Semantic Segmentation for Visual SLAM Augmentation

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Problem Statement

To develop a model which can achieve:

- ❖ dynamic obstacle detection (vehicles, pedestrians)
- ❖ static object detection (signboards, streetlights, traffic lights)
- ❖ road area detection for emphasising the drivable boundaries

in order to filter features for Visual SLAM methods.

Introduction: Simultaneous Localisation and Mapping

- Given some kind of data (inertial measurements using wheel odometry, visual odometry, LiDAR point data) can a robot simultaneously:
  - Determine its location in the world?
  - Determine where objects in the world are relative to its location?
- First solved in the 80s by Extended (non-linear) Kalman Filters till late 2000s
- Current SOTA approaches: all based on observed data (e.g. SeqSLAM, S-PTAM, RTAB-MAP)

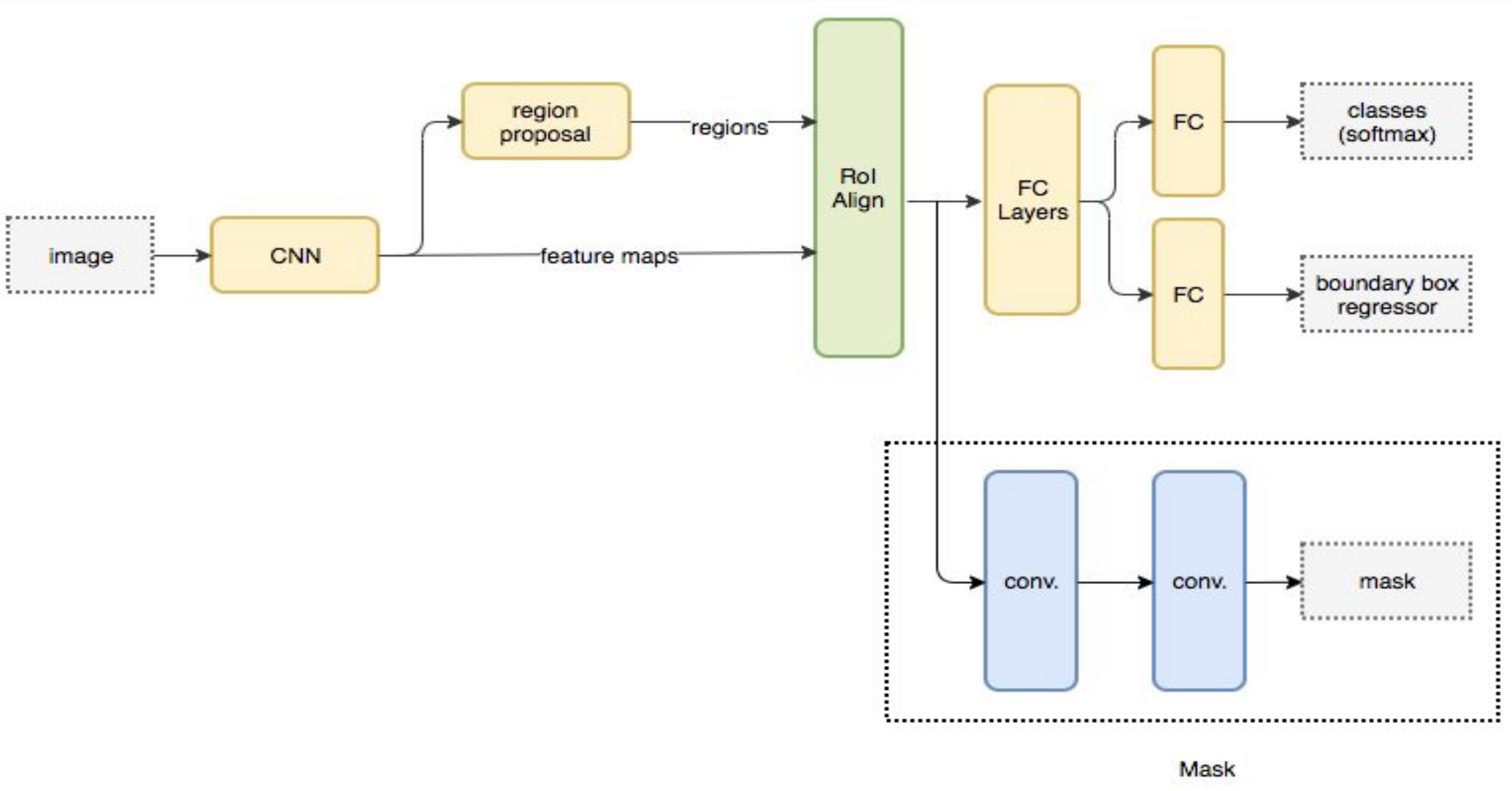
Introduction: Semantic Segmentation

- Process of labelling each pixel of an object in an image
- Also covers instance segmentation, where each instance is recognised as an individual object
- Architectures available include U-Net (for biomedical image segmentation) and Mask R-CNN (state of the art) based on R-CNN, Fast R-CNN and Faster R-CNN.

Architecture: Mask R-CNN

- Builds upon the Faster R-CNN object detection method
- Faster R-CNN first uses a ConvNet to extract feature maps from the images
- These feature maps are then passed through a Region Proposal Network (RPN) which returns the candidate bounding boxes
- Apply an RoI pooling layer on these candidate bounding boxes to bring all the candidates to the same size
- Finally, the proposals are passed to a fully connected layer to classify and output the bounding boxes for objects

Architecture: Mask R-CNN



Datasets

Microsoft Common Objects in Context (COCO)

- Object segmentation
- Mask-RCNN training started from weights pre-trained on COCO
- 1.5 million object instances with 330k images

IIITA Campus dataset

- 838 grayscale images
- Resolution: 1280 x 720
- Contains classes:

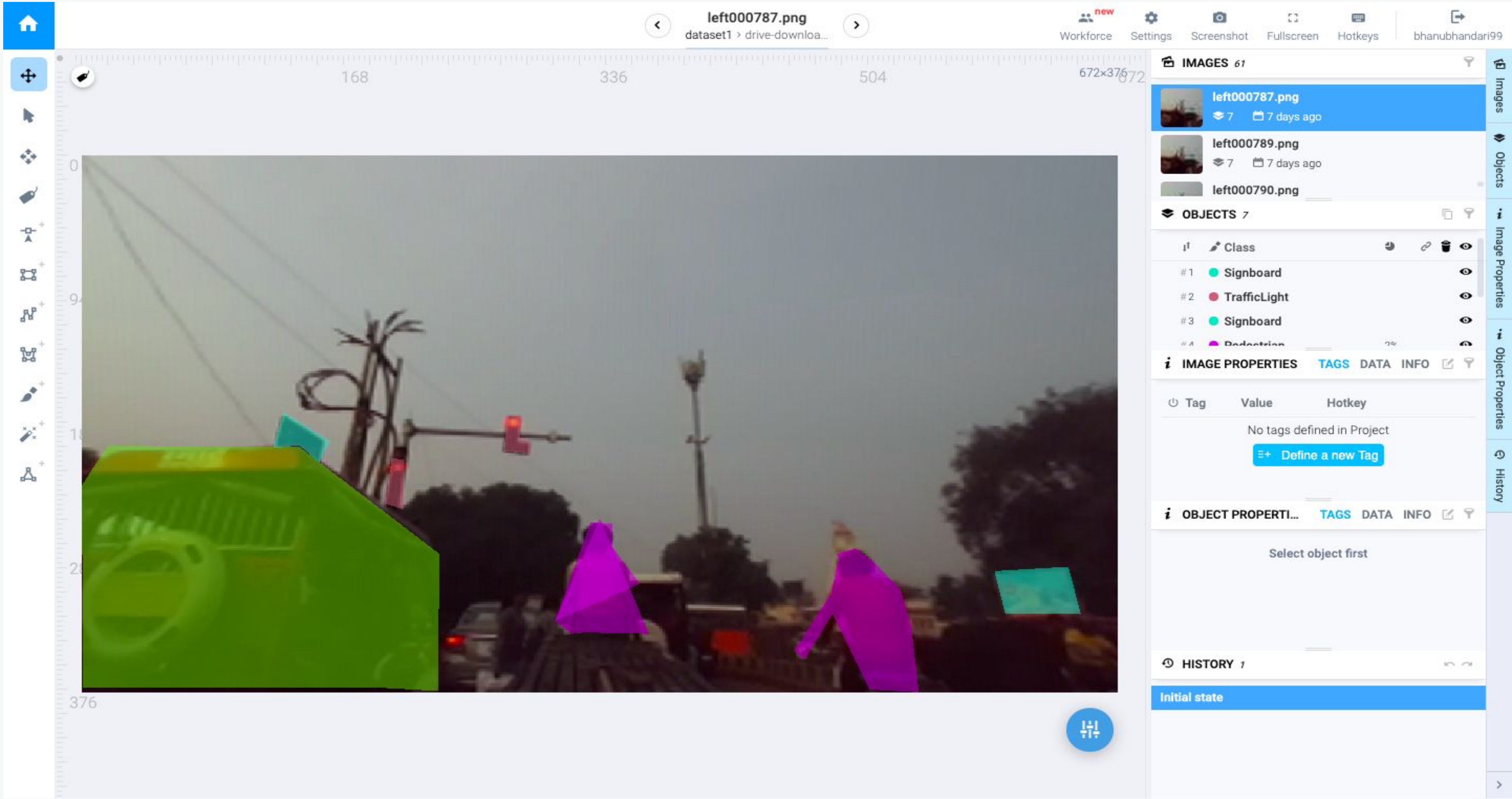
  street light, road, vehicle, pedestrian, sign board

Prayagraj Dataset

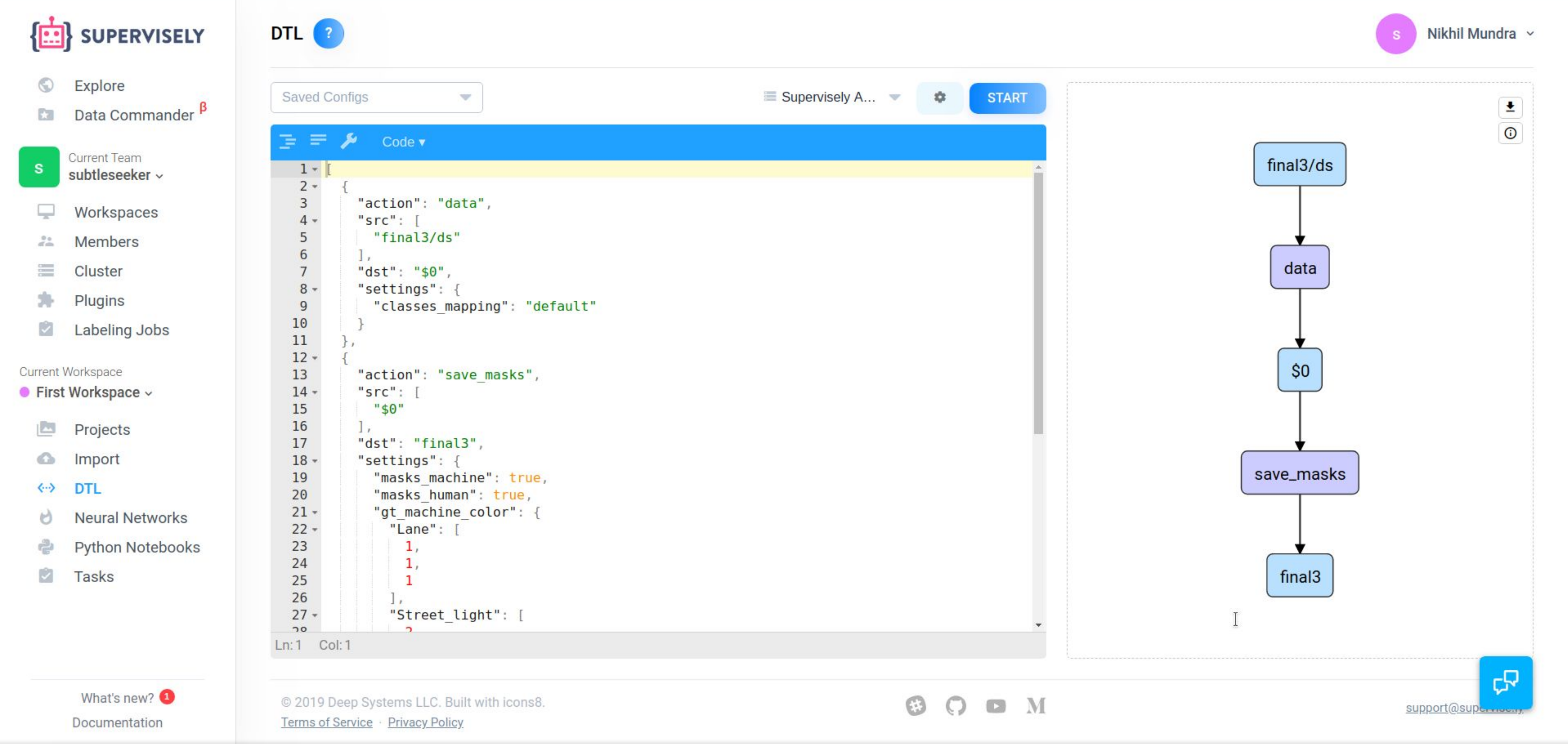
- 100 RGB images
- Resolution: 640 x 480
- Contains classes:

  streetlight, traffic light, road, vehicle, pedestrian, signboard

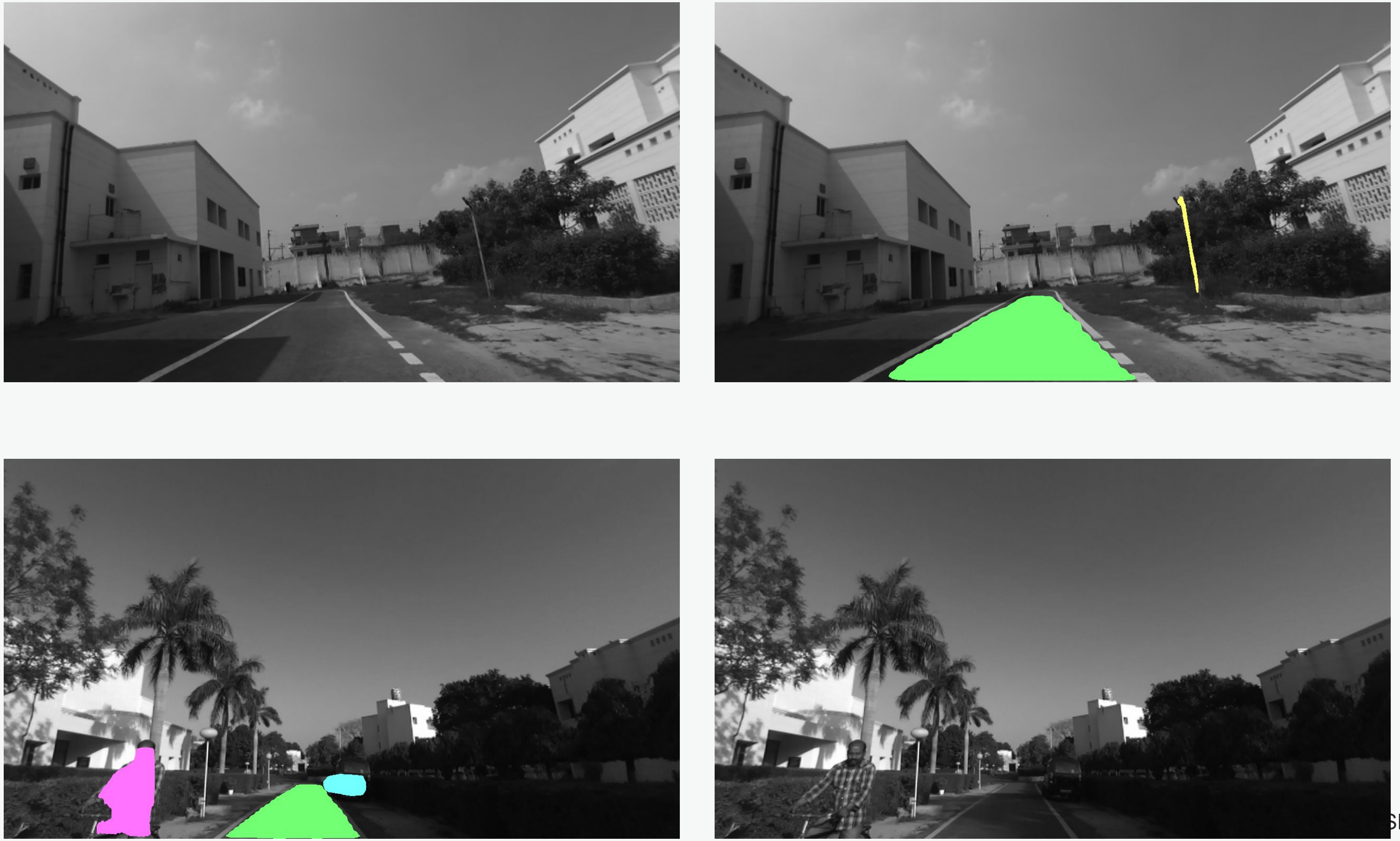
Semantic Segmentation Workflow: Preprocessing



Semantic Segmentation Workflow: DTL



Results: IIITA dataset



Results: IIITA dataset

Class	IoU score
Road	86.2%
Pedestrian	1.23% (~absent)
Vehicle	6.14%
Signboards	5.36%
Street Light	9.06%

Average IOU score = 84%

Results: Prayagraj dataset

Results: Prayagraj dataset

Class	IoU score
Road	86.2%
Pedestrian	43.82%
Vehicle	82.15%
Signboards	7.05%
Street Light	18.22%
Traffic Light	36.16%

Average IOU score = 73%

Future Scope

- Integrate the above framework with an existing Visual SLAM method and evaluate performance improvements
- Use the network and extrapolate depth information from stereo cameras, thus leading to geographical coordinates of objects and the scene