1 Introduction

The aim of this paper is to propose the design and production of an hardware synthesizer, starting from an existing digital sound engine. In the sections that follow, it will be explained the background and the rationale behind the project, as well as the initial research undertaken. Then, it will be depicted a "blueprint" of the product: the general concept, the architecture of the system – both hardware and software – and the production plan will be covered in detail. In the last part the evaluation criteria will be set, in order to have a concrete measure of the work outcomes.

2 Background and Motivation

This project has been shaped and will be realised keeping as a pivotal point the *chiptune* subculture and its principles. As will be discussed in the next paragraphs, the product is conceived to be used by people already familiar with the environment and limitations of this musical style. Its purpose is to give users a different and more modern way to interact with a well-known set of sounds and synthesis capabilities.

2.1 Pushing the Limits Using Contraints

Chiptune As stated by Collins et al. (2014) the term *chiptune* has multiple definitions. Also known as *chip music* or *8-bit music*, it derives from the sound chips that, in the first generation of computers and gaming consoles, were used to balance the processing power of generating sound effects and music from the CPU. In its strictiest meaning, chiptune is used to refer to music created entirely from the original, vintage audio chips. Nevertheless, modifications that do not alter the nature of the sound produced are allowed.
The broadest definition is more related to the aesthetics of the sound, rather then to the source generating it. The entire subculture which gravitates around the foundations and features of chip music can be called *chiptune* too. Anyway, this paper and the related project will try to stick to the strictiest definition of the word, in order to create a product able to maintain the sound fidelity of the old processors.

DMG-001 and trackers In particular, the following study focuses on the Nintendo DMG-001 from 1989, known with the commercial name of *Game Boy*, which is supposedly one of the most popular tools for the production of chip music. From the official datasheet (Nintendo, 2019) portable console runs on a custom *Sharp LR35902* 8-bit CPU, similar to the *Zilog Z80*[1] and has four

[1] Popular 8-bit microprocessor widely used from the 1970s to the mid-1980s in desktop and home computers, military applications, synthesizers, arcade machines...

audio channels[2]:

Channel	Type	Features
1	Quadrangular[3]	- Volume envelope - 4-mode pulse width - Frequency register from C3 upwards - Frequency envelope
2	Quadrangular	- Volume envelope - 4-mode pulse width - Frequency register from C3 upwards
3	Wave	- User-definable waveforms - Bank of 32 samples (4-bit each) - Frequency register from C2 upwards
4	Pseudo-random noise	- White and brown noise

Back in the analog era (i.e. before the first DAWs were created and deployed), the tools to compose and produce music on digital computers and consoles were the *music trackers*. They can be defined as precursors of the modern music production softwares: notes, parameters, effects and other commands, in this type of vertical sequencer, are given as letters, numbers or hexadecimal digits into a fixed, time-slotted grid. Fig.1 shows an example of a tracker interface: *Little Sound Dj*, the most popular music editor for Game Boy consoles. The implementation of this tracker, along with other softwares like *nanoloop* and *mGB*, will be considered in the design of the proposed product.

2.2 Rationale

Despite being one of the cardinal points in the *Chiptune* subculture, the idea of maintaning the limitations given by the hardware is too general and vague, and a distinction is necessary. During the composition and execution of 8-bit music, two main types of constraints can be addressed:

- **Processing capabilities** – The true and interesting challenge, i.e. to try to push the hardware CPU to its limit, creating complex sounds and tracks on a level that was considered unachievable, given the limited digital resources.

[2] To be precise, as stated in the 8BC Chiptune Wiki (2007), the console has a fifth – and least known – channel: it is an analogue input channel that allows external synthesis on cartridge to be mixed with the sound generated by the other channels. No cartridges are known to use this channel and its functionality, though.

[3] Also known as *pulse wave* or *square wave*.

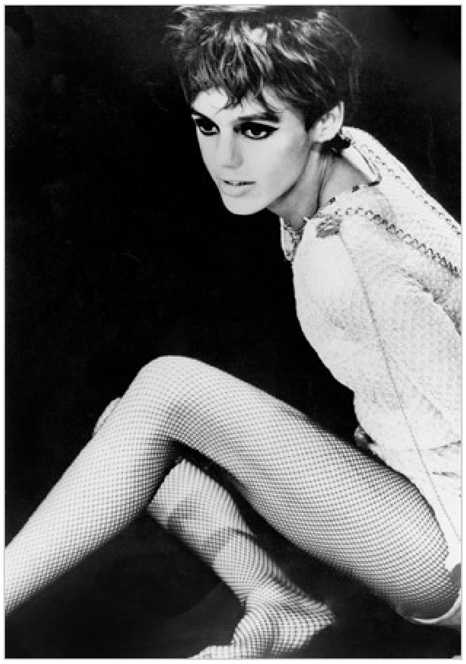

Figure 1: *Song* Screen on the popular LSDJ tracker for Game Boy (Kotlinski, J., 2007)

- **User interface** – Even though someone could disagree with this opinion, from a practical view, limitations in the UI can be considered nothing more than an obstacle in the production process. If we take the DMG-001 as an example, being constrained by a D-pad and four push buttons has nothing to share with the concept of taking out deep and articulated music from a 4.19 MHz CPU with 8 KB of RAM.

So, it is clear that a limitation in the UI is unnecessary and – most of the time – unwanted. For this reasons, the aim behind the proposed product is to renew the link between chiptune musicians and instruments, expanding the interactive capabilities of the Game Boy, without perverting the characteristic soundscape and the core aspects of its composition process.

3 Name of the Project

3.1 Concept

3.2 System Architecture

Hardware

Controls

User Interface

DMG-001 Mods

Sound

Midi Functionality

Screen

Power

Embedded Software

3.3 Production

Resources

Schedule

4 Discussion

4.1 Minimum Viable Product

4.2 Evaluation Criteria

5 Conclusions

References

Collins, K. and Kapralos, B. and Tessler, H. and Paul, J. L. (2014) *The Oxford Handbook of Interactive Audio.* USA: Oxford University Press.

Marquez, I. (2014) Playing new music with old games: The chiptune subculture. *G— A— M— E Games as Art, Media, Entertainment* [Online], 1 (3), pp. 67-79. Available from: <`http://www.gamejournal.it/wp-content/uploads/2014/04/GAME_3_Subcultures_Journal_Marquez.pdf`> [Accessed 20 October 2019].

Nintendo (2019) *Game Boy, Game Boy Color, Game Boy Pocket Technical Data* [Support page] [Online] Available from: <https://www.nintendo.co.uk/Support/Game-Boy-Pocket-Color/Product-information/Technical-data/Technical-data-619585.html> [Accessed 20 October 2019].

8BC Chiptune Wiki (2007) *Game Boy* [Online] Available from: <https://web.archive.org/web/20080221140919/http://8bitcollective.com/wiki/index.php?title=Game_Boy#Sound> [Accessed 5 October 2019].

Kotlinski, J. (2007) *Little Sound Dj v3.7.4 - Operating Manual* [Online] Available from: <https://www.littlesounddj.com/lsd/latest/documentation/LSDj_3_7_4.pdf> [Accessed 20 September 2019].

In this module, you will develop an original interactive or reactive system in which music or sound is a key component. Innovative and imaginative methods of interaction by a participant should be explored, and this could be for any relevant context (performance, composition, installation, game, sound toy, etc).

During the first half of the module, you should consider and develop a written proposal and plan for this project. Your proposal should be around 2000 words and address the following areas:

Section 1 Overall project aims and rationale Who is your project aimed at?

In what situation/context is it designed to be used?

- Live performance
- Music production

How and why will people engage with it?

- It will be an easy and straightforward way of making chiptune music

Section 2 Details of project What are the key hardware/software elements in your project?

- Sound engine: GameBoy DMG-01 (1989)
- New Hardware Interface

What sounds will your system work with? The system will generate sound using the sound chip of the GameBoy

What will the relationship be between user inputs and the sound parameters (mapping)? To interact with the sound, the Midi protocol will be used. Since the GameBoy can't read and understand Midi messages, a translation unit is required amid the interface and the sound engine (i.e. an Arduino board).

How does this mapping support your overall project aims?

Section 3 Evidence of contextual awareness, research and reading What other similar systems have you looked at? How has your idea developed from this research?

What relevant concepts have fed into your design process?

Section 4 Plan for implementation What resources do you require to complete your project? What specific tasks do you need to complete and by when?

This should be written using appropriate academic language with reference to relevant texts/media using Harvard format.