Connect 4 Arduino

Introduction

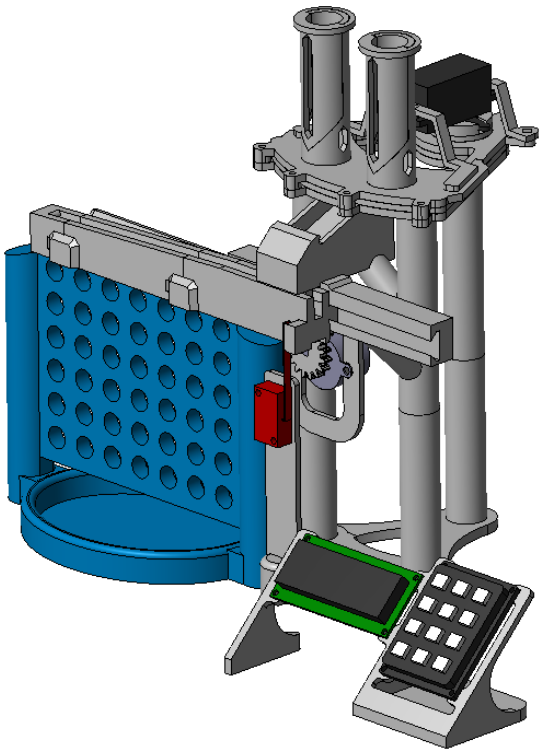
These instructions describe the making, assembly and workings of a Connect 4 game created for use with an Arduino microcontroller. The game consists of a purchased game board, 3D printed parts and electrical components to create a machine that plays the game, it is controlled by the Arduino and played by computer or human players.

3D Printed Parts

Part	Quantity	Material (Grams)	Print time (Minutes)
Base front	1	13.3	115
Base rear	1	6.2	56
Switch mount	1	7.4	65
Control panel (2 versions included)	1	20.3	163
Control panel support	1	4.6	44
Lower pillar	3	11.4 (34.2)	89 (267)
Upper pillar A	1	13.6	106
Upper pillar B	1	18.6	139
Upper pillar C	1	18.2	138
Guideway A	1	10.2	87
Guideway B	1	11.3	93
Selector A	1	3.7	35
Selector B	1	18.1	150
Selector C	1	20.9	166
Rack A	1	2.3	24
Rack B	1	2.3	25
Rack C	1	1.5	15
Cog	1	2	23
Stepper motor mount	1	5.6	55
Counter chute	1	17.2	137
Counter chute nudger	1	0.5	6
Dropper base plate A	1	13.3	114
Dropper base plate B	1	6.6	59
Dropper counter selector A	1	11.2	94
Dropper counter selector B	1	6.8	60
Dropper top plate A	1	14.4	129
Dropper top plate B	1	6.2	61
Servo adaptor (2 versions included)	1	4	37
Servo mount A	1	3.5	42
Servo mount B	1	2.1	27
Magazine (2 versions included)	2	9.4 (18.8)	102 (204)
Total	**34**	**318.9**	**2736 (45.6 hours)**

Other Components

Component	Pins	Notes
Arduino Uno		
Stepper motor and controller board (28BYJ-48)	8-11	
Standard size servo	3	
12 key keypad	A0	
16 x 2 LCD with serial interface	SDA SCL	
Microswitch (preferably with a long lever)	2	Normally closed
Piezo buzzer	4	
Grab & Go Connect 4 game. This version was selected for two reasons, it is physically small so less 3D printing was needed and the counters are flat so can be fed from a stacked magazine, in the full sized Connect 4 the counters lock together when stacked.		
Resistors		10k for switch circuit 100 ohm for piezo buzzer 5k and 2k for keypad
Breadboard		
Jumper wires		
Nuts and bolts		
Adhesive		
Paint		
Power supply		



Wiring

There are 6 individual circuits involved in this project,

- Microswitch
- Piezo buzzer
- Servo
- Keypad
- Stepper motor
- LCD with Serial Interface

Each of these is described widely on the internet and the details will not be repeated here.

A circuit diagram that suits my particular hardware is included. Not all my hardware is available in Fritzing, so some elements are representations of the components used.

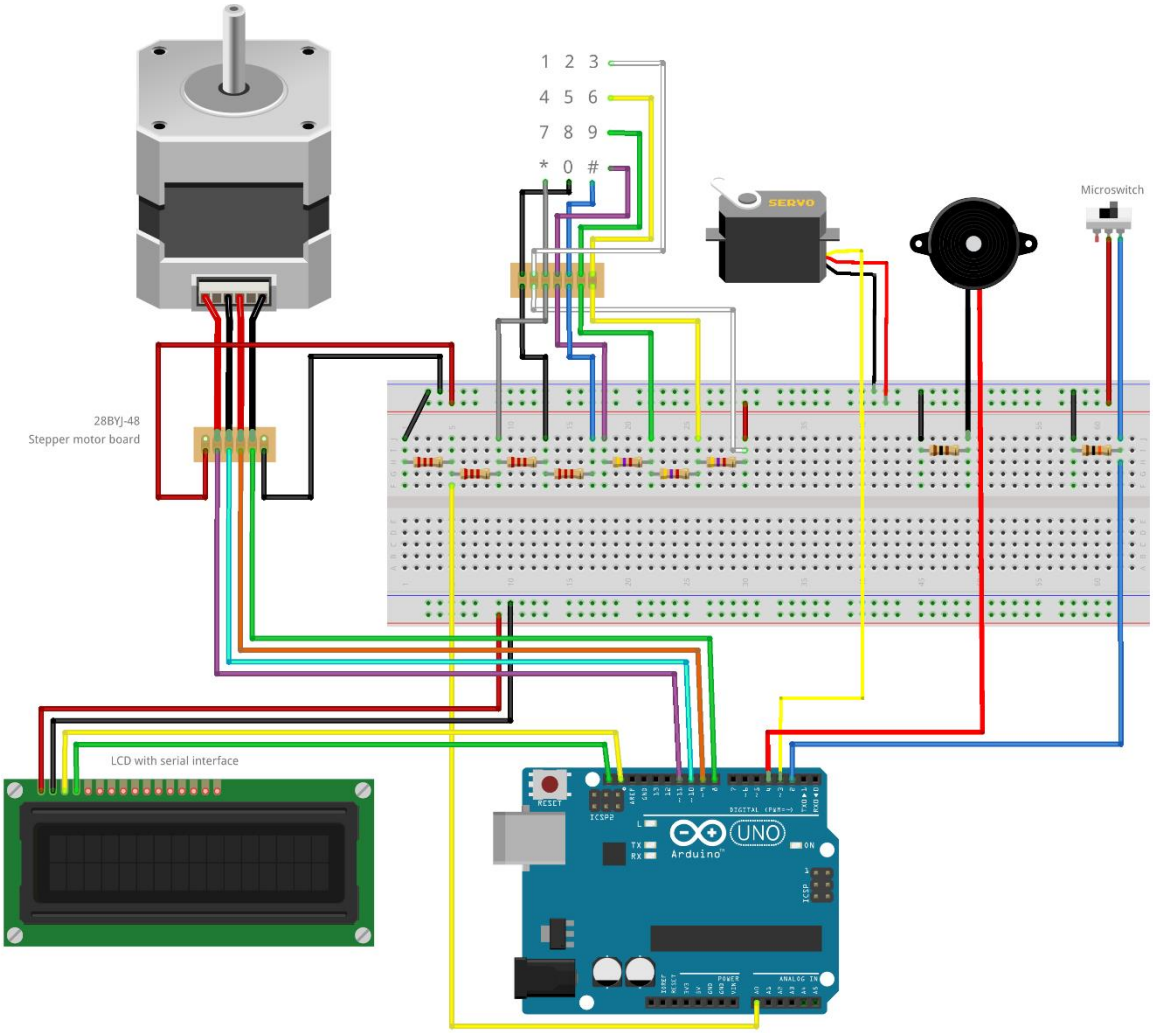


Figure 1: Complete wiring diagram

Assembly

All parts except one of the servo adaptors can be printed without support, orientate the parts when printing to make sure that no support is necessary.

Once the base parts have been printed they can be assembled, glue them together so that they are flat. Next glue the pillar lowers into the base, leave the switch holder off until later in the build so that the switch position relative to the selector can be set.

When the upper pillar parts and the counter chute have been printed, the upper pillars can be glued into position. Do not glue the chute in just yet, use it to align the upper pillars, the supports for the chute are not at 90 degrees so be careful in this step. You may want to wait until the selector guideway is printed before assembling these parts to ensure it all goes together properly.

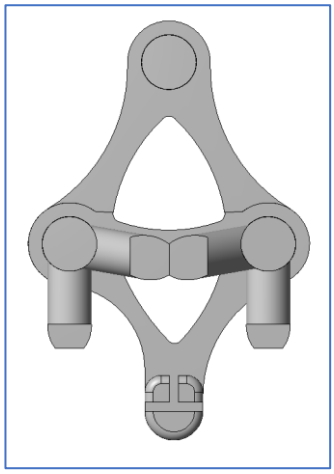


Figure 2:Plan view of base and pillars

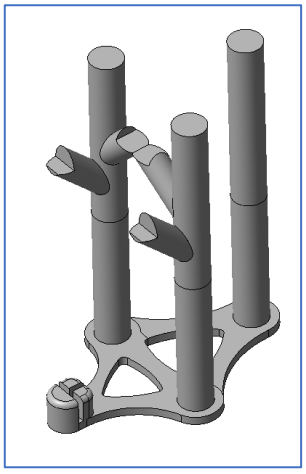


Figure 3: 3D view of complete base and pillars

Print the guideway parts and glue them together with the motor mount, the motor mount may need to be drilled out to suit your motor. Glue the guideway assembly to the pillars, ensuring that it is flat and level, the chute can help the assembly in this stage but don't glue it in just yet. Print and glue the chute nudger into the chute. I have not glued the chute into position at all as it stays in place on its own.

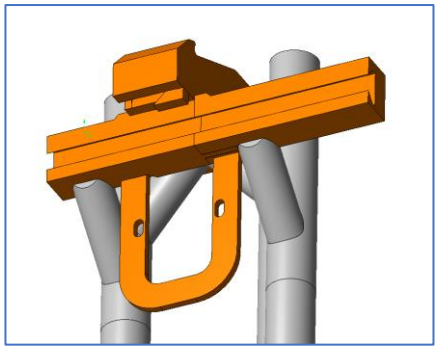


Figure 4:Guideway in position

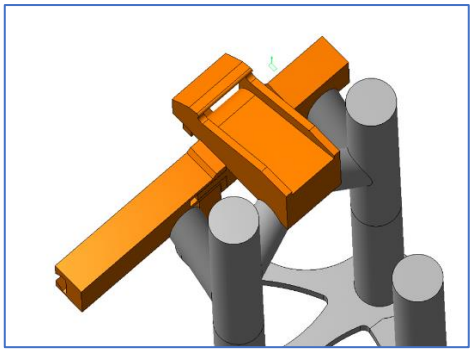


Figure 5:Guideway top view

Next print and assemble the selector, there are 3 main parts and 3 rack parts, make sure you assemble the rack parts in the correct order, the longest part goes in the centre and the teeth at ends are slightly chopped through. Look at the joint lines in Figure 8.

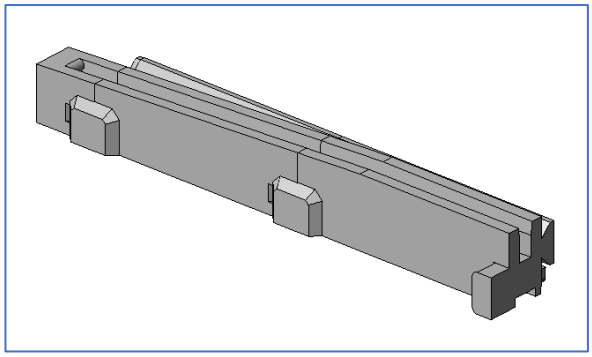


Figure 6:Selector top

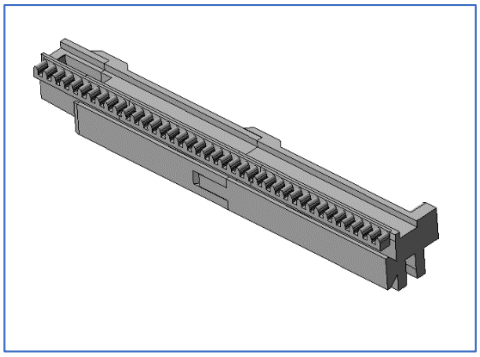


Figure 7:Selector underside

Once the selector is assembled and the gear printed, it can be inserted into the guideway and the motor position can be set-up and tested to ensure a smooth action. The switch can also be mounted so that it is triggered by the lug on the end of the selector. The counter chute nudger should sit in the slot on the top of the column selector.

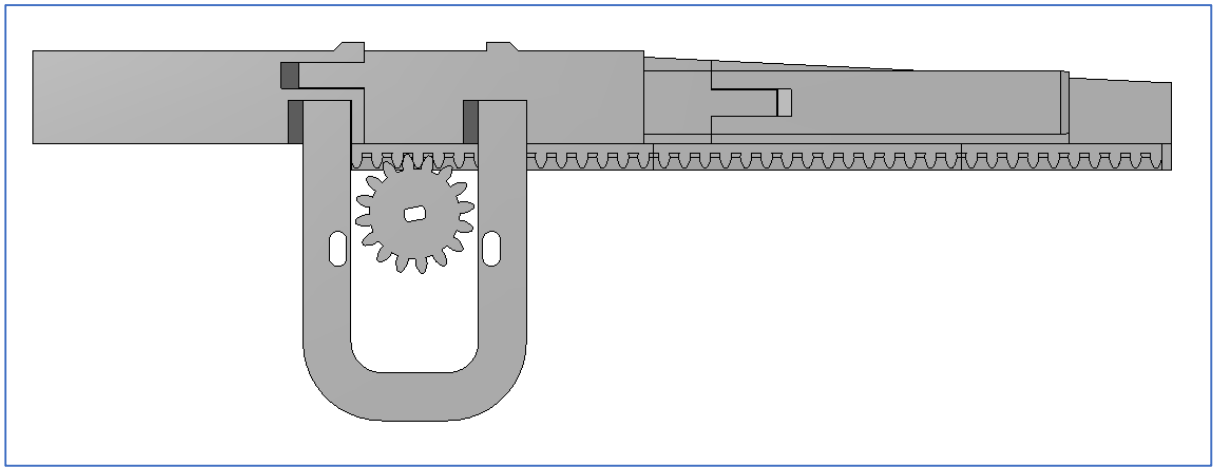


Figure 8:Rear view of selector gear and rack

The counter dropper consists of three plates of two pieces each, the middle plate is driven by the servo, holes and recesses in the plates allow the counter from each magazine to be dropped through the centre hole onto the chute.

Print the 6 plate parts and glue each pair together ensuring they are flat. (Print the top and bottom parts upside down to make them printable without support.) Bolt the 3 plates together to sandwich the middle plate but allow it to move freely, I used some washers as spacers to get it to work as I wanted. The bottom plate has 3 recesses to fit on top of the pillars.

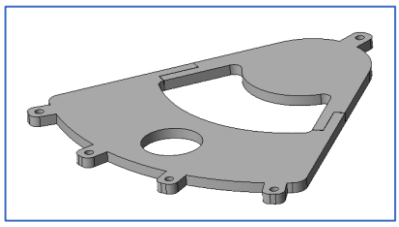


Figure 9:Bottom plate

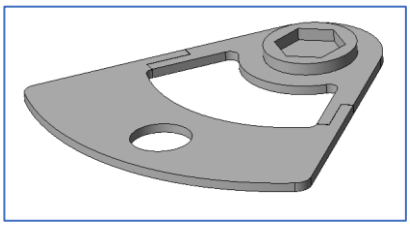


Figure 10:Middle plate

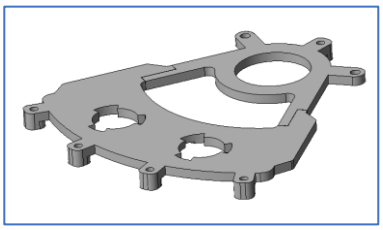


Figure 11:Top plate

Print the servo adaptor (2 options) and mounts, these may need to be adjusted to suit your servo. After fitting the servo, the dropping mechanism can be tested using a servo tester.

Print two magazines, the two part ones allow easier loading as the front is removable, dropping counters in from the top can cause them to sit on end and they will then not drop through the mechanism, they need to be nicely stacked. The magazines do not need to be glued in place and the whole dropper mechanism does not need to be glued on top of the pillars unless it is unstable. I have not glued mine. Mark the left magazine red and the right one yellow with paint or pens to show the players which is which.

Finally print out the control panel pieces and fit your keypad and LCD. There are two versions, one with recesses underneath to hold rubber feet (that protrude by 2mm) and one without.

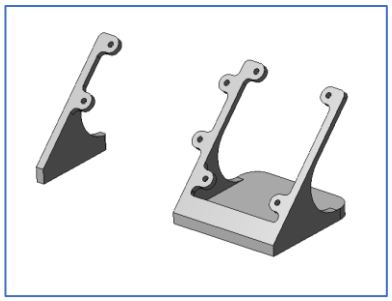
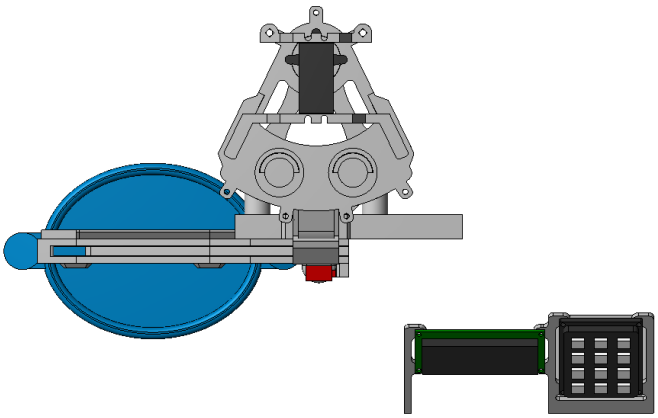
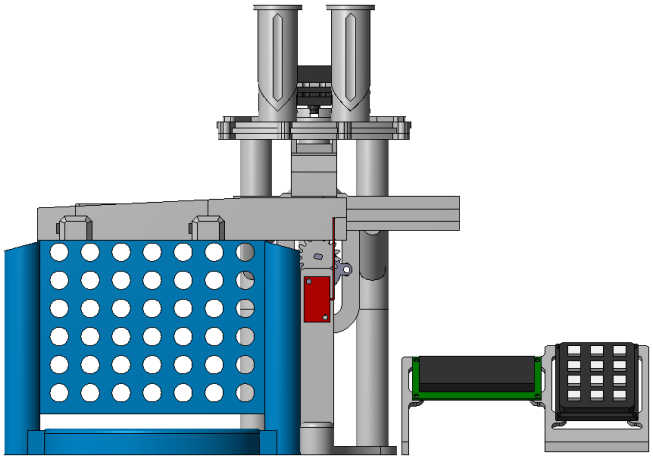
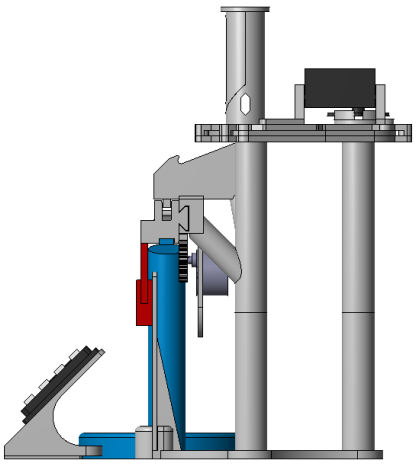


Figure 12:Control panel parts







Set-up

Once the wiring is complete and the sketch has been loaded, the set-up menu is used to obtain the values for the keyboard, servo and column selector. (Although the keys will not work without values so an initial sketch to find some values may be required. Use analogRead() on pin A0 and send them to the serial interface as described on various web pages.)

Keypad: pressing keys shows the voltage on the A0 pin and these values should then be entered in the sketch in the keyValues array. These values are then used to identify keys pressed.

Servo: using the keys, move the servo to the centre and drop positions for the counters, enter these values in the variables, servoCentre, servoRed and servoYellow in the sketch.

Selector: use the keys to count the steps from the reference position to column 1 and the number of steps between columns, enter these values in the referenceSteps and stepsPerColumn variables in the sketch.

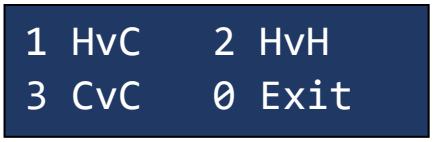
Test

The test menu can then be used to manually move the machine and drop counters. Thoroughly test the operation and iron out any problems before playing the game.

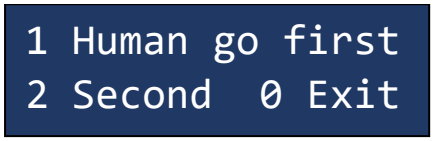
Control Menu

Initial display, when a key is pressed the machine will go through its reference process.

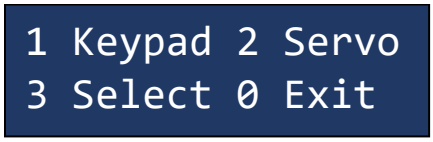
Initial menu, used to initiate a game or go to the test or setup menus.



In the play menu, choose Human v Computer, Human v Human or Computer v Computer game modes.



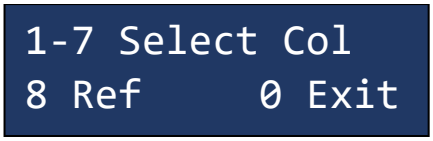
When playing Human v Computer, you can choose to go first or second.



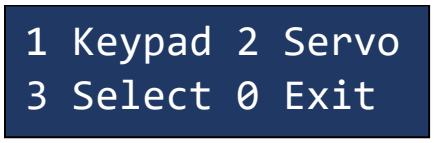
From the test menu, you can choose to test the keypad, servo or selector.

To test the keypad, press keys, the key pressed will be displayed on the top line of the display, wait 5 seconds to automatically exit this menu.

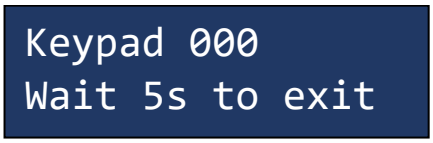
To test the servo, use the 1 and 2 keys to drop counters.



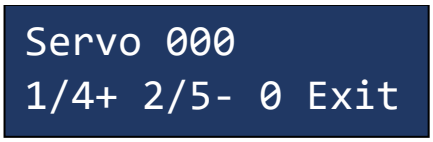
To test the selector use the keys 1 to 7 to move the selector to that column, use 8 to run the reference sequence.



From the set-up menu, you can choose to set-up the keypad, servo or selector.



Pressing keys on the keypad will show the voltage on the A0 pin.



Pressing the 1, 4, 2 and 5 keys will move the servo left and right. The current position will be shown on the top line of the display.

Pressing the 1, 4, 7, 2, 5 and 8 keys will move the stepper motor left and right. The step count will be displayed on the top line of the display. To reset the number press the 9 key.

Gameplay

The game is played by two players, each player can be either a human or computer player. The first to go is always playing red counters. The game type is selected from the Play menu. The computer player will play a defensive game, it does not do strategy :) Once a player wins a tune will play and a message will be displayed. If the game is a draw or it is aborted then a message will be displayed.

Conclusion

I really enjoyed designing and making this project, it has a lot of different elements and getting some parts right took several attempts to get to the final design. The two improvements I would make are the column selector is a little slow, a bigger gear would sort that out. The other would be a better playing algorithm, it plays a very defensive game without any real strategy so there is definitely some room for improvement there even with the limited memory resources of an Arduino Uno.