Deliverable 1

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1 Domain

1.1 Background

1.1.1 What is the domain

The domain chosen has been American Sign Language,it is the predominant language of Deaf communities. This language is used by many people daily however there exist a large number of dialects as well as difficulties in learning sign language. For example, British Sign Language is not the same as American Sign Language and there does not exist a universal language. American Sign Language is a different language to the ones you may think of usually, unlike when having a conversation in English with someone the use of voice has no impact due to the fact it is designed to be understood by deaf people. Letters and therefore words are pronounced using hand gestures. On the other hand, American Sign Language has variations depending on the person who is speaking similar to when people have different accents. American Sign Language (2020) .This can make it difficult to grasp at first, for some people who are new to the language or the difference is too big in comparison to other spoken languages.

Overall sign language is key for our society, we as human beings rely heavily on communication with one another. Sign language allows people with impaired hearing to communicate with other people in a much better way. Although it is not always that easy, as sign language is not known by everyone,so sometimes it can be very difficult to understand what another person is trying to tell you. With all of this being said, the statistics are astonishing, 11 million people are deaf or hard of hearing in the UK, that makes around 16.7% of the population has hearing difficulties . Nonetheless there are only around 150,000 British Sign Language users, this shows clearly the dilemma they are facing. As a consequence of this people with hearing difficulties are more prone to unemployment and mental health issues. Saleem: profoundly deaf user (2019). You could argue one obstacle leads to the other, yet they are both urgent problems to solve.

1.1.2 Motivation

Because of this on the transition to a much-more online world the need for interpreting sign language is necessary for things such as online doctor service or simply online video call communication. As the hardship of lockdown and isolation affects everyone, it impacts Deaf people the most, a vulnerable population which already suffered from loneliness as mentioned earlier has seen the risk of this mental health condition rise. The option of speaking to friends or family members over the phone is much less feasible for them for obvious reasons. In like manner Deaf clubs have being forced to shut down during long periods, they appear a place where they can socialise and stay in contact, the changeover to online meetings in the best cases has being hurtful for the community Heren (2020).The benefits from technology can be used to help, understanding ASL may be very challenging at first; this can be minimised. Undoubtedly the need for this has increased exponentially over the last few months Kalia (2020), during these unprecedented times we are living where COVID-19 has influenced our lifestyle. Online communication is one of the biggest challenges, here we can find a clear example of how without

an interpreter you would have to text chat with one another. This is far from ideal and can be solved.

In addition to this, the other main form of communication for a Deaf person is lip-reading How does a deaf person communicate (2020), while this is a harder and less accurate form of communication it is currently becoming obsolete due to the Government guidelines regarding the COVID-19 pandemic, the issue being the required use of face coverings in enclosed spaces. For this reason, lips are covered by the face covering and are no longer readable, likewise, one other action we must perform to protect each other from the spread of the virus is social distancing with at least 1 metre (when using a face covering) Coronavirus (COVID-19). Lip readers rely heavily on any residual hearing they may have left to interpret a conversation; with the use of face coverings and social distancing the difficulty of recognising any residual hearing has increased greatly and hence the struggle to communicate with any other person.

Moreover the lack of existing systems allow us to explore the broad topic of a American Sign Language interpreter. During our research we encountered some different ideas of interpreting Sign Language, despite this some of them weren't complete, alternatively one other system we found required the use of specific technology which consisted of a glove with in-built sensors. Mehdi and Khan (2002). Our objective is to try and simplify the process through which Sign Language interpretation happens as the limited access to specific equipment can minimise the scope of the solution. This motivated us forward to design a system which is easy to use and using common daily technology.

1.1.3 Other ideas

During our brainstorming we took into account several different ideas and problems, we started by trying to find a problem in a specific domain and then thinking of a solution. The process was narrowed to our current proposal and a Student Hub for the students at the University of Bath, where they could engage and connect with other students. In our selection process we concluded the American Sign Language Interpreter would be more beneficial and contribute to a larger amount of people. At first we explored the option of doing a British Sign Language Interpreter, finally we chose the American Sign Language Interpreter as it has a better and larger data set which we can work with. Also it is spoken with only one hand. This is important as the other hand can be used to hold the device with the camera and record making things easier to use.

1.2 Understanding the Domain

Looking into the described domain, there exists very little in terms of systems that can understand or interpret ASL. The closest system we could find to manage the problem presented in the domain is software that can have text input into them and they will return a series of images that show how to sign out the words or phrases Hand Talk Translator (2020). Due to the lack of already existing solutions to the problem presented in the domain, this significantly increases the usefulness of our solution due to sparsity.

The people working on this project do not have a hearing disability, nor do they actively interact with someone who does, as a result they do not need to use ASL on a regular occasion. As well as this,

nobody who is working on this project is fluent in ASL, with some group members not knowing any of the language. We also presented these questions to our cohort and the majority of our fellow students were in the same position. With these statistics it ha presented a possible need for a quick solution for someone who was suddenly presented with the challenge of being in a conversation with someone using ASL to communicate, as such we believe this presents a need for our solution to the given domain.

Through communicating we have made engagement with potential stakeholders into our system, as anyone could find themselves being in a conversation with someone who uses ASL as a main method to communicate. Because of this, it is clear that our stakeholders in this system are anyone, but mainly people who use ASL to communicate or people who don't know ASL but are likely to have to use it to communicate.

The experience that we do have in the domain is from past experiences, largely in employment, where a member of the public has come to speak to us using sign language and due to us not being fluent in the language we have struggled to communicate with them. Although this presented an issue for us at the time we can see how it would present a much greater issue for people who regularly use sign language to communicate and are unable to do so due to those around them not being fluent. This combined with the new normal of a virtual workplace can present even further frustration on those who rely on ASL as their main method of communication, as having to type messages to communicate can really slow down productivity.

With all these issues considered and combined, our group believes there exists a need for the solution presented below.

1.3 Solution Proposal

Our proposed solution for the domain that we have previously outlined is a system that takes live video input from a phone camera or webcam of someone communicating using ASL, it will then interpret what was said and return the corresponding English letters or words that were signed to the user.

We understand that the technical requirements of this solution may require some complex algorithms to be implemented, so we see the scope of what ASL can be interpreted as being a limiting factor. Because of this we will likely set our initial scope for this project to be able to interpret the 26 signing motions that make the ASL alphabet, with the accuracy of the interpretation being high. If we have more time to expand on this scope towards the end of the project we will look into this depending on how feasible it may be.

A further limiting factor we have noticed is that we have set our initial scope for the system to be able to interpret American sign language (ASL), rather than British sign language (BSL), this was another choice based on the technical complexity of this project. Firstly, the ASL alphabet only uses one hand whereas the BSL alphabet uses two hands, so we made the choice of using ASL as the use of one hand will make it easier for the computer vision aspect of our system to accurately distinguish the different signs. Secondly, upon an initial search into the feasibility of this project we were able to find a much larger data set for the ASL alphabet than we were for the BSL alphabet, meaning that it would be easier to train our system and it would produce much more accurate results.

Since our system will require no user logins or stored personal data, it will be completely fine to use legally as it complies with laws such as GDPR and the Data Protection Act. As well as this, since the proposed system won't store any of the recordings taken once the ASL has been interpreted, it will stand on positively ethical ground for its users.

We think that our proposed system will have a positive commercial impact, as one of the issues within our domain that was highlighted was the fact that people with hearing disabilities often find it hard to find people who understand ASL when in public, such as in bars or shops. As such we believe that our solution will help these people overcome this burden and make it easier for them to return to shops or other commercial establishments.

2 Programme and Methodology

2.1 General Aims

At the core of the project are a set of general aims and objectives. These objectives exist to shape the rest of the project and ensure that the original vision of the project is kept to. These are:

- To create a system that facilitates easier communication between English speaking and ASL non-verbal communicators
- To create an intuitive user interface that is accessible and user-friendly for all stakeholders

These general aims will help to guide our project, and are expanded upon more within our milestones.

2.2 Milestones

There are a set of milestones that serve to give us structure for our development cycles and inform us of our progress. These milestones mark major feature progression within our project, and help to lay out our overall vision for our solution.

- Plan for system structure and stack (Second deliverable)
- Plan for letter recognition library (Second deliverable)
- Proof of concept Python system implementing a machine learning letter recognition model, taught on the ASL Alphabet dataset ASL Alphabet Dataset (2017) (2nd week of Semester 2)
- Generalising proof of concept system into a Python library implementing the model (2nd week of Semester 2)
- Server side API model to allow connections to the ML model (5th week of Semester 2)
  - Secure client-server authorisation implementation
- Client app that hooks into the server side API and displays the responses (5th week of Semester 2)

As our system utilises quite complex technologies, we intend to prototype a working solution early on in our development, and then build on that prototype. This is contrary to a normal development process (where the development of the system itself would coincide with the development of the user interface), but makes sense for our proposed system as a proof of concept allows functionality to be tested and built upon quickly.

Our server-side and client-side systems are being developed largely in isolation from one another, with an API connecting the two. In order to avoid any confusion about the API - the overlap between the two systems - we will create a detailed schema and documentation for the REST API before creating it, so that the server can be built to that specification while the client can be built expecting the server to follow it. All of this allows for much easier parallel development with multiple developers, as both sides can easily write the code for connecting to each other in parallel without one having to wait on the other. Obviously once both sides are created, there will be an in-depth testing process to work through, but we can use tools such as Postman to simulate API calls in the meantime.

2.3 Stakeholder Engagement Methods

As outlined in the introduction we plan on interviewing and surveying our stakeholders to get feedback from them on the project. We will do this at multiple stages of the project, we will use the feedback to assist in the planning of the project as well as to get feedback for the project while it is in development. This will allow us to see what is working and change our plan and direction if needed. This is especially important for our goal of making the project accessible and user friendly for all stakeholders.

2.4 Project Management

We plan to use the agile methodology approach to development. The self organisation aspects of agile will be especially important given the fact we will most likely have to do most (if not all) development remotely this year. We will most likely use scrum to structure our development as our team is the right size and a lot of our team is familiar with it from the CSED module last year. We will use Jira as the platform for organising scrum, as this will allow us to assign tasks, features and bugs to team members and track the progress for the features and towards the milestones. We will only use the Jira for tasks related to development - other tasks and admin related to the deliverables will be handled by assigning tasks in weekly meetings after the sprint reviews.

To allow collaboration within the project we will use git for version control with three individual repositories. The first repository will be for the client side app. The second repository will be for the library which recognises the alphabet from video clips. The last repository will be for the server which serves the REST API, and will use the library to serve requests from the app. For this reason the server repository will have the other two as dependencies. We will host the remote repositories on GitHub as it has a great feature set for collaboration and we are all familiar with it.

We will use the main branch on each repository as the deployment branch. This allows us to use GitHub actions to set up the repository to automatically deploy each branch when the main branch

is updated. This continuous integration setup will allow us to develop faster, spending less time on deployment. We will also include a way for everything to be run locally so that testing and development can be done without having to deploy to the server - this will allow for the hosted version to always be reliable.

On each repository we will set up branches for each feature and bug corresponding to the features and bugs on the Jira. This organisation will allow for easier collaboration between teammates and allow us to assist each other if one of us has become bogged down on any individual task.

We will use pull requests to manage the merging of features and branches into the main branches. We can then use that for code reviews at each sprint review. This will help maintain code quality in the project and help us all stay up to date with each other's work.

2.5 Iterative Development

As we are using scrum we will be using iterative development. This is ideal as we will need to build quickly to our initial requirements. We can then add our stretch goals and additional features if time allows. This is especially important for this project as we are unsure how long a lot of these sections of the project and features will take as we will be using various technologies for the first time.

The use of continuous integration will greatly assist the iterative development style as it encourages more, smaller iterations.

We will also build a set of unit tests for the project. Then we can run the unit tests before any build is submitted to the main branch. This should make our project more reliable and allow for quicker more frequent testing. While this will take a lot of time early in the project, it will save time overall and make the final project better.

2.6 Data collection and data set

We intend to collect no personal data from the users of the app, as this is unnecessary for our project. However we would like to allow for users to opt-in to allowing us to save their input on the server to allow us to train the ML model further.

We have found a very good and large data set of American Sign Language alphabet images with which we can train our ML model. This will allow for the model to get more accurate over time.

2.7 Software stack

We have decided on using a mobile web app stack. This is primarily because we want to have the power of a server to drive the machine learning algorithm, rather than relying on mobile processors. Additionally there is the possibility we could train the ML model further with feedback from users to get more accurate over time.

For the stack we are going to use React Native for the client, as it is a multi-platform solution reducing the development time for multiple operating systems. Additionally as the processing will be done on a server the speed loss of not using native platforms isn't a concern.

For the API and server we intend to use Python Lambdas hosted on AWS. The first reason for this is because we learnt Python in Principles of Programming the whole team will be familiar with it. Another reason is Python Lambdas are easy to set up on Amazon Web Service so we can get a proof of concept quickly. We chose AWS because we get a free tier as students, which, when combined with the widespread support and reliability, makes AWS a very attractive option.

We plan to use Python for the recognition library. This is because of Python's popularity for machine learning and computer vision. We plan to use the OpenCV library as the base of our computer vision and the TensorFlow library for the ML model, both of which have first class support for python.

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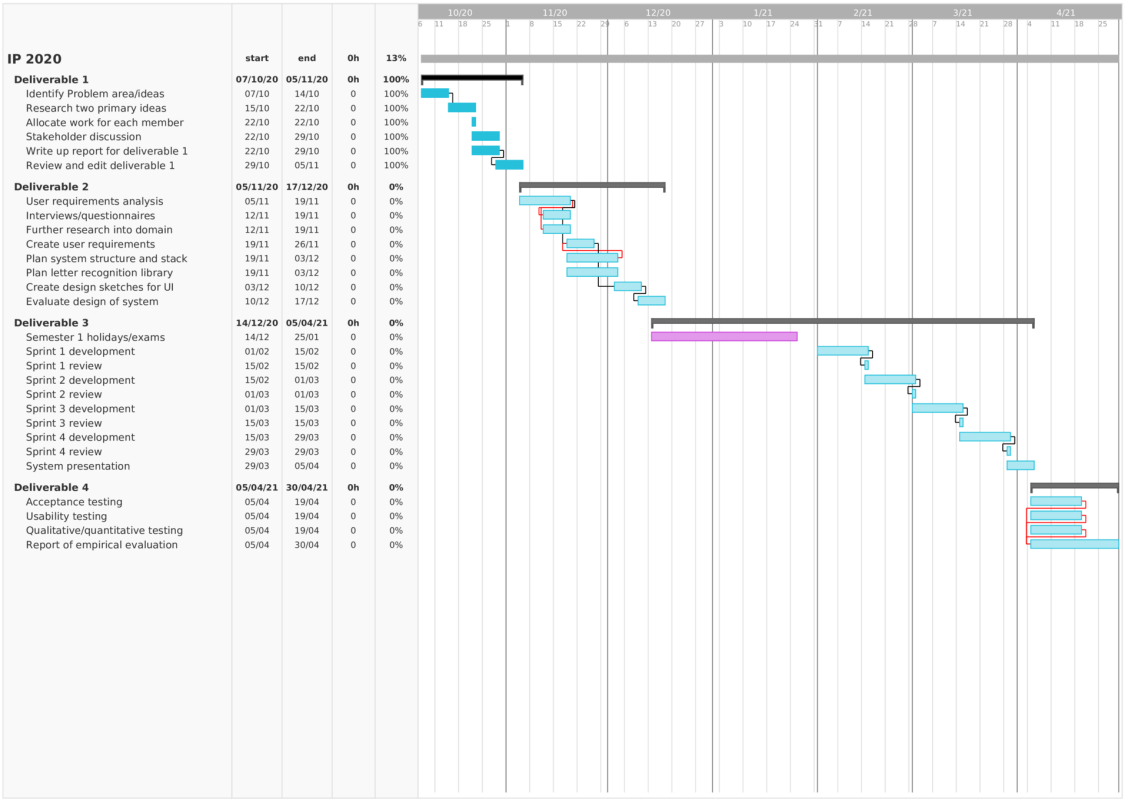
3 Work Plan

The Gantt chart covers the entire development for the project and shows the dependencies between tasks for each deliverable. It was more appropriate to create a Gantt chart over a PERT chart for our proposed system. This is because Gantt chart allows having an overview of both time frames and dependencies for tasks in a linear bar chart style . Whereas a PERT chart would focus more on the dependencies of tasks. The Gantt chart, in conjunction with Jira, will be used to handle time management and the handling of tasks.



IP 2020	start	end	0h	13%
Deliverable 1	**07/10/20**	**05/11/20**	**0h**	**100%**
Identify Problem area/ideas	07/10	14/10	0	100%
Research two primary ideas	15/10	22/10	0	100%
Allocate work for each member	22/10	22/10	0	100%
Stakeholder discussion	22/10	29/10	0	100%
Write up report for deliverable 1	22/10	29/10	0	100%
Review and edit deliverable 1	29/10	05/11	0	100%
Deliverable 2	**05/11/20**	**17/12/20**	**0h**	**0%**
User requirements analysis	05/11	19/11	0	0%
Interviews/questionnaires	12/11	19/11	0	0%
Further research into domain	12/11	19/11	0	0%
Create user requirements	19/11	26/11	0	0%
Plan system structure and stack	19/11	03/12	0	0%
Plan letter recognition library	19/11	03/12	0	0%
Create design sketches for UI	03/12	10/12	0	0%
Evaluate design of system	10/12	17/12	0	0%
Deliverable 3	**14/12/20**	**05/04/21**	**0h**	**0%**
Semester 1 holidays/exams	14/12	25/01	0	0%
Sprint 1 development	01/02	15/02	0	0%
Sprint 1 review	15/02	15/02	0	0%
Sprint 2 development	15/02	01/03	0	0%
Sprint 2 review	01/03	01/03	0	0%
Sprint 3 development	01/03	15/03	0	0%
Sprint 3 review	15/03	15/03	0	0%
Sprint 4 development	15/03	29/03	0	0%
Sprint 4 review	29/03	29/03	0	0%
System presentation	29/03	05/04	0	0%
Deliverable 4	**05/04/21**	**30/04/21**	**0h**	**0%**
Acceptance testing	05/04	19/04	0	0%
Usability testing	05/04	19/04	0	0%
Qualitative/quantitative testing	05/04	19/04	0	0%
Report of empirical evaluation	05/04	30/04	0	0%

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