Speech Recognition and AI in Chess: Creating an Application That Uses Voice Commands to Play Chess

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Abstract. This research leads to the development of a moder chess application of classical chess that utilizes the marvels of modern technologies like speech recognition to make an already popular game more interesting and widely accessible to people that are unable to participate in the game using current inputs. Chess is a game being played for generation, yet it has not died out to the forward march of time because of its structural and logical gameplay. By mixing it with modern marvels of software advancement we revolutionize it in such a way that the inherent traditional game stays with us longer the generation in future unseeable will engage with it too. The proposed application is developed with the support of flutter, python, WebSocket, NLP, speech recognition comes a new era in chess, While also giving a brief insight into the world of ASR models and their comparison. Overall, the study demonstrates that how blending traditional games with modern technologies can preserve their relevance and encourage future generation to engage them with new ways.

Keywords: Speech recognition, NLP (natural language processing), voice recognition, API (application programming interface).

1 Introduction

The classical strategy game called chess, one of the most popular board games on the planet which has existed before some of the most the most prominent empires humanity has seen. The game has a board of which is a grid of 8x8 with 64 squares alternating between dark and light colors (only 2). Columns are vertical which on the board are labelled from a to h from left to right. rows are horizontal labelled from 1 to 8 from top to bottom. A traditional and classical game like chess, which has been said to be around for at least 1500 years, suspected to be created around 6 century CE in India, it was then known by the name of Chaturanga. How can one integrate the likes of modern technologies like and Artificial Intelligence and Speech recognition? It all

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started with the innovator Alan Turing in 1951 when he wrote a theoretical program that could possibly play the game of chess. The algorithm later termed as Turochamp was published in a paper, fully capable of playing chess, due to limitations of the available technologies the algorithm was never developed into a fully executable code but turning acted as a human CPU for the algorithm which resulted in half an hour for each move made by it. The below figure 1 illustrate the design of chessboard.

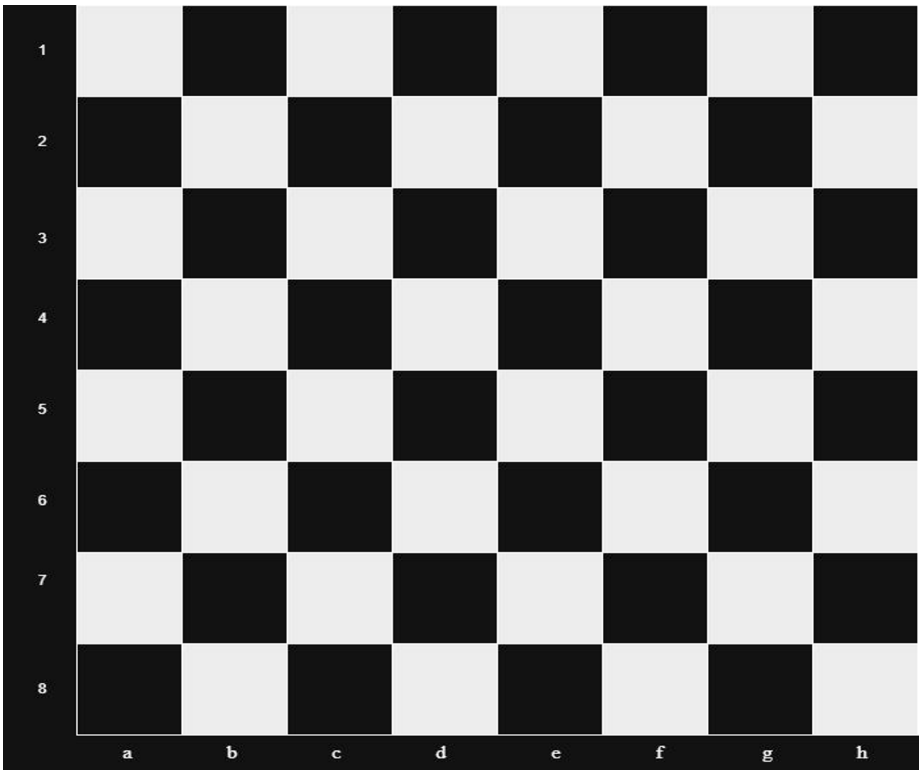

Fig.1. A chess board[1]

All the players start with 16 pieces: -.

1. King (1)
2. Queen (1)
3. Rooks (2)
4. Bishops (2)
5. Knights (2)
6. Pawns (8)

16 pieces

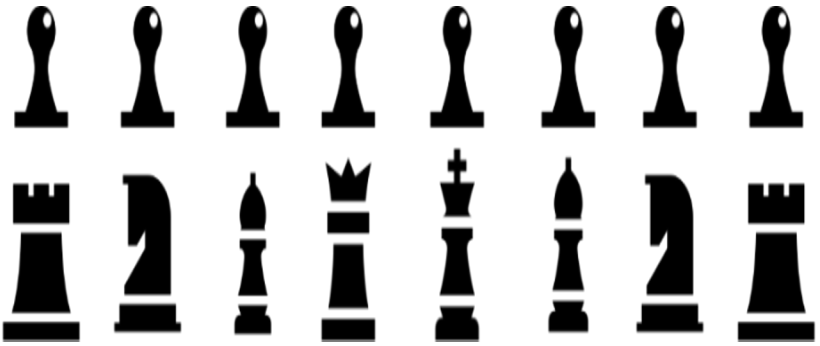

Fig.2. Chess pieces[1]

Chess is often considered a mind training tool that improves overall cognitive skills like problem solving, critical thinking and reasoning, memory and pattern recognition, also enhances concentration and attention. One of the better improvements seen in chess players daily is the ability to make decisions under time constraints. Chess is also linked to improvement in academics, especially math, reading comprehension and spatial intelligence. The majority of the digital chess applications developed so far are constrained to the use of mouse clicks, touchscreen interaction, or keyboard shortcuts. Although applied and used widely, it only works when a player interacts with the system physically by using human hands and fingers. By applying speech recognition to the system and using voice commands to interact with the game creates a scope of non-physical interaction and a new experience of hand-free gaming. In this new ecology of digital chess gaming, players declare their board moves like a declaration on the battlefield in older times, giving a sense of modernism of AI in giving while experiencing the nostalgia of the battlefield. While it enhances the experience of already acquainted players, it also opens the possibility of new players to the game, especially those who were physically challenged, giving them rare joyful life experiences that they were unable to explore yet.

One such group of people are the Visually impaired, being unable to experience the environment around them unlike their peers who were able to see the world around them puts them in a category that are unable to take part in society as others. By utilizing the concept of using your voice to move your chess pieces on the board using the label on the board, consists of numbers and alphabets. Example: - “move knight to F3”, when played as white the knight which rests at the initial position of G1, move the knight (if it is legal).

Voice recognition is a derived technology from natural language processing which uses the voice of the user to convert it text or command to execute by a system. It utilizes machine learning, natural language processing and signal processing to analyze inputs that are in the form of audio, identify speech pattern and interpret

words. The training of a voice recognition system is done in two ways such that they are either depend or not depend on the speakers, i.e. that it could either be trained for a single user or work for any voice of any user. The best example: -

a) Voice search of the google search engine.
b) YOUTUBE voice search.
c) AI assistants like Siri, Alexa, google assistant.

Although a fairly new technology is now being widely made to integrate into various applications that are already deployed and heavily used by the people all over the world. It will be applied to various domains of technology from security, gaming to health.

The objective of this research is to develop a chess application that utilizes the technology of voice recognition and additionally application of ml, speech recognition etc. the creation of this application will create an environment of inclusion for people suffering from various disability that does not allow them to enjoy chess in a traditional manner. This application also strives to improve the already existing use voice recognition system.

2 Literature Review

This paper published in ICECDS-2017 talks about a theorized version of chess system which can be developed specially for the visually impaired people. There are several chess systems throughout the world but none of these systems are available for blind people. Every year several blind contests takes place throughout the world, a system like this would enable them to practice efficiently. For choosing the systems moves, minimax algorithm with alpha-beta pruning technique is used. Here, each of the system unique in terms of their individual depth value. Like, the system created by IBM in 1997 deep blue engine could search to a depth of six to eight pair of moves, and it became the first engine to defeat a grandmaster. Engines vary in terms of depth like Fritz; Hydra utilizes the depth of more than 15. These engines use various techniques like maintaining a move book to reduce computational time, and calculating on opponent's time. However, above techniques are not implemented in our system as our main goal is to build a chess system for blind individuals.

A system for speech recognition in AI is used in the system, it uses the HEARSAY Algorithm to recognize chess moves. This system interprets indirect and informal spoken words; the system is capable of interpreting voice commands in a structured manner. The main task of this system was to recognize the spoken moves in the chess board. Determination of basic parameters like phonetic descriptions and segmentation. Also, use of the syntactic, lexical, semantic, and phonological provenance of knowledge in the generation were also outlined. The author mentions search-free strategies of moves pre-ordering based on the moves used in preceding games. It is assumed that moves occurring in past games are more likely to be suitable

for future position. The speech Recognition time has been decreased using Hidden Markov Models. It shows how to decrease the time spent processing the move, when selecting the reference pattern. Also, GMM (Gaussian Mixture Model)is used for Speech Recognition. Given inputs, refines the weights of each move through maximization algorithms. HMM (Hidden Markov Model) also integrated with SVM model to recognize Hindi. [1]

A study that explores the possibility of integrating the use of voice commands into classical gaming which applies the concept into Tetris. Design of voice command technology This system can work by both voice commands and keyboard. The key of voice command is speech recognition system which uses models like HMM and DTW and Microsoft SDK is better than these two models. It was a high recognition rate. Introduction to Microsoft SDK the speech recognition engine is Microsoft SDK. it has extremely high recognition rate under the command control mode than continuous speech mode. The voice related work is completed by COM component. As a result, programmers only need to concentrate on their own application development call this associated speech application program interface (SAPI) to implement voice function. There are two basic types of speech application program interface engines - Text to speech (TTS) - Speech Recognition Speech engine communicates with SAPI through the medium of DDI layer and SAPI interacts with applications by API. Some primary interfaces of API.
1) Speech Recognition Engine (ISp Recognizer (Isolated Speech Processing)) Interface
2) Speech Recognition Context (ISp Context) Interface
3) Grammar Rules (ISp RecoGrammer) Interface
4) Recognition Results (ISp Phrase)

Interface Choosing grammar language for the engine to analyse and match words according to language, then after this we can define rules for the chess so that it can recognize the voice command. Operation and Performance Test
1) The method of operation as we open it, user interface would appear and the speech recognition engines are activated while the engine is operating it will always monitor at the microphone. Speech training: the more you train the more accuracy you will get.
2) Performance Tests It involves 3 parts-
   a) Recognition Rate Test
   b) Robustness Test
   c) Flexibility Test Conclusion Microsoft SDK gives you a platform for further research investigation. [2]

Another study with the topic to enhance the speech quality by denoising, the use of deep neural networks is suggested that aims to grasp mapping of noisy speech into clear speech. The system that is are proposed for speech enhancement problems is recurrent networks, implemented using encoder-decoder autoencoder, or other similar models. Techniques mentioned above have effective performance in noise reduction

issue, also has effective results in noisy speech recognition. GAN(Generative Adversarial Network) is used widely in various fields. It has fantastic results in creating images similar to natural images, using a generator to make a real image that will fake discriminator. it is used for speech synthesis, that differentiate which one is natural. Wasserstein GAN, which has better results in speech recognition. But speech enhancement is still needed. This paper focus on ASR model of speech enhancement. A model aiming at denoising using GAN is proposed called SEGAN(Speech Enhancement Generative Adversarial Network). In antagonistic training, the discriminator tries to improve the capability of discriminating (artificial and natural) and the generator will improve to give clean speech. After converging they will reach their output. They interpret that SEGAN and GAN will miss some useful information and conclusion of denoised speech is dissapointing. Therefore, user proposes a new model that keeps useful information to itself called DGC-GAN(Deep Generative Convolutional Generative Adversarial Network). DGC-GAN includes and additional ASR network that is classifier that aims to avert GAN from skipping out on useful information With TDNN and GAN mixed it will generate useful information. [3]

One study by university of San Francisco discusses the effect of voice control and it's inter mixing with gaming, Involvement of a player is an extremely important part in the video game design which is called player immersion. Using voice as an add on can add an extra layer of this player immersion. It also makes the game accessible to visually/physically impaired people. Talking about chess, this feature could be a game changer. Voice is an essential part of our daily lives without which we cannot function properly and adding certain actions in a game to voice input would be very interesting. With the time machine learning is getting advanced everyday video games and VRs are good grounds for testing machine learning.

Key Features: - Voice control; human interaction; machine learning; facial expression; game design. Designing a computer or online game is an extremely involved task. The designer needs to work on the plot of the games, the characters design and then development of the game and also implementing changes after the development if required. Interaction of games with the players is really important and focus has been transferred to it in a few years and in an era like this adding voice recognition technology could be a game changer. It will make the game more accessible and will add another layer of immersion in the game. In general speech recognition technology is witnessing a tremendous boom worldwide with assistants like Siri and Cortana. Also voice control games and rising and getting advanced every day. The creation of games with supplementary voice controls is really a very good business idea for the video game industry. The studies which are done on this topic are interesting and have an engaging aspect to having voice-controlled games. As we move forward, we can expect more advancements and research in voice technology applications and games. [4]

The recognition speed was 10ms and segmented. The segments were labelled to specify the phonetic class, syntax used for sentence analysis, whereas phonetic

segmental of lexical items were used for word recognition. Limitations occurred; first vocabulary reduced to 16 words because of word boundary disambiguation. For Ex. Word 'large' is changed to 'big' because of reduced vowel into semivowel /l/. Second was to overcome problem of syntax-directed methods. One cannot blindly parse from left-to-right; user have to locate anchor points through which parsing can be done. This was necessary to compensate for machine errors like spurious words, repetition of words and inclusion of hmm- and ha-like sounds. Third, the simple hierarchical structure introduced errors which have multiplicative effect, i.e. if each of four processes introduced 10 % errors then total error will be 34. [5]

Since the arrival of AI, experimenters have tried to play with chess as an apparatus for experimental innovation. ever since the conception of field of AI was validated, researchers and inventors like Wolfgang von Kempelen experimented with systems(machines) that can play chess. The Turk fooled many into believing machines could play chess in 18th century. However, it wasn't until Claude Shannon published paper titled "A chess Playing Machine". The paper described a chess program as a series of interlinked subprograms. He observed playing perfect chess is impossible, even for a machine- there are estimated 10120 nodes in full chess tree. Even computers capable of evaluating 1016 positions in a second and would need in excess of 1095 years to fully evaluate this tree. Chess is a game of approximation. the reasoning used by chess masters to pick moves. The initial objectives were to – build a system that would vanquish the best human player in the world. the Deep Blue chess machine created by IBM in 1997 achieved this goal, and defeated Gary Kasparov. An objective of machine learning sub-field of Artificial intelligence is to provide a collection of data , to have 'machine' learn the rules from background knowledge. One example is 'teaching' computer how to differentiate odd and even, based on arithmetic properties. [6]

To realize speaker- independent large vocabulary speech recognition, phoneme-based recognition is desirable and accuracy is very important. To recognize larger units such as words or sentences and to perform dynamic time wrapping of speech a powerful method HMM (Hidden Markov Model) is used. We use an approach in which we use HMM with a classifier as front-end processor instead of VQ (Vector Quantization). Classifiers make it easy for the HMM by separating input patterns of each phenomenon. This classifier is based on discriminant analysis and it is one of the multivariate analyses and then we can easily combine it with the HMM which is a stochastic modelling. Furthermore, we combine the score of the classifier on the local features and the score of HMM on the global features to get a recognition result. [7]

Speech recognition is to make a machine understand a human speech by the vocal tract which we make through the airflow from the lungs. It is done by meddling the characteristic of the vocal tract mathematically. This research has been a center of attraction continuously to study the desire of interfacing human and machine. Speech recognition is getting better day by day from limited vocabulary from isolated words to continuous words. A large memory is required if the size of vocabulary is increased

and also it is hard for the recognition system to distinguish a continuous flow of words from the human mouth. We need to increase the size of memory and search time as the number of words to be recognized is increased. [8]

3 Literature Review

The focus of this research is to developing a working prototype of a chess application that utilizes voice command to move chess pieces and in future be deployed to be available to all.

A) System Architecture

The architecture of the developed system is to be divided into 3 major parts for ease of functioning and understanding.

1. FRONTEND – will be written in flutter, it will handle user interface, voice input, user input and chess board rendering.

2. SPEECH RECOGNITION – applied by using combination of google speech to text API and Firebase ML kit, will be used to convert spoken commands into text.

3. BACKEND – using firebase firestone, python and its functions, this will be used to process commands, validate moves, and update game state.

4. WEBSOCKET – applied by using either NODE.JS or firebase extensions which allows us to create a room for multiplayer purposes in real time and low-latency.

B) Voice commands processing

1. SPEECH INPUT CAPTURE – using voice as input for the application by using technology (google speech to text API/ firebase ML kit). Ex “Move pawn to b4”

2. PROCESSING – command is parsed and validated to extract from it the user’s chess moves. All of this is done while following the rules of the game of chess which ensures its legality before it is rendered into the screen.

3. MOVE EXCUTION – once validated the and processed the board of the game updates itself in real time. If the validation is not completed due to wrong/illegal input it flashes error feedback to the user.

4. Alternatives – because of cost of using this speech to text technologies can be high for students, there can be free and innovative way to create this application. For ex: flutter itself has a interface already made ready to use on their website, it can be directly integrated with customization as the developing team wants and use it. Another way is to integrate the Gemini/chat gpt API into the project to process the voice command into text returning it back as a string to be used in the project.

C) Database and Authentication

1. Firebase Databse – stores the stats for real time use and updates.

2. Firebase Authentication – manages and stores user login and session data.

3. Firebase Function – handles rule/legality enforcement and input move validation.

4. Websocket – allows multiplayer gameplay, transposition of chess moves between player instantly, real time updates and synchronization of game state.

5. MongoDB can also be used.

D) Error handling

NLP based correction for common errors in the speech input and recognition. Using confidence scores from the Speech to text API to not accept unclear inputs from the user.By utilizing WebSocket, we ensure minimum lag between the players in multiplayer. Lost connection from the games can be used to restore games in Firebase.

METHODOLOGY FLOW CHART: -

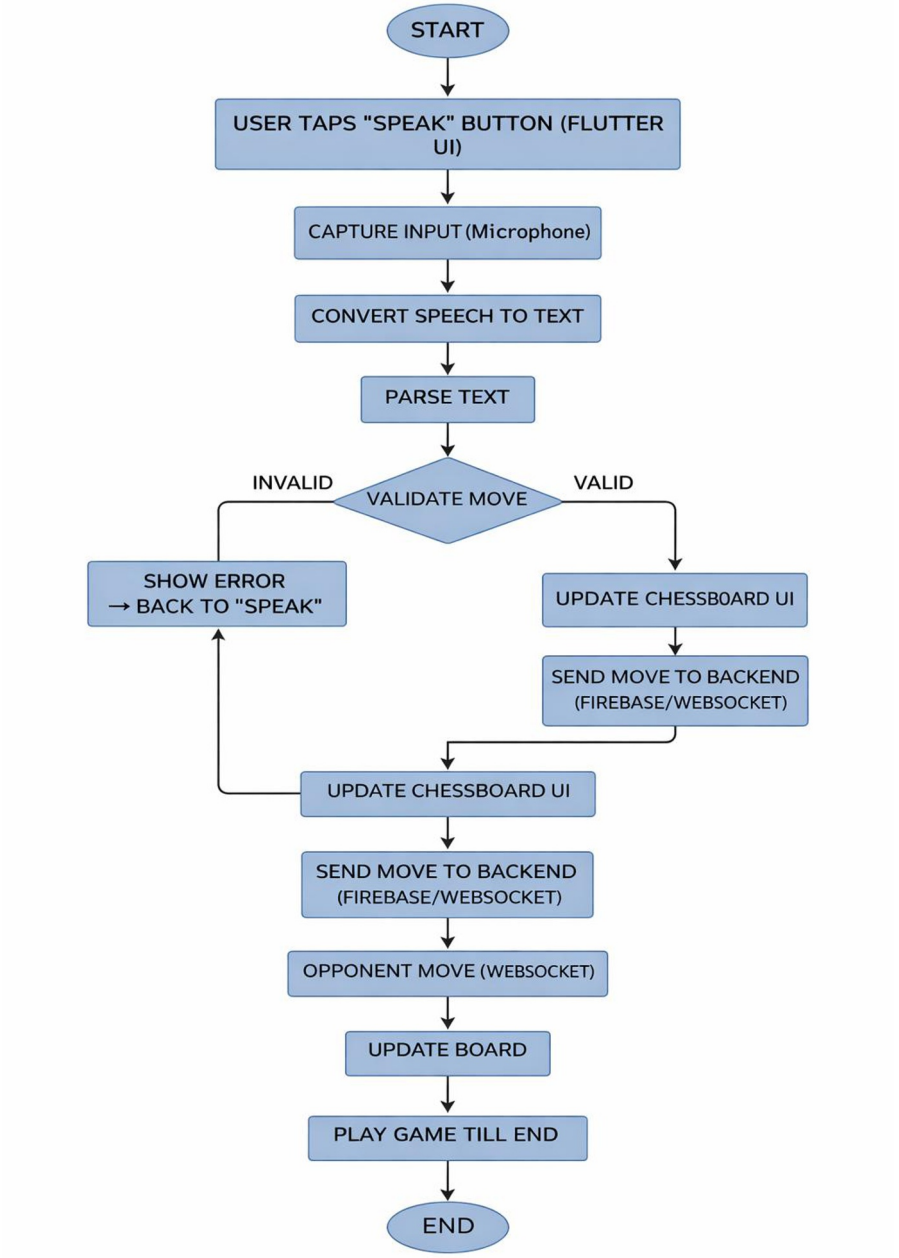

Fig. 3 Flowchart of Proposed work

4 Implementation

To understand the basics of this application could be implemented it is necessary for us to partition it into four key components as said –

A) Frontend Implementation

UI is built using flutter to enhance the experience of game even more. Some key features of the user interface:

1. Voice input button
2. Real time board updates
3. Multiplayer support.

B) Speech recognition

Steps:

1. Tap the "Move" button to input the move as audio.
2. Application records the input and sends to the speech to text API.
3. API process the input and returns a text/transcribed move. EX: "Move pawn to b4".
4. This transcription is parsed to extract its meaning in chess notation.
5. This move is further validated for legality and then executed if correct.

C) Backend Implementation

Main implementation for the backend is to store and manage game states in real time by co-ordination with the WebSocket function [11], but it also stores the users moves, manage player login and session, validation of the legality of the input moves of the player.

D) Real time Multiplayer Implementation

This is done using WebSocket for the instant synchronization of the moves by player in real-time.

A basic functionality of the same is:

1. Player makes a move.
2. This move is sent via WebSocket where the servers validate it and then render it in the UI chess board in front of the opponent.
3. Opponents board is updated in real life.

E) Error Handling and Optimization

NLP based correction for common errors in the speech input and recognition. Using confidence scores from the Speech to text API to not accept unclear inputs from the user.

By utilizing WebSocket, we ensure minimum lag between the players in multiplayer. Lost connection from the games can be used to restore games in Firebase.

F) Testing and Evaluation

This application which is the result of our theorized software design is now ready to be used, but before that it is necessary to test it for maximum output in its current form. This resulted application is tested for:

1. Speech recognition – how accurate and correct the input and processing is by the application.
2. Network latency – rendering of the update by WebSocket will be tested for time in real life.
3. User experience – easy of navigation from page to page and evaluating accessibility and gameplay efficiency

5 Result and Discussion

This study of theorizing the creation of an application that uses voice commands for chess highlights to the readers both the advantages of this innovation and simultaneously its challenges. This application can interpret voice commands input by the user and execute the chess moves extracted from it, but the effectiveness of this technology depends upon few outside, somewhat uncontrollable factors like speech clarity, background noises and many times pronunciation variation. This error can be mitigated by applying NLP based correction and structured command formats. In terms of real-time gameplay, WebSocket provides real-time synchronization making it ideal for the usage of multiplayer gameplay. Firestore allows for storage of game stage and reconnection butt leads to slight delay in board update, this combination though may not sound perfect but when executed works seamlessly.

Overall, this study shows that a voice-controlled chess system is viable and innovative alternative to the old and traditional which could result in a playing environment that offers more accessibility and the convenience of gaming while also applying optimization of speech recognition, response time, and error handling. Using flutter [10] as the base for our application creates for a field to capture users from all hardware background, because of its cross-platform development this application can run on windows, android, iOS and more. The integration of its parallel technology namely firebase we are allowed real time updates in database and our game. Additionally adding web socket to our game allows seamless gameplay because of reduced latency and great multiplayer room experience.

The development of such application results in a horizon of new innovation in chess, through the inclusion of certain group that may not have been included when played chess in a traditional setting, also encourages new formats for the game for example blind chess, where regular players are put in a blind fold to play chess blindly to make the game more interesting and to challenge players in a new way. This application also tests the limit of new technologies evolving every day and waiting to be utilized in the world in the perfect light. This project also gave us a chance to compare existing technologies and their efficacy on paper and in practicality, for example, we

compared the availability and efficiency of various voice to text models to be integrated into the application for playing the game this led to extensive research to find out which model would be the best to be integrated int our system given the conditions and circumstances of our project.

Table 1. Brief comparison between various voice processing services [9].

Model	Google STT	Whisper	Deepspeech	Kaldi	Vosk
Rtf	0.1 – 0.3	0.5 – 1.0	0.2 – 0.5	0.2 – 0.5	0.3–0.6
Wer	5- 8 %	5 – 10 %	10 – 15 %	8 – 12 %	10 –15 %
Cer	2 – 4 %	3 – 6 %	6 – 10 %	5 – 9 %	6 – 10 %
Lang Sup	120+	99+	Eng	Multi	20+
Noise robustness	High	High	Med	Med	Med
Model Size	CloudAPI Only	1.5 – 3 GB	~180MB	Custom	~50-200MB
Latency	Low	Med – High	Med	Med	Low
Training Req	No	Optional	Yes	Yes	Optional
License Type	Proprietary	Open Source	Open Source	Open Source	Open Source
Use Case	Real-Time	Research	Embedded	Research	IOT

RTF (Real-Time Factor): Transcription time / actual audio duration

WER (Word Error Rate): Percentage of incorrectly predicted words

CER (Character Error Rate): Percentage of incorrectly predicted characters

Noise Robustness: Accuracy maintained under background noise conditions

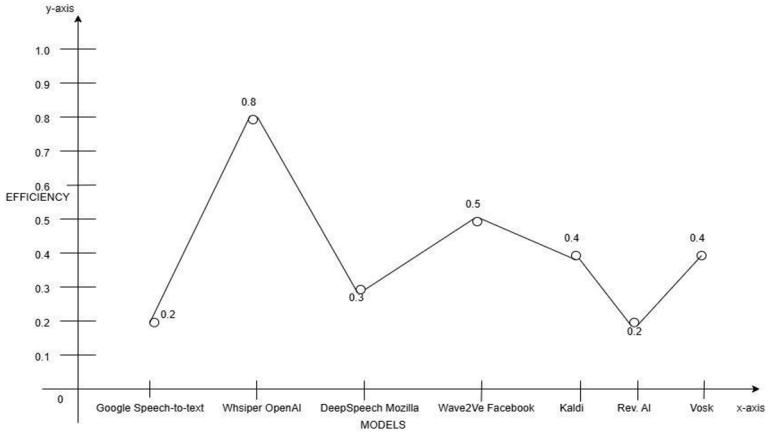

Fig. 4. Efficiency comparison of the models [9].

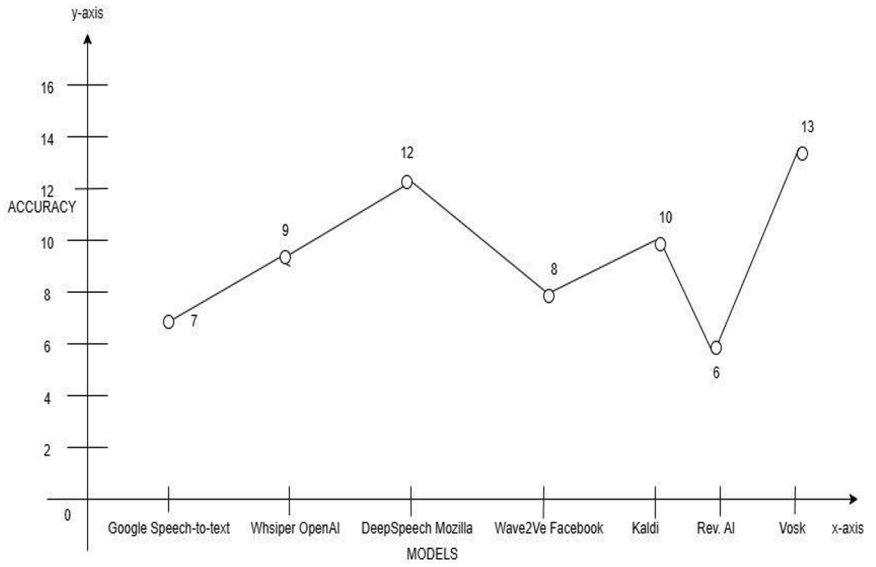

Fig.5. Accuracy comparison of models [9]

The most accurate paraphrase for adjustable audio responses in surveys are produced by ASR algorithm according to a study. In a study they examined four advanced and modern speech-to-text algorithms: Google Cloud Speech-to-Text, Meta's Wav2vec, NVDIA's NeMo and OpenAI's Whisper. The study applied innovative models, with holding from any regulation. This follows the original intended use case. Overall, for data used in the study, it was found that the Google service, which is commonly used in the social science literature, is outstripped by four models, with Whisper (large) having the lowest average WER. [9]

6 Conclusion

The voice-controlled chess application successfully integrates speech recognition, firebase and real time multiplayer for an innovative hands-free gaming experience. While it also results in accessibility, inclusion and interaction there is a need for further requirement in refinement in speech misinterpretation and the applications latency. We also get an insight into ASR as a technology and an industry, from paid perfected models to open-source/ free to use systems. Overall, the system presents a viable yet scalable alternative to the traditional input methods, making chess more interactive and inclusive. This paper presents the design and development of a voice-controlled chess application aimed at enhancing accessibility and user experience through speech recognition technology. By integrating Flutter for the frontend, Firebase for backend services, and WebSockets for real-time multiplayer interaction, the system enables hands-free gameplay and intuitive interaction. The methodology

ensures accurate speech processing, legal move validation, and smooth real-time synchronization. Although challenges such as speech misinterpretation and network dependency remain, the application demonstrates that voice commands can serve as a viable and inclusive alternative to traditional chess input methods.

Future development of the voice-controlled chess application can focus on enhancing speech recognition accuracy by incorporating custom NLP models trained on chess-specific vocabulary. Support for multiple languages and regional accents can make the application more inclusive. Integrating AI-powered move suggestions, voice feedback, and natural dialogue systems will create a more interactive experience. The system can also be extended to include training modes, tutorials, and accessibility features for visually impaired users. Additionally expanding the real-time functionality to cross-platform multiplayer and improving network resilience will make the application more robust and scalable for broader use cases.

References

1. S. K. D. S. S. S. P. a. V. S. B. Bharathi. Speech recognition-based chess system for visually challenged. International Conference on Energy, Communication, Data Analytics and Soft Computing (ICECDS), Chennai, India..
2. X. Y. a. J. Fan. Design and implementation of voice-controlled Tetris game based on Microsoft SDK. International Conference on Multimedia Technology, Hangzhou, no. 2011, doi:10.1109/ICMT.2011.6001825, 2011.
3. N. L. Y. X. D. K. a. K. S. K. Ding. Mutual-Networks for Robust Speech Recognition. 24th International Conference on Pattern Recognition (ICPR), Beijing, China, 2018.
4. https://www.cs.usfca.edu/~byuksel/affectivecomputing/2018_examples/chai.pdf.
5. L. E. a. R. N. D. Reddy. A model and a system for machine recognition of speech. IEEE Transactions on Audio and Electroacoustics, vol. vol. 21, pp. pp. 229-238, , 1973.
6. D. Gleich. Machine Learning in Computer Chess: Genetic Programming and KRK. 2003 .
7. T. K. a. S. Doshita. Phoneme recognition by combining discriminant analysis and HMM. [Proceedings] ICASSP 91: 1991 International Conference on Acoustics, Speech, and Signal Processing, Toronto, ON, Canada, vol. vol.1, pp. pp. 557-560, 1991.
8. S. M. a. M. Bae. On a study of decreasing the processing time in the speech recognition system using the HMM (hidden Markov model) algorithm. MILCOM Proceedings Communications for Network-Centric Operations: Creating the Information, vol. vol.2, no. doi:10.1109/MILCOM.2001.986046., pp. pp. 1224-1228, 2001.
9. J. B. P. C. B. C. Landesvatter. Comparing Speech-to-Text Algorithms for Transcribing Voice Data from Surveys. [Online]. Available: osf.io/preprints/socarxiv/vk6wj_v1., 10-Oct-2023..
10. L. S. Songare, H. P. Singh, S. Bhayal, P. Baniya, A. S. Rajput and P. Lakkadwala. Laptop Price Estimation Using Data-Driven Predictive Analytics. 2025 IEEE International Conference on Advances in Computing Research On Science Engineering and Technology (ACROSET), INDORE, India, 2025, pp. 1-6, doi: 10.1109/ACROSET66531.2025.11281104.
11. https://pages.ably.com/hubfs/the-websocket-handbook.pdf.