VISUAL BASED DISTANCE AND SPEED ESTIMATION FOR COLLISION AVOIDANCE

WAN NURFADZLYEN BINTI WAN NORZURAIDI

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

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DEDICATION

This thesis is dedicated wholeheartedly to my parents Wan Norzuraidi Wan Ismail and Adibah Mohd Yusof

ABSTRACT

Estimation of distance and speed of an object to a stereo camera system have feasible advantages among different applications in various field. Autonomous vehicles and robotics often require distance and speed estimation for collision avoidance. This paper introduces a system to estimate the distance and speed of an object from two 5MP USB cameras. Calibration of stereo cameras are done beforehand using MATLAB Stereo Calibrator Application. The results of the calibration is analysed and used to measure the speed and distance of an object. The accuracy of this suggested approach is calculated and compared using appropriate tool and formula. Triangulation and Euclidean formula is used to measure the distance between object to cameras. Meanwhile, speed of the object is calculated using linear velocity formula at a specified time of 2 seconds. From the result obtained, the average percentage error for 0.05m, 0.06m and 0.07m distance between two cameras are 3.05%, 6.97% and 1.93 % respectively. Accordingly, the average percentage error for speed estimation data is 5.77%.

ABSTRAK

Terdapat pelbagai kelebihan pelaksanaan anggaran jarak dan halaju sesuatu objek ke arah penglihatan stereo. Kelebihan tersebut telah dimanfaatkan dalam banyak aplikasi. Robotik dan kenderaan autonomi selalunya memerlukan pengukuran jarak dan halaju untuk mengelak pelanggaran. Tesis is memperkenalkan sesuatu system yang boleh menganggar jarak dan halaju sesuatu objek ke arah dua 5MP USB kamera. Kalibrasi penglihatan stereo telah dilakukan pada awalnya menggunakan MATLAB Stereo Calibrator Application. Hasil kalibrasi yang didapati telah dianalisis dan digunakan untuk mengukur jarak dan halaju objek ke penglihatan stereo. Ketepatan system ini telah dikira dan dibandingkan menggunakan alatan dan formula yang sesuai. Triangulation dan formula Euclidean telah digunakan untuk mengukur jarak antara objek dan penglihatan stereo. Manakala, halaju objek dianggarkan melalui formula halaju linear. Masa telah ditentukan pada awal projek iaitu 2 saat. Peratusan ketepatan yang didapati telah dikira untuk menyiasat ketepatan system yang diaplikasi. Melalui hasil yang didapati, purata peratusan kesilapan untuk 0.05m, 0.06m dan 0.07m jarak antara kedua kamera adalah 3.05%, 6.97% dan 1.93%. Seterusnya, purata peratusan kesilapan untuk anggaran halaju adalah 5.77%.

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LIST OF SYMBOLS AND ABBREVIATIONS

MP	:	MegaPixel
USB	:	Universal Serial Bus
3D	:	3Dimension
OpenCV	:	Open Computer Vision
LIDAR	:	Light Detection and Ranging

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CHAPTER 1

INTRODUCTION

1.1 Background of Project

Nowadays, autonomous vehicles and robotics gain massive attention. Car companies like Tesla has started manufacturing autonomous technology as an additional system in a vehicle. The launch received great response. Autonomous is define as an intelligent system that are able to migrate with little to no human input. It has long been applied in robotics and vehicles especially for military applications. Although the technology is utterly monumental. A minor improvement for collision avoidance could bring the technology on one step forward. This project proposes a system to estimate and measure the distance and speed of an object to a visual stereo system.

Distance and speed measurement has become extremely significant in autonomous system technology. Intelligent systems that can recognize its environment and analyze the situation is highly challenging. Several ways to analyze the environment for distance measurements are by using active and passive methods [1,2]. Active methods emits signal while passive methods receive information without any signal emission. On the other hand, speed estimation methods are mostly active methods. A signal typically laser or radio signal are emitted for speed detection [3]. Stereo vision for distance and speed measurement falls under passive methods category[1]. Distance is estimated by capturing images and manipulating the data obtained to estimate the position of the object in world point. Meanwhile, speed is calculated by implying distance travelled between 2 sets of frames and the time taken to capture these image frames and incorporate it in linear velocity formula.

Stereo vision is a practical branch of computer vision. It is an efficient and functional main sensors for robotics manipulators and mobile robots to extract information of the surrounding area [4]. Stereo vision is often used to acquire 3D images taken from a pair of image of different points [1]. It is done by using two cameras to capture images as a metaphor of the human eyes [5]. Stereo vision is typically much more inexpensive and low cost as compared to conventional methods. Example of stereo vision applications are navigations in robotics, inspection system and human-computer interaction [6].

1.2 Problem Statement

Collision may occur anywhere anytime without given any warning or sign. Autonomous application specifically needed a system that could support the technology to minimize collision. Existing speed and distance measuring tools are tedious and expensive. Laser rangefinder for measurement of distance are priced up to several hundred depending on the brand and manufacturing company. Meanwhile, speed measuring tools such as LIDAR speed gun are not readily available in this country. Thus, with low cost budget, this proposed method aim not to diminish and prevent accidents completely but rather to assist autonomous application in reducing potential crash by using computer vision.

1.3 Objectives

1. To develop algorithm for speed and distance estimation
2. To construct a distance and speed estimation system using two low cost cameras

1.4 Scope of project

1. Capture images using two 5MP USB cameras
2. Stereo calibration using 9-by-6 checkerboard and MATLAB's Stereo calibration app
3. Process image using stereo calibration parameters
4. Measure distance up to 3 meters using Euclidean distance and Triangulation formula
5. Measure speed in meter per second using linear velocity formula

1.5 Limitations

There are several limitation that occur while doing this project These constraints have impacted the obtained results. Such limitations are divided into three section including limitations on hardware, software and surrounding conditions. Each constraints can be overcome to improve the end results. Hardware limitations for this project are based on the two cameras while software limitations are based from MATLAB and surrounding limitations are established from the environment setting.

1.5.1 Hardware

Two USB cameras are the hardware used in this project. It is universal and can be used to interface on any working computers and personal laptops. Both cameras has a resolution of 5MP with 640 x 480 pixels. Resolutions can go up to 1080 x 1920 pixels for high definition images. Cameras with higher resolutions can take sharper images and more distinct object feature. High quality images require minimal image pre-processing and help for faster object detection.

1.5.2 Software

Software used to develop the distance and speed estimation is MATLAB 2019a. Although this version of MATLAB is the latest version to date, there are still delays and laggings upon operating it. Image capturing are sometimes delayed which contributes to error in estimation of speeds. This limitation can be overcome by optimizing data used in MATLAB to avoid operation deferral. Moreover, extending the computer RAM can also help in reducing software operation delay.

1.5.3 Surrounding

Object detection can be highly affected by the surrounding circumstances. Several factors have contributed to detection and estimation errors. High light intensity can manipulate the object into being too bright and overexposed. Thus, in turn will make it hard to detect the object. Low light intensity on the other hand will make the picture blurry and unclear which also increase the difficulty in object detection.

Furthermore, complex background can also affect object detection. Non-plain background introduces random errors and complicate object detection procedures. Tedious image pre-processing technique is needed to reduce the errors and properly detect the object at high precision. This project uses a plain white background for ease of segmentation and detection of object.

1.6 Thesis Outline

This thesis is compiled into five chapters to cover the research work that is related to visual based distance and speed estimation for collision avoidance. Chapter 1 to 5 conveys the essential matter that build the significance of this project. Each chapters are divided into several subchapters to further explain and unravel the fundamentals of this project. Graphics such as figures, tables and graphs are included in every chapters to portray the locality as close as possible. List of figures and tables are properly listed by chapters including the appropriate captions which interprets the contain of the figures and tables. The final algorithm is attached at the back of this project as appendix.