Research Article

Automatic Measurement System (AMS) for Parcels

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Abstract

The demand for efficiency, accuracy, and cost-effectiveness has never been higher in the rapidly evolving delivery and cargo industry. This work presents a novel system designed to automatically measure the size and volume of rigid objects, addressing key challenges faced by logistics, retail, and transportation companies. Leveraging Computer Vision techniques the proposed system ensures precise and consistent measurements, optimizing space utilization and reducing operational costs. It can be integrated seamlessly with inventory management systems.

Keywords: Inventory management, logistics automation, automated measurement systems, retail, vision

1. Introduction

Inventory space management is one of the key problems in the delivery and cargo industry. Arranging the required storage area takes time and labor, often leading to inefficiencies and increased operational costs. Traditional methods of measuring and organizing inventory can result in underutilized space, overcrowding, and inaccuracies in stock management. On average, manually measuring and recording the dimensions of parcels can take anywhere from 20 seconds to 2 minutes per parcel, depending on the size and complexity of the item. Additionally, manual measurements are prone to errors, which can lead to incorrect shipping costs and improper space utilization, ultimately affecting the overall efficiency of logistics operations. These challenges can cause delays, misplacement of items, and difficulty locating and retrieving goods.

The purpose of this work is to develop and demonstrate an automated measurement system that significantly enhances the efficiency, accuracy, and cost-effectiveness of inventory management in the retail, delivery, and cargo industry. The system aims to address key challenges in logistics, including improving measurement accuracy to reduce errors, increasing efficiency to boost throughput and reduce labor costs, and optimizing space utilization in warehouses.
Integrating real-time data with ERP systems enhances inventory tracking and procurement planning, minimizes operational costs through automation, and ultimately improves customer satisfaction by ensuring reliable delivery estimates and reducing shipping errors. Our system measures width, length, height, volume, weight and volumetric weight.

2. Materials and Methods

2.1. Materials

2.1.1 Stereo Camera

Two monochromatic global shutter Cameras in stereo configuration are used to estimate distances and generate depth masks.

- Monochrome, Global-shutter type
- Max. Frame rate: Up to 90 fps
- Output resolution: Up to 1280 × 720
- Field of View (FOV): 65° × 40°

An additional RGB (Red-Greed-Blue) Camera is used for visualization purposes.

- Max. Frame rate: 30 fps
- Output resolution: 1920 × 1080

2.1.2 Industrial-Grade Panel Computer

An Industrial-Grade Panel Computer with powerful hardware and high-performance open-source platform is used.

- CPU: Hexa-core 64-bit ARM processor
- GPU: Quad-core

- RAM: 4GB
- Operating System: Ubuntu 18.04

2.1.3 Scale

A custom-made scale was designed and developed using load cells. The margin of error is 10 grams. Maximum payload capacity is 45 kg. The system communicates with the custom-made scale via an RS-232 interface.

2.1.4 Barcode reader:

An industrial barcode reader is used for barcode recognition.

A general view of the system is shown in Figure 1.

Figure 1. A general view of the system

2.2. Method

The Barcode scanner captures the barcode information of each parcel, providing relevant data for inventory management systems. For the measuring process to start, a barcode has to be scanned.

Movement detection must be implemented using background subtraction techniques. This method involves capturing a static background frame and continuously comparing it with subsequent frames to detect changes. The difference between the background and the current frame highlights moving objects when ongoing movement is present. The detected movement regions are then processed to ensure accurate tracking of objects in motion dynamically. Movement is detected throughout the measurement process to ensure no object or movement interferes with the parcel.

For distance estimation and depth mask generation, we utilized a two-cameras setup with distance decode. This camera provides high-resolution depth data. The depth data generated by the Stereo Camera is processed to create depth masks, which represent the distance of each pixel from the camera. These depth masks are crucial for determining the dimensions of objects in three-dimensional space. The dimensions of objects are measured by processing the depth masks generated by Stereo Camera. The depth mask provides a pixel-wise distance measurement, which can be translated into real-world dimensions. By identifying the boundaries of the object within the depth mask, we calculate the dimensions using Euclidian distance. The stereo camera's calibration data provide pixel-to-distance conversion. The accuracy of these measurements is validated with the known reference dimensions of parcels.

Weight information for objects is gathered using a scale.

A user interface (UI) was developed to display the measurement results in real time. The interface offers intuitive visualizations and easy access to detailed data.

3. Result

Our work demonstrated a high level of accuracy across a diverse range of parcel sizes, weights and lighting conditions. The automated measurement system achieved an impressive 97% accuracy in estimating the physical sizes of approximately 3,000 parcels.

Another essential aspect of our system is its seamless integration with existing Enterprise Resource Planning (ERP) systems and Warehouse Management Systems (WMS). Real-time measurement data can be automatically updated in the ERP/WMS system, facilitating better inventory tracking, procurement planning, and financial management.

The system is able to detect more than one parcel (Figure 2). In this case, the system alerts users to remove one of them.

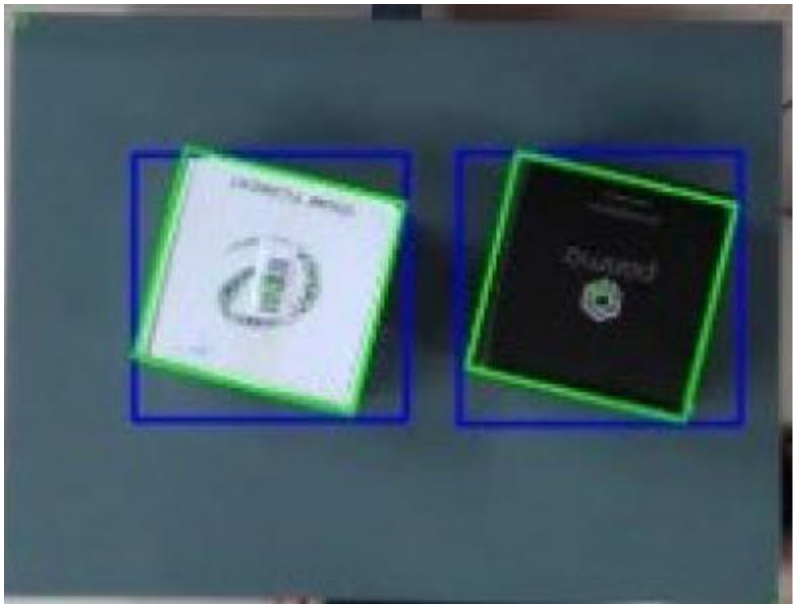

Figure 2. Detection of multiple parcels

The physical sizes of tested parcels ranged from the smallest to several larger sizes, as detailed below:

Minimum Object Size (Width x Length x Height): 15 x 20 x 5 cm.

Max. Width: 60 cm, (while $Length_{max}$ = 80 cm and $Height_{max}$ = 40 cm.)
Max. Length: 80 cm, (while $Width_{max}$ = 60 cm and $Height_{max}$ = 40 cm.)
Max. Height: 89 cm, (while $Width_{max}$ = 25 cm and $Length_{max}$ = 25 cm.)

Min. Weight: 0.60 kg
Max. Weight: 45 kg

On average, it takes 2.5 seconds to measure a parcel.

Reference dimensions of a parcel are shown in Figure 3.

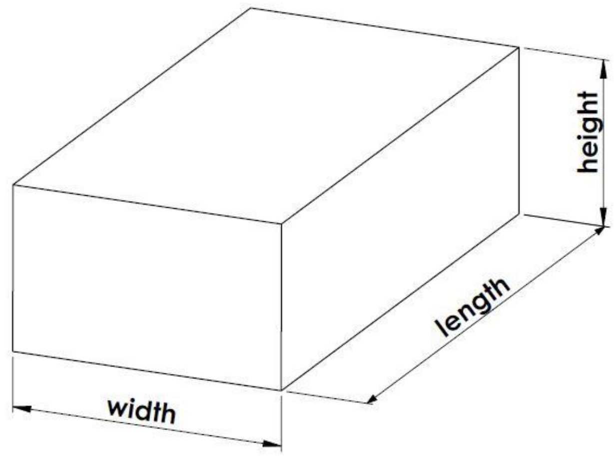

Figure 3. Reference dimensions of a parcel

4. Discussion and Conclusion

This study demonstrates the effectiveness and benefits of using an automated measurement system in the delivery and cargo industry. Achieving 97% accuracy in dimension and weight measurements over 3,000 parcels of various physical sizes, the system addresses key challenges in inventory management, such as inefficiencies, high labor costs, and errors associated with manual measurement processes.

For further improvements recently developed segmentation and oriented bounding box detection models should be used to improve speed, accuracy, and ranges. For the sake of simplicity, we haven't explored such methods.

Our findings suggest that automated measurement technologies are poised to become a cornerstone in the future of the retail, delivery, and cargo industry, driving significant advancements in operational performance and customer service.

5. Acknowledge

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