IMAGING RADAR IS A KEY SENSOR FOR FREE SPACE MAPPING

The first necessary condition to support autonomous decision making is to be able to distinguish drivable from non drivable portions of the immediate driving environment. Free space mapping is the basis for navigation, path planning, and obstacle avoidance, which require a reliable estimate of the empty vs. occupied space in the vehicle's environment.

Free space mapping used for vehicle autonomy cannot be performed exclusively with one sensor. The purpose of sensor-redundancy is not only to provide a fail-safe mechanism, but also to exploit the individual sensors' advantages to achieve better coverage. An imaging radar, with its high sensitivity, high-resolution, full spatial sensing (including elevation), and all-weather-all-visibility performance, is the perfect candidate to counter the contrast-based free space mapping performed by cameras.

WHY IS IMAGING RADAR THE BEST SENSOR TO COMPLEMENT THE CAMERA?

Cameras give good azimuth and elevation mapping, and are a common sensor used for free space mapping, but there's a "but" here.

Camera doesn't have reliable range resolution, nor good depth perception, and therefore it cannot accurately measure the distance to the target ahead, which can be crucial for path planning. The radar provides a highly accurate mapping of the targets' distances. In addition, radars operate in any weather and lighting conditions, so when a camera is used, radar is a great solution for sensor redundancy.

WHAT'S THE ROLE OF LIDAR?

LiDARs provide a good free space solution for mid ranges. Lidars don't measure Doppler directly, and need to rely on tracking to determine which objects are stationary. Some lidars offer an ultra high resolution of 0.1 degree, higher than the radar's 1 degree; however, this doesn't have a meaningful impact in the free space mapping, since driving decisions require wide safety margins and cannot be taken based on 0.1 degree separations. Taking into account LiDAR cost and limited functionality in challenging weather conditions, it should be considered as a backup sensor to an Imaging Radar + camera suite.

WHY NOT USE A TRADITIONAL AUTOMOTIVE RADAR?

In contrast to the aforementioned 0.1 degree resolution of LiDARs, traditional radars with their 5 degree (or worse) resolution are also inadequate for the task of free-space mapping, as they cannot provide a detailed enough occupancy grid of their driving scenario. In low resolution radars, objects appear to be much bigger than they actually are, making it impossible to understand their boundaries and exact locations.

Detecting Stationary Objects

Due to their low azimuth resolution and lack of elevation resolution, traditional radars that were originally designed for controlling emergency braking and adaptive cruise control are limited to detecting moving vehicles, and typically discard all detections of the stationary environment as clutter. While moving objects can be separated by their doppler measurements, stationary objects may be unified by mistake into one oversized block, or be discarded.

Arbe's Imaging Radar, on the other hand, is very effective in detecting stationary objects, determining the road geometry and curvature, and mapping the objects that need to be avoided, such as guard rails, concrete walls, vehicles parked in the lane, etc.

Handling False Alarms

Traditional radars have a high level of false alarms. False alarms trigger the radar to report phantom objects and false positives. For this reason, traditional radar-based post processing algorithms raise the detection threshold, which results in decreased radar sensitivity and may lead to hazardous situations or even accidents.

Superior channel count that yields improved spatial separation in an imaging radar like Arbe's, together with advanced post-processing, reduces false alarms with close to zero instances of phantom objects, eliminating both false-positive and false-negative scenarios. This enables the generation of a free space map the vehicle can rely on.

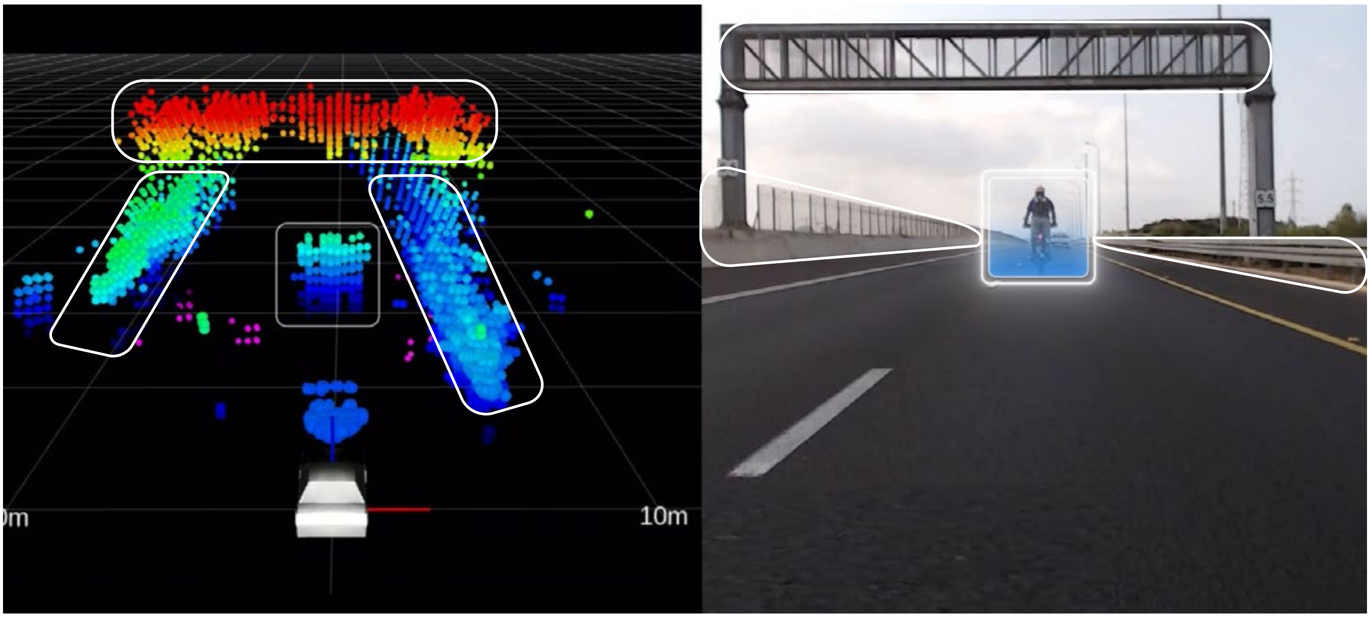
A FREE SPACE MAP GENERATED BY THE IMAGING RADAR

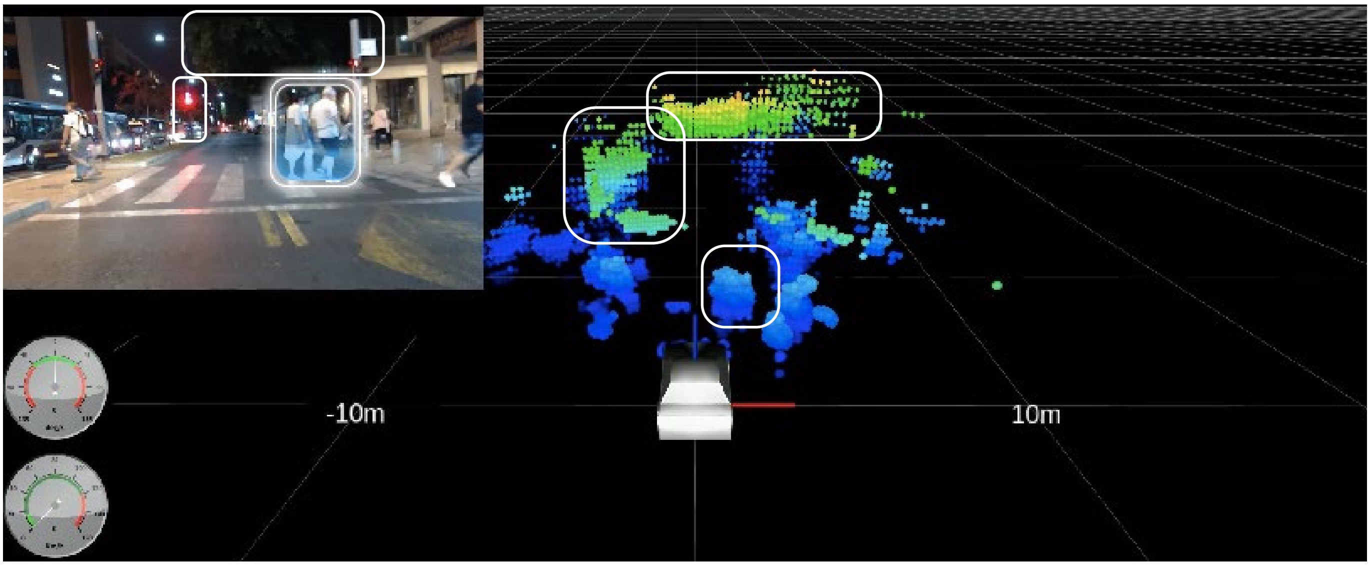
A free space grid map is a 2D occupancy map whose interpretation is a "pixel"-wise probability of being free. This map takes into account information from the current frame as well as a "memory-component" from previous frames to increase the confidence level of its free-space inference, making sure that spurious, false positive detections that are detected despite other noise cleaning algorithms are washed out, and correcting for transient occlusions

The Importance of High Elevation Resolution

As mentioned, the free space map is a 2D map, a bird's eye view of the driving environment. In radar terms, this is a range-azimuth map. Each pixel on the map tells us if the corresponding range and azimuth are drivable or not. An important subtlety, however, is that being a 2D output map does not mean that the third spatial dimension, elevation, bears no significance for the ability to reliably map the free space that surrounds the car. In fact, the opposite is true -- being able to tell the difference between an obstacle that is irrelevant for driving, such as a road sign, and an obstacle that should be avoided, such as construction-barriers, lies in elevation resolution, which makes the imaging radar crucial for free space mapping.

SEPARATING OBJECTS BY THEIR ELEVATION





CONCLUSIONS

Since an imaging radar satisfies the key requirements for free space mapping (high spatial resolution in all dimensions, regardless of the lighting or weather conditions, to long ranges, and at high reliability), and due to its complementary high Doppler resolution that allows it to distinguish efficiently between stationary and dynamic detections, the Imaging Radar is a mandatory component of the sensor suite that maps the free space in real time.