2012 年英特尔杯大学生电子设计竞赛嵌入式系统专题邀请赛

2012 Intel Cup Undergraduate Electronic Design Contest

- Embedded System Design Invitational Contest

作品设计报告

Final Report

Intel Cup Embedded System Design Contest

Title: **Guitar Robot**

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GUITAR ROBOT

ABSTRACT

This project aims to develop a programmable instrument which works like an acoustic guitar. It is a combination work of mechanical design, software development and hardware integration. In this work, we built all the hardware of this instrument by ourselves. In order to get a better design, we reviewed some existed work first. And then we designed the 3D model of the instrument by using AutoCAD. The implementation work is based on Intel@ Atom CPU platform. We use pneumatic system to play the guitar, use PLC and demo board work as the control module, and use the COM serial port as the communication interface. MIDI file is used as the music source. It has been decoded to generate the control signal and passed to the control module. Meanwhile, 3D graphic has been generated according to notes that decoded from the MIDI file for visualization effect of the music.

This system is suitable to be placed at airport, restaurant and indoor place etc. And it can replace human to conduct music performance.

Key words: Programmable Instrument, Automated Control, MIDI Decoding, Pneumatic Device, 3D Graphic

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Chapter 1 Introduction

1.1 Background

Robot technology is getting more and more popular nowadays. The first stage is represented by industrial robot, the second stage is represented by robot with sense, and the third stage is represented by smart robot which can release human beings from heavy repeating work and even dangerous work. Since all our team mates are music fans, we are motivated to develop a programmable instrument which works like an acoustic guitar.

The original music robot was using automatic gears to create music. In 1863, the first music robot called Pianista was created in Foumeaux [1]. In early 1990s, Trimpin created a instrument called Krantkontrol which is something like an integration of 12 guitars and each guitar have a string system constructed by a motor and a H-bridge.

The designs of our system are mostly inspired from guitar robot of LEMUR and Team Dare. LEMUR (2003) designed their guitar robot as a 4X1 string instrument, which cover almost all the basic element of our project both in hardware and software. The mechanical robot has 3 basic components: support body, string pluck system, and tone control system [2].

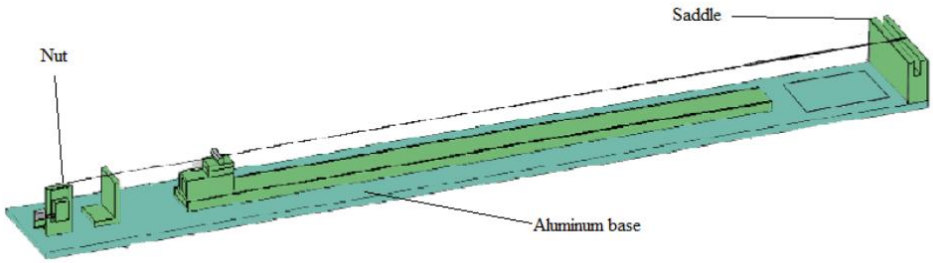

Figure 1-1 LEMUR's guitar robot

Team Dare won the first price of Artemis Orchestra competition in 2008; the guitar robot they built could play a real guitar. The mechanical structure of Team Dare can also divide into 3 parts: tone control system, string pluck system and support bracket. [3]

Figure 1-2 Team Dare's guitar robot

1.2 Overview of our system

After a synthesis of precedent studies, the original design is combine the basic structure of LEMUR's and the tone control system of Team Dare's. The reason is obviously: LEMUR's basic design is small, light and moveable, and the string pluck system of it is very efficient and clear. The only thing they lacked is the tone control system, and Team Dare's design is the best choice. The accurate and dexterous press can make the tone clear and stable. Figure 1-3 shows the system design.

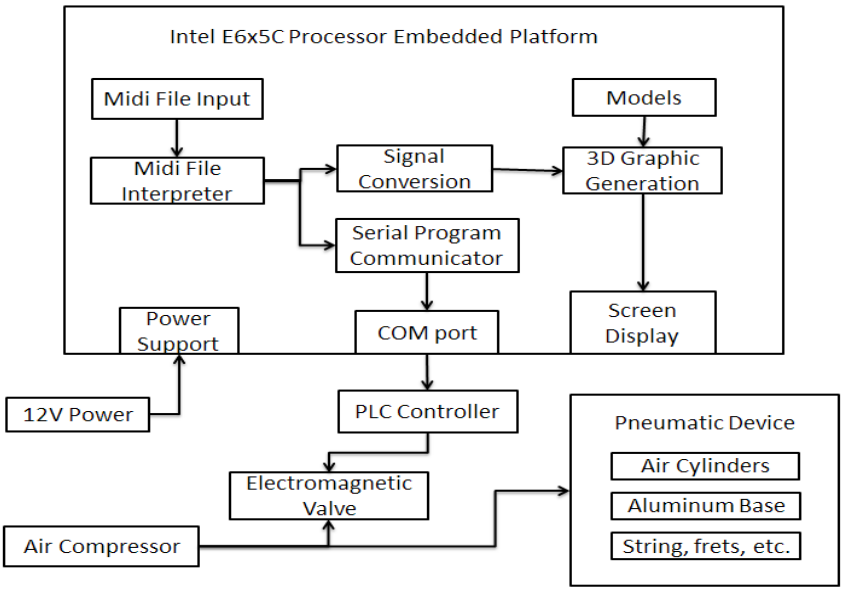

Figure 2-1 Overview of the System Design

This project aimed to create a programmable instrument which works like an acoustic guitar and dynamically generate graphic image. The project involves hardware construction as well as software development work. It required us to build all the hardware of this instrument by ourselves, and develop an application to control the instrument to play songs.

Chapter 2 System Design and Implementation

2.1 Hardware

The design of our guitar robot is shown in Figure 2-1. There're three parts need to build up: support base system, string pluck system and pneumatic control based tone control system.

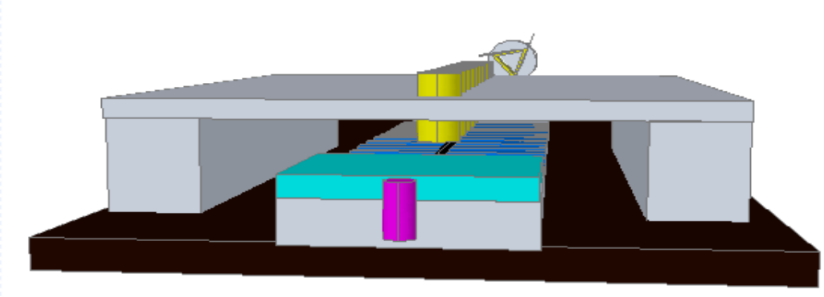

Figure 2-1 3D Model of Our Guitar Instrument

2.1.1 Support base system

Our support base system consists of an aluminum alloy, and several hollow aluminums. Their function is to support air cylinders, making sure they can fix in synthetic glass, and not fall down.

2.1.2 Plucking string system

At first time, our pluck system is similar to LEMUR's, which can be directly drove by the servo motor, and pluck the string every 1/3 turn. However, our motor does not work well, that is, the motor cannot control the paddles turn 1/3 accurately.
Based on the inevitable problem, we design a new plucking string system, which is made of two parts, such as air cylinders and plectrum. The air cylinder connects the electromagnetic valve, which can give air cylinder power to pluck the string directly.

2.1.3 Tone control system

This part is the core of our hardware system. The main part contains 36 air cylinders which are drove by the air compressor and controlled by the air flow control system. When we need to press particular fret, the air channel of its cylinder will open, and the cylinder will keep pressing the fret. And every 12 air cylinders also connects a group of electromagnetic valves which controlled by PLC controller.

2.2 Software Design

Our software system can be divided into three parts, and they are MIDI analysis, serial-port communication, and 3D graphic generation for visualizing music. MIDI music file will be decoded first, and the decoded information will be send to PLC controller, finally, the pneumatic device will triggered to play the guitar.
The decoded MIDI musical information will be utilized for two purposes, one is used as the input to dynamically generate the 3D graphic for visualization effect of the music, and the other will be converted to the control signal and sent to PLC via two serial ports.

2.2.1 MIDI File

MIDI is short for Musical Instrument Digital Interface, which is designed by a famous manufacture YAMAHA, can record information like instruction to play the instrument and it is convenient for storage because of its small size [4].
While decoding MIDI file, the program will recognize the header chunk and track chunks. For music elements which are store in track chunks, the interpreter will read the duration time and the event. Afterwards, we get tone and string we need to play from the event. Finally, the decoded signals will be sent via RS232 COM port to PLC as the control signals.

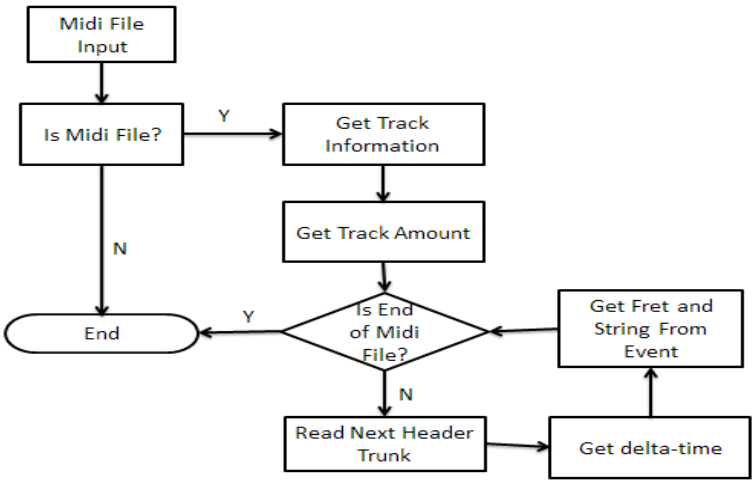

Figure 2-2 MIDI File Deconding Procedures

2.2.2 Real-time 3D Visualization

Music visualization aims to generate graphical image according to music sound wave, so that the display is react to the music in an interesting way. In addition, this kind of visualization could be artistic and the audience could gain better understanding of the music. The following elements are strongly related to the music sound: pitch, loudness, tone. From these data we could analysis and convert to adjustable graphical model. Therefore, the visual elements of composition of the image, objects, scenes, general effect of color, light and shade are changing corresponding to the music.

As a result, the music visualization can dynamically display music in an artistic way.

In this project, we use the Open Graphics Library as the graphic tool and 3dsmax [6] for our model design. The reason is obvious: OpenGL have already become a widely use and powerful standard and it is fully satisfy our requirements, the library offers functions of translation, rotation, ratio transformation, mirror image, projection transformation like parallel projection and perspective projection, RGBA mode or color index mode, lighting function such as emitted light, ambient light, diffuse light and specular light and texture mapping which provides details close to reality. What's more, image process function like blending, antialiasing and fog, double buffer to ensure the fluent animation, special effects including depth cue and motion blur. With the help of various libraries like GLU and GLUT, we can make nice display.[5] The advantage of 3dsmax is that, the requirements for the hardware is low, expert to editing models and good support of plugins and scripts.

Firstly, the models should be well prepared and designed using 3dsmax by editing basic models via twisting, sizing, integration and adjusting points and faces. With the help of 3dexploreration, we can convert 3ds model files to data arrays including samples of texture and materials, coordination of face, vertices, texture and normal.

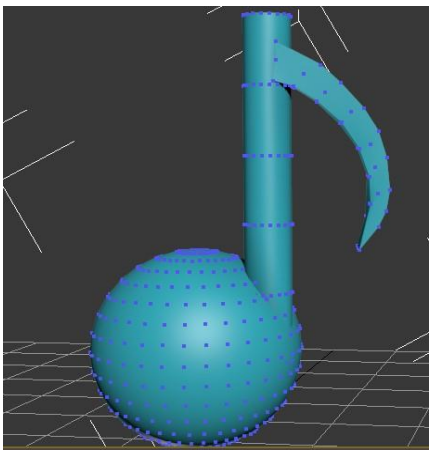

Figure 2-3 Image of musical note

Afterwards, we can use the message mechanism build in Windows framework to initialize the window and modify model parameters, then render it again. In OpenGL framework, firstly we load model data. Secondly paint the raw model and do transformations, colors, texture and other effects. According to the pass in message from midi file interrelation, we adjust render parameters so that the visualization could be done.

Chapter 3 System Test

3.1 Hardware Test

1. The plucking system can pluck the string normally, no delay.
2. The tone control system can control the air cylinder well.
3. The support system works normally,

3.2 Software Test

1. MIDI analysis can decode MIDI file well, we can get the right outcome.
2. The serial-port part can send data to PLC, operate air cylinder well
3. Music visualization can correctly react to the music.

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