

Liquid Handling System

MG6103 Design & DE6102 Engineering Project

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Supervisor: Adam Liberatore

Client: Martin Hohmann-Marriott (United Scientist Ltd.)



Introduction

"Liquid handling system" is used to dispense small amounts of liquid accurately. In order to create this system electrical and mechanical designs need to be incorporated effectively. The electrical sector oversaw motor control (Arduino Nano and coding) and wiring system, including printed circuit boards (PCB's). The 3D printing and parts design was overseen by the mechanical sector. This project was requested by the client, United Scientist and the conditions that were provided by the client are as follows;

1. A pipette to control the dispensing of small amounts of liquid to a minimum of 100uL (microliter).
 2. A motor control system to direct the pipette into the desired position that is controlled by a stepper motor (NEMA Series) via TMC2130 Driver with Arduino NANO.
- Throughout this group project we were able to diagnose problems and develop a critical thinking pathway to resolve issues.

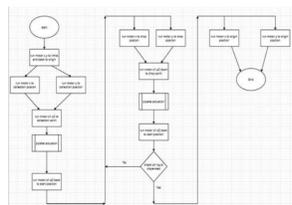
Problem

There were several developments and discussions during this project. From the beginning to the end of the project the group members focused on the client's request, which are defined as;

- Pipetting System – using a standardised clinical syringe that holds and releases liquid.
- Syringe Movement – NEMA 17 Stepper Motor that controls threaded rod.
- Platform Movement – NEMA 17 Stepper Motor with rail system that allows platform to move from point A to B.
- Control Signal – Raspberry Pi that communicates with 2 Arduino and TMC2130 Stepper Motor Drivers.
- PCB(Printed Circuit Board) - Machinable circuit board designs that provides the ability for mass production.
- User-Interface – Touch pad and RaspberryPi that can control system outputs.

Modelling Approach

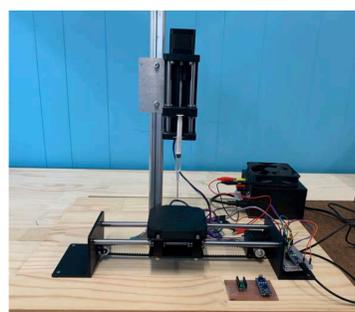
Our modelling approach to meet our clients' needs was to effectively establish what type of design would satisfy clients' needs by researching existing models. After consultation and weighing the pros and cons, features we could apply to our design were discussing and decided upon. The feature we decided to add to our design based on our client's requirements and vision are;



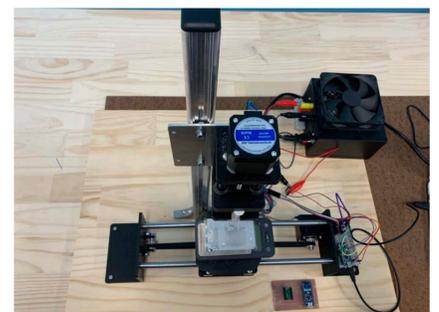
Process Flow Chart

- A Gantry with a frame that holds the pipette system and moves in the y and z-axis using a stepper motor, with a gantry moving in the x-axis and with housing for a beaker.
- A motorized 3D printed pipette system that is powered by a stepper motor.

Prototype



Prototype of System

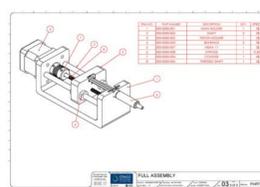


Prototype of System

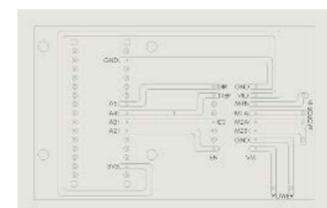
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Arduino Code for X-axis and Pipetting System
// Define pins for stepper motor and driver
#define STEP_PIN 2
#define DIR_PIN 3
#define ENA_PIN 4
// Define pins for Raspberry Pi
#define RPI_PIN_1 5
#define RPI_PIN_2 6
// Define pins for TMC2130 driver
#define TMC2130_STEP 7
#define TMC2130_DIR 8
// Define pins for Arduino Nano
#define ARDUINO_STEP 9
#define ARDUINO_DIR 10
// Define pins for Raspberry Pi
#define RPI_PIN_3 11
#define RPI_PIN_4 12
// Define pins for TMC2130 driver
#define TMC2130_STEP 13
#define TMC2130_DIR 14
// Define pins for Arduino Nano
#define ARDUINO_STEP 15
#define ARDUINO_DIR 16
// Define pins for Raspberry Pi
#define RPI_PIN_5 17
#define RPI_PIN_6 18
// Define pins for TMC2130 driver
#define TMC2130_STEP 19
#define TMC2130_DIR 20
// Define pins for Arduino Nano
#define ARDUINO_STEP 21
#define ARDUINO_DIR 22
// Define pins for Raspberry Pi
#define RPI_PIN_7 23
#define RPI_PIN_8 24
// Define pins for TMC2130 driver
#define TMC2130_STEP 25
#define TMC2130_DIR 26
// Define pins for Arduino Nano
#define ARDUINO_STEP 27
#define ARDUINO_DIR 28
// Define pins for Raspberry Pi
#define RPI_PIN_9 29
#define RPI_PIN_10 30
// Define pins for TMC2130 driver
#define TMC2130_STEP 31
#define TMC2130_DIR 32
// Define pins for Arduino Nano
#define ARDUINO_STEP 33
#define ARDUINO_DIR 34
// Define pins for Raspberry Pi
#define RPI_PIN_11 35
#define RPI_PIN_12 36
// Define pins for TMC2130 driver
#define TMC2130_STEP 37
#define TMC2130_DIR 38
// Define pins for Arduino Nano
#define ARDUINO_STEP 39
#define ARDUINO_DIR 40
// Define pins for Raspberry Pi
#define RPI_PIN_13 41
#define RPI_PIN_14 42
// Define pins for TMC2130 driver
#define TMC2130_STEP 43
#define TMC2130_DIR 44
// Define pins for Arduino Nano
#define ARDUINO_STEP 45
#define ARDUINO_DIR 46
// Define pins for Raspberry Pi
#define RPI_PIN_15 47
#define RPI_PIN_16 48
// Define pins for TMC2130 driver
#define TMC2130_STEP 49
#define TMC2130_DIR 50
// Define pins for Arduino Nano
#define ARDUINO_STEP 51
#define ARDUINO_DIR 52
// Define pins for Raspberry Pi
#define RPI_PIN_17 53
#define RPI_PIN_18 54
// Define pins for TMC2130 driver
#define TMC2130_STEP 55
#define TMC2130_DIR 56
// Define pins for Arduino Nano
#define ARDUINO_STEP 57
#define ARDUINO_DIR 58
// Define pins for Raspberry Pi
#define RPI_PIN_19 59
#define RPI_PIN_20 60
// Define pins for TMC2130 driver
#define TMC2130_STEP 61
#define TMC2130_DIR 62
// Define pins for Arduino Nano
#define ARDUINO_STEP 63
#define ARDUINO_DIR 64
// Define pins for Raspberry Pi
#define RPI_PIN_21 65
#define RPI_PIN_22 66
// Define pins for TMC2130 driver
#define TMC2130_STEP 67
#define TMC2130_DIR 68
// Define pins for Arduino Nano
#define ARDUINO_STEP 69
#define ARDUINO_DIR 70
// Define pins for Raspberry Pi
#define RPI_PIN_23 71
#define RPI_PIN_24 72
// Define pins for TMC2130 driver
#define TMC2130_STEP 73
#define TMC2130_DIR 74
// Define pins for Arduino Nano
#define ARDUINO_STEP 75
#define ARDUINO_DIR 76
// Define pins for Raspberry Pi
#define RPI_PIN_25 77
#define RPI_PIN_26 78
// Define pins for TMC2130 driver
#define TMC2130_STEP 79
#define TMC2130_DIR 80
// Define pins for Arduino Nano
#define ARDUINO_STEP 81
#define ARDUINO_DIR 82
// Define pins for Raspberry Pi
#define RPI_PIN_27 83
#define RPI_PIN_28 84
// Define pins for TMC2130 driver
#define TMC2130_STEP 85
#define TMC2130_DIR 86
// Define pins for Arduino Nano
#define ARDUINO_STEP 87
#define ARDUINO_DIR 88
// Define pins for Raspberry Pi
#define RPI_PIN_29 89
#define RPI_PIN_30 90
// Define pins for TMC2130 driver
#define TMC2130_STEP 91
#define TMC2130_DIR 92
// Define pins for Arduino Nano
#define ARDUINO_STEP 93
#define ARDUINO_DIR 94
// Define pins for Raspberry Pi
#define RPI_PIN_31 95
#define RPI_PIN_32 96
// Define pins for TMC2130 driver
#define TMC2130_STEP 97
#define TMC2130_DIR 98
// Define pins for Arduino Nano
#define ARDUINO_STEP 99
#define ARDUINO_DIR 100
// Define pins for Raspberry Pi
#define RPI_PIN_33 101
#define RPI_PIN_34 102
// Define pins for TMC2130 driver
#define TMC2130_STEP 103
#define TMC2130_DIR 104
// Define pins for Arduino Nano
#define ARDUINO_STEP 105
#define ARDUINO_DIR 106
// Define pins for Raspberry Pi
#define RPI_PIN_35 107
#define RPI_PIN_36 108
// Define pins for TMC2130 driver
#define TMC2130_STEP 109
#define TMC2130_DIR 110
// Define pins for Arduino Nano
#define ARDUINO_STEP 111
#define ARDUINO_DIR 112
// Define pins for Raspberry Pi
#define RPI_PIN_37 113
#define RPI_PIN_38 114
// Define pins for TMC2130 driver
#define TMC2130_STEP 115
#define TMC2130_DIR 116
// Define pins for Arduino Nano
#define ARDUINO_STEP 117
#define ARDUINO_DIR 118
// Define pins for Raspberry Pi
#define RPI_PIN_39 119
#define RPI_PIN_40 120
// Define pins for TMC2130 driver
#define TMC2130_STEP 121
#define TMC2130_DIR 122
// Define pins for Arduino Nano
#define ARDUINO_STEP 123
#define ARDUINO_DIR 124
// Define pins for Raspberry Pi
#define RPI_PIN_41 125
#define RPI_PIN_42 126
// Define pins for TMC2130 driver
#define TMC2130_STEP 127
#define TMC2130_DIR 128
// Define pins for Arduino Nano
#define ARDUINO_STEP 129
#define ARDUINO_DIR 130
// Define pins for Raspberry Pi
#define RPI_PIN_43 131
#define RPI_PIN_44 132
// Define pins for TMC2130 driver
#define TMC2130_STEP 133
#define TMC2130_DIR 134
// Define pins for Arduino Nano
#define ARDUINO_STEP 135
#define ARDUINO_DIR 136
// Define pins for Raspberry Pi
#define RPI_PIN_45 137
#define RPI_PIN_46 138
// Define pins for TMC2130 driver
#define TMC2130_STEP 139
#define TMC2130_DIR 140
// Define pins for Arduino Nano
#define ARDUINO_STEP 141
#define ARDUINO_DIR 142
// Define pins for Raspberry Pi
#define RPI_PIN_47 143
#define RPI_PIN_48 144
// Define pins for TMC2130 driver
#define TMC2130_STEP 145
#define TMC2130_DIR 146
// Define pins for Arduino Nano
#define ARDUINO_STEP 147
#define ARDUINO_DIR 148
// Define pins for Raspberry Pi
#define RPI_PIN_49 149
#define RPI_PIN_50 150
// Define pins for TMC2130 driver
#define TMC2130_STEP 151
#define TMC2130_DIR 152
// Define pins for Arduino Nano
#define ARDUINO_STEP 153
#define ARDUINO_DIR 154
// Define pins for Raspberry Pi
#define RPI_PIN_51 155
#define RPI_PIN_52 156
// Define pins for TMC2130 driver
#define TMC2130_STEP 157
#define TMC2130_DIR 158
// Define pins for Arduino Nano
#define ARDUINO_STEP 159
#define ARDUINO_DIR 160
// Define pins for Raspberry Pi
#define RPI_PIN_53 161
#define RPI_PIN_54 162
// Define pins for TMC2130 driver
#define TMC2130_STEP 163
#define TMC2130_DIR 164
// Define pins for Arduino Nano
#define ARDUINO_STEP 165
#define ARDUINO_DIR 166
// Define pins for Raspberry Pi
#define RPI_PIN_55 167
#define RPI_PIN_56 168
// Define pins for TMC2130 driver
#define TMC2130_STEP 169
#define TMC2130_DIR 170
// Define pins for Arduino Nano
#define ARDUINO_STEP 171
#define ARDUINO_DIR 172
// Define pins for Raspberry Pi
#define RPI_PIN_57 173
#define RPI_PIN_58 174
// Define pins for TMC2130 driver
#define TMC2130_STEP 175
#define TMC2130_DIR 176
// Define pins for Arduino Nano
#define ARDUINO_STEP 177
#define ARDUINO_DIR 178
// Define pins for Raspberry Pi
#define RPI_PIN_59 179
#define RPI_PIN_60 180
// Define pins for TMC2130 driver
#define TMC2130_STEP 181
#define TMC2130_DIR 182
// Define pins for Arduino Nano
#define ARDUINO_STEP 183
#define ARDUINO_DIR 184
// Define pins for Raspberry Pi
#define RPI_PIN_61 185
#define RPI_PIN_62 186
// Define pins for TMC2130 driver
#define TMC2130_STEP 187
#define TMC2130_DIR 188
// Define pins for Arduino Nano
#define ARDUINO_STEP 189
#define ARDUINO_DIR 190
// Define pins for Raspberry Pi
#define RPI_PIN_63 191
#define RPI_PIN_64 192
// Define pins for TMC2130 driver
#define TMC2130_STEP 193
#define TMC2130_DIR 194
// Define pins for Arduino Nano
#define ARDUINO_STEP 195
#define ARDUINO_DIR 196
// Define pins for Raspberry Pi
#define RPI_PIN_65 197
#define RPI_PIN_66 198
// Define pins for TMC2130 driver
#define TMC2130_STEP 199
#define TMC2130_DIR 200
// Define pins for Arduino Nano
#define ARDUINO_STEP 201
#define ARDUINO_DIR 202
// Define pins for Raspberry Pi
#define RPI_PIN_67 203
#define RPI_PIN_68 204
// Define pins for TMC2130 driver
#define TMC2130_STEP 205
#define TMC2130_DIR 206
// Define pins for Arduino Nano
#define ARDUINO_STEP 207
#define ARDUINO_DIR 208
// Define pins for Raspberry Pi
#define RPI_PIN_69 209
#define RPI_PIN_70 210
// Define pins for TMC2130 driver
#define TMC2130_STEP 211
#define TMC2130_DIR 212
// Define pins for Arduino Nano
#define ARDUINO_STEP 213
#define ARDUINO_DIR 214
// Define pins for Raspberry Pi
#define RPI_PIN_71 215
#define RPI_PIN_72 216
// Define pins for TMC2130 driver
#define TMC2130_STEP 217
#define TMC2130_DIR 218
// Define pins for Arduino Nano
#define ARDUINO_STEP 219
#define ARDUINO_DIR 220
// Define pins for Raspberry Pi
#define RPI_PIN_73 221
#define RPI_PIN_74 222
// Define pins for TMC2130 driver
#define TMC2130_STEP 223
#define TMC2130_DIR 224
// Define pins for Arduino Nano
#define ARDUINO_STEP 225
#define ARDUINO_DIR 226
// Define pins for Raspberry Pi
#define RPI_PIN_75 227
#define RPI_PIN_76 228
// Define pins for TMC2130 driver
#define TMC2130_STEP 229
#define TMC2130_DIR 230
// Define pins for Arduino Nano
#define ARDUINO_STEP 231
#define ARDUINO_DIR 232
// Define pins for Raspberry Pi
#define RPI_PIN_77 233
#define RPI_PIN_78 234
// Define pins for TMC2130 driver
#define TMC2130_STEP 235
#define TMC2130_DIR 236
// Define pins for Arduino Nano
#define ARDUINO_STEP 237
#define ARDUINO_DIR 238
// Define pins for Raspberry Pi
#define RPI_PIN_79 239
#define RPI_PIN_80 240
// Define pins for TMC2130 driver
#define TMC2130_STEP 241
#define TMC2130_DIR 242
// Define pins for Arduino Nano
#define ARDUINO_STEP 243
#define ARDUINO_DIR 244
// Define pins for Raspberry Pi
#define RPI_PIN_81 245
#define RPI_PIN_82 246
// Define pins for TMC2130 driver
#define TMC2130_STEP 247
#define TMC2130_DIR 248
// Define pins for Arduino Nano
#define ARDUINO_STEP 249
#define ARDUINO_DIR 250
// Define pins for Raspberry Pi
#define RPI_PIN_83 251
#define RPI_PIN_84 252
// Define pins for TMC2130 driver
#define TMC2130_STEP 253
#define TMC2130_DIR 254
// Define pins for Arduino Nano
#define ARDUINO_STEP 255
#define ARDUINO_DIR 256
// Define pins for Raspberry Pi
#define RPI_PIN_85 257
#define RPI_PIN_86 258
// Define pins for TMC2130 driver
#define TMC2130_STEP 259
#define TMC2130_DIR 260
// Define pins for Arduino Nano
#define ARDUINO_STEP 261
#define ARDUINO_DIR 262
// Define pins for Raspberry Pi
#define RPI_PIN_87 263
#define RPI_PIN_88 264
// Define pins for TMC2130 driver
#define TMC2130_STEP 265
#define TMC2130_DIR 266
// Define pins for Arduino Nano
#define ARDUINO_STEP 267
#define ARDUINO_DIR 268
// Define pins for Raspberry Pi
#define RPI_PIN_89 269
#define RPI_PIN_90 270
// Define pins for TMC2130 driver
#define TMC2130_STEP 271
#define TMC2130_DIR 272
// Define pins for Arduino Nano
#define ARDUINO_STEP 273
#define ARDUINO_DIR 274
// Define pins for Raspberry Pi
#define RPI_PIN_91 275
#define RPI_PIN_92 276
// Define pins for TMC2130 driver
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#define TMC2130_DIR 278
// Define pins for Arduino Nano
#define ARDUINO_STEP 279
#define ARDUINO_DIR 280
// Define pins for Raspberry Pi
#define RPI_PIN_93 281
#define RPI_PIN_94 282
// Define pins for TMC2130 driver
#define TMC2130_STEP 283
#define TMC2130_DIR 284
// Define pins for Arduino Nano
#define ARDUINO_STEP 285
#define ARDUINO_DIR 286
// Define pins for Raspberry Pi
#define RPI_PIN_95 287
#define RPI_PIN_96 288
// Define pins for TMC2130 driver
#define TMC2130_STEP 289
#define TMC2130_DIR 290
// Define pins for Arduino Nano
#define ARDUINO_STEP 291
#define ARDUINO_DIR 292
// Define pins for Raspberry Pi
#define RPI_PIN_97 293
#define RPI_PIN_98 294
// Define pins for TMC2130 driver
#define TMC2130_STEP 295
#define TMC2130_DIR 296
// Define pins for Arduino Nano
#define ARDUINO_STEP 297
#define ARDUINO_DIR 298
// Define pins for Raspberry Pi
#define RPI_PIN_99 299
#define RPI_PIN_100 300
// Define pins for TMC2130 driver
#define TMC2130_STEP 301
#define TMC2130_DIR 302
// Define pins for Arduino Nano
#define ARDUINO_STEP 303
#define ARDUINO_DIR 304
// Define pins for Raspberry Pi
#define RPI_PIN_101 305
#define RPI_PIN_102 306
// Define pins for TMC2130 driver
#define TMC2130_STEP 307
#define TMC2130_DIR 308
// Define pins for Arduino Nano
#define ARDUINO_STEP 309
#define ARDUINO_DIR 310
// Define pins for Raspberry Pi
#define RPI_PIN_103 311
#define RPI_PIN_104 312
// Define pins for TMC2130 driver
#define TMC2130_STEP 313
#define TMC2130_DIR 314
// Define pins for Arduino Nano
#define ARDUINO_STEP 315
#define ARDUINO_DIR 316
// Define pins for Raspberry Pi
#define RPI_PIN_105 317
#define RPI_PIN_106 318
// Define pins for TMC2130 driver
#define TMC2130_STEP 319
#define TMC2130_DIR 320
// Define pins for Arduino Nano
#define ARDUINO_STEP 321
#define ARDUINO_DIR 322
// Define pins for Raspberry Pi
#define RPI_PIN_107 323
#define RPI_PIN_108 324
// Define pins for TMC2130 driver
#define TMC2130_STEP 325
#define TMC2130_DIR 326
// Define pins for Arduino Nano
#define ARDUINO_STEP 327
#define ARDUINO_DIR 328
// Define pins for Raspberry Pi
#define RPI_PIN_109 329
#define RPI_PIN_110 330
// Define pins for TMC2130 driver
#define TMC2130_STEP 331
#define TMC2130_DIR 332
// Define pins for Arduino Nano
#define ARDUINO_STEP 333
#define ARDUINO_DIR 334
// Define pins for Raspberry Pi
#define RPI_PIN_111 335
#define RPI_PIN_112 336
// Define pins for TMC2130 driver
#define TMC2130_STEP 337
#define TMC2130_DIR 338
// Define pins for Arduino Nano
#define ARDUINO_STEP 339
#define ARDUINO_DIR 340
// Define pins for Raspberry Pi
#define RPI_PIN_113 341
#define RPI_PIN_114 342
// Define pins for TMC2130 driver
#define TMC2130_STEP 343
#define TMC2130_DIR 344
// Define pins for Arduino Nano
#define ARDUINO_STEP 345
#define ARDUINO_DIR 346
// Define pins for Raspberry Pi
#define RPI_PIN_115 347
#define RPI_PIN_116 348
// Define pins for TMC2130 driver
#define TMC2130_STEP 349
#define TMC2130_DIR 350
// Define pins for Arduino Nano
#define ARDUINO_STEP 351
#define ARDUINO_DIR 352
// Define pins for Raspberry Pi
#define RPI_PIN_117 353
#define RPI_PIN_118 354
// Define pins for TMC2130 driver
#define TMC2130_STEP 355
#define TMC2130_DIR 356
// Define pins for Arduino Nano
#define ARDUINO_STEP 357
#define ARDUINO_DIR 358
// Define pins for Raspberry Pi
#define RPI_PIN_119 359
#define RPI_PIN_120 360
// Define pins for TMC2130 driver
#define TMC2130_STEP 361
#define TMC2130_DIR 362
// Define pins for Arduino Nano
#define ARDUINO_STEP 363
#define ARDUINO_DIR 364
// Define pins for Raspberry Pi
#define RPI_PIN_121 365
#define RPI_PIN_122 366
// Define pins for TMC2130 driver
#define TMC2130_STEP 367
#define TMC2130_DIR 368
// Define pins for Arduino Nano
#define ARDUINO_STEP 369
#define ARDUINO_DIR 370
// Define pins for Raspberry Pi
#define RPI_PIN_123 371
#define RPI_PIN_124 372
// Define pins for TMC2130 driver
#define TMC2130_STEP 373
#define TMC2130_DIR 374
// Define pins for Arduino Nano
#define ARDUINO_STEP 375
#define ARDUINO_DIR 376
// Define pins for Raspberry Pi
#define RPI_PIN_125 377
#define RPI_PIN_126 378
// Define pins for TMC2130 driver
#define TMC2130_STEP 379
#define TMC2130_DIR 380
// Define pins for Arduino Nano
#define ARDUINO_STEP 381
#define ARDUINO_DIR 382
// Define pins for Raspberry Pi
#define RPI_PIN_127 383
#define RPI_PIN_128 384
// Define pins for TMC2130 driver
#define TMC2130_STEP 385
#define TMC2130_DIR 386
// Define pins for Arduino Nano
#define ARDUINO_STEP 387
#define ARDUINO_DIR 388
// Define pins for Raspberry Pi
#define RPI_PIN_129 389
#define RPI_PIN_130 390
// Define pins for TMC2130 driver
#define TMC2130_STEP 391
#define TMC2130_DIR 392
// Define pins for Arduino Nano
#define ARDUINO_STEP 393
#define ARDUINO_DIR 394
// Define pins for Raspberry Pi
#define RPI_PIN_131 395
#define RPI_PIN_132 396
// Define pins for TMC2130 driver
#define TMC2130_STEP 397
#define TMC2130_DIR 398
// Define pins for Arduino Nano
#define ARDUINO_STEP 399
#define ARDUINO_DIR 400
// Define pins for Raspberry Pi
#define RPI_PIN_133 401
#define RPI_PIN_134 402
// Define pins for TMC2130 driver
#define TMC2130_STEP 403
#define TMC2130_DIR 404
// Define pins for Arduino Nano
#define ARDUINO_STEP 405
#define ARDUINO_DIR 406
// Define pins for Raspberry Pi
#define RPI_PIN_135 407
#define RPI_PIN_136 408
// Define pins for TMC2130 driver
#define TMC2130_STEP 409
#define TMC2130_DIR 410
// Define pins for Arduino Nano
#define ARDUINO_STEP 411
#define ARDUINO_DIR 412
// Define pins for Raspberry Pi
#define RPI_PIN_137 413
#define RPI_PIN_138 414
// Define pins for TMC2130 driver
#define TMC2130_STEP 415
#define TMC2130_DIR 416
// Define pins for Arduino Nano
#define ARDUINO_STEP 417
#define ARDUINO_DIR 418
// Define pins for Raspberry Pi
#define RPI_PIN_139 419
#define RPI_PIN_140 420
// Define pins for TMC2130 driver
#define TMC2130_STEP 421
#define TMC2130_DIR 422
// Define pins for Arduino Nano
#define ARDUINO_STEP 423
#define ARDUINO_DIR 424
// Define pins for Raspberry Pi
#define RPI_PIN_141 425
#define RPI_PIN_142 426
// Define pins for TMC2130 driver
#define TMC2130_STEP 427
#define TMC2130_DIR 428
// Define pins for Arduino Nano
#define ARDUINO_STEP 429
#define ARDUINO_DIR 430
// Define pins for Raspberry Pi
#define RPI_PIN_143 431
#define RPI_PIN_144 432
// Define pins for TMC2130 driver
#define TMC2130_STEP 433
#define TMC2130_DIR 434
// Define pins for Arduino Nano
#define ARDUINO_STEP 435
#define ARDUINO_DIR 436
// Define pins for Raspberry Pi
#define RPI_PIN_145 437
#define RPI_PIN_146 438
// Define pins for TMC2130 driver
#define TMC2130_STEP 439
#define TMC2130_DIR 440
// Define pins for Arduino Nano
#define ARDUINO_STEP 441
#define ARDUINO_DIR 442
// Define pins for Raspberry Pi
#define RPI_PIN_147 443
#define RPI_PIN_148 444
// Define pins for TMC2130 driver
#define TMC2130_STEP 445
#define TMC2130_DIR 446
// Define pins for Arduino Nano
#define ARDUINO_STEP 447
#define ARDUINO_DIR 448
// Define pins for Raspberry Pi
#define RPI_PIN_149 449
#define RPI_PIN_150 450
// Define pins for TMC2130 driver
#define TMC2130_STEP 451
#define TMC2130_DIR 452
// Define pins for Arduino Nano
#define ARDUINO_STEP 453
#define ARDUINO_DIR 454
// Define pins for Raspberry Pi
#define RPI_PIN_151 455
#define RPI_PIN_152 456
// Define pins for TMC2130 driver
#define TMC2130_STEP 457
#define TMC2130_DIR 458
// Define pins for Arduino Nano
#define ARDUINO_STEP 459
#define ARDUINO_DIR 460
// Define pins for Raspberry Pi
#define RPI_PIN_153 461
#define RPI_PIN_154 462
// Define pins for TMC2130 driver
#define TMC2130_STEP 463
#define TMC2130_DIR 464
// Define pins for Arduino Nano
#define ARDUINO_STEP 465
#define ARDUINO_DIR 466
// Define pins for Raspberry Pi
#define RPI_PIN_155 467
#define RPI_PIN_156 468
// Define pins for TMC2130 driver
#define TMC2130_STEP 469
#define TMC2130_DIR 470
// Define pins for Arduino Nano
#define ARDUINO_STEP 471
#define ARDUINO_DIR 472
// Define pins for Raspberry Pi
#define RPI_PIN_157 473
#define RPI_PIN_158 474
// Define pins for TMC2130 driver
#define TMC2130_STEP 475
#define TMC2130_DIR 476
// Define pins for Arduino Nano
#define ARDUINO_STEP 477
#define ARDUINO_DIR 478
// Define pins for Raspberry Pi
#define RPI_PIN_159 479
#define RPI_PIN_160 480
// Define pins for TMC2130 driver
#define TMC2130_STEP 481
#define TMC2130_DIR 482
// Define pins for Arduino Nano
#define ARDUINO_STEP 483
#define ARDUINO_DIR 484
// Define pins for Raspberry Pi
#define RPI_PIN_161 485
#define RPI_PIN_162 486
// Define pins for TMC2130 driver
#define TMC2130_STEP 487
#define TMC2130_DIR 488
// Define pins for Arduino Nano
#define ARDUINO_STEP 489
#define ARDUINO_DIR 490
// Define pins for Raspberry Pi
#define RPI_PIN_163 491
#define RPI_PIN_164 492
// Define pins for TMC2130 driver
#define TMC2130_STEP 493
#define TMC2130_DIR 494
// Define pins for Arduino Nano
#define ARDUINO_STEP 495
#define ARDUINO_DIR 496
// Define pins for Raspberry Pi
#define RPI_PIN_165 497
#define RPI_PIN_166 498
// Define pins for TMC2130 driver
#define TMC2130_STEP 499
#define TMC2130_DIR 500
    
```

Arduino Code for X-axis and Pipetting System

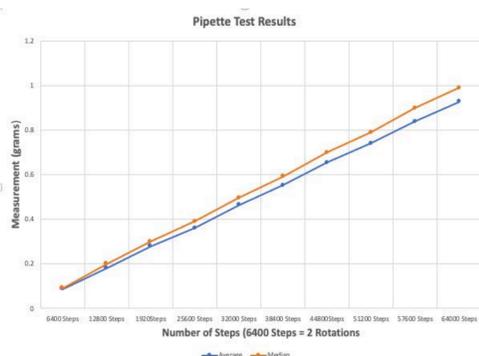


Pipette holder Design



Circuit Board Design

Result and Discussion



	6400 Steps	12800 Steps	19205Steps	25600 Steps	32000 Steps	38400 Steps	44800Steps	51200 Steps	57600 Steps	64000 Steps
Average	0.086596342	0.180725035	0.27980913	0.360450953	0.464187408	0.552996486	0.654174784	0.740861196	0.839527863	0.927310107
Median	0.09	0.2	0.3	0.39	0.4965	0.592	0.7	0.79	0.9	0.99

Testing has been conducted from quantities 100 microliters to 1ml. Tap water was used for testing and a standard measurement of 1gram = 1ml has been used to transform the weight value measured to ml's distributed by the pipette. When measuring the weight of water dispensed by the pipette, jewelers' scales were used to an accuracy of 0.01g. This was not the ideal equipment for testing and in the future an accuracy of 0.001g is recommended. The code for motor control of the pipette shows 1 full rotation of 3200 steps. Therefore, this has been used as a constant during testing. As shown in the table (above) and the graphic (left), the testing starts at 2 full rotations which coincides with 100 microliters (0.1ml) and increases at even amounts to an amount of 1ml. The test results show a general relationship between 2 full rotations, distributing 100 microliters. The averages shown indicate a higher degree of accuracy when analyzing these results and further testing with higher accuracy equipment is recommended. In conclusion, for the purpose of this project it is assumed that 2 full rotations (6400 steps) distributes 0.1ml or 100 microliters of fluid, being the smallest amount of liquid required to be dispensed. In regard to the movement of the X-axis, problems were faced while testing and a solution was not found to the occasional 'jittery movement' of the platform. It is assumed that a current limiting issue is not providing enough torque to the motor to overcome the resistance of the ball bearings while the platform moves along the shafts.

Conclusion and Future Work

This project was an overall success, and many problems were overcome to develop this unit. The Product though is not Complete. Problems integrating the user interface have meant this is not included in the final product. This was limited by the Arduino's not communicating with each other and the system is required to be controlled by a computer. Time limitations and minor product design alterations have also changed the way the Product looks and functions. Pros - The automated syringe can accurately dispense 100uL to 1mL, and the x-axis platform does function. Cons - There is no functioning user interface so all inputs must be uploaded to the Arduino manually via a computer. The x-axis motor does not operate as desired. There are no limits set on either of the motors, so the motor could break the equipment if inputs are incorrect. The RaspberryPi system was also not able to be implemented.

Future Work

- User Interface – Keypad to input a volume and distance with an LCD display screen and including a RaspberryPi.
- Introducing Y and Z axis for freedom of movement and less hands-on work for the User
- Setting limits on the Motors by introducing the SPI function of the TMC2130 driver
- Add housing for beaker on x-axis platform
- Replacing the pipette stand with a gantry that would connect all individual aspects, to make a complete unit

