HawkEye: Through Fog High Resolution Imaging Using Millimeter Wave Radar

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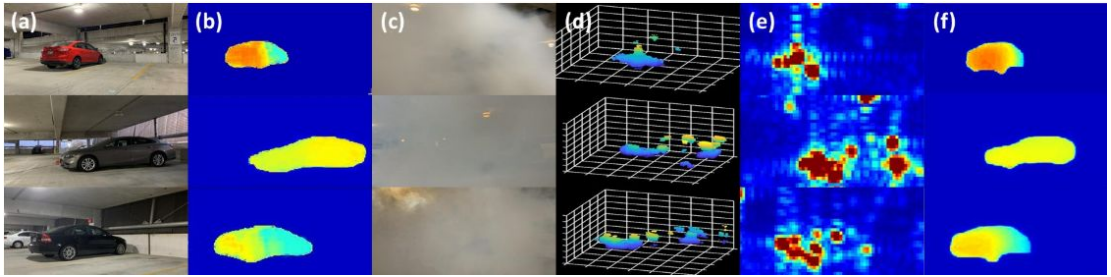
ECSE-6560 Modern Communication Systems

Background

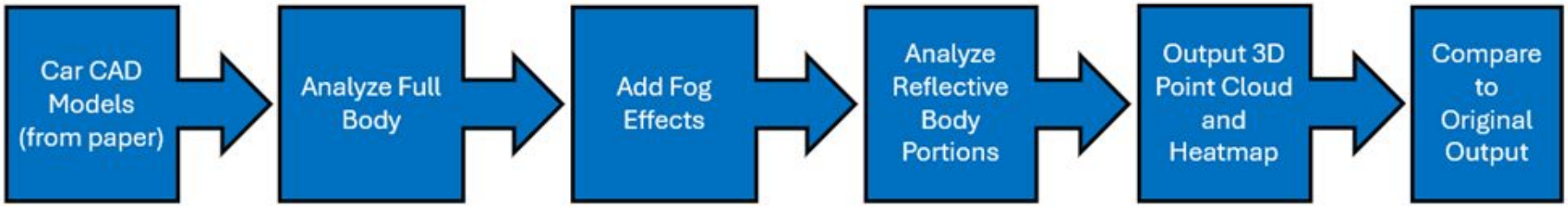
- Alternative sensor to LIDAR and optical - MM wave radar
- Pro: Can penetrate dense fog
- Con: Low resolution, specularity, and sensitive to noise
- cGAN architecture to recover high frequency shapes
- Data synthesizer to create training data for deep learning
- Our focus is on the data synthesizer steps



Goal and Basic Overview

(1) To understand and use the paper's process given their synthesizer.

(2) To independently recreate the data synthesizer portion and generate similar intermediate and final maps.



Used:

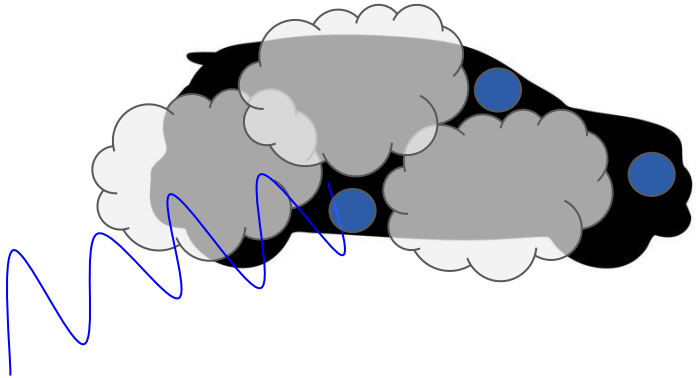
- Paper's GitHub repository
  - MatLab libraries
  - Car CAD models

Process

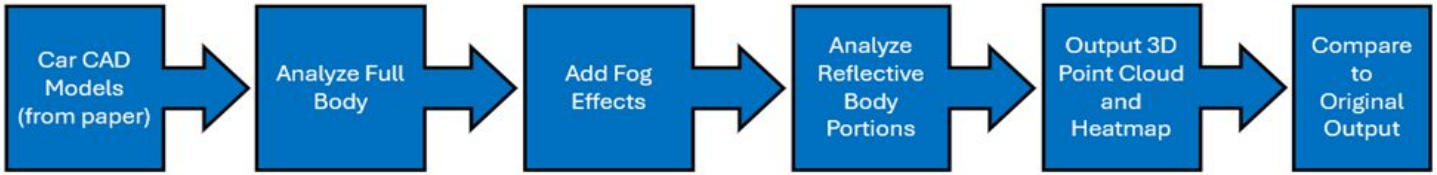
1. Create 3D point cloud by scanning CAD model
2. Construct bounding box using the maximum positions of the point cloud
3. Rotate the point cloud and bounding box by a random angle around the z-axis and translate by a random distance
    a. Must translate the point cloud because we (and the paper's authors) assume that the radar exists at the origin of the cartesian frame (0m,0m,0m)
4. Remove occluded points from the point cloud to approximate what the radar sees
    a. Convert cartesian points to circular points, and then only keep the first point for each viewing angle the radar "sees"

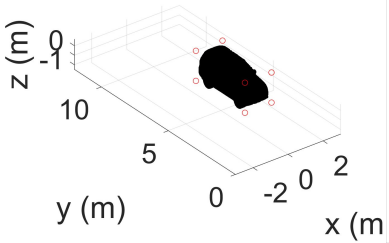
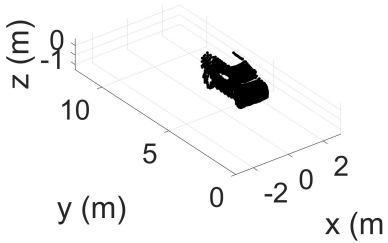
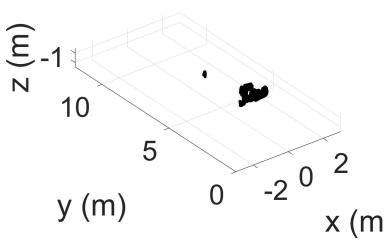
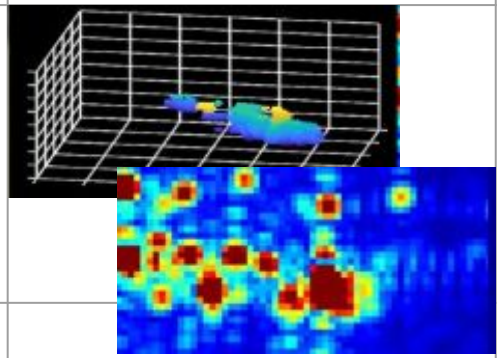
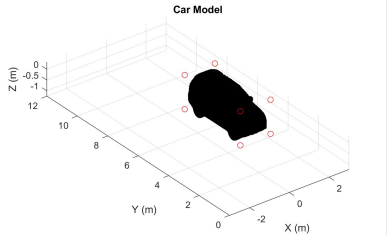
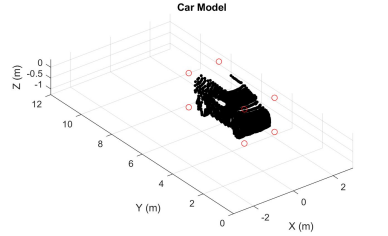
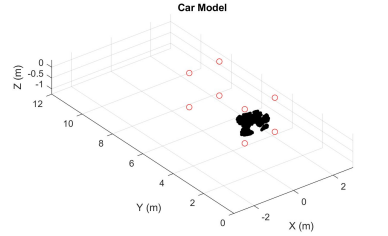
Process, Cont.

5. Model specularity of un-occluded points
    a. Calculate the specularity of each point by calculating its elevation angle and angle relative to the nearest edge of the bounding box (points with surface normals close to parallel with radar will be more reflective)
    b. Construct specularity “blobs” centered about likely “high-reflectivity” points
6. Simulate mm-wave radar to generate heat map



Results



	Rotated/translated point cloud	Occlude non-visible points	Reflective points	Heat Map
HawkEye				
Recreation				

Conclusion

- Successfully achieved most of our goals
  - Understood and used the paper's synthesizer
  - Developed our own synthesizer to produce similar results
- Accurate and effective intermediate steps, namely full body analysis/point cloud and occlusion
- Slightly off reflective model
- Incomplete heat map and radar simulation

Future Work:

- Reflective model improvements
- Finalize heat map
- More detailed radar simulation
- Incorporate the deep learning model
- Incorporate hardware

Q&A

References

[1] J. Guan, S. Madani, S. Jog, S. Gupta and H. Hassanieh, "Through Fog High-Resolution Imaging Using Millimeter Wave Radar," 2020 IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR), Seattle, WA, USA, 2020, pp. 11461-11470, doi: 10.1109/CVPR42600.2020.01148. keywords: {Radar imaging;Millimeter wave radar;Automobiles;Image resolution;Three-dimensional displays;Two dimensional displays},