Innovative Approaches to Language Education: Machine Learning, and 2D Games

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***Abstract*— Explore the innovative fusion of machine learning, and 2D game development in Hindi learning. This approach aims to transform language education by incorporating gaming elements and machine learning, creating more immersive and effective learning experiences. Cultural simulations allow learners to practice language skills in authentic scenarios, while gamified language exercises reinforce vocabulary, grammar, and comprehension skills.**

The integration of machine learning, specifically natural language and audio processing, along with 2D game production has resulted in a dramatic shift in language instruction. The game's pronunciation checkers evaluate and offer feedback on users' pronunciation. A Puzzle-based game is used to provide lively and captivating language-learning settings that encourage learners' motivation and involvement. With challenges including reading and comprehension tests, dialogues, and discussions, this gives students the chance to practice and apply language abilities in context-rich scenarios.

***Index Terms*—gamed development, language game, pronunciation checker, machine learning in game development**

I. INTRODUCTION

Language education is undergoing a significant transformation due to the integration of advanced technologies like machine learning, Natural Language and Audio Processing, and 2D game development. RPG 2D games with puzzles offer dynamic and engaging language-learning environments, fostering motivation and engagement among learners.

RPG 2D games with puzzles provide learners with opportunities to practice and apply language skills in context-rich environments, addressing challenges such as reading and comprehension tasks, dialogues, and conversations. These innovative approaches can address longstanding challenges faced by language learners, such as achieving native-like pronunciation and maintaining learner motivation and engagement.

Pronunciation checkers in these games utilize sophisticated machine learning algorithms to analyze and provide feedback on learners' pronunciation accuracy. By providing immediate and personalized feedback, these tools help refine pronunciation skills more effectively, leading to greater language proficiency. The integration of these tools represents a departure from traditional pedagogical approaches, offering personalized and immersive learning experiences that cater to diverse needs and preferences.

The integration of pronunciation checkers and RPG 2D games with puzzles into language education represents a significant departure from traditional pedagogical approaches. RPG 2D games with puzzles provide learners with opportunities to practice and apply language skills in context-rich environments. As players progress through the game, they encounter a variety of language challenges, from reading and comprehension tasks to dialogues and conversations. By integrating language learning seamlessly into gameplay, RPG 2D games with puzzles make language acquisition more engaging, effective, and enjoyable. These tools utilize technology to offer immersive learning experiences, tailored to accommodate the varied needs and preferences of learners.

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Thus, the integration of machine learning-powered pronunciation checkers and RPG 2D games with puzzles represents a transformative approach to language education. By leveraging technology to provide personalized, immersive, and engaging learning experiences, these tools have the potential to revolutionize language acquisition, making it more effective, enjoyable, and accessible to learners worldwide.

II. LITERATURE SURVEY

1. This study [10] advocates for a psycho-pedagogical approach to designing DEGs, emphasizing the importance of considering individual learner characteristics, such as motivation and learning style, in game design. The authors propose a dynamic learner model that adjusts to learners' changing immersive and motivational states, highlighting the effectiveness of personalized learning experiences.

2. The paper [11] underscores the significance of incorporating learning styles into the design of adaptive learning systems. Findings suggest that aligning educational games with learners' preferred learning styles can lead to improved learning outcomes, highlighting the potential for personalized educational experiences.

3. This [12] explores the integration of DEGs into VLEs to enhance adaptability and assessment capabilities. They propose a middleware architecture to facilitate seamless integration, demonstrating its effectiveness through case studies. This study underscores the importance of creating student-centred courses that dynamically adjust to individual needs.

4. The potential of game-like simulations in adaptive learning, emphasizing the need for sophisticated learning architectures to support their integration into educational environments is highlighted in the paper [13]. The authors propose solutions for tracking student performance and delivering educational resources effectively, promoting the widespread adoption of serious games in education.

5. This research[14] aims to combine adaptive tutoring with interactive storytelling in DEGs. By intelligently modifying gameplay and story elements based on learners' interests and learning pace, the project seeks to create tailored and engaging learning environments. The study highlights the potential of ontological frameworks in enhancing the efficacy of educational gaming experiences.

Recent conference papers that deeply inspire this project:

1. [8]Computational thinking (CT) is a crucial 21st-century skill, but students often have a negative attitude towards learning it. Educational games have been used to promote CT, but they often lack adaptability and focus on abstract knowledge. To address this, researchers developed an adaptive game to engage children with customised game play and learning goals. Research on Estonian primary school children revealed that the game prompts children to feel both challenged and joyful, fostering confidence as they engage in game play. All children responded positively to the game, recognizing it as a valuable learning tool.

2. [9]The Japanese language is crucial for foreigners studying or working in Japan, but learning it is time-consuming and challenging. Amidst the COVID-19 pandemic, online and computer-aided tools have become indispensable for facilitating learning. However, a lot of them lack personalized content and social interaction, reducing user engagement. This study introduces a Japanese language E-learning platform integrating automatic vocabulary exercises, a recommendation system, and a multiplayer game to foster social interaction, with the goal of enhancing the learning experience by making it more engaging

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and effective.

3. Action-packed games hold great promise as instruments for cognitive training. This is because of their efficiency, natural motive power, and benefits for cognition. However, commercial video games lack control over unique features, while scientific games often lack appeal and collect insufficient data. To address these issues, a game framework for cognitive training is proposed. It fulfills crucial criteria for gamifying experimental environments, including modularity, accessibility, adaptivity, and variety. Through the collection of extensive datasets and the systematic exploration of scientific hypotheses within a controlled setting, this framework will make a substantial contribution to research on cognitive training.

4. The study employs natural language modelling to produce strategic moves in an ancient game. Specifically, the Generative Pretrained Transformer is trained to emulate the style of champions within the game, offering textual descriptions of move sequences. This model generates valid yet novel Go strategies not seen before. The text generated by the model is utilized for game visualization and creative patterns, such as in the Sabaki project's game engine, which incorporates auto-replays. The findings demonstrate that language modelling effectively captures the sequencing format and strategic formations observed in championship games. Moreover, this approach opens up new avenues for exploring over 40 other board games using historical text annotations as training data.

These conference papers contribute to the ongoing discourse on adaptive educational games, exploring topics such as computational thinking, language learning, cognitive training, and natural language modelling in gaming contexts. Together, these studies and papers highlight the diverse applications and potential of Digital Educational Games in promoting effective learning of language.

III. SYSTEM ARCHITECTURE AND DESIGN

The system design and architecture is explained in Fig. 1. It encompasses a language learning platform focused on teaching Hindi through an interesting game. Users access the platform and start solving puzzles tailored to Hindi language acquisition. The puzzles and the game have a theme and story line adding to the cultural simulation and helping understand the language further. These puzzles span various challenges, including word formation, phonics matching, and contextual vocabulary application. Each puzzle contributes towards the main story line and rewarding fast learning. Integrated within the game is a Pronunciation Checker, activated when puzzles necessitate pronunciation assessment. Speaking is essential for any language, more focus is drawn here as Hindi language uses Devanagari script hence reading takes longer than learning speaking. Player can start gaining confidence early on, this makes the game more engaging. Users pronounce Hindi words or phrases, with pronunciation accuracy evaluated through automatic speech recognition (ASR) technology. Correct pronunciations are acknowledged, while incorrect ones prompt corrective feedback. Upon successfully solving a puzzle, users seamlessly progress to the next level. In instances of difficulty, users have the option to request hints to aid in puzzle completion. For scalability and adaptability, the system is designed to dynamically adjust puzzle difficulty based on user proficiency levels. This feature lays the groundwork for future expansion and production deployment, ensuring an engaging and challenging gaming experience for users across skill levels. Performance metrics, including time taken to solve puzzles and number of attempts, are recorded for analysis. These metrics serve as valuable input for potential integration with a difficulty predictor AI, facilitating adaptive puzzle difficulty adjustments and optimizing the system's efficacy and user engagement. In summary, the system offers immersive and personalized Hindi language learning experiences through the integration of adaptive puzzle games with pronunciation checking capabilities. By providing tailored challenges and incorporating user feedback mechanisms, the system enhances user

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engagement and effectiveness in language acquisition.

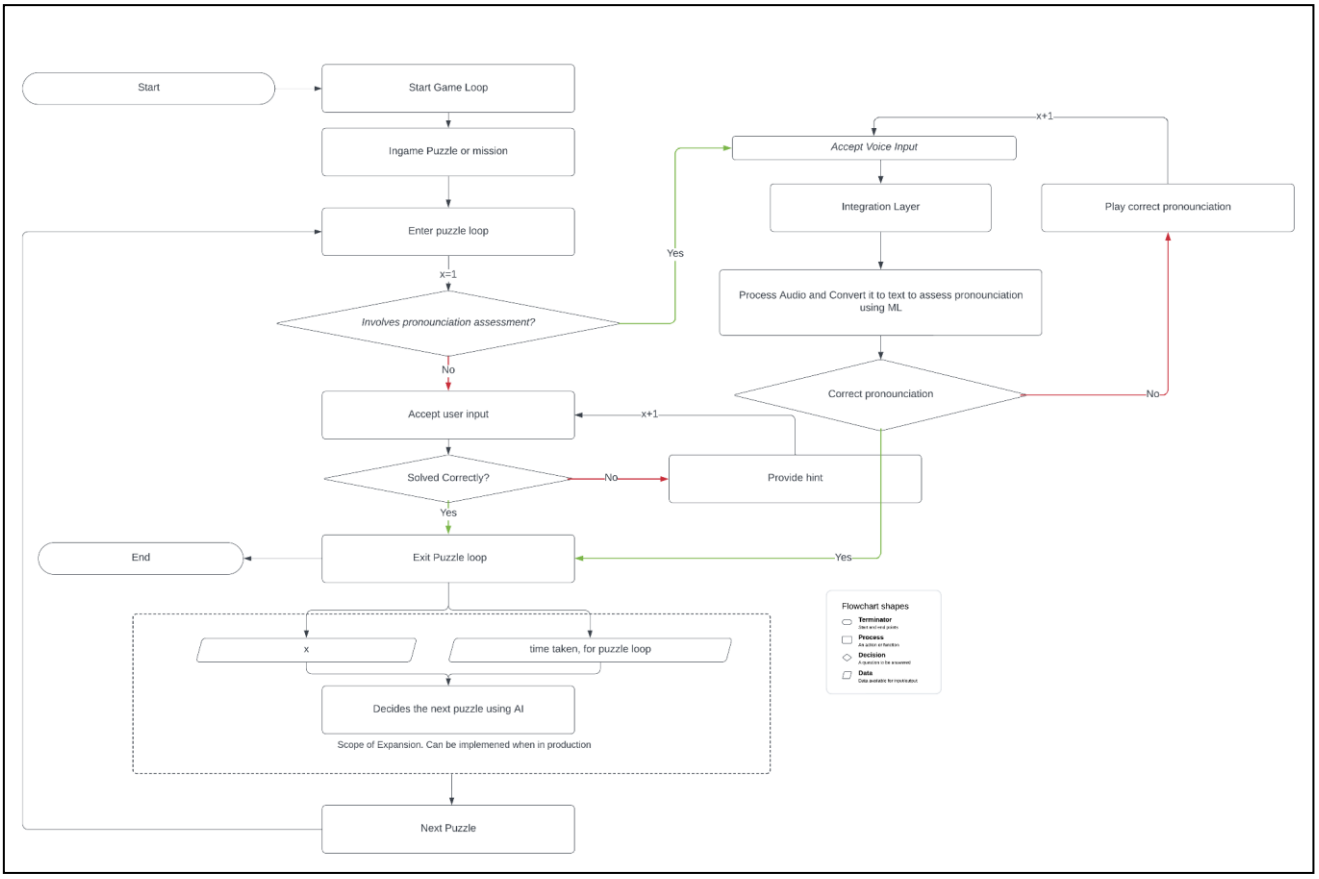

Fig. 1. System Architecture

The steps of voice recognition processing are depicted in Fig. 2. Supervised pattern recognition involves two stages: training and testing. The process of extraction of features relevant for classification is common to both phases. The class whose model most closely resembles the test pattern is declared to contain the

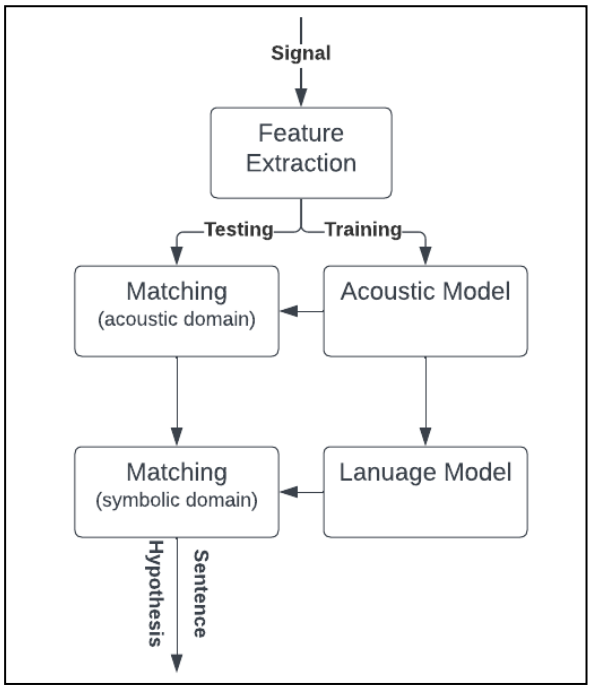

Fig 2. Automatic Speech Recognition (ASR) architecture

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test pattern. With that, Hindi text is generated from the audio input. [4] discussed that K-means transformation, histogram equalization, linear contrast stretching, and share-based features are all used to detect leukemia. A method for automatically classifying leukocytes using microscopic images is proposed. This proposed model used MATLAB to find leukemia cells in healthy blood cells, and it requires no medical equipment or expert and heavily relies on automation. [6] presented an innovative visual aid framework for completely blind people, which takes the form of a pair of glasses. The following are some of the most essential characteristics of the proposed device. The complicated algorithm processing is carried out on the Raspberry Pi 3 Model B+, which has low-end computing power.

IV. METHODOLOGY

The main methodology and working of the project can be defined intro three main steps: A. Game Development B. ASR Development C. Integration of game with ASR

A. Game Development

Methodology for Developing a 2D RPG Game with Modular Puzzles to Teach Hindi Language on Unity. The development of a 2D RPG game with modular puzzles to facilitate Hindi language learning on the Unity platform involves a structured approach to ensure effectiveness, engagement, and educational value. The methodology outlined below encompasses the key steps involved in this process:

1) Research and Planning:
    a) Conduct a thorough review of existing educational games and language learning methodologies.
    b) Define learning objectives and curriculum-aligned content for teaching Hindi language through the game.
    c) Plan the game mechanics, story line, characters, and visual aesthetics to create an immersive and engaging experience.
2) Game Design:
    a) Option for players to engage with the learning content.
    b) Create game levels and environments that reflect cultural elements of Hindi-speaking regions, immersing players in an authentic linguistic and cultural experience.

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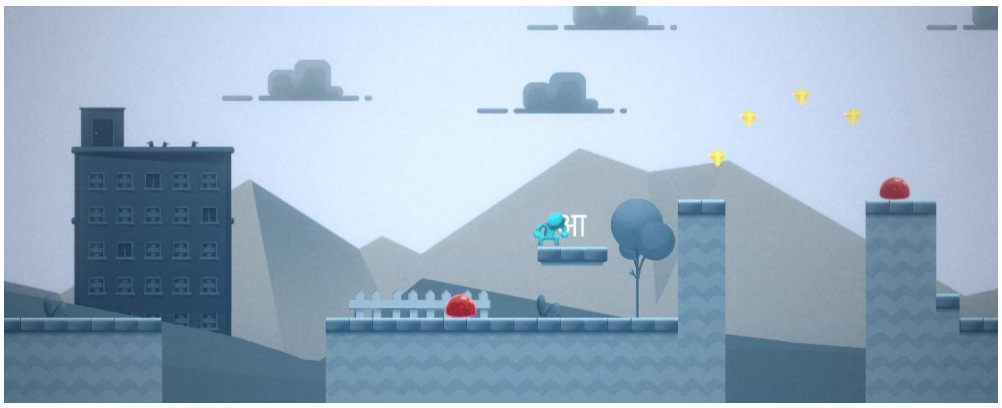

Fig. 3 UI screenshot

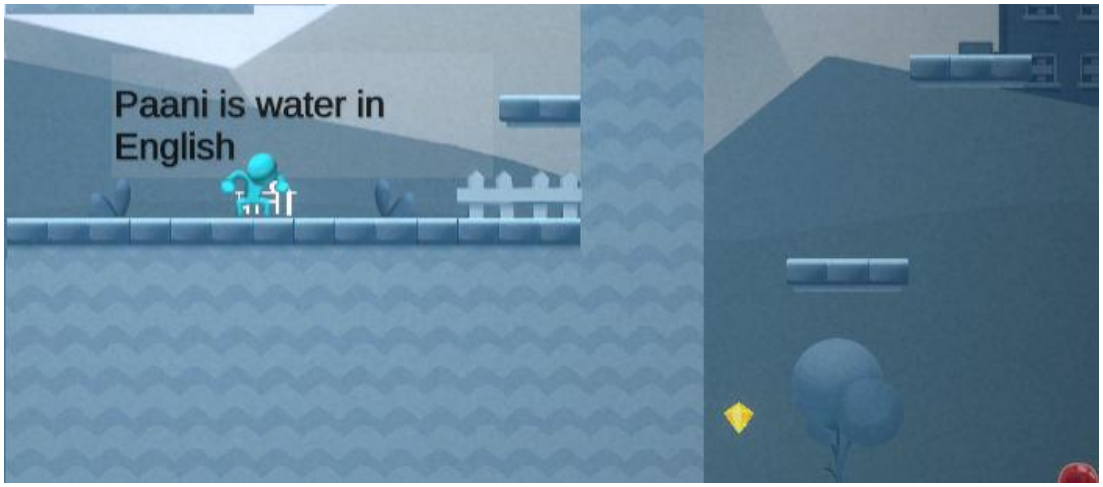

Fig. 4 UI screenshot

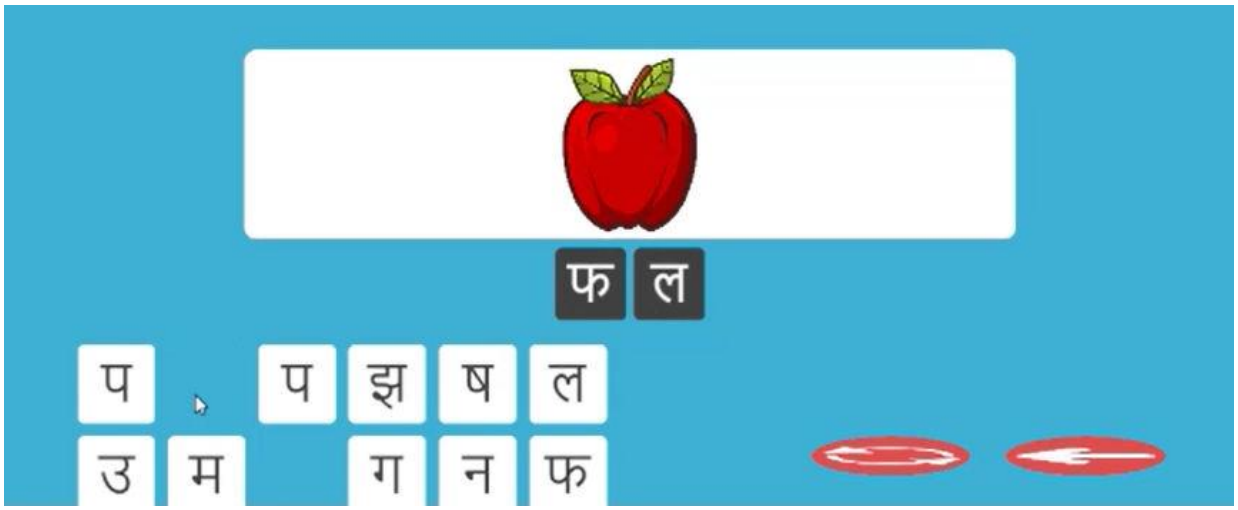

Fig. 5 UI screenshot

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3) Unity Development:

a) Utilize the Unity game development platform to build the 2D RPG game environment, incorporating features such as sprite-based graphics, animations, and user interface elements.

b) Implement modular puzzle mechanics using Unity's scripting capabilities, ensuring flexibility and scalability for adding new puzzles and challenges.

c) Integrate audio-visual feedback mechanisms to provide real-time guidance and reinforcement for players as they progress through the game and solve puzzles.

4) Content Creation:

a) Develop high-quality multimedia assets, including graphics, audio recordings, and written text, to support language learning objectives and enhance player engagement.

b) Create a diverse range of puzzle types, such as word puzzles, matching games, interactive dialogues, and contextual scenarios, to cater to different learning styles and preferences.

5) Testing and Iteration:

a) Conduct alpha and beta testing phases to gather feedback from target users, including language learners and educators.

b) Iteratively refine and optimize game mechanics, puzzle designs, and user interface elements based on user feedback and performance analytics.

c) Ensure compatibility and usability across different devices and platforms to maximize accessibility for a diverse audience of learners.

6) Evaluation and Assessment:

a) Assess the effectiveness of the game as a language learning tool through qualitative and quantitative evaluation methods.

b) Measure learning outcomes, engagement levels, and player satisfaction using pre-defined assessment criteria and metrics.

c) Analyze user feedback, performance data, and learning progress to identify strengths, weaknesses, and areas for improvement in the game design and educational content.

B. ASR Development

1) Data Collection The database used was provided by IIT Madras, a technical and research university in Chennai, India, offers a wide range of courses and research in various disciplines. IIT Madras also provides ASR online, offline, MT, and Speech2Speech services. Gram Vaani operates voice-based participatory media platforms using IVR (Interactive Voice Response) as the primary channel for interaction. Users call a unique phone number, and the IVR server automatically calls back, allowing users to record or listen to voice messages. These messages range from hyperlocal news to questions on agriculture, health, social entitlements, and folk songs and poems. The dataset comprises:

- Training labelled data:- 100 hrs
- Training unlabelled data:- 1000 hrs
- Development labelled data:- 5 hrs
- Testing data:- 3 hrs

Database Link:- https://sites.google.com/view/gramvaaniasrchallenge/dataset?authuser=

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2) Data Preprocessing
For preprocessing the data first normalize the audio levels to ensure consistent volume levels across different recordings, than background noise are removed and artifacts from the audio signals using noise reduction techniques or audio filtering methods.
After that the audio recordings are segmented the into smaller, manageable chunks or utterances to facilitate training and processing. Finally the speaker normalization or normalization of speech rate to address variability in speaking styles across different speakers is performed.

3) Model Training
To initiate the training process, we utilized the Wave2vec2 architecture as the foundational framework for our Automatic Speech Recognition (ASR) system. We fine-tuned the pre-trained Wave2vec2 model using our collected Hindi speech dataset. Through this process, the model was trained to extract meaningful representations of the input audio signals, capturing essential linguistic features and context crucial for accurate speech recognition.

4) Model Evaluation and Fine-Tuning
Following training, the trained ASR model underwent evaluation on a separate validation dataset to assess its performance metrics, including accuracy and word error rate (WER). Based on the validation results, fine-tuning of model hyperparameters, architecture, and training processes were conducted to enhance performance and generalization capabilities.

5) Inference and Deployment
Upon successful training and validation, the trained ASR model was deployed for real-time inference on new Hindi audio inputs. The model processed the input audio signals to generate corresponding Hindi text transcripts, which were post-processed to correct any spelling errors or inconsistencies. The final output, comprising accurate Hindi text transcripts, is used against a defined text that is used to check the pronunciation of the user.

C. Integration of the game with ASR
1) In Unity, generate a canvas with UI elements. Starting a new project entails preparing a workspace for game creation. In this context, text and other UI components, like buttons, are contained inside a Canvas. A platform for graphically designing and positioning these pieces by including a Canvas in the environment is built. The application's Start Button, Stop Button, and Text components are essential to user interaction as they offer the ability to begin and stop speech recording and display the transcripted results.

2) Attach a script to manage user interface interactions. Unity uses C# scripts to provide the functionality and behavior of GameObjects in a scene. These scripts enable interaction and communication with other components when they are attached to a GameObject. Add a script that controls how the user interacts with the UI elements—like clicking buttons. The script allows the Start and Stop buttons to initiate and stop the recording process when they are pressed by referencing the UI components and configuring event listeners.

3) Record audio from the microphone and encode it to MP3 format in real-time by using Unity's Microphone class to access the device's microphone. Setting up a system to continually record audio data and encode it in a compatible format, like MP3, is necessary for recording microphone input. Additionally, in order to ensure effective resource use and prevent excessive data gathering, monitor the recording's duration and automatically end the process when it reaches the appropriate length.

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4) After training, a voice recognition model must be saved in a specific directory together with any related processing elements. A Python web framework called FastAPI makes it easier to create scalable and reliable APIs for implementing machine learning models. Using FastAPI expose endpoints that take audio files as input, process the audio data using the trained model, and then return the transcription in an organized format (like JSON).

5) A Unity addon called Hugging Face makes it easier to incorporate machine learning models and APIs into Unity projects Configuring the extension to interact with the API endpoint necessary for integrating the previously developed Speech Recognition API and facilitating smooth data transfer between Unity and the server.

6) Testing is an essential phase in game development, ensuring that the implemented features function as intended and meet the specified requirements. In the context, testing involves verifying the end-to-end flow of data from microphone input to API processing and result display. By running the Unity scene, and suitably interacting with the UI elements, initiate recording, speak into the microphone, and observe the transcribed results displayed in real-time, confirming the successful integration and functionality of the speech recognition feature.

D. Uniqueness and future prospects

The game defined above introduces several novel features and approaches to language education. Here are some aspects of its novelty:

1) Integration of Language Learning with Gaming: The game uniquely combines language learning with gaming elements, offering an immersive and engaging experience for learners. By embedding language learning objectives within a gaming framework, the game provides a dynamic and interactive environment for users to acquire Hindi language skills.

2) Modular Puzzle Design: The inclusion of modular puzzles within the game introduces a novel approach to language learning. These puzzles cover various aspects of Hindi language acquisition, including vocabulary, grammar, phonetics, and contextual usage. The modular design allows for flexibility and adaptability, enabling learners to progress at their own pace and focus on specific areas of language learning.

3) Pronunciation Checker: The inclusion of a pronunciation checker feature further enhances the game's novelty. By integrating automatic speech recognition (ASR) technology, the game offers real-time feedback on pronunciation accuracy, allowing learners to improve their spoken Hindi skills. This innovative feature adds an interactive element to language learning and promotes authentic language use.

4) Seamless Integration of Educational Content: The seamless integration of educational content within the game environment is another novel aspect. Through the use of storytelling, characters, and thematic elements, the game contextualizes language learning objectives and reinforces learning through meaningful engagement. This integration fosters a holistic learning experience that extends beyond mere vocabulary acquisition.

5) Adaptive Difficulty Levels: The future scope of incorporation of adaptive difficulty levels within the game adds a novel dimension to the learning experience. By dynamically adjusting puzzle difficulty based on user proficiency levels, the game ensures that learners are appropriately challenged and engaged. This adaptive approach promotes effective learning by providing personalized learning experiences tailored to individual skill levels.

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V. CONCLUSION

In conclusion the development of a 2D RPG game for teaching Hindi language is a significant project in language education. The game provides a dynamic and interactive environment and engaging story line and activities for learners to acquire Hindi skills. Modular puzzles cover various aspects of language learning, and adaptive difficulty levels and pronunciation checker feature offer personalized learning experiences. The seamless integration of educational content and data-driven learning analytics enhances the learning experience, providing meaningful feedback and recommendations for improvement. This project demonstrates the potential of gamification and technology in transforming language education.

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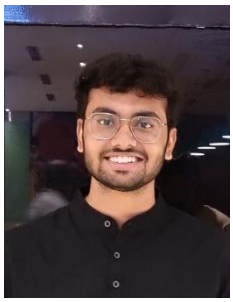

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