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System Requirement Specification

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"Object identifier to hearing and verbally impaired students"

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Declaration Page

We hereby certify that this project report and all the artifacts associated with it is our own work and it has not been submitted before nor is currently being submitted for any degree program.

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Abstract

A disorder that impacts one's capacity to talk and hear is known as speech impairment. There are over 420 million individuals who suffer from speech impairment. To communicate with others, these individuals utilize sign language. Even though it is an effective mode of communication, communicating with the speech impaired persons remains a barrier for those who do not understand sign language. The objective of this paper is to create an application which converts detected objects to its relevant sign language. The application captures an object with the camera on the mobile phone, then pre-processes it with image processing.

Keywords: Image processing, Object detection, Machine learning, Deep learning, Computer vision, Sign language

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Abbreviation Table

Abbreviation	Explanation
CNN	Convolutional Neural Networks
R-CNN	Region-Convolutional Neural Network
NLP	Natural Language Processing
HCI	Human Computer Interaction
UX	User Experience
UI	User Interface
GIF	Graphical Interchange Format
ML	Machine Learning
XP	Extreme Programming
ASD	Adaptive Software Development
DSD	Dynamic System Development

Chapter 1 : Introduction

1.1 Chapter Overview

In the introductory chapter it will provide a foundation of the project background so that a thorough understanding (comprehensive grasp) of the problem domain can be provided with the difficulties encountered by the existing solutions or software, the aim, scope of the project, a rich picture diagram in order to get a clear understanding about the process, the objectives of the project and the resource requirements in which it gives a detailed knowledge about the hardware, software and the datasets used. finally, followed with a chapter summary of everything covered in the chapter.

1.2 Problem Background

One of the most crucial components of all living organisms' daily lives is communication, but due to interpersonal communication comprising a huge number of interconnected components, any examination of the process is certain to be challenging (Hargie, 1997 According to the World Health Organization, more than 5% of the planet's population, or 430 million people, require treatment to address their "disabling" hearing loss (432 million adults and 34 million children). Hearing loss will affect nearly 700 million individuals by 2050 or one out of every 10 people (Deafness and hearing loss, 2021).

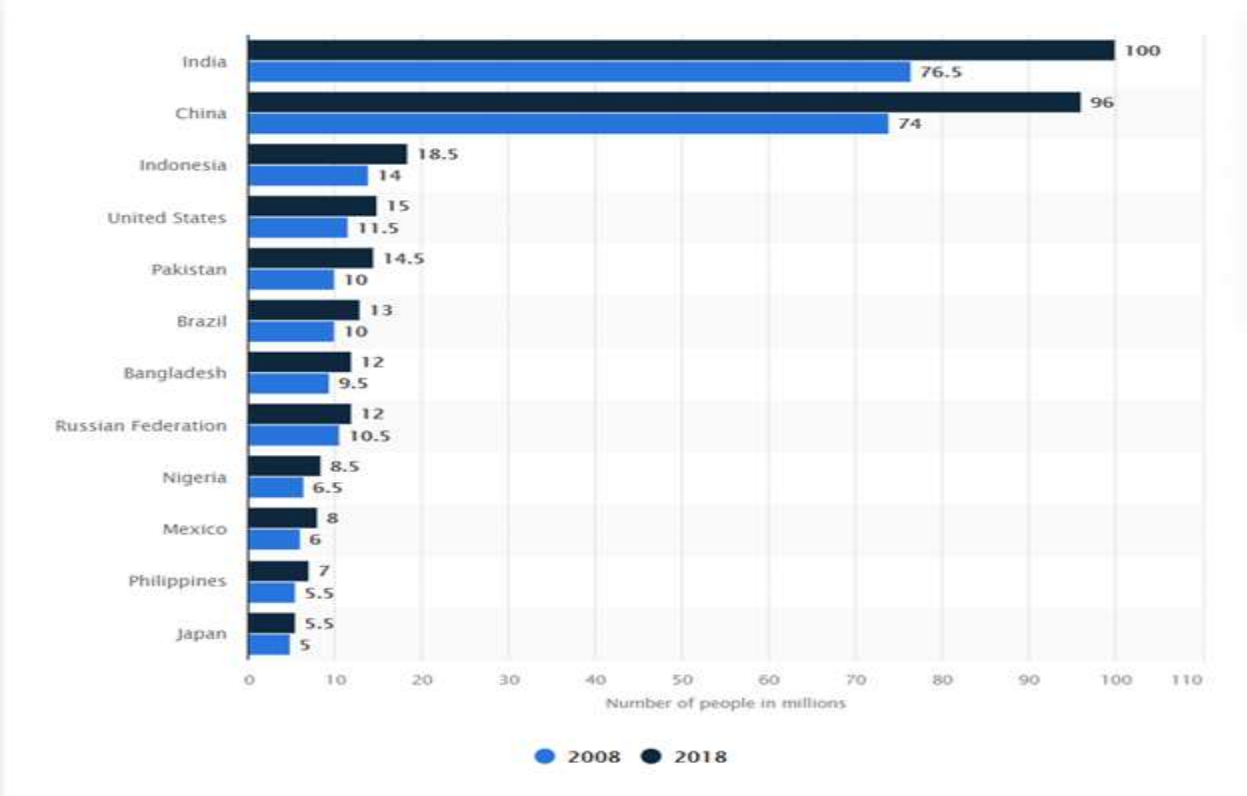

Figure 1.1: A statistical graph of number of deaf people from 2008 and 2018 (Elflein,2021)

Sign language which is used to communicate with the verbally impaired has come a long way in the field of computer science with the use of machine learning. Where methods like convolutional neural networks (CNNs), a feature extraction model in deep learning that has lately shown to be particularly successful at image recognition, are utilized in sign language identification (Pigou et al., 2015). Other domains, such as computer vision, computer graphics, natural language processing, human computer interaction, linguistics, and deaf culture, are also essential for the efficient development of sign language recognition, creation, and interpretation systems. (Bragg et al., 2019).

Although there are remarkable parallels amongst sign languages, they are not universal, and they are not mutually intelligible. Every country has its own sign language to help the verbally impaired. However, complications emerge when ordinary people do not have a solid knowledge of sign language. As a result, both sides disagree to be cordial and speak with one another since they are unable to grasp what the other is trying to say (Manoj Kumar et al., 2020).

With the use of object detection our research focuses on a real time object detection to sign language system which is going to help the verbally impaired people to communicate with the “normal people” and also as an educational purpose the “normal people” can also learn about the sign language for the necessary object.

1.3 Problem Statement

Communication is a key fact of human existence, but not all people are able to communicate in the same way because some people have communication disorders such as hearing impaired, and mute. So, they can hardly communicate with normal people.

1.4 Research Gap

Although there is much research about sign language there is a significant gap when it comes to education. Because most of the research was based on sign language to verbal language conversion or verbal language to sign language conversion. Basically, it acts as an interpreter. Also due to the lack of accuracy sometimes those applications predict mistakes. So as the identified research gap improves the accuracy and efficiency when detecting objects and predicting the relevant sign in sign language with a minimum processing delay can be considered.

1.5 Research Questions

Q1: How to improve the accuracy and reduce the processing delay when detecting objects and convert it into the relevant sign in the sign language?

Q2: What are the technical aspects that can be used to improve the quality and the accuracy of the output?

Q3: What are the techniques that can be used to improve the end user's knowledge in the specific context?

Q4: How to predict an understandable sign of the object to the end user?

1.6 Research Aim

The aim of this research is to design, implement, evaluate, and test a self-learning and communication aid for hearing and verbally impaired students.

To further elaborate on the aim, A Self- a learning aid for students with hearing impairments from grade 1 to grade 4. In most of the schools for students in this grade range, they teach object identification such as identifying stationery, types of shapes, vegetables, animals, fruits, etc. The main objective is to detect those objects and display them using sign language. Here these students

can learn how to express an unknown object in sign language even without the help of another person. Another thing is creating a portal that can communicate with normal students and verbally/ hearing impaired students. In this case, the communication in English is translated into sign language. This allows any aged person to communicate with a student who uses sign language.

1.7 Project Scope

1.7.1 In-Scope

- Object to sign language converter - In object to Sign Language, the input is an object, and the output is an animated character, or a Sign language made with signing graphics.
- This system is made for hearing/ verbally impaired students and normal people who are interested in learning sign language on a regular basis.
- Students at deaf schools in grades 1 - 4 are the target audience for this system.

1.7.2 Out-Scope

- The same device is used to identify the object, process it, and output it. As an example, a mobile phone or a laptop. As a result, the scope of this project is limited to one or two device devices.
- Only the English language will be available for this application.
- This is not an offline system.

1.8 Rich Picture Diagram

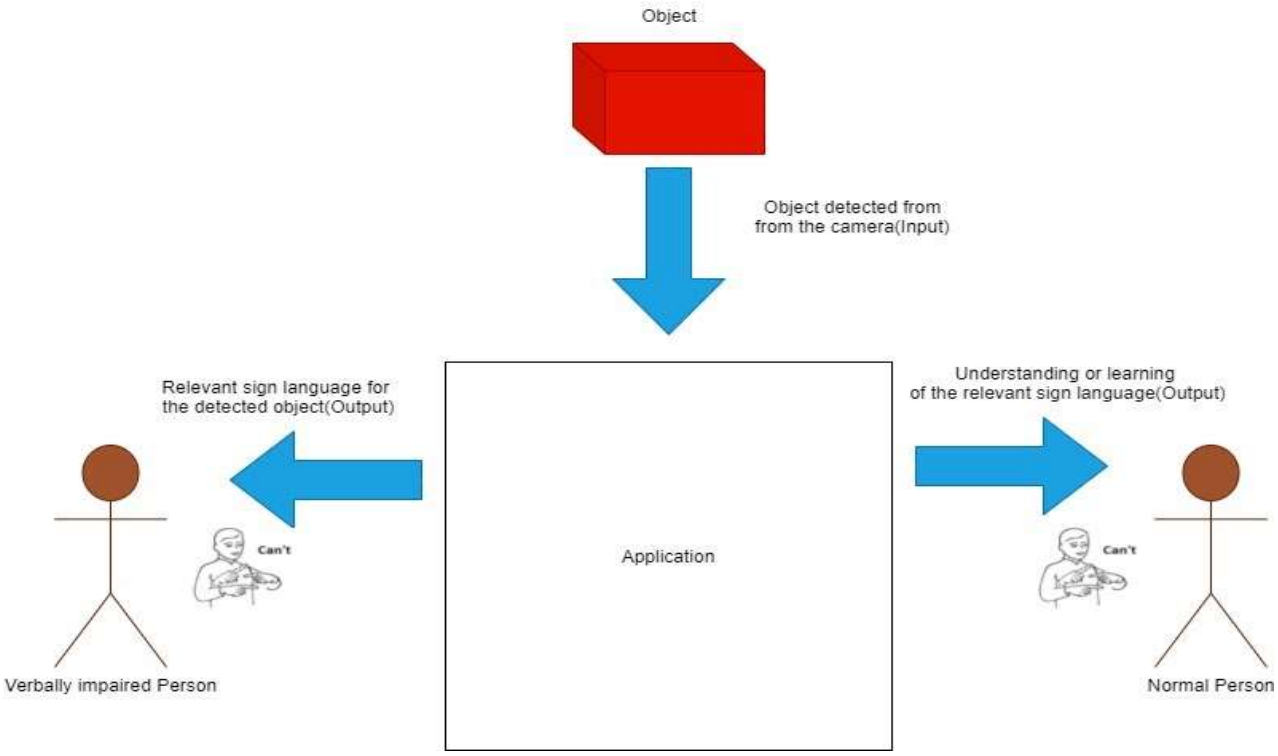

Figure 1.2: Rich picture diagram (User - Composed)

1.9 Objectives

The objectives are defined as follows for research aim and the research questions in the project.

1.9.1 Research Objectives

- To detect objects in real-time, efficiently, and more accurately using neural networks algorithms
- To identify the best NLP technique that suits the voice recognition, sentence building, and text to sign conversion

1.9.2 Academic Objectives

Table 1.1 : Academic Objectives of the project

#	Description
Gaining knowledge and understanding of different types of object detection tools	Research how detect objects could be done using different algorithms & select the most accurate.
Improving problem-solving skills	When solving problems, a thorough study and analysis of the problem are essential
Developing time management and project management skills	Work on time, complete and submit assignments on time
Improving interpersonal communication, leadership & supportive skills	Communication and collaboration between members are essential when working as a team

1.9.3 Operational Objectives

Table 1.2- Operational objectives of the project

Objective Number	Objective description
Objective 1: Research about object and sign language	Doing well in-depth research on how object detection and sign language works. Limitations of the current object detection and sign language systems.
Objective 2: Data gathering	Gathering data sets for such as objects and sign languages Doing a competitor analysis table.

objective 3: Study and review existing work	Studying and reviewing all the existing work and then coming up with a work analysis table with a summary of the review done.
Objective 4: Tools	Getting all the necessary software and libraries for the application.
Objective 5: Design and requirements	Creating an application prototype. Analyzing the functional and non-functional requirements. Designing the rich picture diagram to display the solution in a simple way.
Objective 6: Implement	Usage of most appropriate and efficient technologies. Create a very user friendly for better user experience (UX) and user interface(UI).
Objective 7: Test	Getting user feedback and improving the application and Fixing bugs. Testing the application to check if the results are accurate.
Objective 8: Evaluate	Demonstrate that all requirements for system evaluation have been met and prepare an evaluation report.

1.10 Resource Requirements

The following tables indicate the software, hardware, and data resources that are needed for this research project. These resources are subject to change due to the nature of this project.

1.10.1 Hardware Requirements

Table 1.3- Hardware requirements for the project

Hardware Requirements	Description
Quad core processor	To run the server with multiple threads.
8 GB minimum RAM	To run the server effectively without crashing
1GB minimum disk space	For storage of log files, databases, etc.
Minimum 10MP camera	To detect the object clearly.
Internet	The Internet is needed since the application is online based.

1.10.2 Software Requirements

Table 1.4- Software requirements for the project

Software Requirements	Description
IntelliJ Idea 17.3	Windows application and service development.
Flutter(v2.5)	Develop the mobile application and components.
Microsoft Office Tools (2019)	MS Word, MS Project for documentation.
Visual Paradigm (v14.2)	Architecture Diagrams for documentation
ClickUp (v2.0)	For project planning, scheduling, resource allocation, and change management, project management software is utilized.
Slack(v4.22)	Used to communicate between team members
TensorFlow (v2.7.0)	To builds models using data flow graphs
Media pipe(v0.7)	To build multimodal applied machine learning pipelines.
GitHub (v3.1)	To safely preserve the source code in a version control system.

1.10.3 Data Requirements

- Machine Learning Datasets – From Kaggle and Google Dataset Search
- Machine Learning Model Objects

1.11 Chapter 1 Summary

The numerous decisions made about the project's commencement and progression were detailed in this chapter. Expectations, objectives, aims, rich picture diagram of the solution, overview and deliverables are all carefully defined so that they may be carried out without uncertainly. The project's requirements for a successful completion are also drafted so that the project can proceed without any interruption.

Chapter 2 : Literature Review

2.1 Chapter Overview

The project's introduction was covered in the preceding chapter. This chapter, which is the literature review, and a critical evaluation will be done on the previous research done by other researchers to determine suitable approaches, methodologies, and technologies which are already currently available, as well as their benefits and drawbacks, to determine the correct plan for the project.

2.2 Literature Review

2.2.1 Concept Map

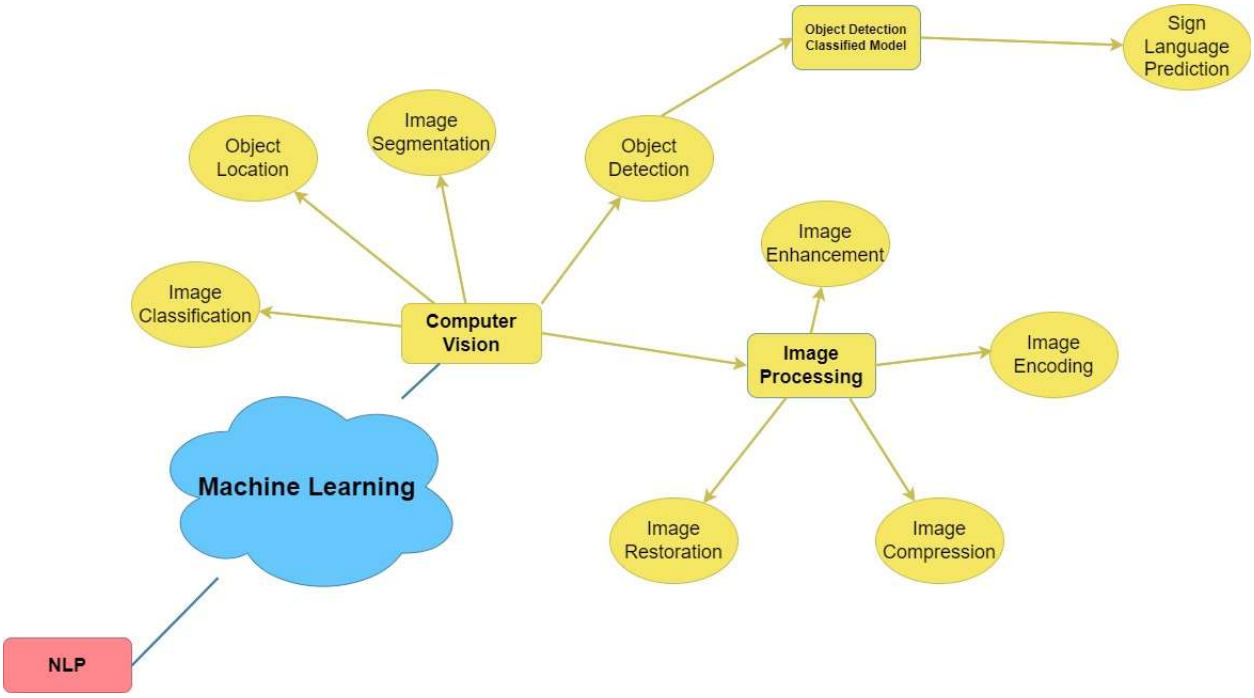

Figure 2.1 : Concept Map(User-Composed)

2.2.2 Machine Learning

With the use of Machine learning, a subcategory of Artificial intelligence, has transformed multiple sectors in the past several decades (Alom et al., n.d.). The basic goal of machine learning is to characterize the connection between a collection of observable quantities (inputs), and a set of variables associated to these inputs (outputs) (Baştanlar and Özuysal, 2013). Optimization, control, and troubleshooting are all performed with machine learning models for example, in medicine, machine learning is utilized for medical diagnosis, while in telecommunications, patterns are examined for network optimization and quality enhancement (Ethem Alpaydin, 2020).

Machine learning uses two types of techniques:

1) Supervised learning:

The algorithm creates a function that translates input to the desired outputs. The classification issue is a common supervised learning challenge in which the learner must learn(or estimate the behavior of) a function that maps a vector into one of many classes by studying multiple input-output samples of the function.

1. Regression
2. Classification

2) Unsupervised learning:

There are no models available for a set of inputs labeled examples (Zhang, 2010).

2.2.3 Deep Learning

Deep learning involves learning numerous levels of representation for the fundamental distribution of the data to be modeled autonomously. A deep learning system collects the low and high level of information required for categorization autonomously. A feature that is hierarchically dependent on other characteristics is referred to as a high-level feature. For example, in computer vision this means that a deep learning model will learn its own low-level representation from a raw image then construct representation based upon these low-level constructions (such as linear or non-linear configurations of those low-level constructions) and continue the cycle for higher levels (Lauzon, 2012).

2.2.4 Natural Learning Techniques

Natural language processing is a field of artificial intelligence that allows a computer to read, interpret, and modify language using human language principles. This allows the user's voice to be understood naturally by the machine. Identified text is divided into smaller word units. This

process is called tokenization. Tokenization splits words, sets, characters, numbers, punctuation, etc. There are two advantages to tokenization. one is reduced by a search significant degree. another one is effective in the use of storage space (Chowdhury, G., 2021). The main function of sentence segmentation is to divide all the text into meaningful sentences. This function also includes identifying the gaps between the words in the sentence and the sentence boundaries. There are libraries for paraphrasing like NLTK, Spacy, Stanford Core NLP. NLTK is an open-source python library. It's good for pre-processing & tokenizing. Stanford Core NLP is an open-source java library. Spacy is the best library among them and is encoded by CPython. SpaCy can train datasets in less time and get better results (Silva, P., Goncalves,2020). Stemming is the process of reducing the word base or root form. Simply words, understanding the context of any text and reducing the structure of the words. After parsing sentences, words are categorized as nouns, adjectives, verbs. Named Entity Recognizer helps to identify all types of named and numerical entities and nouns in a sentence compared to the context in which it is used. It's essential for grammar analysis and knowing the vocabulary (Ieeexplore.ieee.org, 2021).

Advantages and disadvantages of NLP;

NLP technology can do text analysis at scale on a range of documents, internal systems, and mails, and it can handle lots of data in seconds or minutes. In a couple of minutes, NLP-based technologies may be trained to understand language and requirements. Natural language processing can save time and money, streamline, and automate processes, and make real-time, data-driven choices for any development. And it is easy to use and easy to implement using a SaaS tool and it's very efficient. Users can ask any inquiry and receive a quick answer in seconds. The question is answered precisely using NLP. It is quick and simple to grasp, and it does not provide additional or undesirable information.

It is possible that training will take a considerable amount of time. It can take weeks to reach a high degree of performance when a new model is constructed without the help of a pre-trained model. NLP is designed to perform a single, unique purpose and has a limited set of functionalities and it isn't 100 percent accurate. There is always a possibility of errors in predictions and results. It is unpredictable and unable to adjust to a new domain. These are NLP's drawbacks.

2.2.5 Computer Vision

Computer vision is a branch of artificial intelligence that can extract precise information from visual aids such as digital photographs and movies. It provides a detailed study of visual data using a computer, with a similar approach to human vision. In recent trends in computer vision due to learning approaches and the development of neural networks, there are some primary computer vision techniques(Xu et al., 2020).

- Object detection
- Image Classification
- Object Localization
- Image Segmentation

Object detection is the main function of computer vision. The task here is to define objects, label them, and render border boxes. The advantage here is that you can sort not just one object but several objects at once.

Image Classification's primary function is to clarify the distorted interior class variation, image distortion, background, or light conditions confusing images. It is also the process of identifying an object, defining the class in question, and identifying its possibilities. Derivatives identified objects using selective search. The SVM classifier determines whether the object is included in the corresponding windows. Convolutional Neural Networks (CNNs) feed network images and categorize network data.

Object Localization identifies objects and puts boundary boxes around them. This considers the positioning of the objects. Although this is an improved way of locating the gross object, in most cases it does not determine the exact location of the object. This is a disadvantage of object localization (Voulodimos et al., 2018).

Image Segmentation separates and frames the whole image. This categorizes the entire image into pixels that can be labeled and sorted. That is the boundary of each selected object. The specialty here is a pixel-wise prediction of the model, unlike image classification. (Buckler, M.., 2017.)

The advantages and disadvantages of computer vision can be summarized as follows.

The ability of digital image analysis technology to generate accurate descriptive information about graphical information in many fields has contributed to its widespread use. Computer vision is a simple and fast process. Due to the absence of human factors such as fatigue and external factors such as illness, emotions the work is done efficiently. Also, the accuracy of the computer imagination and the computer vision confirms the better accuracy of the final product. Computer vision is an easy and quick way to retrieve data that is difficult to obtain manually. It is also a special advantage to be able to view missed attributes and recall archives.

The quality of the images captured in the computer display affects the final output. If the image is blurred for some reason, it is difficult for the application to identify the object. This difficulty also occurs in dark or nocturnal conditions. Also, computer vision is a disadvantage if the relevant devices do not work properly(Brosnan and Sun, 2002).

2.2.5.1 Object Detection

Object detection is a computer vision approach that uses automation to locate occurrences of things in digital photos and movies. Object detection creates boundary boxes around multiple successful targets in a still picture or video data (Paper, 2021). It is also one of the most fundamental computer vision issues, and it can give useful information for semantic comprehension of pictures and videos. It's implemented in a range of applications, such as picture categorization, human behavior analysis, face recognition, and self-driving cars (Zhao, Zheng, Xu and Wu, 2019). When it comes to object detection there are three main steps which are: detecting relevant moving objects, tracking them from frame to frame, and analyzing object tracks to determine their activity (Yilmaz, Javed and Shah, 2006). When it comes to object detection, object tracking is critical. The task of establishing the position, path, and qualities of objects of interest using sensor information is known as object tracking. A sensor can be any measuring equipment that collects information about the things in the surrounding, such as radar, sonar, cameras, or any other type of sensor. The quantity of objects, their identities, and their state, such as locations, speeds, and in certain situations, their characteristics, are all common objectives of object tracking (Sudhash Challa et al., 2011).

Given edge detection is at the forefront of image processing for object recognition, a thorough grasp of edge detection methods is essential.

There are five different types of edge detectors which are:

- Gradient edge detectors
- Zero crossing (second derivative)
- Laplacian of Gaussian
- Gaussian edge detectors
- Colored edge detectors

Where which of these types have their own advantages and disadvantages.

The classical operator gradient edge and Zero crossing operator detectors, as an advantage it has a simple detection of edges and their location but in classical operator gradient edge as a disadvantage it is very sensitive to noise which reduces the accuracy whereas in the zero-crossing

operator sometimes it responds to the same existing edges. Laplacian of gaussian as an advantage it has a feature of finding the right edge location and testing a larger region around the pixel, as a disadvantage where corners, curves, and places where the grey level intensity function fluctuates are all affected because of the Laplacian filter, it is difficult to determine the orientation of an edge. Gaussian edge detection it has an advantage of finding the error rate, localization and response using the probability improved signal to noise ratio, which allows for better detection , in a noisy environment as a disadvantage it has complex computations, erroneous zero crossing and prolonged computations. The colored edge detectors one of the modern technologies as an advantage object recognition is highly accurate and efficient as a disadvantage computation are difficult and complex compared the Gaussian edge detector (Sharifi, Fathy and Mahmoudi, 2002).

2.2.5.1.1 Object Detection Classified Models

The capability which allows the machines to replicate conscious minds as humans can be briefly described as computer vision (Verdhan, 2021). Computer vision can identify the main features that are present in objects using image classification and image localization also using bounding boxes around the object. Due to the vast development in object recognition, Object detection can be classified into two categories as Model-based on classification and Model-based on the region proposal (Pal and M.Chawan, 2019).

Model-based on the region proposal

1.CNN

Convolutional Neural Networks are made up of neurons that are capable of learning from data. So, CNN's and traditional neural networks are quite similar. Accordingly, in CNNs also there are some miss functions. In traditional neural networks, the input was taken as a single vector and flowed through a sequence of hidden layers that contain neurons (Verdhan, 2021). But in inputs of Convolutional Neural Networks are images that are 2D arrays of pixels with RGB. To perform multiple convolutions, the CNN model uses Rectified Linear Unit (ReLU) (Pal and M.Chawan, 2019). A Convolutional Neural Network consists of an input layer, a hidden layer as well as a fully connected layer. Also, CNN performs better than the Multi-layer Perceptrons because the input matrix should be converted into a numeric vector without spatial structure to feed the input. Due to this reason, CNN was built to clarify the patterns in complex data. A key difference between Multi-layer Perceptron and Convolutional Neural networks is the type of hidden layers that incorporate with the model. In CNN the neurons are arranged in a three-dimensional manner (height, width, depth) (Verdhan, 2021).

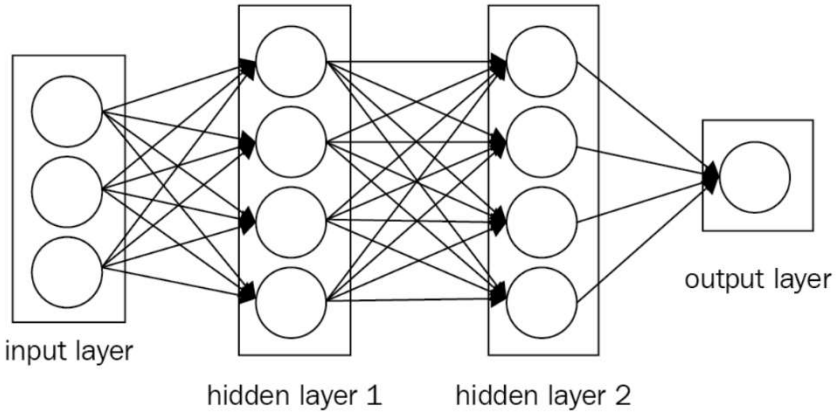

Figure 2.2: A regular three-layer neural network(Verdhan, 2021)

In object detection, CNN cannot recognize the objects with an overlapping background, not only that, but it can also only detect a single object at a particular time. So, this may affect the efficiency when it detects multiple objects (Pal and Chawan, 2019). Although the CNN models are good in object classification, CNNs are not able to localize the objects inside the image (Montserrat et al., 2017).

2.R-CNN

Region-Convolutional Neural Network (R-CNN) is also another region proposal-based method in the field of object detection. Since the introduction of R-CNN, there has been a vast improvement in the model of R-CNN. As an example, the reduction of the size of the input image and improved detection accuracy was introduced in SPP-net with the launching of the spatial pyramid pooling (SPP) layer in R-CNN (Wu et al., 2020). The Region-Convolutional Neural Network consists of three main areas. Namely, (1). Region Extractor, (2). Feature Extractor, (3). Classifier (Pal and Chawan, 2019). OverFeat is also one of the methods used in deep learning to detect objects in the early stage. When compared to the OverFeat, R-CNN takes a higher place in detection accuracy. When generating the regional proposals, R-CNN uses a selective search approach (algorithm). With a support vector machine, the region proposal is classified and identified. Finally, by the linear regression the size and the position of the region's proposal is fine-tuned (Wu et al., 2020). Not only that, Region-Convolutional Neural Networks use a pre-trained AlexNet.

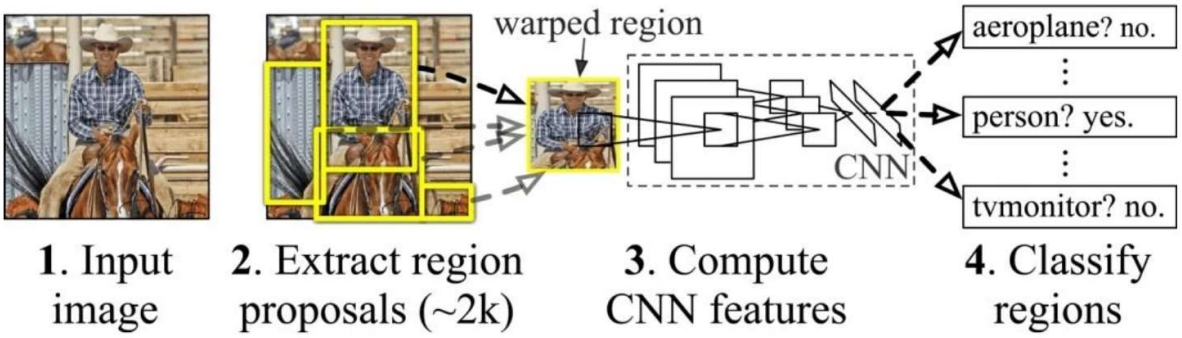

Figure 2.3: Concept of Region-Convolutional Neural Network.

Region-Convolutional Neural Network extracts 2000 regions in every image (Pal and Chawan, 2019). Because of using a selective search approach that is extracted by a CNN feature there are still some shortcomings. Due to the vast amount of data usage R-CNN is slow. Not only that because the R-CNN is not end-to-end, but each step must also be saved separately.

But with the introduction of SPP-Net, reduce the size of the input images. Also, the fixed features in various size images are restored with the Convolutional features on the SPP layer. So, this helps to reduce the calculations and slightly improve the detecting speed (Wu et al., 2020).

3.Fast R-CNN

Fast Region-Based Convolutional Neural Network is an improved version of the Region-Based Convolutional Neural Network. In Fast R-CNN there are 2 parts Namely (1). Convolutional Network for feature extraction. (2). Region of Interest (RoI) network with an RoI- pooling layer connected that predicts the output as object classes and bounding boxes. In Fast R-CNN the entire image is taken as the input and extracted from the features in each region by the Region of Interest pooling layer. The RoI layers crop and resize the images to create fixed-sized vectors for each object proposal. And it predicts a feature map as the output. Finally, the featured vectors flow through a fully connected layer and release two outputs. They are (i) probability for each object class and background class. (2) Bounding box coordinates (Wang, Shrivastava and Gupta, 2017, p).

Lately, this methodology has been applied in pixel-wise systems such as semantic segmentation. Not only that, but Fast Region also-based Convolutional Neural Network frameworks are used in notable object detection by considering them as binary classification problems. Also, with the use

of SoftMax the neural network can produce a prominent rating of notable areas (Wang, Ma and Chen, 2016).

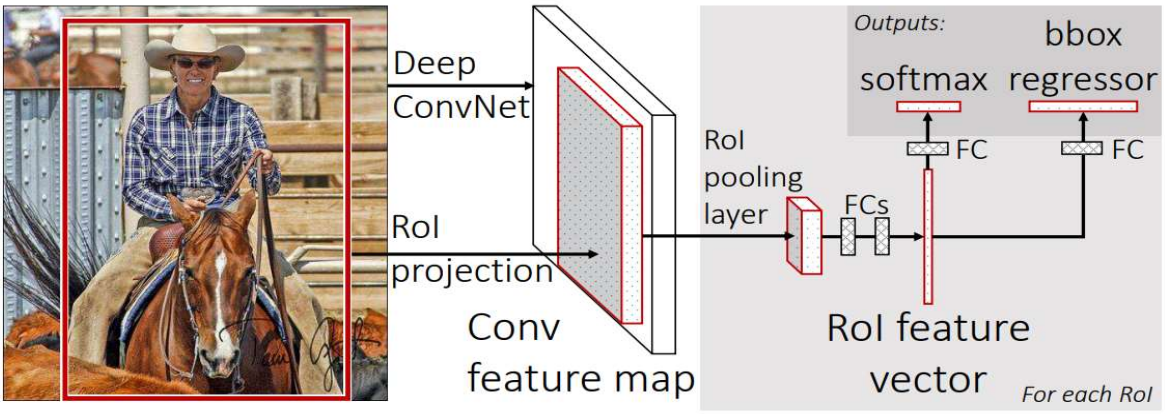

Figure 2.4: Fast R-CNN architecture (Girshick, no date)

4.Faster R-CNN

It's worth noting that fast region based CNNs employ GPUs, but region proposal techniques used in study are initiated on the CPU, causing such runtime comparisons unfair. Re-implementing proposal computation for the GPU is an effective method to speed it up. This may be a good engineering approach but ignoring that down-stream detection network means that major possibilities for sharing computing are neglected. The convolutional feature maps employed by region-based detectors, such as Faster R-CNN, may also be used to generate region suggestions, according to current results (Ren et al., 2017).

2.2.6 Sign Language Prediction

This can be used by deaf persons to communicate together or to learn sign language. It would also allow non-sign language speakers to converse with deaf people. It helps to improve communications between deaf and hearing persons. It can also be used in cases where a translator is necessary. And deaf students can improve their education knowledge on this conversion (Manoj Kumar et al., 2020). When ordinary people can translate simple text to sign language it will be easy to communicate with deaf and mute persons.

Text to Sign Language is the feature where the user can input any English text and get output as a sign language. The conversion of text to sign language can easily produce the correct answers. (Manoj Kumar et al., 2020). And users can type the sentence they want to transmit and then check

whether they're correct. In this conversion text is the most important thing. Because sign language grammar rules are not standardized, it will be difficult to follow them and the user enters complex sentences, the translation will take a very long time.

There are two methods for detecting sign language. One is image or vision-based and the other one is device-based. Pre-processing, feature extraction, and categorization are all part of the simple phase of sign identification. The term "pre-processing" refers to the process of removing an undesired element from a context. (Manoj Kumar et al., 2020).

Text can have one or more text, but it will generate simple words at the end. The support of several libraries in and semantic analysis is used to convert text into sign language in real-time. Graphical Interchange Format (GIF) graphics using selected hand signs are created using Semantic Analysis. It provides users with the appropriate hand signs for text.

2.2.7 Image Processing

Image processing is an interesting field that gives advanced graphical data for humans, and machine perception. The most fundamental image processing technique is to improve raw images obtained from cameras or sensors. This field has improved a lot in recent times. So, there are so many applications and software's introduced to make this process easy, fast, and more accurate. The image processing mostly focuses on,

- Image preprocessing
- Image enhancement
- Image segmentation
- Feature extraction
- Image classification

The elimination of noise and other irregularities from a digital image using a computer is what image processing is all about. An image can be thought of as a two-dimensional function f(x,y), where x and y are spatial coordinates. Image processing techniques are becoming more common and used in many applications such as remote sensing, medical imaging, military, film industry, printing industry, etc. (Chitradevi and Srimathi, 2014).

Switching the pixel brightness value of a digital image is Image enhancement. Image enhancement algorithms are introduced to improve the visual impact of certain images. They are,

a. Contrast stretching.

b. Noise filtering.

c. Histogram modification.

Noise Filtering is a technique for removing avoidable data from an image. It's also used to remove several kinds of noise from the images. This feature is primarily interactive. Various filters like low pass, high pass, mean, median, etc., are available.

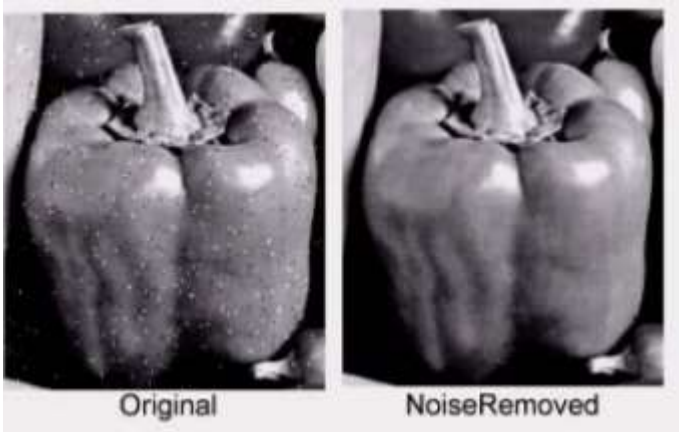

Figure 2.5: Noise Removal

Histograms imitate the characteristics of an image. Histogram modifying simply is modifying the characteristics of an image. When limitations come up, Noise filtering might deteriorate image details and the image's edges. So, we might not get the exact image that we process from object detection. Histogram Equalization may boost background noise contrast while lowering the useful signal(Mateos Pérez and Pascau, 2013).

In digital image processing and computer vision, image segmentation is the process of separating a digital image into numerous sections. There are three main ways to image segmentation that might be considered. The approaches are Threshold, Edge, and Region-based.

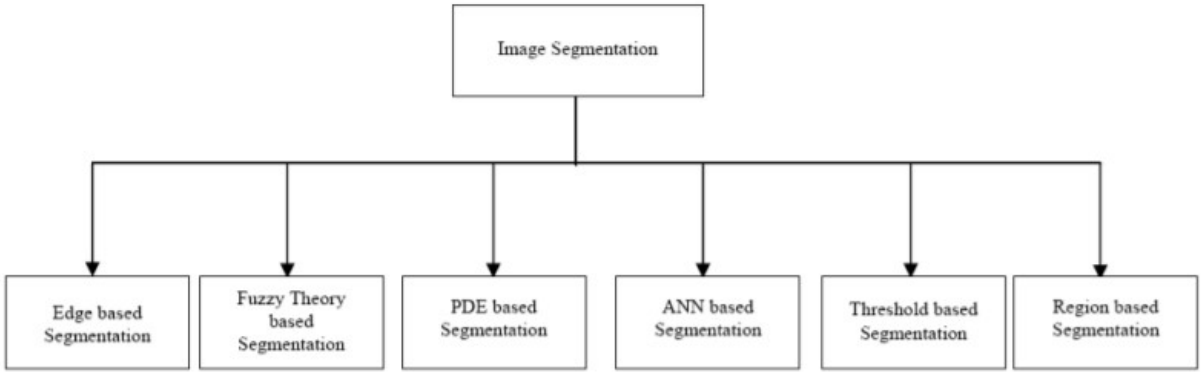

Figure 2.6: Image segmentation techniques (Khan, 2014)

Image segmentation analyzes a digital image by dividing it into numerous parts. It's also utilized to tell apart different items in an image. The researchers devised several image segmentation techniques to make images smooth and straightforward to judge. It has been discovered that there is no perfect approach for image segmentation because the outcome is dependent on a variety of parameters. Such as pixel color, texture, intensity, the similarity of images, image content, and problem domain (Khan, 2014).

As a result, there is no way to examine a single solution for all types of images, and no method can perform well for all types of images. As a result, it is preferable to utilize a hybrid approach that combines different methodologies to solve the picture segmentation problem.

Advantages and limitations of image processing

Image processing has so many advantages such as Images can be given more sharpness and a better visual appearance. In digital image processing and computer vision, image segmentation is the process of separating a digital image into numerous sections. There are three main ways to image segmentation that might be considered.

Digital image processing has advantages as well as limitations also. Misuse of copyright is a common limitation. While image processing the quality of the image will be reduced if it is enlarged to a certain size. The processor of the device should be faster for a better experience. Another main limitation is cost effectiveness. The initial cost is high depending upon the system used. (Khedaskar, Rokade and Patil, 2018).

2.3 Chapter Summary

The literature review chapter provided a critical assessment of current practices, technologies, and procedures, identifying their benefits and flaws. A summarized review on the types of the core theories which are used such as machine learning, deep learning, computer vision techniques such as object detection and image processing, natural language processing and sign language recognition. Object detection techniques such as the CNN and faster and more developed and advanced Faster R-CNN and the types of different edge detectors used in object detection with its improvements and drawbacks are also featured in this chapter. The steps of image processing are also covered with a detailed overview of how it works and the conversion of object detection to text to sign language works.

Chapter 3 : Methodology

3.1 Chapter Overview

The evaluation of literature related to the project domain was discussed in the previous chapter. It will justify the project's development model. The most appropriate design methodology, as well as the evaluation metrics used, will be described in depth. The project management methods that have been chosen will also be discussed. It will be explained how the work breakdown structure works and what project management software is being used. The risks of the project are also described in this chapter, as is the risk mitigation plan.

3.2 Research Methodology

Choosing a suitable research methodology is important for the success of this project. The purpose of this research is to provide a solution using new technology to represent certain objects & sign language. There is a wide range of effective research that can be performed, both qualitative and quantitative research. Qualitative research can be used to establish generalizable facts like graphs, numbers. Qualitative research uses words. It enables the gathering of in-depth insights on topics. Qualitative research is best suited to the requirements of this project for verbally impaired people to identify unknown objects using object detection then present in sign language.

3.3 Development Methodology

Developing software is a resource-intensive process that involves several different groups of people. To develop successful software, the developer team should select an appropriate software development methodology based on the requirements. There are a few main types of software development methodologies. They are.

1. Waterfall Methodology.
2. Rapid Application Development.
3. Agile Methodology.
4. Scrum Methodology

In each methodology there are specific pros and cons. So, the development team should select the most suitable methodology by analyzing the pros and cons of methodologies as well as the user requirements.

1.Waterfall Methodology

Waterfall methodology is a risk-averse approach that organizes techniques for managing large scale projects that comprise programmers and a system that will have a significant influence on the business. Waterfall methodology is the most traditional development methodology that has a flow of phases. In this methodology, one phase should be completed to begin another phase. So, the rigidity of this methodology has been challenged. Because of the inflexibility of the approach, projects completed using waterfall methodology might take even months and years to complete.

2.Rapid Application Development.

The rapid application development approach is substantially shorter than the Waterfall methodology. This methodology is very well suited for small scale projects that need to be developed quickly. Although the Waterfall method needs more documentation and resources, the Rapid development methodology makes sense for small scale projects with minimum resources-intensive.

3.Agile Methodologies.

Rapid development and waterfall development methodologies place a greater emphasis on system documentation and process compliance. So, this causes the development more costly and time consuming. Agile software development methodology was introduced in response to these drawbacks. The agile methodologies are mainly focused on code rather than the design of the implementation. This approach is built on an iterative process. Also, the intent of agile methodology is to offer working software and focus on adapting according to the customer need.

Principles of agile development.

- Customer involvement
- Incremental delivery
- People do not process
- Embrace change
- Maintain simplicity

Most popular agile methodologies.

- Scrum
- Extreme Programming (XP)

- Adaptive Software Development (ASD)
- Feature Driven Development (FDD)
- Dynamic System Development (DSD)
- Crystal Method

4. Scrum Methodology.

Scrum allows us to focus on delivering the solution with the best business value in a short period of time as a collaborative team. The team will self-manage to identify the best strategy to provide the highest priority feature. According to this methodology the final goal or the final achievement is split and assigned among the team members.

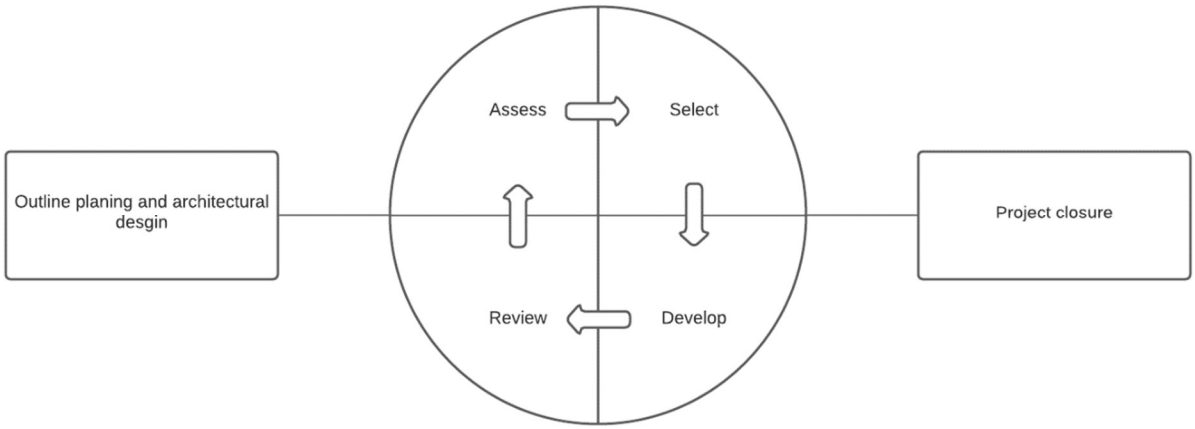

Figure 3.1 :Process of SCRUM (User-Composed)

5.Extreme Programming (XP)

Extreme programming is a software development process which aims to increase the software quality and adapt according to the customer requirements.

XP is based on four main values.

1. Communication
2. Simplicity
3. Feed Back
4. Courage

6.Adaptive Software development (ASD)

Adaptive development methodology is used to develop complicated systems.
Three phases of ASD.

1. Speculation
2. Collaboration
3. Learning

7.Feature Driven Development (FDD)

Feature Driven Development is more focused on identifying features and prioritizing them according to a hierarchy. The top priority feature will be completed first.

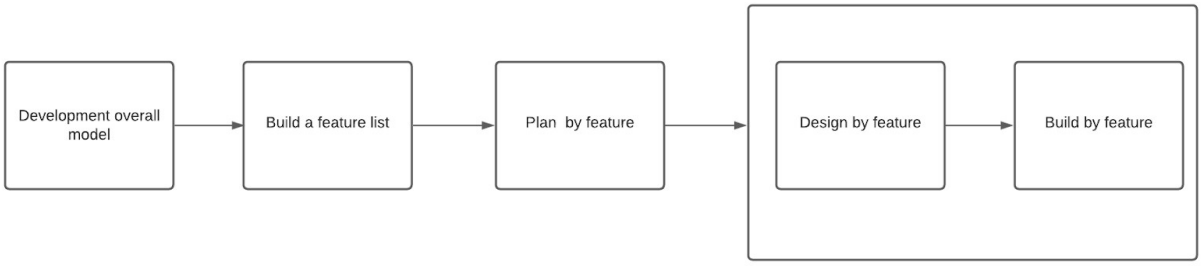

Figure 3.2: Feature Driven development (User-Composed)

8.Crystal

Crystal involves application of multiple process models to identify the applicability of the solution supplied based on problem characteristics. This will be accomplished via face-to-face communication and by using workshops by reviewing the projects completed.

By considering the pros and cons of the development methodologies the team Beta tech (development team) identified that the suitable development methodology for the proposed solution will be Agile Development Methodology.

Benefits of using Agile methodology.

- Ability to make modifications.
- Deliver the product with excellent quality
- Ability to complete the project quickly.
- Reduce the risk because of the user interaction.

3.4 Design Methodology

There are many design approaches. So, the development team should be wise enough to choose the best approach. Accordingly, team beta tech selects the Object-Oriented Design approach. Although the Structured Design Approach split the goal into several small goals, this approach is inflexible in modification. Object-Oriented Design mostly focused on Object-Oriented concepts. By the way, with the use of OOD (Object-Oriented Design approach) the components can be reused not only that OOD allows testing, debugging as well as managing easily.

3.5 Evaluation Methodology

The Evaluation Methodology is a tool that is used to better understand the procedures involved in conducting a quality assessment. A faculty member can acquire what they need to know about determining the quality of a performance, product, or talent by following this approach. Some criteria under this methodology will be discussed below.

The time required for user-mode apps to fully initialize before their user interface becomes accessible to the end-user is an important metric of user experience. Slow-loading applications might signal system problems, resource limitations, and user irritation. When the application is hosted online the loading time to the home page will be measured.

The impact of the application upon the users will be measured by a simple survey that users can complete within the app. The trained RCNN or CNN model's speed and accuracy will be tested. And the performance change will be also measured by comparing to previous evaluations of this model as well as the other similar models.

3.6 Project Management Methodology

Agile, Scrum, Kanban, Scrumban, Waterfall, and PRINCE2 are some of the most prominent project management methodologies. This project will be managed using the agile project management technique. Agile project management is an iterative method that emphasizes rapid value delivery and quick feedback from the team to swiftly adjust to changing circumstances. It primarily focuses on things like working in small groups, displaying processes to create clarity, collaborative client work, and receiving feedback as quickly as possible. One of the most essential characteristics of agile project management is that it promotes a culture of continual improvement. Instead of a single critical milestone at the conclusion of the project, teams engage in many learning cycles as it progresses.

3.7 Teamwork Breakdown Structure

Please refer Appendix A to view the teamwork breakdown structure.

3.8 Gantt Chart

Please refer Appendix B to view the Gantt chart.

3.9 Usage of Project Management and Collaboration Software in the Project

The author has provided a thorough overview of how they have used project management techniques to complete the project successfully. To properly communicate, discuss, and document the project's progress, a variety of communication channels have been deployed.

Online services such as WhatsApp and Slack have been utilized to communicate among team members. At the start of the project, a separate workspace on Slack was created with the name "SDGP" and numerous channels within. Since then, the workspace has been used to share crucial data such as Google drive links, project progress updates, and so on.

On Tuesdays, Thursdays, and Sundays, general meetings were held to discuss and review the previous week's progress, current work, and next week's targets, accordingly. The authors agreed on a general meeting time of 11 a.m. on Tuesdays, 4 p.m. on Thursdays, and 10 p.m. on Sundays. All the meetings were held via Google Meet.

All the documentation was done in a shared Google drive folder among the project members called "SDGP." During the documentation of the project, members took turns collaborating with one another. On a weekly basis, the progress was assessed. To keep track of the task management, a ClickUp workspace called "SDGP" was being used. Several boards, such as "To Do," "Tasks in Progress," "Task Completed," "Assignee," etc. were built and are updated weekly by the members. View Appendix C for ClickUp usage, View Appendix D for use of Slack, View Appendix E for meeting logs

3.10 Risks and Mitigation

Table 3.1 : Risks and Mitigation for project

No	Risk	Probability	Impact	Mitigation Action

01	Couldn't meet physically. (Covid-19 pandemic situation)	High	High	• In that case we used Google Meet, Zoom, and MS Teams tools for this.
02	Lack of Knowledge	High	Medium	• Getting advice from experts and past year students. • sharing knowledge between team members and self-studying how to recover from the difficulties. • Awareness of new technologies.
03	Unavailability of data sets.	edium	edium	• In that case we found some couple of free open accessible datasets. • It has medium accuracy. • Modifying the dataset if the dataset does not have enough data.
04	Accuracy	Medium	Medium	• Plan of time to allow adequate time to test and modify the machine learning module to achieve the highest level of accuracy.
05	Lack of time	Medium	Medium	• Set a time limit for completing a task and use appropriate time management. • Prioritize important tasks and stick to a schedule. • Assign work to team members in a fair and equitable manner.

06	Scope creep	Medium	High	• Developers must supervise the extension at any point where new requirements should be added and the proposed structure should prioritize the Center requirements over the attractive requirements.
07	Implementation problems	High	High	• Get the appropriate implementation resources. Ex: Common and easy • Find alternate ways to achieve the task. • This project wants to exclude things that are mentioned in the SRS document, but this will be like the project and there might be additional features included in the final project.
08	Deadline	High	High	• Create an Action Plan for priorities and reduce distractions.

3.11 Chapter Summary

The Methodologies chapter gave a brief explanation of the methodologies which are used to research, develop, design, evaluate, and manage the application. The risks involved, as well as the system's mitigation plan, were highlighted. Team breakdown structure is also mentioned in a Lucid chart. The usage of project management and collaboration software in the project was discussed in detail. The next chapter is System Requirements Specification, which covers the project's requirement engineering phase.

Chapter 4 : System Requirements Specifications

4.1 Chapter Overview

The various methodologies related to the project domain were discussed in the previous chapter. The focus of the following chapter was on collecting and analyzing system requirements. The use case diagram and use case specifications have been included in the requirement analysis section. In addition to Software Requirements Specification, it will introduce and analyze the stakeholders, requirement elicitation techniques, and methods with their outcomes, and finally, our system's functional and non-functional requirements are defined with a clear scope.

4.2 Stakeholder Analysis

4.2.1 Onion Model

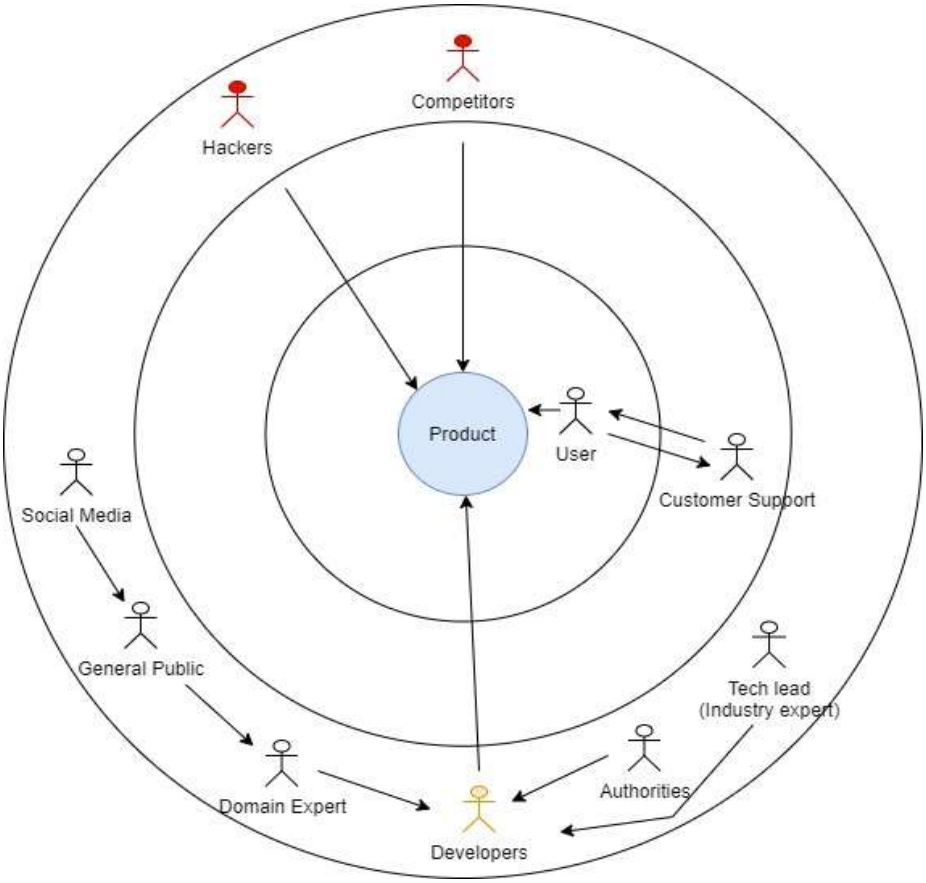

Figure 4.1 : Onion Model(User-Composed)

4.2.2 Stakeholder Descriptions

Table 4.1 Stakeholder Descriptions

Stakeholder	**Viewpoint**
Functional beneficiary	
Users	Users will be able to save money and learn the sign language for the objects using the application without attending sign languages classes.
Financial beneficiary	
Developers	Will be able to make a paid version of the application and earn money.
Social beneficiary	
General public	Will be able benefit from reduction of time wastage and get better service.
Operational beneficiary	

Developers	Will design the high-level architecture and then implement the system according to the high-level architecture.
Customer Support	Will assist the users on how the application works.
Negative Stakeholders	
Competitors	Will aim to build a better system than the proposed system.
Hackers	Want to obstruct the functionality of the system.
Regulatory	
Authorities	Will check if the correct information is sent out.
Experts	
Domain expert	Want to assist with the information about the domain.
Tech Lead	Want to assist with the implementation of the system in the most efficient way.
Neighboring systems	

Social media	Promote the application.

4.3 Selection of Requirement Elicitation Techniques/Methods

The phrase "requirement" refers to what a project's users require from it. Getting the correct requirements will provide us not only a better understanding of your stakeholders, but it will also help us bring value to your project. There are a variety of methods for gathering requirements. However, not every one of them can be employed in every situation. The requirements for this project were gathered using the following approaches.

1.Brainstorming

2.Document analysis

3.Questionnaire

4. Interviews

5.Prototyping

In the Literature Review phase of this study, the Document Analysis was done comprehensively using the techniques stated above. As a result, the focus of this chapter will be on the specifics of how and why the other methods were selected for the requirement gathering process, as well as the logic behind the choice, by discussing the benefits and drawbacks of each technique, as well as the level of relevance they have for the stakeholders.

4.3.1 Brainstorming

Brainstorming is the process of a set of individuals with similar aims exchanging ideas to come up with a clear and simple, more developed answer. This approach for gathering requirements is unique in that it allows you to look at the problem from several angles.

4.3.2 Questionnaire

A questionnaire consists of multiple questions that the target audience must answer to gain the user's perspective. Because surveys may reach a wide range of individuals, they can generate a high number of replies in a short amount of time. The number of prospective participants will be enormous, especially because the individual taking the survey does not have to divulge their identity.

Individual users are the primary target audience of this project, according to the onion model diagram. 13 questions were prepared with this in mind. These questions include a lot of options and are extremely clear about what they're for. The survey was inspired by the difficulties people confront while attempting to interact with the verbally impaired. These questions were created in this manner to gain better information about the target audience and to find a research gap that might be filled with a unique and efficient solution.

4.3.3 Interviews

Interviews are structured question-and-answer sessions between two people, one of whom the interviewer is and the other the respondent. This dialogue differs from questionnaire questions in that it contains open-ended inquiries that allow the respondent to comment on his or her replies.

4.3.4 Prototyping

Prototyping is a method through which developers can turn their ideas into physical or digital prototypes. A team may capture the core design principles of a software and test it on consumers by creating prototypes. Developers may then validate and enhance the product in a way that is more tailored to the user's wants.

4.4 Discussion/Analysis of Results

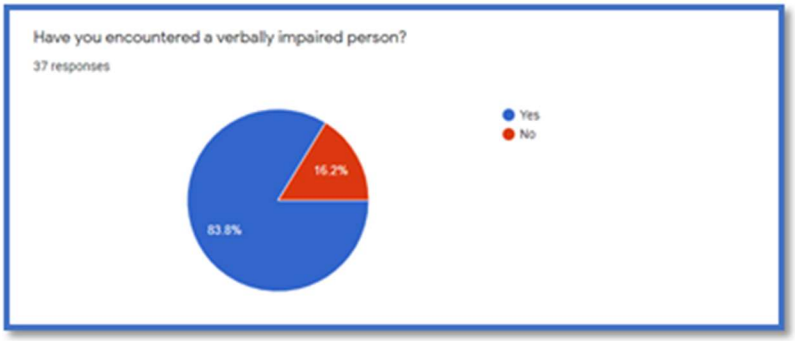

Figure 4.2 : Data gathered 1

Analysis:- The above figure shows that 83.8% of participants of the survey had encountered a verbally impaired person and 16.2% of participants have not had such an experience.

Conclusion:- This result reveals that many people had to communicate with verbally impaired persons. It means that there should be a good communication method to communicate with differently abled people.

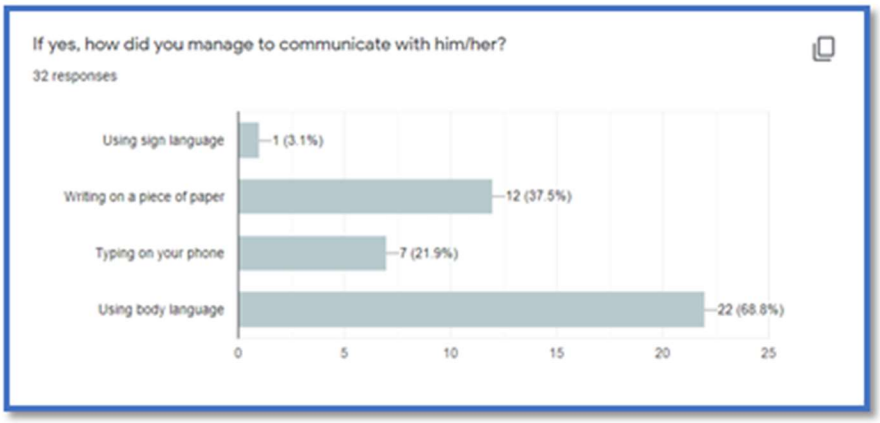

Figure 4.3 : Data gathered 2

Analysis:- The survey reveals that 22 participants manage to communicate using body language, 12 participants manage to communicate by writing on a piece of paper, 7 participants tried out typing on their phone and only one participant managed to use sign language.

Conclusion:- According to the results, most of the public uses body language which is not an efficient way to communicate. The use of sign language is less because people may have not any knowledge of it. So, the proposed platform will be a great opportunity for them to learn sign language.

Figure 4.4 : Data gathered 3

Analysis:- The above figure shows a scale of 1 to 10, how the participants rate their situation when communicating with a verbally impaired person. 17.6% of participants rated 3, 7, and 9 on the scale. Same number of participants 11.8% rate on the scale as 4,5 and 6. 8.8% of participants rated as 8 on the scale. Only one participant rated as 1 on the scale.

Conclusion:- According to the results the many people rate as bad on the scale about their communication method because of not efficiency of their method.

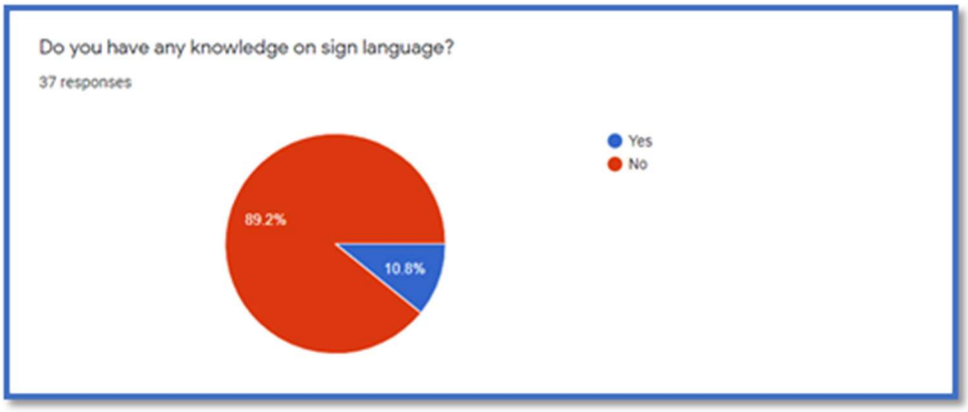

Figure 4.5 : Data gathered 4

Analysis:- 89.2% of participants have no knowledge on sign language and 10.8% of participants have knowledge on sign language.

Conclusion:- This result emphasizes that the public needs to learn about sign language to communicate with verbally impaired persons.

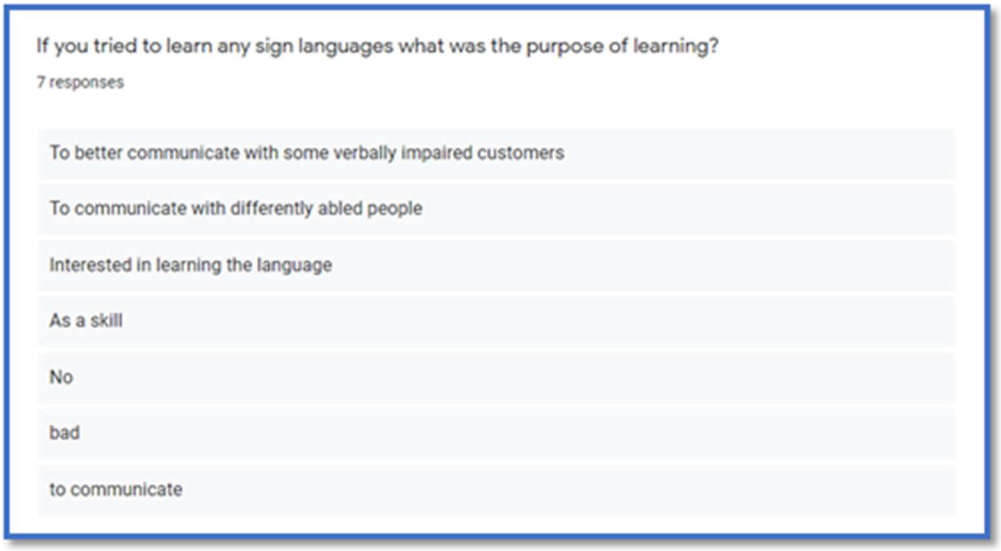

Figure 4.6 : Data gathered 5

Analysis:- The above figure shows the purposes of learning sign language for the participants of the survey. It reveals 7 responses as follows above.

Conclusion:- The simple summary of the above responses is the public has an interest in sign language and some of them want to learn sign language because they might have faced difficulties on such occasions.

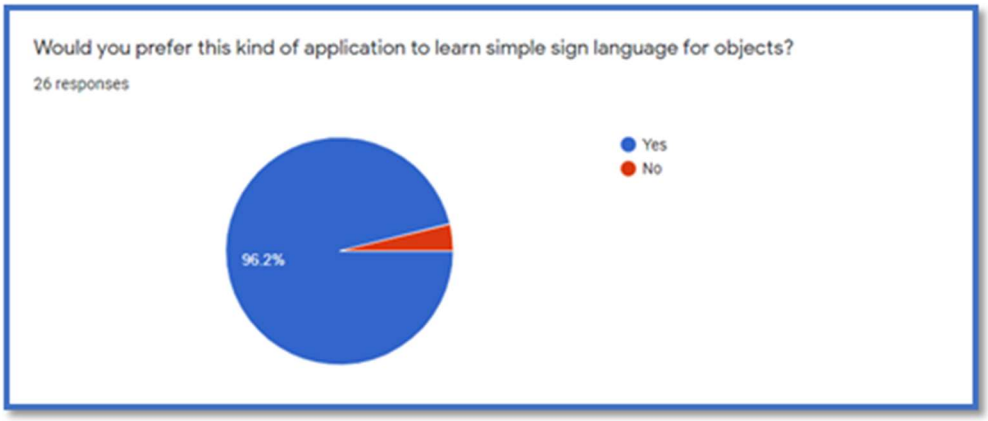

Figure 4.7 : Data gathered 6

Analysis:- The survey reveals that 96.2% of participants prefer the application to learn simple sign language for objects and the other percentage of participants don't prefer the application to learn simple sign language for objects.

Conclusion:- The results show straight away that people would like to use this kind of application to learn simple sign language for objects.

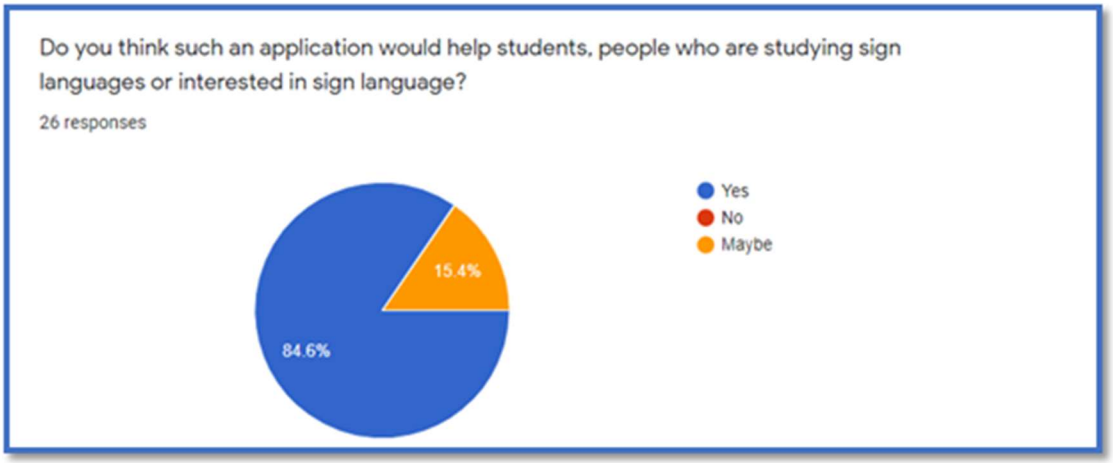

Figure 4.8 : Data gathered 7

Analysis:- The above figure shows 84.6% of participants think that this application would help students, people who are studying sign languages or interested in it. 15.4% of users are not sure

whether this application will help students, people who are studying sign languages, or interested in it.

Conclusion:- The opinion of the public is this application would help verbally impaired students for their studies. And people who are keen on learning sign language or have any interest in sign language this application might be very helpful to them.

4.5 Use Case Diagram

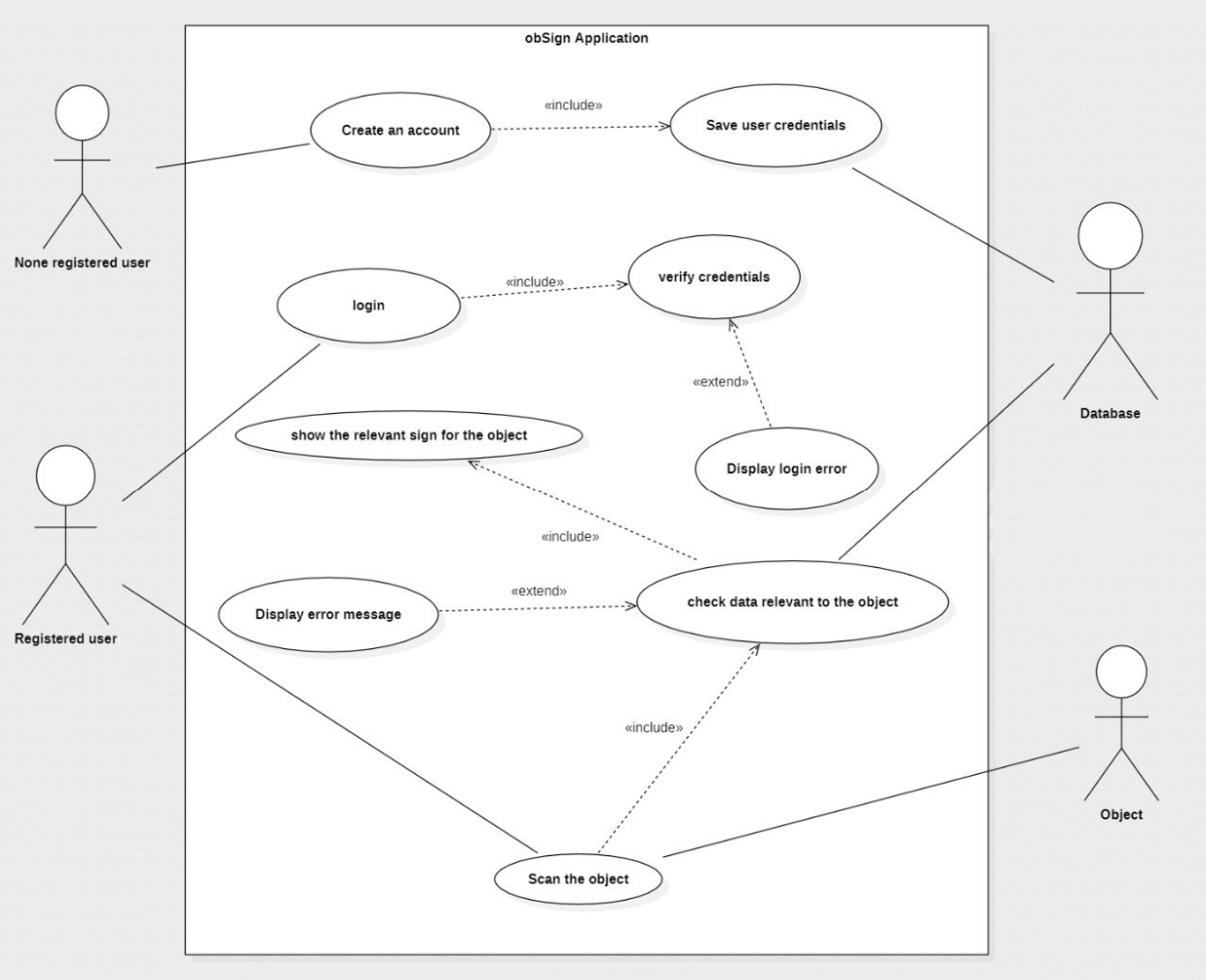

Figure 4.9 : Use Case Diagram

4.6 Use Case Descriptions

Table 4.2 : Use Case Description 1

Use Case Name	Create an account	
Use Case Id	UC-001	
Description	This use case describes the how to register to the system by creating an account.	
Priority	High	
Primary Actor	Non -Registered user	
Supporting Actor	NONE	
Pre-conditions	User should not have register to the system	
Trigger	When the user goes to the sign page after open the application.	
Main Flow ow Event	User Action	System Response
	1) Press the sign-up button. 3) Enter the credentials.	2) Brings the nonregistered user to the sign-up interface. 4) Create a use account.
Exception Flow	User Action	System Response
	3.b Enter the credentials.	3. Invalid user credentials. 3.a Ask the user to re-enter the credentials.
Alternate Flow	User Action	System Response
		4. If already an account exists according to the entered credentials. 4.a Display “Already an account exists” message. 4.b Re directing to the login page.
Exclusions	NONE	
Inclusions	Save user credentials.	
Post Conditions	1. Makes the user as registered user.	

Table 4.3 : Use Case Description 2

Use Case Name	Save user credentials	
Use Case Id	UC-002	
Description	This use case describes the how the system saves the user credentials in the database.	
Priority	High	
Primary Actor	Database	
Supporting Actor	NONE	
Pre-conditions	Proceed only after completing create an account.	
Trigger	After user enter the credentials to create an account.	
Main Flow ow Event	User Action	System Response
	NONE	1) Save the data in a database.
Exception Flow	User Action	System Response
	NONE	NONE
Alternate Flow	User Action	System Response
	NONE	NONE
Exclusions	NONE	
Inclusions	NONE	
Post Conditions	NONE	

Table 4.4 : Use Case Description 3

Use Case Name	Login	
Use Case Id	UC-003	
Description	This use case describes the how an existing user login to the system.	
Priority	High	
Primary Actor	Registered user.	
Supporting Actor	System.	
Pre-conditions	User should be a registered user.	
Trigger	When the user goes to the login page after open the application.	
Main Flow ow Event	User Action	System Response
	1) Press the login press. 3) Enter the credentials of the registered account.	2) Bring the user to the login page.
Exception Flow	User Action	System Response
		3.1 Invalid account credentials. 3.1.a. Display "Incorrect Credentials" message.

	3.1.c. Enter the credentials.	3.1.b. Ask the user to re-enter the credentials. 3.2. If there is no registered account. 3.2.a Display "There is no any existing account according to the input credentials" 3.2.b Re-direct to the create an account page.
Alternate Flow	User Action	System Response
	1 User select the forgot password.	2 Directed to the re-set password.
Exclusions	NONE	
Inclusions	Verify credentials	
Post Conditions	NONE	

Table 4.5 : Use Case Description 4

Use Case Name	Verify credentials	
Use Case Id	UC-004	
Description	This use case describes the how system verify the credentials of a registered account.	
Priority	High	
Primary Actor	System	
Supporting Actor	NONE	
Pre-conditions	Users proceed by entering the account credentials.	
Trigger	After the user enter account credentials.	
Main Flow ow Event	User Action	System Response
	NONE	1) System checks whether the credentials are valid.
Exception Flow	User Action	System Response
	NONE	1. Invalid credentials 1.a Redirect to the login page
Alternate Flow	User Action	System Response
	NONE	NONE
Exclusions	Display Login	
Inclusions	NONE	
Post Conditions	Verify the account is a valid account.	

Table 4.6 : Use Case Description 5

Use Case Name	Display login error	
Use Case Id	UC-004	
Description	This use case describes the how to display the login error message if the account credentials are invalid.	
Priority	High	
Primary Actor	System	
Supporting Actor	NONE	
Pre-conditions	Invalid account credentials	
Trigger	If the account credentials are invalid	
Main Flow ow Event	User Action	System Response
	NONE	1) Display login error message
Exception Flow	User Action	System Response
	NONE	NONE
Alternate Flow	User Action	System Response
	NONE	NONE
Exclusions	NONE	
Inclusions	NONE	
Post Conditions	NONE	

Table 4.7 : Use Case Description 6

Use Case Name	Scan the object
Use Case ID	UC-006
Description	The system should scan the object the user is holding the camera on
Priority	High Level
Primary Actor	object
Supporting Actors	Registered user
Pre-Conditions	User Must have passed the verification step & focus the object at the camera to identify.

Trigger	User should Hold the camera towards the object and press the scan button	
Main flow	**Actors**	**System**
	6.1)User Select object identification option 6.3) User press scan Button and focus the camera on the object	6.2)System Loads scan interface
Exception flow	**Actors**	**System**
	6.1)User press scan button 6.3)User connects to the internet again	6.2)Scan page does not load due to no internet Connection 6.4)Scan page loads
Alternate flow	**Actors**	**System**
	6.1)User Not focusing correctly on any object 6.3) User should try again	6.2)System will ask to re- scan
Exclusions	None	
Inclusions	Image with scanned object	
Post Conditions	Check the database for relevant to the object	

Table 4.8 : Use Case Description 7

Use Case Name	Check Data relevant to the object
Use Case ID	UC-007

Description	Here it checks to see if there is a database that matches the scanned object	
Priority	High Level	
Primary Actor	Database	
Supporting Actors	Object	
Pre-Conditions	User Successfully Scanned object. The data sets related to the scanned object should be introduced.	
Trigger	None	
Main flow	**Actors**	**System**
	None	7.1)System Find out if there are any data sets related to the object
Exception flow	**Actors**	**System**
	None	None
Alternate flow	**Actors**	**System**
	None	None
Exclusions	None	
Inclusions	None	

Post Conditions	Object will be scanned

Table 4.9 : Use Case Description 8

Use Case Name	Display An Error Message	
Use Case ID	UC-008	
Description	The system will Display Error Message	
Priority	Low Level	
Primary Actor	Database	
Supporting Actors	None	
Pre-Conditions	Has checking the database related to the object	
Trigger	Failed to check the database related to the object	
Main flow	**Actors**	**System**
	None	8.1)Identify that the object has no relevant database 8.2)Displays an error
Exception flow	**Actors**	**System**
	None	None
Alternate flow	**Actors**	**System**

	8.2)User press try again Button	8.1)Display in error message and Try Again 8.3)System redirect to the scan interface
Exclusions	None	
Inclusions	None	
Post Conditions	Displayed failure	

Table 4.10 : Use Case Description 9

Use Case Name	Show the relevant sign for the object	
Use Case ID	UC-009	
Description	Displaying the identified object in sign language	
Priority	High Level	
Primary Actor	Database	
Supporting Actors	None	
Pre-Conditions	Successfully identified the database related to the object	
Trigger	Shows to the user using sign language	
Main flow	**Actors**	**System**

	None	9.1)Represent the data in the database in sign language 9.2) Display of the Result via sign language
Exception flow	**Actors**	**System**
	None	None
Alternate flow	**Actors**	**System**
	None	None
Exclusions	Sign language result	
Inclusions	None	
Post Conditions	Displayed Result	

4.7 Functional Requirements

Table 4.11 : Functional Requirements

Number	Requirements	Description	Priority
FR1	Username and password Verification	To proceed, the user will be needed to provide the registered login and password at the start of the program.	Low

FR2	Recognizing and identifying the object through the user's mobile camera	The first step of the primary detection method. The user will have to hold the phone camera in an aligned manner to detect the object.	High
FR3	Providing the default character for use of the application	Default camera is added in the application to click the picture to process the relevant feature for the object selected by the user. Only difference is the default camera will not use any filter to the image so it will be more accurate when identifying the object.	Medium

4.8 Non-Functional Requirements

Table 4.12 : Non-Functional Requirements

Number	Requirement	Description
NFR1	Accuracy	The suggested project should be able to identify the object by requiring the user to hold the mobile camera in the right position, after which the system will compare the object to an existing database and display the object's sign language.
NFR2	Performance	The system should be able to identify the object and process the data with the existing database in real time without any delays.

NFR3	Usability	The system will be basic and simple, with interactive elements that make it simple to use and increase user experience.
NFR4	Scalability	The system should be able to identify a wide range of items while being consistent.
NFR5	Security	User's data should be kept private and cannot be misused.
NFR6	Maintainability	Comprehensive and clear documentation should be given upon request so that designers or analysts may quickly become acquainted with the framework.

4.9 Chapter Summary

SRS chapter looked at the appropriate stakeholders, the Onion model, selection of requirement elicitation techniques/methods with functional and non-functional needs, as well as their priority levels, use case diagram, use case descriptions in detail. The next chapter is Social, Legal, Ethical, and Professional Issues, which discuss in detail SLEP issues.

Chapter 5 : Social, Legal, Ethical and Professional Issues

5.1 Chapter Overview

The project's requirement engineering phase was discussed in the previous chapter. The following chapter is about social, legal, ethical, and professional issues relevant to the research project and how those issues are mitigated.

5.2 SLEP Issues and Mitigation

It is essential to make sure all the legal, social, ethical, and professional issues are handled during the research project. The legal, social, ethical, and professional issues related to Obsign are detailed below.

5.2.1 Legal Issues

The suggested application will be carefully developed under data privacy rules. All the datasets used in this project were obtained under the terms and conditions of the providers, and the datasets to be utilized will be done so in accordance with applicable legal and ethical standards. When developing obSign, Data protection rules were held in high respect. The data was not altered with or manipulated in any manner. It wasn't utilized for any criminal purposes, either. The terms of use and conditions published on Kaggle were thoroughly examined before using the dataset for this project.

The software used in this project was legally purchased, and all software used in our projects will be regarded to be utilized under the law. But some tools are open source. The users' personal information was not collected through the questionnaires sent out during the requirement elicitation stage and it was kept anonymous.

5.2.2 Social Issues

The purpose of the Beta Tech team is to develop a project that does not have any cultural effect. For people who don't like to learn sign language, the app would be inappropriate. obSign was created in just English, which may have an impact on persons who do not understand English. As a future improvement, multi-language support will be implemented.

5.2.3 Ethical Issues

Ethical issues can be found in any of the projects, based on that, some ethical issues are discussed here. When something is discussed in the project, if any material is derived from a research article, that information is clearly stated in the reference part to avoid plagiarism.

Before beginning the project's interviews with the industry experts and volunteers of the questionnaire conducted to collect data from the public, permission was requested first and the purpose of the interview was explained to the interviewee, as well as how the information will be used. Before beginning the interview, consent was acquired, and the public had the option of declining to participate if they so desired.

5.2.4 Professional Issues

All the information gathered through the questionnaire and interview was never shared with a third party and will not be shared in the future.

Professionally the dataset was collected. During the development of the project and the authoring of the report, data sets, questionnaire responses, and other cited material were not updated or changed.

5.3 Chapter Summary

The Social, Legal, Ethical, and Professional issues chapter gave a brief explanation of how social issues, legal issues, ethical issues, and professional issues are appropriate for the research project and how those issues are mitigated. The next chapter is System Architecture & Design which covers the architecture and design part of the research project

Chapter 6 : System Architecture & Design

6.1 Chapter Overview

This chapter gives a high-level overview of the system's design decisions and diagrams. The high-level architecture diagram, class diagram, sequence diagram, activity diagram, and wireframe are all included in this chapter.

6.2 System Architecture Design

The system's architecture is represented in the diagram below. The data, logic, and presentation layers are organized in a three-tier design. The logic layer contributes the most to the research, while the presentation and data layers are largely driven by applications. The database tier shows the two databases going to use. The presentation tier illustrates the web application front end. The domain logic layer contains the modular approach of the backend logic of obSign.

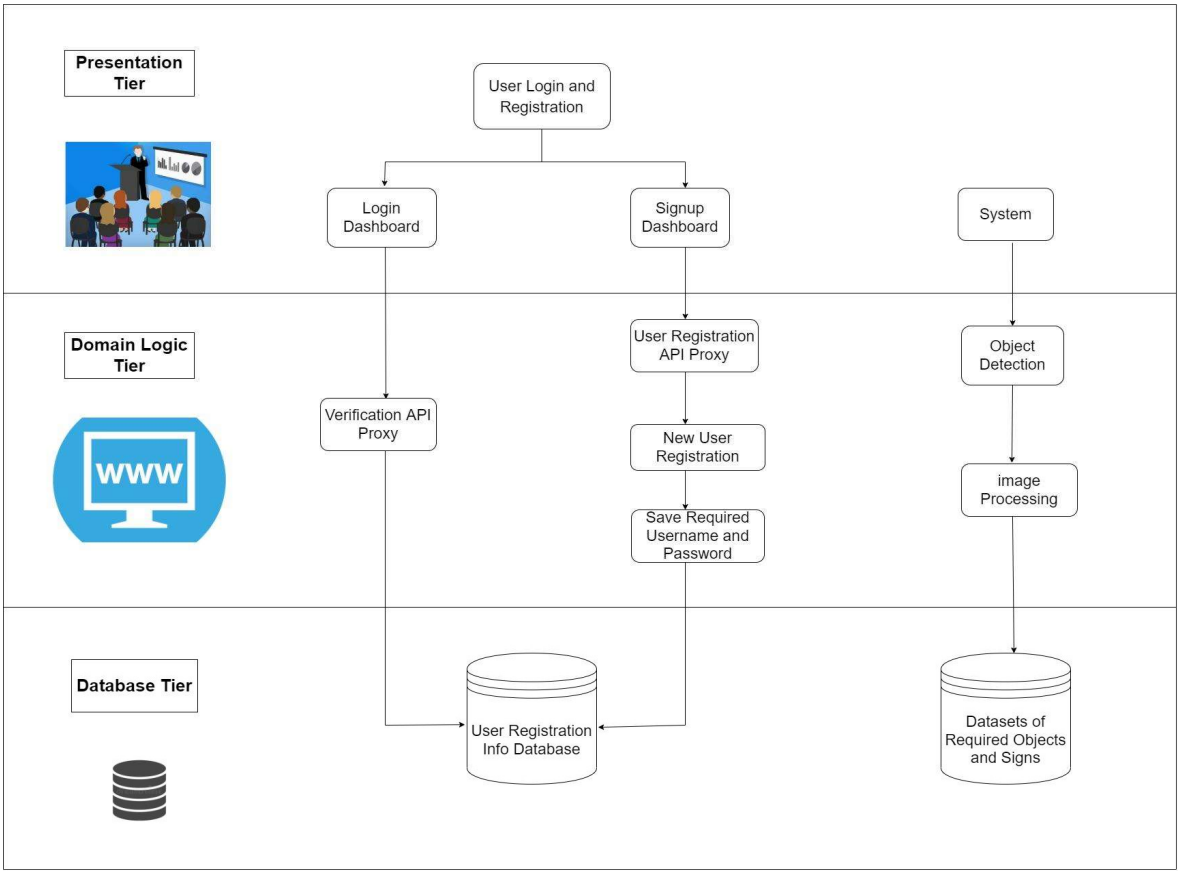

Figure 6.1 : Layered Architecture Diagram

6.3 System Design

6.3.1 Class Diagram

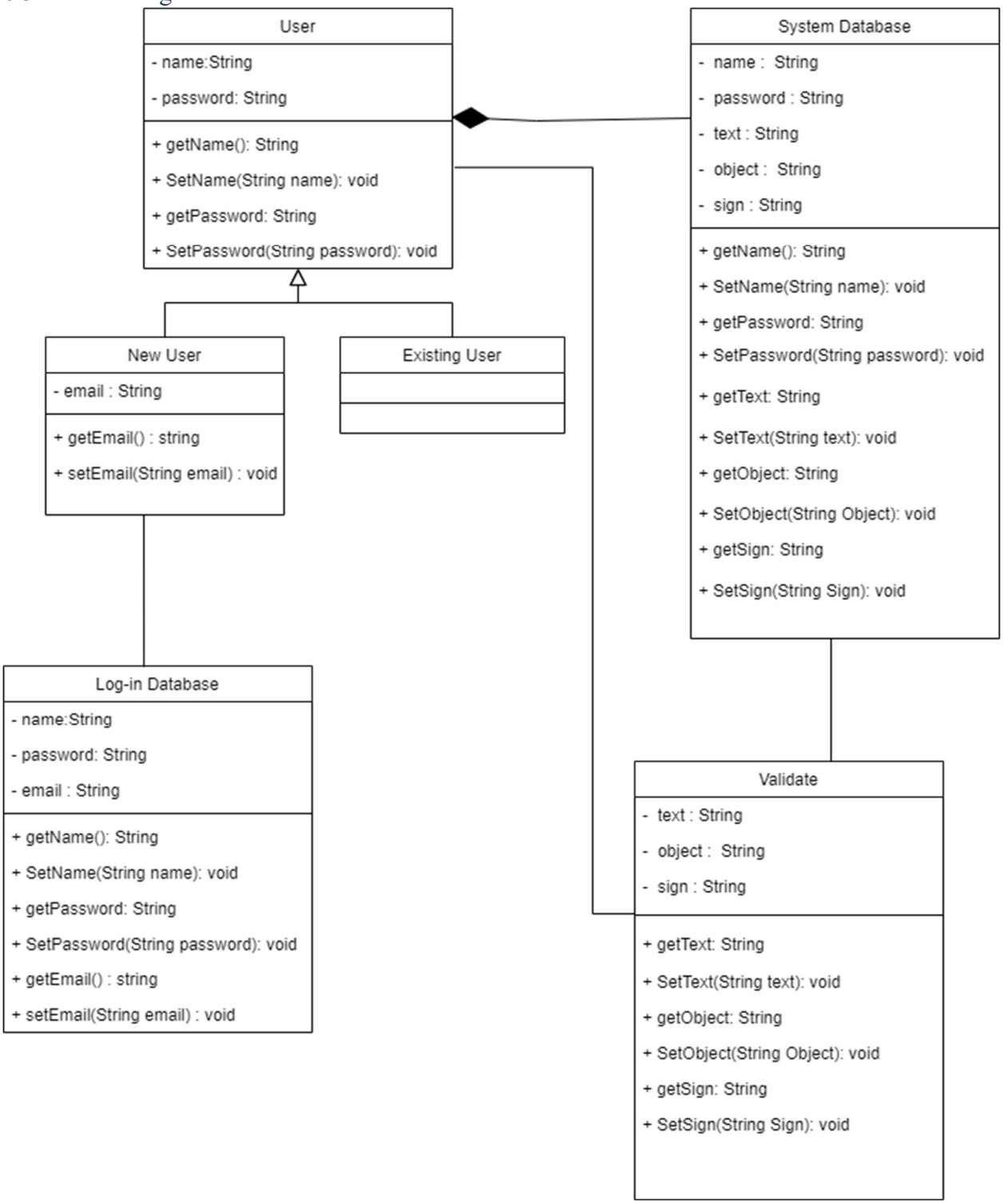

Figure 6.2 : Class Diagram

6.3.2 Sequence Diagram

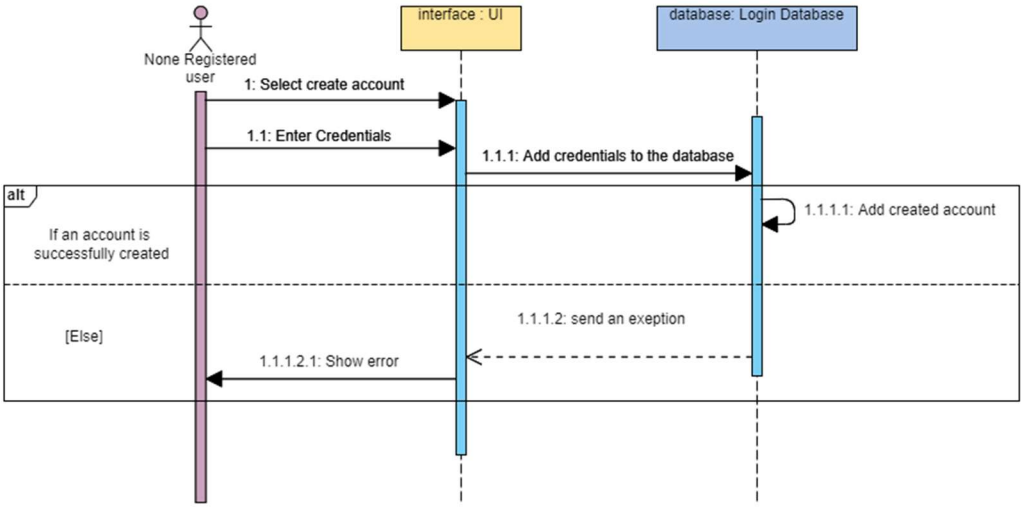

Figure 6.3 : Register sequence diagram

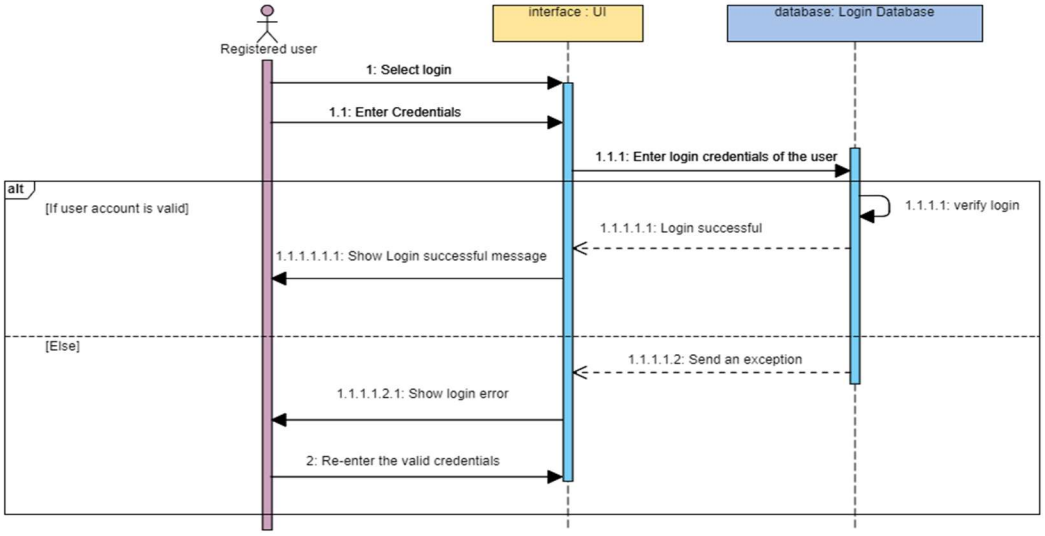

Figure 6.4 : Login sequence diagram

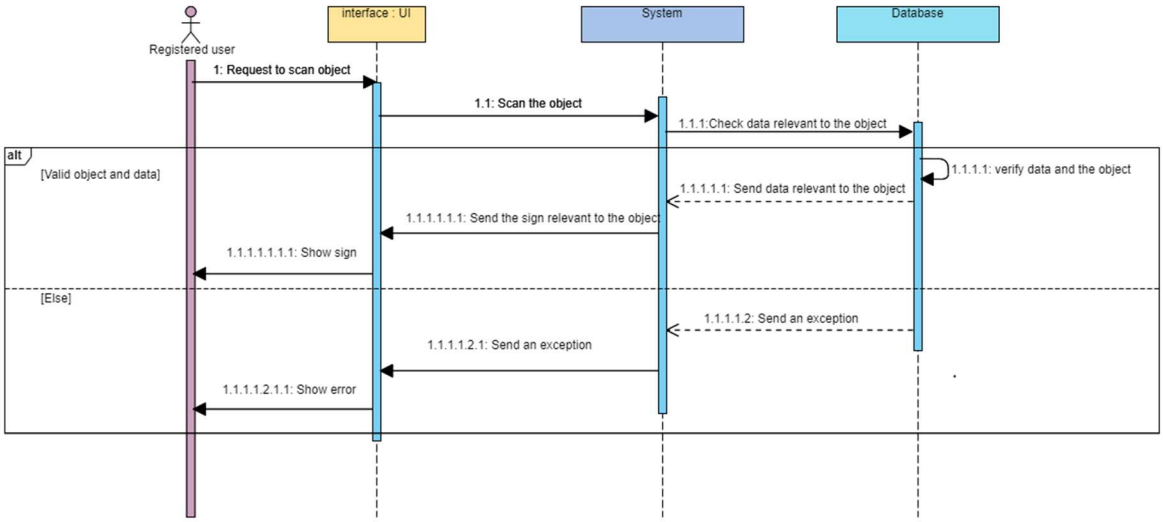

Figure 6.5 : Scan object and predict sign sequence diagram

6.3.3 UI-Design

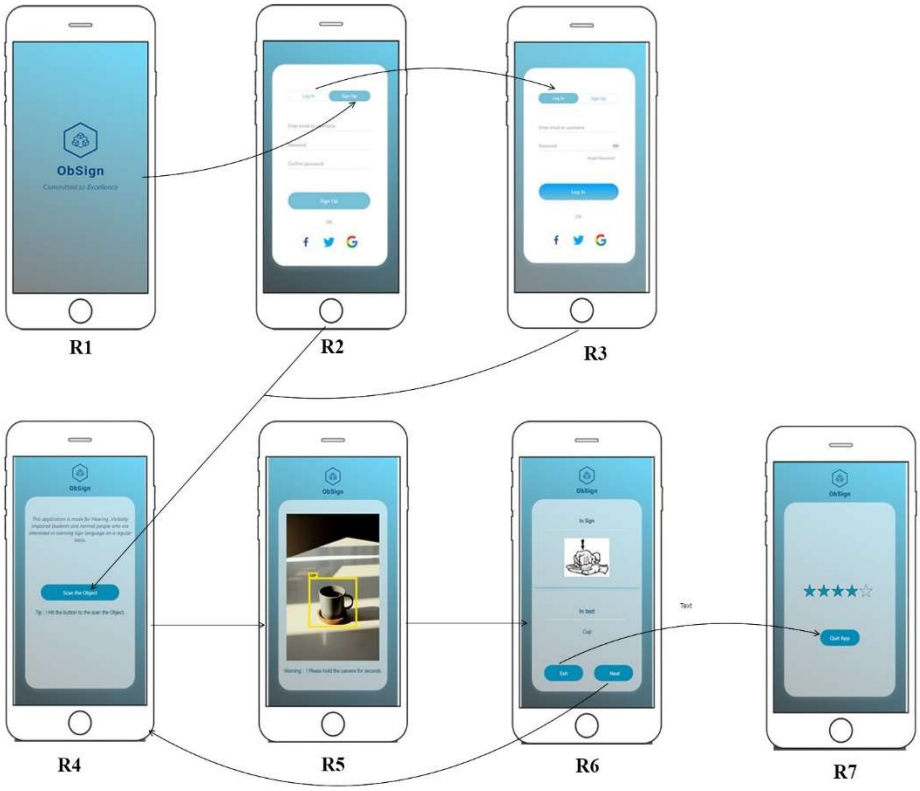

Figure 6.6 : UI Design Structure

Table 6.1 : UI Design Description

Relationship	Description
R1	Landing Page with obSign Logo & and app slogan (5 Seconds Hold page).
R2	If a user needs to register tap the sign-up button. After the registration then the page will be allowed to move to the main page.
R3	If a user already registered the app, then user tap the log in button. After the user entered the username & password the page will be allowed to move to the main page.
R4	In this page display top of the page the app logo, and in the bar box top display what truly who needs this app. In the center of the page have a one button called “Scan the object” and has some user-friendly commands.
R5	In this page display top of the page the app logo, When the click the (R4) button, it will redirect to the default camera of the app. Once open the camera the app will identify what are the objects in through the camera. User can get some commands for the identity purposes.
R6	In this page display top of the page the app logo, In the bar box top user can see the (R5) identified objects convert to sign language with sign images and the text. In the bottom of the bar box user can see this page has two buttons called “Exit” & “Next”. When the user taps the “Exit” button user will exit the app. And user tap the “Next” button it will goes to again (R4) page.
R7	In this page display top of the page the app logo, In the bar box center displayed the star rating system. This page only displayed when the user hit the button called “Exit” in (R6) page.

6.3.4 Process Flowchart

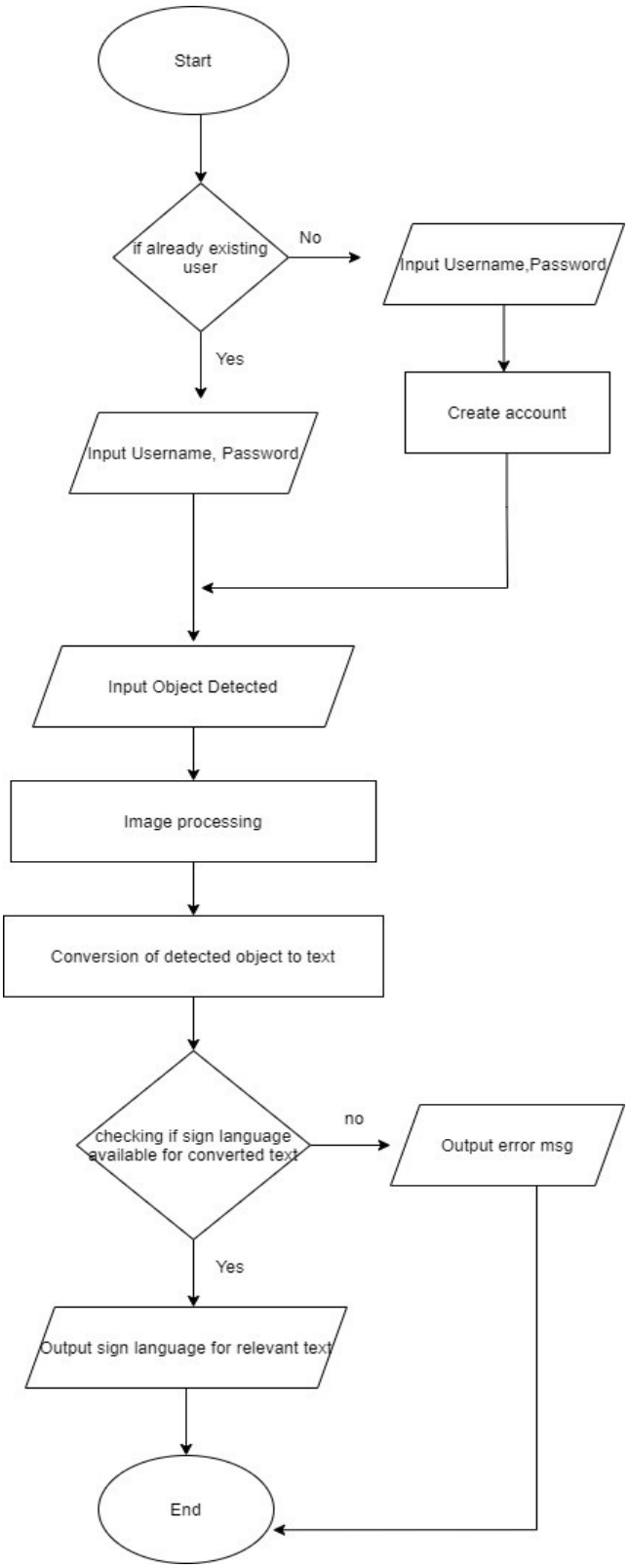

Figure 6.7 : Flowchart

6.4 Chapter Summary

This chapter covered the High level and low levels of the designs required for constructing the application as well as diagrams that aid users in comprehending the entire system. These are a High-level architecture diagram, class diagram, activity diagram, sequence diagrams, UI design prototype with wireframes, and describe the system process flow.

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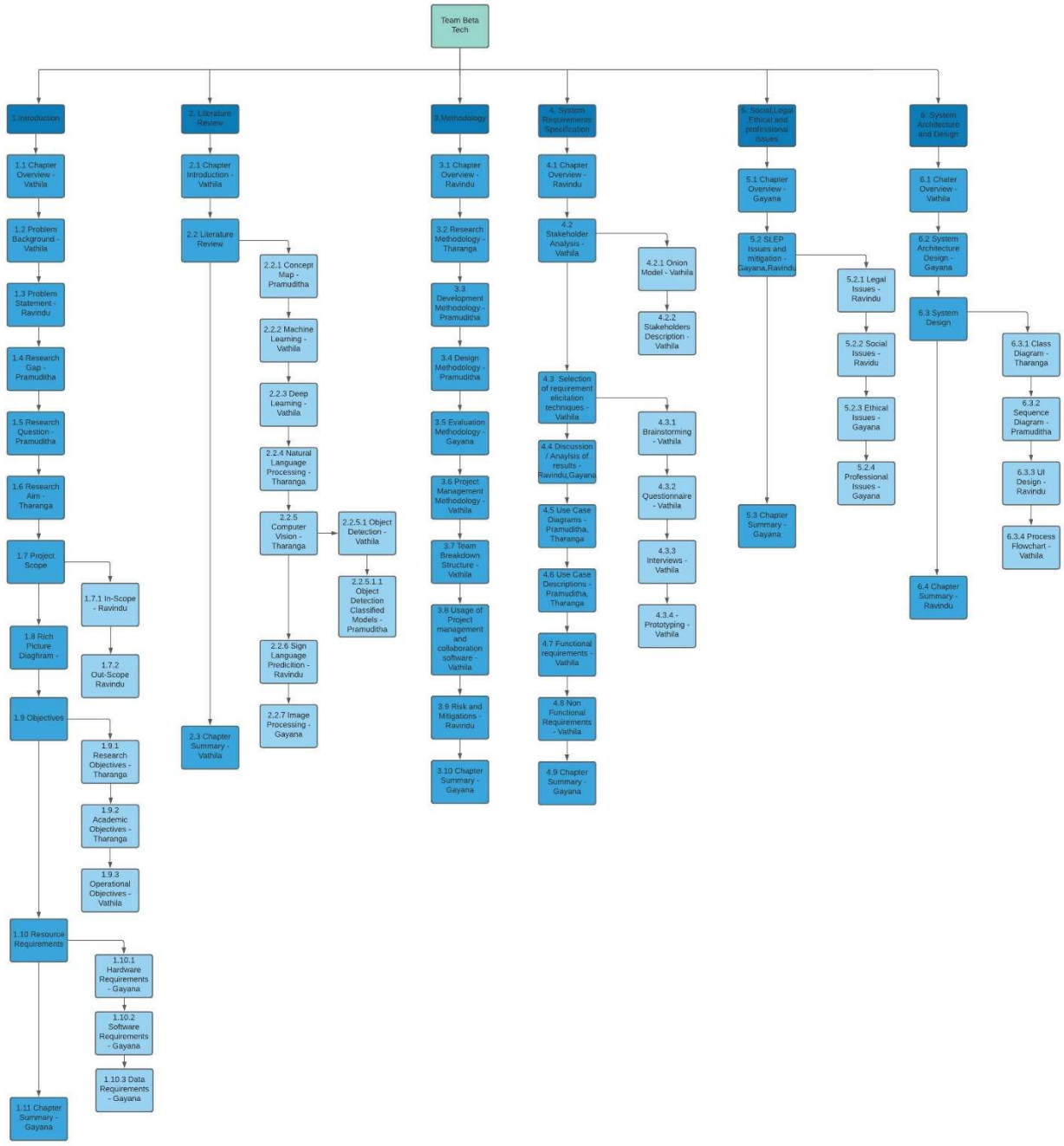
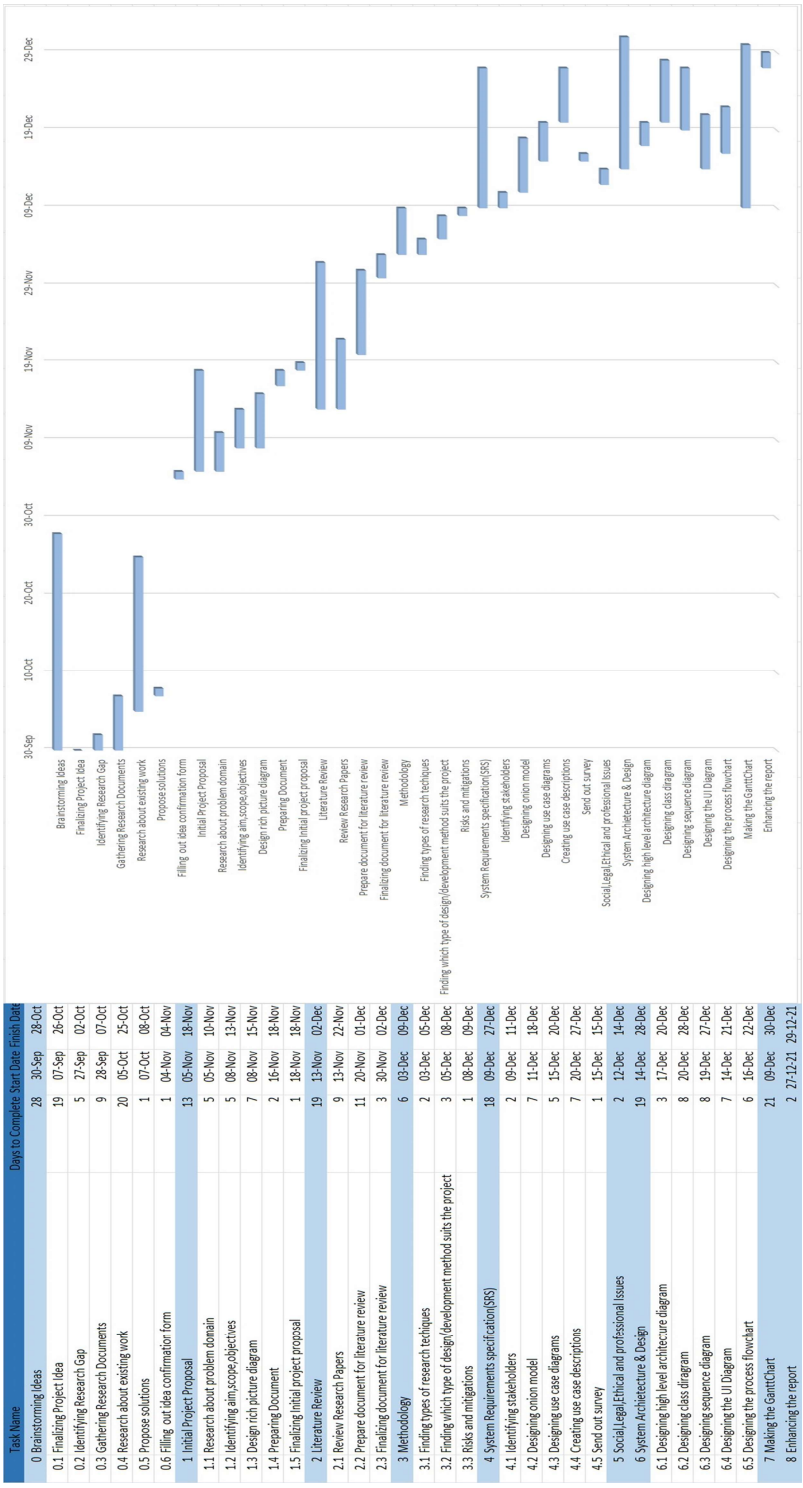
Appendix

Appendix A

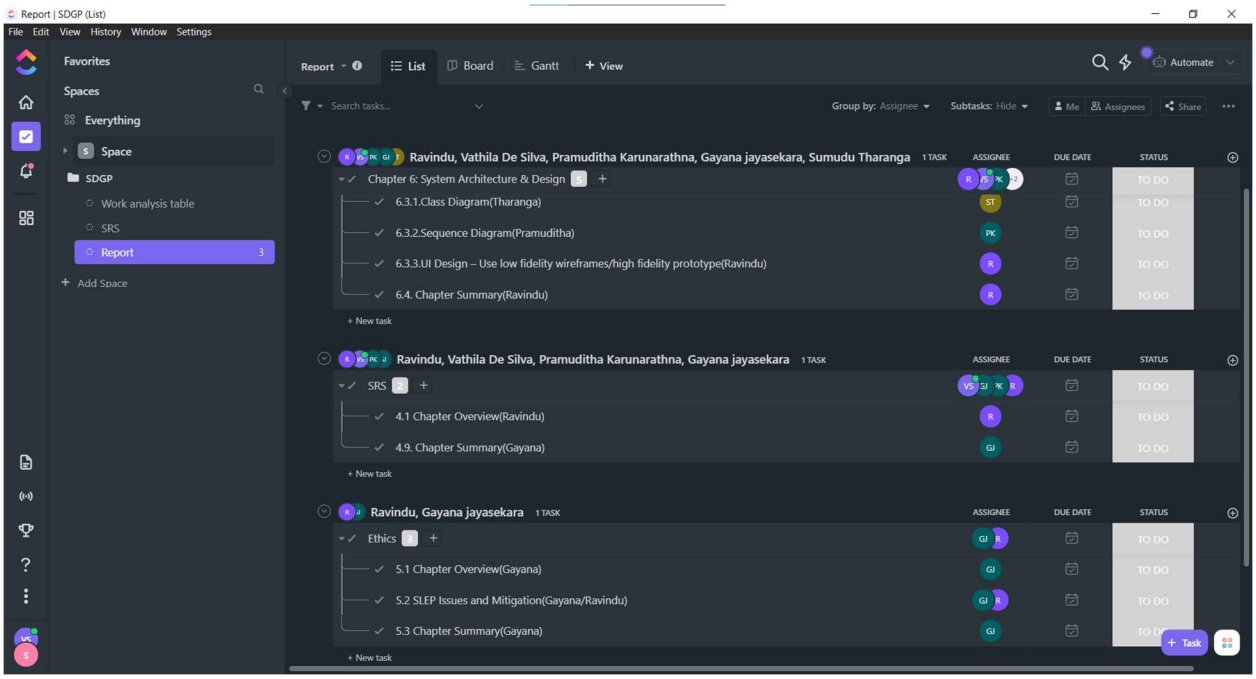


Appendix B

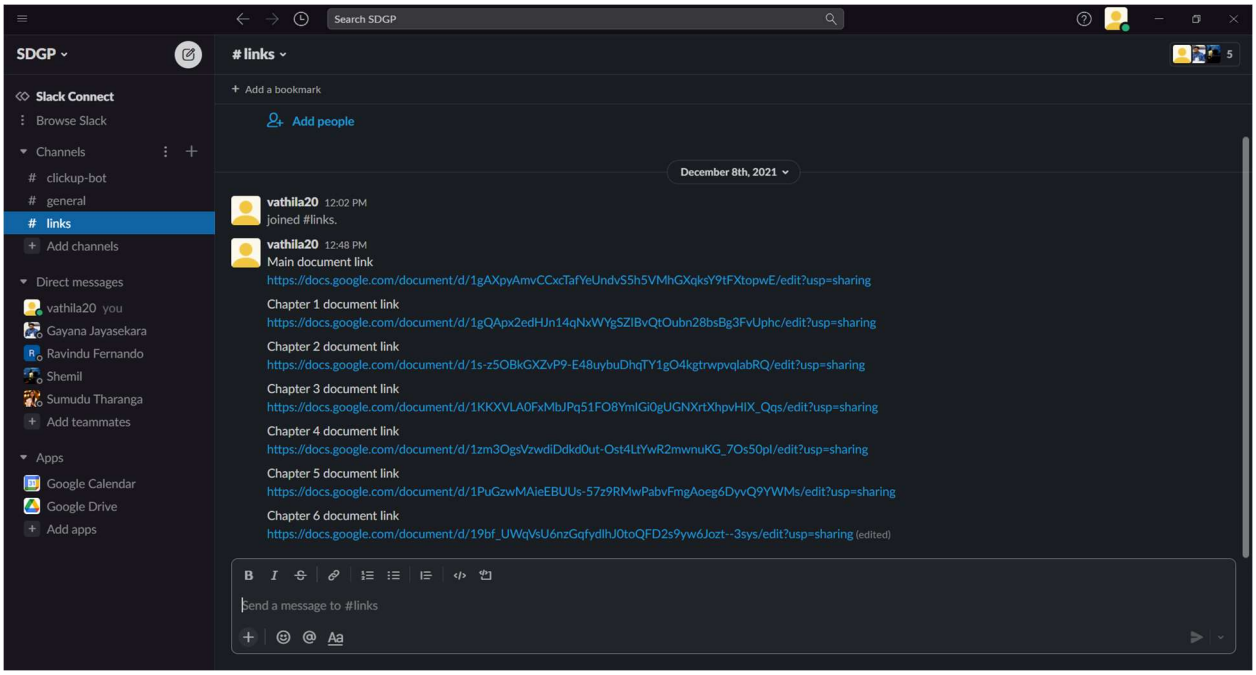
Task Name	Days to Complete	Start Date	Finish Date
0 Brainstorming Ideas	28	30-Sep	28-Oct
0.1 Finalizing Project Idea	19	07-Sep	26-Oct
0.2 Identifying Research Gap	5	27-Sep	02-Oct
0.3 Gathering Research Documents	9	28-Sep	07-Oct
0.4 Research about existing work	20	05-Oct	25-Oct
0.5 Propose solutions	1	07-Oct	08-Oct
0.6 Filling out idea confirmation form	1	04-Nov	04-Nov
1 Initial Project Proposal	13	05-Nov	18-Nov
1.1 Research about problem domain	5	05-Nov	10-Nov
1.2 Identifying aim,scope,objectives	5	08-Nov	13-Nov
1.3 Design rich picture diagram	7	08-Nov	15-Nov
1.4 Preparing Document	2	16-Nov	18-Nov
1.5 Finalizing Initial project proposal	1	18-Nov	18-Nov
2 Literature Review	19	13-Nov	02-Dec
2.1 Review Research Papers	9	13-Nov	22-Nov
2.2 Prepare document for literature review	11	20-Nov	01-Dec
2.3 Finalizing document for literature review	3	30-Nov	02-Dec
3 Methodology	6	03-Dec	09-Dec
3.1 Finding types of research techiques	2	03-Dec	05-Dec
3.2 Finding which type of design/development method suits the project	3	05-Dec	08-Dec
3.3 Risks and mitigations	1	08-Dec	09-Dec
4 System Requirements specification(SRS)	18	09-Dec	27-Dec
4.1 Identifying stakeholders	2	09-Dec	11-Dec
4.2 Designing onion model	7	11-Dec	18-Dec
4.3 Designing use case diagrams	5	15-Dec	20-Dec
4.4 Creating use case descriptions	7	20-Dec	27-Dec
4.5 Send out survey	1	15-Dec	15-Dec
5 Social,Legal,Ethical and professional Issues	2	12-Dec	14-Dec
6 System Architecture & Design	19	14-Dec	28-Dec
6.1 Designing high level architecture diagram	3	17-Dec	20-Dec
6.2 Designing class diagram	8	20-Dec	28-Dec
6.3 Designing sequence diagram	8	19-Dec	27-Dec
6.4 Designing the UI Diagram	7	14-Dec	21-Dec
6.5 Designing the process flowchart	6	16-Dec	22-Dec
7 Making the GanttChart	21	09-Dec	30-Dec
8 Enhancing the report	2	27-12-21	29-12-21



Appendix C



Appendix D



Appendix E

Date	Progress	Attendance
12th October 2021	Meeting with Sir Deshan and Sir Dilan about the idea to get a better understanding	Vathila(P) Pramuditha(P) Gayana(P) Tharanga(P) Ravindu(P)
14th October 2021	Meeting with Sir Torin(Mentor) to present idea	Vathila(P) Pramuditha(P) Gayana(P) Tharanga(P) Ravindu(P)
18th October 2021	Group meeting to do the Tutorial of SDGP week 3	Vathila(P) Pramuditha(P) Gayana(P) Tharanga(P) Ravindu(P)
21st October 2021	Meeting with Sir Torin(Mentor) to discuss the project proposal	Vathila(P) Pramuditha(P) Gayana(P) Tharanga(P) Ravindu(P)
26th October 2021	Discussion of project management techniques	Vathila(P) Pramuditha(P) Gayana(P)

		Tharanga(P) Ravindu(P)
28th October 2021	Getting feedback on the project proposal by Sir Torin	Vathila(P) Pramuditha(P) Gayana(P) Tharanga(P) Ravindu(P)
2nd November 2021	Group meeting to do the target audience tutorial	Vathila(P) Pramuditha(P) Gayana(P) Tharanga(P) Ravindu(P)
9th November 2021	Group meeting to do the stakeholder tutorial	Vathila(P) Pramuditha(P) Gayana(P) Tharanga(P) Ravindu(P)
9th November 2021	Fixing the errors in the report chapter 1	Vathila(P) Pramuditha(P) Gayana(P) Tharanga(P) Ravindu(P)
14th November 2021	Group meeting to discuss the chapter 2 of the report	Vathila(P) Pramuditha(P) Gayana(P) Tharanga(P)

		Ravindu(P)
16th November 2021	Group meeting to discuss the progress of chapter 2 and clarify some doubts and methodologies tutorial	Vathila(P) Pramuditha(P) Gayana(P) Tharanga(P) Ravindu(P)
23rd November 2021	SDGP Tutorial Git	Vathila(P) Pramuditha(P) Gayana(P) Tharanga(P) Ravindu(P)
30th November	Group meeting after chapter 2 feedback session to fix the errors in chapter 2	Vathila(P) Pramuditha(P) Gayana(P) Tharanga(P) Ravindu(P)
2nd December 2021	Discussion on chapter 3	Vathila(P) Pramuditha(P) Gayana(P) Tharanga(P) Ravindu(P)
07th December 2021	Discussion on chapter 3 progress and software architecture tutorial	Vathila(P) Pramuditha(P) Gayana(P) Tharanga(P) Ravindu(P)

09th December 2021	General group meeting discussion on the chapters covered(1-3) and changers that need to be made	Vathila(P) Pramuditha(P) Gayana(P) Tharanga(P) Ravindu(P)
14th December 2021	Discussion on the diagram in chapter 4 and 6	Vathila(P) Pramuditha(P) Gayana(P) Tharanga(P) Ravindu(P)
18th December 2021	Discussion on use case diagrams and descriptions	Vathila(P) Pramuditha(P) Gayana(P) Tharanga(P) Ravindu(P)
27th December 2021	Discussion on chapter 6 sequence diagram and class diagram	Vathila(P) Pramuditha(P) Gayana(P) Tharanga(P) Ravindu(P)
30th December 2021	Document formatting and diagrams discussion	Vathila(P) Pramuditha(P) Gayana(P) Tharanga(P) Ravindu(P)

15th January 2022	Discussion on the start of implementation and document submission	Vathila(P) Pramuditha(P) Gayana(P) Tharanga(P) Ravindu(P)