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Smart Divyang Vadya Guru

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Abstract: ***This paper presents the development of Smart Divyang Vadya Guru, an AI-based real-time musical instrument training and performance evaluation system designed to make music education more accessible to differently abled learners, particularly visually and hearing-impaired individuals. Traditional music learning methods primarily depend on auditory and visual instructions, which can create difficulties for learners with different accessibility requirements. The proposed system addresses these challenges by integrating audio signal processing, intelligent note detection, performance evaluation, and multiple feedback mechanisms into a single interactive platform.***

The system captures musical input through a microphone and uses the YIN pitch detection algorithm to identify the notes played by the learner. The detected notes are compared with predefined target notes to identify incorrect or missed notes and evaluate playing accuracy. Based on the evaluation, the system provides real-time feedback through visual indicators and speech-based instructions. An ESP32-based haptic feedback unit with a vibration motor is incorporated to provide tactile alerts, enabling hearing-impaired learners to receive feedback without depending entirely on sound. Speech-based guidance and voice interaction further assist visually impaired learners in navigating the platform and following music lessons. The system supports multiple musical instruments, including piano, guitar, Carnatic violin, and Carnatic flute, with different learning levels to accommodate individual skill development. By combining AI-based pitch detection, automated performance assessment, and accessible feedback techniques, Smart Divyang Vadya Guru aims to provide an inclusive, interactive, and independent music-learning environment for differently abled individuals.

Keywords: Artificial Intelligence, Smart Divyang Vadya Guru, Musical Instrument Training, YIN Pitch Detection, Real-Time Performance Evaluation, Assistive Technology, Haptic Feedback, Speech-Based Assistance, Accessible Music Education.

I. INTRODUCTION

Music is a universal form of expression, yet its learning process has traditionally been centered around auditory perception. This creates limitations for individuals who are deaf or hard of hearing, restricting their ability to fully participate in music education. With the rapid advancement of artificial intelligence and digital technologies, new opportunities have emerged to redesign music learning systems in a more inclusive manner. AI-driven platforms are now capable of analyzing complex audio signals and providing real-time feedback, making the learning process more interactive and adaptive.

In recent years, researchers have explored the use of vibrotactile feedback as an alternative medium for conveying musical information. By translating sound features such as rhythm, pitch, and intensity into vibration patterns, these systems enable users to perceive music through touch. When combined with AI techniques, such systems can further personalize learning experiences, adapting feedback based on user performance and preferences. This integration of AI and assistive technology represents a significant shift from traditional teaching methods toward multisensory learning environments.

This paper surveys the existing research in AI-based music education and assistive technologies, with a particular emphasis on vibrometer-based systems for deaf users. It reviews different system designs, methodologies, and applications, while also identifying key challenges and future research directions. The goal is to provide insights into how technology can transform music education into a more accessible and inclusive domain for all learners.

II. LITERATURE PAPER

[1] The work carried out discusses the integration of artificial intelligence into vocal music teaching to make learning more interactive, personalized, and efficient. Unlike traditional methods that depend on manual and sometimes inconsistent instructor feedback, the system uses AI to analyze voice inputs and provide instant guidance on pitch, tone, and rhythm. It offers features such as real-time evaluation, progress tracking, and adaptive learning paths, creating a dynamic learning environment tailored to individual users. By automating feedback and supporting independent practice, the platform reduces instructor workload while maintaining quality, improves accessibility, and enables scalable, technology-driven music education.

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[2] The work carried out presents an AI-driven system for violin performance evaluation that improves traditional music learning by providing automated and personalized feedback. It highlights how conventional methods rely on subjective teacher assessment, which can be slow and inconsistent, while the proposed approach uses deep learning models like CNN and LSTM to analyze pitch, rhythm, and expression more accurately. The system is trained on a large dataset and uses audio processing techniques to extract meaningful features for evaluation. It also includes a real-time feedback mechanism that helps learners identify mistakes and improve their performance efficiently. Experimental results show that the AI-based system significantly reduces error rates and enhances learning outcomes compared to traditional methods. Overall, the study demonstrates that integrating AI into music education can make performance assessment more objective, efficient, and adaptable.

[3 The work carried out outlines several future directions to enhance the AI-based violin performance evaluation system. It suggests using more advanced models, such as Transformer-based architectures, to better capture complex musical patterns and improve feedback accuracy. The system can also be improved by handling subtle aspects like timbre variations and intricate rhythm structures more effectively. Another key area is the integration of multimodal data, such as video analysis, to evaluate posture and playing techniques alongside audio. The paper also emphasizes the need for larger and more diverse datasets to improve model reliability across different users and styles. Overall, future work aims to make the system more comprehensive, accurate, and adaptable for real-world music learning.

[4] The work carried out discusses future improvements for the AI-based violin performance evaluation system to make it more accurate and effective. It suggests using advanced models like Transformer-based architectures to better understand complex musical patterns and improve feedback quality. The system can also be enhanced by capturing subtle aspects such as timbre variations and detailed rhythm structures. Another important direction is integrating multimodal data, including video, to analyze posture and playing techniques along with audio. The paper also highlights the need for larger and more diverse datasets to improve performance across different users and styles. Overall, these advancements aim to make the system more comprehensive, reliable, and suitable for real-world music learning.

[5] The work carried out outlines several future improvements for the AI-based violin performance evaluation system to enhance its overall effectiveness. It suggests the use of advanced models like Transformer-based architectures to better capture complex musical patterns and improve feedback accuracy. The system can be further developed to analyze subtle aspects such as timbre variations and detailed rhythm structures more precisely. It also proposes integrating multimodal inputs, including video, to assess posture and playing techniques along with audio performance. Additionally, expanding the dataset with more diverse samples can improve the system's adaptability across different users and styles. Overall, these advancements aim to make the system more accurate, comprehensive, and suitable for practical music learning environments.

[6] The work carried out discusses the concept of smart musical instruments (SMIs), which combine traditional musical instruments with modern technologies like sensors, embedded intelligence, and wireless connectivity. It explains how these instruments go beyond regular digital instruments by enabling interaction not only between the player and the instrument, but also with other musicians, devices, and even audiences. The paper reviews existing developments, including augmented and networked instruments, and highlights how combining these approaches creates more advanced and interactive systems. It also proposes a structured design framework and key principles to guide the development of such instruments. Additionally, the study explores potential applications like collaborative music creation, learning, and live performances. Finally, it identifies current challenges and suggests future research directions to improve the practicality and adoption of smart musical instruments.

[7] The work carried out highlights how artificial intelligence is transforming music teaching systems by making learning more interactive, personalized, and efficient. It explains that AI-based systems can analyze a learner's performance, identify mistakes, and provide instant feedback, which helps students improve faster. The paper also discusses the use of technologies like machine learning and pattern recognition to support tasks such as note detection, rhythm analysis, and automated evaluation. In addition, it emphasizes the importance of user-friendly design so that both beginners and advanced learners can easily use the system. The study points out that such systems can support self-learning and reduce the need for constant human supervision. Overall, it suggests that AI-driven music teaching systems have strong potential to enhance modern education and reshape traditional learning methods.

[8] The work carried out focuses on the design of a vocal music teaching system for music students using artificial intelligence to improve learning and teaching methods. It explains how AI helps overcome limitations of traditional education by providing interactive, flexible, and resource-rich learning platforms. The system is designed with features like performance analysis, online learning, assignment management, and real-time feedback to support both teachers and students. It also highlights the use of expert systems and neural networks to evaluate student performance and personalize learning experiences.

The study shows that many students prefer AI-based learning due to its convenience and effectiveness. Overall, the paper concludes that integrating AI into vocal music education can enhance teaching quality, promote self-learning, and modernize the overall education system.

[9] The work carried out presents the development of an AI-based music teaching system that aims to improve the overall learning experience for students. It explains how artificial intelligence techniques are used to analyze musical performance, detect errors, and provide instant feedback to learners. The system includes features such as note recognition, rhythm evaluation, and personalized guidance to help students practice effectively. It also highlights the role of machine learning in adapting to different skill levels and learning styles. The study shows that such systems can make music education more flexible, interactive, and accessible. Overall, the paper concludes that AI-driven solutions have strong potential to enhance traditional music teaching methods and support self-learning..

[10] The work carried out discusses how artificial intelligence can be effectively applied to piano music teaching to improve both learning and teaching processes. It explains that AI technology helps in analyzing students' performance, identifying errors, and providing real-time feedback, which enhances practice efficiency. The study also highlights the use of intelligent systems to personalize learning based on individual skill levels and progress. In addition, it emphasizes that AI-based platforms make learning more flexible and accessible compared to traditional methods. The paper shows that students are more engaged and motivated when using interactive and technology-driven tools. Overall, it concludes that integrating AI into piano education can significantly enhance teaching quality and modernize music learning.

[11] The work carried out presents an intelligent piano teaching system based on artificial intelligence that aims to overcome the limitations of conventional classroom instruction. It explains how the system captures a learner's performance, extracts features such as notes, timing, and dynamics, and compares them with standard reference data to detect errors. The study highlights the use of machine learning models to evaluate performance and generate corrective suggestions automatically. It also discusses how personalized learning paths can be created according to each student's skill level and progress. The paper shows that such a system improves practice efficiency, reduces dependence on teachers, and keeps learners motivated. Overall, it concludes that AI-based piano teaching platforms can make music education more objective, interactive, and effective.

[12] The work carried out focuses on the design of a music teaching system based on artificial intelligence to improve the quality and flexibility of music education. It explains the overall system architecture, which includes modules for audio acquisition, feature extraction, performance evaluation, and learner management. The study highlights how intelligent algorithms analyze musical elements such as pitch, rhythm, and melody and provide immediate feedback to students. It also describes the use of online resources and interactive interfaces to support self-paced learning outside the classroom. The paper shows that learners benefit from timely guidance and individualized practice plans. Overall, it concludes that AI-based music teaching systems can complement traditional teaching and enhance learning outcomes.

[13] The work carried out proposes an intelligent music teaching model that uses big data technology to improve the teaching process. It explains how large volumes of learner data, such as practice records, performance scores, and learning behavior, are collected and analyzed to understand individual needs. The study uses data mining and fuzzy-based techniques to evaluate student performance and recommend suitable learning content. It also highlights how the model supports teachers by providing data-driven insights for adjusting teaching strategies. The paper shows that the approach improves personalization, learning efficiency, and the accuracy of assessment. Overall, it concludes that big data can play an important role in building adaptive and intelligent music education systems.

[14] The work carried out discusses deep learning approaches used in the development of smart applications across different domains. It explains how neural network architectures such as convolutional and recurrent networks can learn complex patterns from raw data without extensive manual feature engineering. The study reviews the use of these models for tasks such as recognition, classification, and prediction in intelligent systems. It also highlights the importance of training data quality, computational resources, and model optimization for reliable performance. The paper shows that deep learning improves accuracy and adaptability compared to conventional rule-based methods. Overall, it concludes that these approaches form a strong foundation for building intelligent, real-time applications, including those in music analysis and education.

[15] The work carried out presents an AI-based smart system designed for real-time monitoring and intelligent decision-making. It explains how sensors and data acquisition units collect information continuously, which is then processed using artificial intelligence techniques to detect events and patterns. The study highlights the importance of low-latency processing so that the system can respond immediately to changes in input conditions. It also discusses how the system can be made adaptive by learning from previous data to improve its accuracy over time.

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The paper shows that real-time monitoring combined with AI increases reliability and reduces the need for manual supervision. Overall, it concludes that such smart systems are well suited for applications requiring continuous analysis and instant feedback.

[16] The work carried out describes the development of an AI music generator using the Streamlit framework and deep learning techniques. It explains how a neural network is trained on musical data to learn note sequences and patterns, which are then used to generate new musical compositions automatically. The study highlights the use of Streamlit to build a simple, interactive web interface where users can set parameters and listen to the generated output. It also discusses the data preprocessing steps and the model training process required for producing coherent melodies. The paper shows that such a system makes music generation accessible even to users without formal musical knowledge. Overall, it concludes that deep learning combined with lightweight web frameworks enables easy deployment of creative AI applications.

[17] The work carried out investigates deep learning-based methods for automatic music generation and evaluates their ability to produce high-quality musical content. It explains how models such as recurrent networks and transformer-based architectures learn the structure, rhythm, and harmony of music from large datasets. The study highlights the techniques used for representing music in a form suitable for neural networks and for sampling new sequences from trained models. It also discusses evaluation measures that compare the generated music with human compositions. The paper shows that deep learning models can generate coherent and stylistically consistent music with improved diversity. Overall, it concludes that these methods have strong potential for creative assistance, music education, and interactive composition tools.

[18] The work carried out reviews various artificial intelligence techniques used for music generation, ranging from rule-based and probabilistic models to modern neural network approaches. It explains how methods such as recurrent networks, generative adversarial networks, variational autoencoders, and transformers are applied to compose melodies, harmonies, and accompaniments. The study compares these techniques in terms of output quality, creativity, controllability, and computational requirements. It also highlights challenges such as maintaining long-term musical structure, limited datasets, and the difficulty of evaluating creative output objectively. The paper shows that no single technique is best for every task and that the choice depends on the application. Overall, it concludes that continued research is needed to make AI-generated music more expressive, controllable, and practical.

[19] The work carried out presents an AI-based music generation system that produces new musical pieces using machine learning models trained on existing music data. It explains the steps involved, including data collection, preprocessing of musical sequences, model training, and generation of new melodies. The study highlights how the system learns patterns of notes and rhythm and uses them to create original compositions in a chosen style. It also discusses the use of a simple user interface through which learners and enthusiasts can interact with the generator. The paper shows that the system generates pleasing and structured music with limited user input. Overall, it concludes that AI-based generation can support creativity and also serve as a useful tool in music learning and practice.

[20] The work carried out explores the use of Long Short-Term Memory (LSTM) networks for generating music by modeling the temporal dependencies present in musical sequences. It explains how the network is trained on sequences of notes so that it can predict the next note and gradually produce complete melodies. The study highlights the ability of LSTM networks to retain long-range information, which helps in maintaining rhythm and structure across a composition. It also discusses the representation of musical data and the training strategies used to improve output quality. The paper shows that the generated music is more coherent than that of earlier sequence-modeling methods. Overall, it concludes that LSTM-based models are an effective foundation for intelligent music generation and interactive music systems.

III. METHODOLOGY

The proposed system is developed as an inclusive and intelligent music learning platform for Divyang (differently abled) learners by integrating artificial intelligence, real-time music analysis, tactile feedback, and speech-based assistance. The system is designed to overcome the limitations of conventional music learning methods by providing personalized training, real-time performance evaluation, and accessible feedback. The implementation consists of user management, audio acquisition, music signal processing, AI-based performance evaluation, tactile feedback, speech assistance, adaptive learning, database management, and system testing modules. The system requirements are identified by considering the challenges faced by differently abled learners during conventional music training. The major requirements include accessible user interaction, real-time performance evaluation, rhythm indication through tactile feedback, speech-based instructions, personalized learning, and secure storage of learner information. Based on these requirements, the system architecture is designed by integrating the user interface, audio input unit, music processing module, AI evaluation module, feedback modules, database, and subscription management system. The learning platform provides three levels, namely Free Beginner Mode, Standard Subscription Mode, and Premium Subscription Mode, with different levels of learning content and interactive features.

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The user registration and subscription module allows learners to create individual accounts and select an appropriate learning plan. User information, selected learning level, practice history, subscription details, and performance records are stored in the database. The Free Beginner Mode provides basic lessons and exercises, while the Standard and Premium modes provide advanced learning materials, personalized exercises, detailed performance analysis, and additional interactive features. This module enables the system to maintain individual learner profiles and track their progress throughout the training process.

The audio acquisition and music processing module captures the learner's musical performance using a microphone or suitable audio input device. The sound produced by the musical instrument is captured and converted into a digital audio signal for further processing. The acquired audio signal is processed to identify important musical characteristics such as pitch, rhythm, tempo, note sequence, and timing information. Signal-processing techniques are applied to extract relevant musical features from the recorded or continuously acquired audio. The processed musical information is then passed to the AI-based performance evaluation module for further analysis.

The AI-based performance evaluation module acts as the core component of the proposed system. The musical features extracted from the learner's audio are compared with predefined reference patterns corresponding to the selected lesson or exercise. Artificial intelligence and machine-learning techniques are used to identify deviations in pitch, timing, rhythm, and note accuracy. The system detects incorrect notes, missed notes, delayed notes, and other performance deviations and generates an overall performance score. Based on the detected errors, suitable corrective suggestions are generated to help the learner improve musical accuracy and performance.

To improve accessibility for hearing-impaired learners, a tactile feedback mechanism is incorporated into the system. Musical beats, rhythm patterns, and timing information obtained during music processing are converted into predefined tactile patterns using an actuator-based feedback interface. The learner can perceive rhythmic information through physical sensations instead of depending completely on auditory signals. The tactile feedback module operates in synchronization with the music-processing and AI-evaluation modules, allowing the learner to receive immediate feedback during practice.

The speech-based assistance module uses text-to-speech technology to provide voice instructions, navigation support, lesson guidance, and performance feedback. Information generated by the AI evaluation module is converted into speech and communicated to the learner. The module can announce detected errors, provide practice instructions, explain lessons, and communicate performance scores. This feature improves accessibility for visually impaired learners and users who require voice-based interaction during the learning process.

The real-time feedback and adaptive-learning module continuously monitors the learner's performance during practice. When an incorrect note, timing error, or rhythm deviation is detected, the system provides immediate corrective feedback through the appropriate feedback interface. The adaptive-learning mechanism adjusts the difficulty of exercises according to the learner's performance and progress. Learners demonstrating consistent improvement can be provided with more challenging exercises, while learners experiencing difficulties can receive simpler exercises and additional practice recommendations. This approach enables personalized learning according to individual capabilities and learning speed.

A centralized database is implemented to store user profiles, lesson materials, practice history, performance scores, feedback reports, subscription information, and learning progress. The stored information is used to track the learner's improvement over multiple practice sessions and generate personalized progress reports. Appropriate authentication and access-control mechanisms are considered to protect user information and performance data. The database also enables the system to retain individual learning history and provide suitable recommendations during subsequent practice sessions.

The implemented system is tested under different operating conditions to evaluate its functionality, accuracy, response time, accessibility, and usability. Functional testing is performed to verify the operation of individual modules, including audio acquisition, music analysis, AI-based evaluation, tactile feedback, speech assistance, database management, and user registration. Performance testing is carried out to evaluate pitch and timing detection, error identification, scoring accuracy, and real-time response. Usability and accessibility testing are also performed to determine the effectiveness of the system for differently abled learners. User feedback obtained during testing is used to improve the system's interface, feedback mechanisms, and adaptive-learning performance.

After successful integration and testing, the system can be deployed as an accessible music learning platform for computers and mobile devices. The modular design allows additional musical instruments, languages, AI models, and accessibility features to be incorporated in future versions. The final implementation provides a personalized and interactive environment in which Divyang learners can practice musical instruments, identify their mistakes, receive real-time feedback, and progressively improve their musical skills with greater independence.

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IV. BLOCK DIAGRAM

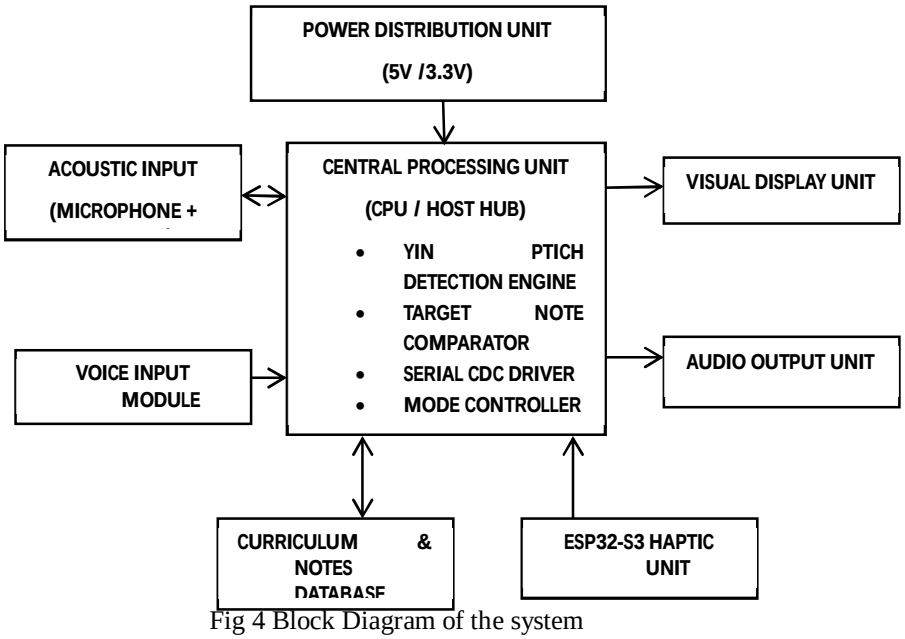


Fig 4 Block Diagram of the system

The block diagram shows how the different hardware and software modules of the system communicate with the Central Processing Unit (CPU/Host Hub)

A. Power Distribution Unit (5V / 3.3V)

The power distribution unit supplies the required 5V and 3.3V power to the different components of the system. It ensures that the CPU, input modules, and haptic unit receive the appropriate operating voltage.

B. Acoustic Input – Microphone + ADC

The microphone captures the sound produced by the musical instrument. The ADC (Analog-to-Digital Converter converts the captured analog audio signal into digital data that can be processed by the CPU. The acoustic data is sent to the central processing unit for pitch detection and note identification.

C. Voice Input Module

This module accepts voice commands from the user. The commands can be used to control functions such as selecting the instrument, choosing a level, or changing the operating mode. The processed voice input is sent to the CPU.

D. Central Processing Unit (CPU / Host Hub)

This is the main processing block of the system. It receives inputs from the microphone, voice module, curriculum database, and haptic unit and performs the required processing.

The CPU contains the following major functions:

- YIN Pitch Detection Engine: Detects the fundamental frequency or pitch of the sound produced by the instrument.
- Target Note Comparator: Compares the detected note with the expected or target note and determines whether the user played the correct note.
- Serial CDC Driver: Handles serial communication between the processing system and external hardware such as the ESP32-S3.
- Mode Controller: Controls different operating modes of the system, such as training, evaluation, and feedback modes.

E. Curriculum & Notes Database

This database stores the learning curriculum, target notes, exercises, and musical information required for training. The CPU accesses this database to determine which note or sequence the user is expected to play.

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F. ESP32-S3 Haptic Unit

The ESP32-S3 controls the haptic feedback mechanism, such as the wearable vibrometer/wristband. When the system detects a wrong, delayed, or otherwise incorrect note, the CPU communicates with the ESP32-S3, which generates the required vibration feedback for the user.

G. Visual Display Unit

The visual display provides information to the user, such as the selected instrument, target note, detected note, performance status, and score. This allows the user to visually understand their performance.

H. Audio Output Unit

The audio output provides sound-based feedback to the user. It can be used to provide auditory guidance, confirmation, or spoken information, particularly to improve accessibility for visually impaired users.

V. FLOWCHART

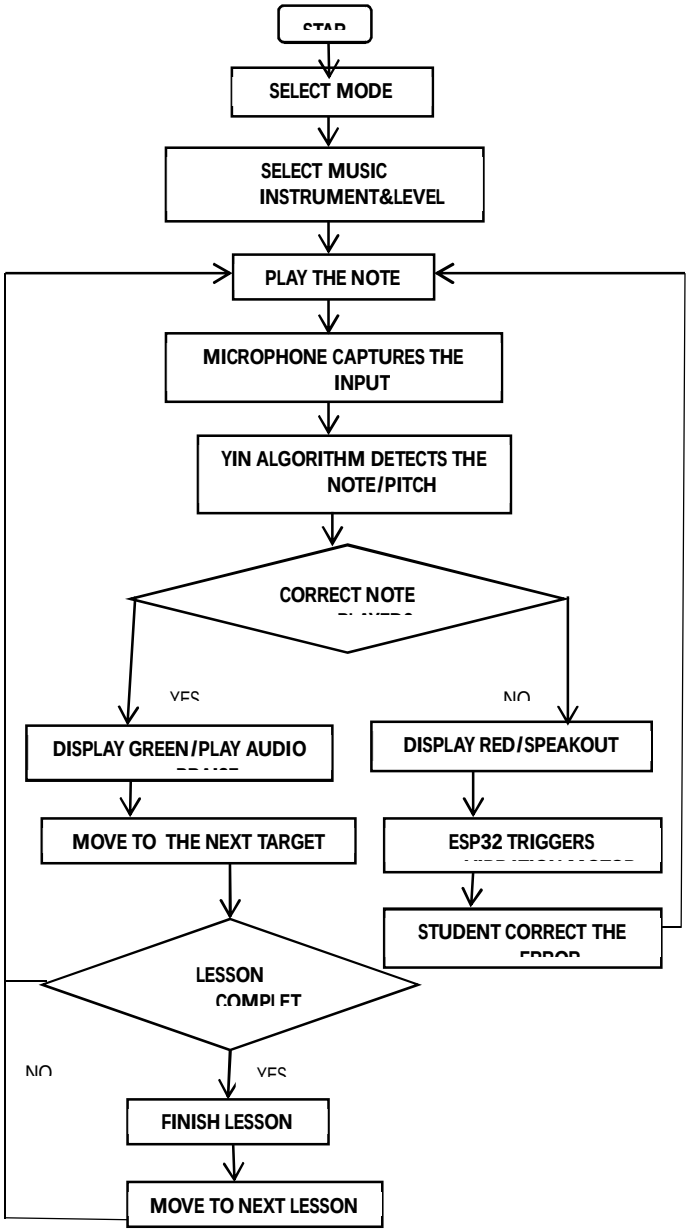


Fig 4 Flowchart of the system

The flowchart represents the implementation workflow of the proposed AI-based real-time music instrument training and performance evaluation system for Divyang learners. The system combines audio acquisition, pitch detection, real-time error identification, and accessible feedback to provide an interactive learning experience.

1) Start and Mode Selection: The process begins when the learner starts the system and selects the appropriate training mode based on their accessibility requirements.
2) Instrument and Level Selection: The learner selects the musical instrument and difficulty level. This allows the system to provide suitable target notes according to the learner's current skill level.
3) Playing the Target Note: The system presents a target note, and the learner attempts to reproduce the note using the selected musical instrument.
4) Microphone-Based Input Capture: The microphone captures the audio produced by the learner's instrument. The captured signal is provided to the music-processing module for real-time analysis.
5) Pitch Detection Using YIN Algorithm: The captured audio is processed using the YIN pitch-detection algorithm to estimate the fundamental frequency of the played note. The detected pitch is then compared with the expected target note.
6) Correct Note Verification: The system determines whether the detected note matches the target note within the defined accuracy range. This decision controls the subsequent feedback and learning process.
7) Correct Note Feedback: If the note is correct, the system provides positive feedback through a green visual indication and audio praise. The learner is then directed to the next target note.
8) Incorrect Note Feedback: If the detected note is incorrect, the system displays a red visual indication and provides spoken correction. An ESP32-based feedback unit can also activate the feedback motor to provide an immediate tactile alert, which is particularly useful for learners with hearing impairment.
9) Error Correction and Repetition: The learner corrects the mistake and repeats the note. The system again captures and analyzes the input, creating a continuous practice–evaluation–correction loop until the target note is performed correctly.
10) Lesson Completion: After all target notes in the current lesson are successfully completed, the system identifies the lesson as completed and allows the learner to proceed to the next lesson.
11) Next Lesson and Adaptive Learning: The learner can continue with the next lesson, where the difficulty can be adjusted according to their performance and progress. Thus, the implementation provides a continuous and personalized learning process.

Overall, the flowchart implements **a** real-time closed-loop music training system in which the learner plays a note, the microphone captures the sound, the YIN algorithm detects its pitch, and the system compares it with the target note. Based on the result, appropriate visual, audio, and tactile feedback is generated. Incorrect performances are repeated and corrected, while successful performances lead to the next target note. This approach enables continuous performance evaluation and accessible music training for Divyang learners

VI. FUTURE SCOPE

Here's the future scope for your AI music teacher project, explained in simple terms with enough detail to actually use in a report or presentation:

1) Adding more instruments over time: Right now you're covering piano, guitar, violin, and flute. In the future, this could expand to almost any instrument drums, tabla, saxophone, ukulele because the core method (listening to sound, detecting pitch and timing) works the same way regardless of instrument. Each new instrument just needs its own frequency range and sensitivity settings, the way we tuned flute differently from piano.
2) Adding technique feedback, not just note correction: Right now, the system only tells the user *whether* the right note was played, not *how* it was played. A future version could add a small motion sensor (an IMU, which we talked about earlier and deliberately left out of your current build) to also sense things like bowing angle for violin or wrist posture for piano helping catch technique mistakes, not just note mistakes.
3) Personalized difficulty and progress tracking: As the student improves, the AI could automatically make exercises harder, track which notes/timings they struggle with most, and adjust what it teaches next. This turns it from a one-size-fits-all tool into something that adapts to each learner, like how language-learning apps adjust difficulty based on your mistakes.
4) Making the wearable smaller and commercial-ready: Right now you're building a prototype with breadboard components. In the future, this moves to the custom PCB stage we discussed shrinking everything down to a genuinely wearable, comfortable, all-day device, closer to something that could actually be sold or distributed to schools/individuals.

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5) Making it work without needing a phone nearby: Right now, the wearable depends on a phone doing the audio detection and sending signals over BLE. In the future, if processing power allows, the AI detection itself could run directly inside the wearable, so students don't need to keep a phone connected during practice.
6) Multi-language support: Since blind users get spoken feedback (text-to-speech), this feature could expand to support multiple languages, making the tool usable by non-English speaking students as well.
7) Community and teacher-connected features: A future version could let a real music teacher remotely check a student's practice history and progress from the AI system's data, bridging AI-assisted self-practice with actual human instruction. This is often how assistive-tech tools that start as one-time projects mature into genuinely useful products.
8) Broader accessibility research contribution: Since your project sits at the intersection of music education and accessibility tech, it has genuine potential beyond just a personal/college project — it could be developed into a published research paper or entered into assistive-technology competitions, especially given how specific and well-thought-out your vibration-based feedback approach already is.

VII. RESULT

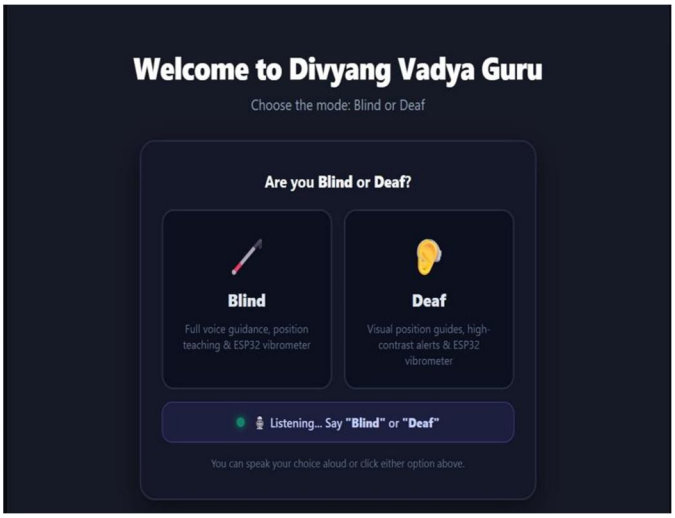


Fig 6.1:Mode-selection landing screen

Letting the user choose Blind or Deaf mode by voice command or click, each paired with ESP32-based vibromotor feedback

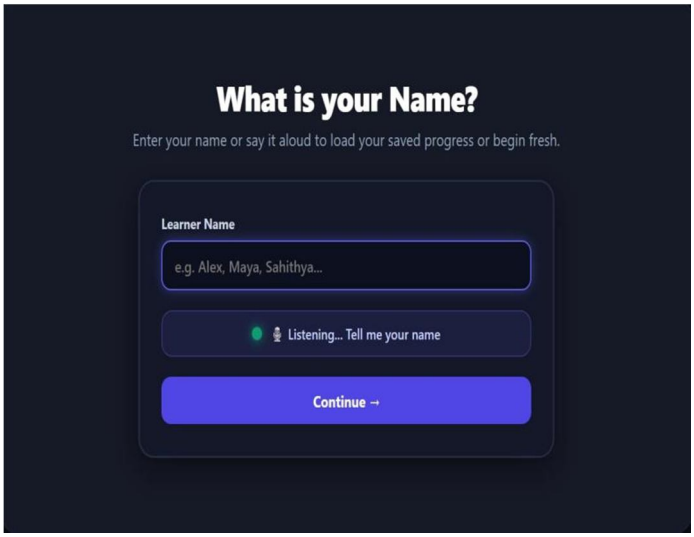


Fig 6.2:Learner name entry screen

Allowing the user to type their name or say it aloud, used to load saved progress or begin a new session. A microphone status indicator shows "Listening… Tell me your name," reinforcing the same voice-first accessibility pattern used on the mode-selection screen, followed by a "Continue" button to proceed.

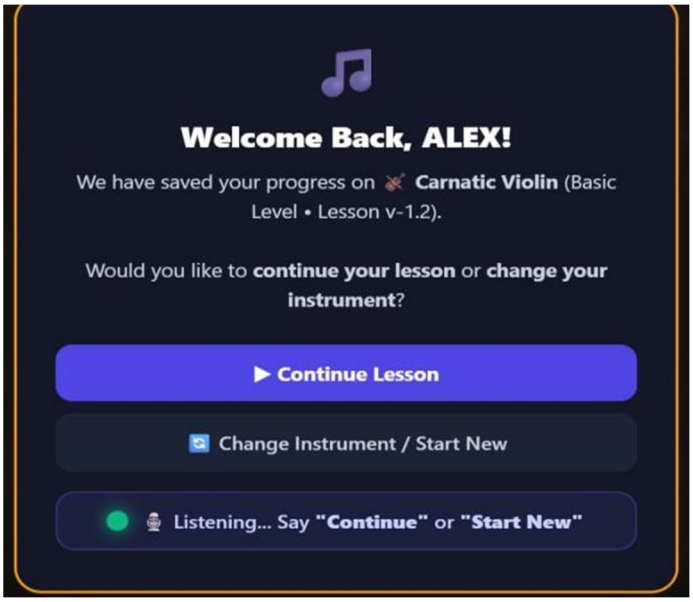


Fig 6.3 If details entered previously,the AI asks if lesson has to be continued or start a new lesson.

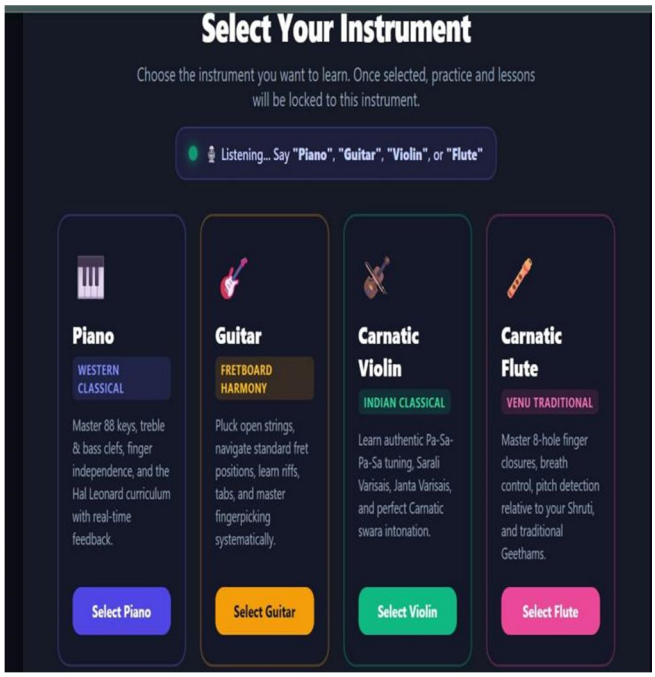


Figure 6.4 Selection of instrument

Instrument selection screen, letting the user choose which instrument to learn Piano, Guitar, Carnatic Violin, or Carnatic Flute each with a short description of what the module teaches. A voice-command prompt allows selection by speech as well as clicking, consistent with the voice-first accessibility pattern used throughout the site. Selecting an instrument locks practice and lessons to that choice.

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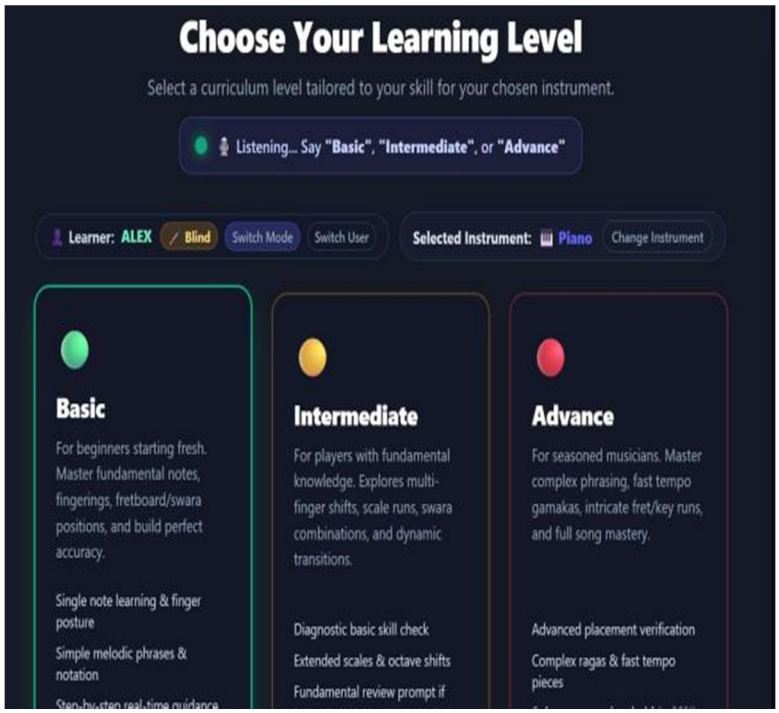


Figure 6.5: Choose the learning level

Learning level selection screen, letting the user choose Basic, Intermediate, or Advance curricula for their selected instrument, each with level-specific focus areas listed. Selectable by voice command or click, with the active learner profile and chosen instrument shown at the top.

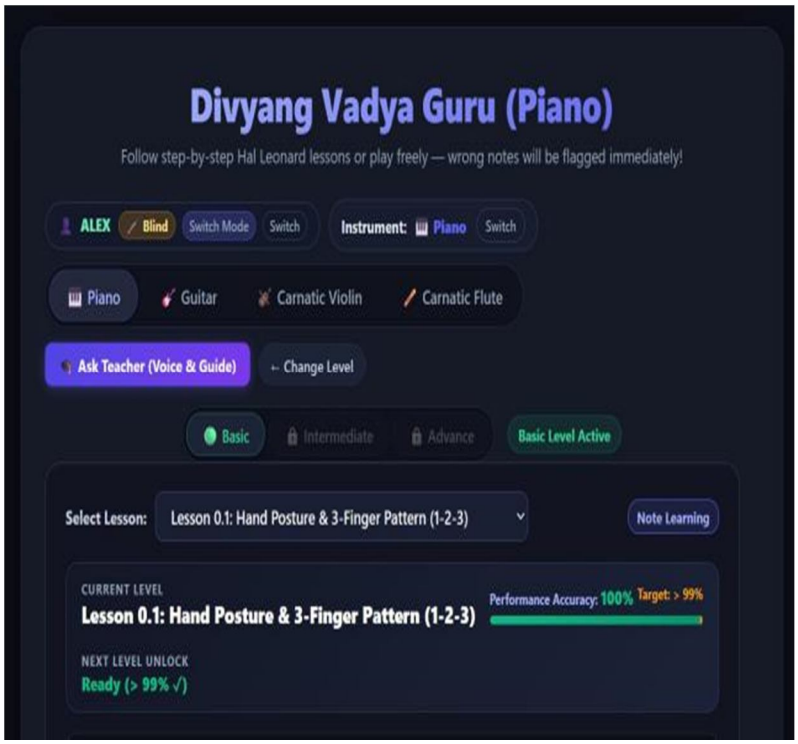


Fig 6..6 User Interface of the AI-Based Musical Instrument Training and Performance Evaluation System.

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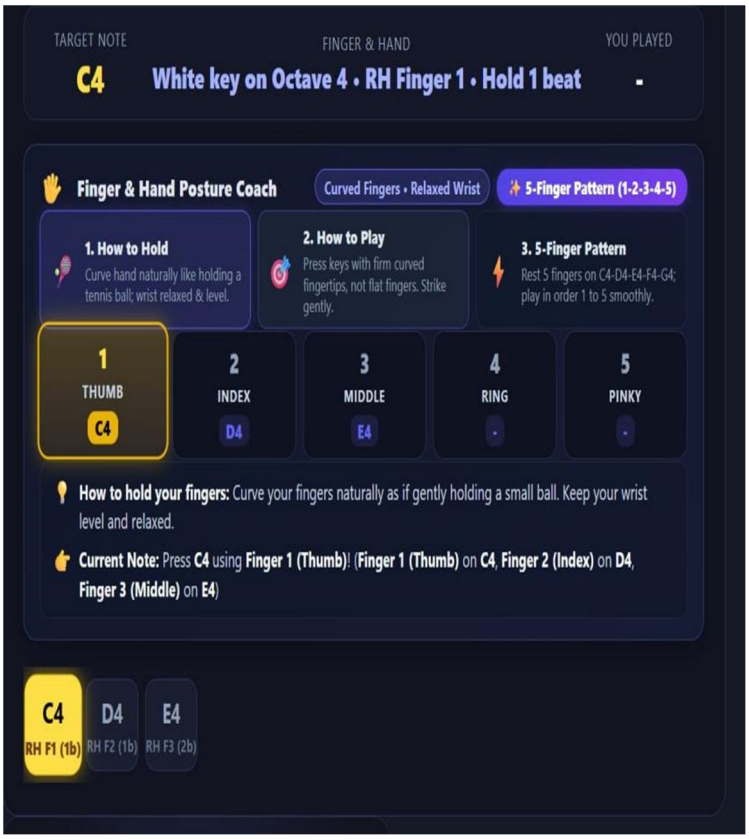


Figure 6.7: Finger and hand posture coaching screen

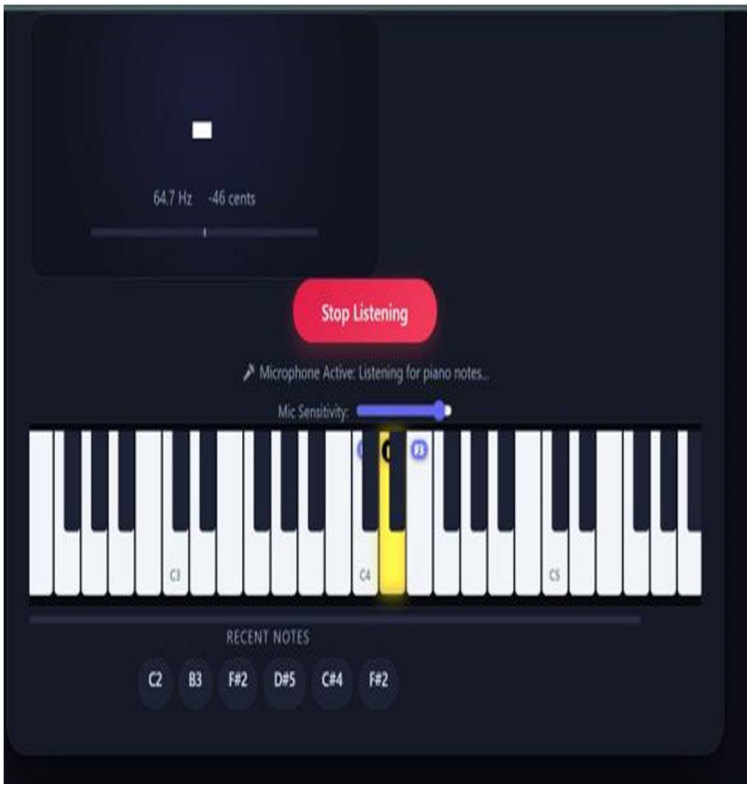


Figure 6.8: Real-time pitch detection interface showing live frequency (Hz), cents

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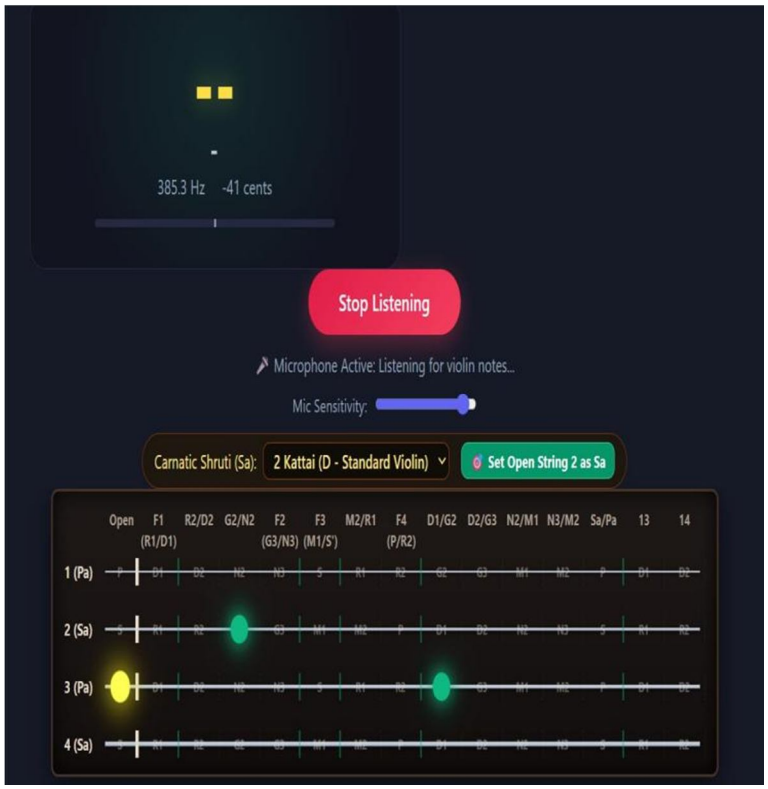


Figure 6.9: Violin pitch-detection interface with Carnatic swara mapping, showing live frequency/cents readout, shruti (tonic) calibration, and a fingerboard chart highlighting the detected note position.

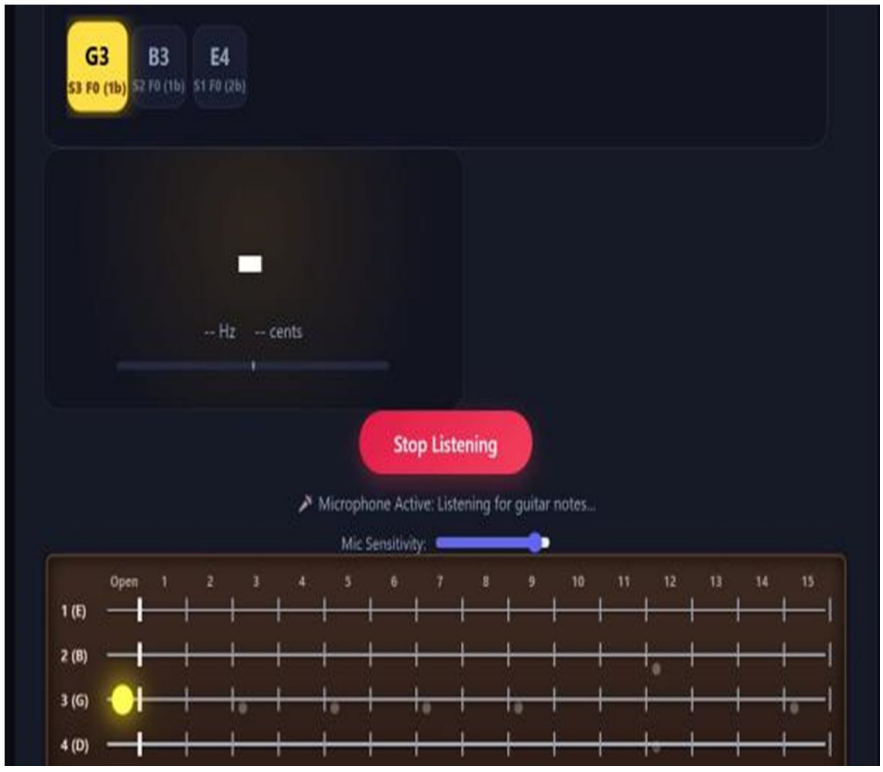


Figure 6.10: Guitar pitch-detection interface showing the current target note (G3), an interactive fretboard highlighting the matching string/fret position, and a live Hz/cents readout awaiting input.

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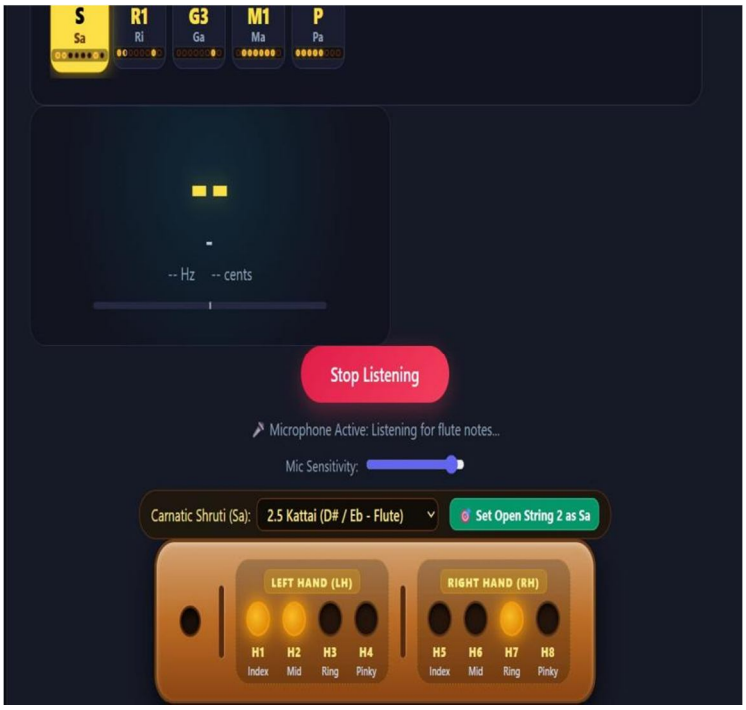


Figure 6.11: Flute pitch-detection interface with Carnatic swara mapping, showing live frequency/cents readout, shruti calibration, and a finger-hole diagram indicating correct hand positioning for the target note

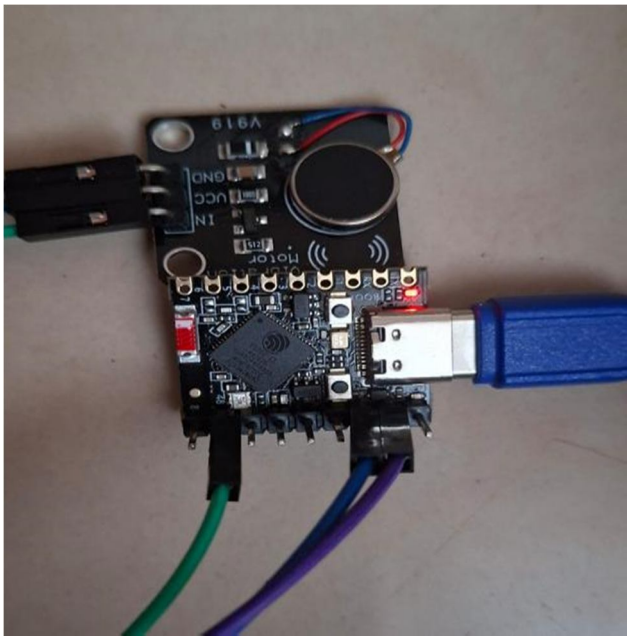


Figure 6.12: Assembled ESP32-C3 Super Mini with vibration motor driver module and onboard coin vibration motor.

VIII. CONCLUSION

The Smart Divyang Vadya Guru system was successfully developed as an interactive and accessible music-learning platform for Divyang users. The developed system provides a user-friendly interface through which users can register, log in, select their accessibility requirement, choose a musical instrument, and select an appropriate learning level. The frontend interface was designed to make the learning process simple and easy to understand. A virtual keyboard was also developed to allow users to practise musical notes directly through the system.

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The system successfully detects the musical notes played by the user and compares them with the required notes. When the correct note is played, the system continues the training sequence and updates the user's progress. When an incorrect note is played, the system identifies the error and provides feedback to the user. A scoring system was implemented to evaluate the user's performance based on the notes played correctly and incorrectly. This helps the user understand their performance while practising and provides a more interactive learning experience.

The project also includes accessibility features to support users with different disabilities. Speech-based guidance is provided to assist users who require audio instructions, while vibration-based feedback is planned to provide physical feedback for users who cannot depend on audio information. The integration of the physical vibration unit is being further developed using the selected hardware components. The backend and frontend components were also connected to support communication between the user interface and the music-learning system.

The developed system demonstrates that AI and interactive technology can be used to make music education more inclusive and accessible. Instead of depending completely on traditional methods of learning music, users can receive immediate feedback while practising. The system can help users learn at their own pace and gradually improve their musical skills. The combination of note detection, scoring, speech guidance, visual feedback, and vibration-based assistance provides a foundation for an accessible digital music-learning platform.

IX. APPLICATIONS

1) Music Education and Training: The proposed system can be used in music schools, colleges, academies, and training centers to provide interactive instrument learning. It helps learners practise independently by providing real-time performance evaluation and immediate feedback on pitch, rhythm, timing, and note accuracy.

2) Assistive Music Technology: The system can support Divyang learners by providing accessible learning through visual, speech-based, and tactile feedback. These features help users with hearing or visual impairments understand musical instructions and practise instruments more effectively.

3) Professional Music Practice: The system can be used by musicians for individual practice and performance improvement. It identifies errors in notes, pitch, rhythm, and timing and provides performance scores, helping musicians monitor their progress and improve their skills.

4) Music Therapy and Rehabilitation :The system can be used in music therapy and rehabilitation environments to provide structured and personalized musical exercises. Continuous performance tracking and feedback can help users practise at their own pace while monitoring their improvement

5) Music Examination and Skill Assessment: The system can be used for automated music examinations and skill assessment. It evaluates parameters such as pitch, rhythm, tempo, timing, and note correctness to generate performance scores and progress reports, supporting more consistent and objective evaluation.

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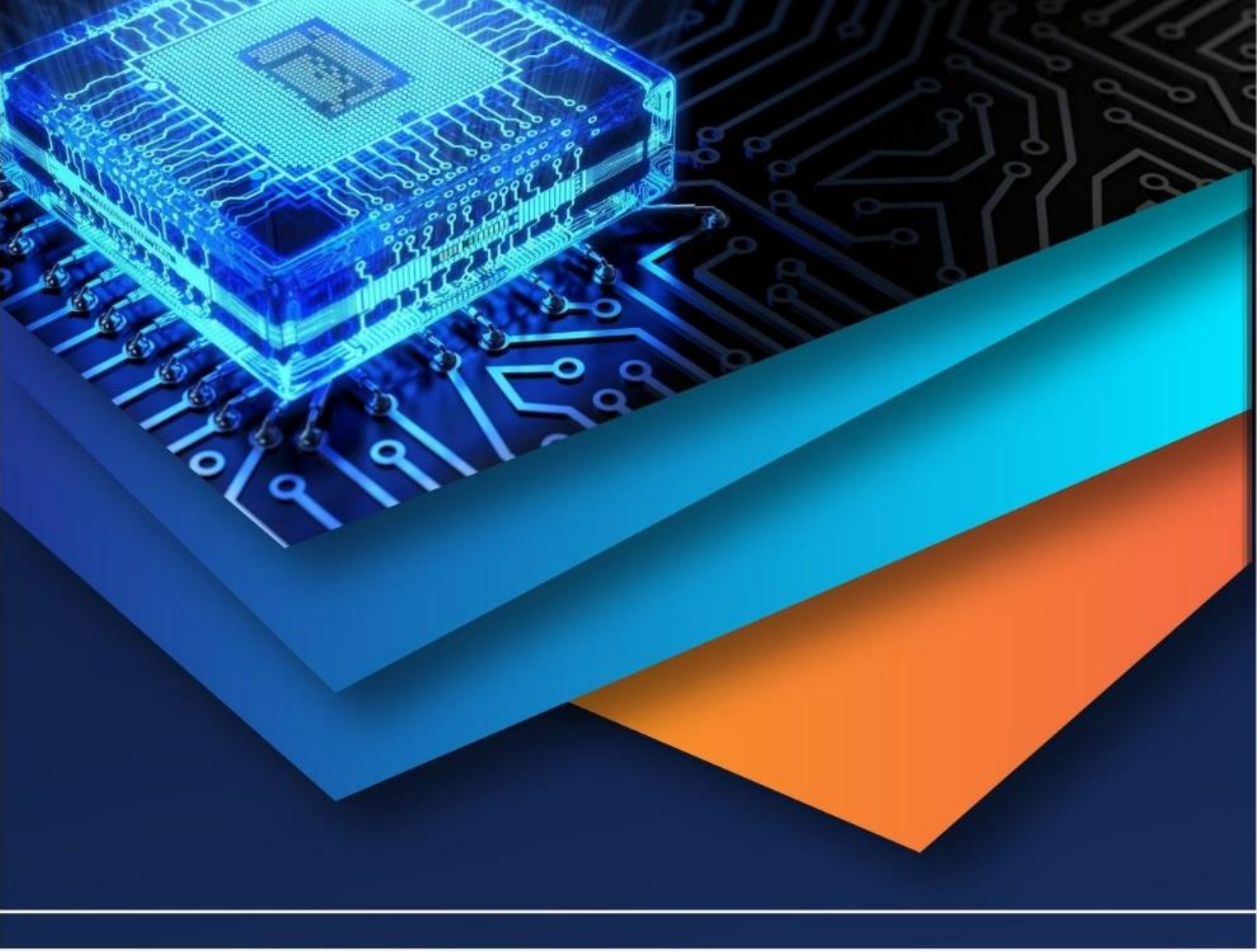
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