

Flooduino

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Abstract

The goal of this project was to create our own implementation of the game Flood-it on an Arduino. The outcome is a fully functioning implementation of the game encased in a cardboard housing which resembles an old arcade machine. To do this we used an Arduino Mega, a LED-matrix, a DFplayer Mini along with a speaker and some Buttons. Furthermore all of our own code is written in C and the project is compiled using the Arduino IDE. Everything is coordinated by the Arduino Mega on which the LED-matrix, a DFplayer Mini and the buttons are connected. The LED-matrix displays the current state of the game, the DFplayer Mini along with the speaker play music depending on the different stages and the three buttons allow the player to interact with the device.

Introduction

The goal of the game Flood-it is to fill a grid of differently colored cells with the same color in the maximal number of allowed moves. To start with the player can choose the size of the grid and how many colors should appear on the grid. Then each move the player can choose the color of the top left cell which is then propagated down the grid using a flood fill algorithm at the end of each move. If the player manages to use no more than some predetermined number of moves he wins, however if he uses more moves he loses.

To do this we used The Arduino Mega which was beneficial for us because of its increased memory capacity and its many connection pins. In addition we used a 64x64 LED-matrix from Waveshare as visual output, a DFplayer Mini to control the music, a Speaker for auditory output and three buttons as input. The LED-matrix always displays whatever stage the game is in at the current moment. These being the start screen, selection screen, the game and a win/loss screen. The DFplayer Mini functions similarly as it plays different music depending on the different stages of the game. The buttons consist of the arrow keys up and down as well as an enter key. The arrow keys are used to increase or decrease the field size and the amount of colors used in the selection screen and as a way to select the color in the game itself. The enter key is used every where else meaning to switch to the next stage and to initiate the flood fill algorithm.

We first created a prototype using C and raylib which is able to be run on any computer. Then we migrated this code over to the Arduino where changes were made wherever necessary. This includes using an Adafruit library instead of raylib for the visual output. Implementing controls for the DFplayer Mini as

well as detecting the button presses. Next everything was build together using two breadboards, one for the buttons and one for the DFplayer Mini. Necessary connections between the devices where made using wires and transistors. Finally a cardboard housing was build which is made out of cardboard boxes that we bought in a hardware store. The shape was cut out and glued together using hot glue such that it resembles an old arcade.

Methodology

Prototype

It is necessary to quickly mention the prototype we had created. It was made completely in C using the raylib graphics library for visual output. At its core it consists of three modules being the input, game logic and the output. The input module's function is to detect any button presses made while the game is running. It does this using a function to detect button presses from the raylib library. The output module implements some methods which are used to update the window in which the game is shown. To achieve this we used the raylib library as well. The main part is the game logic module in which the main loop is run. It is the entry point and is responsible for most actions. Mainly it is used to initialize everything, parse input and outputs using the aforementioned modules, run the game loop, check whether a button has been pressed and update the screen which shows the current state of the game.

Arduino Implementation

To implement the

Input

For the final product we decided to use three buttons. The arrow keys up and down as well as an enter key. These are used as following. At the beginning of the game the player presses enter to switch from the start screen to the selection screen. Here the size of the field is chosen first. The player can press up or down to increase or decrease the size of the field and press enter to select a size. Afterwards the amount of colors can be chosen where just like the field size the number of colors is increased or decreased with the arrow keys and selected with the enter key. After this is done the game switches to the main game. To select the color of the top left cell the up and down arrows are used to switch between the different colors. Enter is used to initiate the flood fill algorithm and marks the end of a

move. Depending on whether the player filled the field with the same color within the allowed number of moves he is prompted with won or lost screen. Pressing enter in either will restart the game and switch to the start screen.

For the buttons we had two options. One was to use keyboard switches with breakout boards. This would make for much nicer buttons but would include a higher cost and more work. The second option where regular breadboard buttons which can be bought in any electronics store. We ultimately decided on the second option since it meant less cost and less work for us. The buttons work using interrupts. Every time a button is pressed an interrupt is triggered which increases an internal variable which tracks how often a button has been pressed. This allows us to register any button presses regardless of what the processor is doing. The game loop will check for each counter if it is bigger than zero and perform actions accordingly.

A challenge we faced here where the high bounce times of the buttons. A bounce describes the period after a button has been pressed where rapid oscillations trigger multiple unwanted button presses. To deal with this we used a debounce period in which any further button presses are ignored. This was ultimately put at 250 milliseconds which is quite a long time. This leads to the truncation of any button clicks which were made in rapid succession. However, in our experience this is rarely a problem since the game does not require rapid button presses.

Visual Output

One challenge we faced was to figure out how to display images on the LED-matrix. This was especially difficult since there was no clear guide on how to do this. Our basic idea is to convert the image to an array of rgb values, using a Java program, and store this array on the Arduino which can then be displayed with the Adafruit library. However this process was not straight forward as the colors have to be stored as 16-bit values compared to the normal 32 and each value has to be split and stored in two sequential fields of the array. To add to this there still remains some uncertainty about the exact order every value has to have. This process required a lot of testing and experimenting but in the end we managed to get it to work.

Music

We decided at the beginning of the assembly of our arcade that we wanted to implement music for the game to enhance the experience for the player. We ended up deciding that every stage of the game has its own music which loops if the song

is over. This was to be achieved using a DFplayer Mini which is a device that operates independently from the Arduino, playing music saved on an inserted sd card. Additionally to this we acquired a speaker for auditory output.

Initially we intended to use a library to control the speaker which used hardware serial but this would not work in combination with the screen. To circumnavigate this we communicated directly with the device to change volume and skip as well as loop songs. Normally this is achieved using button presses but since the music should work independently of the input we used transistors to simulate a button press. At its core there are two resistors, one simulates a long button press on the IO 2 pin which increases the volume, and the other simulates a short button press on the IO 1 pin which skips to the next song. Using this the game increases the volume at the start of the game and skips to the next song if the stage is changed. If a song is over we skip ahead 5 times to loop the song indefinitely.

Our biggest problem was to get the DFplayer Mini working with the transistors. After realizing that it would not work with the library we needed to find a different route which lead us to the usage of transistors. This required us to figure out how we can get the necessary functionality out of the basic control we had over the device, fine tune the timing of current flowing through the transistor and implementing this into the main loop of the game.

Housing

The housing was the last thing we decided on and built. Since the game and the hardware used is reminiscent of old arcade games like PAC-MAN we decided to go with a similar look for the housing. It was heavily inspired by old arcades popular in the 1980's.

The upper part which holds all the components including LED-matrix, buttons, the speaker and the Arduino was the most complex part to build. Its individual parts were cut out of cardboard and glued together using hot glue. For the screen and the keys little compartments were made to hold them in place. The speaker is embedded in the side with the screen and the back has a little door which allows access to the inside where the Arduino is hidden. The middle and lower part consist of two boxes stacked on top of each other and act as a base for the top part.

The most difficult part was simply our inexperience with crafting things out of cardboard. We had to make up a design and hope it would work and look nice the first time trying since the process was very time consuming. However we managed to get it to work roughly as we expected it to work and look like.

Conclusion