Real-Time Hand Tracking for Air Musical Instruments: A Computer Vision Perspective

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ABSTRACT

The system introduces a new way to use computer vision to create and interact with musical instruments. It allows users to play instruments like the piano, guitar, and drums without physically touching them. Using a standard webcam, the system captures the user's hand movements and translates them into music. Each module in the system has a unique way of interaction: the Air Piano module tracks finger movements to play virtual piano keys, the Air Guitar module uses gestures to mimic strumming and changing chords, and the drum machine uses colour detection to play drum sounds based on the position of a blue ball. Users can record their music sessions and review them later to practice and improve. It is particularly valuable for those who cannot afford physical instruments due to financial constraints, making music education accessible to a broader audience. Additionally, for individuals living in apartments or small spaces where physical instruments may be impractical due to space limitations, this system provides a practical solution by eliminating the need for physical space. By using this system, everyone has the opportunity to learn and enjoy music without the barriers of cost or space constraints.

Keywords: Computer Vision, Hand Tracking, Gesture Recognition, MediaPipe

INTRODUCTION

In this research paper, we explore a project that uses computer vision and hand tracking to create a virtual musical instrument system. This system includes features like an air piano, air guitar, and air drum, each designed to provide an interactive and immersive experience. The air piano allows users to play virtual piano keys by tracking their hand movements, while the air guitar allows users to strum virtual strings and change chords using hand gestures. The air

drum setup simulates playing a drum kit by detecting a drumstick with a blue ball and producing sounds when it touches different parts of the drum. The goal of this project is to offer a novel way for people to engage with music, using everyday cameras and simple hand gestures to play and record music without needing physical instruments.

LITERATURE SURVEY

Title: Air Drums: Playing Drums Using Computer Vision

Authors: Carl Timothy Santelices Tolentino, Agatha Uy, Prospero Naval

Abstract: The cost of a drum kit is an investment. Most new drummers will eventually become drummers. To continue my craft. What is the purpose of this study? The goal is to accelerate the adoption of drummers. You can experience drumming for free. So that drummers can practice without any burden, Without a full drum kit. So, you can get experience Drumming for a wider audience. Solutions that we are exploring Developing a virtual drum kit prototype. All the user needs are a laptop with a camera. With easily accessible tip marker Drum sticks and knee movements like construction paper. To implement this, Python-based OpenCV was used, and Detection using a colour-based droplet detection concept marker. This prototype also showed potential. For further development with released applications Can be used as a USB controller and MIDI controller.

Title: The Air Guitar: Developing a Cost-Effective Digital Guitar

Authors: Jacob Holton, Karan Chawala, Erik Haukenes, Josie Li

Abstract: Music is a powerful tool in learning and has advantages that no other education can match. Research shows that playing an instrument can improve intelligence, motiva- tion, and intelligence. Music education helps students succeed in school, work, and life. But public schools often struggle to fund music programs, leaving low-income students without these benefits. In addition, students can prioritize other activi- ties other than music. Despite these challenges, technology has made learning music easier, with computer software allowing students to create music without instruments.

EXISTING SYSTEM

Many digital music systems for instruments such as pianos, guitars, and drums rely on keyboards to produce sounds. While this method is commonly used in digital music creation, it often comes with significant issues that can impact the overall user experience. Some systems incorporate motion detection tools like the Leap Motion Controller to play piano sounds, which can enhance musical interaction. the Leap Motion Controller is relatively expensive, making it a costly option for generating piano sounds.

Disadvantages

Current air piano systems typically lack black keys, a critical component for playing a diverse range of music. This absence limits the musical range and accuracy of the air piano. Furthermore, many existing systems do not include recording and

playback features, which are essential for practice and improvement. Musicians who play multiple instruments might also face challenges when using separate systems for each instrument. In contrast, our system facilitates easy switching between the air piano, air guitar, and air drums, offering greater convenience and usability.

RESULTS AND DISCUSSION

In this research paper, we explore a project that uses computer vision and hand tracking to create a virtual musical instrument system. This system includes features like an air piano, air guitar, and air drum, each designed to provide an interactive and immersive experience. The air piano allows users to play virtual piano keys by tracking their hand movements, while the air guitar allows users to strum virtual strings and change chords using hand gestures. The air drum setup simulates playing a drum kit by detecting a drumstick with a blue ball and producing sounds when it touches different parts of the drum. The goal of this project is to offer a novel way for people to engage with music, using everyday cameras and simple hand gestures to play and record music without needing physical instruments. This approach aims to make music more accessible and enjoyable, blending technology with creativity to enhance the way we experience and perform music.

PROPOSED SYSTEM

The Air Instruments project lets users play musical instruments through hand movements detected by a webcam. It features three modules: Air Piano, Air

Guitar, and Air Drum. Each module offers a unique virtual music experience. Users select their instrument from a main menu and interact with it using real-time video input. The system uses computer vision for accurate gesture recognition. The Air Piano maps hand movements to virtual keys, producing piano sounds with visual feedback. The Air Guitar uses hand detection and hand gesture recognition for strumming and chord changes, providing real-time audio feedback. The Air Drum uses colour detection to map a ball on a drumstick to different drum sounds. The project also includes recording features for capturing and reviewing performances, combining real-time analysis and gesture recognition for an engaging musical experience.
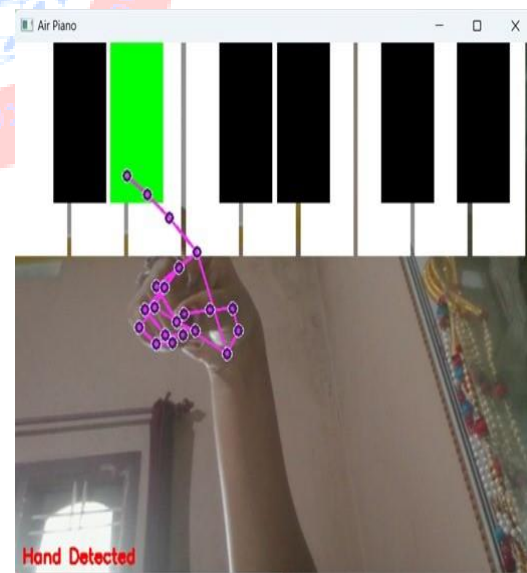
IMPLEMENTATION

Fig 1: Air Piano

Piano Modules: The Air Piano module lets users play a virtual piano using hand tracking through a webcam. It detects hand

and finger positions to simulate piano key presses, including both white and black keys for a one octave of notes. The Record Performance feature allows users to capture and save audio, aiding in practice and skill improvement. The View Performance module helps to view the recorded file.
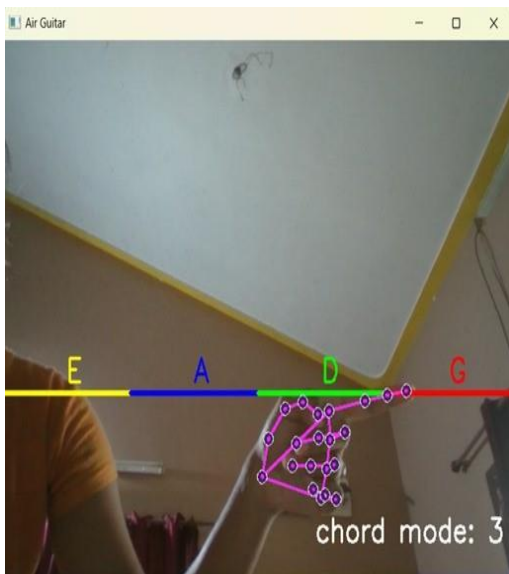

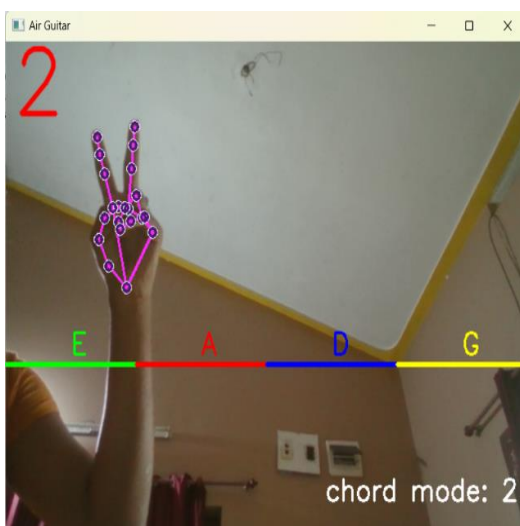
Fig 2: Air Guitar(Chord mode 3)

Fig 3: Air Guitar(Chord mode 2)

Guitar Module: The Air Guitar module allows users to simulate guitar playing through hand gestures using computer vision. It detects hand positions and movements to emulate strumming and chordmode changes(from 0 to 3), supporting various techniques like fingerpicking and chord switching. This provides a realistic guitar-playing experience without a physical instrument. The Record Performance feature captures the audio, enabling users to save and review their sessions for practice and improvement. The View Performance module facilitates playback of recorded sessions with controls for play and pause.
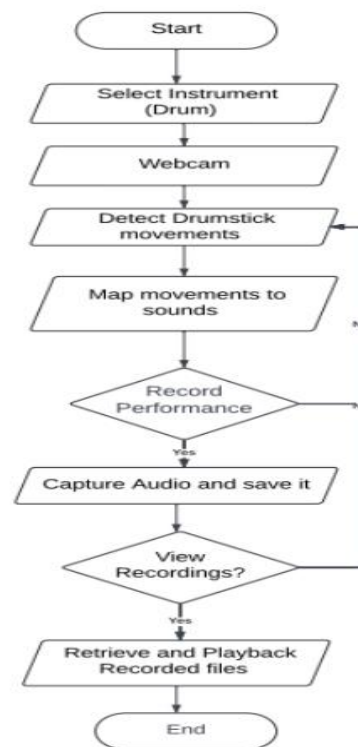

Fig 4: Air drum Flowchart

Drum Module: The Air Drum module lets users simulate drumming using drumsticks.

It uses colour detection to identify and track the drumsticks, typically marked with a colour like blue, and translates movements into drum sounds. This module too has recording and viewing feature like other instrumental modules.

RESULTS AND DISCUSSION

Sl. NO	Test title	Description	Input data	Testcase steps	Expected result	Actual result	status
03	Air Guitar	Ensure that the system correctly detects hand gesture for switching chords and strumming and generates sound accordingly	User's hand, webcam	1.run the program 2.select guitar from the instrument menu 3.select air guitar from the instrument menu 4.position hands in the camera's view 5.perform hand gesture to switch the chords from 0 to 3 6.simulate strumming motions.	The system should correctly detect chord switching and strumming gestures and should trigger the sound accordingly	The system does the chord switching and strumming gestures and also triggers the sound accordingly	pass

Fig 5: Test Case of Air Guitar

The implementation of the air musical instruments system demonstrated the feasibility and functionality of using computer vision and hand tracking to interact with virtual musical instruments. Each module—air piano, air guitar, and air drum—was tested to evaluate performance, accuracy, and user experience.

Air Piano: The Air Piano module lets users play a virtual piano using hand tracking through a webcam. It detects hand and finger positions to simulate piano key presses, including both white and black keys for a one octave notes. The system provides a responsive musical interaction without physical touch. The Record Performance feature allows users to capture and save audio for later review, aiding in practice and skill improvement. The View Performance module complements this by offering playback options. This feedback helps users assess and enhance their performance effectively.

Air Guitar: The air guitar module allowed users to play virtual strings and switch chords based on hand gestures. The chord mode setting worked effectively, with users able to strum virtual strings and produce accurate chord sounds. The system's hand gesture recognition was robust, but some difficulty was observed when users' hand movements were not well-lit or were partially obscured. The ability to rub the index finger along the string line produced the expected sounds, mimicking the experience of playing a real guitar.

Air Drum: The air drum module detected the drumstick's blue ball and responded accurately when it touched different drum components. The system successfully simulated the sounds of the Hi-Hat, Bass Drum, Snare Drum, and Tom Drum. Users reported a realistic drumming experience, with accurate sound production matching their drumstick movements.

CONCLUSION

The project leverages computer vision to create a contactless music system where users play instruments using hand movements. It features three modules: air piano, air guitar, and air drum. Each module offers unique interactions with digital instruments—hand movements for piano notes, gestures for guitar chords and strumming, and colour detection for

drumsticks. The system also includes a recording feature for capturing and reviewing performances. Built with Python, OpenCV, and Pygame, it ensures accurate tracking and sound processing.

FUTURE ENHANCEMENTS

• One major enhancement could be expanding the range of musical instruments available, adding options like the violin, saxophone, or flute to provide a broader musical experience.

• developing multi-ser support would allow multiple players to interact with the system simultaneously, fostering collaborative music lessons.

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