

## 基於 ROS 之智慧伴奏系統

### Smart Accompaniment System Based on ROS

隊伍名稱

鼓手休假去

Give the Drummer a Holiday,  
Please~

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## 作品摘要

在大家所熟悉的樂團表演中，是由一群不同樂器領域的人組成，例如：爵士鼓、吉他等。而在樂團練習及排演時需事先排定時間或撇除一些外在因素才能聚在一起練習。因此，我們為了能夠只有自己一人也能完成一首音樂的演奏而開發了一套基於ROS（Robot Operating System）之智慧伴奏系統。在此設計了一套能根據吉他音色做檢測並計算出其節拍，並讓爵士鼓也能跟著此節拍來打擊的系統。透過先將收到的吉他聲音訊號做處理，來得到其節奏（BPM），藉由偵測到的BPM值，再控制馬達揮動鼓棒，打擊到鼓面，使其可以與吉他一起伴奏，讓個人練習也能夠演奏出樂團的表演，產生音樂磅礴的效果。此系統特色為鼓可以隨著吉他手的演奏速度快慢而改變打擊的節奏，有別於市面上只能以固定節奏打擊的機器人打鼓系統。此外，也設計了踏板讓吉他手可以依演奏需求做更換大鼓與小鼓的組合搭配，讓獨自一人也能擁有樂團的演出效果。

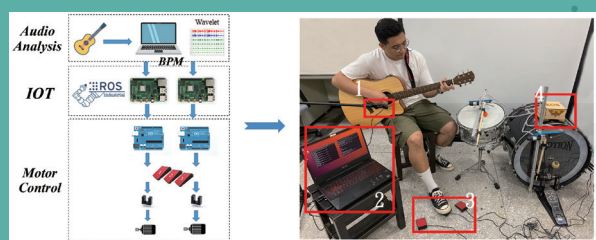
## 音樂分析

我們利用離散小波轉換同時具有訊號在時域與頻率上的特徵值來分析吉他的音樂訊號。在此使用多貝西（Daubechies Wavelet）家族的db5來做訊號的基底函數，經小波五階轉換後重構訊號，再作降採樣與提取自相關係數，最後計算出吉他的BPM（beats per minute），BPM為現今計算音樂速度的標準，就可以得到吉他手所彈奏的節拍速度。

## 互聯網與馬達控制

使用ROS通訊中的主題（Topic）方式作為通訊方法，首先所有節點（Node）需到節點管理器（Master）註冊，而身為發佈訊息的節點（Publisher）則會發佈特定Topic的訊息，訂閱訊息的節點（Subscriber）在master的指揮下則會訂閱該Topic，而達到互相接收訊息的方式。

先經由電腦錄製一段吉他音樂，當電腦分析出音樂的BPM後，發佈topic為chatter的訊息，訊息內容為BPM數值。而身為訂閱者的樹莓派，訂閱/chatter的訊息，收到訊息後會將訊息傳遞給Arduino UNO去控制馬達敲擊爵士鼓。在此結合光遮斷器來讓馬達控制的鼓棒可以精準地敲打出準確的拍子，及根據不同的BPM值來加快或減慢鼓棒敲擊的節奏。也可透過三個踏板來選擇當下適合的大鼓與小鼓的組合或是不打鼓來達成一個人的樂團表演的智慧伴奏系統。



▲ 圖一 系統架構應用圖（編號 1麥克風、編號 2 電腦計算 BPM 值、編號 3 踏板、編號 4 樹莓派 Arduino 等裝置）

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研究領域

智慧電子應用、FPGA 應用、AIoT、機器人應用、嵌入式系統

## Abstract

In a familiar band performance, it is a group of people who play different instruments, such as snare drums and guitar. In band practice and rehearsal, it is necessary to set up a time in advance or set aside some external factors to get together to practice. Therefore, we have developed an intelligent accompaniment system based on ROS (Robot Operating System) in order to play a piece of music by ourselves. The system is designed to detect and calculate the rhythm of the guitar tone, and allow the snare drums to play along with the rhythm. By first processing the received guitar sound signal to get its rhythm (BPM), and then using the detected BPM value to control the motor to swing the drum stick, so that it can accompany the guitar. This allows individuals to practice and perform as an orchestra. This system features a drum that can change the tempo as the guitarist plays faster or slower. In addition, the pedal is also designed to allow the guitarist to change the combination of big drums and snare drums according to the performance needs, so that the soloist can also have the performance effect of an orchestra.

### Music Signal Analysis

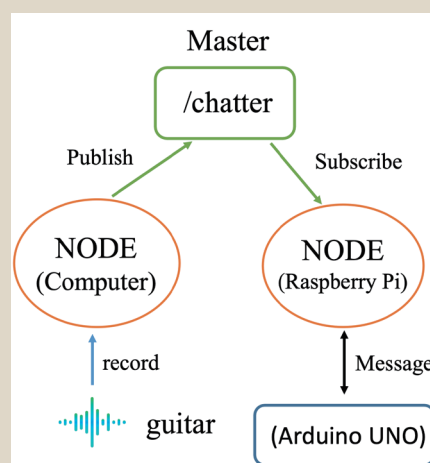
The discrete wavelet conversion is used to analyze the music signal of the guitar by having the characteristic values of the signal in both time domain and frequency domain. Here the db5 of the Daubechies Wavelet family is used as the base function of the signal, and the signal is reconstructed after the wavelet fifth order conversion, then do the down-sampling and the autocorrelation coefficient is extracted. Finally the BPM (beats per minute) of the guitar is calculated, so you can get the beat speed played by the guitarist.

### Internet and Motor Control

Using the topic method of ROS communication as the

communication method, first of all, all the nodes need to register with the node manager (Master), and the node who is the publisher of the message will publish the message of a specific topic, and the node who subscribes to the message (Subscriber) will subscribe to the topic under the command of the master, and achieve the way of receiving messages from each other.

First, the guitar music is recorded by the computer. When the computer analyzes the BPM of the music, it sends a message to the topic named chatter, and the message content is the BPM value. The Raspberry Pi, as a subscriber, subscribes chatter's message, and after receiving the message, it will send the message to the Arduino UNO to control the motor to play the jazz drum. This is combined with a photo interrupter to allow the motor-controlled drumsticks to precisely strike the exact beat and speed up or slow down the rhythm of the drumsticks according to different BPM values. The three pedals can also be used to select the appropriate combination of big and small drums to achieve an intelligent accompaniment system for a solo band performance.



▲ Fig. 2 ROS communication