Rear Dump Truck Measurement Design Using Laser For Loading Process Automation

Muhammad Irwan Yanwari[1], I Ketut Agung Enriko[2]

[1] *Electrical Engineering Department, Politeknik Negeri Semarang, Semarang, Central Java, Indonesia*
[2] *PT. Telkom Indonesia, Jakarta, West Java, Indonesia*

Abstract— Transportation of goods using trucks is an irreplaceable method. However, it is undeniable that the truck-based method of transporting goods often attracts controversies, such as over-loading and products containing hazardous chemicals. This makes the need for automation of loading goods to trucks so that intentional or unintentional errors such as overloading and damage caused when an accident occurs in the process of loading chemical goods can be minimized. Of the four stages proposed in the automation process, namely (1) Trucks enter the cargo loading area, (2) Measurement of the volume or capacity of the vessel, (3) Calculation of the ideal arrangement of products on the vessel, and (4) The process of loading goods using a robotic devices. This article contains the design process for measuring the volume or capacity of the vessel. The measurement process is carried out using a plus (+) laser module and the steps taken in the measurement process are scanning the vessel that is highlighted using the laser module at several angles using a camera and calculating the length, width, and height of the body using trigonometric formulas. With the automation of loading goods, it is hoped that human intervention in the loading and unloading process can be eliminated so that errors that may occur can be minimized.

Keywords— Measurement, Laser, Loading Process.

1. Introduction

Transportation of goods using trucks is an irreplaceable method. However, it is undeniable that the truck-based method of transporting goods is often controversial. Some of the problems are the cargo on the fleet which is judged to exceed the safe capacity (both in terms of truck capacity and the load limit of the road) [1], the goods being loaded contain hazardous materials or should not be touched directly (for example, fertilizers that are can cause irritation) [2], and also incur additional costs in the process of loading goods from the warehouse to the truck fleet (human labor costs) [3]. Although several companies have implemented technology in the process of loading goods on the tailgate, human involvement in the process of arranging goods on the body is still difficult to avoid [4]. Currently, digital image processing has developed rapidly. Not a few industries use this technology to map and survey space and buildings such as places of worship [5], historic buildings [6], and natural structures [7].

1.1. Laser Scan

Laser scan technology in 3-dimensional (3D) fields has revolutionized the field of mapping and surveying. This technology provides advantages in terms of accuracy, simple data processing, and low cost [8]. Laser scanning, also known as light detection and ranging (LiDAR), has been widely used to quickly and accurately obtain three-dimensional (3D) topographical data of visible surfaces. The basic principle of LiDAR involves a laser beam to measure the distance from the instrument to the object surface based on the travel time between transmitting and receiving a signal called the laser pulse, and the 3D coordinates of the intersection point between the laser pulse and the laser signal are computed to obtain the shape of the object [9].

1.2. Truck Types

Trucks have different types of bodies. Dump truck, starting from the Rear Dump, Side Dump Truck, and Bottom Dump Truck types, have different loading and unloading methods [10]. Rear Dump Truck is a truck with the process of loading goods from behind the truck, this is because the opening in the tailgate is on the back.

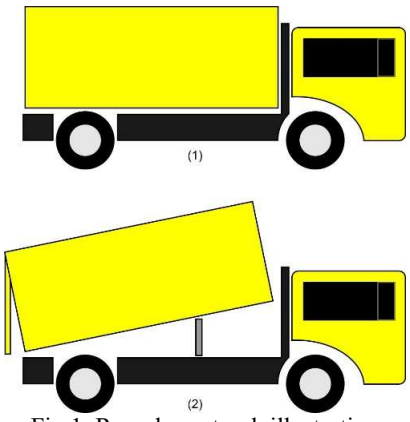

Fig 1. Rear dump truck illustration

Side Dump Truck is a type of truck with the process of loading goods from the side. In this type of truck the tailgate has an opening on one side of the body.

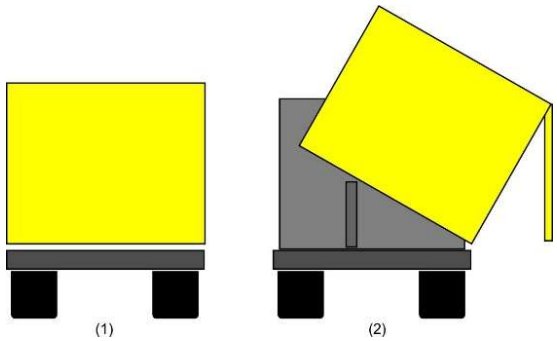

Fig 2. Side dump truck illustration

Bottom Dump Truck is a semitrailer (Bottom - Dump Tractor - Wagon) that transports and unloads goods through the bottom of the tub that can be opened in the middle. The tub door is the bottom side extending from front to back.

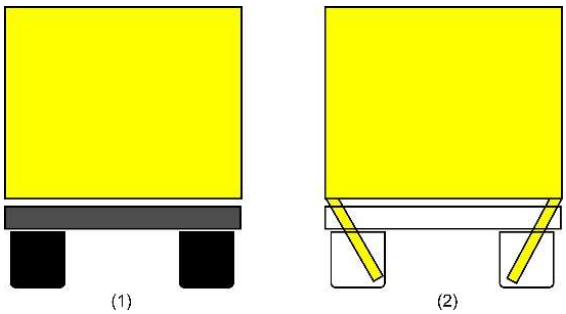

Fig 3. Bottom dump truck illustration

1.3. Trigonomertry

Trigonometry is a field of mathematics that explains the relationship between angles and sides in triangles [11]. Trigonometry is a field of mathematics that has various implementations in everyday life [12].

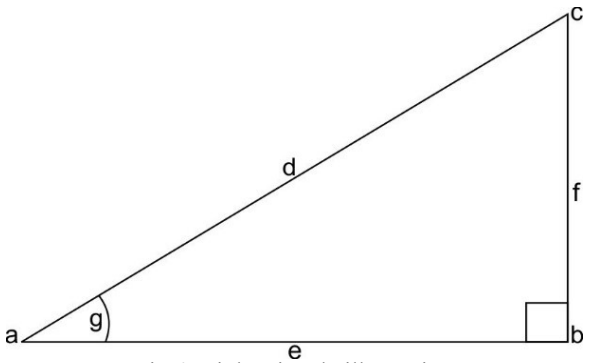

Fig 4. Right triangle illustration

A right triangle is a triangle in which one of the angles is 90 degrees [13]. In a right triangle, there is a theory called the Pythagorean theorem where the sum of the squares of e and f is the sum of the squares of d.

$$e^2 + f^2 = d^2$$

In addition, there is also the theory of sine and cosine where

$$\cos g = \frac{\text{adjacent}}{\text{hypotenuse}} = \frac{e}{d}$$

$$\sin g = \frac{\text{opposite}}{\text{hypotenuse}} = \frac{f}{d}$$

2. Device Design

The process of automation of loading and unloading of goods, especially in the process of loading goods from the warehouse to the truck, can be done in various ways on various types of trucks. In the proposed method, the type of truck used is Rear Dump Truck and the process of loading goods can be divided into several steps, namely:

1. The truck enters the loading area.
2. **Measurement of truck volume or capacity.**
3. Calculation of the ideal arrangement of products on the truck.
4. The process of loading goods using robotics devices.

Truck measurement process is a very important step because with the measurement process, the automation system can calculate the ideal amount of cargo in one product transport. The proposed truck body measurement process consists of five components based on the components of the equipment used (figure 5).

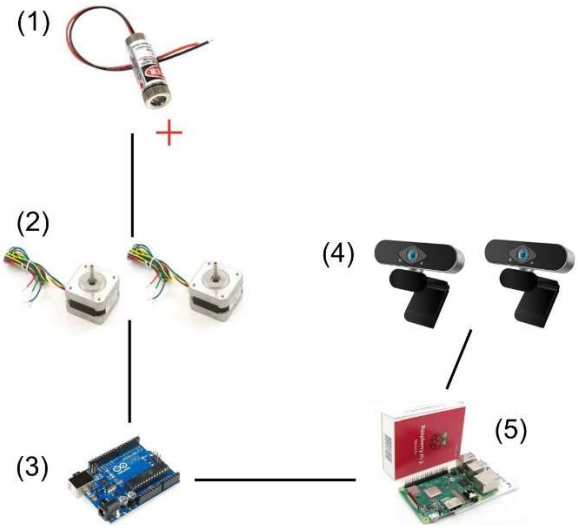

Fig 5. Devices components

1. **5mm laser cross module**, a cross-shaped laser is fired towards the tailgate to line the inside of the tailgate.
2. **Servo motor**, the motor is used to rotate the laser to obtain tailgate marking at various angles. In the given design there are two servo motors which are used to rotate the laser both vertically and horizontally.
3. **Arduino uno**, Arduino is used to adjust the rotation of the servo, the length of the laser is used and provides the timing of the capture of the image.
4. **Webcam camera**, the camera is used to capture images of the tailgate being measured. In the proposed system design, there are two cameras to make it easier to capture 3D fields like the human eye.
5. **Raspberry Pi**, raspberry is used as the main component in data processing. All images captured by the camera will be processed by this component. in addition to being used to calculate the size of the tailgate.

The body scanning process occurs when the truck enters the loading area with the tailgate pointing at the camera module (figure 6). When the truck is in a position ready to load goods, the laser is turned on and rotated using a servo slowly. During the servo rotation process, the camera captures images of the tailgate being shot using a laser from various angles (each angle will be recorded to determine the cos and sin values of that angle). The captured images are then processed using raspberries to determine the volume of the tailgate and how many items can be safely loaded on the truck. The image below is an illustration of a scan to find the length and width of the tailgate.

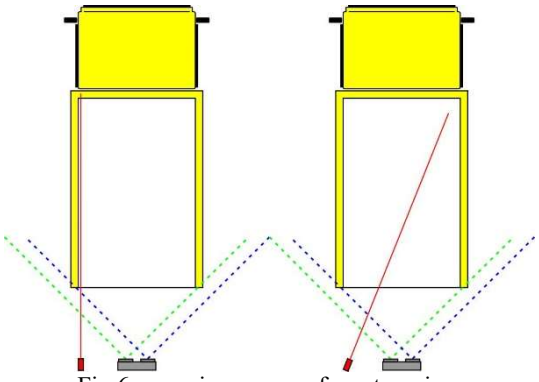

Fig 6. scanning process from top view

With data where the angle is X and the front side is symbolized by Y (the width of the tailgate as shown in Figure 7).

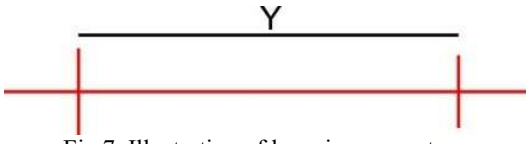

Fig 7. Illustration of laser image capture

Then the hypotenuse (Z) can be obtained by using the formula bellow

$$\sin X = \frac{Y}{Z}, \qquad Z = \frac{Y}{\sin X}$$

And the distance between the laser module and the body (E or tailgate length) can be found using the formula bellow

$$\cos X = \frac{E}{Z}, \qquad E = (\cos X)\ x\ Z$$

In the process of determining the height of the tailgate, a scan is carried out from the bottom up. An illustration of the scanning process is depicted in Figure 8.

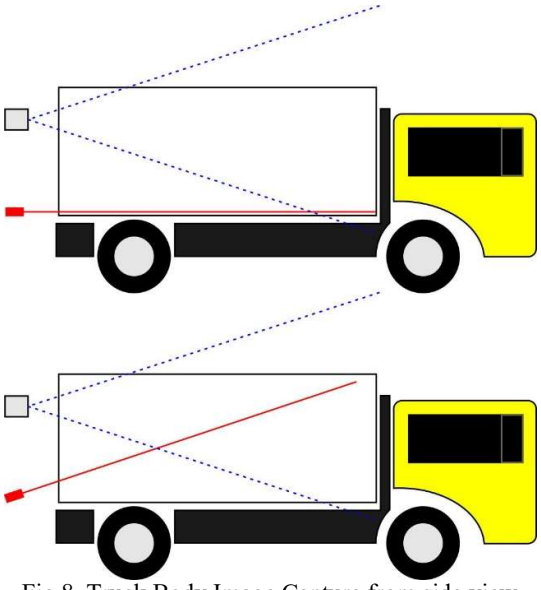

Fig 8. Truck Body Image Capture from side view

In measuring the height of the tailgate, no further calculations are needed, this is because it is different from the length of the truck which is not captured directly, the height of the truck can be seen from the camera capture. After the scanning process is carried out, the length (E), width (Y), and tailgate height (F) will be found. Calculation of the volume of the tub can be done using a simple formula for calculating the volume of the block, namely :

$$Volume = Length\ x\ width\ x\ Height$$

3. Result

The process of measuring the capacity of the body may experience errors because the position of the laser module is not aligned with the bottom left corner of the tailgate.

This problem can be solved by adding two servo motors that can move the laser module vertically and horizontally to adjust the position of the lower left corner of the tailgate. After getting the size of the tailgate capacity, the process of loading goods can continue to calculate the ideal product arrangement in the tailgate. The calculation of the preparation of goods and the layout of the preparation will of course be influenced by the size of the volume of goods.

The next problem is to determine the unit of measurement for conversion. In the scan results, the image size is still in the form of pixels, so a defined value is needed to convert the pixel value into centimeters (CM) or meters (M).

4. Conclusion

This article discusses one part of a series of automation processes for loading goods from the warehouse to enter the shipping process, namely the process of measuring the capacity of the tailgate. From the scanning process can be found the width and height of the tailgate. By performing calculations based on trigonometric formulas, the length of the tailgate can be found.

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