KAMI LIMU

Cohort 8 Group Members and Roles

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Problem Background

In Kenya's rapidly evolving educational landscape, higher education plays a crucial role in driving economic development and innovation. Universities are essential for developing the country's human capital, particularly in technology, a sector that is poised to be a key driver of Kenya's future economy. However, access to quality higher education remains uneven, with several challenges persisting despite improvements in enrollment. According to data from the Kenya National Bureau of Statistics, university enrollment has increased by 48% over the past five years, yet issues such as inadequate academic resources, outdated curricula, and limited accessibility continue to hinder the full realisation of education's potential [1]. Among these challenges is the lack of inclusivity for students with disabilities, particularly those who are deaf or hard of hearing. While higher education institutions have made efforts to accommodate these students, significant gaps remain, especially as learning increasingly shifts to virtual platforms.

In Kenya, the deaf community faces numerous challenges due to discrimination, communication barriers, and limited access to essential services. Some 85% of deaf people face these challenges,

which has led to social inequality and poverty [2]. They are also often marginalised and isolated, which hinders their social participation and inclusion. The situation is exacerbated by limited accessibility features in popular virtual learning platforms, which often lack real-time sign language interpretation and advanced captioning capabilities. This disconnect not only affects individual students but also undermines Kenya's broader goals of inclusive education and economic progress. Deaf students, like Winnie, a 22-year-old computer science major at USIU Africa, face substantial barriers to accessing online learning content and engaging with their peers, which in turn affects their academic performance and social integration.

The persistence of these issues can be attributed to several factors, including limited funding for inclusive technologies, a lack of awareness around accessibility needs, and the slow pace at which educational institutions adopt new digital practices. Programs like the Inclusive Digital Education Project [3] have made some progress by introducing captioning services for online learning. However, these initiatives often fall short, as they do not fully address the complexity of academic content or the unique needs of deaf students. For instance, while captioning is helpful, it often fails to capture the nuanced academic vocabulary or keep pace with real-time discussions.

Our project, SignStream, seeks to bridge this gap by developing an AI-powered platform that integrates real-time sign language interpretation of tech vocabularies into existing virtual learning tools. Unlike other solutions, SignStream is tailored specifically for higher education, with features such as academic terminology support and a user-friendly interface designed to minimise cognitive load. By collaborating closely with students like Winnie we ensure that our solution is both technologically advanced and culturally sensitive.

The key research questions we aim to address include how real-time sign language interpretation can be seamlessly integrated into virtual learning platforms without compromising user

experience. We also seek to understand the impact of an accessible virtual learning environment on the academic success and social inclusion of deaf students in higher education. Furthermore, we will explore how Machine Learning can be leveraged to enhance the accuracy and efficiency of sign language interpretation in academic contexts. Through SignStream, we aim to empower students like Winnie to fully participate in their education and contribute meaningfully to Kenya's burgeoning technology sector.

Market Opportunity

The market opportunity for addressing accessibility in videoconferencing and virtual learning environments is substantial, driven by the growing demand for inclusive digital tools. Two current alternatives partially address the problem but leave significant gaps. First, existing video conferencing platforms, such as Zoom, offer basic accessibility features like automatic speech recognition (ASR)-based captioning. However, these solutions lack the necessary accuracy for academic or technical contexts and fail to provide real-time sign language interpretation. This limits the participation of deaf and hard-of-hearing individuals in educational and professional settings. Second, manual accommodations, such as hiring sign language interpreters or providing alternative resources like large-print materials, are employed by some organisations. While these approaches are effective to a degree, they are expensive and logistically burdensome, particularly for smaller institutions or independent users. Moreover, these manual solutions are not scalable and cannot consistently address the accessibility needs of large audiences in dynamic environments like higher education.

What is currently missing is a fully integrated, AI-powered solution that combines accurate, real-time sign language interpretation and advanced captioning within the same platform. Most existing platforms do not offer specialised features such as academic terminology support, and their interfaces are often not optimised for accessibility, making navigation difficult for users

with varying hardware or abilities. Additionally, there is a need for more intuitive, user-friendly platforms that simplify the learning experience for deaf and hard-of-hearing students without placing excessive cognitive strain on them.

By addressing these gaps, we can capitalise on the growing need for inclusive digital communication tools. The COVID-19 pandemic has dramatically accelerated the use of video conferencing platforms, with Zoom, for example, reporting a 500% increase in users within just two months [4]. As the world continues to embrace remote learning and work, the demand for accessibility features will continue to rise, creating a significant market opportunity.

In terms of market size, the global video conferencing market was valued at $13.78 billion in 2020 and is expected to surpass $50 billion by 2026 [4, 9]. This growth indicates a strong demand for solutions like SignStream, which specifically addresses the needs of over 466 million people worldwide with disabling hearing loss, including nearly 3 million Kenyans [5]. By enabling deaf and hard-of-hearing students to participate fully in education and the workforce, SignStream can tap into a significant portion of this market, driving productivity and reducing unemployment rates in sectors that benefit from accessible digital communication. Additionally, providing educational accessibility will have long-term economic benefits, contributing to a more skilled and diverse workforce, especially in the technology sector, where Kenya is experiencing rapid growth.

Solution Idea

Target User

The primary target users for this project are deaf tech students in universities, a demographic that faces significant challenges in accessing virtual learning environments. These students, often

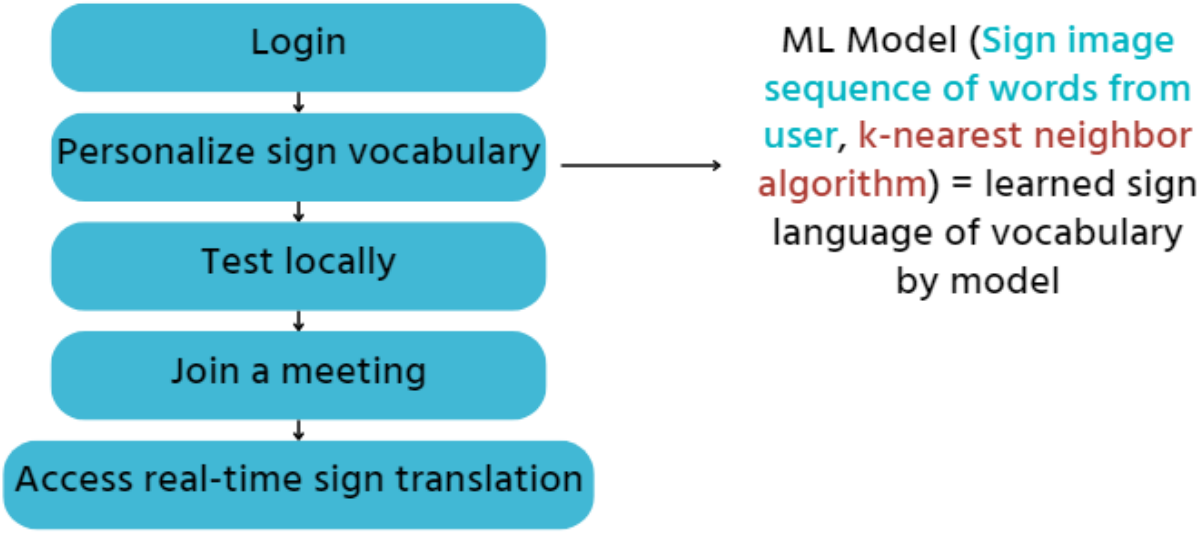
reliant on sign language for communication, encounter barriers due to the lack of integrated sign language interpretation in popular video conferencing tools. This target group was chosen because they represent a critical intersection of two growing sectors—technology and higher education—both of which are pivotal to Kenya's future economic development.

The problem extends beyond just deaf tech students, as it also indirectly affects hearing students, professors, and institutions committed to inclusive education. However, by focusing on deaf students in technology programs, we aim to directly address the specific educational needs of this group, which often faces higher dropout rates due to the lack of accessibility tools in virtual learning environments. Addressing this problem for tech students will likely yield insights and solutions that can be expanded to other fields of study and sectors.

Solution Prototype

The proposed solution is a web-based application that functions as an add-on to existing video conferencing tools such as Zoom, Microsoft Teams, and Google Meet. This application allows deaf students to share their screens and start signing, with the system translating the sign language input into both voice and text outputs. The key feature of this platform is its ability to allow users to customise a set of vocabulary signs, tailored to specific academic and technical terminology. The use of a K-nearest neighbour (KNN) algorithm enables local testing of the system before joining a live meeting, ensuring accurate and efficient translation during the conference.

The solution follows a straightforward process:



1. **User Login:** The user logs into the web-based application.
2. **Customization:** The user customises their vocabulary set, uploading or selecting specific signs that correspond to complex academic terminology.
3. **Local Testing:** Before joining a live meeting, the user runs a local test using the KNN algorithm to ensure that the system is correctly interpreting their signs based on the customised vocabulary.
4. **Meeting Integration:** Once the test is successful, the user can join a video conference. The system automatically translates their sign language into real-time voice and text output, ensuring full participation in the meeting.

This approach ensures seamless integration with popular platforms(Google meet, Zoom) and allows users to personalise their experience, enhancing both accessibility and usability. Unlike other solutions that require users to join a separate platform, this add-on provides flexibility and ease of use, making it more adaptable for daily academic interactions.

The prototype will rely on AI-driven sign language interpretation, supported by continuous machine learning to improve accuracy, especially for specialised academic content. By enabling users to contribute and refine their own vocabulary sets, the system becomes more precise over time, adapting to the specific needs of different users and fields of study.

Assumptions Made

Several assumptions underlie this solution's design:

- Deaf tech students prefer video-based communication with sign language interpretation over text-based solutions.
- Internet connectivity will be reliable enough to support real-time translation without lag or significant disruption.
- The KNN algorithm will be effective in recognizing user-specific signs from a customizable dataset.

While these assumptions are informed by existing research and user needs, ongoing testing and feedback from the target user group will be critical to refining the solution and addressing any unforeseen challenges.

Value proposition

SignStream empowers deaf tech students in universities by providing a seamless, customizable sign language interpretation tool that integrates with existing video conferencing platforms. This solution enables real-time translation of sign language into voice and text, ensuring a personalised learning experience for each deaf student who uses video conferencing tools.

Technologies Used

TensorFlow: Powers the real-time training and classification of hand gestures, essential for translating sign language accurately.

K-Nearest Neighbors (KNN): Used for classifying gestures based on similarity, making it effective for real-time sign language recognition.

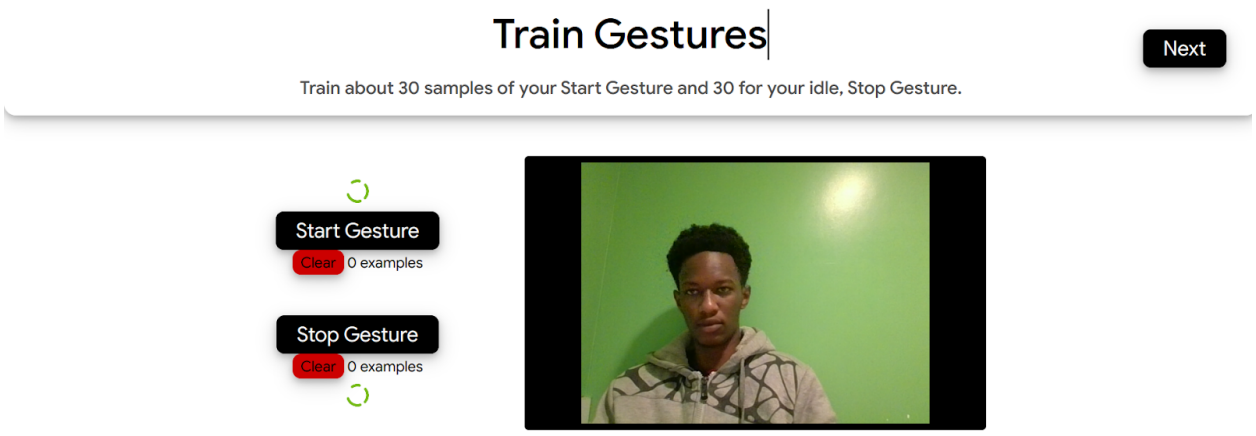
HTML/CSS: Provides the structure and styling for a simple, user-friendly interface.

JavaScript: Manages front-end interactions, including gesture recognition, text-to-speech, and video call functionality.

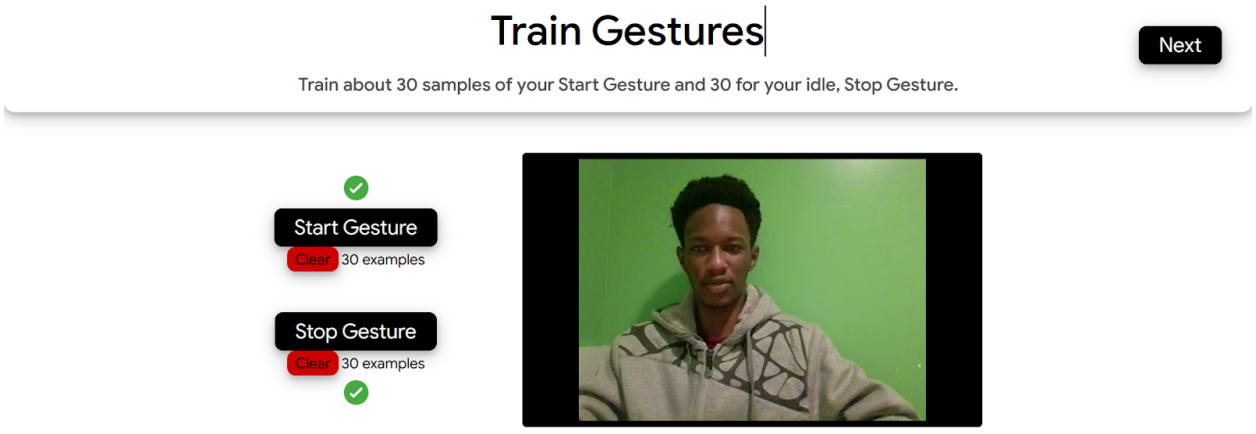
Node.js: Supports server-side operations and smooth app functionality, both locally and on a live server.

Git: Ensures version control and smooth collaboration during development.

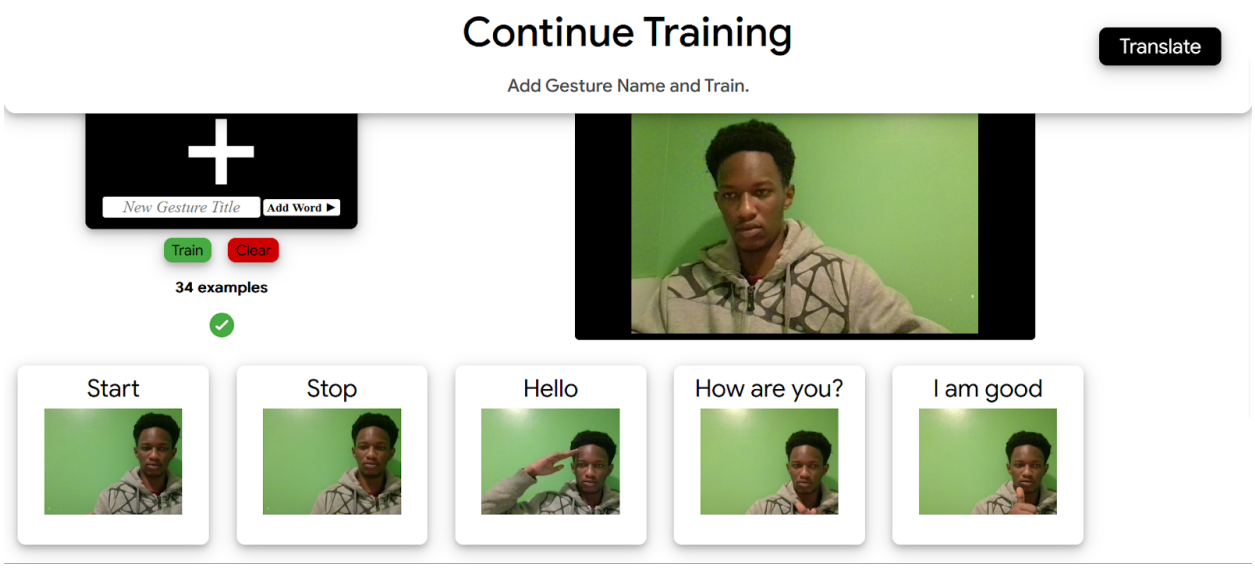
Screenshots of Main Modules



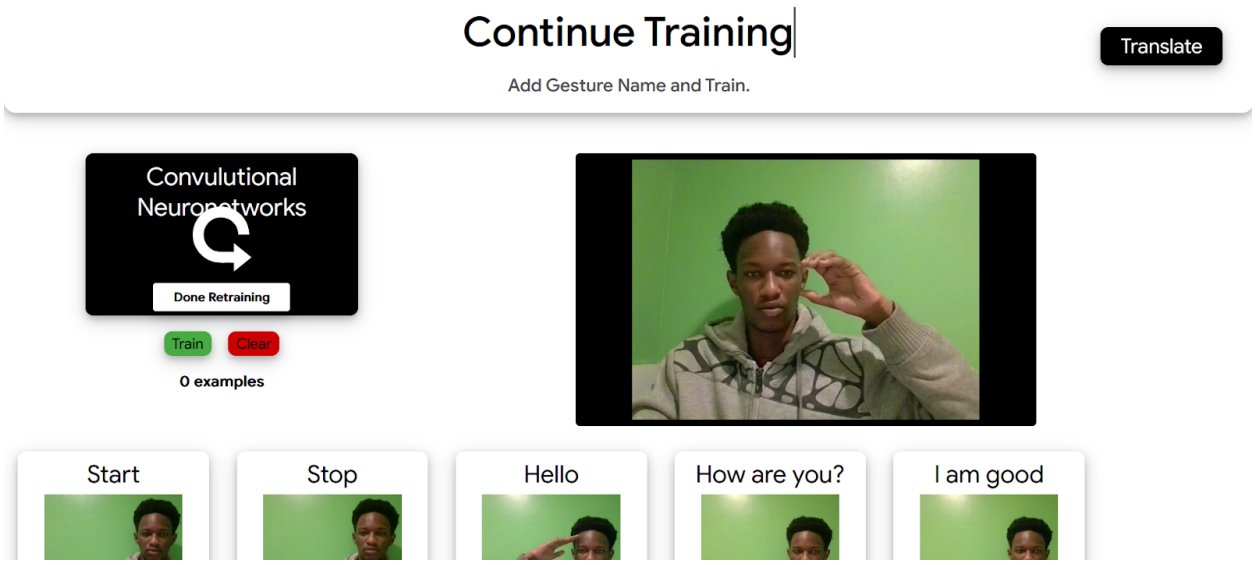
In natural language processing (NLP) for English, we typically rely on punctuation marks (such as commas, periods, etc.) to identify the end of a sentence. However, in sign language, the boundaries of sentences or words are indicated by specific signs or gestures. Since these cues vary depending on the type of sign language, we are offering users the ability to customise which gestures they will use to signal the start or end of a sentence.



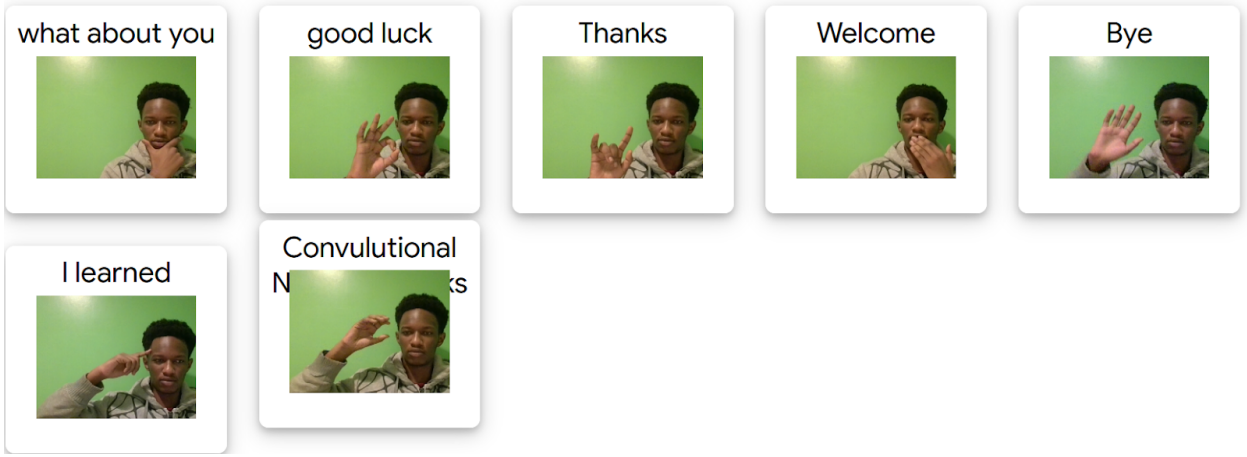
Our model will require at least 30 sample images to accurately learn and recognize the custom gesture signals for starting or ending a sentence. These samples will help the model understand the variations and nuances in the user's chosen gestures.



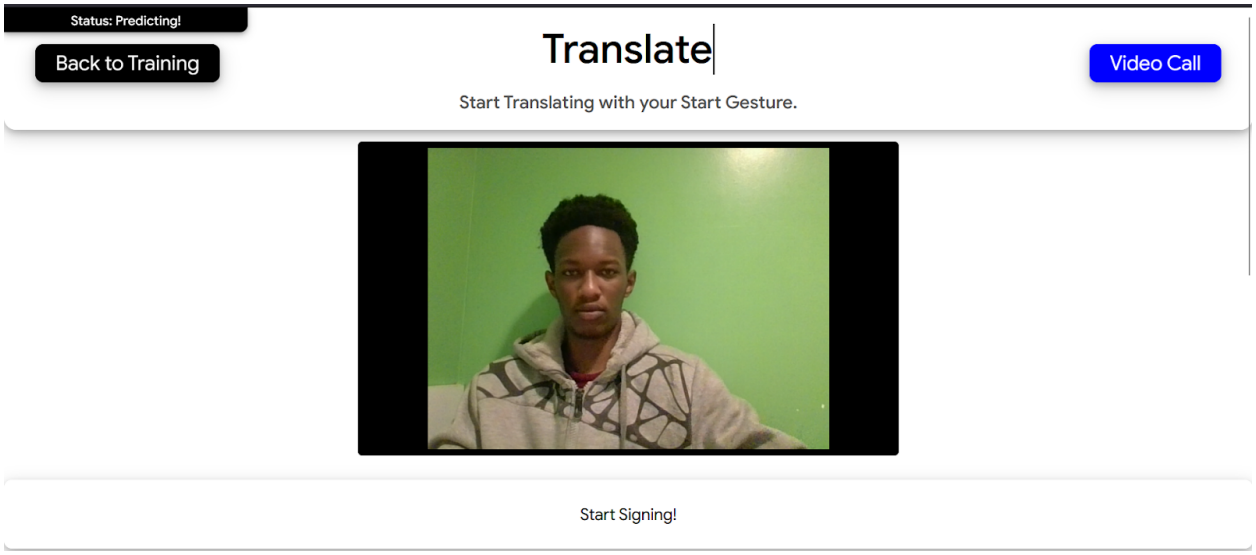
This platform offers customization and personalization of sign language. Users can view a list of day-to-day words that our model recognizes, and if the signs differ in their specific dialect, they have the ability to customise or retrain the model for that particular word or phrase. A key feature is the ability to teach the model technical jargon, which is often absent in many datasets. This personalization is especially beneficial for deaf users in video conferencing apps, enhancing their learning and communication experience.



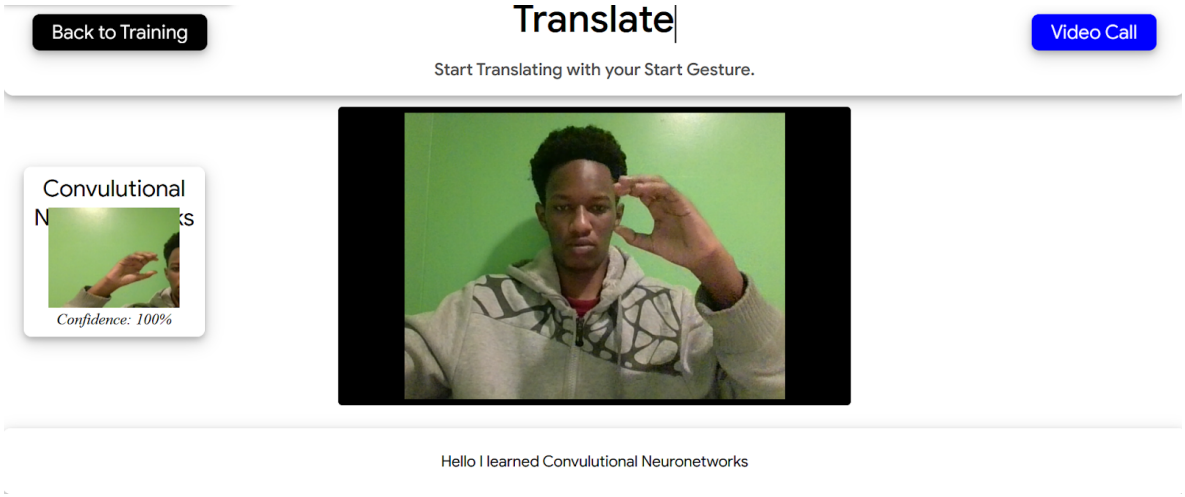
In the above image, the user is teaching our model a new word: Convolutional Neural Networks (CNN). This is an impressive achievement, as it will be added to the other words the model already knows. Now, when the user joins a meeting, they will be able to use technical jargon seamlessly.



You can now see that it has been added to the end of the list of words that our model recognizes.



Now, the user can start using the words our model has learned, engaging in class discussions by raising questions and making comments without the need for a sign language interpreter. Their learning experience is fully customised to their dialect and area of study, allowing them to use technical jargon, which our model will translate in real time.



When the user signs during a meeting, our model translates their signs into both text and speech in real-time, ensuring that everyone in the meeting can understand them without the need for a sign language interpreter. This not only enhances accessibility for the deaf or hard-of-hearing but also fosters seamless communication in diverse settings, such as classrooms and professional environments. By enabling users to express themselves fully, including using technical jargon, this technology personalised the learning experience and promotes inclusivity, allowing users to participate more confidently and independently.

Link to the solution

GitHub link: https://github.com/Sign-Stream/SignStream.git

Link to the executable mode:

Business Model

Our business model will focus on two primary revenue streams: a freemium model for individual users and institutional partnerships with universities that serve deaf students.

1. Freemium Model for Individuals

The freemium model will offer basic features of the SignStream platform for free, such as limited vocabulary customization and access to basic real-time translation. For users who require more advanced features—such as unlimited vocabulary sets, enhanced accuracy for academic terminology, and priority technical support—we will offer premium subscriptions.

- **Free Tier:** Provides limited vocabulary customization and basic access to real-time translation services.
- **Premium Subscription:** Priced at **Ksh 500 per month** for individual users. This tier includes access to unlimited vocabulary customization.

We expect a conversion rate of 10% of free users to paid users, which aligns with common conversion rates for digital platforms [6]. Assuming we can reach 50,000 deaf tech students and similar users across Kenya within two years, our premium user base would be approximately 5,000 paid users, generating Ksh 2.5 million per month in subscription revenue.

2. University Partnerships

In addition to individual users, we will actively seek partnerships with universities that have deaf students enrolled. We will offer these institutions tailored packages that integrate SignStream into their existing digital learning platforms.

- **University Package:** We plan to offer institutions a pricing model based on the number of users (students and faculty) who require our services. We estimate that a package would cost Ksh 420,000 per year for institutions with up to 100 deaf students. This would include full integration with the university's existing video conferencing tools, personalised training for faculty, and ongoing support.

There are 30 universities in Kenya that cater to deaf students or have inclusive education programs [7]. If we can secure partnerships with 10 universities within the first 2 years, we could generate an additional Ksh 4.2 million annually from institutional partnerships.

Financial Sustainability

We aim for a sustainable business model by diversifying revenue streams between individuals and institutions. Our break-even point will be achievable within two years by capturing a portion of the deaf tech student population and securing institutional contracts.

- **Total estimated revenue in Year 2**:

- **Individual subscriptions**: Ksh 15 million (assuming gradual growth to 5,000 paid users)
- **University partnerships**: Ksh 4.2 million (from 10 universities)

By leveraging this model, we ensure both a scalable growth path through individual subscriptions and stable revenue through long-term university partnerships, positioning SignStream for financial sustainability.

Responsible Computing

In developing *SignStream*, we consider ethical and social implications throughout its lifecycle. As a result we are adhering to the following key principles that guide us to maintain responsible computing:

- **Accountability**: We ensure accountability through collaborations with deaf tech students and academic institutions. We have scanned through resources, from research papers, articles from institutions focusing on persons with disabilities, and many more that have provided us with valid facts and statistics to support our statements and conclusions.
- **Inclusion**: Our objective is to bridge the communication gap between the deaf or hard of hearing and those with the ability and in return encompassing all individuals in communication.
- **Privacy and security**: User data is protected by local storage, ensuring it remains within the user's control. No personal data is transmitted to external servers, safeguarding privacy. Our system employs best practices in encryption and data protection to secure communication and prevent exploitation.

- **Accessibility**: SignStream is designed to be accessible on a variety of platforms and devices, ensuring that people from different walks of life can easily access and use the platform, regardless of the technology they have at their disposal.

Through these principles, we aim to foster a more inclusive and responsible digital learning environment, enabling deaf and hard-of-hearing students to thrive in their educational journeys.

Traction

Our journey toward creating an impactful solution has been driven by meaningful user interactions and testing, particularly with members of the deaf community.

1. **User Engagement**:
   We've connected with key stakeholders, including Winnie, the leader of the Deaf Society at USIU Africa. Through her leadership role, she has offered invaluable insights into the accessibility challenges faced by deaf students in virtual learning environments. Her feedback helped us tailor the solution to meet the specific needs of this community.
2. **Product Testing**:
   So far, four users, including Winnie, have tested our platform. Winnie specifically used the sign language translation feature during her virtual classes and shared how it improved her communication experience. According to Winnie:
   "I never thought I could say 'Micro:bit' with ease. SignStream has helped me express myself better."
3. **Revenue**:
   We haven't yet generated revenue, but we are in active discussions with universities, including USIU, to introduce our freemium model. This will offer institutions affordable access to our solution for their deaf students.

4. **Impact**:
   Winnie's experience is just one example of the positive impact our platform is already making. By reducing her reliance on delayed interpretation services, she can now engage more actively and independently in virtual classes, showing the potential of our solution to enhance accessibility across higher education.

Funding for SignStream

To successfully implement SignStream, we will require funding for both the **pilot stage** and the subsequent **three years of development and scaling**. Below is a breakdown of our funding needs, based on market value estimates for the Kenyan tech and education sectors.

Pilot Stage (First 12 Months)

The pilot stage will focus on developing the core platform, testing with a select group of deaf tech students, and refining the product based on their feedback. This stage will also include initial university outreach to ensure the platform's integration within educational institutions.

Item	Cost Estimate(Kshs)	Description
Platform Development	3,500,000	Development of web-based application and ML integration
Sign Language Data Collection	1,000,000	Collection and customization of vocabularies for deaf students
University Pilot Partnerships	800,000	Outreach and onboarding 3 universities for initial testing
Hardware and Software Tools	500,000	Servers, cloud services, and software tools for development

User Testing and Feedback	300,000	Stipends for deaf students participating in the pilot
Marketing and Outreach	400,000	Initial marketing to universities and deaf tech communities
Operational Expenses	1,000,000	Office space, utilities, and administrative costs

Total for Pilot Stage: Ksh 7,500,000

Post-Pilot (Years 2-3)

Following the pilot, we will scale the platform, expand university partnerships, and refine the platform's capabilities based on user feedback. This stage will also involve adding advanced features and ensuring long-term sustainability.

Item	Cost Estimate(Kshs)	Description
Scaling the Platform	4,000,000	Refining ML algorithms and expanding sign language vocabularies
University Partnership	2,000,000	Expanding to 10 universities, including training programs for staff
Customer Support Infrastructure	1,500,000	Setting up customer service systems for tech support
Advanced Marketing & Outreach	2,000,000	Targeting universities and deaf students nationwide
Operational Expenses	1,500,000	Salaries, office space, and operational costs

Total Post-Pilot (Years 2-3): Ksh 11,000,000

The team

The SignStream team possesses a strong set of complementary skills essential for the project's success.

Victoria Rotich is responsible for frontend development, utilising HTML and CSS to design user interfaces that are both visually engaging and user-friendly.

Fidel Otieno manages the backend development, focusing on implementing JavaScript logic to ensure seamless functionality and an optimal user experience.

Danny Ercy, our machine learning engineer, is focused on decentralising the AI model. This approach will improve the platform's scalability and performance, enabling users to train their vocabulary data locally without depending heavily on centralised systems.

This well-rounded team is equipped to tackle both the technical and functional aspects of the SignStream platform, ensuring that it is reliable, scalable, and accessible to deaf tech students in universities.

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