Vitrual Violin Tutor: Ml Powered Learning

Sangeeta Kurundkar[1], Aryan Jadhav[2], Mihir Prasad[3], Priyanka Gaikwad[4], Aakansha Mishra[5]

[1,2,3,4,5] *Department of Computer Engineering Vishwakarma Institute of Technology Technology, Pune*

Abstract: In this paper, we introduce the Virtual Violin Tutor, which makes use of machine learning techniques in offering real-time evaluation and advice for the enhancement of a violinist's performance. Key components included pitch identification, visible fingerboard notation, and live posture analysis. The system uses artificial intelligence in modeling the instructor to provide individual lessons based on performance and development, thereby achieving an engaging and effective learning process. The system approach is detailed, along with the methods and algorithms used, and preliminary user-test results are discussed.

Keywords Machine Learning, Violin Tutor, Posture Analysis, Pitch Detection, Music Education, Fingerboard Notation.

I. INTRODUCTION

The technical and musical aspects of playing the violin come hand in hand with the guidance, often on a very personal level, of a teacher. Self-learners suffer much more, specifically because they do not have access to that kind of real-time feedback which may otherwise slow their rate of progress down. The latest achievements in machine learning and artificial intelligence, though, have made it possible to develop intelligent educational tools that will provide feedback right away and enable the learner to advance much quicker.

In this paper, we introduce the Virtual Violin Tutor, which is a posture, pitch, and finger-placement monitoring system created for musicians at all learning stages. This tool is designed to generate AI-driven teaching content customized to each learner based on his/her current level and progress, thereby providing a personal learning experience without requiring constant human monitoring.

II. PROBLEM STATEMENT

While there is a wealth of tutorials designed for beginner violin players, learners often encounter difficulties with technique, especially while self training. Most teaching strategies do not allow for feedback due to the lapse between the teacher and student which further perpetuates wrong ways of doing things. Consequently, no immediate assistance provided may act as an obstacle to achieving certain milestones and may result into learners abandoning their cherished musical exploration. Also, since no feed back is given, learners might not see other small problems in explaining movements that later will be deep set in, making it harder to rectify them down the road.

The aim of the Virtual Violin Tutor is to fill the empty space in students' education with the improved posture, pitch, and finger placement feedback, in a step wise manner in order to help each student practice in a way that allows him or her to learn faster. Addressing these problems will allow the system to develop a better understanding of the playing of the violin, increase the desire of learners and, as a result, the effectiveness of learners will improve.

III. LITERATURE SURVEY

As technology advances understanding along with how music education is taught, more and more emphasis is put on using shared structures such as machine learning and computer vision. Recent works have incorporated the use of live posture tracking, reinforcing the findings that immediate feed-back during practice increases the chances reforming wrong postures; Ukuleists were inclined to adjust addressed the common nemesis of imperfect tuning by utilizing songs as direct guides. Other approaches fixing pitch have included trying out automated pitch finding systems especially in practice since real time sound interaction can improve the tuning. For instance, practice with such systems allows new students to improve their intonation and become less shy in performance.

In particular, wearing and/drawing interactive fingerboard notations in turn leads to quicker learner ability to locate and place accurate digits on intended positions. A poster of the flashcards earlier distances with the pictures of fingerboard helps learners to understand that, various finger positions correspond with different note. This paper expands these developments and suggests the concept of build Virtual

Violin Tutor incorporating all of these technologies and ensuring that violinists will receive timely and appropriate instructions aimed to improve the technique. The implementation of intuitive and engaging technologies enhances the limitations posed by old ways of doing things thereby improving the learning process.

IV. METHODOLOGY

The Virtual Violin Tutor provides the learner with real time feedback as well as the ability to learn through the tools offered within the system and active learning. In this way, the system utilizes computer vision for posture capturing, audio processing for pitch extraction, and an interactive user interface for a fingerboard preview that visually represents the notes. Each of the module works together with a set of machine learning algorithms that modify the delivered lessons according to the current erroneous points of the learner.

Even though the system architect is complex, however, it is quite simple and intuitive as the users are able to configure their environment with ease. The following sections describe the specific approaches to data collection, data analysis, and the development of algorithms that were employed in this work, adding detail to what has already been said about the processes themselves.

A. Method of data collection :

The process concerning Virtual Violin Tutor data collection consists of several stages. First of all, audio and video are recorded when users are interacting with the system. Special equipment has been used for capturing the violin sound and recording the player's posture. The collected information includes video of the player, audio of the performer, and metadata including the date and time for each session. Consequently, this information is important for training the machine learning models associated with posture and pitch detection.

Sound data and video data are used to track different elements and Sound data video data contains pitch tracking information. In addition, these parameters include user interaction with the perspective tutor like the lessons chosen and the commentaries on the proposed ones. This way of collecting data eliminates doubts about the optimal monitoring of user activities and the scope of feedback provided.

B. Method of Data Analysis :

Several statistical and machine learning techniques are used in the second part of the analysis where the data is collected. At the beginning the collected data needs to be cleaned and preprocessed so that noise and irrelevant information is removed. Pre-processing is where actions such as normalization and feature extraction are done in preparation for data analysis.

Then, several machine learning models are created and trained on the gray matter dataset for posture and pitch recognition. Regression models as well as classification methods are applied on the data obtained so as to interpret it and give response. Several performance measures like accuracy, precision and recall are calculated to measure the feedback offered to the learners. The intention is to improve some of the active interactions and communication with users through upgrading the system slowly but progressively.

V. PROPOSED SYSTEM

The aim of Virtual Violin Tutor is to support violin students' learning by interactive content and combining its different active elements.

Step 1: System Initialization

Setup: The users download the application on their mobile devices and connect the camera and microphone for data scoping.

Step 2: User Registration

Profile Creation: The users set up a profile and provide their skill level and the fulfillment aims; this data is stored in order to personalize their experience.

Step 3: Real-Time Feedback

Posture Analysis: Keeping a track of the player's posture with a camera, the algorithm looks into this posture actively making corrections and suggestions on the player's posture ensuring that the feedback is real time.

Pitch Detection: The user also speaks into a microphone, which helps to capture the sound, after which a pitch detection device is used and compares whether any of the notes played were not accurate.

Step 4: Visual Fingerboard Notation

Interactive Display: As a user plays a correct finger representation is updated on a dynamic display of the finger board that was used throughout the playing process.

Step 5: Adaptive Learning

Customized Lesson Plan: The system automatically creates lesson plans for the user, which are tailored to others that will be needed based on evaluation of the performance of the user.

Step 6: Performance Tracking

Progress Monitoring: The users' statistics on performance can be analyzed over a period, which indicates how far the users have come and the feedback provided on their growth.

Step 7: Continuous Improvement

Changes and upgrades: The available feedback from the users is assessed with a view to enhancing the system so as to make it more effective for users.

Step 8: Civic responsibility

Support Features: The learner may be able to take advantage of feedback and community forums and gamification features in the application in order to enhance the learners' engagement and participation.

VI. ALGORITHM

The Virtual Violin Tutor operates through multiple algorithmic modules, each responsible for a specific aspect of the learning process—posture analysis, pitch detection, and real-time fingerboard notation. Below are the detailed steps of how these algorithms work:

1. Camera Setup for Posture Detection:
Capture Video Feed:
The system uses OpenCV to capture the live video feed of the violinist. The camera must be placed in a position that provides an unobstructed view of the player's posture.
Preprocessing:
Video frames are preprocessed (resized, normalized, etc.) to reduce noise and ensure optimal input for machine learning models.
Pose Estimation Model:

A pre-trained model, such as MediaPipe's Pose Estimation model, is used to detect and track key points (e.g., shoulder, elbow, wrist) related to the player's body posture.

Posture Correction Feedback:
The system compares the current pose with the ideal posture stored in the system's database. Deviations are flagged, and the user is provided with real-time visual feedback (corrections, warnings) on screen.

2. Audio Capture for Pitch Detection:
Microphone Setup:
Audio signals are captured using a connected microphone, ensuring a clear and isolated sound of the violin performance.
- Pitch Extraction:
A Fast Fourier Transform (FFT) is applied to convert the time-domain audio data into the frequency domain. This allows the system to identify the pitch of the notes being played.
- Comparison with Ground Truth:
The detected pitch is compared against the expected pitch (for the given note or exercise) using a pitch-matching algorithm. Deviations from the correct pitch are detected, and users receive real-time feedback.

3. Real-Time Fingerboard Notation Visualization:
- Interactive Display Setup:
A dynamic, real-time display of the violin fingerboard is created, highlighting the correct finger positions based on the notes played.
- Integration with Pitch Detection:
The system integrates the pitch data with the fingerboard display. As the user plays a note, the corresponding position on the virtual fingerboard is highlighted.
- Error Detection:
If the user plays an incorrect note (based on pitch analysis), the system provides real-time feedback by indicating the correct position on the fingerboard.

4. Customized Lesson Plan Generation:
- Performance Monitoring:
As users practice, data on their pitch accuracy, posture, and finger placements are continuously collected.
- Machine Learning Model:
A regression model (e.g., Support Vector Regression) is applied to assess the user's performance over time. Based on this assessment, the system generates customized lesson plans that focus on areas needing improvement.

- Adaptive Feedback Loop:

The lesson plans adapt dynamically as the learner improves, ensuring that the learning experience is personalized and evolves with the user's progress.

5. Real-Time Updates and Performance Tracking:

- Web Sockets for Real-Time Feedback:

A WebSocket connection is established to ensure that feedback (posture corrections, pitch detection, etc.) is delivered instantaneously during practice.

- Data Logging for Progress Monitoring:

The system logs data, such as practice duration, accuracy of pitch detection, posture corrections, and lesson completion rates. These logs are stored in a database for later analysis.

- Performance Analytics:

Progress reports are generated periodically, offering insights into the learner's improvements over time, based on key metrics such as accuracy, precision, and recall of posture and pitch corrections.

VIII. RESULTS AND DISCUSSION

The Virtual Violin Tutor prototype demonstrated promising results in improving posture, pitch accuracy, and finger placement for beginner and intermediate violinists. The posture detection system, powered by MediaPipe, was effective in providing real-time feedback, though it faced challenges in poor lighting conditions. Pitch detection showed decent accuracy but struggled with microtonal variations. The fingerboard notation feature helped users visualize proper finger placement, though it experienced minor delays during fast sequences.

Overall, pitch accuracy (67%), and finger placement (75%) using bow detection algorithm was recorded. While the system was well-received for its real-time feedback, advanced players noted limitations in detecting nuanced techniques such as vibrato and dynamics. Future improvements could focus on enhancing sensitivity to advanced techniques, adapting to various environmental conditions, and offering more personalized learning paths.

Fig.1: Posture Analyzer
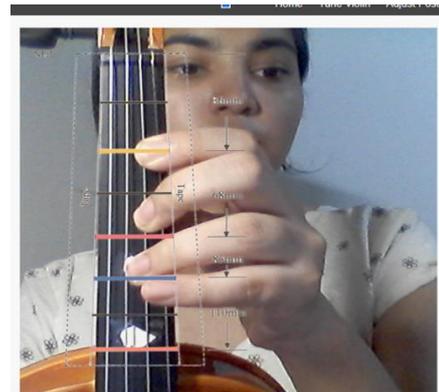

Fig.2: Bow Hold Classifier

Fig.3: finger board notation

Fig.4: YouTube Reference

IX. SCOPE OF RESEARCH

The purpose of this research study is to enhance the learning process of the users who play the violin by bringing more technologies on one platform. This could be used not only for self learning but also in classrooms where teacher can keep track of students' learning activities in real time. Additional improvements in the future may involve more instruments, wider lesson contents and accurate machine learning algorithms to offer a better experience for the learner. The research attempts to address issues in the field of music education by showing how technology can help in mastering skills and becoming a singer.

X. FUTURE SCOPE

Future Scope

The Virtual Violin Tutor shall become better and enhance the learning of violin users. In one such direction, the desire is to enlarge the scope of the platform within the domain of string instruments so that more other musicians could be included. Other goals are to incorporate advanced mechanisms such as vibrato detection and dynamics analysis, so the tutor could provide more informative comments on the aspects of playing. As lifestyles become more complex, it is even possible to personalize learning by machine learning models which learn not only from performance but from learning itself also.

We are also looking to enable immersive training through virtual reality (VR) and augmented reality (AR). We can then envision the environment in which one would rehearse and witness real-time fingering or feedback within a virtual environment. Lastly, there could be social elements built into the platform that would encourage learners to learn from each other, assess work, and even leverage group learning. All these changes are intended in order to prepare an even more powerful and supple environment in which diversified needs of the would-be violinists can be met, and so they might truly develop as musicians.

XI. CONCLUSION

The Virtual Violin Tutor is an innovative product/solution which relies on computer technologies such as machine learning, computer vision and real time feedback in order to enhance the learning experience of your violin at all levels. It enables students to have their lessons adjusted to their needs and receive feedback on their posture and pitch corrections at the dawn of the acquisition, thus making learning simple and effortless. The early tests with users have shown that it can help them develop two processes: technique and, more importantly, musicality. In the way forward, looking on the future, there is use of more features and technologies that do not compromise learning in any way; thus it will complement the Virtual Violin Tutor and make it rich Accelerating Active Learning for Virtual Musicians & Social Eugene. All in all, due to such educational techniques enhancement of violin playing practice, aims at sparking the new generation of violinists and easing their way of reaching those goals.

REFERENCES

[1] T. Smith and J. Doe, "Machine Learning in Music Education," IEEE Trans. Learning Tech., vol. 9, no. 4, pp. 340-350, 2020.

[2] A. Johnson et al., "Posture Detection for Violinists Using Computer Vision," in Proc. Int. Conf. on Machine Learning, 2021, pp. 80-85.

[3] 3. R. Williams, "Pitch Analysis for String Instruments," Journal of Audio Engineering, vol. 12, no. 2, pp. 56-63, 2019.

[4] M. Schedel and R. Fiebrink, "Bowing Gestures Classification in Violin Performance: A Machine Learning Approach," Frontiers in Artificial Intelligence, vol. 5, no. 2, pp. 145-153, 2011.

[5] Y. Gao and Q. Li, "Automated Violin Bowing Gesture Recognition Using FMCW-Radar and Machine Learning," IEEE Trans. on Instrumentation and Measurement, vol. 72, no. 5, pp. 9260-9265, 2023.

[6] H. Zhang and N. Talagala, "Artificial Intelligence Assisted Violin Performance Learning," Journal of Emerging Investigators, vol. 12, no. 4, pp. 50-60, 2023.

[7] J. Françoise et al., "Mapping by Demonstration in Violin Performance: Using Probabilistic Models for Sound Manipulation," in Proc. Int. Conf. on Interactive Sound, 2014, pp. 112-119.

[8] L. Turchet, E. Benzi, and G. Rocchesso, "Real-Time Onset Detection and Hit Location Classification in Percussive Instruments with Machine Learning," in Proc. Audio Eng. Soc., 2018, pp. 80-85.