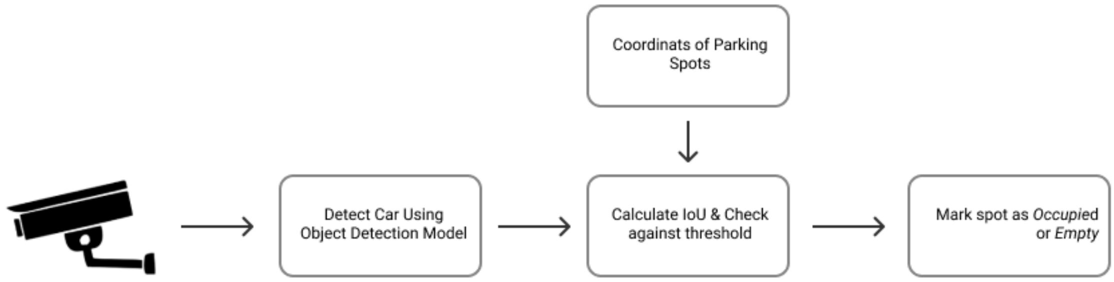
AI Assistance In Video Analytics Of Parking Plot

1. Problem Statement

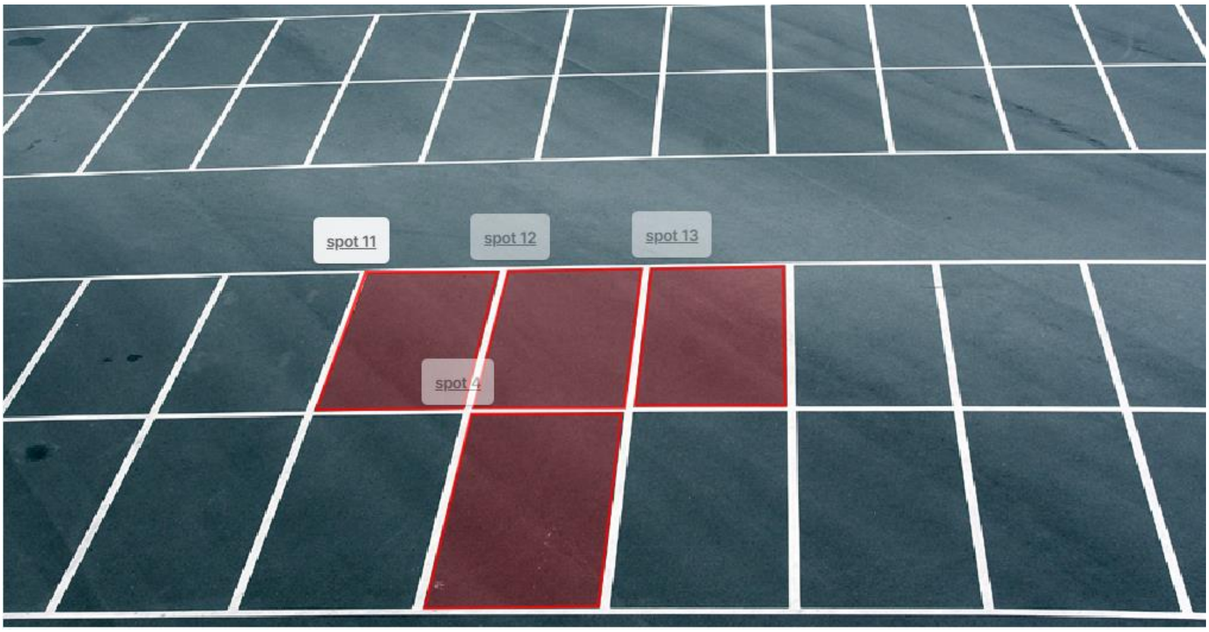
Managing a parking lot is cumbersome, more so for commercial spaces involved in logistics operations. The central task of the system is to detect the occupancy of the parking spots. Along with these, there are other auxiliary tasks associated such as vehicles lying idle for too long or not being parked properly, predicting occupancy of spots, and monitoring human activity in the area.

2. Proposed Approach



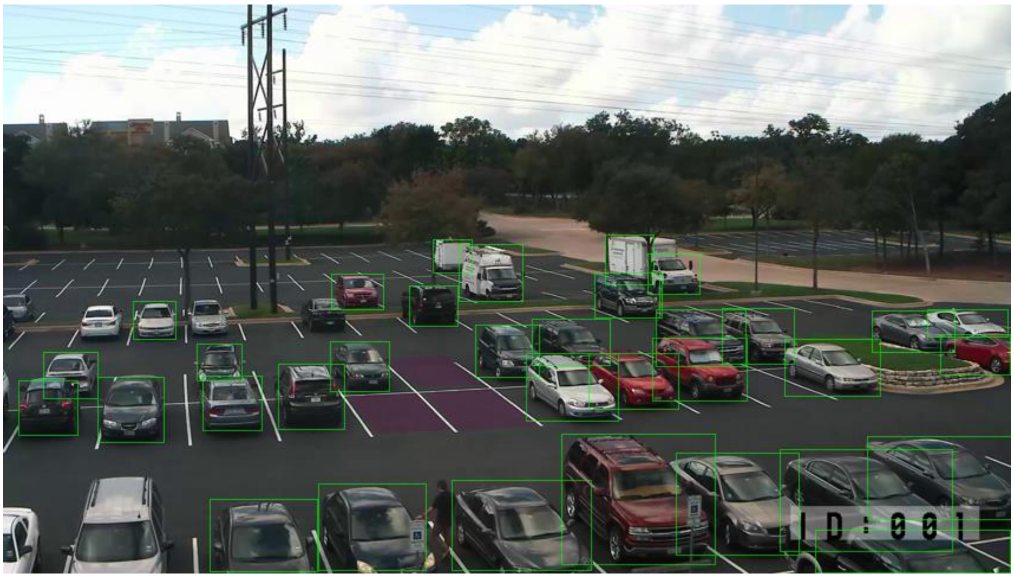
2.1 Detecting Parking Spots

On first thought, detecting the parking spot boundary in real-time seems like a good idea but the cameras are going to be stationary so simply detecting the spot boundaries once and/or manually labeling them would be better. The problem with line detection approaches is that depending on the lighting conditions and wearing paint they become unreliable. Not to mention that the vehicles can cover them. Simply marking the spot once is much more robust. We can use image labeling tools like the Universal Data Tool, to mark the individual parking spots as illustrated in the image below.



2.2. Detecting Vehicles

We can train a custom detection or instance segmentation model such as the state-of-the-art YOLO or YOLOACT on images/videos of vehicles captured by the cameras in our parking lot to ensure a model with maximum fidelity.



Comparing the two approaches:

1. Using a simple object detection model to find the bounding box of vehicles.

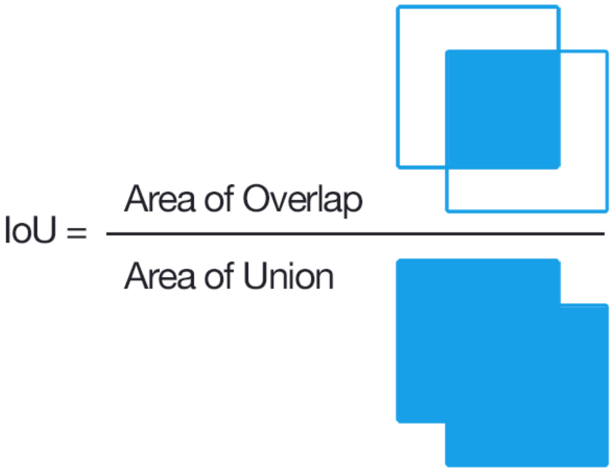
   Drawback – slightly inaccurate because bounding boxes tend to have a lot of empty space.

2. Using an instance segmentation model to create a pixel-wise mask for each vehicle.

Drawback – harder to train, higher computational requirements which make them slow.

2.4. Deducing Occupancy

Using the vehicles' bounding box or pixel-wise mask we decide occupancy by calculating the IoU metric with nearby parking spots.



2.5. Detecting Deviations

2.5.1. Wrongly Parked Vehicles

Using the detected vehicle coordinates and parking spot coordinates we can crop the image to obtain a small Region-of-Interest (ROI) and use a custom classification model to detect whether the vehicles are parked incorrectly. Alternatively, we can leverage the visible parking spot corners and the edges of vehicles' masks to deduce whether it's parked correctly using some coordinate geometry.

2.5.2. Idle Vehicles

We can choose a threshold for the maximum allowed parking time. Whenever a vehicle is parked a timer will start, as soon as the timer crosses this threshold an alert will be raised.

2.6 Predicting Occupancy

Using the data we collect from the cameras we can create a time-series model for predicting the occupancy of individual parking spots.

3. Challenges/Issues Faced

- Vehicles may block the view of the camera.
- Images/videos captured in the night or during rainy/overcast conditions may cause false detections.

References

[1] https://stackoverflow.com/questions/45322630/how-to-detect-lines-in-opencv

[2] https://medium.com/the-research-nest/parking-space-detection-using-deep-learning-9fc99a63875e

[3] https://towardsdatascience.com/parking-spot-detection-using-mask-rcnn-cb2db74a0ff5

[4] https://www.immersivelimit.com/tutorials/train-yolact-with-a-custom-coco-dataset

[5] https://universaldatatool.com/app/

[6] https://agile-giss.copernicus.org/articles/2/9/2021/agile-giss-2-9-2021.pdf