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Implementation of Automatic Piano Player Using MATLAB Graphical User Interface

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ABSTRACT

The conventional piano is often expensive and not portable, its ambidexterity and ubiquity have made it one of the world's most familiar and famous musical instruments. Here in this paper, Proposing Implementation of Automatic Piano Player by using MATLAB GUI software. In this paper we had used the most powerful features of the MATLAB i. e GUI (Graphical User Interface) Toolbox to generate various frequency tones of a piano. This paper presents how MATLAB generates virtual keyboard of a piano via GUI then click on key using mouse then it will generate that tone. And depending upon which key is pressed the frequency related that key will be played.

Keywords*: *MATLAB Software, Notes, GUI (Graphic User Interface), Octaves.

1. INTRODUCTION

In this study, piano notes have been determined using both traditional acoustic analyses as well as programming procedures in MATLAB GUI. The piano is an auditory stringed musical instrument, in which the strings are struck by hammers. It is played using a keyboard, which consists a row of keys that the performer presses down or strikes with the fingers and thumbs of both hands to cause the hammers to strike the strings. The piano was invented in the year 1698 by Bartolommeo Cristofer, the piano is widely employed in classical, jazz, traditional and popular music for solo and accompaniment. Although the piano is very heavy and thus not portable and is expensive.

An acoustic piano usually has a protective wooden case surrounding the soundboard and metal strings, which are strung under great tension on a heavy metal frame. Most modern pianos have a row of combination of 88 black and white keys out of which 52 are white keys for the notes of the C Major (the notes C, D, E, F, G, A and B) and 36 are shorter black keys, which are raised above the white keys. This means that the piano can play 88 different notes, starting from the deepest bass range to the highest treble range. The black keys are also known as accidental notes, which are the sharp and flat notes, which are F#, G#, Bb, C#, and Eb, which are needed to play in all twelve keys. There are usually more than one string per key. The strings can produce sound when the keys are pressured or struck, and quieted by a damper when the hands are lifted off the keyboard. The notes can be maintained, even when the keys are freed, by the use of pedals at the base of the piano. Unlike the two major keyboard instruments that were used widely before the piano was invented are the pipe organ and the harpsichord, the weight or force with which a performer presses or strikes the keys on a piano changes the dynamics and tone of the instrument's sound. The word piano is a shortened form of pianoforte. In the Italian musical terms piano and forte indicate "soft" and "loud" respectively.

1.1. Piano Timbre

The information given in this is relevant in the discussion of piano timbre; how sound is generated on the piano and how a timbre can be changed, how the room may affect the timbre, and how musical sensation changes with

the room or musical actions. The sound from a piano is caused by a order of closely succeeding events. +The piano is an amazed stringed instrument, where each string corresponds to a key on the piano keyboard. When a key is pressed down on the keyboard, this activates a set of levers connected to one another. The movement of the levers leads to a hammer striking the string. Vibration of the string are moved to the soundboard via a wooden bridge, causing the soundboard to resound.

The formula for the frequency of a vibrating string is:

$$F_0 = 1/2\sqrt{(T/M)}$$

Where L is the length of the string, T is the tension and M is mass per unit length.

2. HISTORY

Ortmann's The Physiological Mechanics of Piano Technique from 1929 gives an intricate review of the parts of the skeleton used for piano playing as well as the appropriate muscles. He also presents different timbres, provided with descriptions and playing techniques. Drawings of lines and arrows explaining movement of the arm are bestowed, found from his research on piano technique. More recent research such as Silva et al have studied various recordings of the similar music. Performed analysis included computing self-similarity matrices in order to detect structural similarities between the audio signals as well as Chroma-based signal properties, and their method proved to be successful. Chroma give knowledge on the harmonic nature of the signal. For the Chroma analysis, the Chroma Toolbox in MATLAB was used.

2.1. Types of Piano

MATLAB also supports developing applications with graphical user interface features. MATLAB includes GUIDE (GUI development environment) for graphically designing GUIs. It also has tightly combined graph-plotting features. For example, the function plot can be used to produce a graph from two vectors x and y in 2-dimensions.

Modern auditory pianos have two basic types, the grand piano and the upright piano, with different manners of each. There are also specialized and unique pianos, electric pianos based on electromechanical designs, electronic pianos are based on synthesizer which generates piano-like tones using oscillators, and digital pianos using digital samples of acoustic sounds.

1) Grand

In grand pianos, the frame and strings are horizontal connected to the keyboard, with the strings prolonging away from the keyboard. The action lies underneath the strings, and uses gravity as its means of return to a state of rest. There are many sizes of grand pianos available in the market. A rough generalization distinguishes by their length. Upright pianos, also called vertical pianos and are more compact because the frame and strings are vertical connected to the keyboard. Upright pianos are usually less expensive than the grand pianos. Upright pianos are widely used in churches, schools, music conservatories and university music programs as rehearsal and practice instruments, and they are also popular models for in-home purchase. The hammers struck horizontally, and return to their resting position via springs, which are susceptible to degradation. Upright pianos have unusually tall frames and long strings are sometimes called upright grand pianos. The upright pianos are distinguished by their height.

2) Electric, Electronic, Digital

The first electric pianos are invented in late 1920s used metal strings with a magnetic pickup, an amplifier and a loudspeaker. The electric pianos that became most popular in pop and rock music. Fender Rhodes a teacher from University of Southern California used metal tines in place of strings and used electromagnetic pickups identical to those on an electric guitar. The resulting electrical, analog signal can then be amplified with a keyboard amplifier. Electric pianos are not often used in classical music, where the essential usage of them is as inexpensive rehearsal. Electric pianos are also known as Fender Rhodes pianos they have more popular and important instruments as they are used in funk, jazz fusion and some rock music genres. Electronic pianos are non-auditory they do not have strings, tines or hammers, but have a type of synthesizer that replicate or imitates piano sounds using oscillators and filters that synthesize the sound of an acoustic piano. The synthesizer need to be connected to a keyboard amplifier and speaker to generate sound, however some electronic keyboards have a built-in amplifier and speaker.

Digital pianos are also non-auditory. They do not have strings or hammers in it. Digital pianos use digital sampling technology to exactly reproduce the acoustic sound of each piano note and they also need to be connected to a keyboard amplifier and speaker to produce sound, however most digital pianos have a built-in amplifier and speaker. Instead, a person can practice with headphones to prevent disturbing others. Digital pianos can contain

sustain pedals, weighted keys, more than one voice options and MIDI interfaces. MIDI inputs and outputs allow a digital piano to be connected to other electronic instruments or musical devices.

3) Virtual Piano

The virtual piano is designed using Graphical User Interface and played using your mouse and usually comes with many features found on a digital piano. Virtual piano player software can simultaneously play MIDI music files, highlight the piano keys.

Timbre is a well-known approach in music and baptize attributes describing a sound or sound vibes. All instruments vigilante a characteristic timbre making it possible to differentiate one type of instrument from another. An instrument can also produce an extent of distinctive timbres. It is highly appropriate for a musician aware about these inherited properties of the instrument, as well as relevant technical skills in order to change the musical expression.

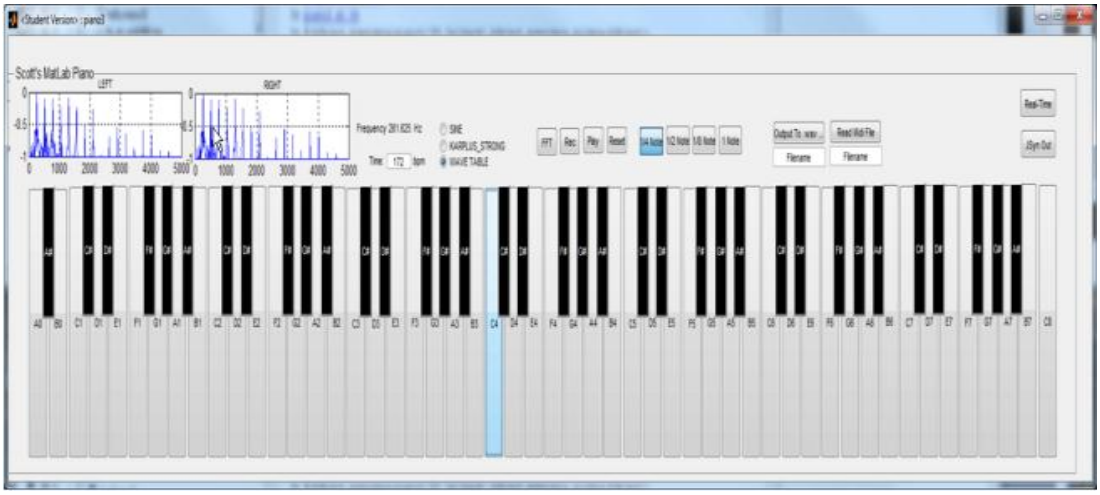

Figure 1. Virtual Piano

3. IMPLEMENTATION

From the existing piano, we have determined frequencies of each and every key. We have assigned those frequencies to virtual keyboard. And we also studied that, how to simulate the graph of each frequency tone by using graphical user interface (GUI).

A graphical user interface (GUI) is a user interface erected with graphical objects, such as push buttons, radio buttons, axes, text fields, sliders, and menus. In general, these objects already have significance to most computer users. For example, when you move a slider on the layout editor of GUI, a value changes; when you press an OK button, your settings are enforced and the dialog box is ousted. Of course, to influence this built-in intimacy, you must be persistent in how you use the distinct GUI-building components. Applications that support GUIs are generally simple to learn and use since the person using the application does not need to perceive what commands are feasible or how they work. The action that results from a specific user action can be made clear by the design of the interface. The sections that follow illustrate how to create MATLAB GUIs. This consists of laying out the components, programming them to do specific things in response to user actions, and saving and launching the GUIs.

The process of implementing a GUI involves two basic tasks:

- Laying out the GUI components
- Programming the GUI components GUIDE chiefly is intent of layout tools. However, GUIDE also produces an M-file that includes code to handle the initialization and launching of the GUI. This M-file supports a framework for the implementation of the callbacks (the functions that execute when users activate components in the GUI). The application of a GUI, While it is possible to write an M-file that includes all the commands to lay out a GUI, it is simple to use GUIDE to layout the components commonly and to produce two files that save and launch the GUI:

FIG-file: includes a complete information of the GUI figure and all of its children (ui controls and axes), as well as the values of all object properties.

M-file**:** includes the functions that dispatch and control the GUI and also the callbacks which are defined as sub functions. This M-file is referred to as the application M-file in this documentation.

3.1. Piano key frequencies

This is a list of the complete frequencies in hertz (cycles per second) of the keys of a modern 88-keys standard or 102-keys piano in 12 -tone equal temperament, with the 49th key as the center and fixed with 440 Hz (referred to as A440). Each subsequent pitch is derived by multiplying (ascending) to the left or dividing (descending) to the right previous by the twelfth root of two (approximately 1.0594631...). This deviation from equal temperament is called the Railsback curve.

The following equation gives the frequency f of the n^{th} key, as shown in the table:

$$f(n) = (\sqrt[12]{2})^{n-49} \times 440\text{Hz}$$

(a' = A4 = A440 is the 49th key on the idealized piano)

Alternatively, this can be written as:

$$f(n) = 2^{n-49/12} \times 440\text{Hz}$$

Conversely, starting from a frequency on the idealized piano tuned to A440, one obtains the key number by:

$$n = 12\log_2 (f/440\text{Hz}) + 49$$

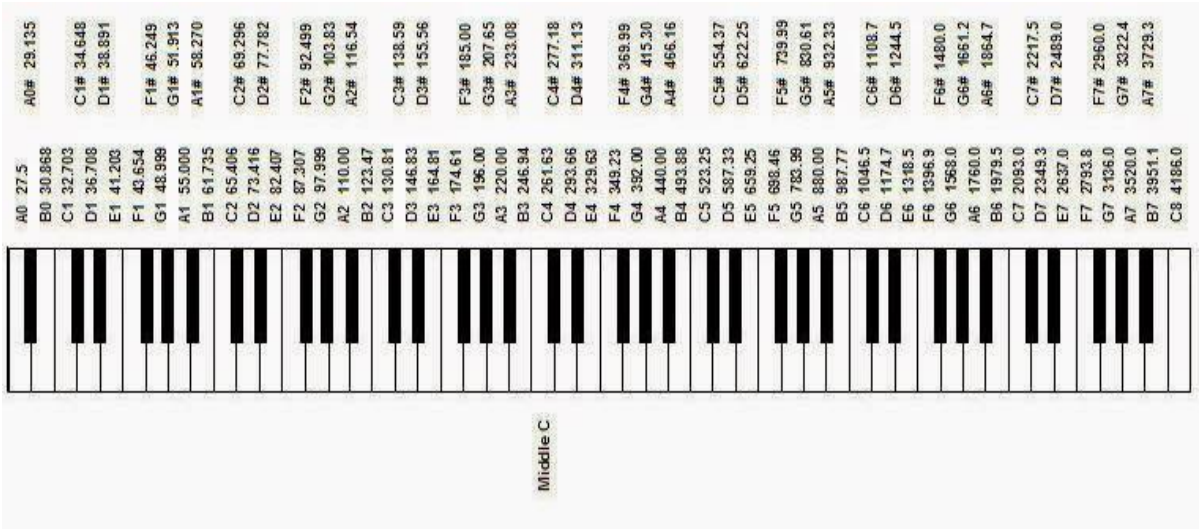

Figure 2. Key frequencies of 88 keys piano

An 88-key piano, with the octaves numbered and Middle C (cyan) and A440 (yellow) highlighted.

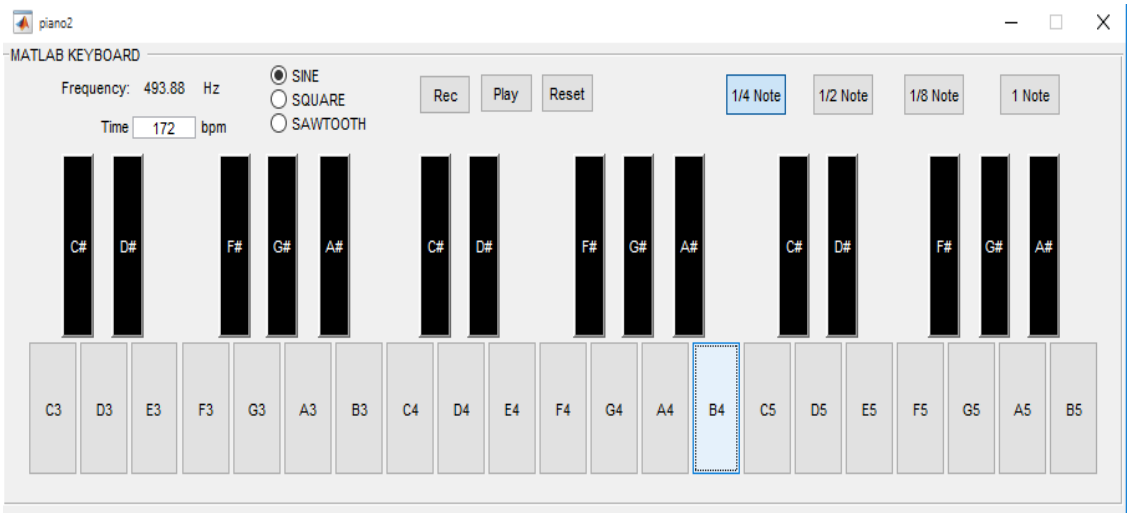

Figure 3. Automatic Piano of 36 keys

3.2. Flow Chart

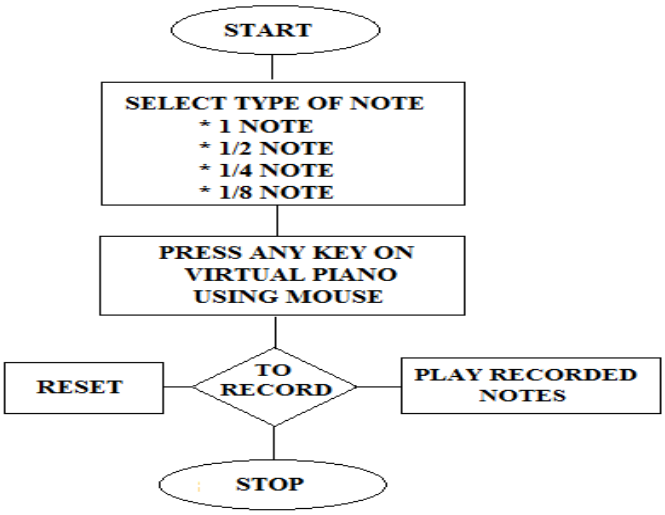

Figure 4. Flowchart of Automatic Piano

4. FUTURE SCOPE

MIDI recordings may be studied in order to give a more precise dynamic and temporal analysis. The latter enables a better identification of differences in timing. Conducting hearing tests may be considered. Introducing the various recordings to a group of people unfamiliar with the content of the project might be informative in terms of finding out more about how the various timbres are perceived.

5. CONCLUSION

Virtual piano already prevails but one cannot determine frequency graph of each tone hence to determine the frequency graph, here adopting MATLAB software. For displaying virtual piano, the most powerful component of MATLAB i.e. GUI (Graphical User Interface) is used and for giving input to each and every key. As everyone knows that in all around the world, Digitization of each and everything is done. As there was a problem in previous conventional piano, it was not easy to handle due to bulky size. By using the MATLAB GUI tool we have successfully implemented automatic piano player with 36 keys in which 15 are black keys and 21 are white keys. Since the future is all about digitizing, as the wooden piano were replaced by electronic keyboards in the same way electronics might get replaced by new technological gadgets.

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