INSTITUTE
FOR FUTURE
TECHNOLOGIES
DE VINCI HIGHER EDUCATION

Master thesis

How can sensing techniques redefine our interaction with plants ?

Matthieu SEGUI

June 17, 2024

Supervisor
Clément Duhart and Marc Teyssier

Contents

1 Introduction

2 State of the art

2.1 Plant as sensor

2.1.1 Human-Plant Interaction

The human plant interaction has been studied.

2.1.2 Plant as sensors Plant transformed into sensors

2.1.3 Silicon Made sensors

2.1.4 Sonification on micro-controllers

MCUs* [1] is a kind of small computer based on a single chip. Those devices can be used to generate sound. The most common way of doing electronical music is to use MIDI† [2]. MIDI has been created in order to create music with digital computer. MIDI do not describe directly the audio signal but the human actions to create the signal (such as turn the knob left, push the slider...). MCU are able to produce those kind of directives [3][4]. However, the MCU can produce MIDI but MIDI does not directly generate sounds. A synthetizer is needed to create the sound described.

For our use case of embedding the device, we look at MCU that were able to directly generate the signal from a DAC‡. Projects had been conducted with many microcontrollers such as a small 8 bits AVR microcontrollers (ATmega32) [5]. This paper does not include limitation of such a product but we can guess that the 8 bits microcontroller is limiting the sound quality. A larger project from Shaer and al. [6] is including an Arduino Mega controlling the visual effect of the project, but also the interaction sensors. The Arduino Mega is then sending MIDI information to Teensy 3.2. The Teensy is then generating the sound. The project is still too large to be fully embedded but the Teensy 3.2 is a promising compute unit. The Teensy 3.2 is running at 72 MHz, way faster than the ATmega32 that is operating at 16MHz. The frequency is essential when trying the produce sound signals. Teensy is an Open Source platform for embedded computing and systems made by PJRC. It exists different version of the board and is a alternative to the Arduino platform. Teensy manufacturer also provides an audio shield that can be used with a software to create easily sound. A shield is a piece of hardware which can be plugged directly on the board to enhance capabilities of the board. The software is used through sound patches and return the code equivalent in C++. Michon and al. [7] evaluated the performance of the board on the music generation and playing side. The conclusion state that the Teensy is a good choice in order to create and play easily sound.

2.1.5 Commercial products

2.2 Internet of Plants

2.2.1 Distributed instruments

2.2.2 Sonification using software

* Micro-controllers
† Musical Instrument Digital Interface
‡ Digital to Analog Converter

3 Plant as sensor

3.1 The electronical interface

3.2 Human interaction

3.2.1

3.2.2 User study

3.3 ...

4 Internet of Plants

5 Conclusion

References

Here are the references in citation order.

[1] Adian F Rochim, Mukhlish A Aziz, and Adnan Fauzi. 'Design Log Management System of Computer Network Devices Infrastructures Based on ELK Stack'. In: *2019 International Conference on Electrical Engineering and Computer Science (ICECOS)*. IEEE. 2019, pp. 338–342 (cited on page 2).

[2] Gareth Loy. 'Musicians Make a Standard: The MIDI Phenomenon'. In: *Computer Music Journal* 9.4 (1985), p. 8. DOI: 10.2307/3679619. (Visited on 06/01/2024) (cited on page 2).

[3] I Fazenda, Sao Paulo, and I S Junior. 'Proceedings of the International Conference on New Interfaces for Musical Expression'. In: () (cited on page 2).

[4] I Fazenda, Sao Paulo, and I S Junior. 'Proceedings of the International Conference on New Interfaces for Musical Expression'. In: () (cited on page 2).

[5] Tanvir Hussain and Md Mejbaul Haque. 'AVR Microcontroller Implementation for Customized Sound Generation'. In: *International Journal of Electrical and Computer Engineering (IJECE)* 2.1 (Nov. 2011), pp. 112–119. DOI: 10.11591/ijece.v2i1.139. (Visited on 06/01/2024) (cited on page 2).

[6] Bassam Shaer et al. 'Interactive Capacitive Touch Music Table with Embedded Microcontrollers'. In: *The Journal of Supercomputing* 76.11 (Nov. 2020), pp. 8845–8865. DOI: 10.1007/s11227-020-03167-4. (Visited on 06/01/2024) (cited on page 2).

[7] Romain Michon et al. 'Real Time Audio Digital Signal Processing With Faust and the Teensy'. In: () (cited on page 2).