ECE 445: Auto-Played Guitar

Project Proposal

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Introduction

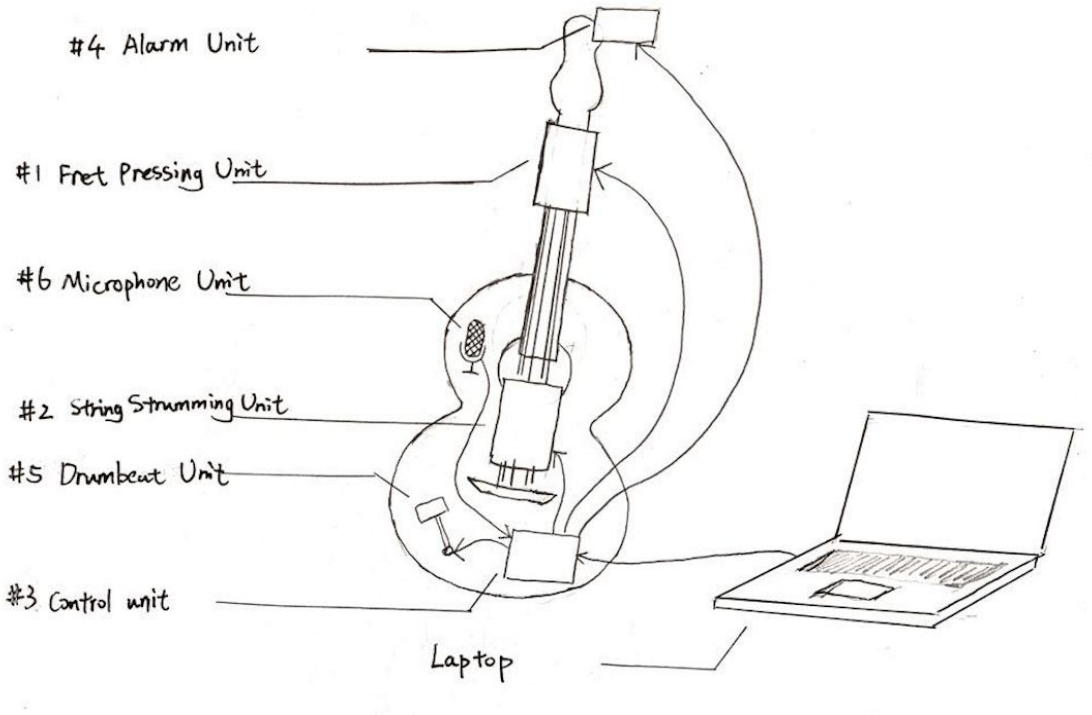
Objective: One to two paragraphs detailing the problem statement and proposed solution.

There are a lot of people or places that need an auto-played guitar for the purpose of demonstration or entertainment. Although the idea of auto-played guitar, just like the auto-played piano that many hotels have for lobby decoration, is not an innovation, all the existing auto-played guitars are expensive to make, too ponderous to be portable, and the auto-played unit has no compatibility to be reinstalled on a variety of guitars. Therefore, the pivot of our design is to build a piece of automatic guitar playing unit that is affordable, portable and compatible with any type of guitars.

Background: One to two paragraphs explaining the context of the problem to be solved by your project, including any relevant references to justify the existence and/or importance of the problem (i.e., the need or want for a solution).

Some people love the original sound of guitar music but lack the time and energy to practice it; Just like the existence and common use of auto-played piano in the lobby of grand hotels[1], some places may need a playing guitar for entertainment or creating atmosphere; guitar stores want to show the good sound quality of the guitars they are selling but it is usually very expensive to hire some to play for a long period of time; music creators want to hear the sound of their customized guitar for testing or for remix; some people may want to hear the authentic sound of guitar music as their wake up alarm; some new guitar learners wish to hear a demonstration of the musical piece that they are practicing on. Although the idea of listening to guitar music can be easily realized by using music players, the beautiful original sounds from different real guitars are irreplaceable. Our project auto-played guitar is a one-for-all solution.

Physical Design: A pictorial representation of your project that puts your solution in context. Not necessarily restricted to your design. Include other external systems relevant to your project (e.g. if your solution connects to a phone via Bluetooth, draw a dotted line between your device and the phone). Note that this is not a block diagram and should explain how the solution is used, not a breakdown of inner components.



The six units of our design should be able to attach to any type of guitar as the above graph shows. The Control Unit will be programmed through the laptop, and is also in charge of sending records from the Microphone Unit to the laptop.

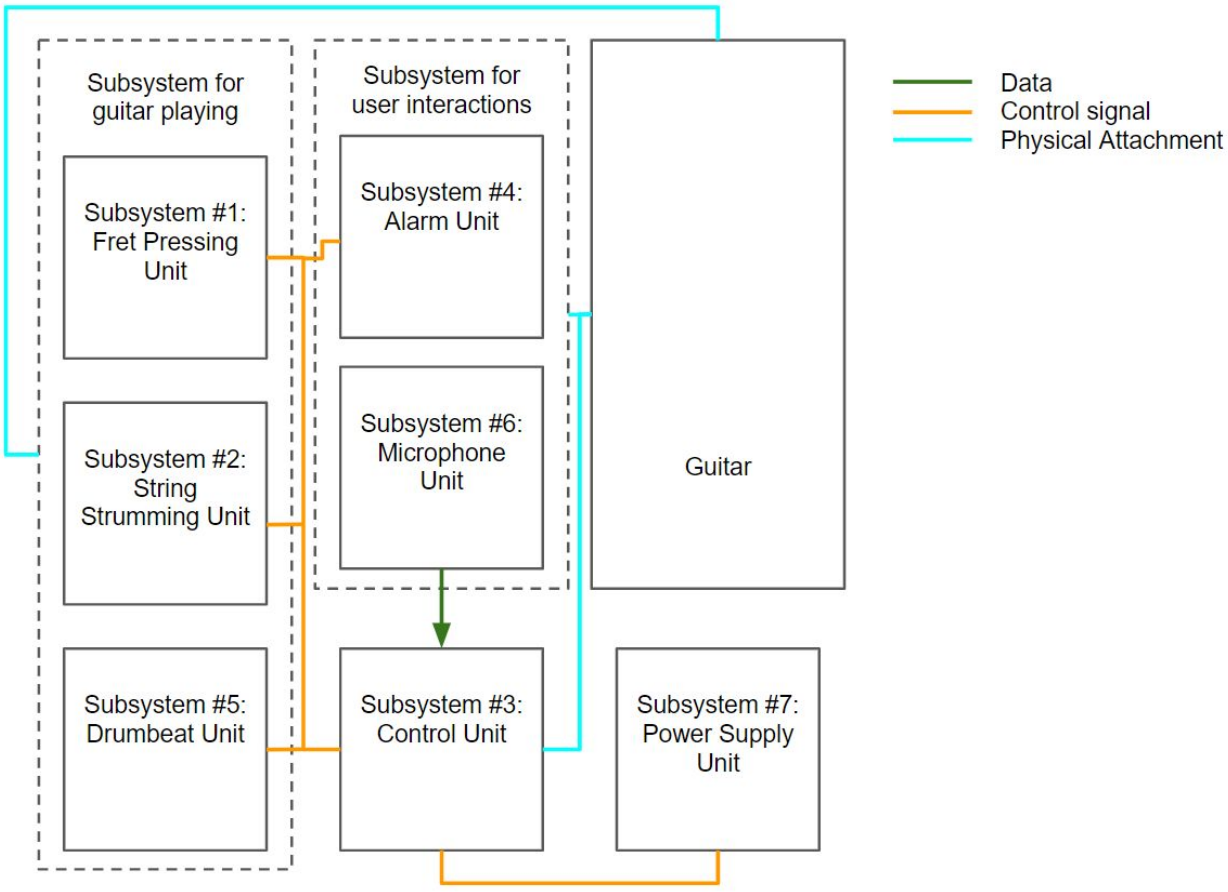
High-level requirements list: A list of three quantitative characteristics that this project must exhibit in order to solve the problem. Each high-level requirement must be stated in complete sentences and displayed as a bulleted list. Avoid mentioning "cost" as a high level requirement.

- Be able to play the correct notes on the guitar in tune and loudly.
- Be able to deliver the drumbeat and guitart note at the correct rhythm, with adjustable tempo

- Alarm functionality with synchronized time in the guitar
- *Additional: Be able to record a piece of music with the microphone and replay with auto-played guitar

Design

Block Diagram: A general block diagram of the design of your solution. Each block should be as modular as possible and represent a subsystem of your design. In other words, they can be implemented independently and re-assembled later. The block diagram should be accompanied by a brief (1 paragraph) description of the high level design justifying that the design will satisfy the high-level requirements.



As illustrated in the figure, a high level design of our system consists of mainly four parts: Subsystem for guitar playing, Subsystem for user interactions, Control unit and Power supply unit. All other Subsystems are controlled collectively by Subsystem #3 Control Unit, which is attached to the body of the guitar. Subsystem for guitar playing, as its name indicates, is responsible for playing music at the correct pitch and rhythm, **which meets our high-level requirement 1 and 2**. Included modules are: Subsystem #1 Fret Pressing Unit: installed on the fretboard (neck) of the guitar for pressing and releasing the strings; Subsystem #2 String Strumming Unit: installed on the body of the guitar for strumming and making sound of the strings. These two units work together to play clear and correct notes according to the program; Subsystem #5 Drumbeat Unit: on the bottom of the guitar, it can periodically strike the guitar body to make drum beats. This unit outputs the tempo and adds some taste to the music being played. In Subsystems for User Interactions, Subsystem #4 Alarm Unit is on the head of the guitar with a LED screen for the user to preset the time for alarm (play the guitar). **The Control Unit keeps synchronized time and compares that with the set alarm time for the alarm functionality**. Subsystem #6 Microphone Unit on the guitar body are for recording and sound input, it should also interact with the control unit, which will analyze the signal and replay the music according to our plan. **This is for the additional functionality.**

Functional Overview: A brief description of the function of each block in the block diagram and explain how each block contributes to the overall design and feature list above. Include a discussion of the interface with other blocks. Every block in the block diagram must have its own description and each description should be 1-2 paragraphs in length.

Subsystem #1: Fret Pressing Unit

This unit is in charge of controlling the actuators attached to the fretboard of the guitar, and it is a crucial part to decide whether the auto-play guitar can play each notes correctly and pellucidly. The initial goal for this unit is to be able to play relatively complex music pieces on the first six frets of the guitar. Given that there are 6 strings on a regular guitar, this unit need to drive at least 6 * 6 = 36 actuators that are hung on the top of the fretboard, pressing or releasing the strings on

each fret. If time allows and everything goes smoothly, the project will support more than just 6 frets.

Subsystem #2: String Strumming Unit

This unit is the part responsible for strumming strings and getting quality sound out of the guitar. The main components of this unit is the signal amplifier and 6 servos (SG90 9G Micro Servo Motor). Each servo is connected to a guitar pick that is in charge of strumming one string. Other than the power supply, each servos should receive an analog signal from the control unit indicating how much and how fast it should turn. There should be at least 4 preset behaviors for servos: quickly strumming, slowly strumming, staying on the string (to mute the sound), and stop in the air (do nothing). It will also instantly react to the analog signal from the control unit.

Subsystem #3: Control Unit

The Control Unit is the pivotal part of the project. It is a STM32F1 board that provides the signals to activate the Fret Pressing Unit, String Strumming Unit and Drumbeat Unit. Also it should be programmed from a laptop to import different music pieces. It takes in data from the Alarm Unit to determine when to play what piece of music as the alarm. It also controls the Microphone Unit in terms of recording and sending the data back to the laptop for analysis.

Subsystem #4: Alarm Unit

The Alarm Unit is one of the advanced functionalities of the project. It puts a small LED screen on the head of the guitar to show the alarm time and two push buttons for adjusting that time. A user can use the push buttons to set the alarm. When there is a change of the time, the Alarm Unit will send the updated time as data into the Control Unit. When the system time of the Control Unit matches the set alarm time, the guitar will play a piece of preset music. Pushing any of the two buttons while the music is playing will stop the performance.

Subsystem #5: Drumbeat Unit

The aim of this unit is to put a servo that connects to a drumstick on the guitar body. It would hit the guitar surface at a certain frequency while playing guitar music. The drum beat serves as an adjunction and enriches the vividity of the performance, while it can be used as a metronome for guitar practicing. It can be activated by the programs in the control unit. Also the angle and speed of servo rotation should be directly controlled by the analog signal from the Control Unit.

Subsystem #6: Microphone Unit

This unit can record the music piece from the guitar and send this music data back into the Control Unit. The control unit should send it to a laptop when requested to do so. The purpose for this unit is for the music writer or singer who wants a record of real guitar sound or a mixture of guitar and other instrument while the guitar is automatically playing.

Subsystem #7: Power Supply Unit

Aiming at portability but also considering that there might be occasions of long time consistent usage, this unit would be the combination of chargeable battery and direct power. Both would supply 5V through USB or direct wiring through PCB to other units.

Block Requirements: Include a list of requirements where if any of these requirements were removed, the subsystem would fail to function. Good example: Power Subsystem must be able to supply at least 500mA to the rest of the system continuously at 5V +/- 0.1V.

Subsystem #1: Fret Pressing Unit

1. The power supply should be 5V (+/- 0.25V) for the linear actuators (ROB-11015) to work properly.
2. The actuators should be stably fixed and hanged precisely on each string of each fret, otherwise the quality of the sound will be inferior.
3. The control matrix should compute fast and correctly the input the 36 actuators with 12 bit signal from the Control Unit.

Subsystem #2: String Strumming Unit

1. The power supply should be 4.8V (+/- 0.2V) for the servos to work properly.
2. The analog signal from the control unit to be (or be turned in to) an analog signal of range 4.8V to 0V.
3. Each servo should respond fast and correctly to the signal of rotation. The delay in performing several actions should be short.

Subsystem #3: Control Unit

1. The USB power supply of the development board needs to be connected to a laptop or a power bank.
3. This unit needs to provide the correct behavior signal to Fret Pressing Unit, String Strumming Unit and Drumbeat Unit.
4. When the recording from the microphone unit ends, the control unit should process the sound signal and save it as an mp3 file to the laptop signal.
5. This unit should monitor the bits from the LED unit and check them with the system clock, if the time matches, it will play a preset piece of music.

Subsystem #4: Alarm Unit

1. The LED screen should be fixed on the head of the guitar.
2. The power supply should be 4.8V (+/- 0.2V) for the LED screen to work properly.
3. The time shown on the LED screen should be able to be changed by two push buttons.
4. The bits representing the time on the LED screen should be sent to the Control Unit, when the time matches the Control Unit system time, the alarm will rise, which means the guitar will automatically play a preset piece of music.
5. When the alarm is ringing, a push to any of the two buttons will not change the time shown on the LED screen but will stop the clock.

Subsystem #5: Drumbeat Unit

1. The power supply should be 4.8V (+/- 0.2V) for the servos to work properly.
2. The analog signal from the control unit to be (or be turned in to) an analog signal of range 4.8V to 0V.
3. The position of this unit on the guitar should guarantee that it can make clear and solid sound.

Subsystem #6: Microphone Unit

1. The power supply should be 4.8V (+/- 0.2V) for the microphone to work properly
2. When the signal command "START RECORDING" from the Control Unit is received, the Microphone should start recording the sound.
3. After the signal command "START RECORDING" is put to low, the sound record should stop and a mp3 file is saved on the laptop connected to the Control Unit.

Subsystem #7: Power Supply Unit

1. The Power Supply Unit must be able to supply a voltage of 5V for a current load up to 5A.
2. The Power Supply Unit must be able to either charge from or convert 120AV voltage to 5V DC.

Risk Analysis: Identify the block or interface that poses the greatest risk to successful completion of the project. Justify your choice.

Subsystem #3 Control Unit is the greatest risk in the project. The main reason is due to the complexity of delivering signals that motivate the Drumbeat Unit, Fret Pressing Unit and String Strumming Unit. The risk is in the decisions, in details, the decision of how fast and how many angles that the servos in the Drumbeat and String Strumming Unit should rotate, and the decision of how to maintain the coordination while several units are performing simultaneously. Also, the data received from the Microphone Unit needs to be processed by the Control Unit and saved as a mp3 file in the laptop, and the Control Unit needs to monitor the Alarm Unit for playing the alarm music, which also introduces complexity and instability for this unit.

Also, Subsystem #1 and #2 might be putting some mechanical difficulties to the system. We need to build a solid frame to attach the two Submodules firmly to a fixed position, otherwise Subsystem #1 wil not be able to press and Subsystem #2 will not be able to strum the right string.

Ethics and Safety

Assess the ethical and safety issues relevant to your project. Consider both issues arising during the development of your project and those which could arise from the accidental or intentional misuse of your project. Specific ethical issues should be discussed in the context of the IEEE and/or ACM Code of Ethics. Cite, but do not copy the Codes. Explain how you will avoid ethical breaches. Cite and discuss relevant safety and regulatory standards as they apply to your project. Review state and federal regulations, industry standards, and campus policy. Identify potential safety concerns in your project.

Our Auto-played guitar module itself is a compact and lightweight device that will attach directly to a guitar. Therefore, it is very hard for the device to cause harm to the user even under situations of misuse. The main concern is the misuse of the device might cause damage to the device itself as well as the guitar.

- The Fret pressing unit utilizes some small motors that should be aligned to the guitar strings. If this unit is not properly placed, the motor might hit some fragile parts of the guitar. During our design, we will make the alignment of the motors on the frame robust enough so that the motors will not shift their place on the frame, also, we will tune the strength of the motion of pressing the string in an attempt to prevent potential damage during misuse.
- The units are connected through physical wires, which might stumble the users if placed wrongly. We will create a physical frame to stabilize the wires in the structure so that the users has much less chance to touch or break the wires.

We anticipate concerns about our work going against #2.6 in ACM Code of Ethics[2] since some people think that machines should never replace human beings in terms of creating art and music. However, in our opinion, the project's purpose is never to replace the human efforts in creating and performing fine music. In contrast, it is rather a means for many more people to enjoy music and get more access to the beautiful and original sound of guitars.

Reference:

[1] Autoplay piano: https://www.youtube.com/watch?v=sxI0PIPZjBQ

[2] Acm.org. (2019). ACM Code of Ethics and Professional Conduct.: https://www.acm.org/code-of-ethics