Task 1 - Image Volume Estimation

Team 45

Incoming Shipment > Scanning > RGB + Depth Map > Shape Detection > Volume Estimation > Update database

Setup: Acrylic sheet with Depth Camera with a **mock Conveyor Belt** mechanism, supported on the sides

Shapes

Object Recognition U2-Net for the Object Recognition purpose

Object Height Calculation

$$\text{Avg BG Depth} = \frac{1}{n} \sum_{(i,j)\epsilon \text{ image}} \text{Depth}(i,j) \qquad \text{Obj Height} = \text{Avg BG Depth} - \text{Min Depth}$$

Cross Sectional Area -- Similarity Scaling and Pixel Enumeration

$$\text{Similarity} = \frac{\text{Min Depth}}{\text{Avg BG Depth}} \qquad \text{Cross-Sec Ar.} = \text{Pixel per Metric} * \text{Similarity}^2 * \text{Pixel Count}$$

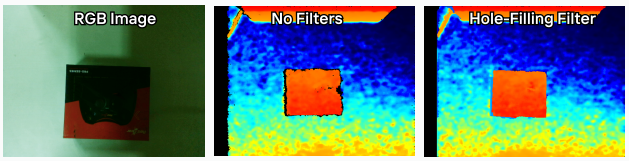
Shape Classification Neural Network for classifying 2D triangle, circle, square faces of a 3D object

Key Advantages:

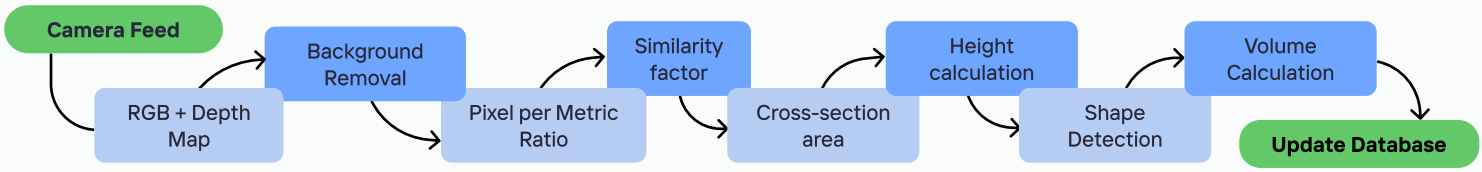
Scalable upwards in industrial setting using the same sensors.
Can handle **moving objects on a conveyor belt** supply.
No manual intervention required between different objects.
Faster and more accurate than Deep Learning based methods. No point cloud generation required.
Dead weight: Use a load sensor interfaced with Arduino to get the dead weight.

Innovation & Accuracy

	TIME TAKEN TO CALCULATE VOLUME	ERROR %
Depth-Based Method	1.5 sec	2%
Point Cloud Method	16 sec	18%



Flowchart



Task 2 - CVRMPD

Geocoding > Distance Matrix > Clustering > Routes > Bin Packing > Dynamic Pickups > Reroutes

Routing using OR tools as the foundation with additional innovations for **robustness**, **scalability** and **flexibility.**

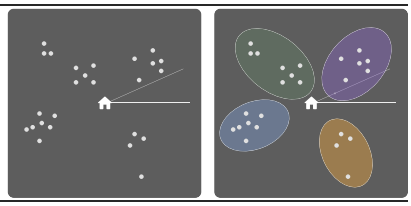
Dynamic Pickups efficent rerouting of orders using previous routes combined with local search meta-heuristics.

Clustering novel iterative sweep algorithm to find spatial clusters

ROUTE FORMATION FOR 2000 NODES

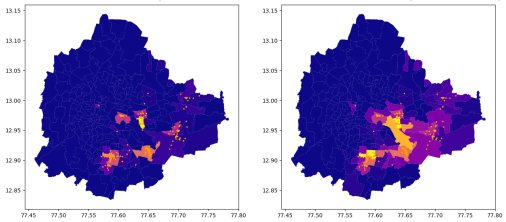
Without Clustering	300 sec
With Clustering	60 sec

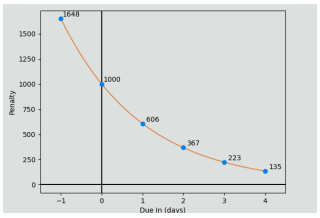
Re-routing also takes only 60 seconds in our solution.



Penalty

A disjunction is a variable that the solver uses to decide whether to include a given location in the solution. Higher the penalty, lower the chances of the order to be carry-forwarded to the next day. This way we aim to maximize on time deliveries.





$$P_{\text{order\_density}} = e^{7p}$$

$$P_{EDD} = 1000 * e^{-\frac{\text{Due In (days)}}{2}}$$

$$P_{\text{dropping}} = P_{EDD} + P_{\text{order\_density}}$$

Flexibility our solution allows room for flexibility for the inclusion of contextual constraints and variables

Balance Vehicle Utilization prioritizes quick delivery by maximizing load distribution among all vehicles.

Time Windows adds a temporal dimension to the routing problem to incorporate EDTs & availability windows.

Weather Conditions utilizes area wise weather conditions to penalize routes through areas with bad weather.

Service Time includes the flexibility to set the service time for each order.

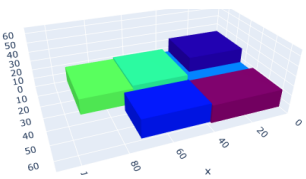
Set Maximum Route Distance And Travel Time

Bin Packing

The bin packing problem is solved to help the driver pack the bag.

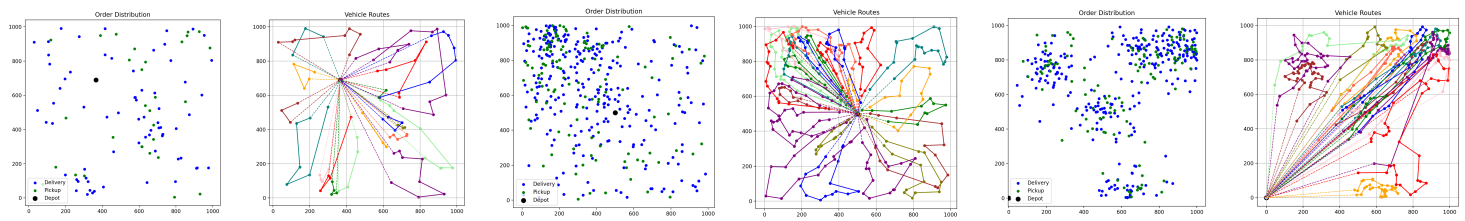
%Efficiency

90 to **95**



Benchmarks

Solution was benchmarked against nodes ranging from **100 to 1000 nodes**. Results obtained in **4-200 seconds** with optimality gaps in range **4-12%**



Uniform Distribution | Dense and Sparse Distribution | Clustered & Corner Depot Distribution