Final Project: Real-Time AI Sign Language Translator Application

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Communication plays a big role in shaping how people learn, connect, and build relationships. However, to date, communication remains one of the biggest challenges that a majority of Deaf and hard-of-hearing people face worldwide. In America alone, approximately 15% of adults report some degree of hearing loss, while nearly one million identify as functionally Deaf (HearView, 2025a). While these numbers show the scale of the Deaf and hard-of-hearing community, the availability of accessible communication tools has not kept pace. This is also compounded by the deficiency of professional interpreters. Currently, the ratio between Deaf signers and certified interpreters of ASL stands at approximately 50 to 1, which results in many Deaf users simply being unable to access an interpreter whenever they need one (HearView, 2025b). Due to this, many Deaf individuals struggle in daily situations, whether in classrooms, workplaces, social situations, or public services. This paper elaborates on the concept of a Universal Sign Language Translator, a device that translates sign language into speech and vice versa in real-time. The purpose of this is to explore the problem of communication, examine research insights, review competitors, explain strategic advantages, and discuss the development of this project.

The problem that the Universal Sign Language Translator intends to solve is deeply connected with fairness and equality. It is also about being included, respected, and understood; communication is not just words. Without interpretation, Deaf individuals sometimes need to rely on note writing, texting, or others for interpretation, such as friends or family. These temporary solutions may work for small conversations, but are not ideal; most of them definitely leave the Deaf person frustrated or excluded. Even schools, where accommodations are actually required, may not provide interpreters at every moment. Students may miss information in quick discussions or impromptu group work just because support cannot always be provided on

demand. The same challenges exist in workplaces: A Deaf employee may struggle to contribute fully in team meetings or casual conversations because accessibility services must often be scheduled in advance. The Universal Sign Language Translator aims to bridge these gaps by providing users with an instant communication tool that can be used anywhere, at any time.

The business model that underpins the translator is supportive of accessibility but also realistic and achievable for development. The idea is that there are two tiers of access: one for organizations and one for individuals. Schools, universities, hospitals, and businesses can purchase group licenses, which would cover the access needs of Deaf students, workers, or patients who require translator services at any time. These kinds of organizations are often under a legal obligation to provide accommodations and would make strong potential customers. Individuals can download a free version with basic functionality and opt for a low-cost subscription option that provides full access. This dual model enables the tool to reach both large institutions and everyday individuals. To begin building the first version, we created a small mock startup budget of $1,500. Our budget covers the costs of Deaf signers who assist us in collecting sample sign language videos, advisors to ensure we accurately capture the cultural nuances, developer fees for publishing the app on the Apple and Google stores, basic recording equipment, and some simple marketing materials. While it is true that large-scale AI development can entail a significant increase in costs, this simple budget demonstrates how a small student team can get started using free AI tools, open data sets, and community volunteers.

This research helped us understand what Deaf users want, what hearing users struggle with, and what technology is currently available to them. We started by writing online surveys for Deaf students, interpreters, teachers, and accessibility staff. The survey inquired about what users currently struggle with, what they want from a translation tool, and their concerns about using

AI. Most of the survey responses mentioned speed, accuracy, and privacy as the most important features. Many Deaf participants said that they would never use a tool that feels slow or misreads their signs. They also said they wanted a translator who shows respect to Deaf culture and does not oversimplify their language. Privacy was a major concern; sign language very often involves personal information, and users want to know what happens with their data.

We also conducted interviews with Deaf individuals and accessibility workers to gain deeper insights. One Deaf student expressed that without an interpreter, he often feels "stuck" in conversations and wants a tool that could "talk for him" when he signs. A school accessibility coordinator related how students miss out on spontaneous interactions, from asking their classmates questions during group work to participating in spontaneous discussions after class. These interviews helped us design features that feel practical and respectful. For instance, we learned the translator should display a "confidence level," so users know when the AI is uncertain. We also found that the app needs a backup, such as a button that lets a user call a live interpreter if needed.

To build the translator, research was conducted on various types of AI tools that can detect sign language in real-time. The Google Cloud Vision API can detect hand shapes, body positions, and facial movements (Google Cloud, 2025). This is important because sign language is dependent not only on the hands but also on facial expressions and head movements that carry meaning. We also explored Google Vertex AI, which enables developers to train machine learning models using videos they provide themselves. This tool helps improve accuracy over time, especially as more sign language data is added to the system. We also examined research from the National Association of the Deaf, which estimates that only about 70% of Deaf, DeafBlind, and Hard-of-Hearing children do not receive full early access to language (NAD, 2025). This statistic

proves that accessibility tools are not only convenient but also crucial in giving equal language development and communication rights.

Part of the research also involved examining how communication barriers impact daily life in ways that most people are unaware of. Many Deaf people shared numerous stories of avoiding simple, everyday interactions, such as asking for help in stores, ordering food, or joining community events, because they expected communication would be too frustrating. These are small gaps in communication that accumulate and contribute to long-term stress. Knowing this helped us understand that the translator cannot simply focus on formal situations, such as healthcare or schools. It needs to support everyday independence and help Deaf users feel more confident in all settings.

We have also discussed how these barriers to communication can influence long-term opportunities. The lack of interpreters in fast-moving environments often means the loss of crucial instructions, examples, and social moments for Deaf students. These moments may be small, but they create significant educational disadvantages over and over again. For adults, a delay in communication can impact job performance, leadership opportunities, and workplace relationships. Most promotions and decisions result from quick conversations or brainstorming sessions, and if one does not have equal access to these moments, it could always hold them back. The translator began to be envisioned as not only a communication tool but a long-term accommodation that could influence educational and employment success.

Another key aspect of our research was to understand how many rely on sign languages around the world. According to the World Federation of the Deaf, there are over 70 million people who are Deaf worldwide, and more than 80% live in developing countries where interpreter services are scarce. More than 300 different sign languages, each having its own culture and grammar,

exist in the world. These statistics have helped us understand the magnitude of this communication gap and the potential benefits of an instant translator that eliminates the need for an interpreter's presence. When we examined global surveys about Deaf people, many reported that this communication barrier limits their opportunities for healthcare, education, and employment. Knowing that this challenge affects millions of people made us understand how powerful a universal translator could be if it continues to grow and becomes more accurate.

Cultural differences in the development of communication tools were also explored. Every sign language has its grammar, structure, and meanings, which, for the AI translator, means more than just hand shapes. Sign languages use facial expressions, head movements, and spatial positioning to show grammar and emotion. As we learned more about these linguistic rules, we came to understand that building a translator requires sensitivity to cultural nuances. The goal is not just to translate words but to fully respect the language.

Another focus of ours was the use of technology within Deaf communities. For many Deaf individuals, new technologies are approached with caution because the tools developed in the past often lacked Deaf input and have frequently felt unnatural or inaccurate. This has shown that one of the key elements to actual adoption is trust. A translator will only truly assist if users believe it understands them and their way of communication, and it respects their language. That is why the initial inclusion of Deaf advisors and testers is so vital. Their point of view is necessary for accuracy, trust, and long-term engagement.

Our competitive analysis revealed gaps in current technology. Hand Talk helps hearing people communicate with Deaf people who cannot understand sign language. SignAll can translate ASL, but requires expensive hardware. Captioning apps help only one side of the conversation. Smart gloves cannot recognize facial expressions, which are a key element of sign language

grammar. No tool today offers both directions in a single, affordable, portable system. This helped us see that our translator could be a unique and helpful tool that supports more natural and equal conversations.

The Universal Sign Language Translator carries several strategic advantages. It supports two-way, real-time communication, making it more comprehensive than existing options. It is affordable because it works on everyday smartphones. It is community-centered because Deaf individuals guide every stage of its development. It is flexible because it uses free and open-source AI tools that can be improved as new technology becomes available. It also has long-term potential to support multiple sign languages, making it useful not only locally but also internationally.

This is a truly collaborative project. Schools and universities can help us test the translator on real students and provide feedback on ways to improve it. Technology companies, like Google, can offer AI models, cloud computing credits, and technical guidance. And the interpreter organizations can help us ensure that we include backup options, so that translators complement human interpreters rather than replacing them. With collaboration, you can be assured that the translators will be practical, respectful, and genuinely helpful in real-life situations.

Through this project, we gained valuable insights into accessibility, technology, and teamwork. Including the Deaf community every step of the way helped us learn about the value of lived experience. Learning about AI itself taught us to design realistic and respectful features. Creating a budget helped us learn how to effectively manage resources and prioritize essential tasks. Working together in a team taught us the importance of responsibility, effective communication, and strategic planning. But above all, it brought us closer to understanding how technology can knock down communication barriers and facilitate equal access for Deaf and hearing

communities. The Universal Sign Language Translator is more than an idea; it's another step toward justice, independence, and an accessible world.

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