

Improving Obstacle Detection with Large Field Of View Stereo Vision

DreamVu Inc.

June 2021

Abstract

This white paper informs the reader how to improve Obstacle Detection and Obstacle Avoidance (ODOA) solutions by utilizing a large field-of-view stereo depth camera. The stereo depth camera in discussion is made by DreamVu Inc. and covers the PAL Mini, the PAL, and ALIA 360° 3D cameras. This paper overviews challenges in obstacle detection for robotic navigation, common approaches used today, and introduces a new approach.

1 Obstacle Detection and Challenges in Robotic Navigation

Obstacle detection and Obstacle Avoidance (ODOA), which is performed by a sensing system deployed on a robot to perceive any obstacle or occurrence which could impact the robot path - static and dynamic, is one of the biggest challenges in robotic navigation today. The robot's navigation computer uses information from its surroundings to plan the most efficient path for the robot, which ensures all obstacles are avoided. The challenge lies in balancing the completeness of this sensing system with cost, complexity, and power consumption all at the same time. Not to mention all of the regulatory challenges and safety certifications that must be incorporated. These solutions can be improved with a large field-of-view stereo vision system. By first starting with a very large field of view, you can then mask the sensing field down to fit the mechanicals of the Autonomous Mobile Robot (AMR). This is a much more efficient and effective way of building a navigation system versus stitching, calibrating and synchronizing many sensors.

2 Common Approaches to Obstacle Detection

The most common approach to ODOA is utilizing 2D, or planar LiDAR. These solutions are effective for an ultra-wide horizontal field-of-view, however they only detect obstacles on the horizontal plane on which they're mounted. This means that a 2D LiDAR will not detect any obstacles above or below this plane, resulting in a degradation of complete situational awareness.

Attempts are made to overcome this challenge by utilizing multiple 2D LiDARs and placing them on different planes at various angles. While 2D LiDAR provides the benefit of a wide horizontal field-of-view, it comes at the expense of the vertical field-of-view and increases the complexity of overcoming the challenge for complete situational awareness.

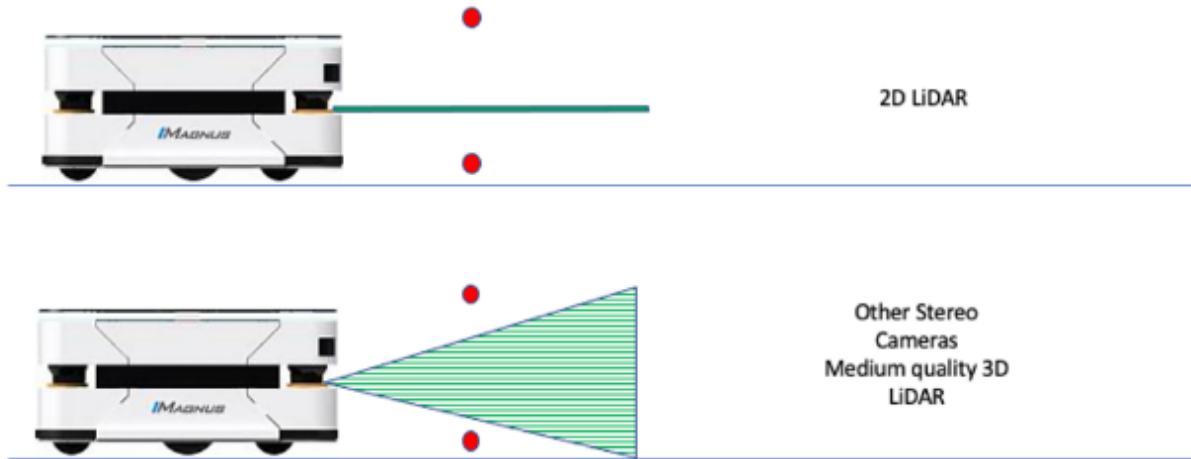


Figure 1 – Common approaches to obstacle detection

Another common approach to ODOA is the traditional stereo camera. There are various stereo cameras on the market that can give roughly the same horizontal and vertical field-of-view, however most of these suffer from small FoV in both horizontal and vertical directions. There is another alternative called 3D LiDAR, which is a multi-channel LiDAR to provide a wider vertical field-of-view. 3D LiDAR come with a cost and power penalties not often affordable for AMRs.

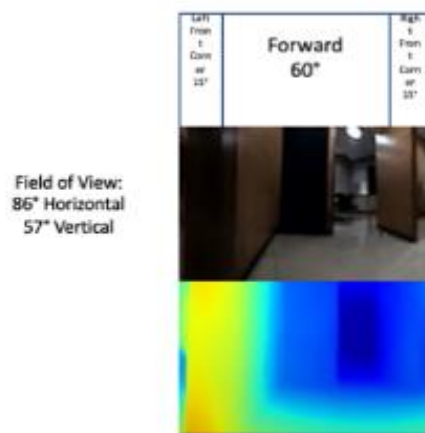


Figure 2 – Field-of-view for standard stereo vision cameras

In figure 2, the stereo vision sensor can see about 90 degrees in the forward direction, a little to the left and a little to the right. This creates tunnel vision for the robot and limits its overall sensing capacity thus reducing its ability to detect and avoid obstacles, especially while maneuvering. In this case, one would want additional sensors pointing to the sides to protect it from turning into an obstacle that's not directly in front of it. By taking standard stereo cameras and combining two or three of them we can minimize these blind spots but then complexities arise with overlapping images. Despite minimizing blind spots there are still nearfield blind spots which are objects directly in front of the sensor. For example 10 to 20 cm nearfield blind spots exist in traditional stereo cameras.

LiDAR and traditional stereo depth cameras provide the opportunity for a different approach.

3 A Different Approach

A new approach which should be considered is starting with something that has a large field-of-view and tailoring it through software to what makes the most sense for that application. Figure 3 shows a sensor with a full 360-degree horizontal field-of-view and 110-degree vertical field. The image in the center represents the forward-facing direction, 0° when mounted on a robot. The left and right edges represent +/- 180°, directly behind the robot. As the labels show, this provides an almost ideal FoV for achieving complete situational awareness. While not every AMR can take advantage of the full 360-degrees, by starting with a large field-of-view and tailoring it down to the usable range, the process is much more efficient than trying to add multiple cameras to create a large field-of-view.

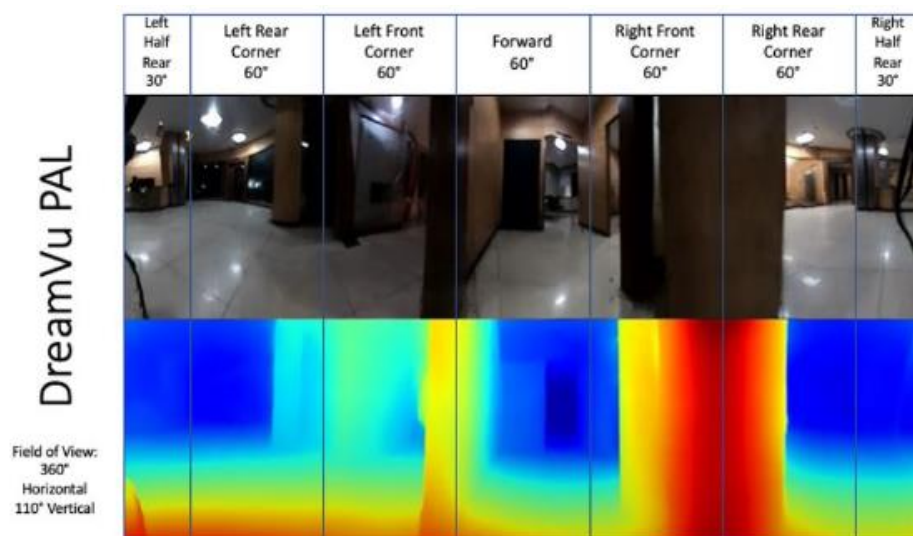


Figure 3 – the field of view of PAL – a 360° 3D camera from DreamVu

Figure 4 represents a comparison of taking advantage of a large FoV stereo camera vs. traditional stereo cameras. Even though the full 360° is not utilized, by taking one 360° stereo camera and placing it in front of the robot, 180° FoV can be utilized in one homogenous sensing field. This allows the robot to maneuver efficiently with one depth camera versus three traditional stereo cameras which would need to be stitched and synchronized to create a comparable field-of-view which still has blind spots. When one stereo camera is used, there is no need for calibrating between multiple sensors, dealing with stitching, and fixing overlaps. This approach is simple, cost effective, and allows for more up-time.

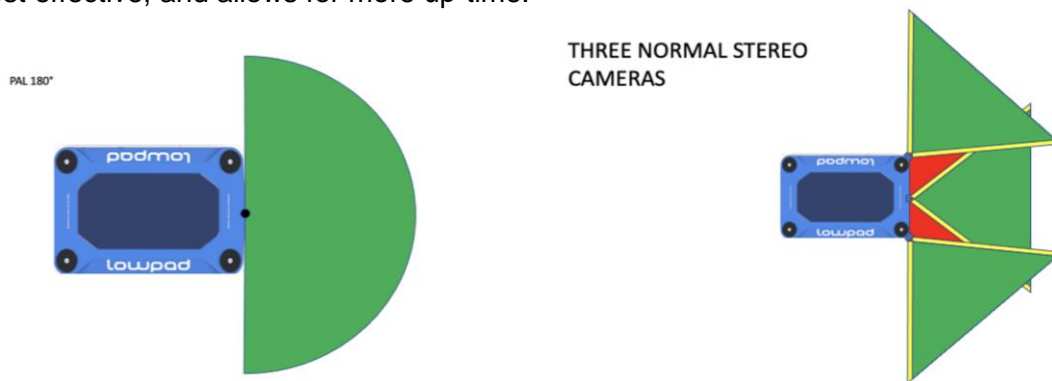


Figure 4 (180° PAL vs. 3x Stereo)

The large vertical FoV also ensures obstacles at any height will be detected. In certain situations one may need to make sure that a robot with or without a payload can navigate under a hanging obstacle such as a sign or a shelf. Large vertical FoV obstacle detection solutions allow the profile of the robot and payload to be programmed into the sensing field so hanging obstacles could be avoided. For example, if the maximum profile is 1 meter high then the system can be programmed with that height plus an appropriate margin so that anything above that can be ignored. If an object is detected at 0.8 meters high, the sensor should detect the obstacle to avoid the robot colliding with it.

In the case of a warehouse AMR which can move in any direction, two cameras can be placed on opposing corners with each providing 270° FoV. Once again, the full 360-degrees is not being utilized in this scenario but the benefit is the large FoV. By combining these two cameras in this way, the AMR now has complete situational awareness. This results in the AMR being free to move in any direction - forward, backward, left, right. It could then turn more efficiently without concern about possibly turning into people or obstacles that are otherwise in the blind spot or objects approaching from behind.

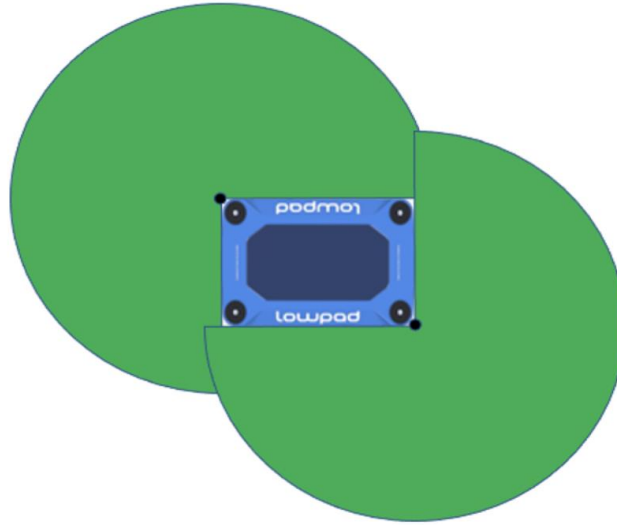


Figure 5 – Top view of warehouse AMR utilizing 2x PAL stereo vision cameras to provide complete situational awareness

By utilizing this method, there is a much simpler way to enable complete situational awareness of autonomous mobile robots (AMR). This solution has been validated as the most optimal and will expand the mobility and ROI of the AMR.

This approach of 3D obstacle detection is architected to be compatible with 2D, 2.5D or 3D mapping solutions. In the 2D mapping scenario, the obstacle map is flattened into a 2D laser scan to connect into 2D localization and mapping such as gmapping or cartographer. This makes it very easy, from a software integration point-of-view, to take advantage of the vertical field-of-view without having to upgrade the mapping solution.

4 Examples of DreamVu Solutions in Action

[Watch Hanging Obstacle Here](#)

This video shows the DreamVu test robot detecting and avoiding obstacles while in motion. If a person steps in front, the robot stops immediately. As the video shows, the map is updated with exceptionally low latency.

[Watch Sudden Appearance Obstacle Here](#)

In this video, the test robot is in motion before a low-profile and fast-moving obstacle moves in front of it on the ground. The robot detects the obstacle and quickly stops moving to avoid any



collision. System users can also see the map updated in real time. The laser scan of the box appears on the map and very quickly the robot detects and avoids it.

[Watch Human Obstacle Here](#)

The next video is one in which the robot can detect and avoid a hanging obstacle. An engineer outside of the robot's motion hangs a box in front of the camera. The robot detects it again, and stops motion. The green laser scan, which is essentially the detection of the obstacle, is updated, and although the obstacle is not on the ground, it is still detected and streamed onto the 2D map.

These videos provide evidence of how the large FoV Obstacle Detection and Obstacle Avoidance (ODOA) solution takes advantage of the vertical field-of-view to detect obstacles and flattens the scene into 2D to be compatible with 2D mapping.

5 The DreamVu Difference

DreamVu is able to support the premise of a large field-of-view in a way that's very cost and power efficient. This is referred to as the DreamVu Difference. What makes DreamVu cameras unique to any other stereo camera is the use of innovative optics in a solid-state body that generate multi-vantage point perspective onto a single image sensor. Traditional stereo cameras have two sensors which create shortcomings such as the need to synchronize each sensor and the existence of a near-field blind spot. Said succinctly – DreamVu provides the largest field-of-view stereo cameras in the most reliable and power and cost-efficient way possible. Figure 6 shows the available product-lines from DreamVu based on depth range.

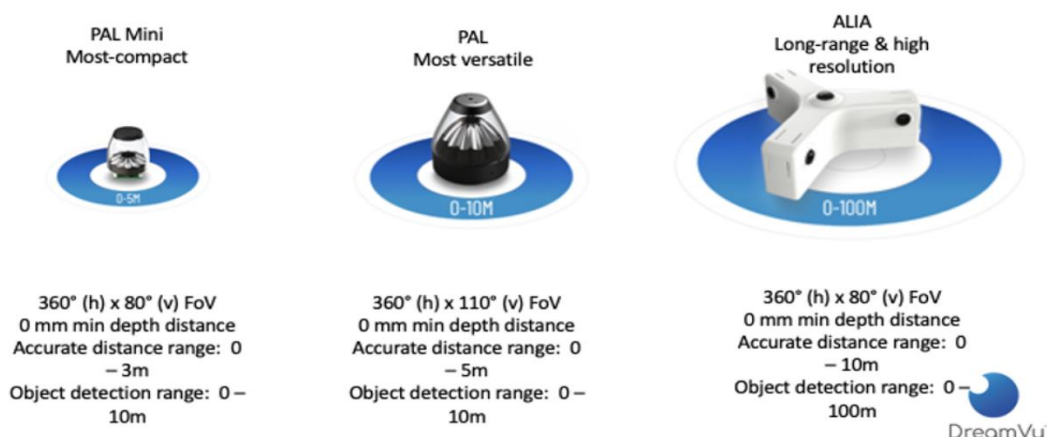


Figure 6 – DreamVu Omnidirectional 3D Vision Systems

6 Summary - Why Field of View Matters

With the premise of why the field-of-view matters; when users start with this large field-of-view stereo camera, AMR maneuverability will improve. The application will have greater real-time situational awareness so the robot will sense what is happening around it, from the ground up to whatever maximum height required. This is an effective and efficient way to do it. Additionally, users can get an increased runtime and don't need to worry about calibrating too many sensors, computational loads for stitching, or trying to fuse multiple sensors together. With all of this in mind, it's easy to see the benefits of starting with a large field-of-view and why it's important.

Visit <https://dreamvu.com/autonomous-mobile-robots-use-case/> to learn more.