Brian Mungandi

Jesse Noble

Dallas Mitchell

ENGR 480

Mosaic Machine Manual

Machine Instructions

Loading the machine:

When we started to work on the machine, we wanted a way to limit the amount of work that the operator needed to do during operation. With our machine we will have to have multiple dispenser units ready to be used and then manually fill each dispenser with an even number of tiles. After all units are filled with the tiles, they are weighted down with a multipurpose counter weight. The counter weight is the same dimensions as the tile, with the exception that the weight is almost as tall as the unit itself. When the units are filled, they are then docked on the side of the table next to the board where the tables are going to be placed.

When the units are docked and in position then the machine will run its program, retrieve the units from their docked position and proceed to run the program that allows it to dispense the tiles.

Starting the machine:

The machine is started by first turning the main power switch to introduce power to our system. A compressed air hose is then attached to the machine at its base as pneumatics are used to power and control our machine tools. Next the appropriate colored dispensers must be placed in their designated area and the robots working area cleared of any obstructions. To run the program the job titled “mosaic” must be chosen from the list of jobs. To run the job, make sure the cursor is located at the top of the program, then the robot’s mode must be switched to run mode, and the servos must be turned on. When ready to run press the go button. If no jams occur the robot will complete the job with no more required actions by the operator.

Clearing Jams:

With this machine jams will most likely happen inside the dispenser unit. While the program is running the machine will retrieve the unit, move to the desired position relative to the board. While the machine attempts to place a tile on the board the plunger mechanism, that is used to push the tile out of the stack and through the dispenser opening, may inadvertently push the tile in a way that doesn’t allow the tile to fall through the opening precisely the way it should. When this happens, the tile becomes stuck in the dispenser channel or stuck in the opening itself. When jammed the robot will sense the problem and stop all robot operations. The dispenser should then be tapped to see if the jam can be easily dislodged. If this does not fix the problem the robot should be switched to teach mode and the dispenser should be released from the grippers by pressing interlock and the 1 key. Once released the dispensers jam can more easily be removed. Once the problem is solved the dispenser can be placed back in the grippers and the robot's operations can continue.

Diagrams:

Mechanical Drawings:

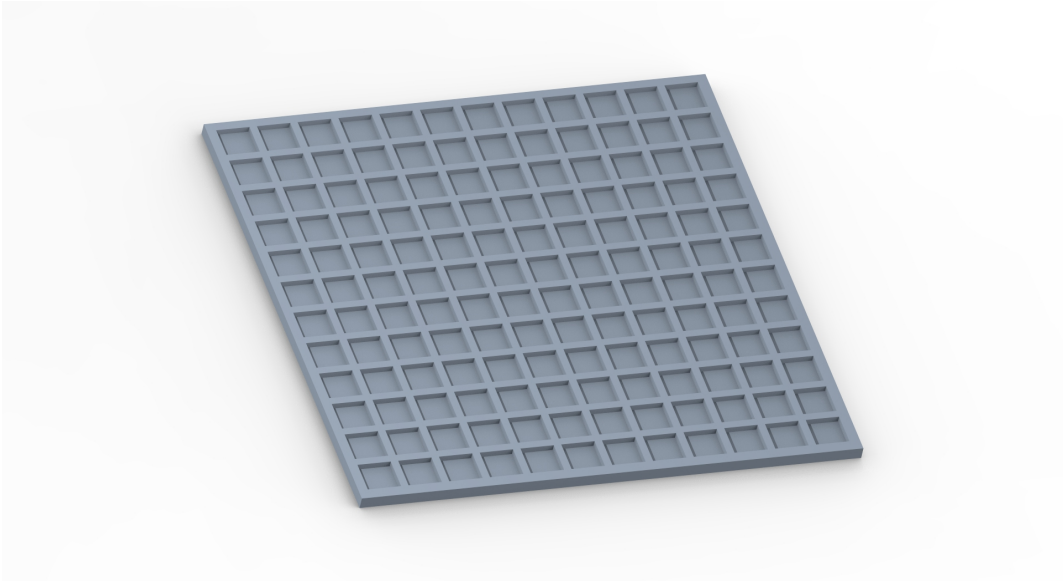

Figure 1- Tile Grid Render. Used to hold tiles upside down for later application of mesh.

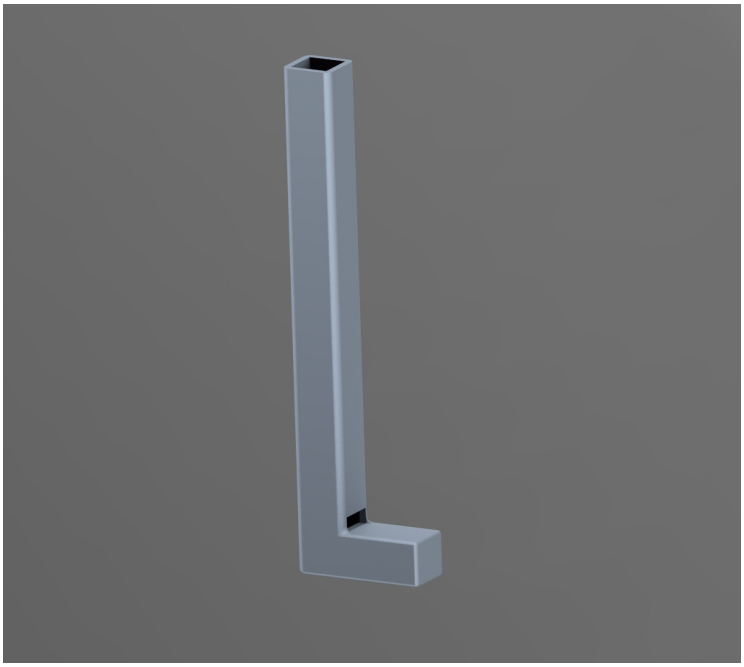

Figure 2- Tile dispenser. Filled with tiles manually and picked up by gripper.

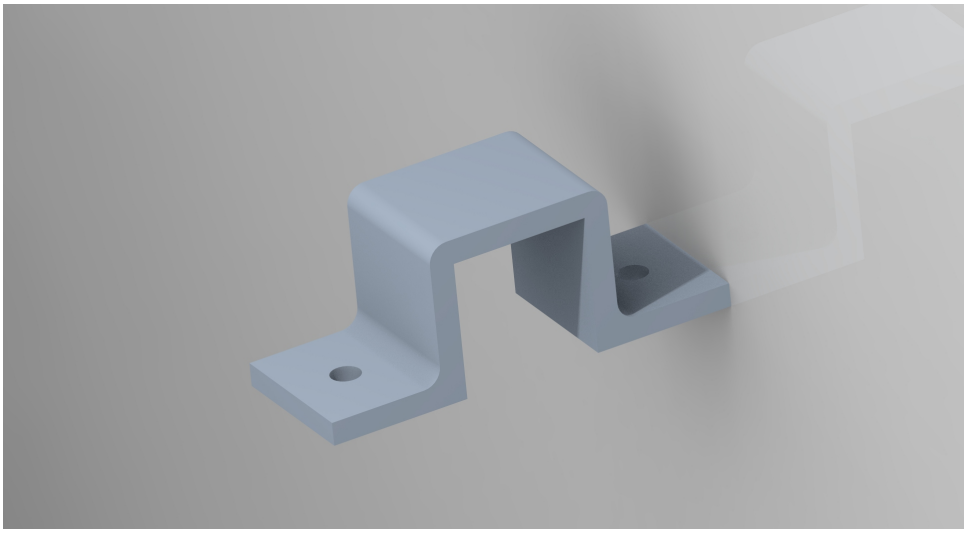

Figure 3- Tile Clip Mount. Used to hold tile clips in place.

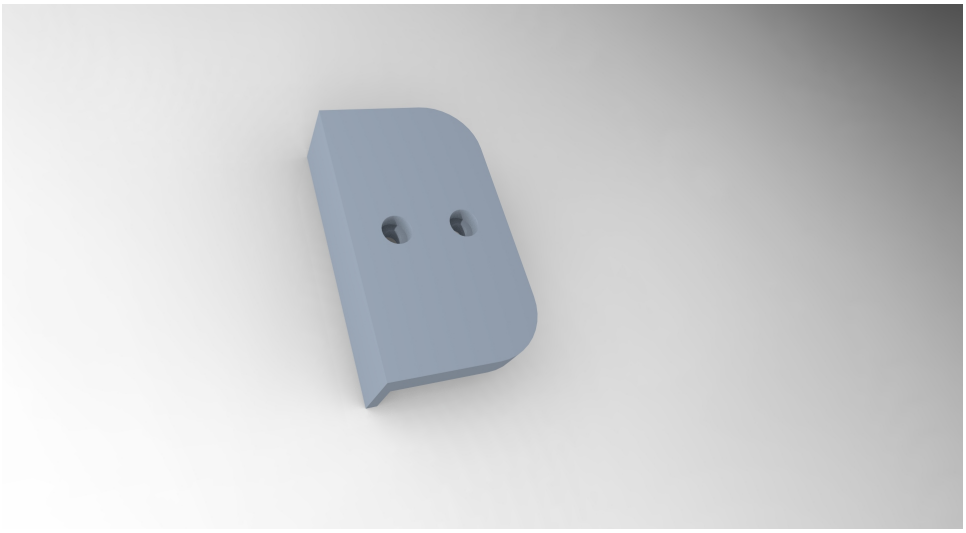

Figure 4- Tile Clip Gripper Attachment. Attached to the pneumatic gripper to add more grip surface.

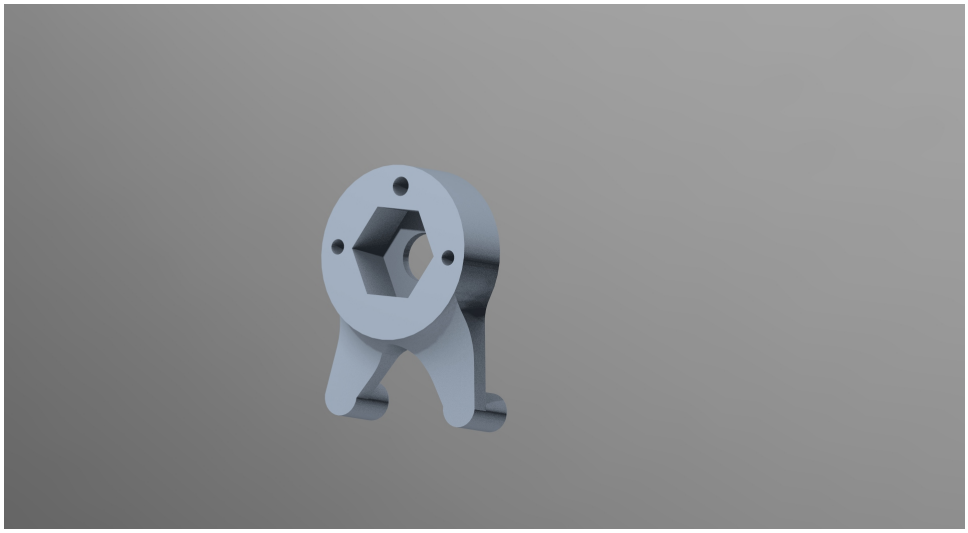

Figure 5- Sensor Mount Part 1. Adds the ability to attach a sensor to the gripper.

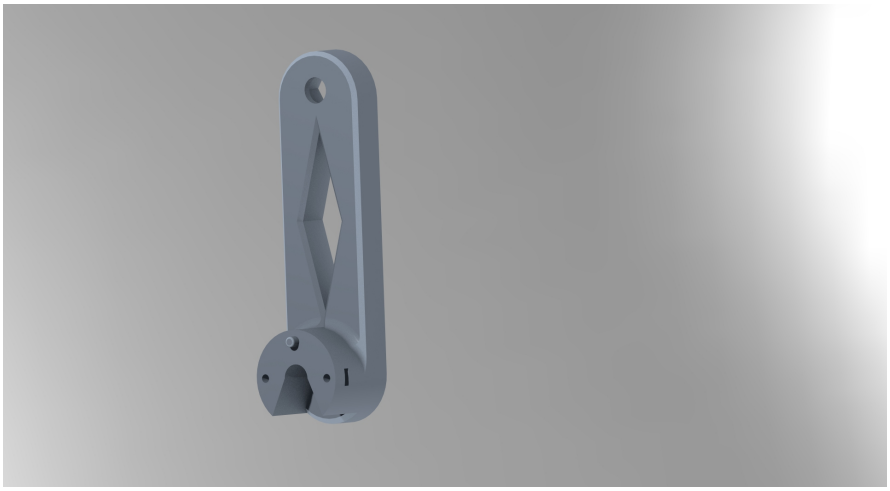

Figure 5- Sensor Mount Part 2.

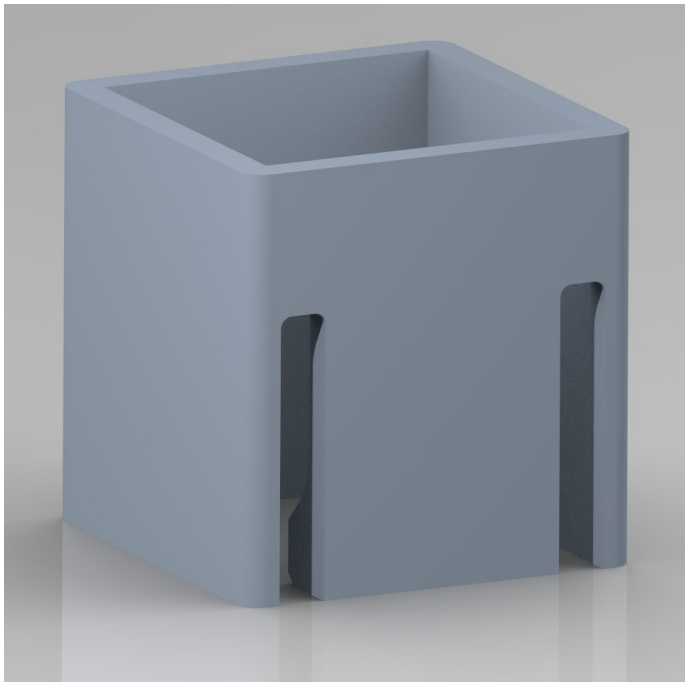

Figure 6 – Tile plug. Slides over the tile clip to prevent tiles being pushed out the loading slot.

Wiring/Pneumatic Diagram

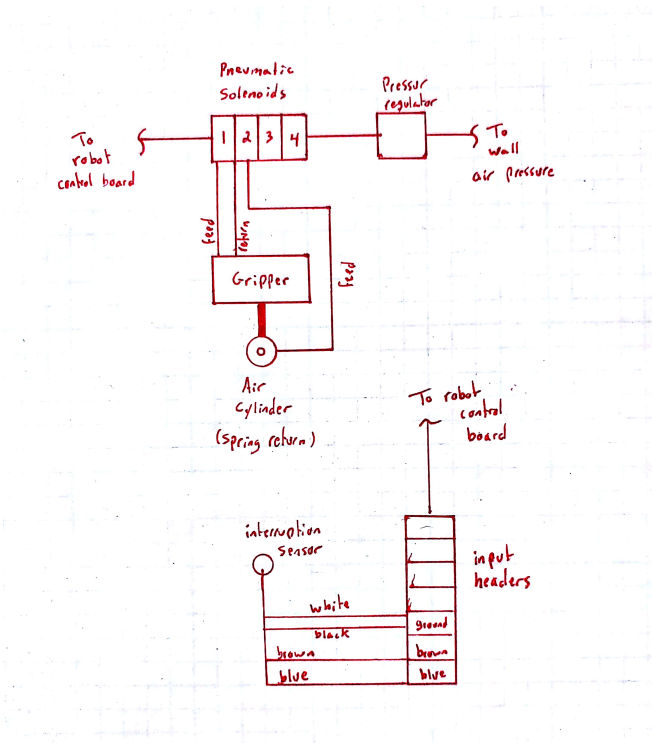

Figure 7 – Wiring Diagram

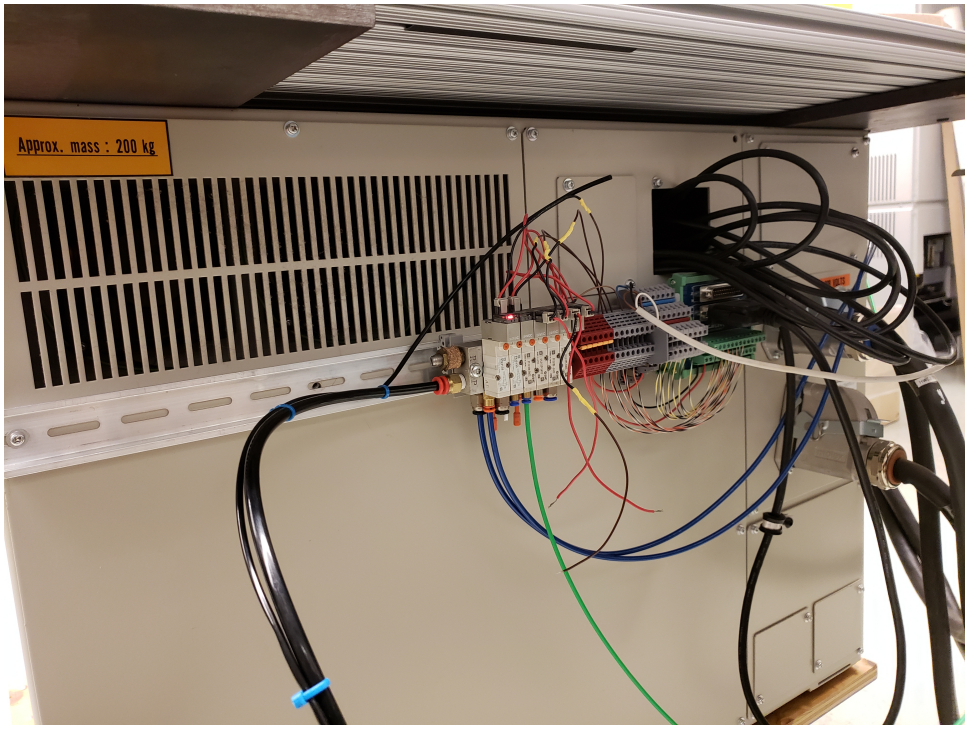

Figure 8 – Input block wiring

Robot Code:

1. /JOB
2. //NAME MOSAIC
3. //POS
4. ///NPOS 41,0,0,0,0,0
5. ///TOOL 0
6. ///POSTYPE PULSE
7. ///PULSE
8. C00000=28317,101266,-27184,65534,81105,-103779 (Programed position coordinates in SLURP coordinates)
9. C00001=29495,105118,-11564,65274,78213,-109117
10. C00002=33181,105825,-9461,63155,77399,-109667
11. C00003=29605,105136,-11507,65211,78188,-109136
12. C00004=23305,107695,-13639,68812,79701,-107392
13. C00005=21739,107027,-16976,69669,80298,-106190
14. C00006=20270,106342,-20158,70494,80792,-105046
15. C00007=18630,105872,-23108,71443,81220,-103922
16. C00008=29495,105118,-11564,65274,78213,-109117
17. C00009=33181,105825,-9461,63155,77399,-109667
18. C00010=29605,105136,-11507,65211,78188,-109136
19. C00011=33358,101849,-25602,62486,80683,-104232
20. C00012=37653,102339,-23375,59915,80038,-104955
21. C00013=33579,101867,-25518,62350,80659,-104260
22. C00014=23840,107002,-16427,68412,80056,-106421
23. C00015=22306,106209,-19758,69272,80621,-105261

```
C00016=20731,105734,-22847,70175,81126,-104086
C00017=17417,107151,-15591,72334,80385,-106811
C00018=30297,101557,-26988,64327,81041,-103765
C00019=37628,102334,-23400,59931,80043,-104949
C00020=33579,101867,-25518,62350,80659,-104260
C00021=37364,101033,-35146,59976,83205,-100528
C00022=42096,101233,-33305,57088,82844,-101262
C00023=37403,101030,-35606,59960,83337,-100338
C00024=24278,106809,-18684,68086,80414,-105512
C00025=22792,106127,-21913,68926,80961,-104353
C00026=19447,107370,-14801,71116,80137,-107064
C00027=17879,106611,-18032,71996,80618,-105922
C00028=36105,100989,-36171,60756,83428,-100096
C00029=42096,101233,-33305,57088,82844,-101262
C00030=37403,101030,-35606,59960,83337,-100338
C00031=42896,101998,-45301,56985,87116,-96185
C00032=48139,101764,-43121,53703,86864,-97335
C00033=33694,102570,-48579,62680,86930,-94256
C00034=24857,106640,-21239,67671,80858,-104448
C00035=21425,107518,-14393,69929,79942,-107169
C00036=19895,106807,-17689,70774,80481,-105987
C00037=18332,106153,-20775,71665,80931,-104867
C00038=42896,101998,-45301,56985,87116,-96185
C00039=48139,101764,-43121,53703,86864,-97335
C00040=37868,102317,-47280,60119,87134,-95060
//INST
///DATE 2018/12/11 13:43
///ATTR SC,RW
///GROUP1 RB1
NOP
DOUT OT#(4) OFF            (Retracts the plunger)
DOUT OT#(1) ON             (Closes the gripper)
MOVJ C00000 VJ=5.00        (Moves to a neutral starting position with a  velocity of 5)
MOVJ C00001 VJ=5.00        (Moves in line with the first tile dispenser)
DOUT OT#(1) OFF            (Opens the gripper)
MOVJ C00002 VJ=0.10        (Moves to the first tile dispenser)
DOUT OT#(1) ON             (Closes on the tile dispenser)
WAIT IN#(2)=ON T=1.00      (Waits for 1 sec)
MOVJ C00003 VJ=0.50        (Removes the dispenser from the holder)
MOVJ C00004 VJ=1.00        (Moves to the first point on the grid)
DOUT OT#(4) ON             (Ejects the plunger)
WAIT IN#(2)=ON T=1.00      (Waits 1 second)
DOUT OT#(4) OFF            (Retracts the plunger)
WAIT IN#(1)=ON             (Waits for the sensor to register that a tile has been dispensed)
MOVJ C00005 VJ=1.00        (Moves to the next grid position and repeats the previous code for the next three postions)
DOUT OT#(4) ON
WAIT IN#(2)=ON T=1.00
DOUT OT#(4) OFF
WAIT IN#(1)=OFF
MOVJ C00006 VJ=1.00
DOUT OT#(4) ON
WAIT IN#(2)=ON T=1.00
DOUT OT#(4) OFF
WAIT IN#(1)=ON
```

78. MOVJ C00007 VJ=1.00
79. DOUT OT#(4) ON
80. WAIT IN#(2)=ON T=1.00
81. DOUT OT#(4) OFF
82. WAIT IN#(1)=OFF
83. MOVJ C00008 VJ=5.00 (Moves in line with the first tile dispenser)
84. MOVJ C00009 VJ=0.10 (Returns the dispenser to its housing)
85. DOUT OT#(1) OFF (Opens the grippers)
86. WAIT IN#(2)=ON T=1.00 (Retracts)
87. MOVJ C00010 VJ=0.50 (Moves to the next tile dispenser)
88. MOVJ C00011 VJ=1.00 (The code for dispensing tiles is then repeated for the next three color dispensers)
89. DOUT OT#(1) OFF
90. MOVJ C00012 VJ=0.10
91. DOUT OT#(1) ON
92. WAIT IN#(2)=ON T=1.00
93. MOVJ C00013 VJ=0.50
94. MOVJ C00014 VJ=1.00
95. DOUT OT#(4) ON
96. WAIT IN#(2)=ON T=1.00
97. DOUT OT#(4) OFF
98. WAIT IN#(1)=ON
99. MOVJ C00015 VJ=1.00
100. DOUT OT#(4) ON
101. WAIT IN#(2)=ON T=1.00
102. DOUT OT#(4) OFF
103. WAIT IN#(1)=OFF
104. MOVJ C00016 VJ=1.00
105. DOUT OT#(4) ON
106. WAIT IN#(2)=ON T=1.00
107. DOUT OT#(4) OFF
108. WAIT IN#(1)=ON
109. MOVJ C00017 VJ=1.00
110. DOUT OT#(4) ON
111. WAIT IN#(2)=ON T=1.00
112. DOUT OT#(4) OFF
113. WAIT IN#(1)=OFF
114. MOVJ C00018 VJ=1.00
115. MOVJ C00019 VJ=0.10
116. DOUT OT#(1) OFF
117. WAIT IN#(2)=ON T=1.00
118. MOVJ C00020 VJ=0.50
119. WAIT IN#(2)=ON T=1.00
120. MOVJ C00021 VJ=1.00
121. MOVJ C00022 VJ=0.10
122. DOUT OT#(1) ON
123. MOVJ C00023 VJ=0.50
124. MOVJ C00024 VJ=0.50
125. DOUT OT#(4) ON
126. WAIT IN#(2)=ON T=1.00
127. DOUT OT#(4) OFF
128. WAIT IN#(1)=ON
129. MOVJ C00025 VJ=0.50
130. DOUT OT#(4) ON
131. WAIT IN#(2)=ON T=1.00

132. DOUT OT#(4) OFF
133. WAIT IN#(1)=OFF
134. MOVJ C00026 VJ=0.50
135. DOUT OT#(4) ON
136. WAIT IN#(2)=ON T=1.00
137. DOUT OT#(4) OFF
138. WAIT IN#(1)=ON
139. MOVJ C00027 VJ=0.50
140. DOUT OT#(4) ON
141. WAIT IN#(2)=ON T=1.00
142. DOUT OT#(4) OFF
143. WAIT IN#(1)=OFF
144. MOVJ C00028 VJ=0.50
145. MOVJ C00029 VJ=0.10
146. DOUT OT#(1) OFF
147. MOVJ C00030 VJ=0.50
148. MOVJ C00031 VJ=1.00
149. MOVJ C00032 VJ=0.10
150. DOUT OT#(1) ON
151. MOVJ C00033 VJ=0.50
152. MOVJ C00034 VJ=0.50
153. DOUT OT#(4) ON
154. WAIT IN#(2)=ON T=1.00
155. DOUT OT#(4) OFF
156. WAIT IN#(1)=ON
157. MOVJ C00035 VJ=0.50
158. DOUT OT#(4) ON
159. WAIT IN#(2)=ON T=1.00
160. DOUT OT#(4) OFF
161. WAIT IN#(1)=OFF
162. MOVJ C00036 VJ=0.50
163. DOUT OT#(4) ON
164. WAIT IN#(2)=ON T=1.00
165. DOUT OT#(4) OFF
166. WAIT IN#(1)=ON
167. MOVJ C00037 VJ=0.50
168. DOUT OT#(4) ON
169. WAIT IN#(2)=ON T=1.00
170. DOUT OT#(4) OFF
171. WAIT IN#(1)=OFF
172. MOVJ C00038 VJ=1.00
173. MOVJ C00039 VJ=0.10
174. DOUT OT#(1) OFF
175. MOVJ C00040 VJ=0.50 (Moves to a neutral location)
176. DOUT OT#(1) ON (Closes the gripper)
177. END (Ends the Job)

Operation of Machine

The machine is divided into two main operations. The first operation is grabbing or returning the required tile dispenser. The second operation is dispensing the tile and sensing whether the tile has been placed. These operations are then repeated in different locations decided by the robots programing. Grabbing the desired dispenser is done by first moving the robot's grabber inline with the dispenser. This is important because the grabbers need to move in a straight line to grab the dispenser to avoid breakage. The grabbers are opened, and then moved to the dispenser and grab them. The robot then reverses pulling the dispenser free to a location free from obstructions before moving to the next position. To return the dispenser the same process is run except in reverse. Dispensing the tile requires a more complex operation. When the robot is in the desired position for a tile a command is triggered that fires a pneumatic plunger pushing out a tile. After one second the plunger is returned. If successful, the tiles will drop, and a senor will be triggered on or off and the program can continue. If the tile became jammed the senor will not be triggered, and the program will stop until the operator clears the jam.

Maintenance

Maintenance of the system is mainly set on maintaining the 3D printed components outside of the robot. Parts will only need to be replaced when the robot does not follow the correct path of motion and crashes either into the dispenser holder or the title grid. The components that may need to be replaced are the plastic tile board, the clip, the clip mount, the gripper attachment, the sensor mount, tile plug and robot part replacements

Tile Grid: The tile grid was made with a 3D printer. If it is damaged the grid can be reprinted. Make sure that the grid spaces are clear from any debris to ensure that the tile fits securely in place.

The Clip: The clip can be 3D printed if one is broken during robot operation. Make sure to check the bottom opening of the clip for any loose filament, this may get in the way of the tiles and with cause a jam of the clip.

The Clip Mount: The clip mounts can also be 3D printed if they are damaged in any way.

The Gripper Mount: The gripper mount can be 3D printed if it is damage. Make sure to attach a strip of sand paper when replacing the mounts to ensure that the gripper will continue to grip the clip securely. Also check to make sure the gripper opens and closes smoothly, cleaning if necessary.

The Sensor Mount: the sensor mount can be 3D printed.

The Tile Plug: the plug may be 3D printed if it is broken or bent too far out of place.

The Robot: General maintenance of the robot must also be done.

Future Improvements

The main improvement that needs to be made is the expansion of the robot's capability to create mosaics larger than 4x4. The initial goal was to construct 12x12 tiles but do to limitations of the robots coding language there was no good way to create larger mosaics. Using MATLAB to program the robot would allow for the robot to be more easily programmed for a variety of mosaic patterns. Additional improvements would be the integration of our tile-loading device so that tiles do not need to be loaded by hand. Additionally integration of a device to apply the mesh to the completed mosaic would further improve the machine. The device also has many 3D printed components that could be replaced with stronger machined aluminum parts.

Performance Data

During operation of the robot, the success rate of tiles landing where they need to be was relatively high. Ignoring operator errors such as loading the tiles incorrectly or forgetting to plug in the air pressure supply, the robot was able to place roughly 15 out of 16 tiles correctly on any given run of the machine. Getting pure performance data of the robot correctly placing tiles is difficult as most of the time the tiles not landing correctly was due to irregularly sized tiles not fitting in either the tile clip or the grid. After 3 runs of the machine, only 2 tiles failed to land correctly resulting in operator intervention. To combat incorrectly landing tiles, each tile was sanded on its edges to prevent blobs of ceramic coating interfering with the layer lines of the 3D printed materials used extensively in the machine. If a faster process was desired, the robot could be programmed to travel faster. This was not done for the final demonstration because a faster speed could lead to more failures and critical failures usually resulted in a broken part as 3D printing does not result in strong parts. A rough estimate of the success rate would be around 93 percent. This percentage does not include failures due to irregular tile shapes.