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Leveraging AI & Computer Vision To Reduce Empty Miles

Enabling Vision AI in Truck Shipping Containers

AI and 3D ToF Smart Camera Solution

For Vehicle Fleet Management Improvement

With NVIDIA Jetson and innoDepX

NVIDIA ELITE PARTNER

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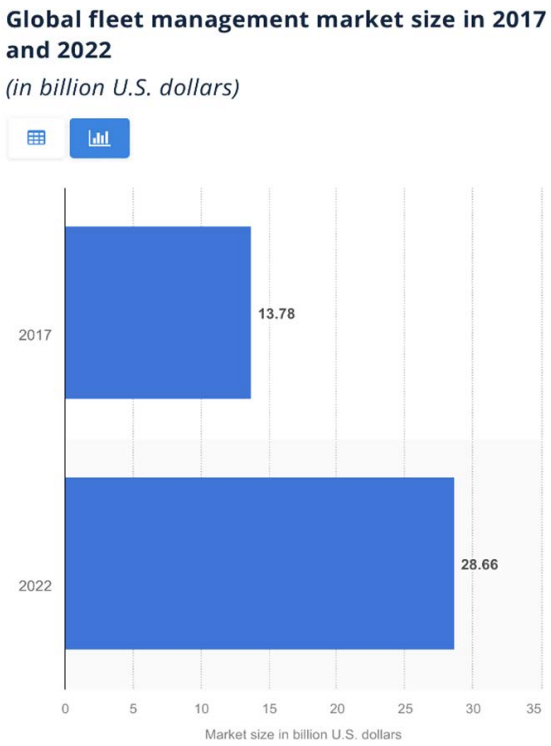
Overview

In recent years, route planning and fuel efficiency have been the main focus of technological developments in the rapidly growing global logistics fleet management market. Although the logistics industry has always played a part in trade and commerce, even advanced route management and monitoring technologies have failed to effectively reduce the problem of empty miles for logistics transport trucks. Containers are not being filled to their full capacity, and according to a Convoy survey, about 35% of trucks on the road today are driving empty.

Empty containers waste fuel and increase carbon emissions, so for logistics operators and fleet managers in charge of logistics fleet management, it is imperative to raise cargo delivery efficiency to reduce fuel costs and carbon emissions. To solve these problems, the critical link is to improve the fleet management team's insight into the utilization rate of each container.

Problems to Solve

- 35% of trucks on the road per day are driving empty
- 87 million CO2-equivalent emissions results from empty miles
- Hard to have precise fuel expense calculation based on GPS



According to Statista, the global fleet management market saw a twofold increase from US$13.78 billion in 2017 to US$28.66 billion in 2022. At this scale, solutions aimed at helping logistics operations improve container space utilization, reduce empty miles, avoid unnecessary carbon emissions, further help the fleet reduce fuel waste, and improve the overall efficiency of the freight logistics system is worth investing in.

statista

Challenges

This whitepaper introduces an AI-based solution that uses a smart camera device installed on the top corner inside a shipping container of a truck to accurately measure its space utilization.

By measuring the space utilization of shipping containers, truck fleets can improve their conveyance processes and reduce empty miles.

Currently, there are two common ways to measure container space utilization: manual and automated measurements. However, these methods have weaknesses such as a lack of accuracy and high installation, maintenance, and personnel training costs.

Manual measurement

Container space utilization is often measured visually by truck drivers or other personnel who provide the data on written papers. However, without proper training, accurately measuring the utilization rate can be challenging, particularly for larger shipping containers.

Automatic measurement

Installing a proximity sensor array in the container is another way to obtain and automatically upload cargo utilization data. However, this method can be costly in terms of manpower, time, and capital outlay for wiring installation and maintenance. Additionally, the sensor array may not provide accurate space utilization data in larger and longer containers due to the limited resolution of current proximity sensors (3 x 12).

AI and 3D ToF Smart Camera Solution

Aetina and iSSA Technology have joined forces to develop a new solution—the AI and 3D ToF Smart Camera Solution—that can measure the container space utilization more accurately to help reduce empty miles. The solution, leveraging NVIDIA Jetson system-on-modules (including Jetson Nano, TX2 NX, Xavier NX), and innoDepX (an iSSA subsidiary) CubiVision Premium, provides an intelligent monitoring system for real-time, accurate calculation of the container load, thereby reducing wasted fuel and carbon emissions.

The intelligent monitoring system consists of a powerful NVIDIA Jetson edge computing device, a high-quality, wide-range 3D depth camera—CubiCAM-Pro, and the innoDepX CubiVision algorithm for detecting objects in the container.

AI and 3D ToF Smart Camera Solution: NVIDA Jetson + innoDepX

For Truck Container Utilization Rate Improvement

NVIDIA Jetson™ × innoDepX

Tightly integrated with edge AI computing platform and 3D ToF long distance sensing camera, enabling a single turn-key solution. Providing fleet management providers and AI developers with a convenient and powerful capacity management and inventory control approach.

- Saving time of manually inspection
- Saving fuel cost up to 30%
- Surveillance on cargo loading percentage in AI
- Simply installation for 40ft container

Through the detection of the 3D depth camera, the analysis of the cargo detection algorithm, and the AI computing power provided by the NVIDIA Jetson system-on-module, this intelligent system can measure the volume of cargo, capture clear images of freight in the container, calculate the utilization rate in real-time, and issue instant alerts on cargo loading conditions.

Blind Zone Area<1%

- Narrow Lens
- Wide Lens
- 15m Sensing Distance

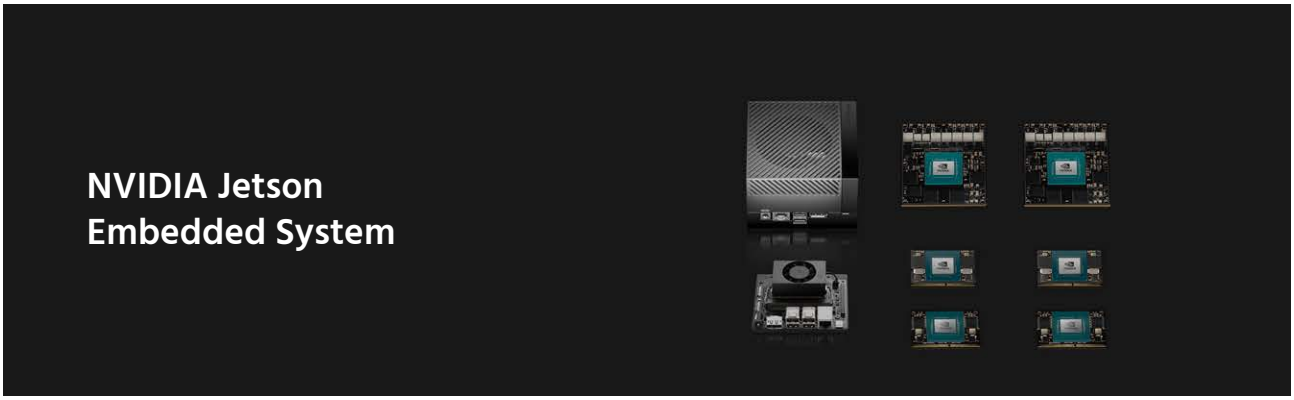
Light Source

- IR 940nm
- Do not affected by Ambient Light Source

Edge Computing

- Volume Measurement
- Cargo Loading Percentage

About the Edge Computing Modules – NVIDIA Jetson

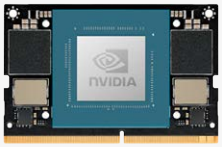


NVIDIA® Jetson™ is the world's leading platform for autonomous machines and other embedded applications; it is used by professional developers to create breakthrough AI products across all industries, and by students and enthusiasts for hands-on AI learning and making amazing projects. Each NVIDIA Jetson is a complete System on Module (SoM) that includes a GPU, CPU, memory, power management, high-speed interfaces, and more.

Supported Jetson Modules


Jetson AGX Orin Series


Jetson Orin NX Series


Jetson Orin Nano Series


Jetson AGX Xavier Series


Jetson Xavier NX Series


Jetson TX2 Series

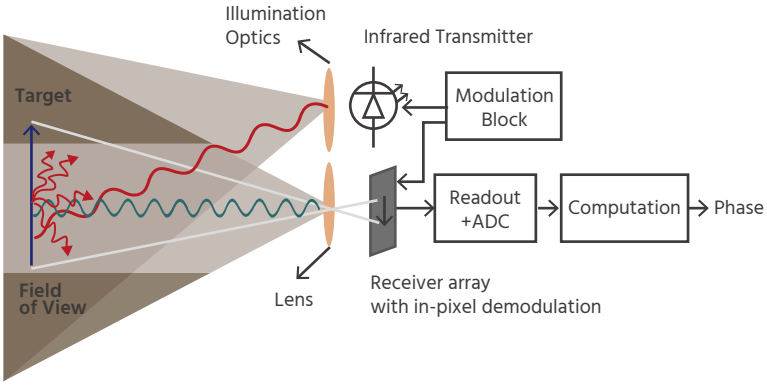

Jetson Nano

With NVIDIA Jetson, developers can accelerate all modern AI networks, easily roll out new features, and leverage the same software for different products and applications. They're available in a wide range of performance, power-efficiency, and form factors so they can be used by customers across all industries.

The AI and 3D ToF Smart Camera Solution leverages NVIDIA Jetson Nano, TX2 NX, and Xavier NX modules. Furthermore, the solution can be tailored to support the latest NVIDIA Jetson Orin SoMs, such as NVIDIA Jetson AGX Orin, Orin NX, and Orin Nano, for higher computing power.

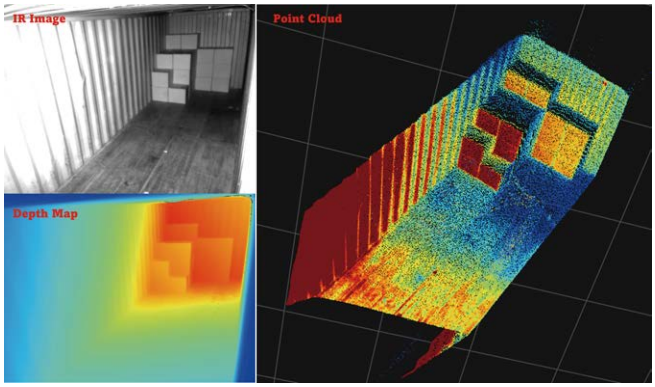
About the 3D ToF Camera

Time-of-Flight (ToF) is an emerging 3D sensing and imaging technology that is gaining traction for use in autonomous vehicles, virtual reality and augmented reality, feature recognition, and image dimensioning. ToF cameras acquire depth images by measuring the time it takes for light to travel from a light source to an object in the scene and back to the pixel array.



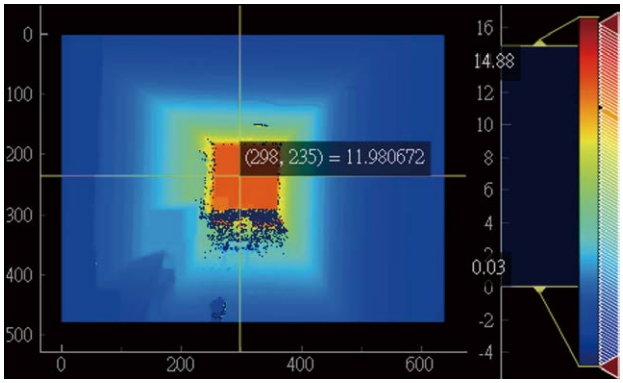
The advantages of the ToF cameras are that they have extremely high spatial resolution, are highly accurate at short distances, work in bright light outdoors and low light indoors, and are not affected by extreme light or no light conditions. Different lenses in the ToF camera can accurately measure distances from 10cm to 12m to calculate space utilization. In short, ToF cameras enable the accurate measurement of cargo loading capacity in the entire space within the container.

About 3D Visual AI Software



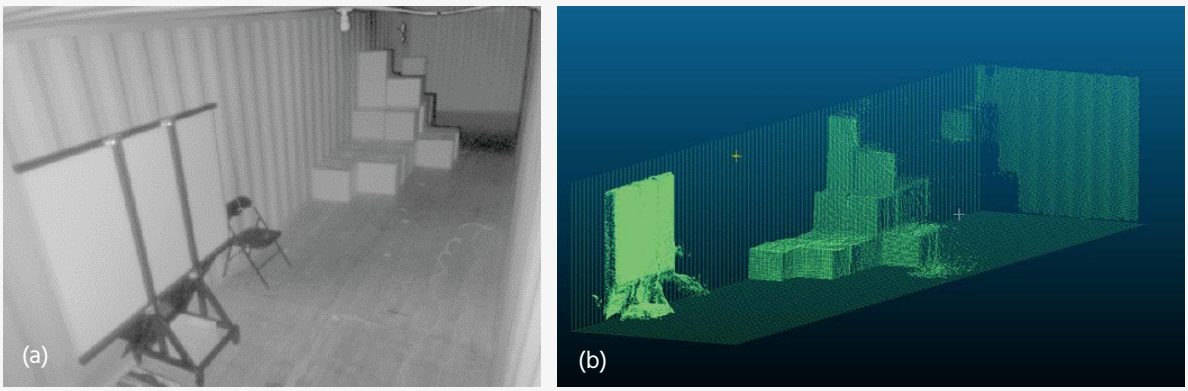
IR Image & 3D Image

IR Image & 3D Image: Infrared image inside the container (upper left), depth map (lower left), and point cloud image. Each pixel in the depth map represents a depth value, interpreted as a 3D image in the point cloud image.

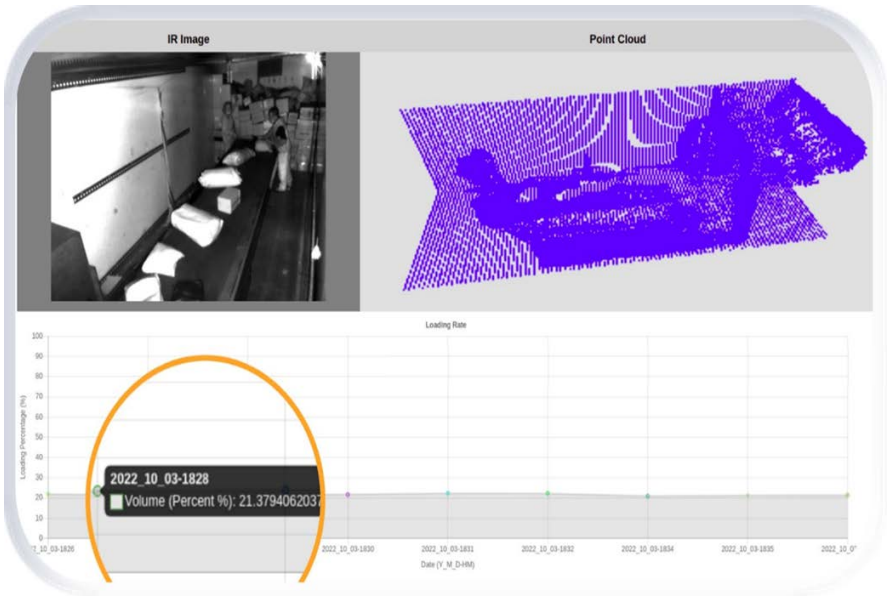


VGA Resolution

VGA Resolution: The depth map with VGA (640 × 480) resolution.



The 3D scene digitization of the container. (a) IR image and (b) the point cloud.



Visualization of the shipping container loading data

Once installed, the 3D ToF camera will begin monitoring the interior of the truck shipping container and provide the following data:

- Real-time cargo utilization percentage
- Infrared images of the container contents
- 3D rendering of the container

Users can visualize this data on the dashboard of their own monitoring tools, which provides them with a clearer understanding of container loading.

Conclusion

The AI and 3D ToF Smart Camera Solution from Aetina and innoDepX enables logistics operators to accurately calculate the cargo utilization rate, so they can load as much cargo as possible to reduce empty miles, and improve fuel usage. This technology also opens the door for suppliers to the logistics industry, such as vehicle systems providers and data analytics companies that provide management platforms for fleet managers, and presents opportunities for expansion into automated warehouse management.

After installation in a single corner of the truck shipping container, the solution, with NVIDIA Jetson, 3D ToF camera, advanced AI volume algorithm, rigorous hardware R&D, and lens switching function, enables an accurate measure of the cargo load. General logistics freight vehicles are equipped with GPS and fuel sensors, which help the fleet management team to obtain vehicle location and fuel-related data through the telematics system, and after analyzing these two data, they can plan the vehicle's route. However, GPS and fuel sensors provide insufficient data to measure "cargo capacity per mile," so Aetina and innoDepX's solution enables the management team to solve this problem. This solution helps the team collect the most critical data for route optimization and management of cargo transportation, allowing fleet managers to keep track of container utilization rates, thereby optimizing route planning, reducing fuel waste, and improving logistics efficiency.

AI-Powered 3D ToF Camera Specification

Advance Edge AI Computing System

- NVIDIA Jetson-based platform
- Power-efficient AI performance
- Application distance up to 12m (40ft) container
- Dimensions: 60.1 x 71 x 197 mm (HxWxL)

3D Time-of-Flight (ToF) Camera

- Wide field of view
- Low latency
- Not affected by ambient light
- Dimensions: 90.9 x 127.5 x 136.3 mm (HxWxL)
- Operating temperature: -20 to 60°C

Specifications

- NVIDIA Jetson Nano, TX2 NX, or Xavier NX
- Supports 4G/5G mobile connection
- Loading percentage accuracy >95%
- Blind zone <1% @ 9–12m (30–40ft)
- Depth measurement >98%

Reference Information

- Empty miles and CO2-equivalent emissions data: https://convoy.com/sustainability/empty-miles/
- Global fleet management market size in 2017 and 2022: https://www.statista.com/statistics/975959/global-fleet-mana-

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