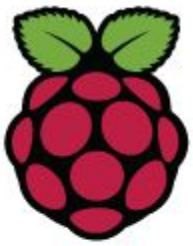

EMBEDDED SYSTEMS

Group Ace - Phase 1

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Group 12

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Introduction

Our specification for this project was to design and implement an embedded system ‘gadget’ which uses an Arduino device and/or a Raspberry Pi. This report will discuss features of the Arduino and Raspberry Pi devices and will outline the reason for our chosen device. We will also outline parts needed, the design and plan for our gadget.

After a discussion we have decided to implement Connect 4 game which will have one player playing in person and the 2nd player will be online.

Assessment of Capabilities

Arduino

The Arduino is an open-source electronics prototyping platform aimed at providing an inexpensive and easy way to allow novices and professionals to create devices to interact with the environment using sensors and actuators. The boards have serial communication interfaces including USB, for loading programs. Arduino provide an Integrated Development Environment (IDE), for programming the microcontrollers, which has support for C, C++ and Java programming languages.

Raspberry Pi

The Raspberry Pi 2 is a single-board computer, the size of a credit card, which was developed to promote basic teaching of computer science in schools. It runs the Linux operating system which is loaded with a MicroSDHC Slot. The Pi2 has a Broadcom chip, 900 MHz quad-core ARM Cortex-A7 CPU, 1GB RAM memory and a Broadcom VideoCore IV GPU.

Decision

For our embedded systems ‘gadget’, after reviewing both the Arduino and Raspberry Pi, we have decided to use both the Arduino and Raspberry Pi2. The Arduino will be used for its IO capabilities and connected to the Pi2 using I^2C. The Pi2 is more powerful, has better camera capabilities which will be used with the hardware accelerated open-cv image analysis to detect where pieces have been placed on the connect 4 board. The development environment we will be using is Python.

Design

In order for front system to make a move it needs to pick up a disc move it over a slot and drop it into the grid

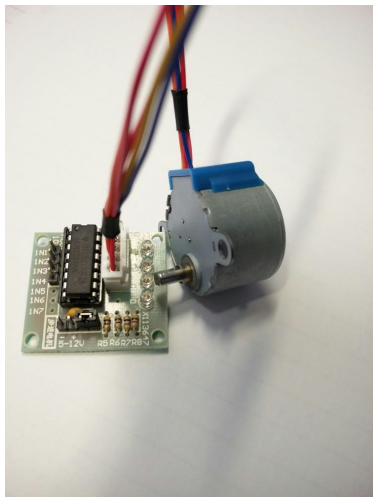
In order to do this a robotic arm moved by stepper motors will be used this will give us high degree of control which will be required to pick up and drop the discs accurately. The stepper motors will be controlled using the GPIO on a raspberry pi 2. In order for the raspberry pi to know where the arm is positioned limit switches will be used to calibrate as zero position for each of the stepper motors at start-up.

Stepper motors

The motor that we are going to use is the 28BYJ-48 Which is a low-cost low-power stepper motor which also comes with a driver board which will make integrating it into the system a lot easier

TABLE 1: Stepper motors specification

Rated Voltage:	DC5V 4-phase
Step angle:	5.625 x 1/64
DC Resistance:	200ë©å±7% (25C)
Insulation Resistance:	>10Më© (500V)
Dielectric Strength:	600V AC / 1mA / 1s
Insulation Grade:	A
No-load Pull in Frequency:	>600Hz
No-load Pull out Frequency:	>1000Hz
Pull in Torque:	>34.3mN.m(120Hz)
Detent Torque:	>34.3mN.m
Temperature Rise:	<40K(120Hz)
Noise:	<40dB (120Hz, No load, 10cm)
Cable length :	23.5CM
Price :	£2.28



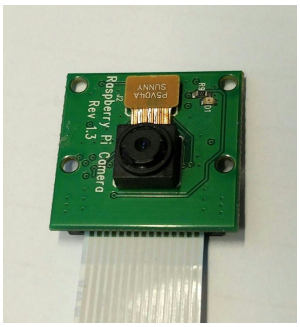
Limits switch

The limits which we are going to use is a simple letter switch which will be small and easy to place around the arm. SPDT-NO/NC Hinge Lever Microswitch, 0.1 A@ 30 V dc RS Stock No.616-0158

TABLE 2: Limits which specification

Switch type:	Switch SPDT
Connection:	Spade cable shoes 6.3 ´ 0.8 mm,189157: although 4.8 ´ 0.5 mm
Switch material:	Silver
Mechanical life:	30 ´ 10^6 functions at max.contact load
Temp. range:	-55°C* to +85°C
Dimensions:	See drawings
Price :	£0.562

Game state



In order to get the current state of the game after the human player's turn. We will use the raspberry pi camera module to take pictures of the grid. Then use openCV to analyse the image by using techniques like edge detection and node detection

TABLE 3: Camera specification

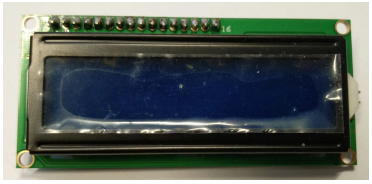
Mode	**Size**	**Aspect Ratio**	**Frame rates**	**FOV**	**Binning**
0	automatic selection				
1	1920x1080	16:9	1-30fps	Partial	None
2	2592x1944	4:3	1-15fps	Full	None
3	2592x1944	4:3	0.1666-1fps	Full	None
4	1296x972	4:3	1-42fps	Full	2x2
5	1296x730	16:9	1-49fps	Full	2x2
6	640x480	4:3	42.1-60fps	Full	2x2 plus skip
7	640x480	4:3	60.1-90fps	Full	2x2 plus skip

Other Option

Another option is to put switches similar to the limit switches above each column and to detect the disc. This way we would just be assuming that the correct discs are inserted using alternate colours so it could easily lose track of the correct game state if the human player makes a mistake.

LCD Screen

In order for the human player to know it is their turn a small LCD screen used to display messages such as your turn, You win, computer wins and online player wins The screen has a resolution of two lines of 16 characters. It has a I2C bus connected to it



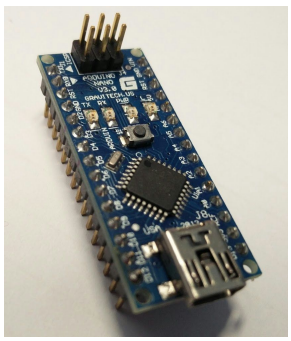
Raspberry pi

The raspberry pi Is the main controller for the system it will be running Raspbian. It's GPIO pins will be used to control the stepper motors and receive signals from the limit switches all of these will require a total of 24 pins.

Table 4 shows what GPIO pin each step motors will be connected to

TABLE 4: GPIO pins

SM-Pin	SM-1	SM-2	SM-3	SM-4	SM-5
1	4	24	10	6	12
2	17	25	9	13	16
3	27	8	11	19	20
4	22	7	5	26	21
limit switches	14	15	18	23	N/A



GPIO pins **2** and **3** will be reserved for I^2c to communicate with an Arduino and LCD screen they Arduino will be used to control start stop and reset buttons as all of the raspberry pies GPIO has been used up by the stepper motors

Wifi Adapter

In order to connect the online player to the device that will require a wireless module to connect to the Wi-Fi this will mean that it will not require an ethernet cable to connect to the Internet

Components List

Stepper motors 28BYJ-48 http://amzn.to/1LmI8GW	5	£11.40
Limits switch RS Stock No.616-0158 http://bit.ly/1OGZLVK	5	£5.62
raspberry pi camera module http://amzn.to/1LJmJt3	1	£18.96
LCD Screen http://amzn.to/1jShKv2	1	£5.99
Raspberry Pi 2 Model B http://amzn.to/1W4eCOv	1	£29.72
Arduino Nano V3.0 http://amzn.to/1M5Taxw	1	£3.16
USB Wifi Adapter http://amzn.to/1jzu5EU	1	£5.94
		totale £80.79

Operation

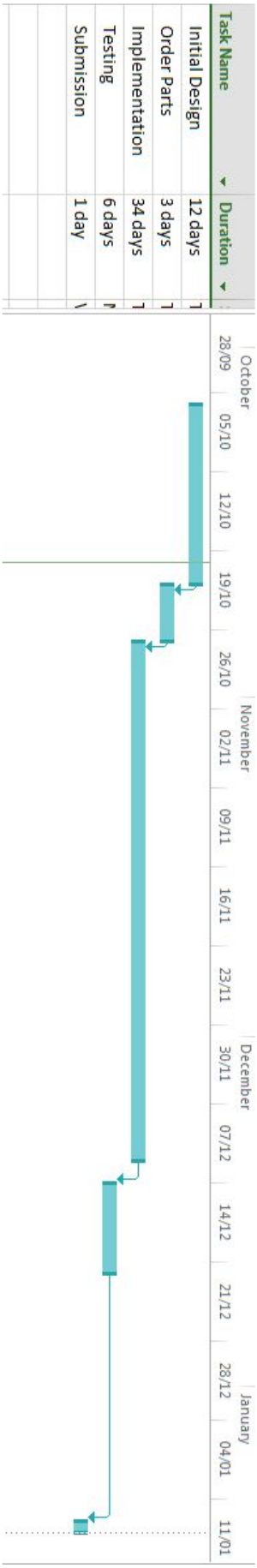
The Connect 4 game will be operated by one player playing in person and a second playing online or through an app. When the player in person makes their move, the camera will detect which move was made and send the information to the Raspberry Pi which will notify the web page or app of that move. The second player will then make their move through the web page or app which will notify the Pi of that move which in turn will notify the robotic arm which will then imitate the move made. This will go on until there is a winner.

Other Option

We were also thinking of an AI which will play against a physical player. This would involve writing the AI in Python which will read in the move played by the player through the camera and then decide which is the best move it can make to win the game.

The AI option is something we would like to implement but for now we will go with a player in person playing someone online. If there is enough time then we might try for the AI option.

Plan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Duration
Initial Design
12 days
Order Parts
3 days
Implementation
34 days
Testing
6 days
Submission
1 day
October
28/09
05/10
12/10
19/10
26/10
November
02/11
09/11
16/11
23/11
December
30/11
07/12
14/12
21/12
28/12
January
04/01
11/01