PERCEPTION INNOVATION

Resolving Edge Cases in ADAS & Autonomous Driving

Edge Case: Flatbed Trailer Across Roadway

Introduction

Human drivers confront and handle an incredible variety of situations and scenarios—terrain, roadway types, traffic conditions, weather conditions—for which autonomous vehicle technology needs to navigate both safely, and efficiently. These are edge cases, and they occur with surprising frequency. In order to achieve advanced levels of autonomy or breakthrough ADAS features, these edge cases must be addressed. In this series, we explore common, real-world scenarios that are difficult for today's conventional perception solutions to handle reliably. We'll then describe how AEye's software definable iDAR™ (Intelligent Detection and Ranging) successfully perceives and responds to these challenges, improving overall safety.

Challenge: Flatbed Trailer Across Roadway

A vehicle equipped with an advanced driver assistance system (ADAS) is traveling 45mph down a four-lane road that passes through a sparsely populated town. Relying on the vehicle to navigate, the ADAS driver has largely stopped paying attention. Ahead, a semi-truck towing a flatbed trailer slowly traverses across the road. As the distance between the vehicle and the trailer shrinks rapidly, it's up to the perception system to detect and classify the trailer, as well as measure its velocity and distance. At SAE Level 3 and beyond, where the car is assumed to be in control, the vehicle's path planning software must make a critical decision about whether to swerve or slam on the brakes before it's too late.

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How Current Solutions Fall Short

Today's advanced driver assistance systems (ADAS) will experience great difficulty recognizing this threat or reacting appropriately. Depending on its sensor configuration and perception training, the system may fail to register the trailer due to its very thin profile.

Camera. A perception system based on camera sensors will be prone to either misinterpret the threat, register a false positive, or miss the threat entirely. In the distance, the trailer will appear as little more than a two-dimensional line across the roadway. If the vehicle is turning, those same pixels could also be interpreted as a guardrail. In order to be accurate in all scenarios, the perception system must be trained in every possible light condition in combination with all color and size permutations. This poses an immense challenge, as there will be instances that haven't been foreseen, creating a potentially deadly combination for perception systems that primarily depend on camera data.

Radar. Approached from the side, the profile of a flatbed trailer is very thin. With no better than a few degrees of angular resolution, radars are ill-equipped to detect such narrow horizontal objects. In this case, a majority of the radar's radio waves will miss the slim profile of the trailer.

Camera + Radar. A perception system that only relies on camera and radar would likely be unable to detect the flatbed trailer and react in time. The camera data would be insufficiently detailed to classify the trailer and would likely lead the perception system to mistakenly classify the trailer as one of several common roadway features. As radar would also be unlikely to accurately detect the full length of the trailer, it would also mislead the perception system. In this instance, the combination of a camera and radar does little to improve the odds of accurately classifying the trailer.

LiDAR. Today's conventional LiDAR produces very dense horizontal scan lines coupled with very poor vertical density. This scan pattern creates a challenge for detection when objects are horizontal, thin, and narrow—it's easy for LiDAR's laser shots to miss them entirely. Some LiDAR shots will hit the trailer. However, it takes time to gather the requisite number of detections to register any object. Depending on the vehicle's speed, this process may take too much time to prevent a collision.

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Successfully Resolving the Challenge with iDAR

A vehicle that enters a scene laterally is very difficult to track. iDAR overcomes this difficulty with its ability to selectively allocate LiDAR shots to Regions of Interest (ROIs). As soon as the LiDAR registers a single detection of the trailer, iDAR dynamically changes both the LiDAR's temporal and spatial sampling density to comprehensively interrogate the trailer, thus gaining critical information like its size and distance ahead.

Software Components

Computer Vision. iDAR combines 2D camera pixels with 3D LiDAR voxels to create Dynamic Vixels. This data type helps the system's AI refine the LiDAR point cloud around the trailer edges, effectively eliminating all the irrelevant points. As a result, iDAR is able to clearly distinguish the trailer from other roadway features, like guardrails and signage.

Cueing. For safety purposes, it's essential to classify threats at range because their identities determine the vehicle's specific and immediate response. To generate a dataset that is rich enough to apply perception algorithms for classification, as soon as LiDAR detects an object, it will cue the AI camera for deeper real-time analysis about its color, size, and shape. The camera will then review the pixels, running algorithms to define the object's possible identities. To gain additional insights, the camera cues the LiDAR for additional data, which allocates more shots.

Feedback Loops. A feedback loop is triggered when an algorithm needs additional data from sensors. In this scenario, a feedback loop will be triggered between the camera and the LiDAR. The camera can cue the LiDAR, and the LiDAR can cue additional interrogation points, or a Dynamic Region of Interest, to determine the trailer's true velocity. This information is sent to the domain controller so that it can decide whether to apply the brakes or swerve to avoid a collision.

The Value of AEye's iDAR

LiDAR sensors embedded with AI for intelligent perception are very different than those that passively collect data. As soon as iDAR registers a single detection of the flatbed trailer, it dynamically modifies the LiDAR scan pattern, scheduling a rapid series of shots to cover the trailer with a dense pattern of laser pulses to extract information about its distance and velocity. Flexible shot allocation vastly reduces the required number of shots per frame to extract the most valuable information in every scenario. This not only enables the vehicle's perception system to more accurately track objects through time and space, it also makes autonomous driving much safer because it eliminates ambiguity, accelerates the perception process, and allows for more efficient use of processing resources.

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