Reinforcement Learning and Inverse Optimization for Autonomous Navigation

Special course - Fall 2023

Rolando Esquivel-Sancho

Week 9 - 27-02-2024:

- Reviewing literature mainly in inverse RL, RL with human feedback and COLREG-compliant collision avoidance.
- Exploring the Data:
    - Question? Land.pickle returning empty list.
    - Question? Depth.pickle vrs depth data in seachart.json.
- Structuring the Python Package:
    - Defining modules and classes for data processing, analysis, and environment implementation.

Week 10 - 04-03-2024:

Imitation library: https://imitation.readthedocs.io/en/latest/#

Algorithms:

- Behavioral Cloning (Policy *)
- Generative Adversarial Imitation Learning (Policy *)
- Adversarial Inverse Reinforcement Learning (Policy, recovers reward func *)
- DAgger (Policy similar to BC but online *)
- Density-Based Reward Modeling (Reward function no interpretable *)
- Maximum Causal Entropy Inverse Reinforcement Learning (Reward *)
- Preference Comparison (Reward)
- Soft Q Imitation Learning (Policy DQN)

Topics & next steps

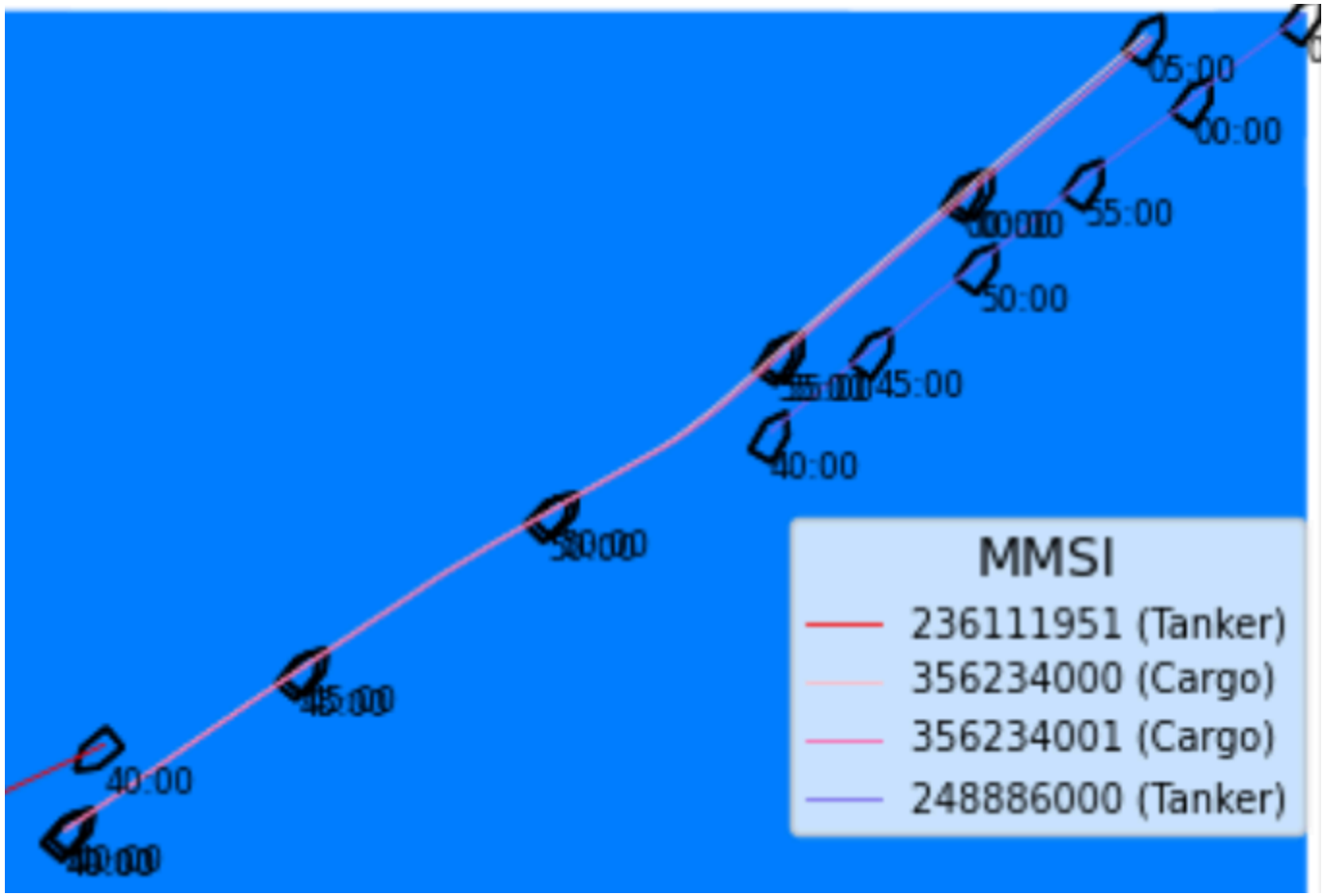
- Create the env with Gymnasium's API
- Actions:
  - Used sog and cog as action vector and keep lon and lat as observations.
  - create the dynamic model.
- Observations:
  - Model as a multiagent systems.
  - Fix number of dynamic objects.
  - observation horizon.
- Limitations on Horizon Length
- Trajectories to Transitions.
- Metrics

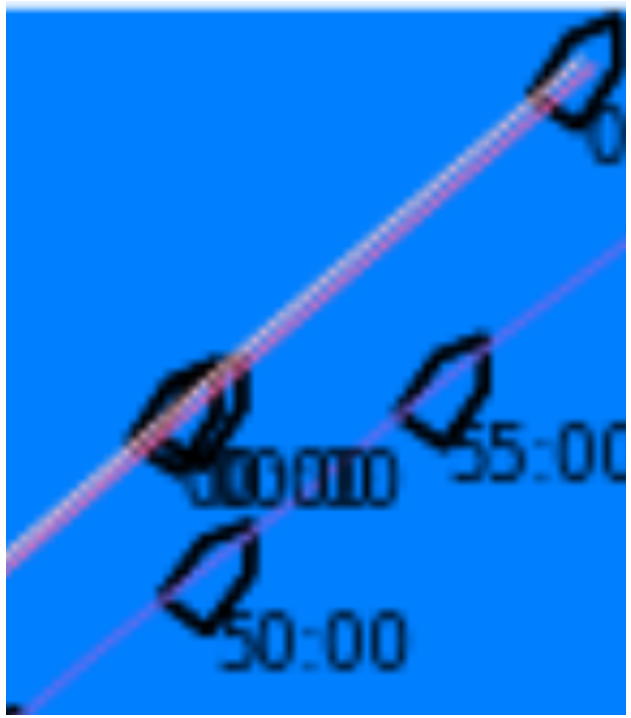
Week 11 - 12-03-2024:

Status:

- action space: `Box(-1, 1, (2,), float32)` -- normalization (max-speed)
- observation space: `Box(0, 255, (W, H), np.uint8)` and `Box(-1, 1, (n_vessels,4), np.uint8)`

- Using the agent accions COG (radians) and SOG (m/s) to generate location.



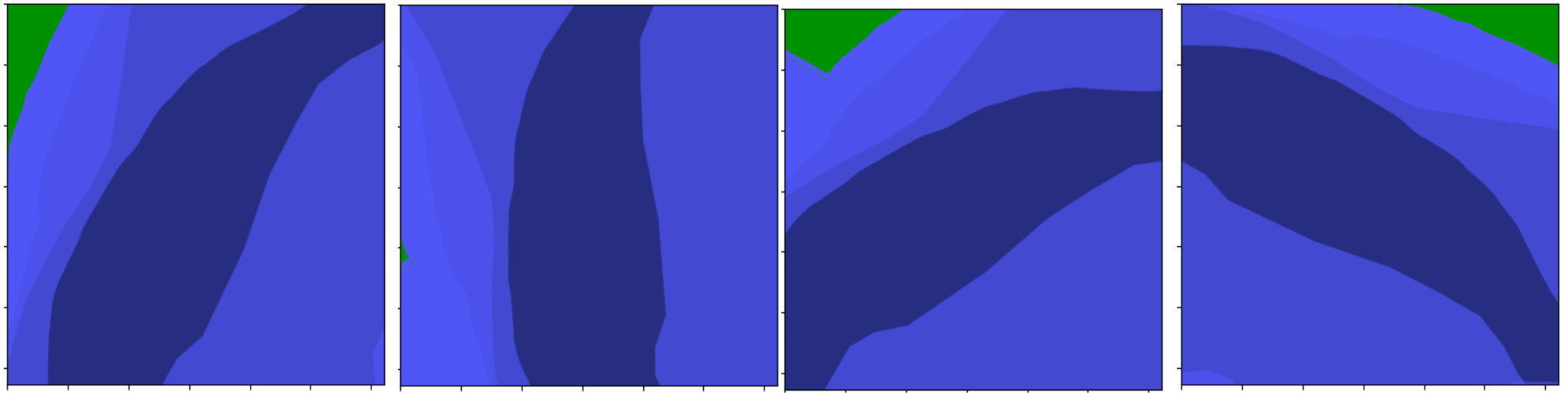


Next steps

- Create Land/Depth observation relative to the agent
- Create trajectory metric.

Week 12 - 19-03-2024:

- Create Land/Depth observation relative to the agent
  Scenario 5 meters per pixel.
  Transformation:



Next steps

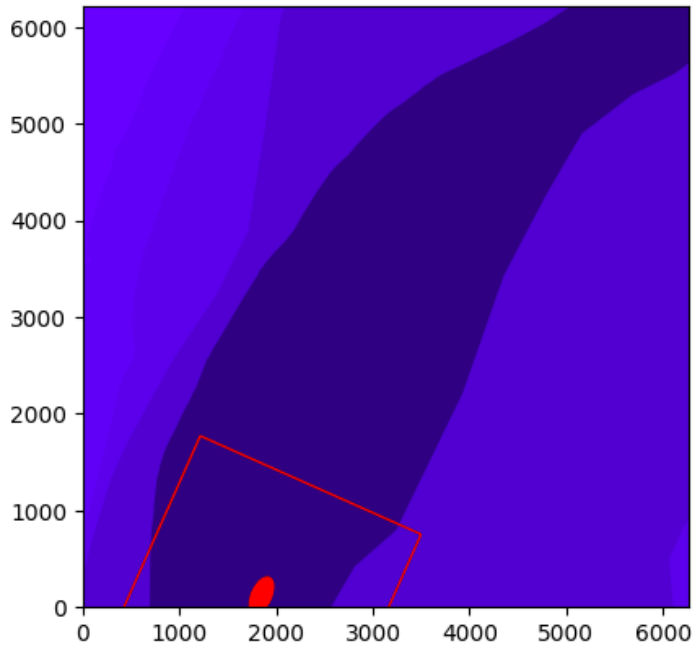
- Create trajectory metric.
- Start the implementation of IRL

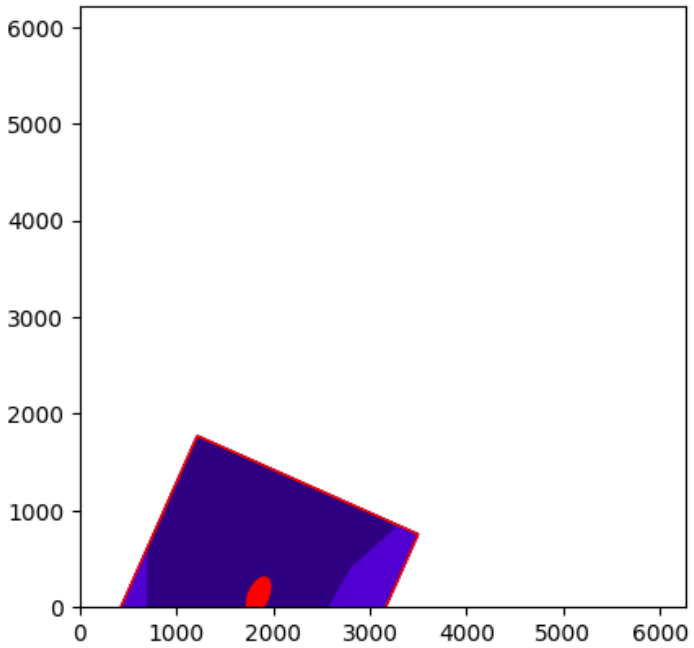
Comments:

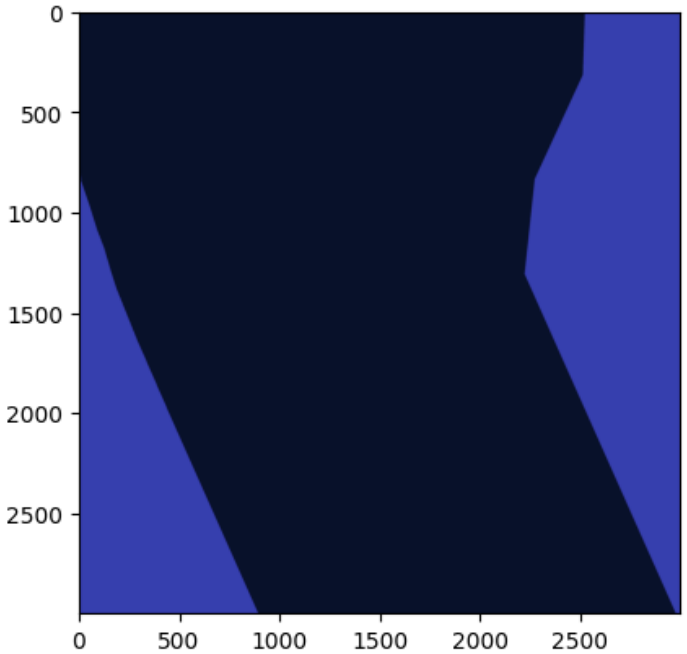
- along track error
- cross track error
- tracking the frames

Week 14 - 02-04-2024:

Croping using polygons and then conver to matrix, filling missing areas with nearest pixel value:

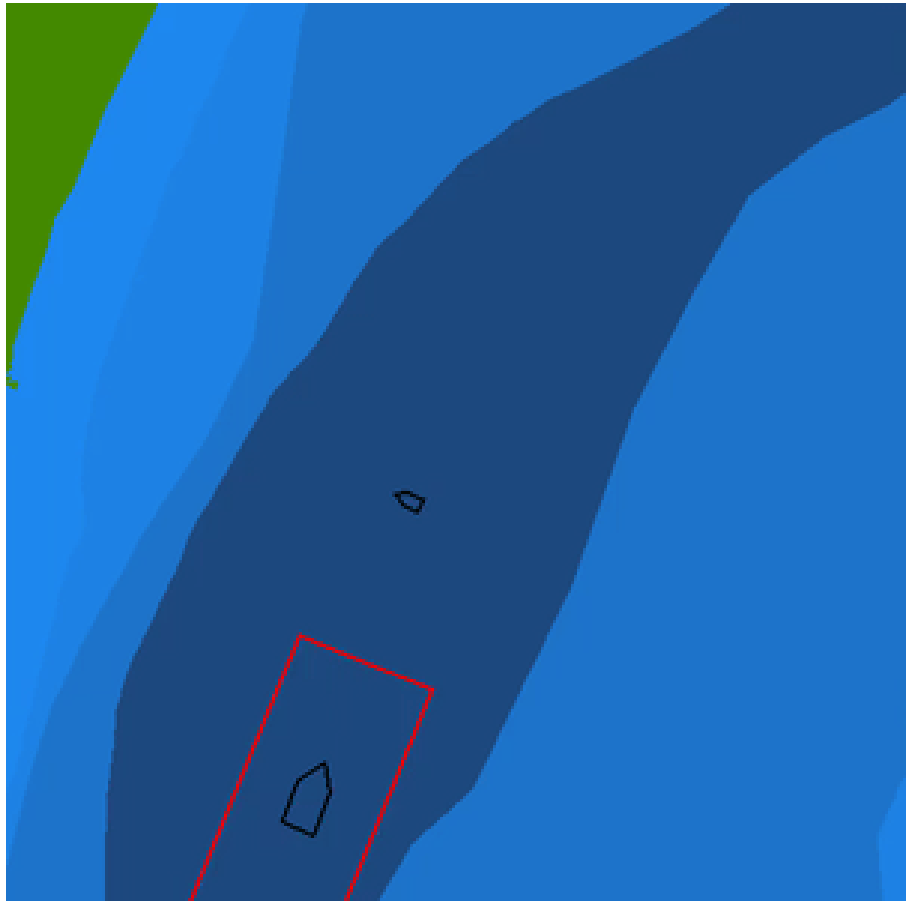






Pygame representation:

Renderization with pygame:

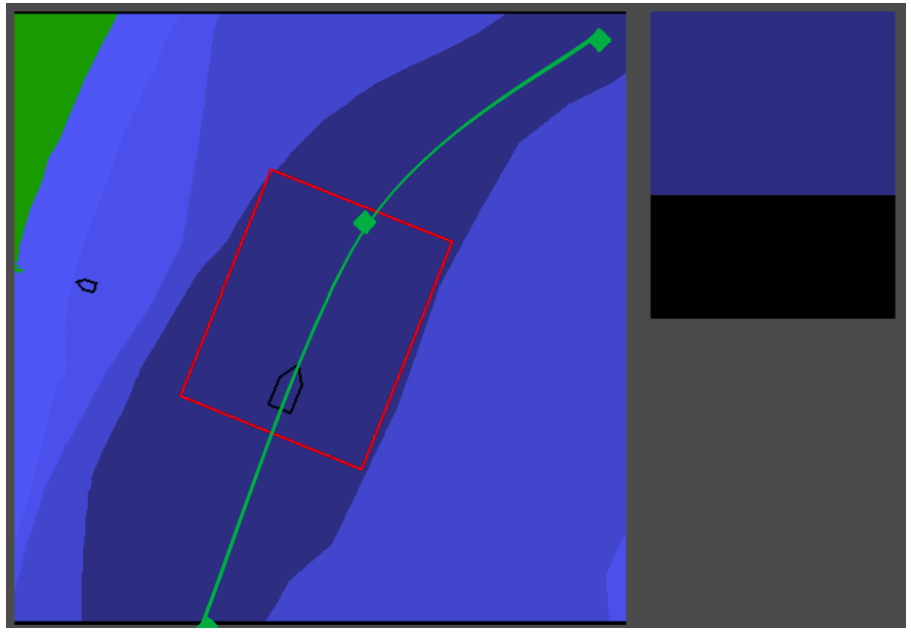


Next steps

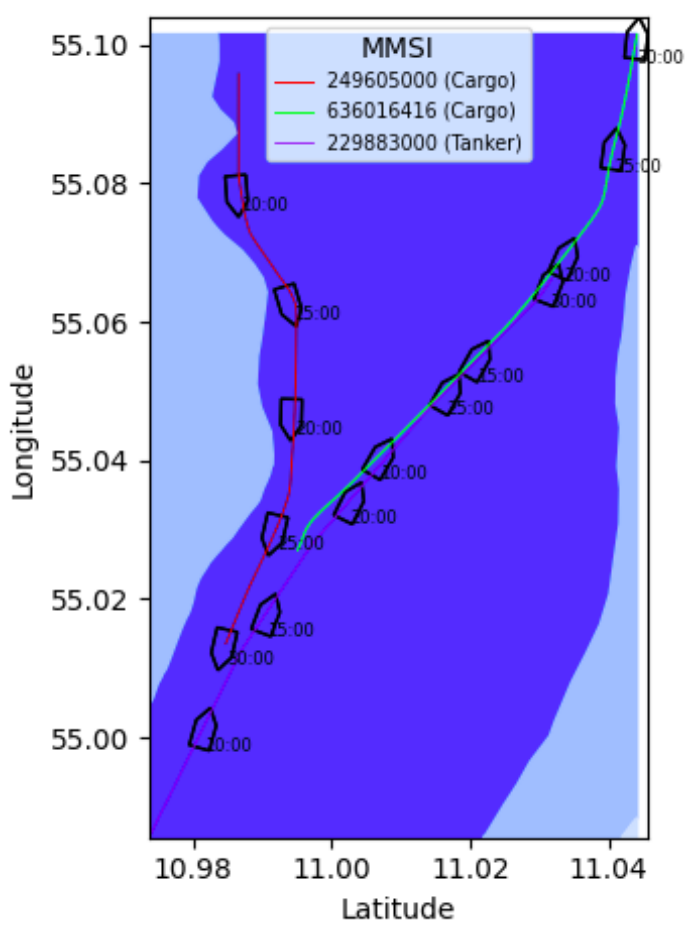
- Fix aspect ratio, some scenarios are not square
- Reading material:
  - DAgger: https://arxiv.org/pdf/1011.0686.pdf
  - IRL without RL: https://arxiv.org/pdf/2303.14623.pdf
  - Situational Awareness: https://backend.orbit.dtu.dk/ws/files/338331238/PhD_thesis_260_sider_-_76_farvede.pdf
- Create trajectory metric. **
- Start the implementation of IRL **

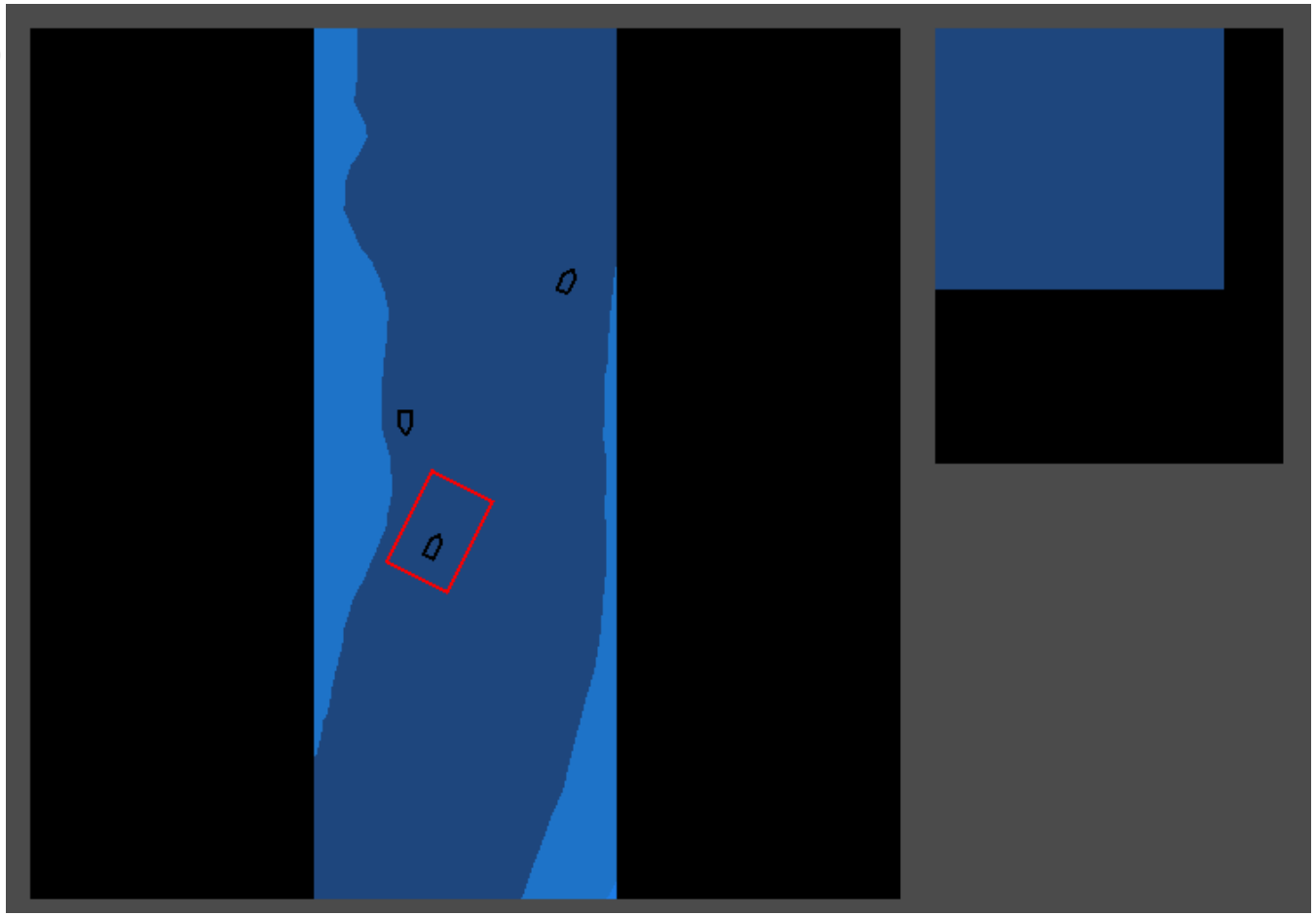
Week 16 - 16-04-2024:

- Observation matrix bug --> the polygons were not property rotated.
- sllib bug lat-long (scenario_to_vessel_states_and_lands_north_east).
- Reading material - GAIL: https://arxiv.org/pdf/1606.03476.pdf
- Report: https://www.overleaf.com/project/6605419761cb289c0b4f724a

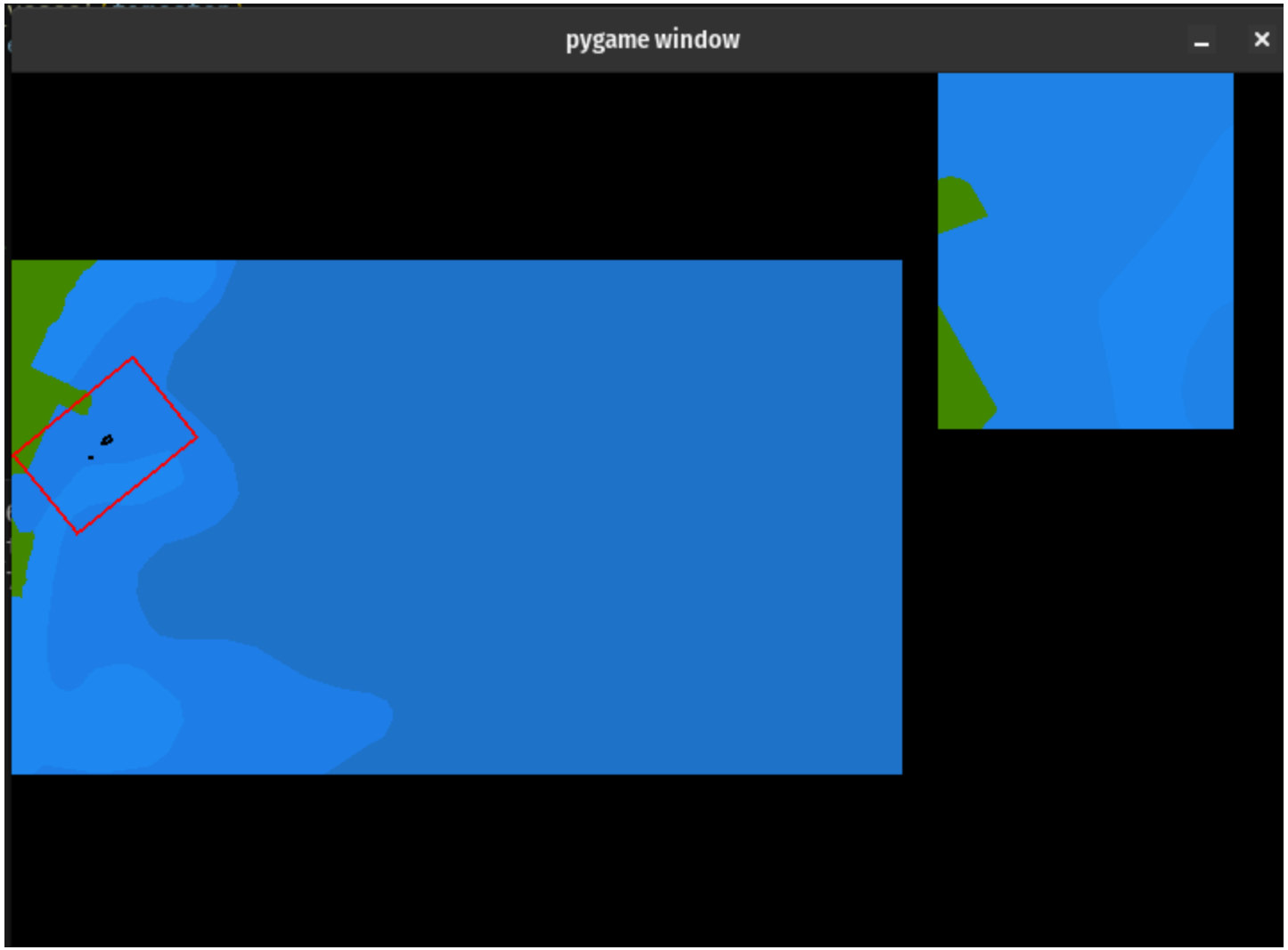


Follow established maritime routes:



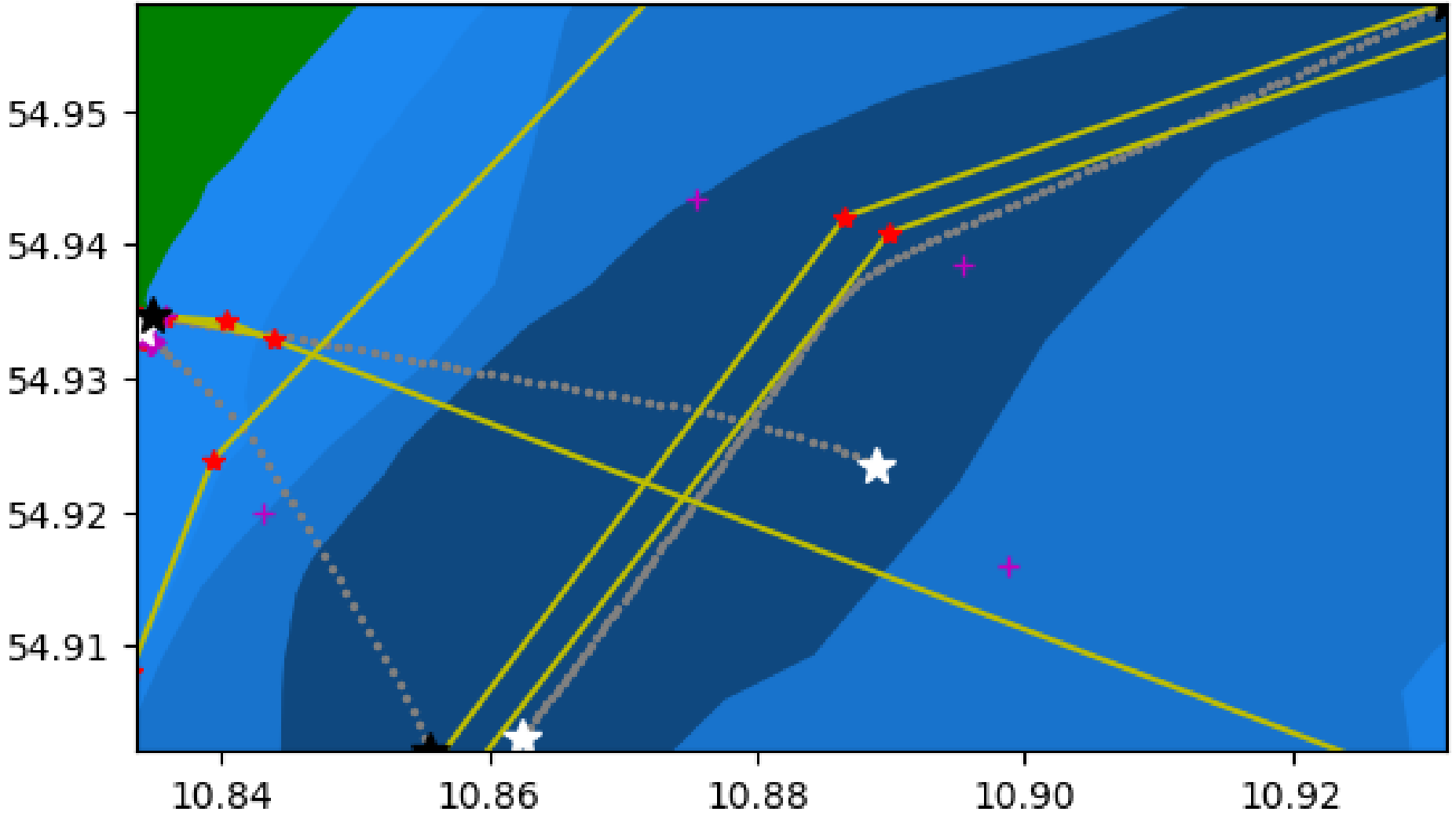


Week 19 - 07-05-2024:



overpy

```
api = overpy.Overpass()
```



Next steps:

- Use the overpy data (nodes and ways) directly in the observation matrix
- Handle the ships as a fixed list.
- Reading material - AIRL: https://arxiv.org/pdf/1710.11248