



Carnegie Mellon University
Carnegie Mellon University

Understanding and Dispensing Ingredients for Smart Robotic Cooking

Progress Review 8

Team B - Ratatouille Robotics



Goals for PR8

[Perception] Build an automated data collection script & collect improved data


[Perception] Collect spectral camera data for all relevant ingredients

[Perception] Integrate the spectral camera windows API with the state planner

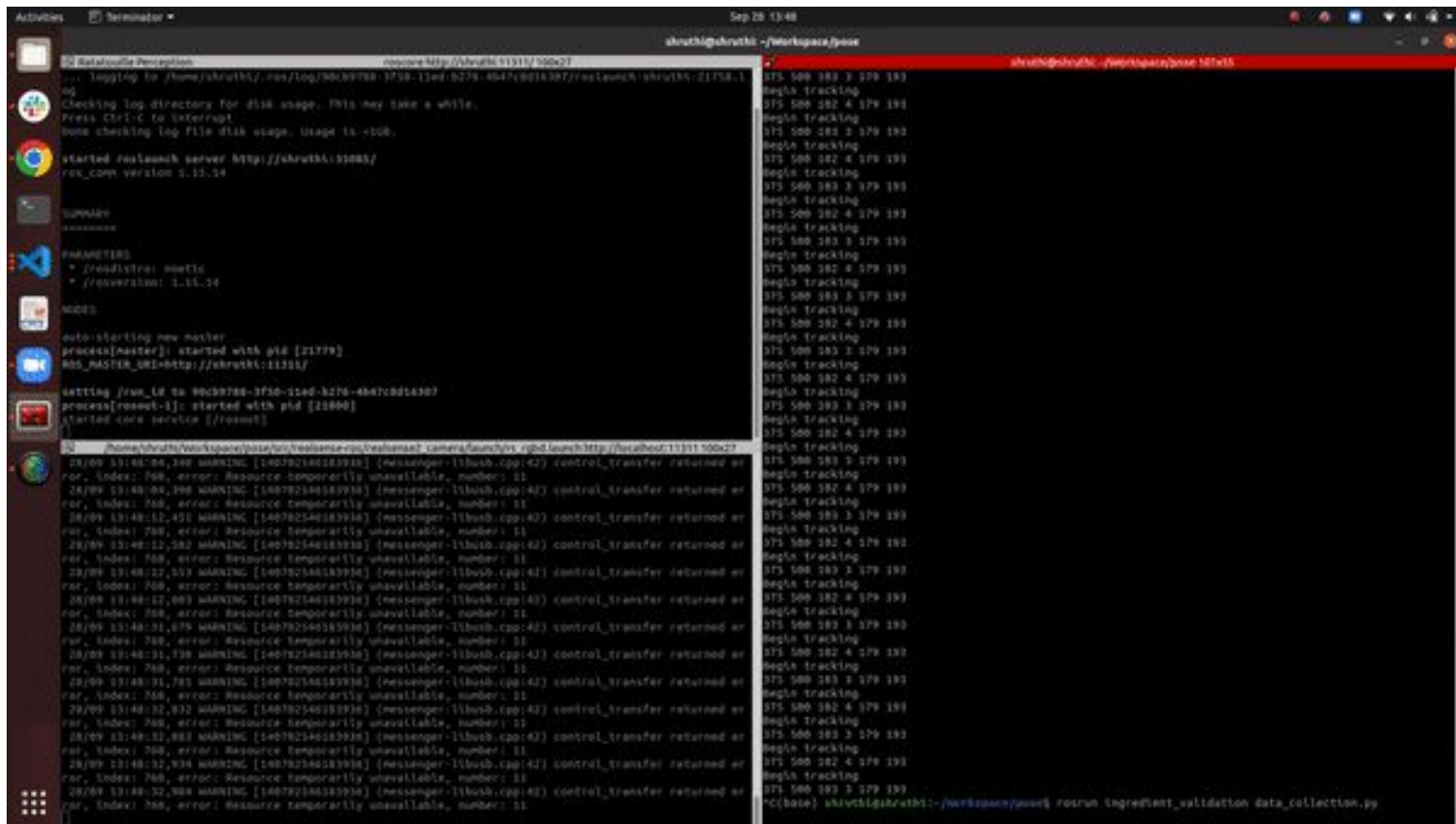
[Controls] Implement controllers for 4 new ingredients at least one of which is a powder

[Planning] Build inventory stock-taking pipeline

Progress

Goals	Status
[Perception] Build an automated data collection script & collect improved data	
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Automated Data Collection



```
AcDives Terminator
Sep 28 13:48
shrvct@shrvct: ~/workspace/pose

DataStudio Description
roscore http://shrvct:11311/50027
... logging to /home/shrvct/.ros/log/14039788-3f38-11e6-b276-486f0c0d1302/ras-launch-shrvct-21758-1
log
Checking log directory for disk usage. This may take a while.
Press Ctrl-C to interrupt.
Done checking log file disk usage. Usage is +0GB.
started ros launch server http://shrvct:11311/50027/
ros_core version 1.11.14

SUMMARY
-----



PARAMETERS
 * /roslauncher_name:
 * /rosversion: 1.11.14

NODES
 auto_starting new master
 process[master]: started with pid [21778]
 ROS_MASTER_URI=http://shrvct:11311/

setting /run_id to 14039788-3f38-11e6-b276-486f0c0d1302
 process[roscpp]: started with pid [21800]
 started core service [roscpp]

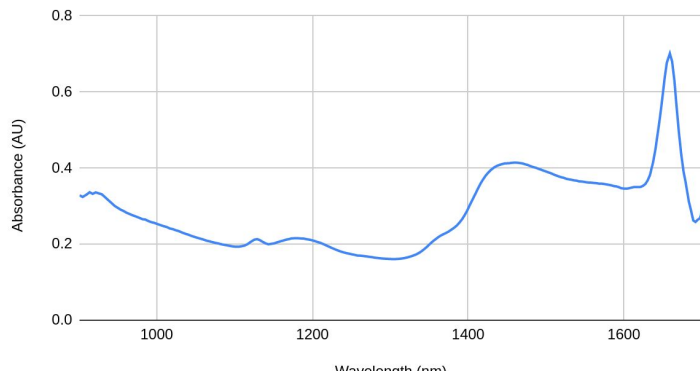
/home/shrvct/.ros/keys/052a26764b812e5fe1c956a4521d5a2/camera.launch.xml: cpud_launch_http://localhost:11311/50027
28/09 13:48:06,100 WARNING [140397883f38] [MessengerLibusb.cpp:42] control_transfer returned an
ror, index: 768, error: Resource temporarily unavailable, number: 11
28/09 13:48:06,199 WARNING [140397883f38] [MessengerLibusb.cpp:42] control_transfer returned an
ror, index: 768, error: Resource temporarily unavailable, number: 11
28/09 13:48:12,451 WARNING [140397883f38] [MessengerLibusb.cpp:42] control_transfer returned an
ror, index: 768, error: Resource temporarily unavailable, number: 11
28/09 13:48:12,582 WARNING [140397883f38] [MessengerLibusb.cpp:42] control_transfer returned an
ror, index: 768, error: Resource temporarily unavailable, number: 11
28/09 13:48:12,632 WARNING [140397883f38] [MessengerLibusb.cpp:42] control_transfer returned an
ror, index: 768, error: Resource temporarily unavailable, number: 11
28/09 13:48:12,681 WARNING [140397883f38] [MessengerLibusb.cpp:42] control_transfer returned an
ror, index: 768, error: Resource temporarily unavailable, number: 11
28/09 13:48:31,675 WARNING [140397883f38] [MessengerLibusb.cpp:42] control_transfer returned an
ror, index: 768, error: Resource temporarily unavailable, number: 11
28/09 13:48:31,738 WARNING [140397883f38] [MessengerLibusb.cpp:42] control_transfer returned an
ror, index: 768, error: Resource temporarily unavailable, number: 11
28/09 13:48:31,781 WARNING [140397883f38] [MessengerLibusb.cpp:42] control_transfer returned an
ror, index: 768, error: Resource temporarily unavailable, number: 11
28/09 13:48:32,832 WARNING [140397883f38] [MessengerLibusb.cpp:42] control_transfer returned an
ror, index: 768, error: Resource temporarily unavailable, number: 11
28/09 13:48:32,881 WARNING [140397883f38] [MessengerLibusb.cpp:42] control_transfer returned an
ror, index: 768, error: Resource temporarily unavailable, number: 11
28/09 13:48:32,934 WARNING [140397883f38] [MessengerLibusb.cpp:42] control_transfer returned an
ror, index: 768, error: Resource temporarily unavailable, number: 11
28/09 13:48:32,984 WARNING [140397883f38] [MessengerLibusb.cpp:42] control_transfer returned an
ror, index: 768, error: Resource temporarily unavailable, number: 11
^C(base) shrvct@shrvct:~/workspace/pose$ roscurl /roscpp/validate_data_collection.py
```

Progress

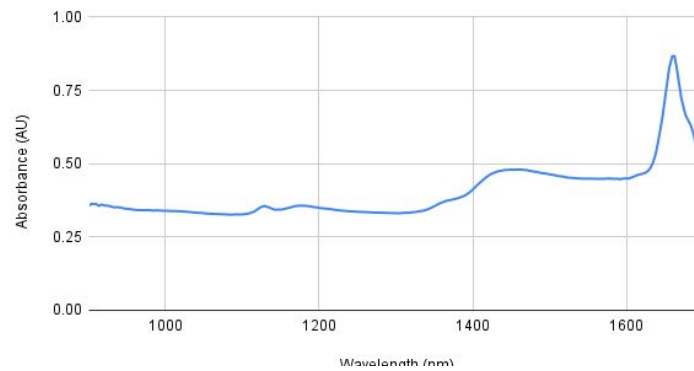
Goals	Status
[Perception] Build an automated data collection script & collect improved data	
[Perception] Collect spectral camera data for all relevant ingredients	
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[Planning] Build initial calibration pipeline	

Spectral Data Collection for Relevant Ingredients

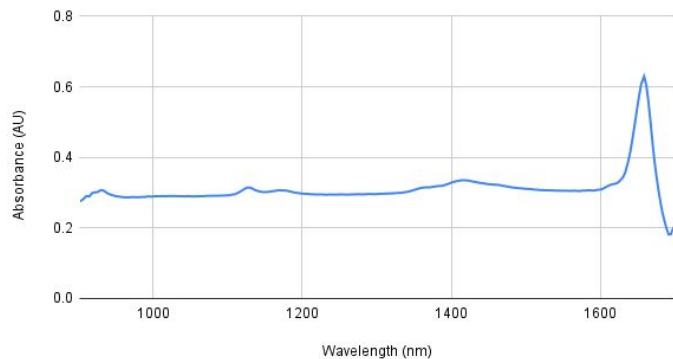
Black pepper



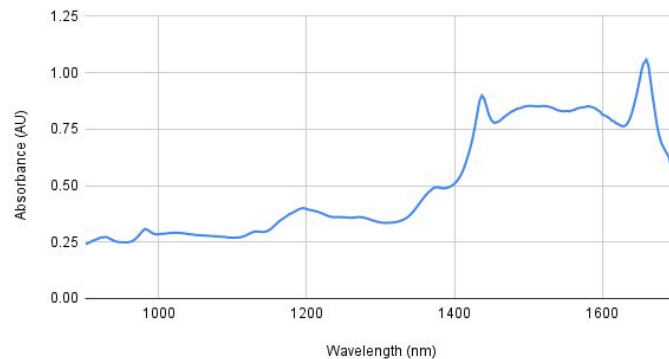
Oregano






Salt



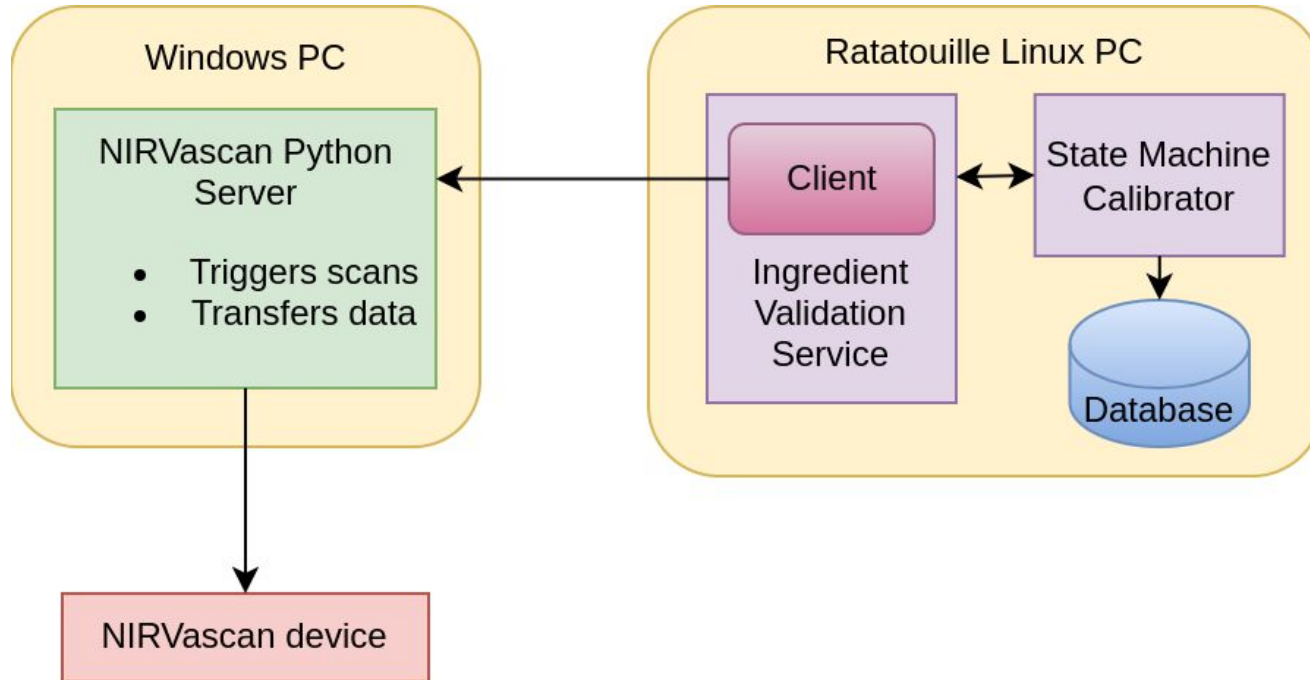
Sugar



Progress

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Spectral Camera Integration with State Planner



Spectral Camera Integration with State Planner

Windows Server & Linux Client: Communication test

TCP client in Ubuntu: Data sample





Windows Spectral Server

```
s/windows_spectral_server.py
Listening
Waiting for connection
Connected to client IP: ('127.0.0.1', 57987)
Received request to scan!
Performing scan...
Sending scan results
Done!
Waiting for connection
```

```
$ python client.py
Connection established
  Wavelength (nm) ... Sample Signal (unitless)
0  900.957557108074 ... -232
1  904.844796792001 ... -172
2  910.021073788255 ... 484
3  913.898249598708 ... -85
4  917.771112320529 ... 672
.. ..
223 1689.14852211624 ... 352
224 1692.03224984519 ... 317
225 1694.9116644855 ... -82
226 1697.78676603718 ... 461
227 1700.65755450023 ... 108

[228 rows x 4 columns]
Closing socket
```

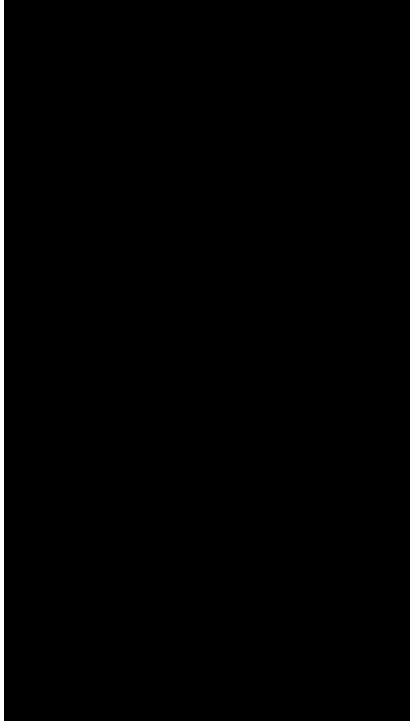
Progress

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New Ingredients

S.No	Ingredient	Status	Targeted Tolerance	Achieved Tolerance
1	Salt	Done	0.5	0.5
2	Chickpea	Done	20	20
3	Bell Pepper	Done	25	20
4	Olives	Done	15	15
5	Sugar	Ongoing	0.5	-
6	Onions	Ongoing	25	-

Dispensing Videos

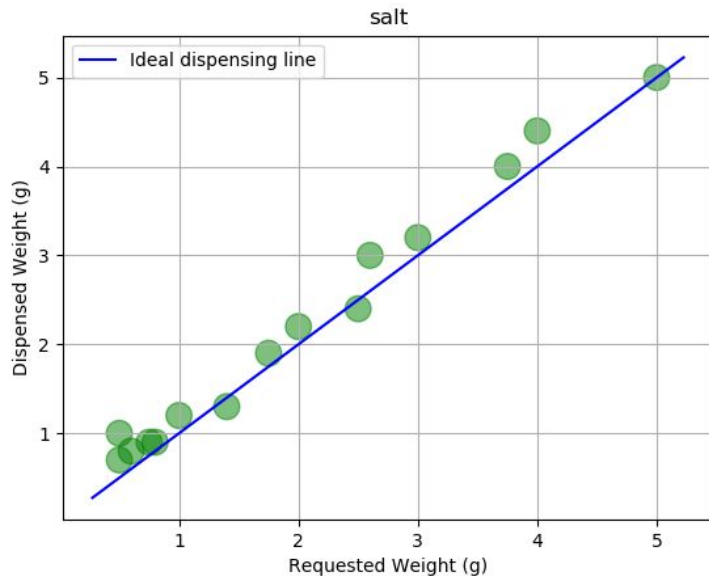


```
[ INFO ] [1664332282.425274239]: Received new planning se
[ INFO ] [1664332282.425371309]: Using planning pipeline
[ INFO ] [1664332282.425429657]: The timeout for planning
ing one
second instead.
[ INFO ] [1664332282.425460210]: Generating LIN trajectory
[ INFO ] [1664332282.426302900]: Execution request receive
[ INFO ] [1664332282.478402524]: Controller 'scaled_pos_jo
[ INFO ] [1664332282.483963314]: Completed trajectory exec
[ INFO ] [1664332282.484041791]: Execution completed: SUCC
[ INFO ] [1664332282.484546427]: Received event 'stop'

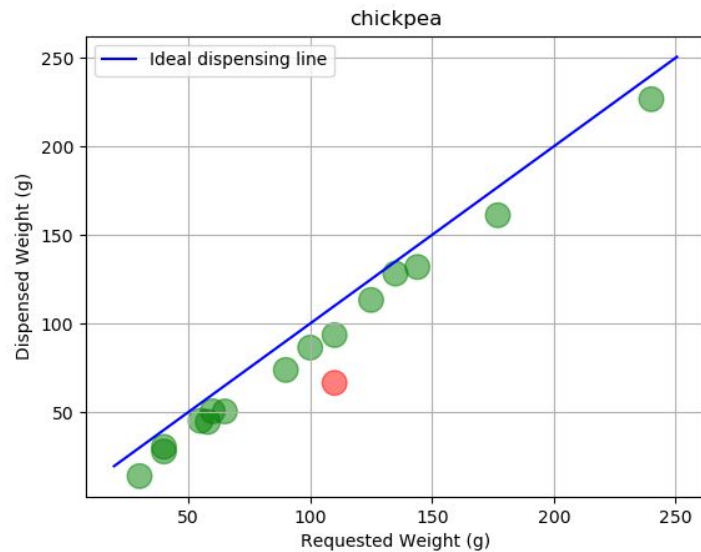
* mohith@mohith-XPS-15: ~/Documents/ra
[ INFO ] [1664332032.214524403]: Ready to take commands for
Enter desired ingredient quantity (in grams): 240
[ INFO ] [1664332041.804290]: Dispensing started...
[ INFO ] [1664332095.638491]: PD control phase completed...
[ INFO ] [1664332098.622402]: Ingredient dispensed successful
Requested Qty: 240.00g  Dispensed Qty: 226.00g
Enter desired ingredient quantity (in grams): 60
[ INFO ] [1664332115.242296]: Dispensing started...
[ INFO ] [1664332139.392592]: PD control phase completed...
[ INFO ] [1664332142.325936]: Ingredient dispensed successful
Requested Qty: 60.00g  Dispensed Qty: 59.50g
Enter desired ingredient quantity (in grams): 40
[ INFO ] [1664332149.392591]: Dispensing started...
[ INFO ] [1664332172.248173]: PD control phase completed...
[ INFO ] [1664332175.129842]: Ingredient dispensed successful
Requested Qty: 40.00g  Dispensed Qty: 39.40g
Enter desired ingredient quantity (in grams): 30
[ INFO ] [1664332185.412165]: Dispensing started...
[ INFO ] [1664332203.774410]: PD control phase completed...
[ INFO ] [1664332206.656151]: Ingredient dispensed successful
Requested Qty: 30.00g  Dispensed Qty: 13.90g
Enter desired ingredient quantity (in grams): 100
[ INFO ] [1664332251.447607]: Dispensing started...
[ INFO ] [1664332279.498448]: PD control phase completed...
[ INFO ] [1664332282.421911]: Ingredient dispensed successful
Requested Qty: 100.00g  Dispensed Qty: 86.40g
Enter desired ingredient quantity (in grams): 90
```



Evaluation

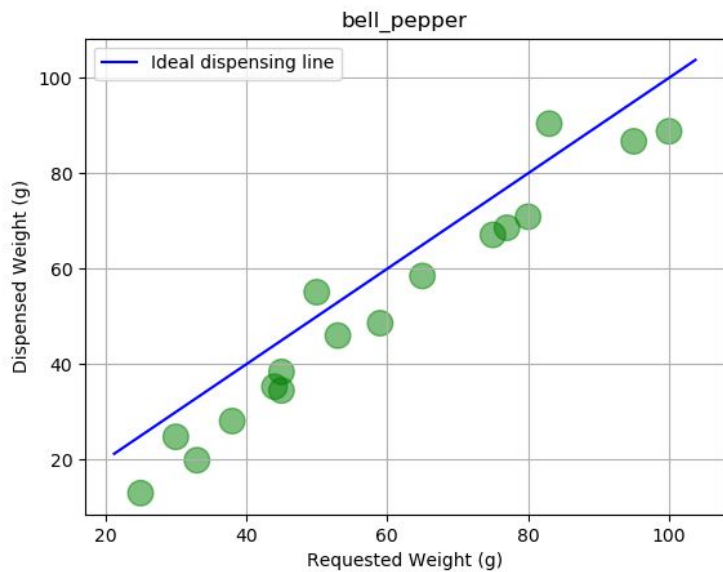


Tolerance: 0.5g
Number of Trials: 15

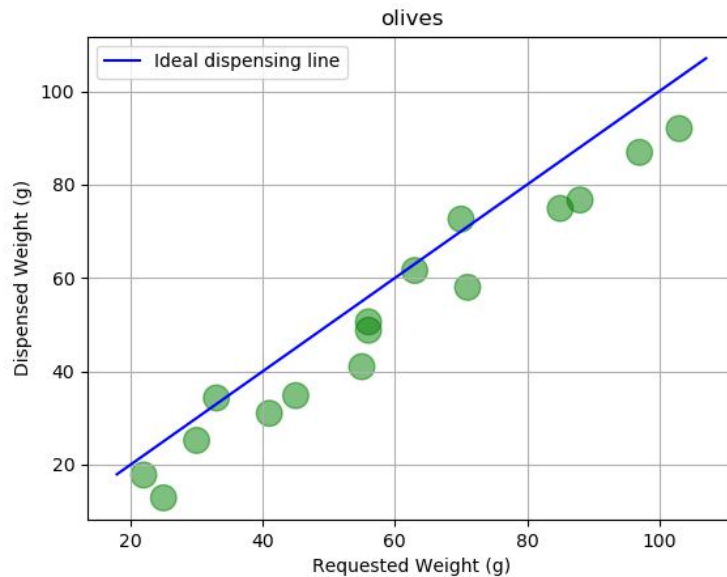


Tolerance: 20g
Number of Trials: 16

Evaluation



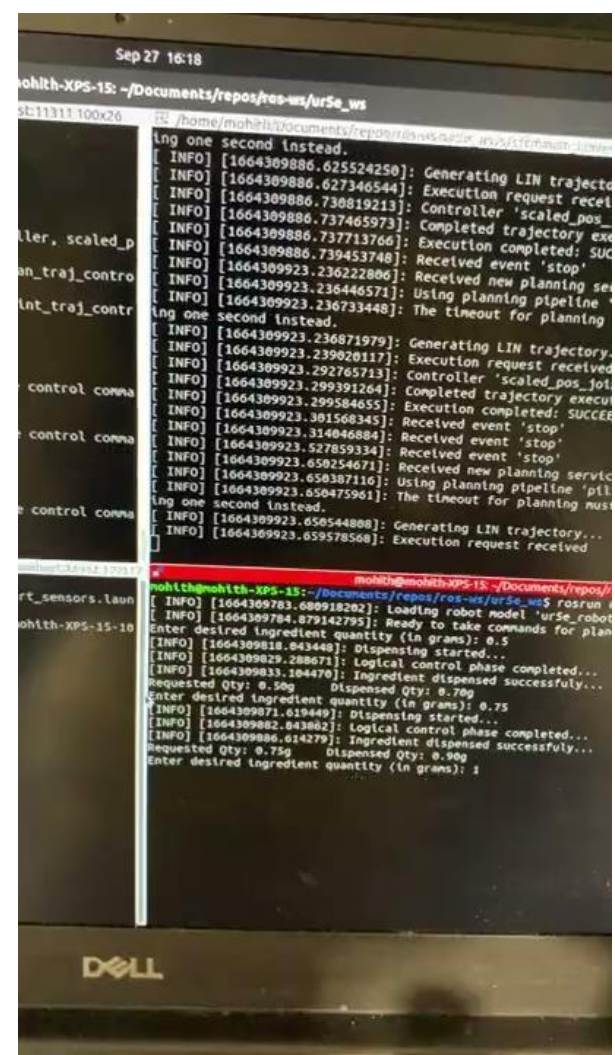
Tolerance: 20g
Number of Trials: 17



Tolerance: 20g
Number of Trials: 16

Powder Dispensing

- Containers with holes on top
- Working:
 - Based on the idea that the contents have to be unsettled to initiate flow
 - Keep shaking until quantity dispensed
 - Important Hyper-parameters
 - *Number of holes*
 - *Size of holes*



Sep 27 16:18

```
mohith@XPS-15: ~/Documents/repos/ros-ws/ur5e_ws
[INFO] [1664309886.625524250]: Generating LIN trajectory
[INFO] [1664309886.627346544]: Execution request received
[INFO] [1664309886.730819213]: Controller 'scaled_pos_
[INFO] [1664309886.737465973]: Completed trajectory exe
[INFO] [1664309886.739453748]: Received event 'stop'
[INFO] [1664309923.236222806]: Received new planning se
[INFO] [1664309923.236446571]: Using planning pipeline
[INFO] [1664309923.236733448]: The timeout for planning
[INFO] [1664309923.236871979]: Generating LIN trajectory
[INFO] [1664309923.239020117]: Execution request received
[INFO] [1664309923.292765713]: Controller 'scaled_pos_fo
[INFO] [1664309923.299391264]: Completed trajectory execu
[INFO] [1664309923.299584655]: Execution completed: success
[INFO] [1664309923.301568345]: Received event 'stop'
[INFO] [1664309923.314046884]: Received event 'stop'
[INFO] [1664309923.527859334]: Received event 'stop'
[INFO] [1664309923.650254671]: Received new planning servic
[INFO] [1664309923.650387116]: Using planning pipeline 'pil
[INFO] [1664309923.650475961]: The timeout for planning must
[INFO] [1664309923.650544808]: Generating LIN trajectory...
[INFO] [1664309923.659578568]: Execution request received

mohith@mohith-XPS-15: ~/Documents/repos/
[INFO] [1664309783.080918202]: Loading robot model 'ur5e_robot
[INFO] [1664309784.879142795]: Ready to take commands for plan
Enter desired ingredient quantity (in grams): 0.5
[INFO] [1664309818.0434448]: Dispensing started...
[INFO] [1664309829.288671]: Logical control phase completed...
[INFO] [1664309833.104470]: Ingredient dispensed successfully...
Requested Qty: 0.50g  Dispensed Qty: 0.70g
Enter desired ingredient quantity (in grams): 0.75
[INFO] [1664309871.610449]: Dispensing started...
[INFO] [1664309882.843082]: Logical control phase completed...
[INFO] [1664309886.014279]: Ingredient dispensed successfully...
Requested Qty: 0.75g  Dispensed Qty: 0.90g
Enter desired ingredient quantity (in grams): 1
```

DELL

Progress

Goals	Status
[Perception] Build an automated data collection script & collect improved data	✓
[Perception] Collect spectral camera data for all relevant ingredients	✓
[Perception] Integrate the spectral camera windows API with the state planner	✓
[Controls] Implement controllers for 4 new ingredients at least one of which is a powder	✓
[Planning] Build initial calibration pipeline	✓

Inventory Stock-taking Pipeline

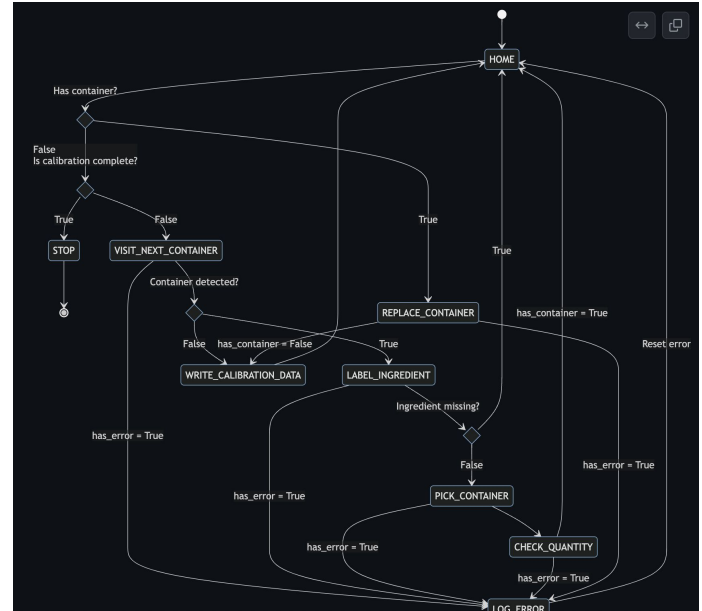
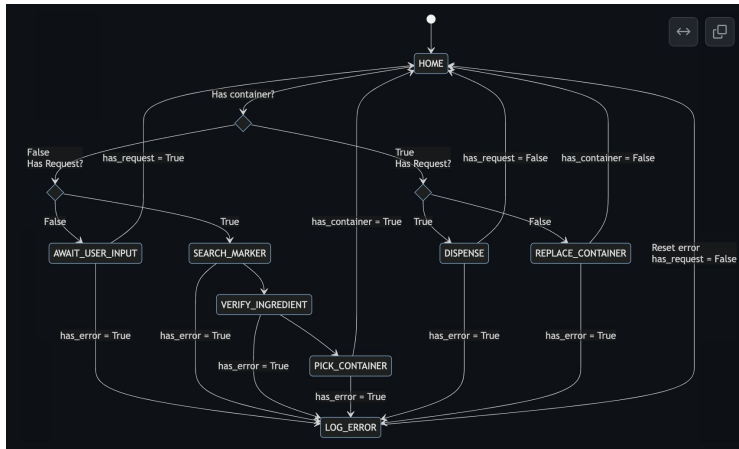
- New high-level planner for inventory stock-taking
- Ability to update inventory for specific containers upon refill
- Ability to resume from partial calibration
- Needs to be supported by system integration
 - new weighing scale
 - spectral camera placement

Calibration Flow

Challenges

- Extending existing high-level planner (below) to include inventory stock-taking flow proved to be challenging due to the additional states, state variables required.

Solution: Separate high-level planner for inventory stock-taking (right).



Challenges

- Noisy weight measurements leading to difficulty in dispensing fine ingredients

Solution:

- Changed logic to accommodate noise within tolerance
- isolate the cooking pot from the vention stand

Challenges

- Building and integrating the NIRVascan C# Windows DLL API was challenging.

Solution: Used Python UI automation to directly use the application as a temporary solution.

Will speak to the vendor and get the build issues cleared for robust integration.

Challenges

- Key hyper-parameters for the controllers seem to hardware elements

Future Work

- Complete integration of second weighing scale
- Complete integration of spectral camera into hardware setup
- Formulate the exact details of the extensions to the existing controller and prepare a roadmap

PR9 Goals

Overarching goal: MVP for FVD complete

- Environment setup complete
 - Cooking pot placement & constraints
 - Sensing station placement
- Ingredient validation using RGB image and spectral data complete
- Calibration routine and state machine workflow complete
- Controller tuned for all committed ingredients

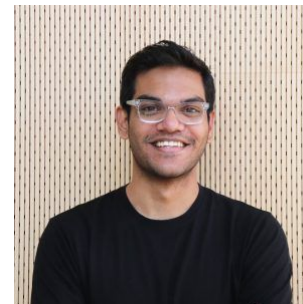
Carnegie Mellon University



Harshit Agrawal
Sensing Lead



Sai Shruthi Balaji
Perception Lead



Abhishek Pavani
Systems Integration Lead

Questions?



Mohith Sakhivel
Robot Learning & Control Lead



Nevin Valsaraj
Software Architect &
Project Manager

