides clear & actionable error messages. It also has extensive documentation and developer guides.

- **Exascale machine learning**

Built on top of TensorFlow 2.0, Keras is an industry-strength framework that can scale to large clusters of GPUs or an entire TPU pod. It's not only possible; it's easy.

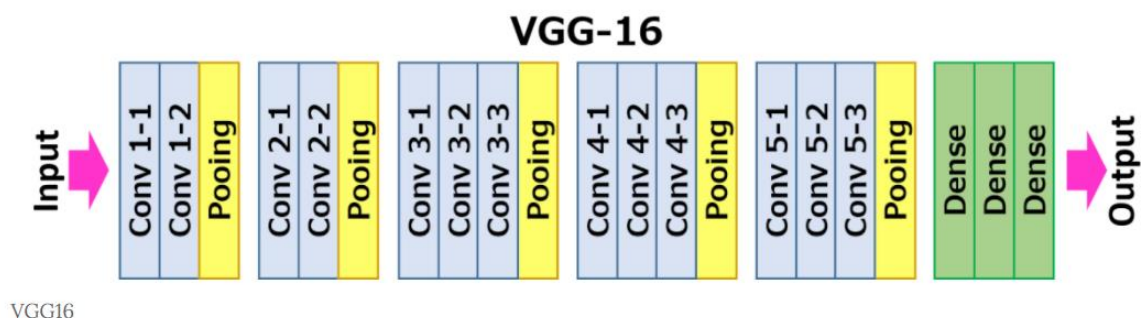
- **Deploy anywhere**

Take advantage of the full deployment capabilities of the TensorFlow platform. You can export Keras models to JavaScript to run directly in the browser, to TF Lite to run on iOS, Android, and embedded devices. It's also easy to serve Keras models as via a web API.

- **Architectures**

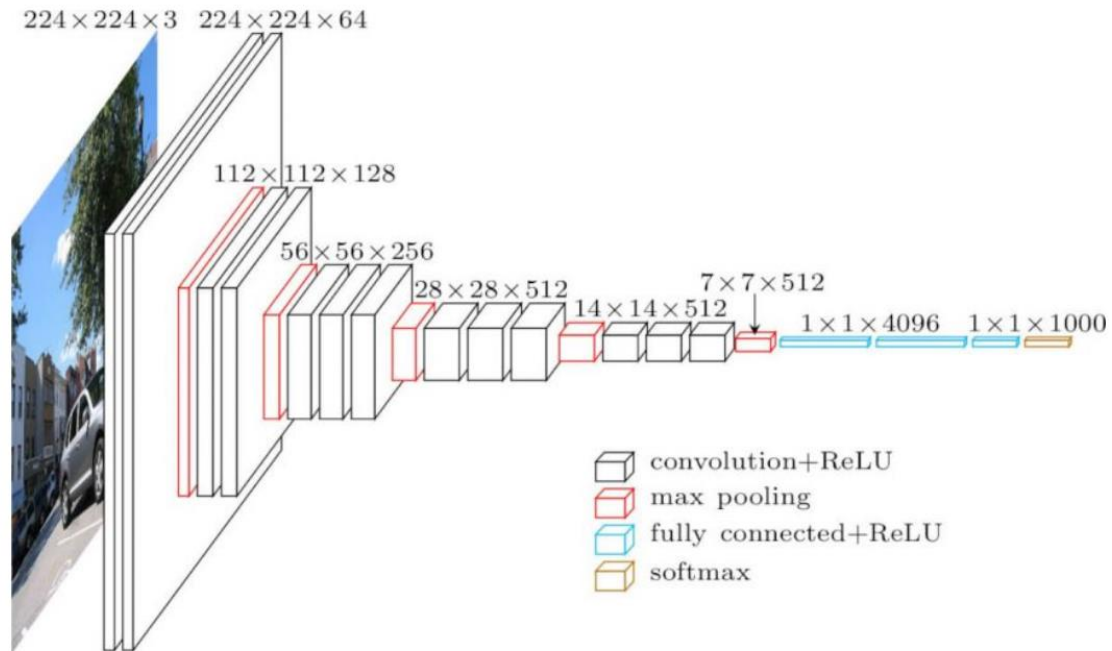
Google LeNet, MobileNet, VGG 16 which are pre-trained models on huge datasets with parameters varying through millions together and deep networks.

**VGG16:** It is a convolutional neural network model proposed by K. Simonyan and A. Zisserman from the University of Oxford in the paper “Very Deep Convolutional Networks for Large-Scale Image Recognition”. The model achieves 92.7% top-5 test accuracy in ImageNet, which is a dataset of over 14 million images belonging to 1000 classes. It was one of the famous Page|23 submitted to ILSVRC-2014. It makes the improvement over AlexNet by replacing large kernel-sized filters (11 and 5 in the first and second convolutional layer, respectively) with multiple 3×3 kernel-sized filters one after another. VGG16 was trained for weeks and was using the NVIDIA Titan Black GPU's.



**Figure 4.7: VGG – 16 Basic Architecture**

The architecture depicted below is VGG16.



**Figure 4.8: VGG – 16 Block Architecture**

### 4.3 System Requirements Summary

This chapter introduces the system analysis process. It gives brief idea whether this project should be done or not based on various feasibility study. It gives the summary of various feasibility studies that were carried out and shows the advantages of doing this project. At the same time, it also gives the overview of various functional and non- functional requirements of the system.

# **SYSTEM ANALYSIS**

## Chapter 5

# SYSTEM ANALYSIS

### 5.1 Introduction to System Analysis

- **System:** A system is an orderly group of interdependent components linked together according to a plan to achieve a specific objective. Its main characteristics are organization, interaction, interdependence, integration and a central objective.
- **Analysis:** Analysis is a detailed study of the various operations performed by a system and their relationships within and outside of the system. One aspect of analysis is defining the boundaries of the system and determining whether or not a candidate system should consider other related systems. During analysis data are collected on the available files decision points and transactions handled by the present system. This involves gathering information and using structured tools for analysis.
- **System Analysis:** System analysis and design are the application of the system approach to problem solving generally using computers. To reconstruct a system the analyst must consider its elements output and inputs, processors, controls, feedback and environment.

### 5.2 Feasibility Study

Feasibility is the determination of whether or not a project is worth doing. The process followed in making this determination is called feasibility Study. This type of study if a project can and should be taken. In the conduct of the feasibility study, the analyst will usually consider seven distinct, but inter-related types of feasibility.

#### 5.2.1 Technical Feasibility

This is considered with specifying equipment and software that will successful satisfy the user requirement the technical needs of the system may vary considerably but might include.

- The facility to provide output at any given time
- Response time under certain condition
- Ability to perform a certain column of transaction at a particular time

#### 5.2.2 Economic Feasibility

Economic analysis is the most frequently used technique for evaluating the effectiveness of a proposed system. More commonly known as cost / benefit analysis. The



procedure is to determine the benefits and savings are expected from a proposed system and compare them with costs. If benefits outweigh costs; a decision is taken to design and implement the system will have to be made if it is to have a chance of being approved. There is an ongoing effort that improves in accuracy at each phase of the system life cycle.

### 5.2.3 Operational Feasibility

- What changes will be brought with this system?
- What organizational structures are distributed?
- What new skills will be required?
- Do the existing staff members have the skill?
- If not, can they be trained?

## 5.3 Functional Requirements

Various functional modules that can be implemented by the system will be:

- **Input Validation:** The system must be able to consider an input from the user to use it for processing.
- **Prediction:** The system must be able to predict the outcome of a test case based on processed results.
- **Data Processing:** The system must be able to process clusters of data in order to form an intelligent system.
- **User Interface:** The system must be able to provide an interface for interaction between user and software.
- **Reporting metrics:** The system should consist of metrics to show performance, accuracy etc to an end user.
- **Distinction:** The system must be able to classify into either blocked or safe divisions.

## 5.4 Non Functional Requirements

Various non functional modules that can be implemented are

### 5.4.1 Accuracy

- The system is entirely based on its ability to be accurate.
- Should show ability to achieve high accuracy on the inputs provided

### **5.4.2 Speed**

- The system must be able to provide results in less time compared to model learning time.
- Speed is essential as input data can vary and can be large.

### **5.4.3 Security**

- The system should not cause any breach such that it causes legal assessment.
- The system must not try to obtain data which might be personal or irrelevant for the task it needs to perform
- The system must not compromise the anonymity of the user accessing its features to other third parties

### **5.4.4 Consistency**

- The system should ensure consistency with its outputs.
- System should be able to provide a consistent and acceptable range of accuracies across its test and validation data.

## **5.5 System Analysis Summary**

This chapter introduces the system analysis process. It gives brief idea whether this project should be done or not based on various feasibility study. It gives the summary of various feasibility studies that were carried out and shows the advantages of doing this project. At the same time, it also gives the overview of various functional and non- functional requirements of the system.

# **SYSTEM DESIGN**

## Chapter 6

# SYSTEM DESIGN

System design is the process of defining the architecture, components, modules, interfaces, and data for a system to satisfy specified requirements. Systems design could be seen as the application of systems theory to product development. Object-oriented analysis and design methods are becoming the most widely used methods for computer systems design. The UML has become the standard language in object-oriented analysis and design.

### 6.1 Logical Design

User interface (UI) design is the process of making interfaces in software or computerized devices with a focus on looks or style. Designers aim to create designs users will find easy to use and pleasurable. UI design typically refers to graphical user interfaces but also includes others, such as voice-controlled ones.

User interfaces are the access points where users interact with designs. Graphical user interfaces (GUIs) are designs' control panels and faces; voice-controlled interfaces involve oral-auditory interaction, while gesture-based interfaces witness users engaging with 3D design spaces via bodily motions. User interface design is a craft that involves building an essential part of the user experience; users are very swift to judge designs on usability and likeability. Designers focus on building interfaces users will find highly usable and efficient. Thus, a thorough understanding of the context's users will find themselves in when making those judgments is crucial.

### 6.2 Design Goals

The following are the design goals that are applicable to virtually every WebApp regardless of application domain, size, or complexity.

1. Simplicity
2. Consistency
3. Identity
4. Visual appeal
5. Compatibility.

Design leads to a model that contains the appropriate mix of aesthetics, content, and technology. The mix will vary depending upon the nature of the application, and as a consequence the design activities that are emphasized will also vary.

## 6.3 Data Flow Diagram

A data flow diagram is a graphical representation of the "flow" of data through an information system, modelling its process aspects. A DFD is often used as a preliminary step to create an overview of the system without going into great detail, which can later be elaborated. DFDs can also be used for the visualization of data processing.

A DFD shows what kind of information will be input to and output from the system, how the data will advance through the system, and where the data will be stored.

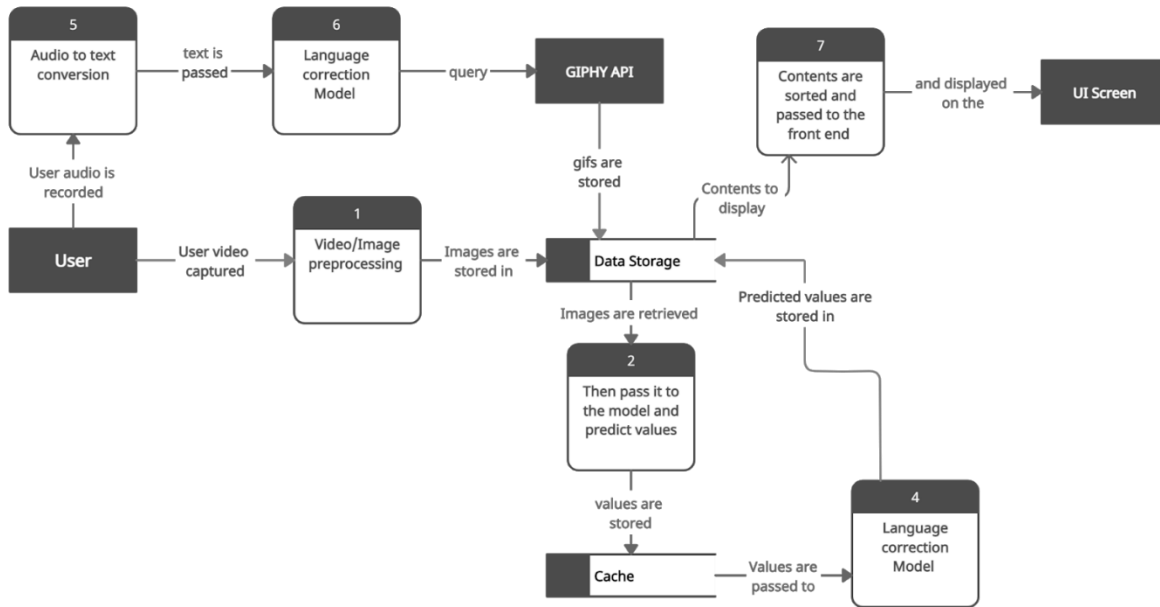


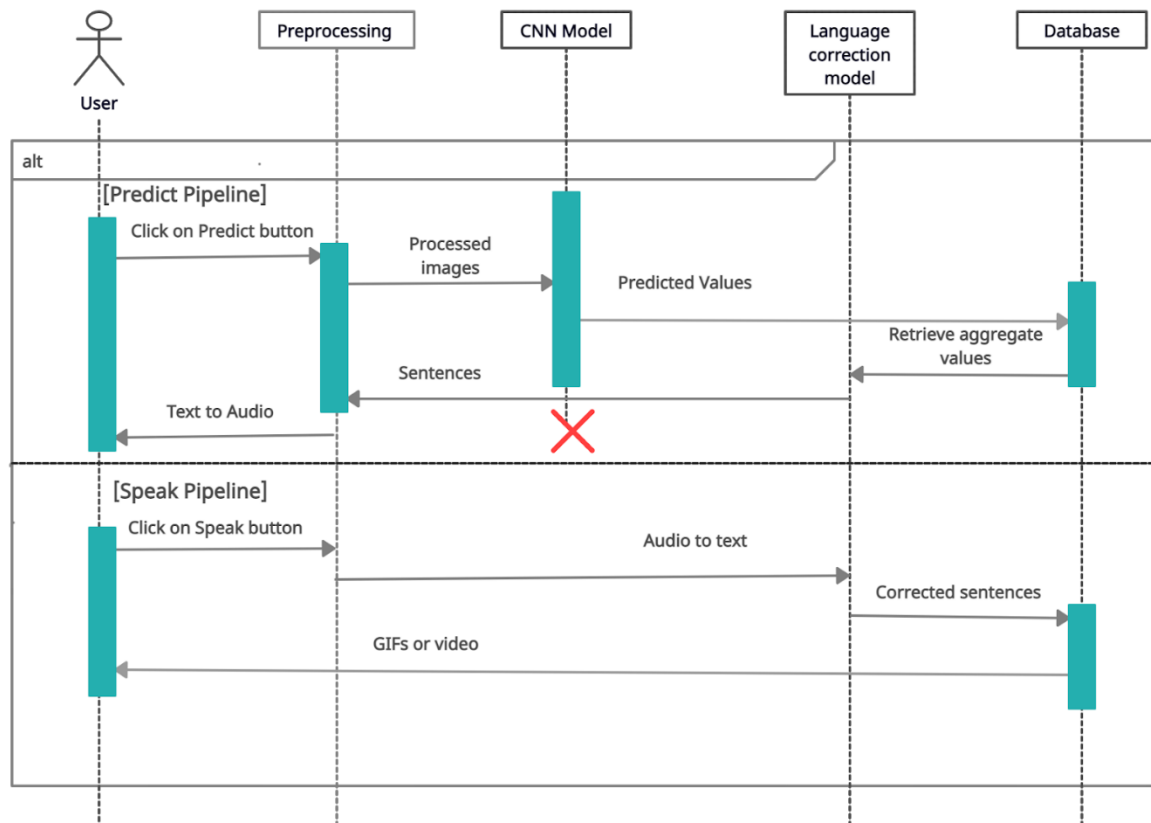
Figure 6.9: Data Flow Diagram

## 6.4 Use Case Diagram

A use case diagram at its simplest is a representation of a user's interaction with the system that shows the relationship between the user and the different use cases in which the user is involved. A use case diagram can identify the different types of users of a system and the different use cases and will often be accompanied by other types of diagrams as well.

While a use case itself might drill into a lot of detail about every possibility, a use case diagram can help provide a higher-level view of the system. It has been said before that "Use case diagrams are the blueprints for your system". They provide the simplified and graphical representation of what the system must actually do.





**Figure 6.11: Sequence Diagram**

## 6.6 Life Cycle Model

The agile model is applied for the software development process in our project.

Agile means relating to or denoting a method of project management, that is characterized by the division of tasks into short phases of work and frequent reassessment and adaptation of plans.

There are 5 phases involved in our project:

- 1. Requirements:** Recognizing hardware and software requirements
- 2. Design:** developing and working on architecture diagram, class diagram, use case design and sequence diagram
- 3. Development:** Training the model using Tensorflow with Transfer Learning and building an UI using Android Studio
- 4. Testing:** Testing with various images and checking whether it classifies the images and signs are retrieved properly
- 5. Deployment:** Deploying on an Android Smartphone using APK feature from Android Studio
- 6. Review:** Test whether accuracy desired has been achieved. Repetitively, this process iterates

to improve accuracy of classification.

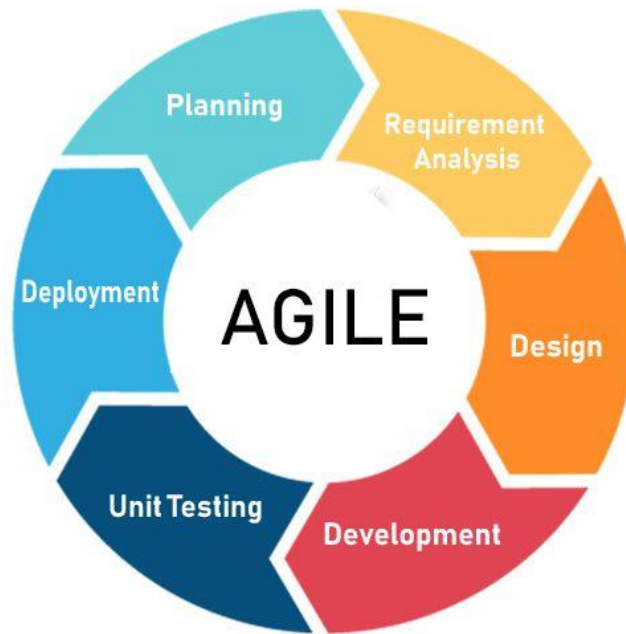


Figure 6.12: Agile Model

## 6.7 Gantt Chart

### 6.7.1 The Gantt Chart for Phase One

The Gantt chart has been prepared for first phase of the project. The single date tasks have been depicted as milestones and are shown along the horizontal line. Similarly, the tasks which take multiple days to accomplish are shown in the vertical line. The Gantt chart has been shown below:

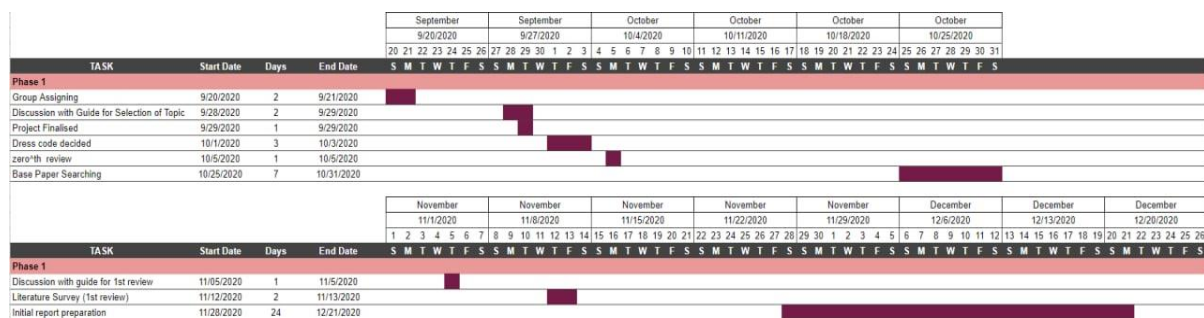


Figure 6.13: Phase one Gantt Chart

### 6.7.2 The Gantt Chart for Phase Two



## **6.8 System Design Summary**

This chapter shows the detailed design of the architecture, components, modules, interfaces, and data for the proposed system to satisfy specified requirements. It shows various standard UML diagrams that are needed to design the system. It provides a visualization of how the data will flow among various components of the system.

# **SYSTEM IMPLEMENTATION**

## **Chapter 7**

# **SYSTEM IMPLEMENTATION**

Systems implementation is the process of defining how the information system should be built (i.e., physical system design), ensuring that the information system is operational and used, ensuring that the information system meets quality standard (i.e., quality assurance).

System Implementation uses the structure created during architectural design and the results of system analysis to construct system elements that meet the stakeholder requirements and system requirements developed in the early life cycle phases. These system elements are then integrated to form intermediate aggregates and finally the complete system-of-interest (SoI).

Implementation is the process that actually yields the lowest-level system elements in the system hierarchy. System elements are made, bought, or reused. Production involves the hardware fabrication processes of forming, removing, joining, and finishing, the software realization processes of coding and testing, or the operational procedures development processes for operators' roles. If implementation involves a production process, a manufacturing system which uses the established technical and management processes may be required.

The purpose of the implementation process is to design and create a system element conforming to that element's design properties and/or requirements. The element is constructed employing appropriate technologies and industry practices. This process bridges the system definition processes and the integration process.

# TESTING

## Chapter 7

### TESTING

Unit testing is a development procedure where programmers create tests as they develop software. The tests are simple short tests that test functionally of a particular unit or module of their code, such as a class or function. Using open source libraries like cunit, oppunit and nunit (for C, C++ and C#) these tests can be automatically run and any problems found quickly. As the tests are developed in parallel with the source unit test demonstrates its correctness.

#### 7.1 Validation and System Testing

Validation testing is a concern which overlaps with integration testing. Ensuring that the application fulfils its specification is a major criterion for the construction of an integration test. Validation testing also overlaps to a large extent with System Testing, where the application is tested with respect to its typical working environment. Consequently, for many processes no clear division between validation and system testing can be made. Specific tests which can be performed in either or both stages include the following.

- **Regression Testing:** Where this version of the software is tested with the automated test harness used with previous versions to ensure that the required features of the previous version are still working in the new version.
- **Recovery Testing:** Where the software is deliberately interrupted in a number of ways off, to ensure that the appropriate techniques for restoring any lost data will function.
- **Security Testing:** Where unauthorized attempts to operate the software, or parts of it, attempted it might also include attempts to obtain access the data, or harm the software installation or even the system software. As with all types of security determined will be able to obtain unauthorized access and the best that can be achieved is to make this process as difficult as possible.
- **Stress Testing :** where abnormal demands are made upon the software by increasing the rate at which it is asked to accept, or the rate at which it is asked to produce information. More complex tests may attempt to create very large data sets or cause the softwares to make excessive demands on the operating system
- **Performance Testing:** Where the performance requirements, if any, are checked. These may include the size of the software when installed, type amount of main memory and/or secondary storage it requires and the demands made of the operating when running with normal limits or the response time.

- **Usability Testing:** The process of usability measurement was introduced in the previous chapter. Even if usability prototypes have been tested whilst the application was constructed, a validation test of the finished product will always be required.
- **Alpha and Beta Testing:** This is where the software is released to the actual end users. An initial release, the alpha release, might be made to selected users who be expected to report bugs and other detailed observations back to the production team. Once the application changes necessitated by the alpha phase can be made to larger more representative set users, before the final release is made to all users.

The final process should be a Software audit where the complete software project is checked to ensure that it meets production management requirements. This ensures that all required documentation has been produced, is in the correct format and is of acceptable quality. The purpose of this review is: firstly to assure the quality of the production process and by implication construction phase commences. A formal hand over from the development team at the end of the audit will mark the transition between the two phases.

- **Integration Testing:** Integration Testing can proceed in a number of different ways, which can be broadly characterized as top down or bottom up. In top down integration testing the high level control routines are tested first, possibly with the middle level control structures present only as stubs. Subprogram stubs were presented in section2 as incomplete subprograms which are only present to allow the higher. Level control routines to be tested. Top down testing can proceed in a depth-first or a breadth-first manner. For depth- first integration each module is tested in increasing detail, replacing more and more levels of detail with actual code rather than stubs. Alternatively, breadth-first would processed by refining all the modules at the same level of control throughout the application .in practice a combination of the two techniques would be used.

At the initial stages all the modules might be only partly functional, possibly being implemented only to deal with non- erroneous data. These would be tested in breadth-first manner, but over a period of time each would be replaced with successive refinements which were closer to the full functionality. This allows depth-first testing of a module to be performed simultaneously with breadth- first testing of all the modules.

- **Unit Testing:** Unit testing deals with testing a unit as a whole. This would test the interaction of many functions but confine the test within one unit. The exact scope of a unit is left to interpretation. Supporting test code, sometimes called Scaffolding, may be necessary to support an individual test. This type of testing is driven by the architecture and implementation teams. This focus is also called black-box testing because only the details of the interface are visible to the test. Limits that are global to a unit are tested here.

In the construction industry, scaffolding is a temporary, easy to assemble and disassemble, frame placed around a building to facilitate the construction of the building. The construction workers first build the scaffolding and then the building. Later the scaffolding is removed, exposing the completed building. Similarly, in software testing, one particular test may need some supporting software. This software establishes can a correct evaluation of the test take place. The scaffolding software may establish state and values for data structures as well as providing dummy external functions for the test. Different scaffolding software may be needed form one test to another test. Scaffolding software rarely is considered part of the system.

Sometimes the scaffolding software becomes larger than the system software being tested. Usually the scaffolding software is not of the same quality as the system software and frequently is quite fragile. A small change in test may lead to much larger changes in the scaffolding. Internal and unit testing can be automated with the help of coverage tools. Analyzes the source code and generated a test that will execute every alternative thread of execution. Typically, the coverage tool is used in a slightly different way. First the coverage tool is used to augment the source by placing information prints after each line of code. Then the testing suite is executed generating an audit trail. This audit trail is analyzed and reports the percent of the total system code executed during the test suite. If the coverage is high and the untested source lines are of low impact to the system's overall quality, then no more additional tests are required.

## 7.6 Testing Summary

This chapter shows the various test results produced by the system. Various kinds of test are performed for each part of the system and as well as the whole system. It shows various pre-defined test cases and result of running these test cases on the system. It provides the

comparison of expected output and the actual output produced by system based on which bugs are identified and eliminated.



# **SCREENSHOTS**

## **Chapter 8**

# **SCREENSHOTS**

### **8.1 Sample Output Summary**

This chapter shows various screenshots of the system. It also shows how data processing happens at various stages of the system and the final output is also displayed. And it also shows the outer interface design of the system.

# CONCLUSION

## **CONCLUSION**

A sign language is a natural mode of communication used by the deaf community. India has large population of speech and hearing impaired but a very small number of certified sign language interpreters are available. Research in hand gesture recognition has gained attention with advancement in the field of computer vision. A Sign Language Interpreter (SLI) decodes and understands the information conveyed by signs. SLI can be a major breakthrough in helping a common people to communicate with the deaf and can help in bridging this communication gap. A SLI can be designed based on video/image processing and deep learning techniques which requires a standard dataset, determination of an optimal feature set, and an appropriate classification technique.

# **BIBLIOGRAPHY**

## **REFERENCES**

**Reference Text Books:**

**Reference Papers:**

**Reference Links:**