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Chapter 1

Xylo-Bot: A Interactive Human-Robot Music Teaching System Design

A novelty Interactive human-robot music teaching system design is presented in this chapter. In order to make robot play xylophone properly, several things need to be done before that. First is to find a proper xylophone with correct timber; second, we have to make the xylophone in a proper position in front of the robot that makes it to be seen properly and be reached to play; finally, design the intelligent music system for NAO.

1.1 NAO: A Humanoid Robot

We used a humanoid robot called NAO developed by Aldebaran Robotics in France [ref]. NAO is 58 cm (23 inches) tall, with 25 degrees of freedom this robot can conduct most of the human behaviors. It also features an onboard multimedia system including, four microphones for voice recognition, and sound localization, two speakers for text-to-speech synthesis, and two HD cameras with maximum image resolution 1280960 for online observation. As shown in Figure 4-1, these utilities are located in the middle of the forehead and the mouth area. NAO's computer vision module includes facial and shape recognition units. By using Choregraphe software (Shown in Figure 4-2), researcher can easily control NAO remotely. Inside the user interface we have access to NAO's cameras. It is also easy to control different joints of the robot (see Figure 4-3). This allows the operator to control and monitor the different activities of robots online. The robot arms have a length of approximately 31 cm. Each arm have five degrees of freedom and is equipped with the sensors to measure the position of each joint. To determine the pose of the instrument and the beaters' heads the robot analyzes images from the lower monocular camera located in its head, which has a diagonal field of view of 73 degree. These dimensions allows us to choose a proper instrument presented in next section.

1.2 Accessories

Due to the size limitation of the toy xylophone, we have to design some accessories for robot to able play.

1.2.1 Xylophone: A Toy for Music Beginner

Attach the picture of xylophone and describe the frequency of all notes. We choose a Sonor Toy Sound SM soprano-xylophone with 11 sound bars of 2 cm in width. The instrument has a size of xx cm x xx cm x xx cm, including the resonateing body. The smallest sound bar is playable in an area of 2.8 cm x 2 cm, the largest in an area of 4.8 cm x 2 cm. The instrument is diatonically tuned in C-Major/a-minor. The beaters/mallet, we use the pair which come with the xylophone with a modified 3D printed grips (details in next subsection) to allow the robot's hands to hold them properly. The mallets are approximately 21 cm in length include a head of 0.8 cm radius.

1.2.2 Mallet Gripper Design

3D printed, need to measure some numbers and list them here, attach the SolidWorks screen shot and actual pictures.

1.2.3 Instrument Stand Design

Laser cut, made of wood, need measurement of all dimensions, attach the SolidWorks screen shot and actual pictures.

1.3 Music Teaching System Design

After all the preparation, we start to design the system, including joint trajectory, vision control and audio feedback

1.3.1 Joint Trajectory

Calibration of kinematic parameters. Try to explain it better at some point, if possible describer the future work may implemented using vision feedback system.

1.3.2 Auditory Feedback System

The purpose of this system is to provide a back and forth interaction using music therapy to teach kid social skills and music knowledge.

Short Time Fourier Transform

The short-time Fourier transform (STFT), is a Fourier-related transform used to determine the sinusoidal frequency and phase content of local sections of a signal as it changes over time.[1] In practice, the procedure for computing STFTs is to divide a longer time signal into shorter segments of equal length and then compute the Fourier transform separately on each shorter segment. This reveals the Fourier spectrum on each shorter segment. One then usually plots the changing spectra as a function of time. Use wiki to attach more pics and more info here. https://en.wikipedia.org/wiki/Short-time$_{F}ourier_{t}ransform$

1.3.3 Dialog System

Speech Recognition

http://doc.aldebaran.com/2-1/naoqi/audio/alspeechrecognition.html

Dynamic Oral Feedback

reason to design the dynamic feedback, NPL may want to have it here.

1.4 Summary

Chapter 2

X-Elophone: A Revolution of Xylophone

2.1 More Sound, More Possibilities

reason why need this design. Due to the limitation of keys. This provides more possibility for different timber and major minor keys. That allows this system to play more customized song which kids love.

2.1.1 Components Selection

Piezo Vibration Sensor

The LDT0-028K is a flexible component comprising a 28 m thick piezoelectric PVDF polymer film with screen-printed Ag-ink electrodes, laminated to a 0.125 mm polyester substrate, and fitted with two crimped contacts. As the piezo film is displaced from the mechanical neutral axis, bending creates very high strain within the piezopolymer and therefore high voltages are generated. When the assembly is deflected by direct contact, the device acts as a flexible "switch", and the generated output is sufficient to trigger MOSFET or CMOS stages directly. If the assembly is supported by its contacts and left to vibrate "in free space" (with the inertia of the clamped/free beam creating bending stress), the device will behave as an accelerometer or vibration sensor. Adding mass, or altering the free length of the element by clamping, can change the resonant frequency and sensitivity of the sensor to suit specific applications. Multi-axis response can be achieved by positioning the mass off center. The LDTM-028K is a vibration sensor where the sensing element comprises a cantilever beam loaded by an additional mass to offer high sensitivity at low frequencies. https://cdn.sparkfun.com/datasheets/Sensors/ForceFlex/LDT$_{S}eries.pdf$

Also have to show the circuit, how to design this and attach the figure from here https://www.sparkfun.com/datasheets/Sensors/Flex/MSI-techman.pdf page 39

Op-Amp

An operational amplifier (often op-amp or opamp) is a DC-coupled high-gain electronic voltage amplifier with a differential input and, usually, a single-ended output.[1] In this configuration, an op-amp produces an output potential (relative to circuit ground) that is typically hundreds of thousands of times larger than the potential difference between its input terminals. Operational amplifiers had their origins in analog computers, where they were used to perform mathematical operations in many linear, non-linear, and frequency-dependent circuits. The popularity of the op-amp as a building block in analog circuits is due to its versatility. By using negative feedback, the characteristics of an op-amp circuit, its gain, input and output impedance, bandwidth etc. are determined by external components and have little dependence on temperature coefficients or engineering tolerance in the op-amp itself. Op-amps are among the most widely used electronic devices today, being used in a vast array of consumer, industrial, and scientific devices. Many standard IC op-amps cost only a few cents in moderate production volume; however, some integrated or hybrid operational amplifiers with special performance specifications may cost over US 100 in small quantities.[2] Op-amps may be packaged as components or used as elements of more complex integrated circuits. The op-amp is one type of differential amplifier. Other types of differential amplifier include the fully differential amplifier (similar to the op-amp, but with two outputs), the instrumentation amplifier (usually built from three op-amps), the isolation amplifier (similar to the instrumentation amplifier, but with tolerance to common-mode voltages that would destroy an ordinary op-amp), and negative-feedback amplifier (usually built from one or more op-amps and a resistive feedback network). https://en.wikipedia.org/wiki/Operational$_{a}mplifierhttps : //ww1.microchip.com/downloads/en/DeviceDoc/21733j.pdf$

Multiplexer

In electronics, a multiplexer (or mux) is a device that selects between several analog or digital input signals and forwards it to a single output line.[1] A multiplexer of $2^n 2^n inputshasnnselectlines, whichareusedtoselectwhichinputlinetosendtotheoutput.[2]Multiplexe$
$input, single-outputswitch, andademultiplexerasasingle-input, multiple-outputswitch.[3]Thesc$
$to-1multiplexerontheleftandanequivalentswitchontheright.Theselselwireconnectsthedesiredinp$
$poleoctal-throwanalogswitch(SP8T)suitableforuseinanalogordigital8 : 1multiplexer/demultiple$

//en.wikipedia.org/wiki/Multiplexerhttps : *//cdn.sparkfun.com/assets/learn*$_t$*utorials*/5/5/3/7

Arduino UNO

The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc.[2][3] The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits.[1] The board has 14 Digital pins, 6 Analog pins, and programmable with the Arduino IDE (Integrated Development Environment) via a type B USB cable.[4] It can be powered by the USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts. It is also similar to the Arduino Nano and Leonardo.[5][6] The hardware reference design is distributed under a Creative Commons Attribution Share-Alike 2.5 license and is available on the Arduino website. Layout and production files for some versions of the hardware are also available.

The word "uno" means "one" in Italian and was chosen to mark the initial release of the Arduino Software.[1] The Uno board is the first in a series of USB-based Arduino boards,[3] and it and version 1.0 of the Arduino IDE were the reference versions of Arduino, now evolved to newer releases.[4] The ATmega328 on the board comes preprogrammed with a bootloader that allows uploading new code to it without the use of an external hardware programmer.[3]

While the Uno communicates using the original STK500 protocol,[1] it differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it uses the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.[7] https://en.wikipedia.org/wiki/Arduino$_U$*noshowblockdiagramofthecode* :

2.1.2 ChucK: A On-the-fly Audio Programming Language

https://www.researchgate.net/profile/Ge$_W$*ang9/publication*/259326122$_T$*he*$_C$*hucK*$_P$*rogramming*$_L$
Timed$_O$*n−the−fly*$_E$*nvironmentality/links*/0c96052*b*02*acb*79*c*2*c*000000.*pdfbrieflydescribethelang*