INTEGRATION DOCUMENT

CONTENTS

OVERVIEW

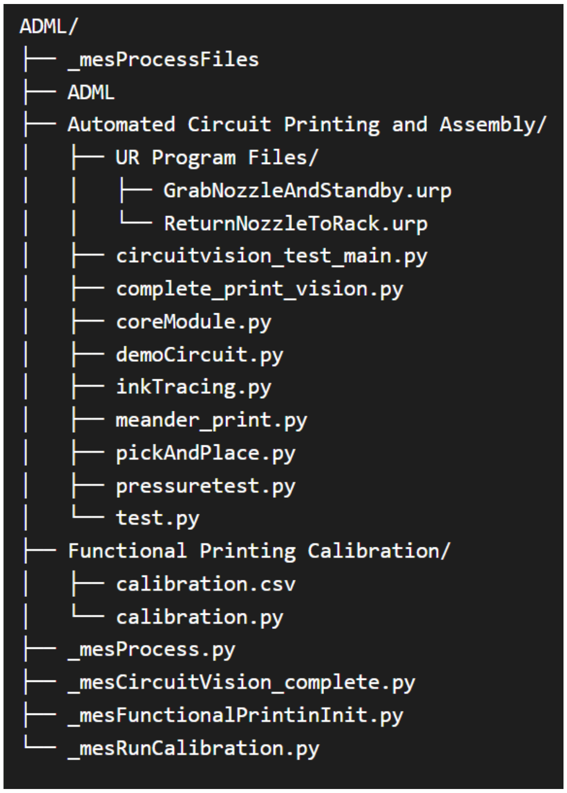
This is a guide to putting together the supporting documentation for Circuit Printing integrated with Vision Tests. The supporting documentation includes code files for Python, BUMES and URP script files, along with pointers to scripts and files already present in the BUMES master branch that we utilize in our implementation.

Within this folder, you will find:

Files_new: Old files, already integrated but here for your reference
Files_alreadypresent: Our files that are described in this document and can be integrated with the current ADML system.
Files_reference: A collection of videos and screenshots for reference, which can provide an intuitive understanding of the vision + printing process
README: the reference/guide document to everything in this folder

What's in here: Our own files and scripts that have to be integrated into the BUMES system.

+ *Some of Juan's files (already integrated into the current system) that we use, for your viewing (CAD/CAM/nc, URP Script files, python files). Instructions to integrate them are not included to avoid redundancy. Instead we focus on integrating our scripts into the system to call upon the current files in use. For your reference, here is a file tree diagram of important integrated files along with our own files:*



```
ADML/
├── _mesProcessFiles
├── ADML
├── Automated Circuit Printing and Assembly/
│   ├── UR Program Files/
│   │   ├── GrabNozzleAndStandby.urp
│   │   └── ReturnNozzleToRack.urp
│   ├── circuitvision_test_main.py
│   ├── complete_print_vision.py
│   ├── coreModule.py
│   ├── demoCircuit.py
│   ├── inkTracing.py
│   ├── meander_print.py
│   ├── pickAndPlace.py
│   ├── pressuretest.py
│   └── test.py
├── Functional Printing Calibration/
│   ├── calibration.csv
│   └── calibration.py
├── _mesProcess.py
├── _mesCircuitVision_complete.py
├── _mesFunctionalPrintinInit.py
└── _mesRunCalibration.py
```

What's already there & Loaded (and therefore not included here): Juan's files: under DirectInkWriting in Rosie and Mary, under git/ADML in VSCode, and his CAM file for machining, loaded in via Mary's script. These files are already present in the original ADML system and have not been changed/edited. They will be called upon by our VSCode and BUMES Scripts.

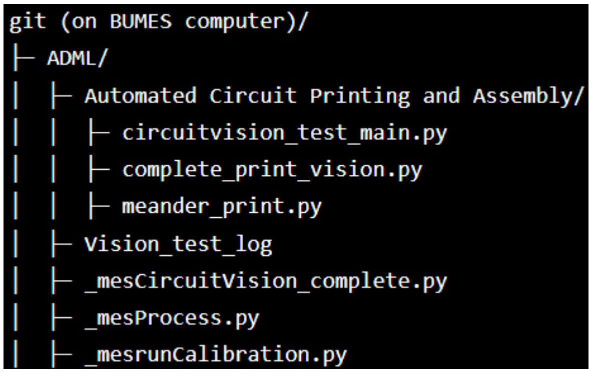
How to run: Once the setup has been completed, everything can be run via BUMES:

1. Make sure to calibrate if it's your first time in a session: Post 'runCalibrationvisiontest' in RealRun mode
2. Calibrate the vision_tests for the session: more details given under 'Python'
3. For the actual run: Post 'TuesPMCircuitPrinting' in RealRun mode.

PROGRAMS

PYTHON

The following files should be placed under the given directories within the git/ADML folder in the BUMES computer by Rosie (There are other files and scripts there. Keep them- the new scripts interact with them):



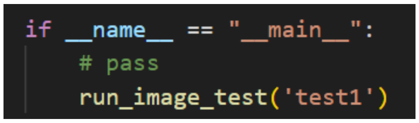
```
git (on BUMES computer)/
├ ADML/
|  ├ Automated Circuit Printing and Assembly/
|  |  ├ circuitvision_test_main.py
|  |  ├ complete_print_vision.py
|  |  ├ meander_print.py
|  ├ Vision_test_log
|  ├ _mesCircuitVision_complete.py
|  ├ _mesProcess.py
|  ├ _mesrunCalibration.py
```

complete_print_vision.py: the main file that performs the meander test, circuit printing, and the vision tests *(Calls upon URP files within Rosie, meander_print.py, demoCircuit.py, coreModule.py, circuitvision_test_main.py).*

circuitvision_test_main.py: contains all the vision tests (test1 → CAM test, test2 → Component Placement Test, test3 → Meander Test) . Run calibration before every session to account for changes in daylight/ external lighting.

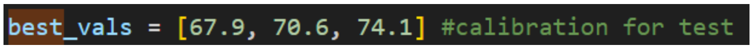
Vision Test/Calibration instructions:

- Go to the bottom of complete_print_vision.py. Under ‘ if __name__ == “__main__” ‘: comment out ‘pass’ and uncomment ‘run_image_test(‘testxxx’)’.
- Change the name of the test to test1, test2 or test3 as required



```
if __name__ == "__main__":
    # pass
    run_image_test('test1')
```

- Run URP file programs/tuepm/Project1pick to pick the stock from the conveyor at Rosie’s station and place it under the camera in the correct orientation.
- Run the specific test (test1 → CAM test, test2 → Component Placement Test, test3 → Meander Test)
- TEST 1: In all likelihood, the test will fail. Enter the current brightness values as seen from the terminal’s feedback in the array in ‘best_vals’



```
best_vals = [67.9, 70.6, 74.1] #calibration for test
```

- TEST 2: no calibration required. Doesn’t depend on surrounding brightness.
- TEST 3: no calibration required. Doesn’t depend on surrounding brightness. Change threshold values as required during testing.
- Run the test again to make sure it passes

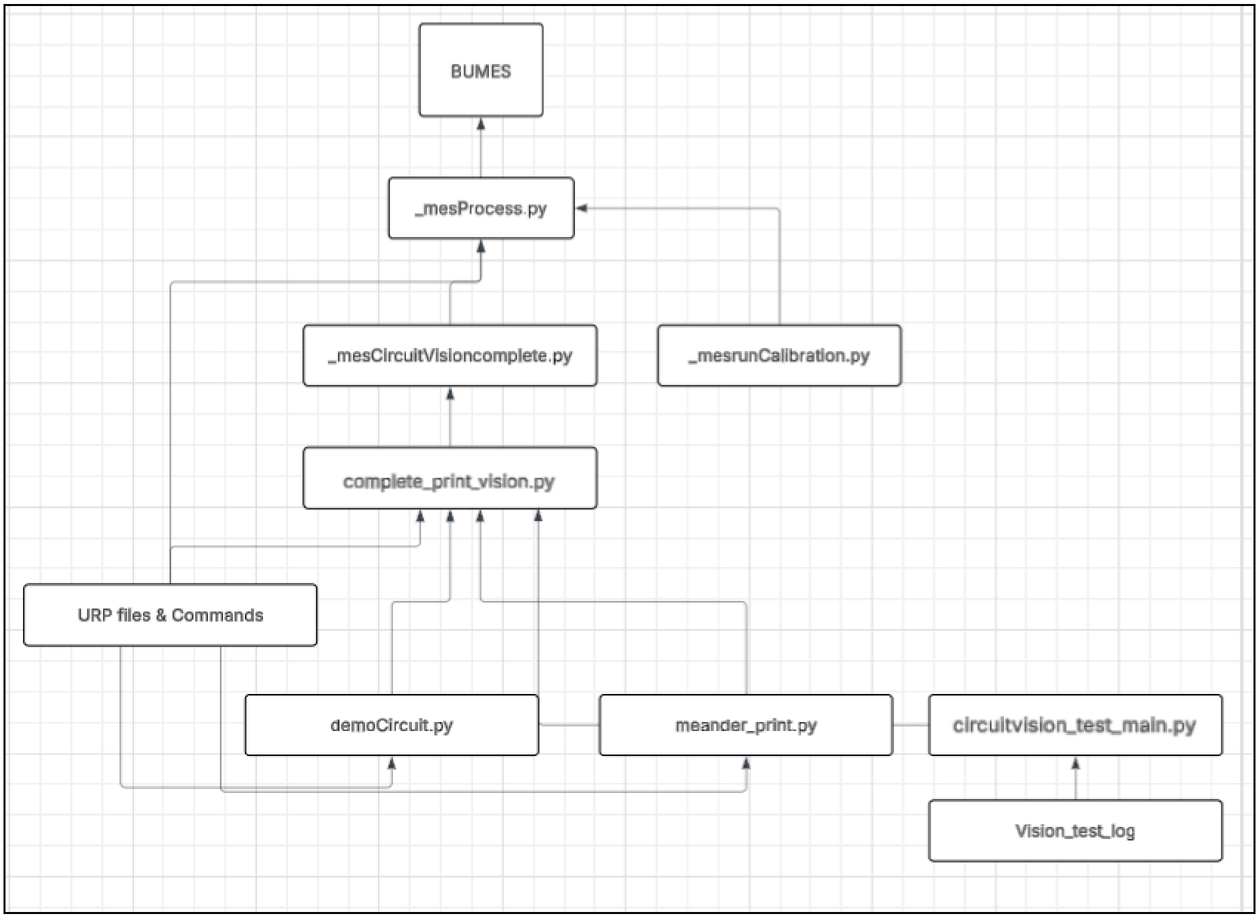
meander_print.py: copy of *inkTracing.py,* to specifically run the meander test.

Vision_test_log.py: logs results from the vision tests as there is no terminal feedback when the programs are run from BUMES. Can be opened to view the realtime outcome of the vision tests.

_mesProcess.py: contains all the BUMES process/function definitions. Is already present in the main system, but this version contains 2 additional function definitions: *circuitVision_complete(),* and *runCalibration(),* that call upon *_mesCircuitVisioncomplete.py* and *_mesrunCalibration.py* respectively. These functions are used by BUMES to run *complete_print_vision.py* and run the *calibration*.

_mesCircuitVisioncomplete.py: is called by *circuitVision_complete(),* within *_mesProcess.py.* calls *complete_print_vision.py.*

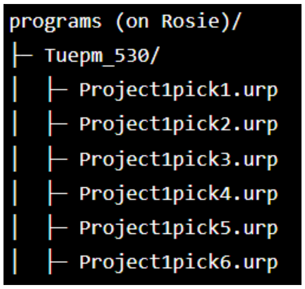
_mesrunCalibration.py: is called by *runCalibration(),* within *_mesProcess.py.* calls *calibration.py.*



Code Dependency Diagram

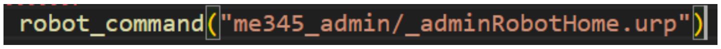
URP

The following programs should be placed under the given directories within the programs folder within Rosie (IP 10.241.34.4)



```
programs (on Rosie)/
├─ Tuepm_530/
│   ├─ Project1pick1.urp
│   ├─ Project1pick2.urp
│   ├─ Project1pick3.urp
│   ├─ Project1pick4.urp
│   ├─ Project1pick5.urp
│   ├─ Project1pick6.urp
```

*NOTE: these programs are referenced by Python Script *complete_print_vision.py.*



```
robot_command("me345_admin/_adminRobotHome.urp")
```

If the directory for these URP scripts are changed, please change the references in *complete_print_vision.py.*

Project1pick: Conveyor to Camera Station

Project1pick2: Camera Station to Vice

Project1pick3: Vice to Camera Station

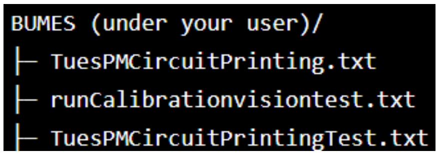
Project1pick4: Camera Station to Successful Component Placement Test Spot

Project1pick5: Camera Station to Successful Meander Test Spot

Project1pick6: Camera Station to Failed Test Spot

BUMES

The following programs can be placed anywhere under BUMES. They control the URP files and the VScode files.



```
BUMES (under your user)/
├─ TuesPMCircuitPrinting.txt
├─ runCalibrationvisiontest.txt
├─ TuesPMCircuitPrintingTest.txt
```

TuesPMCircuitPrinting: The main script. It controls everything, including calling the required URP scripts to load stock into, run and unload from the CNC machine, controlling AgvD, and calling the Python Script *complete_print_vision.py.*
For the run: Post ‘TuesPMCircuitPrinting’ in RealRun mode.

runCalibrationvisiontest: calls the script that runs the Calibration test.
To calibrate: Post ‘runCalibrationvisiontest’ in RealRun mode.

TuesPMCircuitPrintingTest: a test file- a subset of the main script that skips over the CNC parts and only calls *complete_print_vision.py.* Can be used for testing/troubleshooting purposes.

PHYSICAL COMPONENTS

USB CAMERA

Attach the USB camera on the frame meant for Rosie's Camera. Plug the USB connector into the BUMES computer next to Rosie and make sure you get a feed from it (you can run the camera app to test this).

If you aren't able to access the camera or take pictures, its device number may differ from that in the python script *circuitvision_test_main.py*. Since it's an external camera attached to a system with a webcam, its device number would usually be 1. If for any reason the Device number changes, please experiment with different device numbers and update the script.

Note: the python script *circuitvision_test_main.py* references the camera's device number under DEVICE NUMBER = 1.

INK

The ink is prepared according to the formula used in the ink synthesis lab from ME500. This used 0.733g Dowsil FA 4002, 0.1g Xiameter PMX-200, and 5g silver flake powder. In addition to the raw materials, the following equipment was used: Electronic scale, AR-100 Conditioning Mixer, 12mL mixing cup, Weighing paper, Spatula, Pipettes, Gloves. For the first step, the weighing paper is placed upon the scale before closing the doors and hitting the tare button. The 12mL mixing cup is then placed on the scale and zeroed. The 0.733g of Dowsil is added to the cup. The scale is zeroed. Next, 0.1g of Xiameter is added to the mix. The scale is zeroed again and the 5g of silver flakes are added. The cap of the mixing cup is secured. The whole container is reweighed. Using this measurement, the AR-100 Conditioning Mixer is balanced. The device is set to mix for 2 minutes and 30 seconds at 2000 RPM. This process is repeated three times with a one minute interval of rest in between each cycle.

SYRINGES

The syringes had two main procedures that they were set up for. The first was the calibration of the system and the second was for the full circuit printing. There are two syringes that are used in these procedures. One was used for component placement using a vacuum and the other was used for ink printing with pressurized air. The component placement uses the orange, metal tipped nozzle with a black TPU cover. The ink printing the green, plastic nozzle.

Calibration Procedure:
The orange nozzle WITHOUT the black TPU cover must be removed and replaced with the standard orange, metal nozzle. Our group found that some of the green nozzles failed to trip the garage door sensors. We selected one of the tips that could successfully trip the sensor and used that. The syringe bodies must also be pushed all the way down in their holders. This ensures consistent nozzle height when calibrating.

Ink Printing Procedure:
The orange nozzle WITH the black TPU cover must be replaced with the black sharpie marks lining up from the body through the nozzle. If the marks do not line up, rotate 180 degrees and repeat. The ink mixture is then transferred from the container to the next syringe, using 2 spatulas. When all the ink has been transferred, the plunger is inserted into the syringe and some ink is extruded from the green nozzle to make sure it runs.

STOCK

The stock that is used for the base of the circuit print is milled from the HDPE T-stock supply in the ADML. The dimensions of this block is 2”x3”x0.5”. This block is loaded in the corresponding gravity feeder at Mary’s station. In addition to the physical stock used in this process, the tray for inventory D is also placed into Mary’s station. Finally, another unmilled T-stock piece is placed and locked into the vice at Rosie’s station for immediate use of the meander test.