A picture containing tool

Description automatically generatedKluskens Stef

Game Boy MBC1 Emulation

Supervisor: Tesch Tom

Coach: Defoort Stephanie

Graduation Work 2023-2024

Digital Arts and Entertainment

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A close up of a card

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Contents

[Abstract & Key words 2](#_Toc153482830)

[Preface 3](#_Toc153482831)

[List of Figures 4](#_Toc153482832)

[Introduction 5](#_Toc153482833)

[Literature Study / Theoretical Framework 6](#_Toc153482834)

[Research 7](#_Toc153482835)

[1. Topic 1 7](#_Toc153482836)

[1.1. Subtopic 1 7](#_Toc153482837)

[1.1.1. Subtopic 7](#_Toc153482838)

[2. Topic 2 8](#_Toc153482839)

[1.2. Subtopic 1 8](#_Toc153482840)

[1.2.1. Subtopic 8](#_Toc153482841)

[case study 10](#_Toc153482842)

[1. introduction 10](#_Toc153482843)

[2. Modelling 10](#_Toc153482844)

[2.1. Blockout 11](#_Toc153482845)

[2.2. Zbrush 12](#_Toc153482846)

[3. Texturing 12](#_Toc153482847)

[4. Shading 12](#_Toc153482848)

[5. Lighting 13](#_Toc153482849)

[Discussion 14](#_Toc153482850)

[Conclusion 15](#_Toc153482851)

[Future work 16](#_Toc153482852)

[Critical Reflection 17](#_Toc153482853)

[References 18](#_Toc153482854)

[Acknowledgements 19](#_Toc153482855)

[Appendices 20](#_Toc153482856)

# Abstract & Key words

**An abstract explains the outline of the paper concisely (the methods, results, etc.). Maximum length of 250 words, preferably both in English and Dutch.**

In this paper, I’m discussing the implementation of the MBC1 in a Game Boy emulator.

# Preface

***A preface is a statement of the author's reasons for undertaking the work and may include personal comments that are not directly relevant to other sections of the thesis or dissertation.* No word count limit.**

I chose this topic because I’ve been interested in emulating a retro console for a while. I chose the Game Boy for nostalgic reasons. The Game Boy is the console I used the most when I was a kid. It holds a special place in my heart and that’s why I wanted to delve deeper into its inner workings by working on an emulator.

# List of Figures

**The list of figures lists the figures in the order in which they appear throughout the thesis. They may be numbered sequentially, or be subdivided following the chapters in which they appear.**

Figure 1: A picture showing something

Figure 2: A graph showing another thing

Figure 3.1: A tabel showing yet another thing, that appears in chapter 3.

# Introduction

**In the introduction, you write the background of your topic and discuss the observation that spurred you on to do this research project. Explain the purpose of the paper and present your research question(s) and the hypothesis at the end of this section. This section is typically a couple of pages long.**

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# Literature Study / Theoretical Framework

**In the literature review, you present the secondary research you have conducted. You detail the background of your topics and write about the concepts that are relevant to the study. Assume that not every reader has the same skillset or -level as you do! This section typically requires a substantial amount of references and can be a lengthy section that requires a considerable amount of pages.**

For my literature review, I have to start with the thesis on Game Boy Emulation in C++ by Brecht Uytterschaut. This is the backbone of my work as I am continuing on his work by adding a memory bank controller to his emulator to allow it to run larger games.  
In his thesis, he explains how the Game Boy’s CPU works and how he implemented it. He talks about the opcodes, the instructions, that the CPU has. He mentions that he didn’t implement all of the instructions, only those that are needed to run Tetris, one of the few games that can run without an MBC.  
He then talks about the PPU, the Picture Processing Unit, which handles the graphics. He explains how the different layers work. These are the background, the window or UI, and the sprites.  
He finishes by shortly explaining how he implemented the input and how the memory bank controllers work. This part was really useful for me as a starting point on the MBC.

The MBCs chapter on gbdev.io explains how every type of MBC works with the Game Boy. The part that is most interesting for this thesis, is the sub-chapter MBC1. It explains what the MBC1 is and how it works. It then gives a detailed overview of all the read and write functionality for the different memory addresses. This has been a vital reference in emulating the MBC1 myself.

This chapter in codeslinger’s version of a Game Boy emulator shows an implementation of the MBC1 and MBC2. It starts with detecting what kind of MBC a game uses, by reading the correct memory address. It goes on to detect if the game is using RAM banks and how to get the size of those. He then explains the reading and writing to the ROM and RAM banks. This is a simplified version, but a good continuation after the gbdev.io chapters.

Brendan Byers’s website has a post about the MBCs in Game Boys. In this post he talks about all the different kinds of MBCs. He then gives a short explanation on what happens at the different memory addresses. He also gives more info on how to access the MBC information from the cartridge header.

Brendan Byers’s website also has an interesting post about ROM and RAM bank switching. He takes the info from gbdev.io and expands on it. For every memory address in the reading and writing process, he gives a more detailed explanation on what is happening.  
After that, he goes into more detail on how bank switching works in practice, by taking a look at a disassembly of a Pokemon game.

The chapter on the CPU instruction set from gbdev.io gives an overview of all of the instructions the CPU can do. This overview made it easier to find what instructions were missing from the emulator I got.

The cartridge header chapter from gbdev.io gives a great overview on what all the memory addresses in the cartridge header hold. This is where I could find where in memory the ROM and RAM data was stored.

Game Boy: Complete Technical Reference gives an explanation of the full working of the original Game Boy. This reference is very useful, as understanding how the console works in real life, will help in understanding how to emulate it.  
Chapter 8 covers the MBC1 mapper chip. This gives a wealth of information about the MBC1’s inner working.

# Research

**In the research section, you detail the elements of your experiment(s), the tests, objects you will test upon and subjects you will test with, the data gathering, data cleaning or feature extraction, measurements, … and you present the results obtained in an objective manner for each of the tests you conducted.**

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## Topic 1

### Subtopic 1

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### Subtopic

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## Topic 2

### Subtopic 1

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# case study

**Alternatively, as opposed to research, you might have opted for a case study. Whichever you choose, you detail the elements of your experiment(s), the tests, objects you will test upon and subjects you will test with, the data gathering, data cleaning or feature extraction, measurements, … and you present the results obtained in an objective manner for each of the tests you conducted.**

The test object of my grad work experiment will be a Game Boy emulator which I modified to have a memory bank controller. For the testing, I will use a test rom. These roms give scores on the emulator used in order to give an indication on how well it emulates the Game Boy. I will test the emulator before and after implementing the memory bank controller. This will give me 2 sets of data to compare.

I will also both fully implement 1 memory bank controller and start on another. This way, I can test if the inheritance would work the way I envision it would.

## introduction

**In the introduction, you write the background of your topic, explain the purpose of the paper more broadly, and explain the hypothesis, and the research question(s).**

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## Modelling

### Blockout

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Figure 1 : MAKING OF THE HOBBIT: THE DESOLATION OF SMAUG – LAKETOWN (WETA DIGITAL, 2014)

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### Zbrush

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## Texturing

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## Shading

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# Discussion

**In this section, you offer an interpretation of the results you obtained and try to relate them to the theoretical framework you presented. This is typically not a very long section, but obviously one of the most important ones.**

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# Conclusion

**In this section, you ascertain the demonstrable outcomes of your study and outline the merits of the project for the academic field and the discourse community. This is typically not a very long section, but obviously also one of the more important ones.**

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# Future work

**This section is sometimes standalone, sometimes incorporated in the conclusion. It looks at the shortcomings of the study, alternative strategies, and what could be the next course of action in the research field. This is typically not a very long section.**

For future work on this emulator, there are a couple of things to improve the project.

More MBCs:  
I only implemented MBC1 completely, since that was the goal of this thesis. There are so many more MBCs, if they were to be added, this emulator would be able to play more games that were made for the Game Boy.  
Implementing the other MBCs would also increase the accuracy in which the original Game Boy is being emulated.

Sound:  
I did not have the time to implement sound on top of the MBC1. Adding sound would be interesting as it would be nice to hear those nice 8-bit sounds being played again.

# Critical Reflection

**This section is typically associated with a bachelor paper, not other forms of serious writing. It allows the student to reflect on the learning outcomes, both academically and in terms of personal growth.**

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# References

**In this section, you list all the references you made in alphabetical order; consequently adhere to the referencing style you have chosen.**

Casey Raes (2014), Processing (second edition).

Saccade. (n.d.). In Wikpedia. Retrieved November 6 2016 from <https://en.wikipedia.org/wiki/Saccade>

Sarah Northway (2016) A year in VR Northway [Powerpoint slides] from <https://www.gdcvault.com/play/1024631/A-Year-in-VR-A>

# Acknowledgements

**In this section, you can thank people who contributed to your work in a meaningful way.**

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# Appendices

**In many cases, there are items that were developed for a research paper that can’t go into the actual paper in full. Things suc as code, art pieces, output of statistical analysis, questionnaires, … In this section, you can present these elements; use the first page to list and number the items, then paste them sequentially. If some items are too large, you can store them online, and link to them. Common practice is to keep those links active at least one year after the publication of the thesis.**

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