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Ground Integrity Inspection using FMCW Radar

Objective :Develop technologies that enable reliable, robust and certifiable robot assisted ground integrity assessments, autonomous decision making and intervention capabilities for environments where hidden operational threats exist.

Introduction & Background

- Robots are capable of travelling over a wide range of terrain.
- Most of the research in path planning for robotic autonomous systems has been directed towards the detection of targets based on Simultaneous Location And Mapping (SLAM) and the prevention of their collision.
- Depending on the terrain, the robot may enter the surface of soft texture and impede travel.
- In order to ensure the stability and safety of the robot during operation, contrast recognition in the return signal of a mono-static k-band radar system is used to detect compromised ground integrity.
- Complete investigation to assess the radar is sensitive to various ground conditions.

Figure1: Warthog robot in different terrain[1]

Methodology

- Two groups of static experiments were carried out for different terrain environments.
- The first group selected water and edible oil for signal comparison.

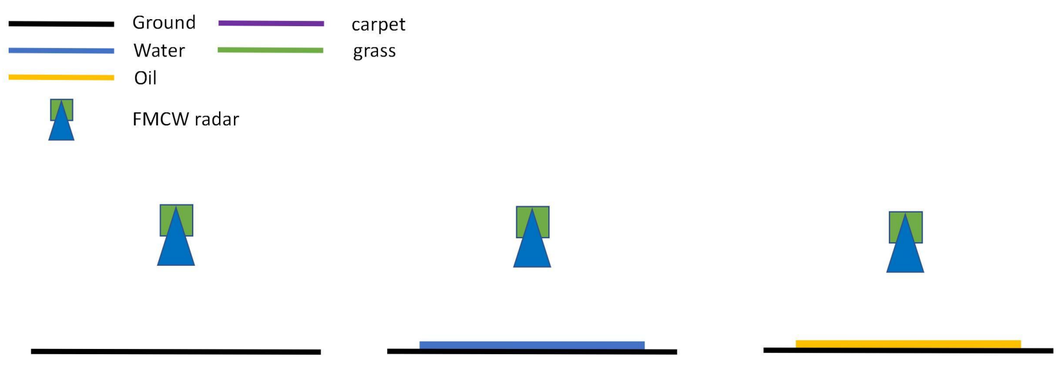

Figure2:Experiment with different liquid

- The second group used grass to simulate the real land environment, and performed signal analysis for soft and hard materials, respectively.

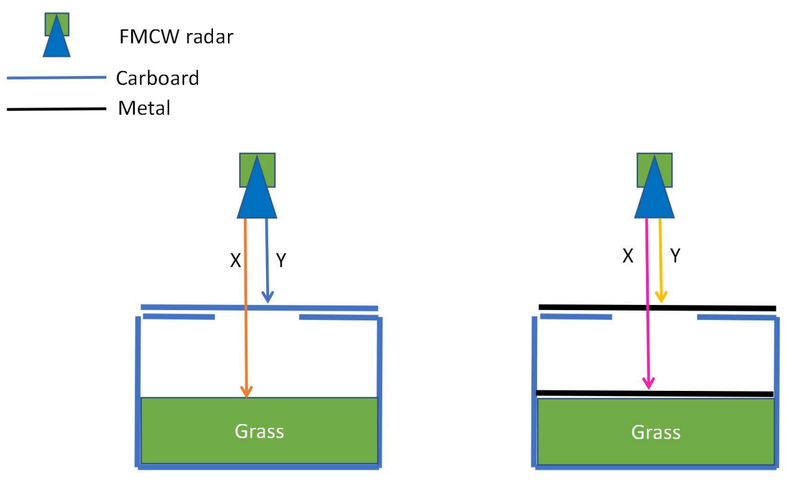

Figure3: Experiment with soft and hard material

Results & Summary

- As for the liquid test, it is clear that it has the significant amplitude comparing with the dry area.
- oil and water comparison, the experimental results show that the amplitude difference between the two is not obvious.

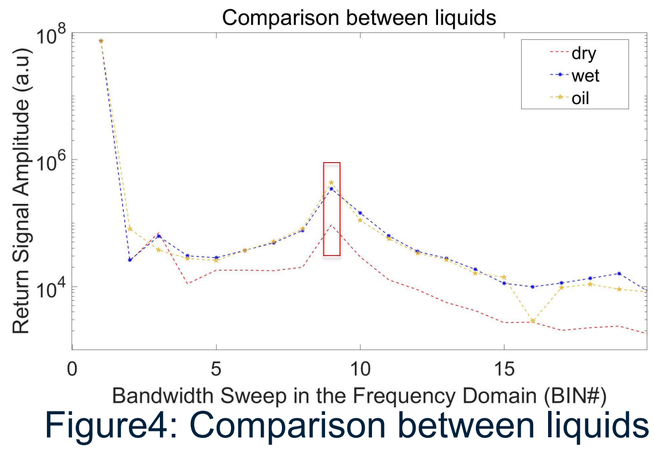

Figure4: Comparison between liquids

- For crack detection, there is a significant difference in the distance at which the radar detects the obstacle.
- For the detection of solids, there are significant differences in the amplitude of the signals returned from soft and hard materials (cardboard and metal plates).

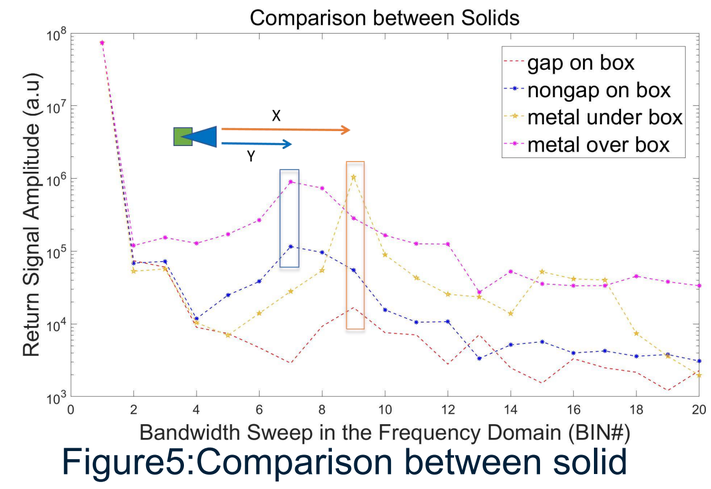

Figure5:Comparison between solid

Conclusion

- Obstacles created on the road (e.g. cracks, liquids, hardness of solids, etc.) can be distinguished and classified according to the radar feedback.) [3].
- A sensor for reliable, robust and safe navigation

Future work

- In the future, this research can be applied to navigation in mobile robots (e.g. AGVs) and can avoid unsafe factors in path planning [4].
- Application of FMCW radar onboard the Jackal in an autonomous mission.

Reference

[1]J. Blanche et al., 2021, **Millimeter-Wave Sensing for Avoidance of High Risk Ground Conditions for Mobile Robots**
[2]Natalia Galin et al., **Validation of Airborne FMCW Radar Measurements of Snow Thickness Over Sea Ice in Antarctica**
[3]Renjie Wan et al., **Moving Target Detection Using The 2D-FFT Algorithm For Automotive FMCW Radars**
[4]Seongwook Lee et al., **Mutual Interference Suppression Using Wavelet Denoising in Automotive FMCW Radar Systems**