Interactive Music Science Collaborative Activities

Team Teaching for STEAM Education

Deliverable 4.12
Final version of actuation technology for sounding physical objects

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Executive Summary

In this deliverable we present the final version of the actuation technology of real physical instruments.

We introduce the HyVibe smart instrument technology, and the reason why such technology has been chosen and used.

The goal is to analyze simple sounding structures (like a metallic table or a wooden box) to reveal its acoustical and musical properties.

Version Log			
Date	**Version No.**	**Author**	**Change**
04-06-2018	0.1	Robert Piéchaud, Quentin Lamérand (IRCAM)	Initial content
28-06-2018	0.2	Robert Piéchaud, Quentin Lamérand (IRCAM)	Updated content
03-07-2018	0.3	Robert Piéchaud, Quentin Lamérand (IRCAM)	Updated content, ready for review
13-07-2018	0.4	Robert Piéchaud, Quentin Lamérand (IRCAM)	Revision to address reviewers comments
17-07-2018	1.0	Vassilis Katsouros (ATHENA)	Submission to the EU

Disclaimer

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LIST OF ABBREVIATIONS

Abbreviation	Description
ATHENA	ATHENA RESEARCH AND INNOVATION CENTER IN INFORMATION COMMUNICATION & KNOWLEDGE TECHNOLOGIES
UCLL	UC LIMBURG
EA	ELLINOGERMANIKI AGOGI SCHOLI PANAGEA SAVVA AE
IRCAM	INSTITUT DE RECHERCHE ET DE COORDINATION ACOUSTIQUE MUSIQUE
LEOPOLY	3D FOR ALL SZAMITASTECHNIKAI FEJLESZTO KFT
CABRI	Cabrilog SAS
WIRIS	MATHS FOR MORE SL
UNIFRI	UNIVERSITE DE FRIBOURG
3D	Three dimension(al)

1. Introduction

Unlike many other activities and technologies of iMuSciCA's workbench, the actuation technology[1] happens in the "real world". This project involves two transducers :

- an electric actuator, similar to the moving part of a loudspeaker, used to force a surface to vibrate
- a piezo sensor, converting the vibration to an electric current, used to measure the response

They are connected to a device based on a microcontroller. The code programmed in this microcontroller will analyse the resonance of the surface.

2. Installation and technical requirements

The current setup is made of:

- a HyVibe[2] device, plugged to a 9V power supply
- a computer hosting a local HTTP server that communicates with the HyVibe over Bluetooth
- a resonating surface (here a metallic table) equipped with a pair of sensor/actuator, connected to the HyVibe.

[1] See deliverable 4.6 for more information on this topic
[2] http://hyvibe.audio

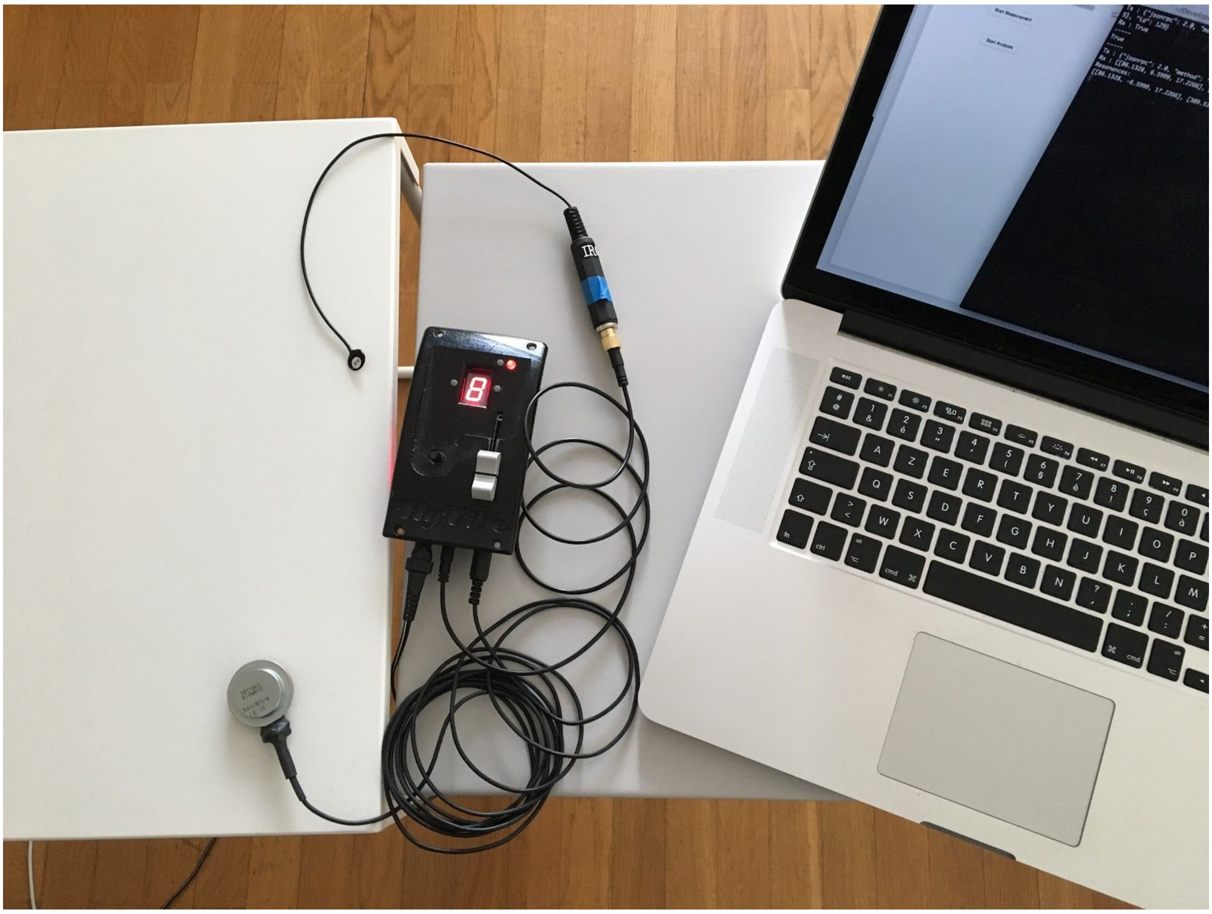

Fig.1: The prototype setup: a metallic table equipped with sensor & actuator connected to the HyVibe.

Once the table, sensor and actuators have been set up and plugged in, the HyVibe must be turned on. Run the hyvibeServer.py script to start the server and go to http://localhost:8080
There, you will be able to send commands to analyse the resonance of the surface.

3. Description of the demonstrator

3.1. HyVibe, Coala successor

Adrien Mamou-Mani, former IRCAM searcher and designer of the Coala, created the HyVibe company to develop further the technology involved in the Coala. This new device is now based on a dedicated microcontroller instead of a development single-board computer (BeagleBone) with a software.
One of the most interesting new capabilities is that the resonance peak analysis is done directly on the microcontroller and can be received via Bluetooth.

3.2. Starting up the HyVibe

3.2.1. Pair the device

Before starting the HTTP server, and after powering the device, you must pair in your Bluetooth settings panel.

3.2.2. Start HTTP server

You will need to install python 3 on your machine. You can download it here:
https://www.python.org/downloads/
Then start by running this command:

```
./hyVibeServer.py
```

3.2.3. Go to the actuation technology page

An iframe pointing to http://localhost:8080 will display the page with the form to control the resonance peaks analysis.

3.2.4. Sending the sweep sound

We chose a range of 100 to 1400 hz for our chirp, and we can hear the result as filtered by our metallic surface.

2.2.5. Displaying the transfer function

Once the chirp is over, the analysis will be done automatically by the device and the data displayed on the web page.
As stated earlier, the transfer function is the Fourier transform of the output over the system input. So in abscissa are the frequencies (ranging from 100 to 1400 Hz) and in ordinate the amplitude (in DB):

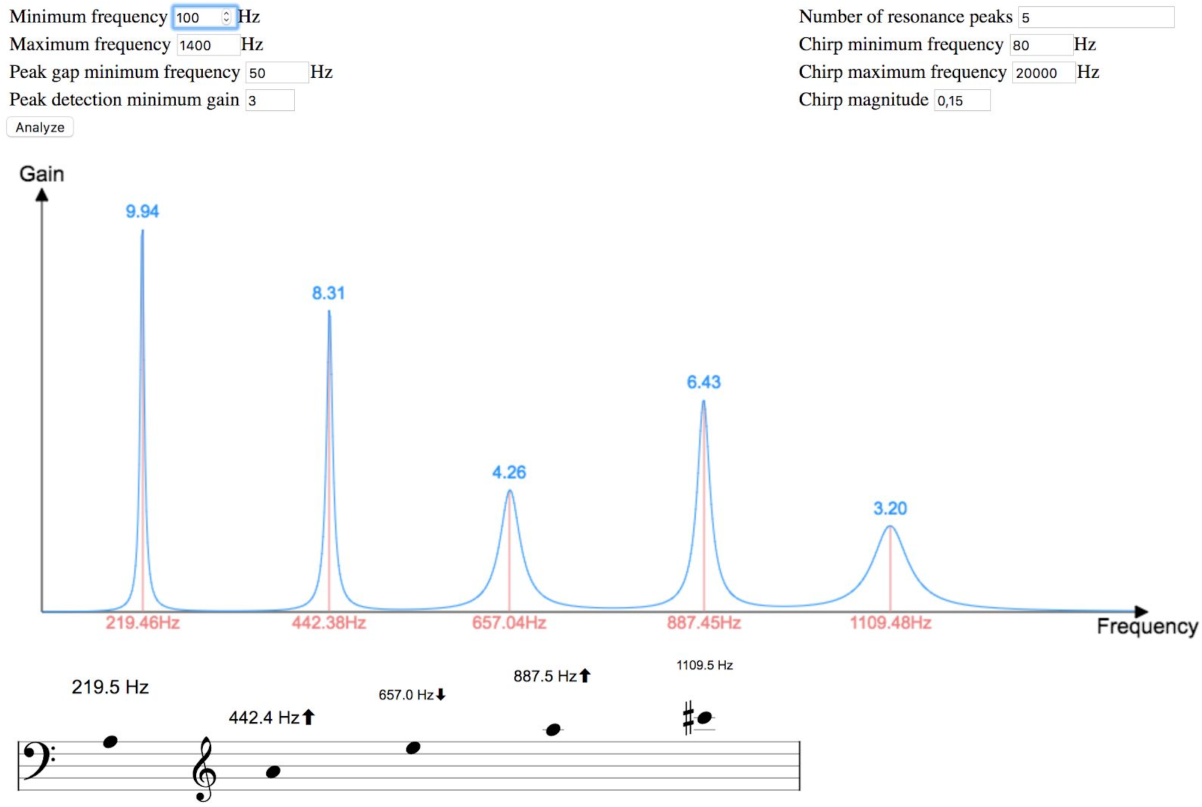

Fig. 2: The transfer function result, after sending a chirp to the structure. Here, x-axis corresponds to frequencies (ranging from 100 to 1400 Hz), whereas y-axis corresponds to amplitude in dB.

The peaks of the functions represents the frequencies where the structure gets particularly excited. These peak frequencies of the structure are also called *eigenfrequencies*.

3.2.6. Displaying the eigenfrequencies as notes

We represent as well the corresponding eigenfrequencies as a note sequence. For students with a musical background, this representation is probably more natural than a graph:

NB: The arrows by the note accidentals suggest that the notes are not “tempered”, i.e. they generally do not correspond to “perfectly” tuned[3] notes. The display size of the peak frequencies is proportional to the corresponding amplitude.
This score representation highlights the fact that the series of partials (as defined earlier) is far from being harmonic, which matches the perception we have of a rather complex sound when hitting a plate with a mallet.

3.2.7. Comparing the transfer function and the sound

You can then copy the peak frequencies and amplitudes and paste them in the Tone Synthesizer to resynthesize the sound of the analyzed surface.

[3] According to the Western equal temperament. See https://en.wikipedia.org/wiki/Equal_temperament