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
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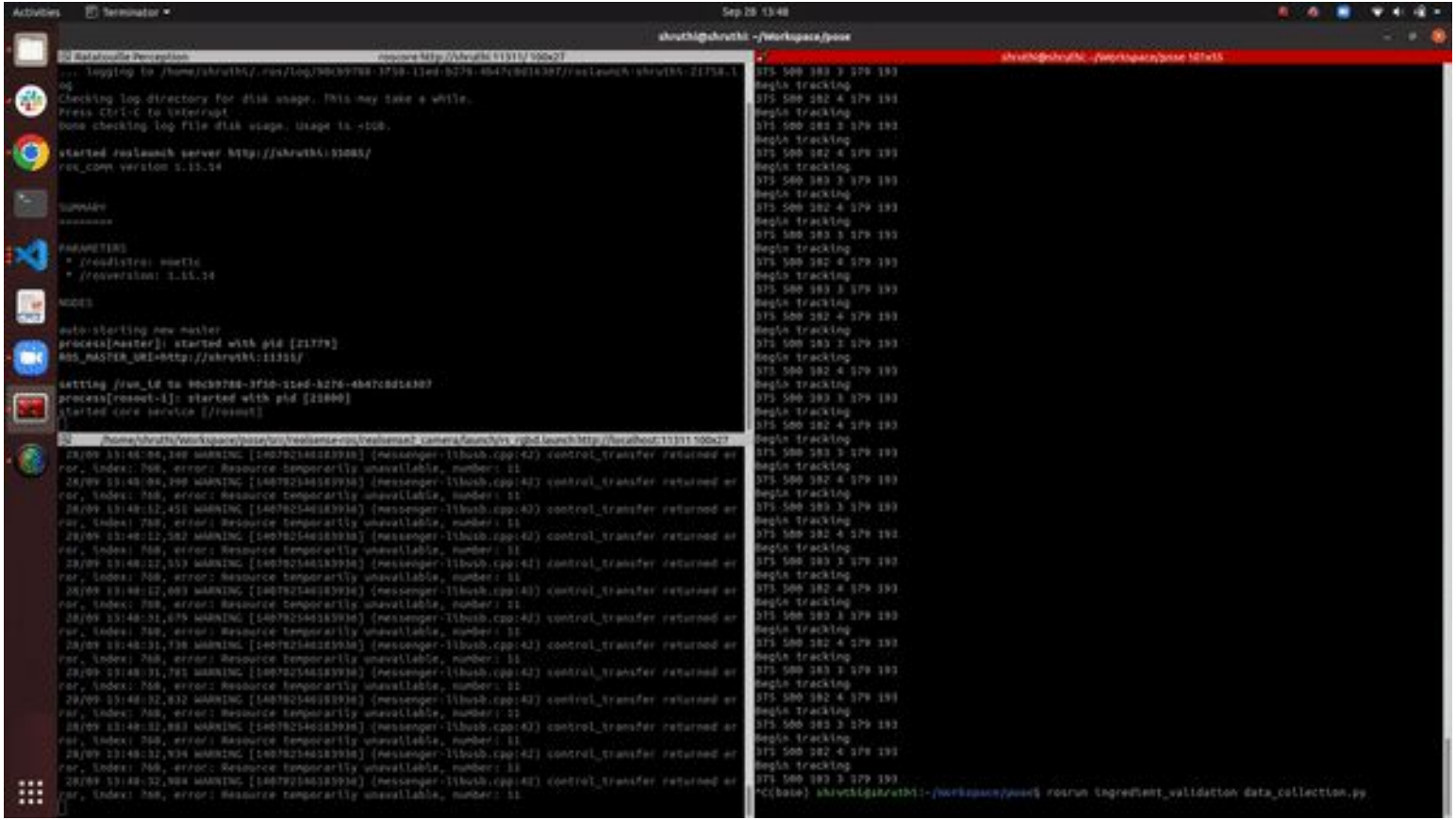
Automated Data Collection



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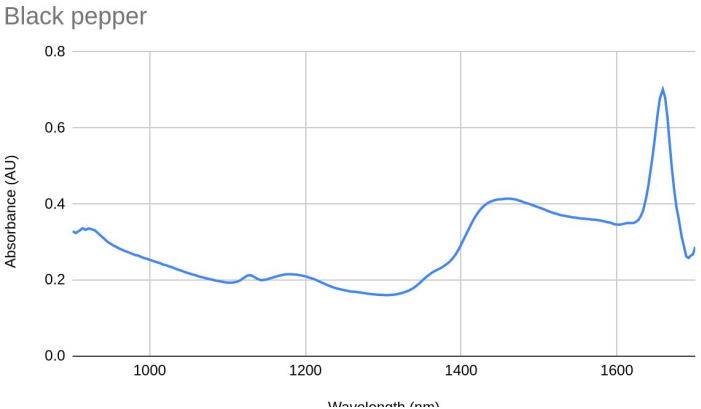
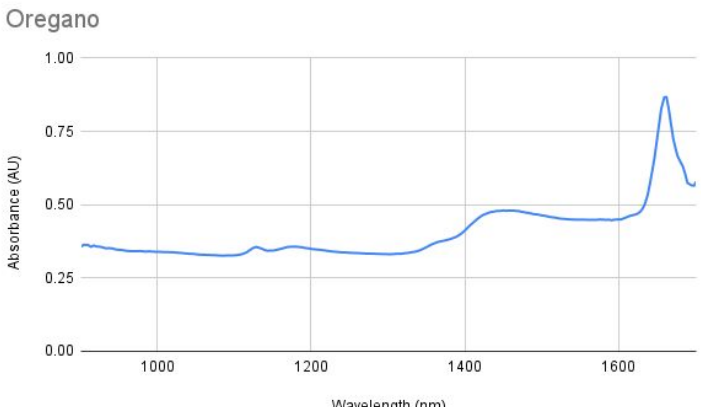
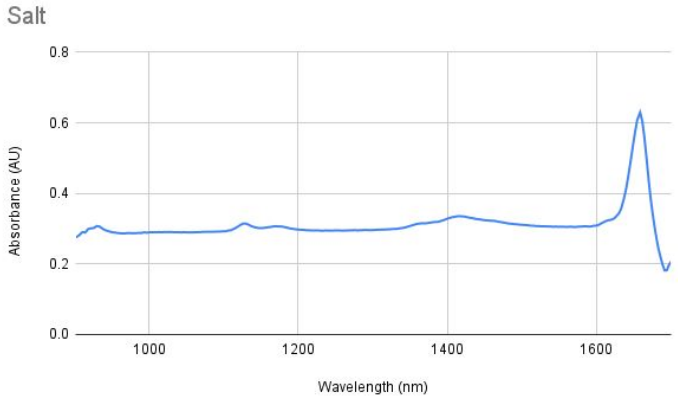
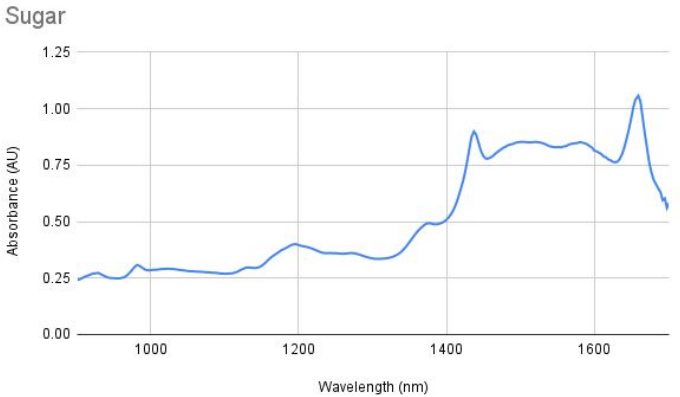
Spectral Data Collection for Relevant Ingredients









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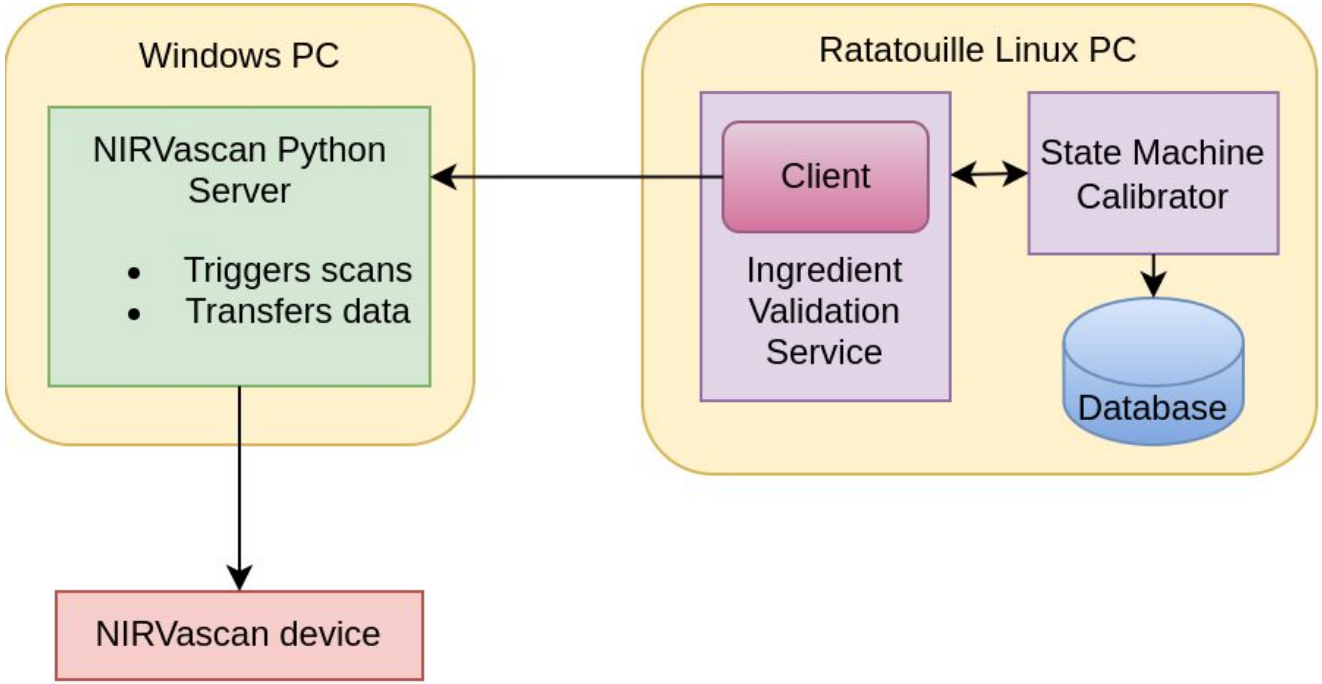
Spectral Camera Integration with State Planner



Spectral Camera Integration with State Planner

Windows Server & Linux Client: Communication test

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
```

TCP client in Ubuntu: Data sample

```
$ 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
```

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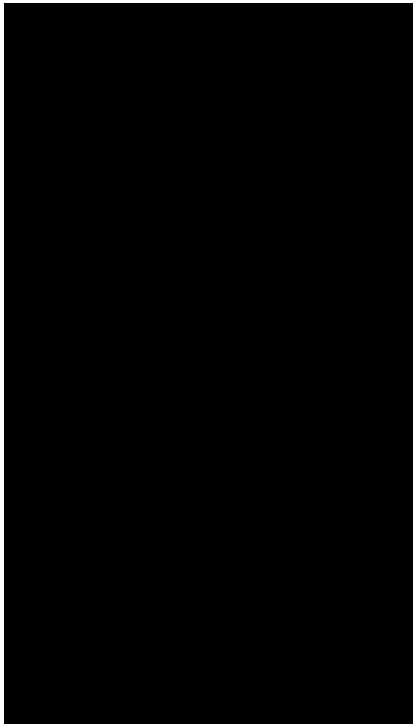
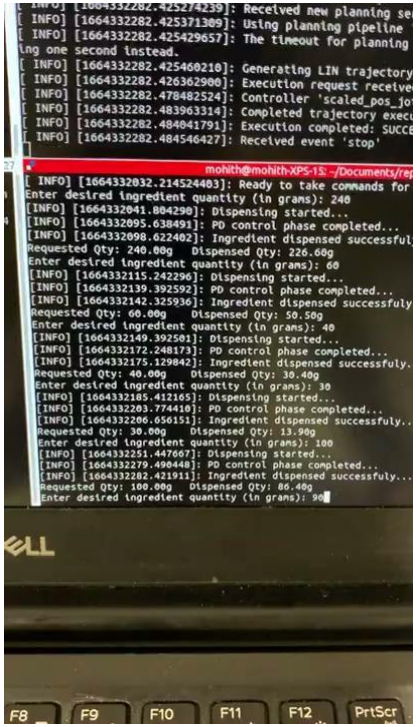
New Ingredients

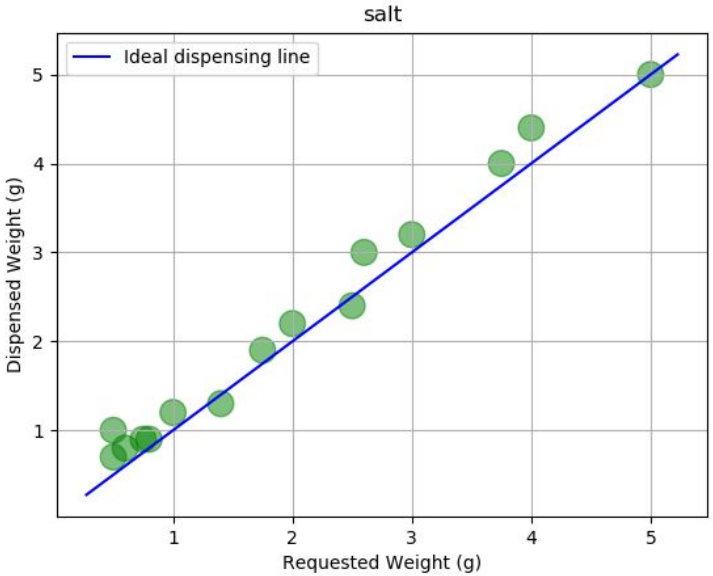
S.No	Ingredient	Status	Targeted Tolerance	Achieved Tolerance
1	Salt	Done	0.5	0.5
2	Chickpea	Done	20	20
3	Bell Pepper	Done	25	20
4	Olives	Done	15	15
5	Sugar	Ongoing	0.5	-
6	Onions	Ongoing	25	-

Dispensing Videos

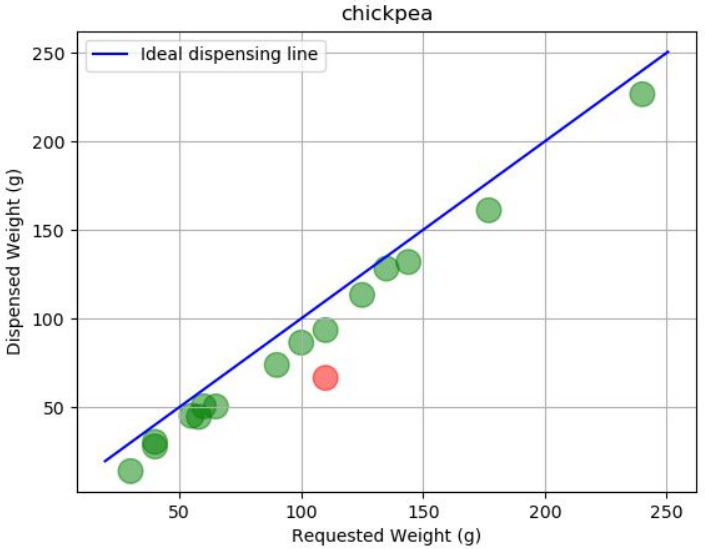




Evaluation

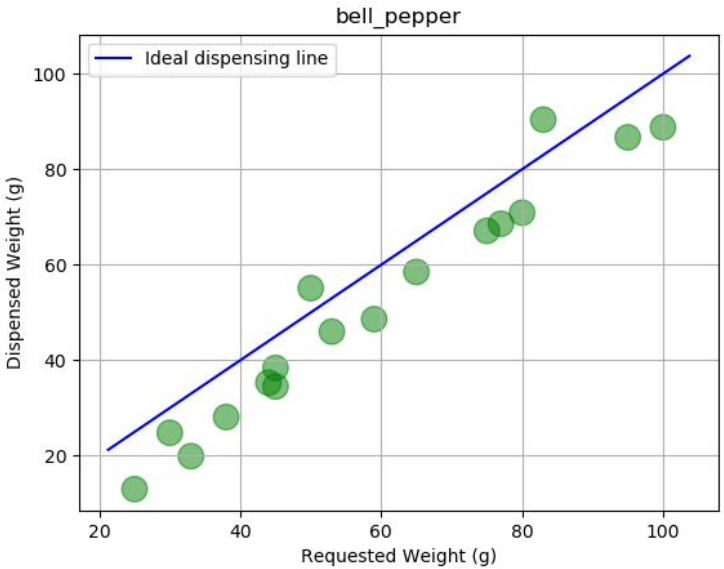


Tolerance: 0.5g
Number of Trials: 15



Tolerance: 20g
Number of Trials: 16

Evaluation



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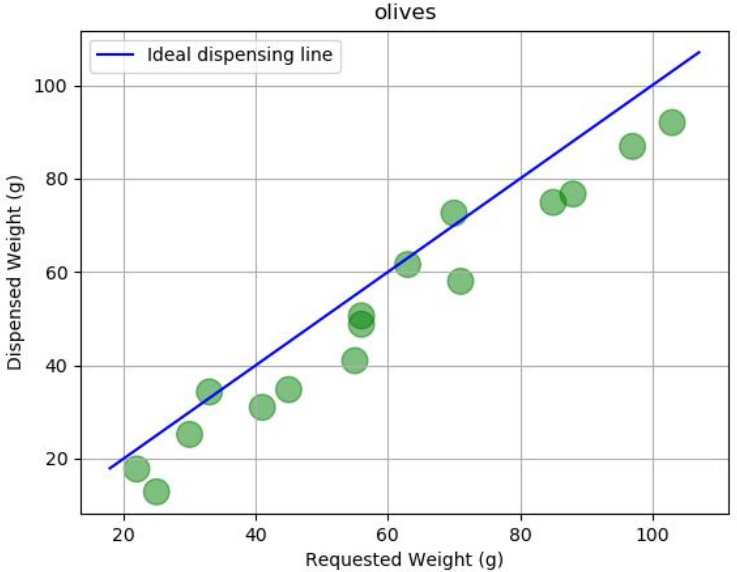
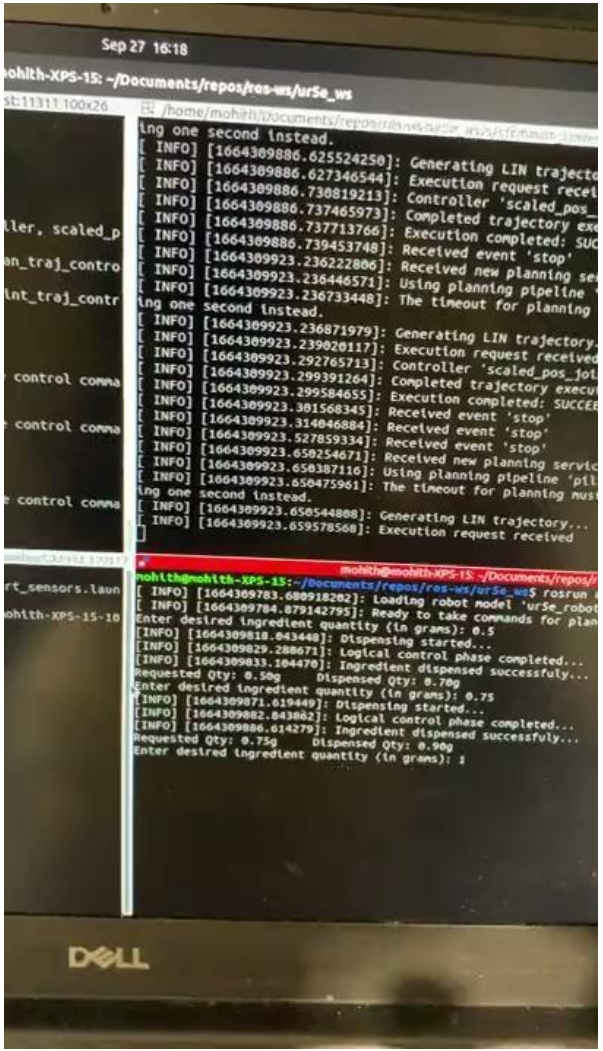


Tolerance: 20g
Number of Trials: 16

Powder Dispensing

- Containers with holes on top

- **<u>Working:</u>**
  - 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*



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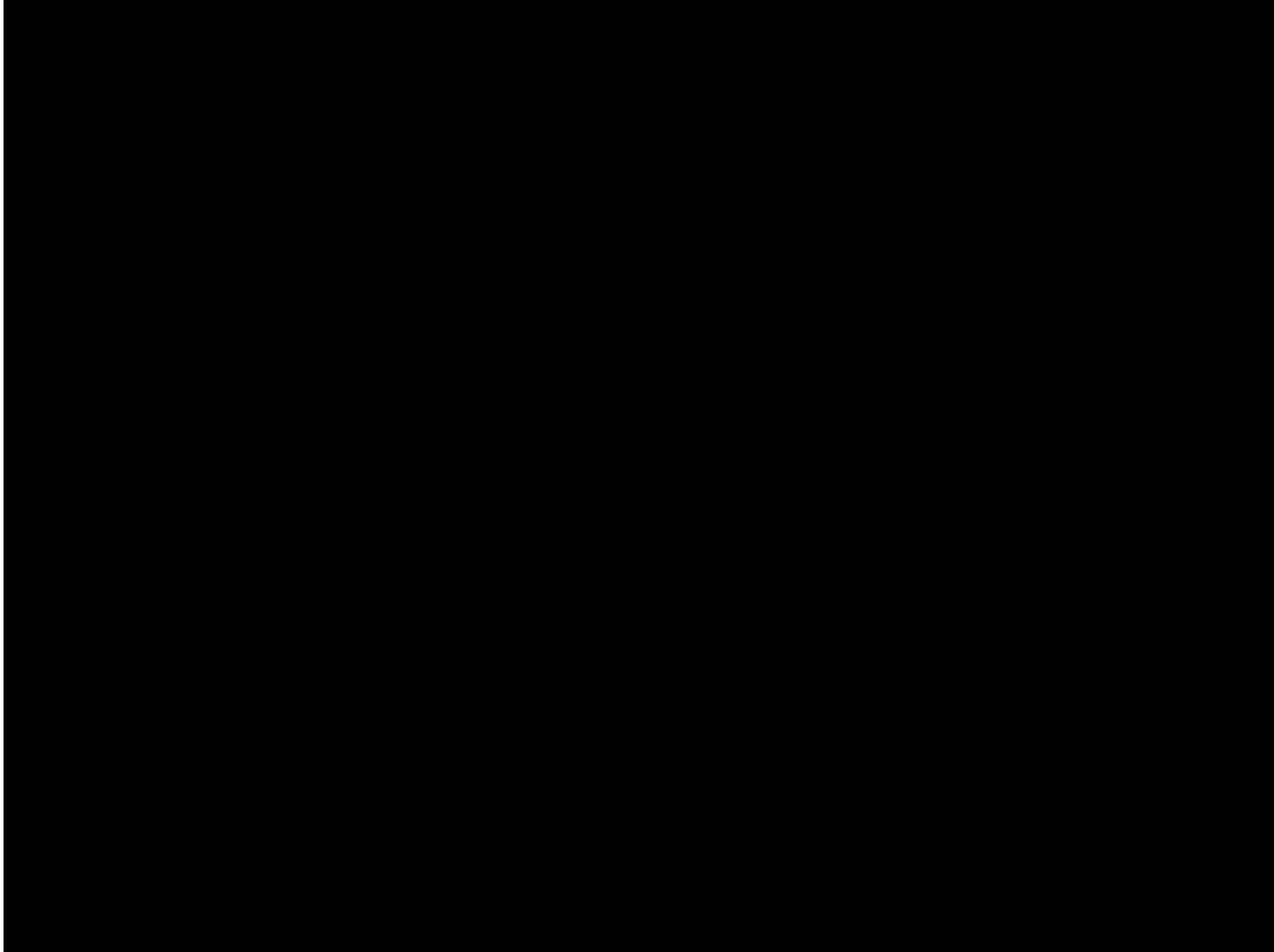
Inventory Stock-taking Pipeline

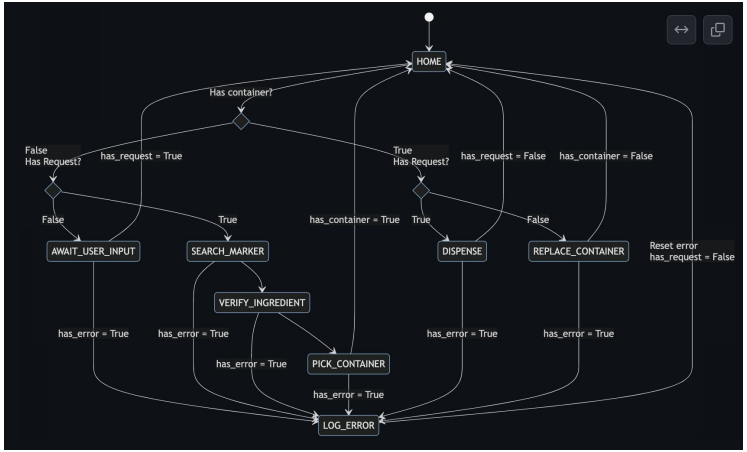
- New high-level planner for inventory stock-taking
- Ability to update inventory for specific containers upon refill
- Ability to resume from partial calibration
- Needs to be supported by system integration
  - new weighing scale
  - spectral camera placement

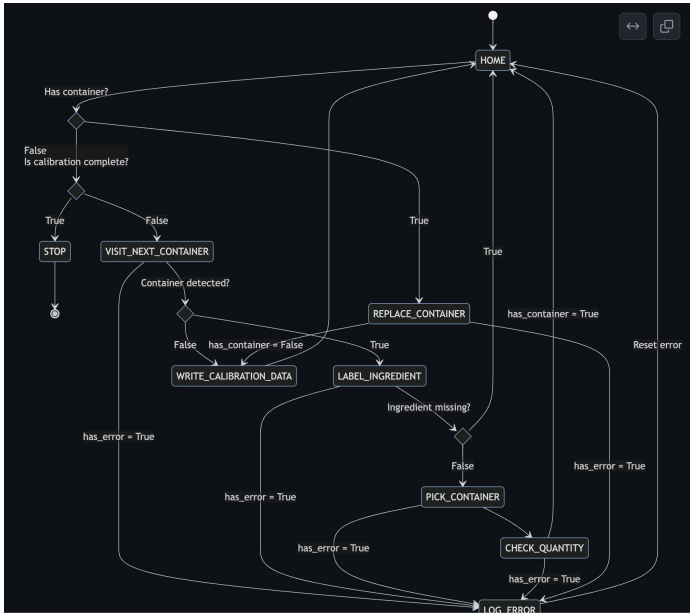
Calibration Flow



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

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Questions?

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Robot Learning & Control Lead

Nevin Valsaraj
Software Architect &
Project Manager


ROBOTS ONLY
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