

AI-YM: AI-based Solutions for Kazakh Sign Language

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I. INTRODUCTION

A. Overview of the project

This project focuses on teaching Kazakh-Russian Sign Language (K-RSL) to hearing people using interactive tools. Our Web-based application has an AI-based solution for recognizing the sign language demonstrated by the user for providing feedback.

B. Objectives and goals

The main objective of this project is to develop a website to learn the Kazakh-Russian sign language with integrated Artificial Intelligence. The objectives followed by this goal are to develop an algorithm using a machine learning model to provide effective feedback and an algorithm to gamify the system to enhance the learning process. In the end, the objective is to integrate the back-end and front-end code, resulting in the website as a product.

II. BACKGROUND/RELATED WORK/LITERATURE REVIEW

As the World Health Organization reports: 446 million people around the world have a hearing disability. For people with hearing disabilities, the sign language is an primary and natural language, however hearing people are not familiar with this language. [1] Thus, as people with hearing loss cannot rely on other modes for effective exchange of information real-time, obstacle occurs which leads to a gap in inclusive communication. [2] In order to address this issue, sign language processing is introduced, an interdisciplinary field focusing on creating technology for sign language recognition and translation. The examples of technology includes using an assistive services such as Siri or Alisa, which takes use of voice, or text translating services. However, this proposed technology has its own limits because researchers may underestimate the importance of datasets that represents real-life scenarios, overlook the linguistics comprehension and so on. [1] Regarding the datasets of K-RSL, the FluentSigners-50 is an newly introduced dataset of sentences which is used by local Deaf community of Kazakhstan every day. Overall, 43,250 samples of data contributes to the better results in training machine learning models and therefore enhancing recognition or translation tasks. [3]

As researchers [1] suggest, in terms of sign language processing tasks, it is crucial to follow an interdisciplinary approach, which involves working the fields of Artificial

Intelligence, involving Deaf people, linguistics and exploring Human-Computer Interaction. In this regard, we stress the importance of using technology to teach and learn sign language. There are a limited number of devices or solutions working on education regarding sign languages due to their nontrivial nature. [4] For instance, researchers of Project called Shuwa, proposed AI-powered learning platform for English, Traditional Chinese and Japanese written and Hong Kong, Japanese and Yongong sign languages. System introduces users interfaces to learn signs of different category, as well as to practice sign by demonstrating the sign into the camera feed, and getting feedback from their machine learning model integrated to the backend. This tool uses an familiar technology such as accessible website and web camera of laptops or smartphones, because the highly advanced 3D cameras or sensor-based technology was holding back the progress made by automatic sign language recognition systems due its unavailability for mass population. [5] Similar efforts in contributing to deaf education was made: learning platform for Indian Sign Language with quiz based system, 3D avatars, smart glasses using Augmented Reality. Evaluating this tools yielded to the conclusion that technologies greatly impact the learning and teaching processes. [6]

III. PROJECT/PRODUCT DESCRIPTION

The project focuses on developing an **intelligent K-RSL educational platform** designed to enhance the learning experience by **providing interactive lessons and personalized quizzes**. By leveraging CV models, users can assess **their accuracy in real-time**, accelerating the learning process and making it more practical.

A. System Features

- **Learning Module:** The learning module consists of several courses, ranging from beginner to advanced levels. Each course is divided into lessons, and each lesson contains a series of tasks. In each task, a specific word or phrase is demonstrated in Kazakh-Russian Sign Language (K-RSL). Users are asked to practice the sign by recording a video, which is then evaluated by AI models for accuracy. The final accuracy score is displayed to the user.
- **Practice Module:** After completing each course, the platform generates a personalized quiz based on the user's

progress and learning history. Quizzes consist of various question types, such as multiple-choice, true/false, fill-in-the-blank, and matching exercises. Users receive instant feedback on their responses, helping them identify areas for improvement.

- **Task and Lesson Tracking:** The system tracks the status of each task and exercise (incomplete, in progress, complete) and updates the progress of lessons and courses accordingly so that users can resume learning a particular lesson on the task they finished the last. Users can also monitor their progress in real time and see completed lessons and courses.
- **Progress Tracking and XP system:** AI-YM additionally features a progress tracking system, including a streak counter and an XP system. Users earn XP points for completing tasks and exercises. Consistent engagement is rewarded through the streak system, which tracks daily activity and motivates users to maintain their learning habits.
- **Real-Time Feedback:** The system provides real-time feedback based on quiz results and task evaluations. Users have access to review completed quizzes and receive accuracy scores and areas for improvement during learning.

B. Requirements and Functionalities

• Functional Requirements:

- Users can access learning and practice modules.
- Users can start and complete courses, lessons, and tasks, as well as quizzes and exercises.
- Users can receive feedback on their performance during both learning and practice modules.
- Users can record and upload their videos.
- System automatically updates the lesson/quiz statuses, XP points, and the streak based on user activities.

• Non-Functional Requirements:

- System should handle real-time updates with a latency of no more than 5 seconds.
- System should be scalable and handle multiple users simultaneously.
- User data, and personal information should be securely stored and protected.

C. Design

The modular architecture was used for developing the platform. The **backend** is implemented using Node.js and Express, while Next.js was used to build the **frontend** of the platform. MongoDB was used to store the **data**, and OpenAI API was utilized for the quiz generation.

IV. PROGRESS THIS SEMESTER

A. Software Engineering Methodology

Our team adopted the **Agile** development methodology this semester. We used Notion as our project management tool to track tasks, deadlines, and team member responsibilities.

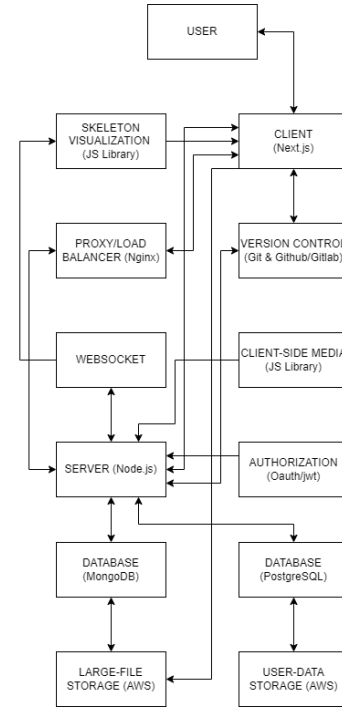


Fig. 1. Design Architecture

The Agile approach allowed us to quickly adapt to changes, incorporate feedback, and improve the project incrementally.

At the beginning of the semester, we held meetings twice a week: one with the full project team and one with our advisors to discuss the overall direction. As the development phase progressed, we increased the number of meetings and transitioned into smaller subgroup sessions focused on specific aspects of the project:

- **Backend Team:** Focused on API development, database schema design, and integrating AI services for quiz generation.
- **Frontend Team:** Worked on implementing the user interface, ensuring responsive design, and connecting the frontend with backend services via RESTful APIs.
- **Design Team:** Concentrated on creating the user experience, designing wireframes, and improving the overall look and feel of the platform.

Additionally, we continued to meet with our advisors once a week for updates and feedback, which helped ensure alignment with project goals and allowed us to address any issues early in the development process.

B. What was implemented this semester

This semester, we successfully developed a working prototype of the AI-YM educational platform, and our accomplishment for this semester includes:

- **Literature Review:** We conducted a literature review and examined Duolingo and SignTown examples to understand existing educational platforms, user engagement

strategies, and the application of AI in personalized learning.

- **UI design:** We spent two sprints on developing a user-friendly and responsive design of the user interface, while also keeping design features from the other AI-YM components.
- **AI-Generated Quizzes:** The platform integrates AI-generated quizzes, which are dynamically created based on the user's progress in the course. The quiz additionally supports different question types (e.g., multiple-choice, true/false, fill-in-the-blank, matching).
- **Progress Tracking and XP System:** We implemented a real-time progress tracking system that updates the status of tasks, lessons, and courses. The platform features an XP system to reward users for completing tasks and quizzes, along with a streak counter to incentivize consistent learning.
- **Backend and API Development:** We built a comprehensive backend using Node.js and Express, providing RESTful APIs for user management, course handling, task tracking, and quiz generation. The backend is integrated with MongoDB for efficient data storage and retrieval.
- **Frontend User Interface:** A responsive and interactive user interface was developed using Next.js. The frontend connects with the backend APIs to display real-time updates and progress tracking for users.

Overall, we achieved our main objectives for this semester by building a functional prototype, integrating core features, conducting a literature review, and testing the platform.

C. Problems encountered

Initially, we focused on Kazakh Sign Language, but soon realized the importance of considering Kazakh-Russian Sign Language (K-RSL) due to the limited availability of datasets specific to Kazakh Sign Language. This shift required adjustments in our approach, as K-RSL is more widely used and offers broader accessibility.

Another challenge was the lack of pedagogical expertise within our team. As students without formal training in educational methodology, developing an effective learning structure was difficult. We recognized the potential benefit of collaborating with professional educators and learning centers to enhance the curriculum, but limited resources and time constraints hindered these efforts.

V. FUTURE WORK

In the future, our team wants to work on machine learning or / and deep learning models to assess the accuracy of signs shown by the user of the program. This work will mainly focus on the isolated signs, and possibility of giving feedback for the continuous signs yet to be explored. Steps to achieve that involve working with dataset, creation if needed, and further dataset preparation and processing. In order to give feedback, in our case the accuracy and precision of the signs, we need to evaluate the different algorithms that work best.

Furthermore, we will work on advancing the gamification part of our learning platform and conduct experiments and testings to research a Human-Computer interaction. The design of our learning platform's interfaces will be modified according to user experience experiments. Regarding the experiments, we also plan to organize focus groups with the Deaf community to improve the teaching methodology proposed by our system.

VI. ETHICAL AND LEGAL CONSIDERATIONS

A. Ethical Issues

As we completed the first part of the project, meaning we developed the learning platform, and we worked with dataset for generating Lessons consisting of phrases in Sign Language. This dataset was presented to us by Human-Robot Interaction and complied with ethical requirements by Ethical Committee of University. The participants of recordings for dataset gave their consent to be filmed, and this practice is also will be followed in our research. Another ethical issue to be considered is data protection and privacy of future users of our Learning platform. First of all, personal data of users that they fill for registration and login will be encrypted in our database, which is closed access. Regarding the filming and camera feed integrated in our web-site, we will not collect those videos in database, ensuring no harm for users.

B. Legal Compliance

For our Computer Vision tasks, we will use Media Pipe, which is open source and no copyrighted software will be used. Regarding its legal compliance, no data will be send to Google servers, ensuring data protection. Data protection Laws of Republic of Kazakhstan also states that consent must be present, which will be taken into consideration as our team will start training machine learning models.

C. Informed Judgments

In the process of developing methodology for teaching sign language, it was important for our team to work with dataset which was collected through all ethical norms and had reliable source. Even though, large datasets contribute to the accuracy and content of our project, we have made decision to work using datasets which satisfies ethical requirements. Second issue was choosing algorithms for our gamification and machine learning tasks. At the beginning, we wanted to collect data from users demonstrating signs to enhance our model. However, as not every learner will give consent, thus making the learning process even more inaccessible, that is why we do not collect any data from camera feed.

D. Sustainability and Social Responsibility

Our project is an commitment for the inclusive communication, and contribution for sign language education. It has positive impact on society, and provides hearing people accessible tools to learn new language. This project is planned to run on long term, and our team wants to ensure this is self-supported and sustained project.

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