TUTORED PROJECT REPORT
PROJECT N°48

Tutor : Mr Zacharewicz

Assembly of an arcade and development of a video game

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Q1 - TP1 - S4

SUMMARY

ABSTRACT

Nowadays, a lot of people feel connected with a video game of their childhood. But with the evolution of technologies, the constant release of new video games on aways more incredible softwares could makes us forget what we once loved. One solution for this : video game arcades. But how can we link an object designed for old games with the new games and softwares of today ? Well, by creating a modern video game for an old machine.

Two computers, four pair of hands and two goals : creating a bartop arcade and developing a video game. In order to obtain two objects really enjoyable for the next year students, GameMaker as our video game editor and AutoCAD to design our bartop, a lot of time, work and creativity were our only tools.

INTRODUCTION

The aim of our project is to build a functional bartop arcade for the student's office and to develop our own video game with it. Those were originally two separated project we fused together. We got the ideas of those two project because we all like challenges and programming so we wanted to make something other students could use and enjoy everyday. For this project, we are under the supervision of Mr Zacharewicz but as he already has a lot of student and tutored project to lead and because we already had an idea about how to carry on this project at first, we are working in autonomy. The main objective is to use as less money as possible in order to build the arcade by using recuperation materials and using Game Maker Studio 2 to develop the game. We spread the task amongst the group so that everyone would do a little bit of everything. For this report we will talk about the arcade and video game separately, we will first resume what we wanted to do with both of our assigned tasks, what knowledge we use and what problems we have encountered during the accomplishment of our project.

VIDEO GAME DEVELOPMENT

We are big fans of video games. From Super Mario when we were kids to the last games coming out these years, everyone of us wanted to be a part of this huge universe. But making a video game is something quite difficult. There is good reasons if the teams conceiving video games sometimes grow up to reach 300 persons on a single game. But we are only four, with basic knowledges in programming and 2-3 hours of YouTube videos about "how to make a good video game" in mind. But we were still very motivated. And we decided to create a video game for our arcade on the subject of physics. Second goal, was to make two playables modes, to expand the game experience.

As the video game world is something very large, we needed to know what type of game we should do. So what is an arcade game ?

"Arcade games often have short levels, which rapidly increase in difficulty with simple and intuitive controls. Game players are essentially renting the game for as long as the game avatar is alive. For this business model to be profitable, the difficulty of the game must be high enough to make the players reach a game-over state and engaging or addictive enough to keep the players playing."

Techopedia - 2018

This is what we needed. A nervous game with an increasing difficulty. What is important for the player is to know that he is in danger, to feel the difficulty. The satisfaction to see the avatar respond as the player anticipate the movement of the enemy or use his skill to dodge some obstacles. This is what keep the player with the controller in his hands.

Because we didn't have enough skills in programming in C, we used the software **Game Maker Studio 2** and we wrote in GMS.

By taking ideas of the recent viral games we chose two game to take inspiration for our two mods, respecting this definition above.

Asteroid, "shoot'em up", Atari,1979
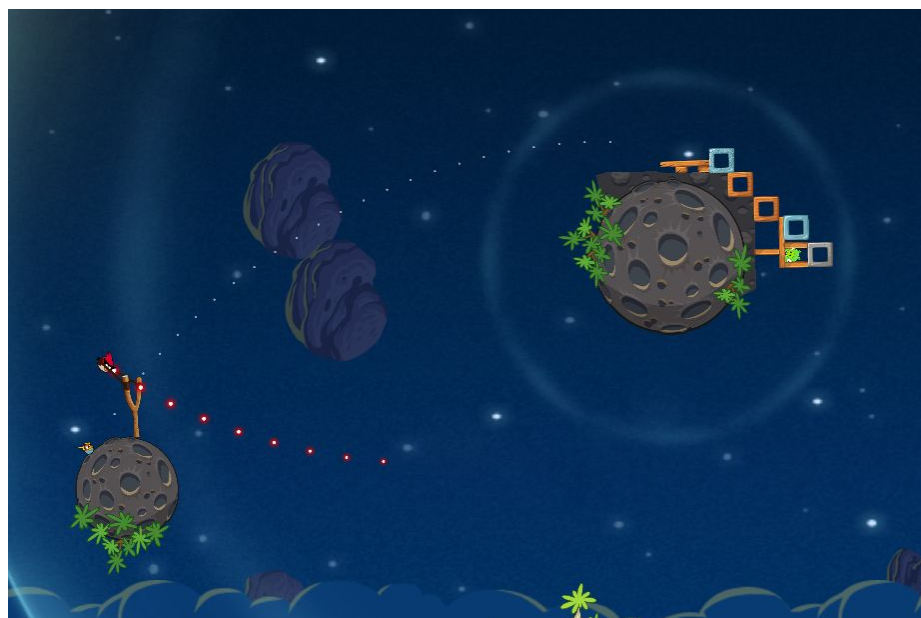
Angry Birds Space, artillery & puzzle, Rovio, 2012

Asteroid is a very nervous game taking place in space, where the goal is to destroy the asteroid trying to destroy you, and **angry birds** is a game where the goal is to destroy an enemy base by launching birds and estimate the trajectory of the birds to reach the target. We have our two games. Because we wanted to integrate physics in it, the game will take place in space, where the laws of gravity reigns. Let's describe them more precisely. **Behold ZERO GRAVITAS.**

1) Exploration mode

The first mode of the game is a **"shoot'em up"**, a type of video game derived from the action game in which the player directs a vehicle or a character to destroy a large number of enemies, while dodging their projectiles to stay alive.

Main goal :
You will pilot a little rocket equipped with different weapons to destroy enemies coming from a bigger ship. The more enemies you destroy, the more points you gain. If you get hit, you lose life point, if they reach 0 you die. The goal is to make the highest score possible.

Level design :
The game take place in a room of 19200*10800 pixels. The screen only display 1920*1080 pixels and follow your ship. this room is generated randomly, therefore every game is different of the others. Your ship will start at a point, with an arrow displaying the direction of the big ship, where the little enemies spawn. On your way you will find planets, maybe encounter comet. There is two types of enemies reacting differently to your movement and equipped with different weapon. You and your enemies move quite fast for the game to be nervous, but the big ship doesn't move and doesn't try to hit you. It's more of an enemy base. Once this ship destroyed, you have to reach the next one and do it again. The enemies will gain in speed, accuracy and life.
The HUD (Head up display, the information always on screen) is composed of your life bar, shield bar, a map and the current score reached. On the bottom right of the screen you will find a scheme designed to call back the button of a controller, for the game to be more intuitive. An arrow also display the direction to follow to find enemies.
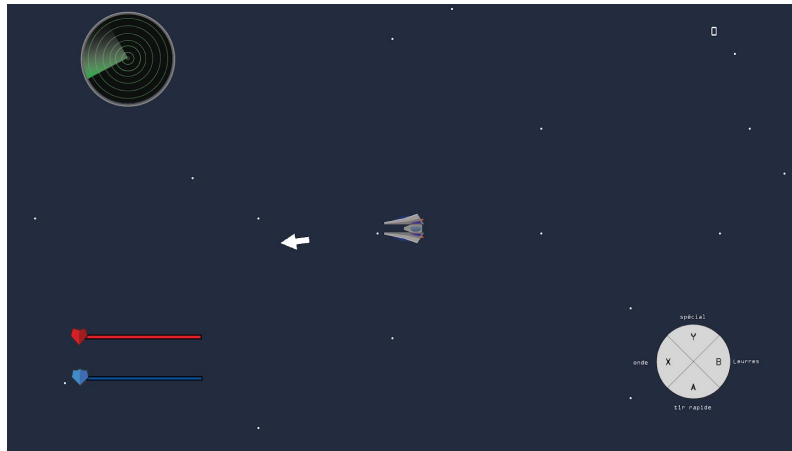
The **HUD**

The movement of the enemies is study to be difficult to anticipate and the movement of the rocket easy to control.
Most important, the world is infinite.

Level mechanics :

Every single one of the planet is generated randomly. An algorithm set first the number of planet to display into the "room" (the scene were the game take place), then place them randomly in the room while respecting a certain distance between them. After that every planet while set up on his side a random "sprite" (the image of the planet), and random gravity field and a random size.

Another algorithm will allow comets to be created at random times, only as a decorative effect.

After that a third algorithm will set the position of the big ship while making sure that it won't appear on a planet, or on you.

The gravity had been designed as a force attracting you to the planet. We simplified it to be less realistic but more "arcade", more fluid and intuitive. It result as a force modifying the movement of the player toward the planet.

The most difficult part was to create an infinite world. To do so, we created an algorithm that occur when the player reach the side of the room (because it is only 19200*10800 pixels big). If the player reach the edges of the room, he is teleported to the opposite side. The planets are destroyed and recreated so the world in front of him is totally different. Except what can be seen on the screen, so the player doesn't note the teleportation. The default of this algorithm is that there is no coming back, as the world behind us as been erased.
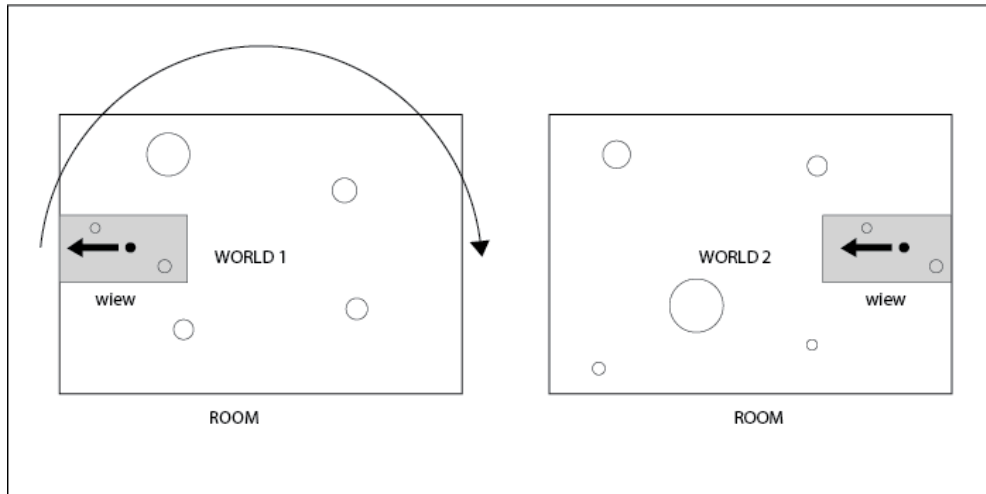
Teleportation Algorithm scheme

Graphics :

The graphics for this mode were created independently from the other one. The designs used for this mode is called "flat design". The flat design or flat design is a graphic interface design style characterized by its minimalism. It is based on the use of simple shapes and bright colors. The design of the rocket had been draw to encourage the player to shoot, and it's conical form make aiming easier. The ally are blue and the enemies are red, making the differentiation also intuitive. Everything has been draw on **Illustrator**.
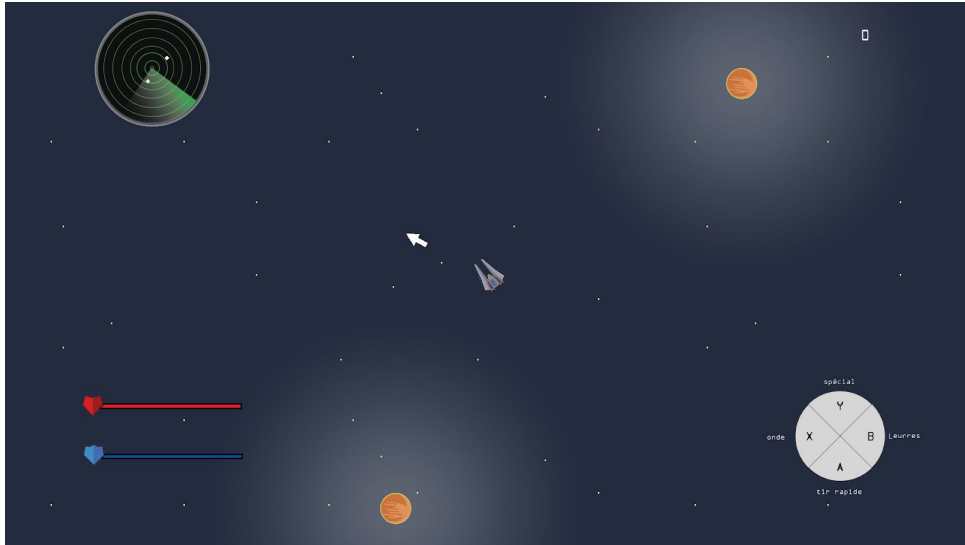
2) Aventure mode

The second mode of the video game Zero Gravitas is called the adventure mode. Irrespective of the first one, the main goal here is to succeed different levels with the lowest number of tries.

Main goal :
Going from point A to point B is the main goal. But it's not always that easy, as we will see later. The number of levels you fail is displayed, so you have to try to finish all the mode with the lowest number of tries.

Level design :
The levels are designed as squared rooms of the common size of a computer screen, 1920*1080 pixels, with a start point, an endpoint to reach, and some space objects to avoid using the gravitational effect.

Different sprites of planets have been created with minor differences in each of them concerning the parameters used to calculate their gravitational attraction : their mass and their radius. Of course in Newton's law of universal gravitation, what we called in the game the "radius" is not a true parameter. It has been created to control the increasing gravitational effect depending on the radius of the object as it is displayed in the level.

Another important point is that objects are not influencing each other. Indeed, planets may be disposed very closely, it will not change anything.

The end point to reach in the levels is represented as a very bright wormhole that takes you from one level to another. "Orbs" are objects that need to be collected in order to "open" the wormhole.

Finally, in more difficult levels, you can find black holes with the strongest gravitational attraction of all objects in the mode.

Level mechanics :

In every level you start, you have 3 lives. If you crash on an object or leave the camera view zone, you will lose one. After three crashes, you go back to the previous level. Sometimes, these lives must be used as tools in order to complete the level. More specifically, you have a limited time of propulsion represented as a limited quantity of fuel. In some levels, you won't have enough fuel to reach all the orbs to collect, so you will have to think smartly about how to achieve these levels by using carefully your lives.

Graphics :

The graphics for this mode were created independently from the other one. It has been decided to focus on the graphics rendering of the levels with only a low knowledge in visuals design. Different backgrounds were created with slightly color changes. Six very simple planets of different colors were also drawn and three more with a sort of "neon" style for the five last levels and so the final atmosphere of the mode. Also, the particles system proposed by the software GameMaker allowed us to draw a nice trail behind the spaceship and animations for collisions […].
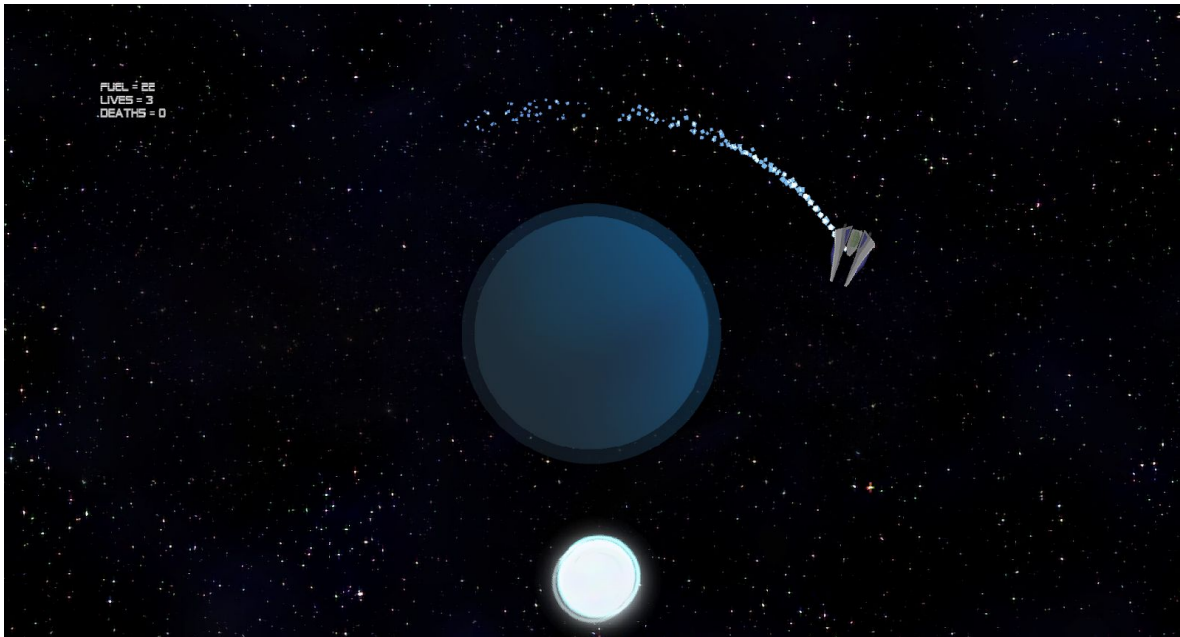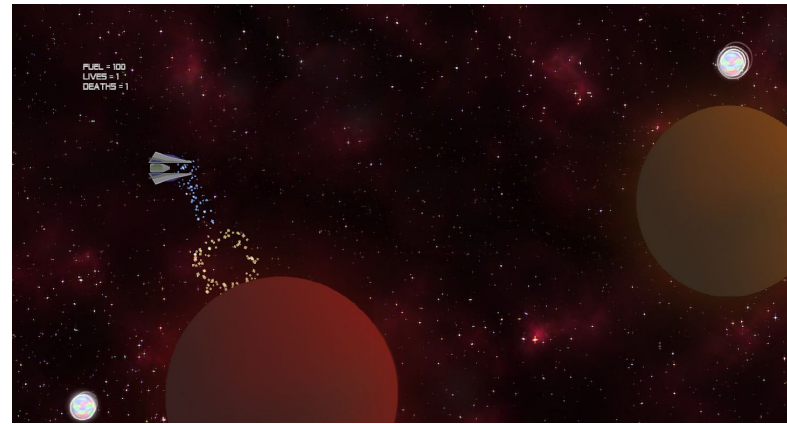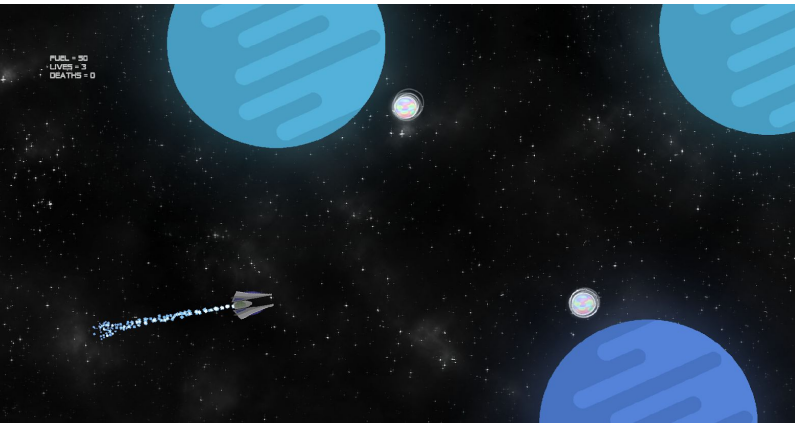
3) Game environment

In order to conciliate both game mode and to improve the player experience, it is important to have great graphics, in game sounds and functional menus.

Using the software Magix Music Maker, musics for the game have been created. An introduction music, with a lot of modern sounds and synthesizers to recreate a space atmosphere (like in science-fiction movies) and two other themes for the rest of the game. One of them is a very slow and relaxing music, the other one is more rhythmic with arpeggios on pianos and organs to simulate a "flight" like sound. The rocket sound have also been created with a lot of reverb added to it in order to give a better sound experience.

Also, we have created easy to use menus which allows players to personalize the gameplay. In fact there is 3 different section on the main menu :
- "Play" is basically a section where you can choose one of the game mode and see your HighScore on each one,
- "Options" is divided into 3 others which are "Controls" to bind keys that you want to play, "Sound" to change the volume of music or sound effects using slidebars and "Graphics" to select a resolution corresponding to your screen. Every option changes will be saved even if the game is closed,
- "Help" which is dedicated for a quick guide and credits.

ARCADE DESIGN

TRON, BMMC,1982

Introduction

The first task was about determining what we wanted to do and what we would need in order to realise it. For this part of the project we quickly agreed on doing a "bartop" : styled arcade which could be played by two player on a large list of old and retro arcade video games. The two player would play with classic arcade command, one joystick and six buttons per player. *(cf. Annex 1)* Bartop is a kind of arcade that is made without the lower half of a classic arcade. It's mean to be more compact, less heavy and easier to carry and transport, it also need less materials. This kind of arcade is made possible thanks to new technology with more and more tiny components. The main challenge is to build the arcade by using a maximum of recycled materials. For the external part, we agreed on using medium wood because it's a viable structure and it can be painted and it's the basic material used for this kind of craftsmanship. For the hardware part we planned to use a Raspberry Pi, a micro-computer about the size of a credit card, powerful enough to run most of retro classic game using the program called *Recalbox*. We also choose it because of the GPIO port of the Raspberry Pi which would help us connecting all the button, joystick and wire directly on it. (without using an additional HUB)

Pictures of a Raspberry Pi 3 Model B

1) Conception

As previously said, we agreed on doing a bartop. To do so, we wanted to conceive a wood solid structure in which every components would fit. Therefore, the first task was to create detailed blueprints of each part of the arcade, by using our CAO skills. We used AutoCAD because it's a professionally used CAO software which is free for student and because it can export usable file for the laser cutting machine. It was also an opportunity to learn how to use a different software than SolidWorks which can be encountered in our future career.

We had to think about every piece dimensions regarding the wood width, screw length and pre-drilling positions, but also components dimensions. We adjusted these blueprints many times because the found equipement were not concordant.
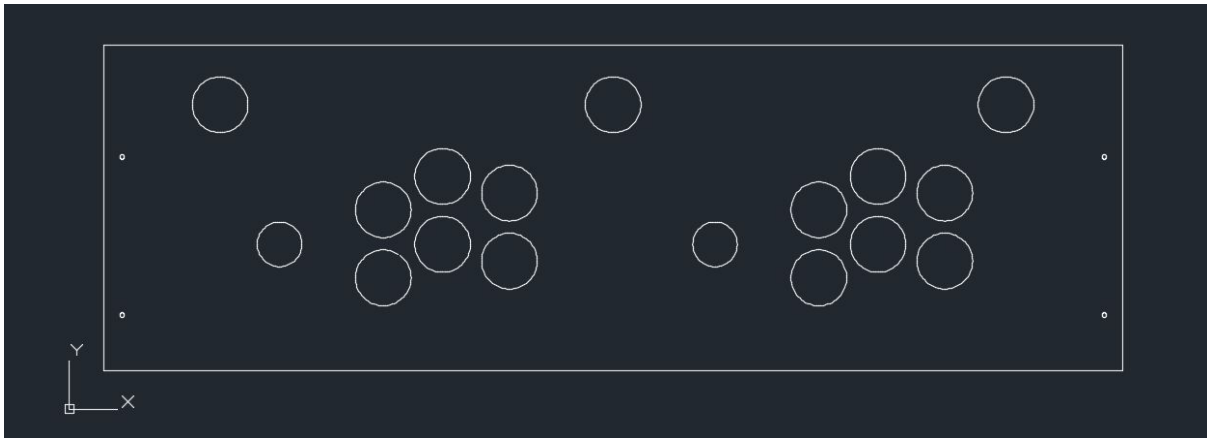
-exemple of an AutoCAD blueprint (the control panel)-

Furthermore, we wanted to make up an assembly instructions booklet in order to be able to remake the arcade and to avoid assembly mistakes. The booklet was assume to be as clear and graphical as possible. We used three softwares : AutoCAD (for blueprints), Cinema 4D (for 3D views) and photoshop (to settle instructions). When we build the bartop, we realised some steps were not optimized and could be improved to be more convenient. In fact, the booklet were upgraded thanks to our experience.
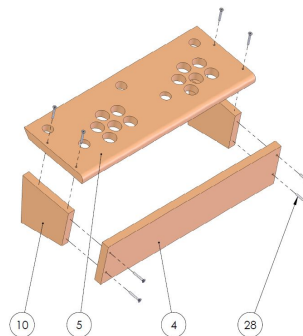
-exemple of an assembly instruction-

2) Materials

In order to keep a low price, we asked the department to have some scavenge components. Thanks to Mr. Gonthier we found the Raspberry Pi, a power supply, a SD card of 32 GB, a screen and connecting wires in the department itself. For the medium wood we use our relation to get pieces drop from the FCBA of Bordeaux. The only part we needed to pay was the buttons and joysticks kit, the screw, the paint as well as the speaker and the audio amplifier. For those, we asked to the department to get a budget and we choose a kit for Raspberry Pi from the japanese brand *Sanwa.* We choose the speaker according to their dimension and their impedance and we went to a DIY store to get the screw and the paint. In total we get a 150€ budget for a project that usually cost around 300€ or more.

3) Hardware

For this part we went to the Fablab to have access to the laser cutting machine, we used it to cut the medium according to the schemes, we had design previously on AutoCAD (by using a student license) which is a suite that combines 3D mechanical computer-aided design and 2D cotation. The laser cutting device was also use for engraving and for the part too big to fit in the machine, we use a jigsaw to cut properly. For more precision in our work we wanted to ask to other department for access to better equipment and better cutting device but with no real success and time was running out *(cf. Annex 2)*. We also used the 3D printer available to be able to make set square and a protection for the Raspberry Pi.

We needed to figure out which port from the GPIO of the raspberry we will use in order to wire two pairs of 6 buttons and two joystick. Using the electronic diagram of the GPIO port. We use the following diagram to know the function of each pin.
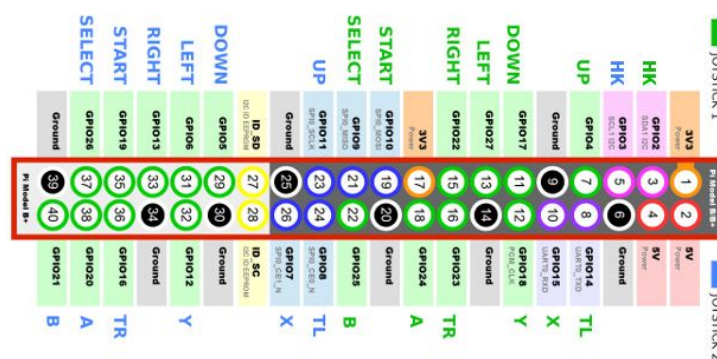
Wiring schemes of the Raspberry pi GPIO port

Thanks to this and the *Sanwa* kit we were able to wire everything without soldering, which make us able to test in real time and correct our error easylli. It also allow other people to modify the system later, or even change the Raspberry pi for a more recent version if they want.

4) Software

For the software of the arcade, everything was built around the Raspberry Pi. We wanted to be able to play retro classic game as well as our own game *Zero gravitas.* We decided to install two OS in dual-boot. Dual-boot is a method which consist of installing multiple OS on a single computer, like installing MAC OS on a PC ou vice-versa. It makes us able to launch whatever OS we choose by selecting them in a menu at the boot of the device. We selected *Raspbian* which is the official Raspberry distribution and is a linux based OS and *RECALBOX* which is an OS dedicated to retro-gaming and have emulator pre-installed. The raspberry Pi is using an SD card as memory, which make it very versatile and easy to use and modify. After successfully installing both OS we needed to configure the Raspberry. The configuration file which is located in /boot/config.txt is easily accessible. We encounter some difficulties with the screen, which was not detecting the signal sent by our Raspberry. Raspberry Pi card are using and HDMI output for video, which can be converted into a DVI-D output at the end, that's what we used. With further testing, we identified the problem as unique to the model of our screen because the raspberry was working any other screen using the same video cable on other screen. The problem was solved by changing the refresh rate in the configuration file.

CONCLUSION

Now, the arcade machine is normally finished and fully playable, as well as the video game *Zero Gravitas.* We haven't manage to make the Zero Gravitas playable on the arcade machine but we are still working on it, and we try to find an alternative which make us no more dependent of a unknown developer. During this project, we all have been able to use a variety of skill we learn during our study inside the Applied Physics and Measurements department. We have learn the way to think, conceive, elaborate and manufacture a complex object, the difficulties behind it and we were able to improve and learn from our mistake. If we were needed to do it all over again, I think we would think the schemes of the arcade differently to ad some clippable part and have more precision, we would also use a different material, maybe not as cheap as medium but easier to work with.

BIBLIOGRAPHY/SITOGRAPHY

Github

Available on : https://github.com/

We use this online forum to gather informations about the operating of the raspberry and the configuration on this computer. It was also very useful because it contain a wide online documentation about Raspberry and linux operating system.

Recalbox

Available on : https://www.recalbox.com/ and https://forum.recalbox.com/

home of the *Recalbo*x OS, we use it to download the OS itself and get the manual to install it correctly.

We use the forum to gather and asks for informations about the recalbox OS and is configuration

Raspberry pi

Available on : https://www.raspberrypi.org/

Official home of the raspberry Pi foundation. It was here were we get the dual-boot system and the Raspbian OS. It's a very useful blog with various news and informations about the raspberry.

ANNEX

-Annex 1-

-Annex 2-

Annex 3 Poster arcade machine

Annex 4 Poster video game