FLEXIBLE AND LOW-COST LASER SCANNER FOR AUTOMATIC TYRE INSPECTION

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DECLARATION

I declare that this thesis entitled "FLEXIBLE AND LOW-COST LASER SCANNER FOR AUTOMATIC TYRE INSPECTION is the result of my research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in the candidature of any other degree.

Signature :

Name : NOORAIN SHAFINAZ BINTI SUBAHIR

Date : 5 JULY 2021

APPROVAL

I hereby declare that I have checked this report entitled "FLEXIBLE AND LOW-COST LASER SCANNER FOR AUTOMATIC TYRE INSPECTION" and in my opinion, this thesis complies the partial fulfillment for awarding the award of the degree of Bachelor of Mechatronics Engineering with Honors

Signature :

Supervisor Name : DR. HAIROL NIZAM MOHD SHAH

Date : 5 JULAI 2021

DEDICATIONS

To my precious father and mother

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ABSTRACT

Show how you can acquire a red line laser scanner using the shelf components, which preserves versatility and precision. Easy and accurate geometric and light parameter calibration procedures are defined. The effects of its application to some of the manufacturing issues in the tire industry will be shown. It has three algorithms to detect the defect of tire tread which are laser and camera calibration, tread profile clarification, and tire classification. First and foremost, a particular approach is suggested here, where the laser and the camera are not positioned in the same situation, but mounted at a wider angle separately. For the whole tire, the surface will be studied by replacing the tire with the black curtain on the floor. A particular approach where lasers and cameras are not mounted in the same frame, but instead wider angles are mounted independently. This scheme can analyze the entire surface of the tire when. This allows for better accuracy and better flexibility when looking for cameras and laser transmitters. In addition, it allows their location to be optimized according to factory specifications. For high accuracy, camera angle and tire displacement are important parts to improve good results. This also involves camera calibration, laser calibration, and profile parameters. MATLAB software is used to develop encoding for identification pictures. Placing a laser and a camera at an angle helps make the projected laser line transfer to the plane of the camera image with surface height differences. While for the second algorithm which is tread profile clarification, will detect the tire tread condition, and here there are three types of tire tread condition either sample 1is replace, sample 2 is considered to replace, and sample 3 is in good condition. It will generate automatically the RGB programmable tread profile and form the graph that shows the class and the tire condition. On the other hand, once the second algorithm is done, the tire classification stage will begin, and where will be seen the tire tread percentage.

ABSTRAK

Tunjukkan bagaimana anda boleh memperoleh pengimbas laser garis merah menggunakan komponen rak, yang mengekalkan fleksibiliti dan ketepatan. Prosedur penentukuran parameter geometri dan cahaya yang mudah dan tepat ditentukan. Kesan penerapannya kepada beberapa masalah pembuatan dalam industri tayar akan ditunjukkan. Ia mempunyai tiga algoritma untuk mengesan kecacatan tapak tayar iaitu kalibrasi laser dan kamera, penjelasan profil tapak, dan klasifikasi tayar. Pertama dan terpenting, pendekatan tertentu disarankan di sini, di mana laser dan kamera tidak diposisikan dalam situasi yang sama, tetapi dipasang pada sudut yang lebih luas secara terpisah. Untuk keseluruhan tayar, permukaannya akan dikaji dengan mengganti tayar dengan tirai hitam di lantai. Pendekatan tertentu di mana laser dan kamera tidak dipasang dalam bingkai yang sama, tetapi sudut yang lebih luas dipasang secara bebas. Skema ini dapat menganalisis keseluruhan permukaan tayar bila. Ini membolehkan ketepatan dan fleksibiliti yang lebih baik ketika mencari kamera dan pemancar laser. Di samping itu, ia membolehkan lokasi mereka dioptimumkan mengikut spesifikasi kilang. Untuk ketepatan yang tinggi, sudut kamera dan penggantian tayar adalah bahagian penting untuk meningkatkan hasil yang baik. Ini juga melibatkan penentukuran kamera, penentukuran laser, dan parameter profil. Perisian MATLAB digunakan untuk mengembangkan pengekodan untuk gambar pengenalan. Menempatkan laser dan kamera pada sudut membantu membuat pemindahan garis laser yang diproyeksikan ke satah gambar kamera dengan perbezaan ketinggian permukaan. Sementara untuk algoritma kedua yang merupakan penjelasan profil tapak, akan mengesan keadaan tapak tayar, dan di sini terdapat tiga jenis keadaan tapak tayar sama ada sampel 1 diganti, sampel 2 dianggap sebagai pengganti, dan sampel 3 dalam keadaan baik. Ia akan menghasilkan profil tapak RGB yang dapat diprogram secara automatik dan membentuk grafik yang menunjukkan kelas dan keadaan tayar. Sebaliknya, setelah algoritma kedua dilakukan, tahap klasifikasi tayar akan bermula, dan di mana akan dilihat peratusan tayar tayar.

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LIST OF SYMBOLS AND ABBREVIATIONS

IoT - Internet of Things

ROI- a region of interest

GIS -geographical information systems

(TPMS)- Tire Pressure Monitoring System

SLAM- simultaneous localization and mapping

θ-Angle

x-photon

o- offset

gout - grey level

G - camera gain

d - height defect

G- Gain

O- Parameter

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Motivation

In this era of globalization, safety has become the top priority in the world. When it comes to the automotive industry, the tire is one of the main parts that should be calculated. The security and comfort of driving strongly depend on a great working inspection of the car tires' condition. However, estimation of tire pressure and also the accurate temperature is not an easy task for some people especially a woman. As a consequence, in the last 20 years, there were various novel tires and inspection devices produced to ensure a safer and convenient driving mode. In a modern environment, this process is mostly done manually by fully engaged workers. For tire inspection, two major innovations have been developed. The first focuses on X-rays, which were published in the 1980s. To detect misalignment of individual belt layers, steel wire location, thread width within the case. This is also intended to monitor pockets that contain spurious substances and to track tire consistency. More specifically, systems have been developed for visual surface inspection. They are meant to describe faults such as imperfect extrusions on the tire surface, not absolute profile circularity, and so on. To overcome all these issues, two important tire innovation ideas have been implemented for automatic tire inspection and one of them is the laser scanner. Since the picture of rubber is primarily standardized as a black color, the laser scanning image is designed to locally calculate the surface shape. Many of these methods are designed on a laser beam and a camera located at a recognized laser angle which is displayed on the surface of the tire. After all, for that aim, scanners predicated on a maximum speed or amplitude modulation are being prosecuted. These systems guarantee exceptionally high precision, but just at the stage where the laser is aiming at. Other than that, these technologies are very costly and limit their distribution. On the other hand, laser scanner presence detection scanning technologies are some of the current commonly adopted. It is designed dependent on highly specific calibration as well as production precision is needed to achieve high precision at a small angle while installing cameras and a detector in a certain situation. This can be troublesome in a manufacturing setting, where there are multiple points of friction and moving parts between the image scanning device and the detector of these tools. To locally determine the pattern and the thickness of the surface, laser scanners have been adopted. Much of certain techniques become centered on a laser line mapped upon this layer of the tire and placed at the specified sensor angle by the image. Put another way, it depends on the flight time or interferometry that matches the aim of the scanner. Figure 1-1 shows the degree of freedom of the emitting laser.

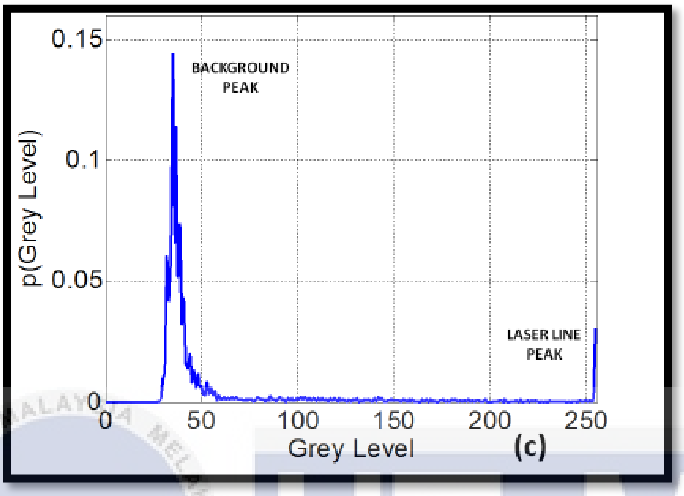

Figure 1-1 Graph degree of freedom laser

1.2 Problem Statement

Nowadays in Malaysia, mechanics still using the manual method for a tire inspection. This happened due to the lack of technology exposure in automotive. This operation is still mostly carried out manually nowadays by committed workers. Like the standard of the outcome, however, it relies critically upon its expertise and amount of sensitivity of the major actions are made by the operator to implement automatic inspection schemes that will interact with human beings. In industry, there are a few countries that had successfully inspect the tire automatically without human vision. It is equipped with specific special design components and produces accurate data from the system. But there a few problems involved which cause a lot of money and it is quite impossible to propose this new technology to a mechanic in Malaysia. They cannot identify the thickness or the thread of the tire with just a glance of the eye or with their sense of touch but they should inspect them with one automatic tire inspection that flexible and low cost.

To overcome this, the camera and laser are the important components that have been used. To get accurate data reading, the angle of the camera should be considered as it helps the laser to get the perfect figure of the tire condition. The displacement of the line laser has to be calculated by proposed an experiment to analyze it. It will simulate by the MATLAB program that had been carried out to perform the three algorithms that had been stated before. The image gained after identify and done the verifying process of the camera calibration is shown in Figures 1-2.

Figure 1-2 Camera calibration

1.3 Research questions.

From the problem statement, 3 major questions will be related to the literature review:

1. What is the suitable software that will use?
2. How to detect the defects of tire inspection affordably?
3. What is the guideline for the thickness of the tire in terms of safety?

1.4 Objectives

Three objectives are highlighted from the research questions in the problem statement and for reaching the aim:

1. To develop a simple and reliable calibration of laser and camera procedure
2. To identify the tread on the tire surface process by using a red line laser scanner
3. To verify the detection algorithm in ensuring the flexibility and accuracy of tire inspection.

1.5 Scope of work and Limitation of the study

The focus of this project relies heavily on the accuracy of the inspection of tires simulate by a programmable control. A particular approach in which the laser detector and sensor using the camera was not ever constructed inside of the relatively similar frame, and yet independently mounted at a wider angle instead. The scheme is capable of analyzing the entire surface of the tire as it is spinning. This allows for better precision and more versatility when locating the laser detector and the sensor which using of camera emitter. It is also monitoring their position as per the factory's requirements. To get high accuracy, camera angle and tire displacement is an important part to enhance the good result. This also involves camera calibration, laser calibration, and profile parameters. Placing the laser and the black and white camera at an angle helps to make any difference in surface height to distort the emission spectrum placed across the image focal plane. It also mainly focused on the accuracy of automatic tire tread inspection by using RGB image processing. Here, the red line laser will be used with the wavelength 635 nm and the operating current is 10mw. MATLAB software is used to develop the coding for the identification of the tire tread condition and categorizes them into three classes which are replaced, consider replace, and good condition.

CHAPTER 2

LITERATURE REVIEW

2.1 Project Overview

Throughout this chapter two, literature reviews have to be observed based on the project of student title. Literature reviews can be searched for from the trusted resources with this project title, such as articles, books, and many more. This chapter also reviews some studies or projects that have some similarities to the other researchers' experiments. There is a comparison between the type of scanner that will be applied and some of the mathematical modeling by each article that has been found.

2.2 Review on previous research

According to the study and results, there are many kinds of research, journals, articles, and projects that have been carried out by researchers all over the world on the controller of the tire inspection. All the previous studies, articles, papers, and projects help me to quickly understand the main idea and the design of my project. Some of the concepts and processes are taken to do this project.

2.2.1 Past Studies of Tire Visual Inspection by Active Image Sensing and Smart Feature Extraction.

This article introduces the latest automated inspection approach that could use the glow stripe visualization of rubber wheels to investigate the outermost layer. Placing the tire on a spinning mat to suppress the standard trend of the exterior of a tire, image sensing of the tire surface was introduced (Tokodachi,2015). After extracting the external thin defect, the suggested process identifies exemptions defect because of the actual tire shape, the eccentricity of the revolving table, and the discrepancy between any of these two rotating bases, three kinds of uneven circularities (Kaizu-cho, Toyota,2015). Consequently, in this review, an inspection process mechanism was invented by interpreting lighter stripes pictures by translating the three-dimensional structure of the tire surface into the detail of the two-dimensional view.

It seems impossible to automate the visual inspection of automotive tires because tires are dark surface-colored rubber materials with a smooth pliable structure. Otherwise, the lighting system calculations are needed by tires to suppress illumination unevenness. Compared to metal and plastic goods, in terms of versatility, shape, and color scheme, it has dissimilarities. An overwhelming number in recent years in different sectors, visual inspection applications are suggested (Kazuhiko Sumi and Shun'ichi Kaneko: "Real Application of Machine Vision Technology", IEEJ Trans. C, Vol. 124, No.3, pp. 598-605, 2004). However, there are significant difficulties with a visual inspection of rubber tires, because there are the following reasons (Hiroyasu Koshimizu, Noriko Nagata, Takio Kurita, Kunihito Kato,2004). Therefore, the tire defects are transparent in contrast and a quite minimal inset. Wheel inspection techniques for both in and out of defects have been suggested to deal with this situation. (Hiroyasu Koshimizu, Takayuki Fujiwara, Wataru Otani, Hirokatsu Mizukusa, and Munetoshi Imada, 2010). Besides, to accurately calculate the tiered surface, it analyzed the measurement techniques by rotating the tires using the lighter strip. Furthermore, it measured a darkroom. Solved the contamination issues as a result I. It discovered, the issue, however, that the informality of the center of symmetry from the observations of experiments conducted exists. Furthermore, to conclude that the eccentricity value as in the consistency of the system is approximately equal to (J. Stephant, 2005). First, the tire shape is not a real circle. Secondly, the deformations element is also related to the board adjustable performance movement. Thirdly, because of a coincidence between two moving axes, eccentricity occurs. The system's procedure must therefore be constructed as Figure 2-1 (Hiroyasu Koshimizu, 2005).

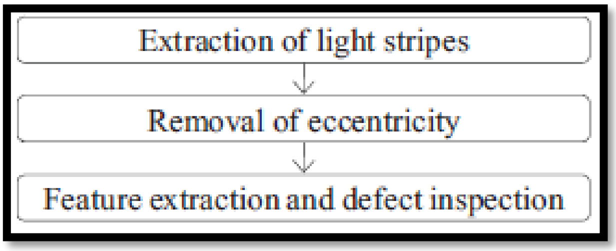

Figure 2-1 The system Procedure (Hiroyasu Koshimizu, 2005)

The projection machines for tires, monitors, and light strips were installed as indicated in Figure 2-3 (Takayuki Fujira,2005). As shown in Figure 2-4, from a single direction the bright strips of turbulence are transferred. Since this system has a positional relationship between the system and the system the camera and machines for projection. The position of the instruments and their parameters are revealed in Figure 2-2. Parallel to the horizontal direction, the screen, and the reflection of the light frame are set.

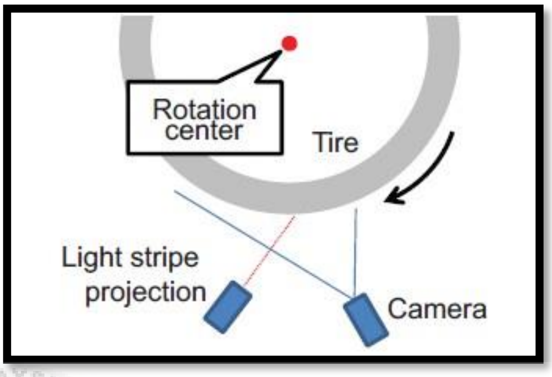

Figure 2-2 Measurement of tire surface with light stripe (Takayuki Fujira,2005)

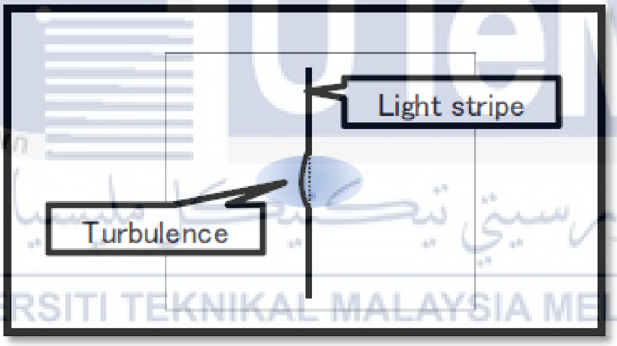

Figure 2-3 An example of the surface of the tire and the pattern of the light stripe. (Gyula Mester,2013)

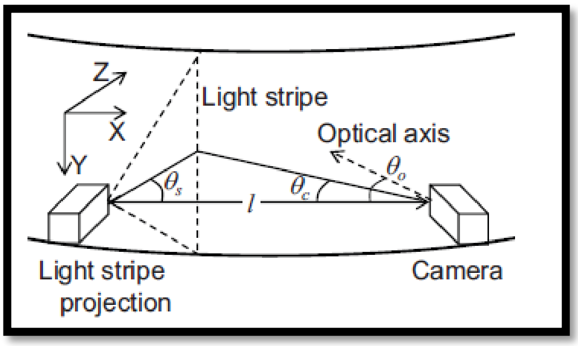

Figure 2-4 Parameter projection of the screen and the light pattern (Hiroyasu Koshimizu,2011)

2.2.2 Past Studies of a Watch in Development of the Intelligent Tire Inspection and Monitoring

In the last decade, tire defects have increased the protection of tire problems and a significant proportion of tire failures have been triggered by manufacturing faults or inadequate repair facilities. (F.Y. Wang,2006). Among them, under-inflated tires are now recognized as one of the main reasons for road accidents. Besides, less well tires can also create quicker damage on the rubber surface, poor vehicle control, and poorer fuel consumption. (Q. Zhou,2006). However, several individuals did not realize they had fewer well tires. (M. Kowalweki,2005). It is mostly because multiple drivers check the tire of their automobile relying on previous survey data. The major problem in visually calculating tire pressure when a tire is significantly less well or dropped caused by natural leakage or variations in environmental weather are the other influencing factors. (J. Stephand,2005). Tire layer textures and temperature testing of the tire surface. In this sector, these are the two frequently described directions (A. Pohl,2006). Tire surface textures affect two aspects at least significantly, coefficients of tire/road friction and tire noise. Since human eyes can estimate the wear level of a tire relatively easily, in the past 30 years, quite the least exposure has been paid to automatic analysis of the surface texture of the tire. (W. Buff,2006). Many energies are put into an inspection of the surface temperature of the tire since a too high temperature can affect the structure of the tire. Additionally, the gained for tire-road friction modeling, it is possible to apply tire surface climate data.

In Figure 2-5, a typical tire pressure variance mechanism is shown. (L. Reindl,2008). From the curves, it could see that at the start of 15 minutes, the tire temperature increases rapidly. After 45 minutes, roughly the temperature of the tire will hit steady-state minutes from the start. At this time, thermal energy is approximately in equilibrium with thermal transfer. Even so, these equations also mean that the temperature increase in each portion of the tire must provide an identical level of a warming trend. (R. Seidhl,2007).

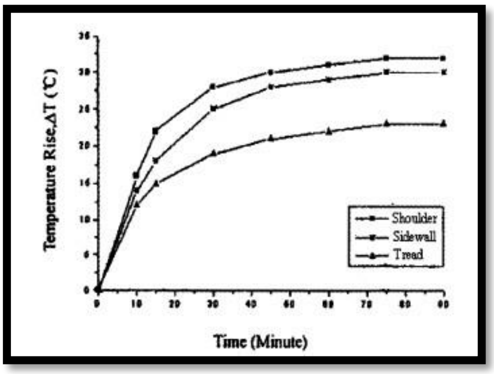

Figure 2-5 Tire temperature variation process (L. Reindl,2008)

How to provide power is the most significant issue that needs to be solved for sensors to tire. An appropriate solution is to transfer torque to the tires by certain forms of sliding touch from the vehicle supply (Y.J Lin,2005). This strategy was once strongly contemplated but ultimately dismissed for both cost and reliability concerns. Using a so-called radio sensor technology is the latest process (U. Sandberg,2006).

Significant efforts have been made on Surface Acoustic Wave (SAW) instruments, since they do not need any other power source and can be wireless connection inspected (K. Seki,2007). An electromagnetic request signal is collected by such a SAW transponder and stored until all noises generated by the transmission of multipath have dropped away (K. Seki,2007). An aspect answer, then they reflect the device of the investigator. In the nearby environment, any physical or chemical quantity factors subsequently, SAW's transmission mechanisms and the result sequence of the system will be altered. The facts of the matter concentrate on SAW tire heating elements: temperature-dependent wave propagation velocity vectors are measured by the angles and shape of the crystalline phase used to manufacture the sensor. (Y.J Lin,2007). They are typically enclosed in a hermetic box because They are quite susceptible to pressure processing. Figure 2-6 shows the temperature sensors typically use SAW modulation oscillators to provide millidegree resolution, good linearity, and minimal thermal conductivity. (G. Zhao,2007).