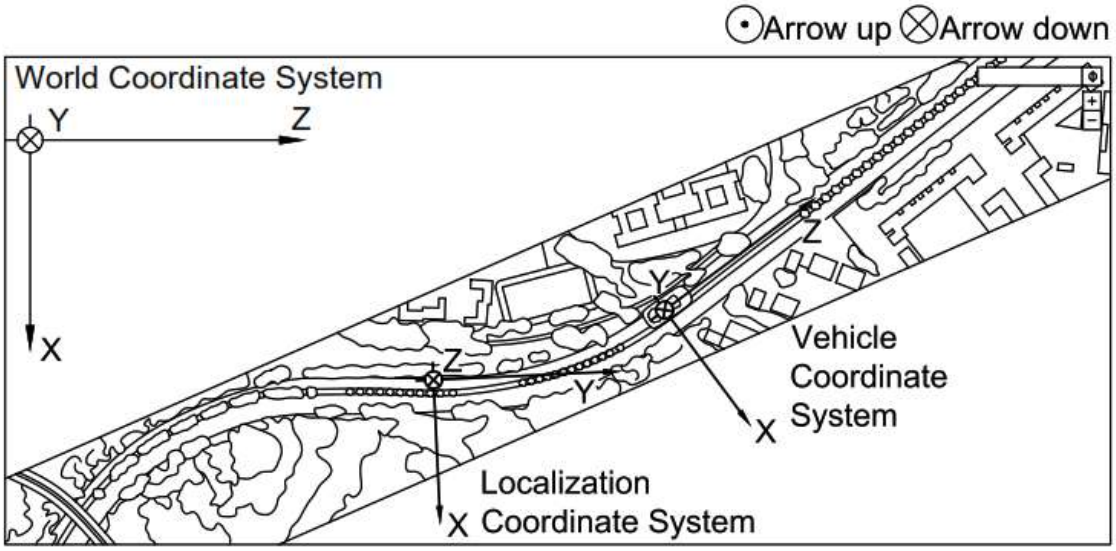

Arrow up
Arrow down
World Coordinate System
Y
Z
X
Z
Y
Vehicle
Coordinate
System
X
Z
Y
X
Localization
Coordinate System

FIG. 1

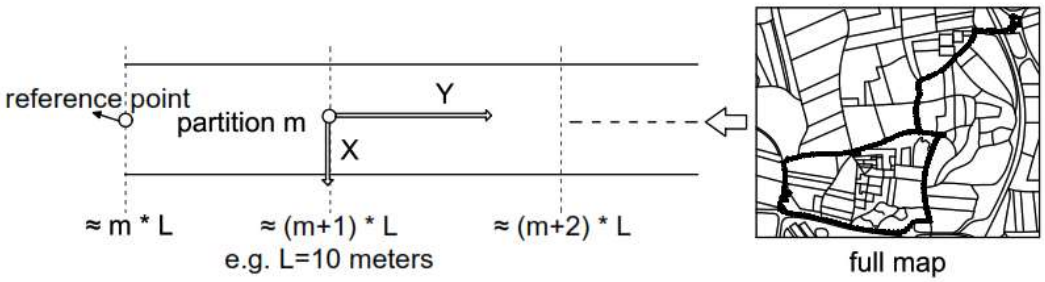

reference point
partition m
Y
X
≈ m * L
≈ (m+1) * L
e.g. L=10 meters
≈ (m+2) * L
full map

FIG. 2

7x ARS430 (4 to the rear, 3 to the front)

1 x Velodyne VLP32. Slightly tilted to the front, which results in a blind spot behind the car

1 x Blackfly front camera next to VLP32

4 x SVC215/220 for 360d view to all sides

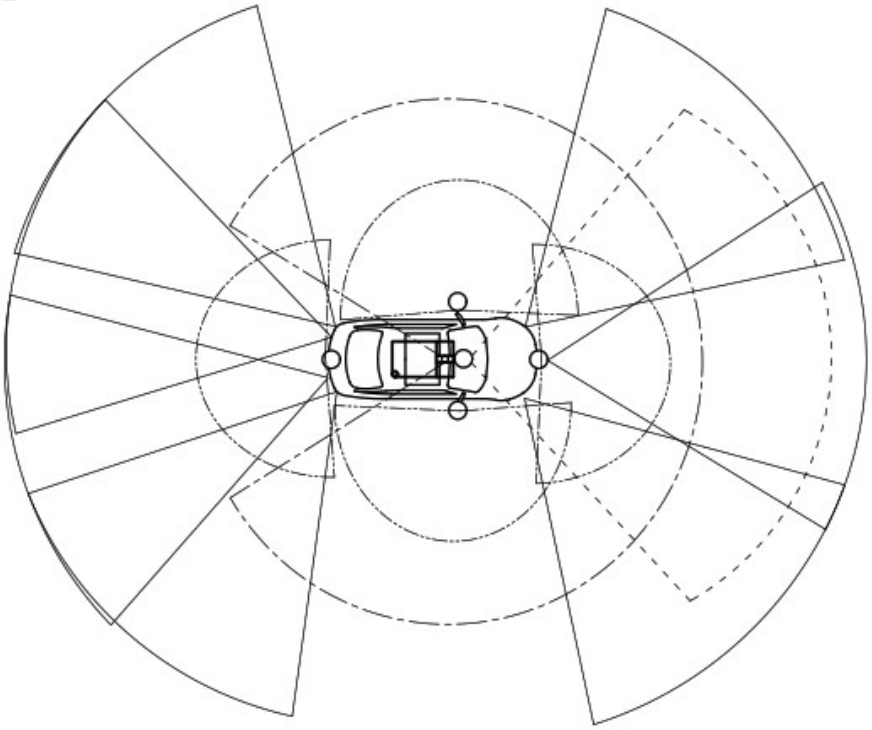


FIG. 3

1 x Blackfly front camera next to VLP32

1 x Velodyne VLP32

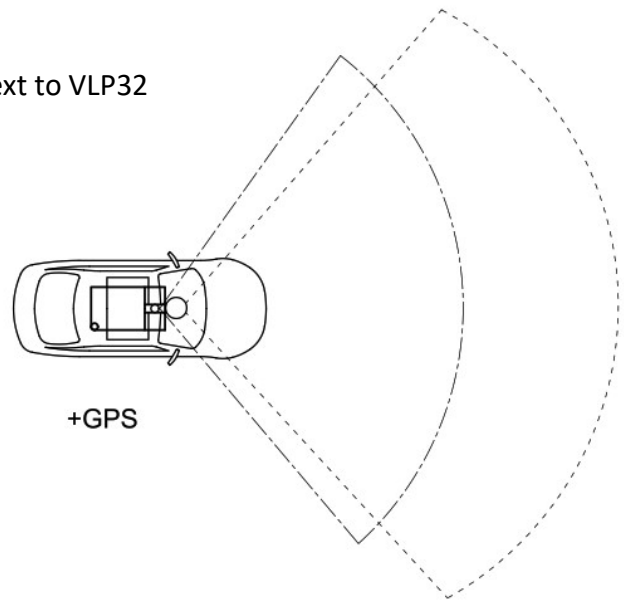
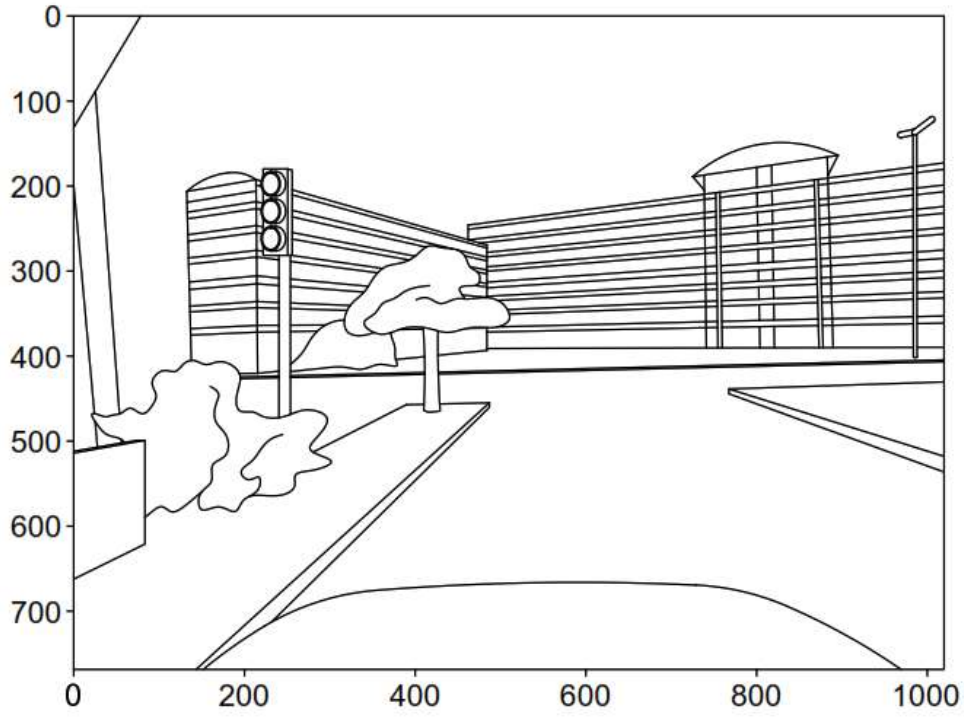
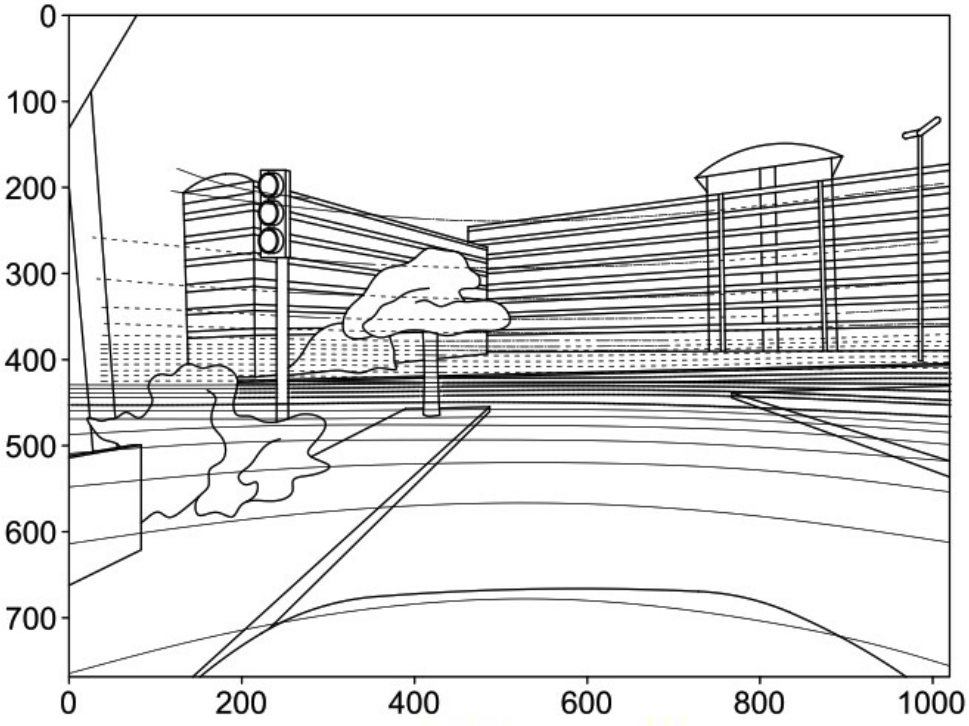


FIG. 4



(a) Original image captured by the front camera.



(b) Mapping of the LiDAR points.

FIG. 5

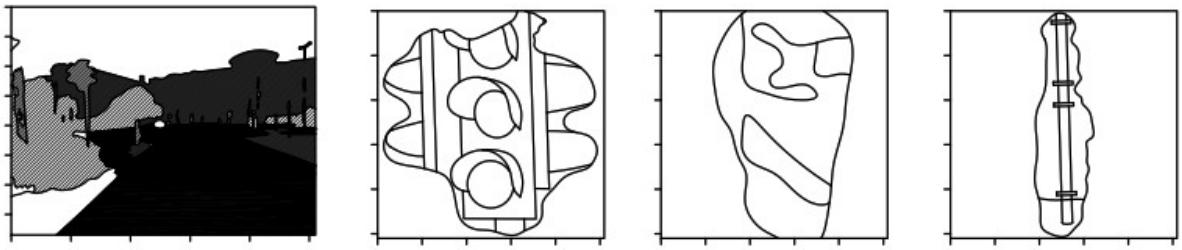


FIG. 6

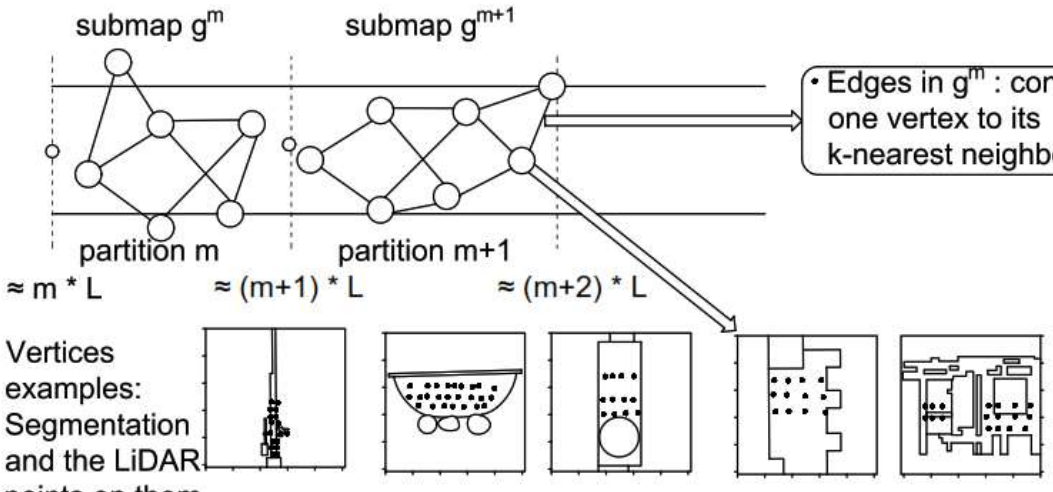

submap g^m
submap g^{m+1}
• Edges in g^m : connect one vertex to its k-nearest neighbors.
partition m
partition m+1
≈ m * L
≈ (m+1) * L
≈ (m+2) * L
Vertices examples: Segmentation and the LiDAR points on them.

FIG. 7

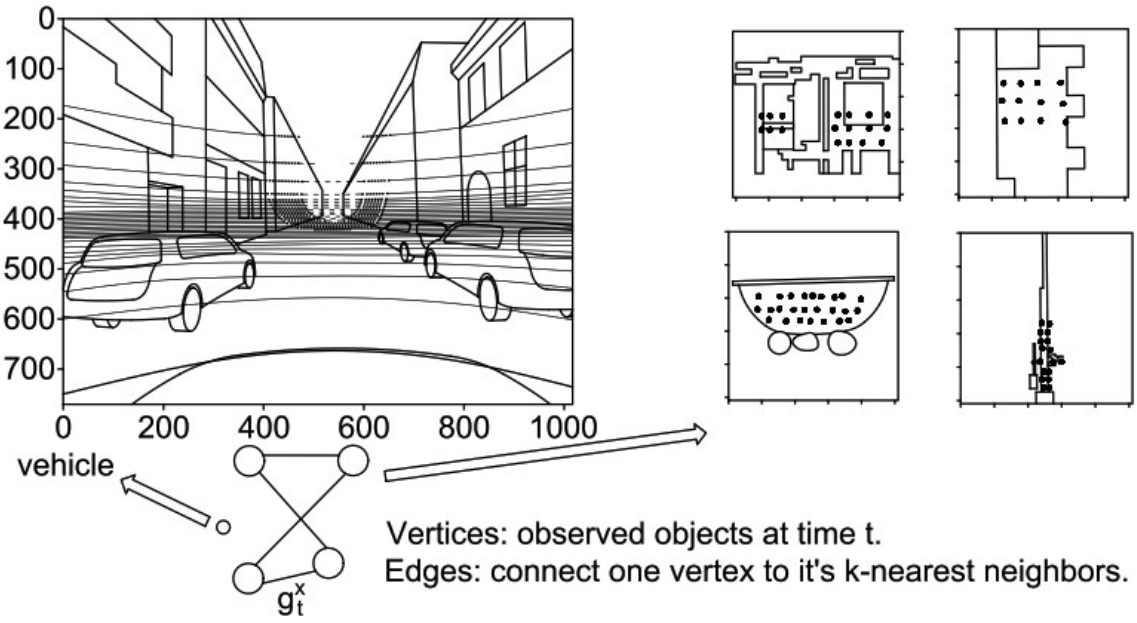

0
100
200
300
400
500
600
700
0
200
400
600
800
1000
vehicle
g_t^x
Vertices: observed objects at time t.
Edges: connect one vertex to it's k-nearest neighbors.

FIG. 8

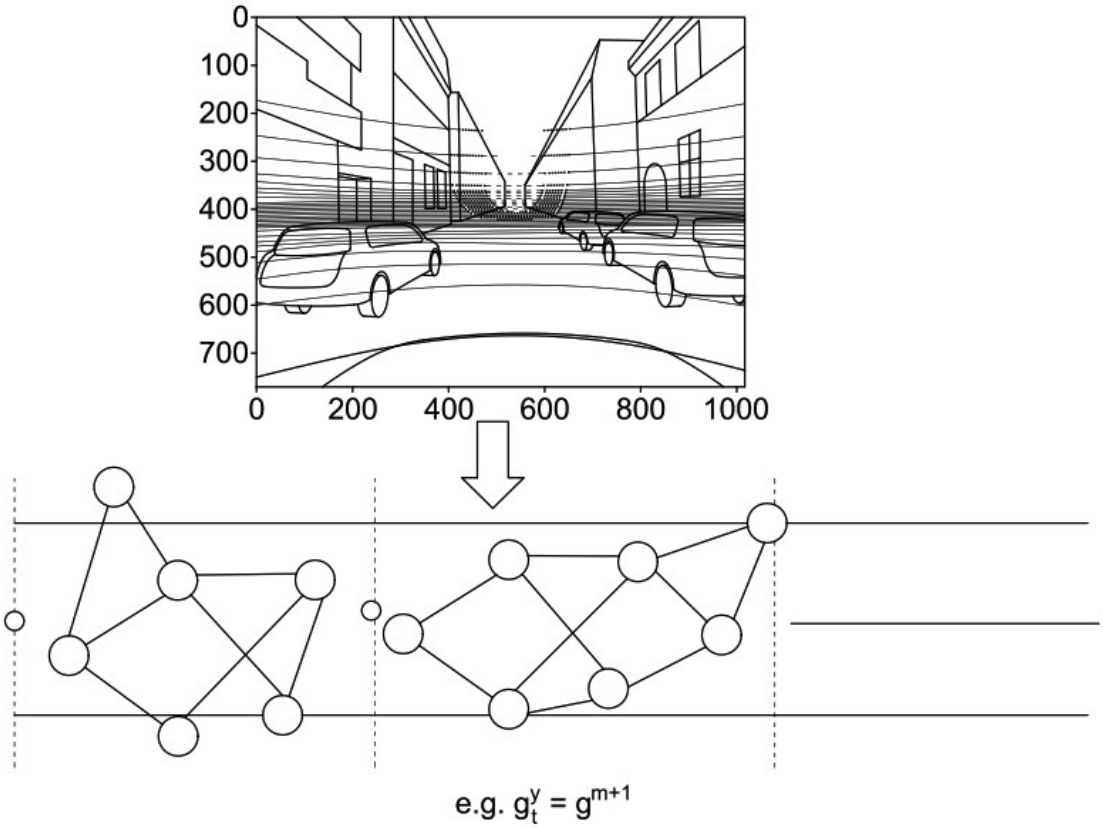

0
100
200
300
400
500
600
700
0
200
400
600
800
1000
e.g. $g_t^y = g^{m+1}$

FIG. 9

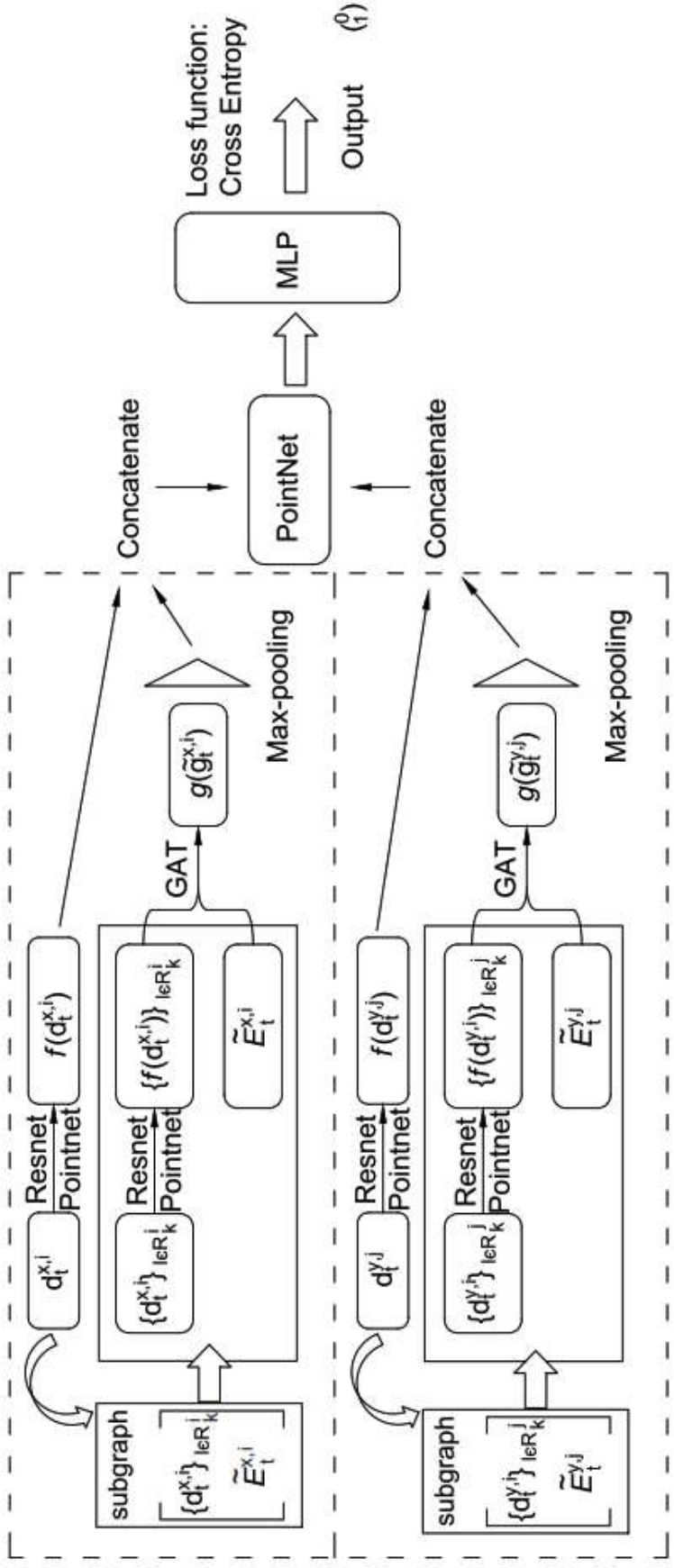

subgraph
Resnet
Pointnet
GAT
Max-pooling
Concatenate
PointNet
MLP
Loss function:
Cross Entropy
Output

FIG. 10

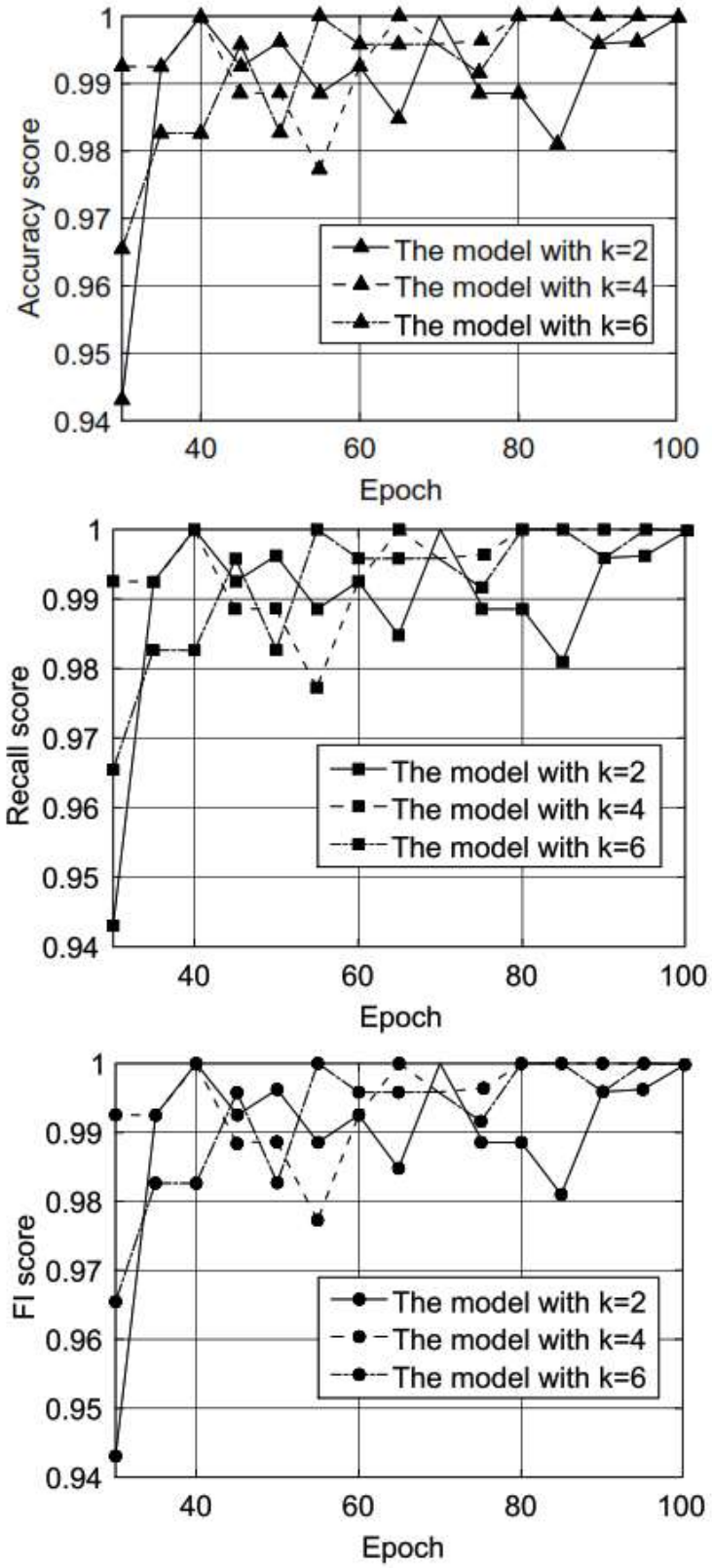

Accuracy score
1
0.99
0.98
0.97
0.96
0.95
0.94
40
60
80
100
Epoch
The model with k=2
The model with k=4
The model with k=6
Recall score
1
0.99
0.98
0.97
0.96
0.95
0.94
40
60
80
100
Epoch
The model with k=2
The model with k=4
The model with k=6
FI score
1
0.99
0.98
0.97
0.96
0.95
0.94
40
60
80
100
Epoch
The model with k=2
The model with k=4
The model with k=6

FIG. 11

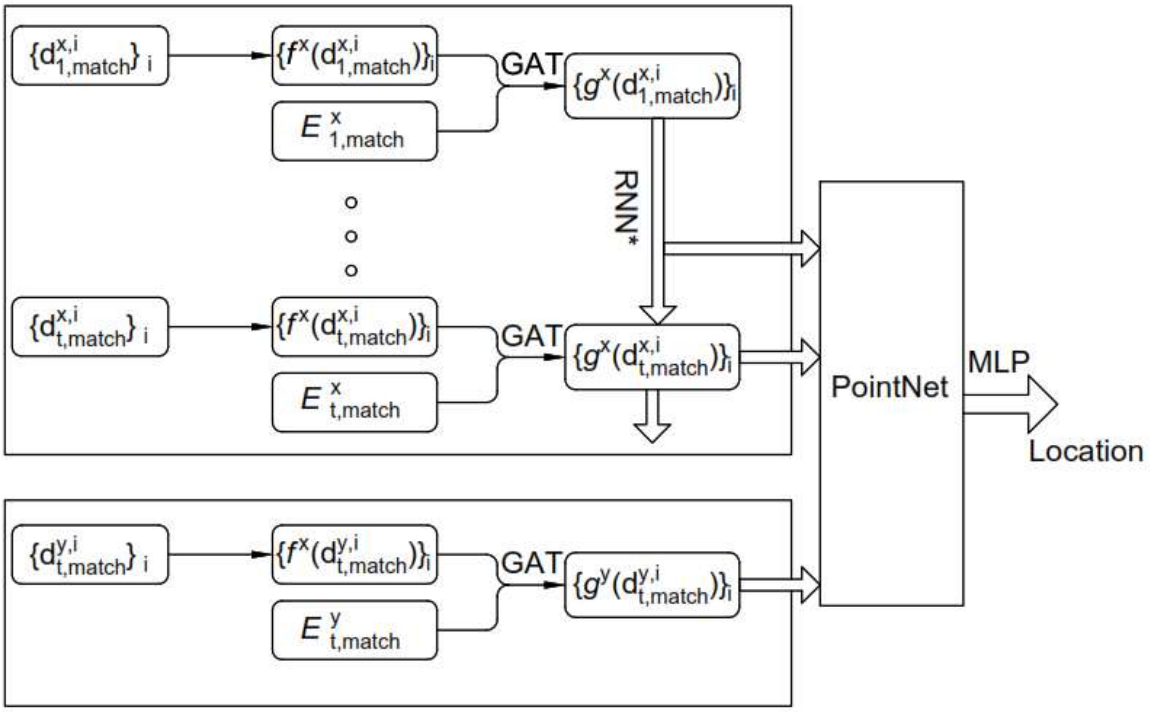

GAT
GAT
GAT
RNN*
PointNet
MLP
Location

FIG. 12

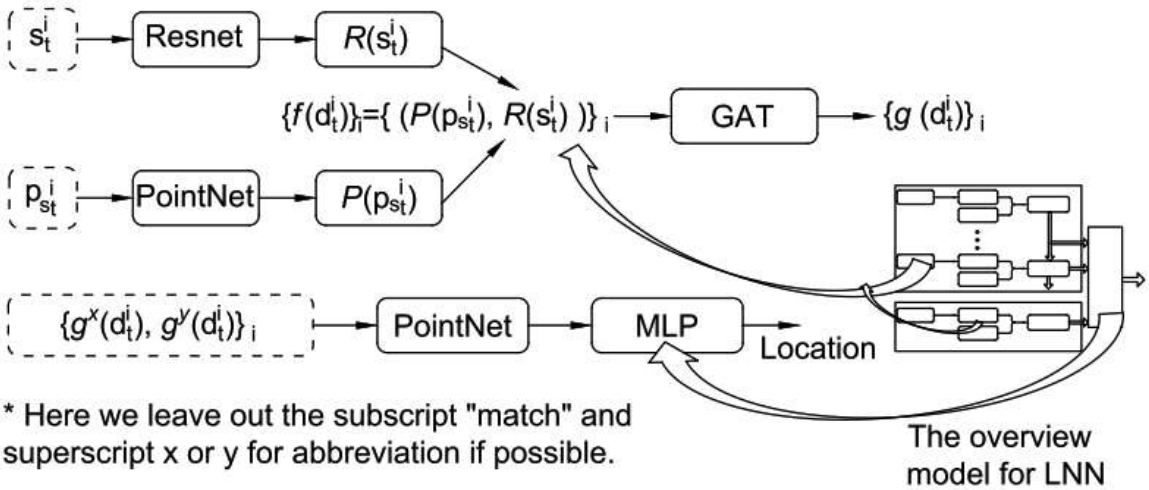
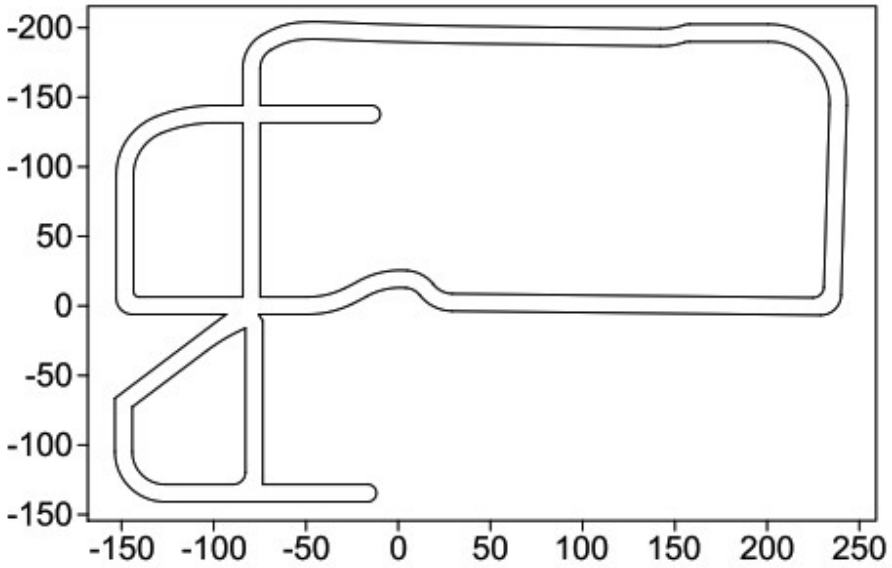
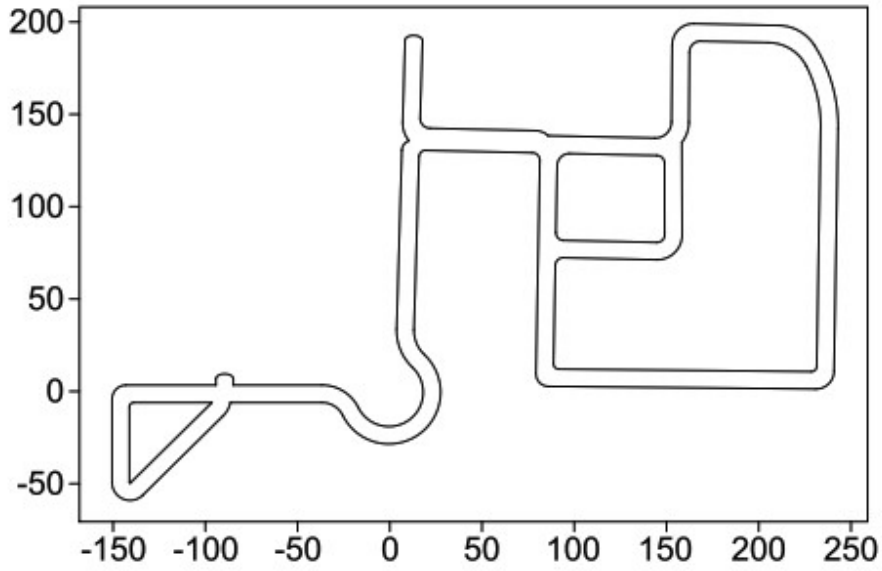

Resnet
PointNet
GAT
PointNet
MLP
Location
* Here we leave out the subscript "match" and superscript x or y for abbreviation if possible.
The overview model for LNN

FIG. 13



(a) Vehicle movement trace in CARLA dataset 1.



(b) Vehicle movement trace in CARLA dataset 2.

FIG. 14

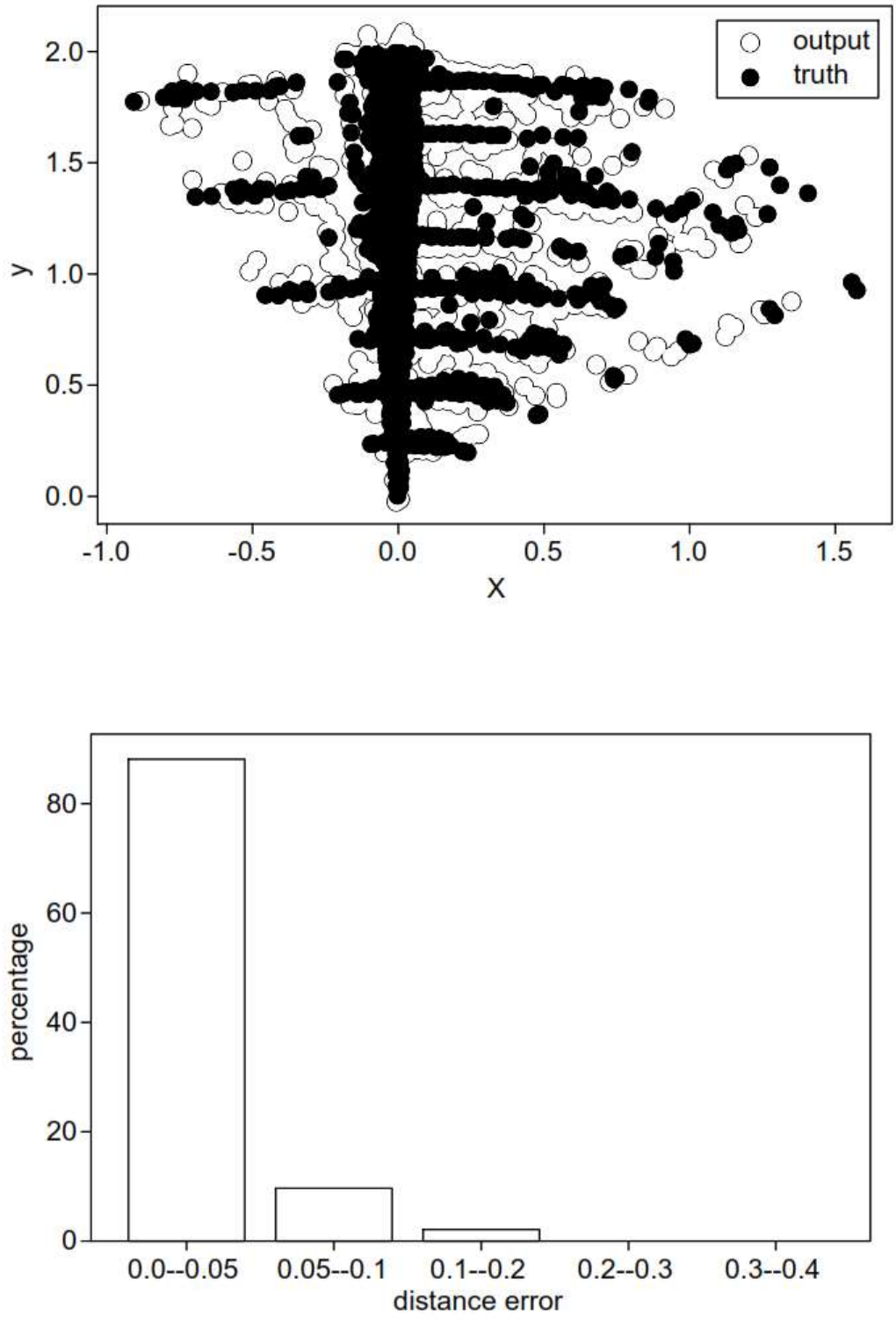

output
truth
2.0
1.5
1.0
0.5
0.0
y
-1.0
-0.5
0.0
0.5
1.0
1.5
X
80
60
40
20
0
percentage
0.0--0.05
0.05--0.1
0.1--0.2
0.2--0.3
0.3--0.4
distance error

FIG. 15

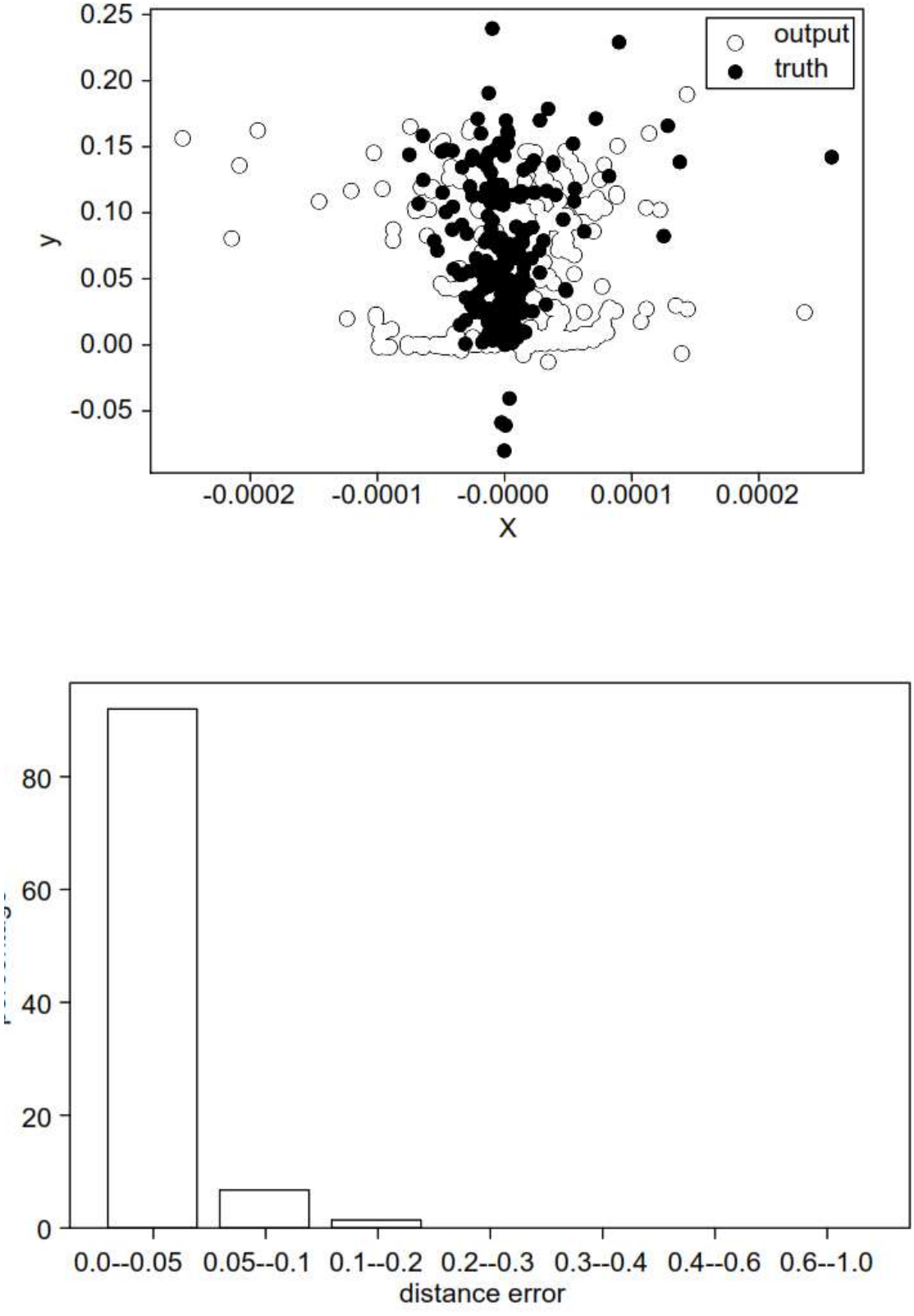

0.25
0.20
0.15
0.10
0.05
0.00
-0.05
y
output
truth
-0.0002
-0.0001
-0.0000
0.0001
0.0002
X
80
60
40
20
0
0.0--0.05
0.05--0.1
0.1--0.2
0.2--0.3
0.3--0.4
0.4--0.6
0.6--1.0
distance error

FIG. 16