# Vision Based Tyre Sorting System

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***Abstract*** **–The tyres being manufactured in tyre industries have different dimensions and tread pattern based on the type of vehicle and customer needs (automobile industries). Depending on dimensions and pattern, tyres are segregated into various classes. A unique class of tyres are lead to their own distinct bins for packaging. The classification of tyres for this purpose is meant as sorting of tyres. The developed solution uses images of the tyres to perform classification. Canny edge detection [1] and Structural similarity index metric (SSIM) [3, 4] are used in the solution for tread pattern identification and comparison respectively. The other feature taken into consideration is the inner and outer diameter of the tyres. Dimensions of the tyres are found by applying contours [5, 6]. For the purpose of managing, the data of when and which class of tyre was recognized is updated into Open source IoT platform, Thingspeak. This paper describes the design, algorithm, flow, and development of a prototype built using GR Lychee microprocessor.**

**Keywords**: **Tyre sorting, IoT, GR Lychee.**

## I. INTRODUCTION

The Indian State of Tamil Nadu has been an ideal hot-spot for tyre manufacturers because of local skill availability, infrastructure, ecosystem and its proximity to the natural rubber producing State of Kerala [3]. In spite of the tough competition by other states, Tamil Nadu continues to be chosen favorite place by all the manufacturers. The rubber goes through a lot of stages before becoming a tyre. The crucial part in a tyre manufacturing process is the sorting of the tyres based on the features. This process is usually done manually. In an era of emerging new technologies and automation, the industries look forward to automate all processes that they carry out. Because of the reduced skilled manpower and accuracy, it is required to automate the process of tyre sorting.

In the automotive industry, the tyres are sorted manually based on dimensions and distinct tread pattern of the tyre. However, in tyre sorting there is a possibility of human error which in turn will reduce the company's reputation among their customers. Hence the system desired should be free of discrepancies in tyres, cost effective and suitable for real time implementation.

The Developed solution takes the advantages of Image processing and open source platforms; most desirable of which is their reliability and economic benefits. The Improved canny algorithm is more robust to noise and clear edges are derived [1]. SSIM is proved to be more consistent that PSNR and HVS methods [3, 4]. Lastly, the contour application is used for measurement of dimensions. Generally, contours are useful for shape analysis and object detection. This paper follows a simple linear time algorithm and Green formula for drawing contour and finding area of the contour respectively [5, 6]. A prototype model was made to simulate the conditions of the sorting section in the industry. For this purpose, few miniature models of tyres were designed and printed using Flashforge 3D printer. The models were designed to vary in diameter and tread pattern.

## II. MODULE DESCRIPITION

### a. Gr-Lychee

GR-LYCHEE is an IoT prototyping board with camera and wireless (Wi-Fi, BLE) module. And GR-LYCHEE is the GR reference board for RZ family RZ/A1LU group products. Pin-compatible with Arduino UNO and ARM mbed enabled development platform. You can also sketch like Arduino with Renesas Web Compiler and IDE for GR.

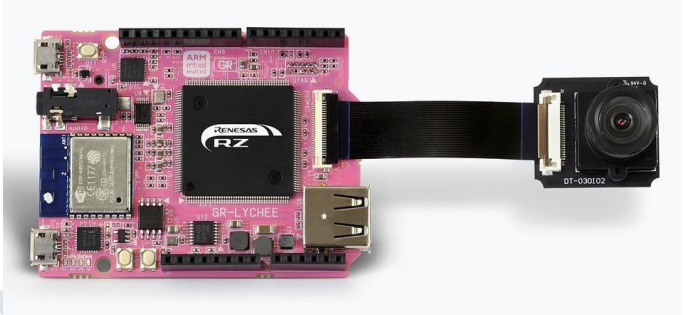


**Fig. 1 GR Lychee with camera**

The RZ/A1LU includes an Arm® Cortex™-A9 processor along with the integrated peripheral functions required to configure a system. The RZ/A1LU includes a 32-Kbyte L1 instruction cache, a 32-Kbyte L1 data cache, and a 128-Kbyte L2 cache.

This LSI also includes on-chip peripheral functions necessary for system configuration, such as a 3-Mbyte large-capacity RAM, 128 Kbytes data-retention RAM(shared by the large-capacity RAM), various timer function, real-time clock, serial communication interface(UART), I2C bus interface and graphics related functions etc.

### b. Camera

The Camera Module can be used to take high-definition video, as well as stills photographs. It's easy to use for beginners but has plenty to offer advanced for those looking to expand the knowledge. There are lots of examples online of people using it for time-lapse, slow-motion, and another video cleverness. It supports 1080p30, 720p60 video modes, as well as still capture. It attaches via a USB port on the Gr Lychee.

### c. Motor

Motor is the most common moving element for a robot among other possibilities including legs, flying, swimming and rolling. A motor provides the speed, accuracy and stability for a robot, the three characteristics very important in designing and build robots.Depending on the design and requirements, standard wheels are used especially for classical methods of driving and steering while oriental and ball wheels are included in the same category and used for balancing a robot.

### d. 3D Model

3D printing is any of various processes in which material is joined or solidified under computer control to create a three-dimensional object. In 3D Printing, a three-dimensional object is built from computer-aided design (CAD) model, usually by successively adding material layer by layer, unlike the conventional machining process, where material is removed from a stock item.

Construction of a model with contemporary methods can take anywhere from several hours to several days, depending on the method used and the size and complexity of the model.

## III. SYSTEM ARCHITECTURE

In order to sketch the working we indeed to consider our prototype work. In our prototype, we made a conveyor (mini) setup consisting of a PC, 2 webcams and a controller. And we have also used few miniature models of tyres using a 3D printer. The webcams are used to capture the images of top view and side view of the tyres and the PC runs python script of our algorithm. After identification of a specific tyre, a trigger signal is provided to the controller (GR Lychee) so that the tyres are sorted with the help of DC motors. Now, when considering a standalone device, we obviously need a processor that can run python compatible with OpenCV library. The apt device would be the GR Lychee. The RZ/A1LU includes an Arm Cortex-A9 processor along with the integrated peripheral functions to configure a system. Hence, it can also serve the purpose of a controller for managing the DC motors. The flow is visualized below.

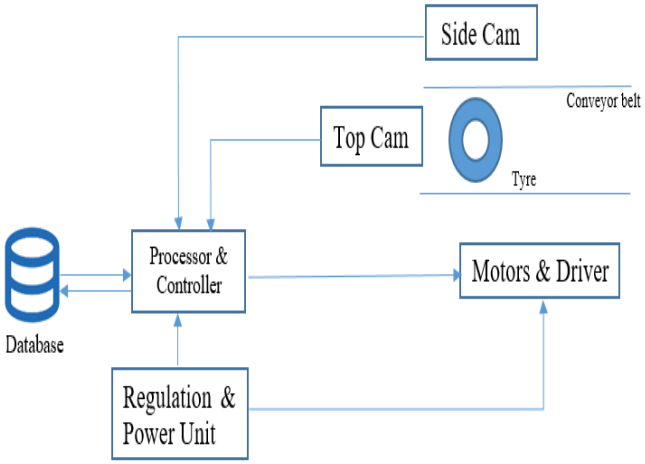


**Fig.2 Block Diagram**

The building block of a project is their components. The relation between components is represented in a diagrammatic way with blocks. Our project consists of the blocks as shown in Fig. 2. The Side camera and Top camera are Logitech c170 web cameras. The Motors used are 9V DC gear motor. We have used GR Lychee and Arduino as two different platforms for the executing the project. For power regulation, a 9V DC adapter is used.

## IV. FLOW CHART

A flow chart represents the algorithmic flow of execution of a project. It is useful to quickly understand the project in first glance. Our project flow chart starts with the diameter recognition and followed by pattern recognition as shown in Fig. 3. The successful identification of these parameters (inner diameter, outer diameter and pattern recognition) lead to sorting of the tyre. Else the tyre is recognized to be not found and made to identify again.

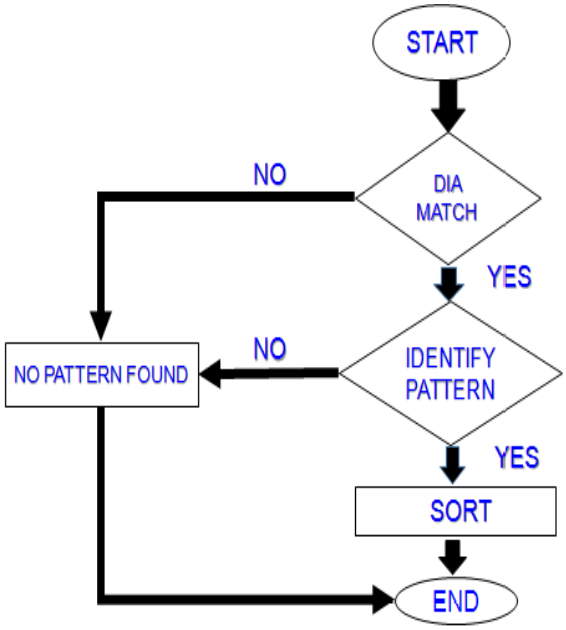


**Fig.3 Flow chart**

If a pattern is not found, then it is taken us new pattern or poor recognition of the existing pattern. In this case, the decision is made by the concerned executives.

## V. METHODOLOGY

The System is divided into two modules. For easier execution, named as, diameter recognition and pattern recognition. Firstly, the tyres are classified based on their diameters by following Module-1 algorithm and to differentiate tyres that have the same diameter, tread pattern of the tyres are identified (by Module-2 algorithm) and thus sorting is being carried out. Upon classification, the information of when (time) and what (type based on diameter and pattern) is logged into the IOT platform.

Initially, the following algorithm has been designed for PC with two webcams. (It will be fairly suitable for our standalone model as well).

**Module - 1 (Diameter Recognition)**

**Step 1: Capture Image**

The Foundation for our project is the image of tyres taken from top and sideways.

**Step 2: Grayscale conversion**

A gray image is one in which the value of each pixel is a single sample representing only an *amount* of light, that is, it carries only intensity information. Color images are often built of several stacked color channels, each of them representing value levels of the given channel.

$$\text{Gray Intensity,} \quad I = \frac{R+G+B}{3}$$

**Step 3: Blur and Threshold**

The Gaussian blur is a type of image-blurring filter that uses a Gaussian function (which also expresses the normal distribution in statistics) for calculating the transformation to apply to each pixel in the image. The formula of a Gaussian function in one dimension is

$$G(X) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{\frac{-x^2}{2\sigma^2}}$$

In two dimensions, it is the product of two such Gaussian functions, one in each dimension:

$$G(X, Y) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{\frac{-x^2+y^2}{2\sigma^2}}$$

**Step 4: Identifying Contours**

A contour line of a function of two variables is a curve along which the function has a constant value, so that the curve joins points of equal value. It is a plane section of the three-dimensional graph of the function $f(x, y)$ parallel to the $x, y$ plane.

**Step 5: Sort (decisive)**

In this step, based on the above classified decision the tyre will be sorted.

**Step 6: Update into IOT**

The information of when and which tyre was recognized is updated into Thingspeak platform.

**Step 7: Repeat step 1.**

**Module – 2 (Pattern Recognition)**

**Step 1: Capture Image**

**Step 2: Grayscale conversion**

**Step 3: Edge detection**

We are using canny edge detection for our project. Canny edge detection is a technique to extract useful structural information from different vision objects and dramatically reduce the amount of data to be processed.

**Step 4: Set Threshold and apply SSIM**

The structural similarity (SSIM) index is a method for predicting the perceived quality of digital television and cinematic pictures, as well as other kinds of digital images and videos.

$$\text{SSIM (x, y)} = \frac{(2\mu_x\mu_y + c_1)(2\sigma_{xy} + c_2)}{(\mu_x^2 + \mu_y^2 + c_1)(\sigma_x^2 + \sigma_y^2 + c_2)}$$

## VI. RESULTS

The Inner diameter and outer diameter are found from the outer and inner contours. The measurement of three tyres are used in our project.

**a. Tyre TYPE 1**

The Inner Diameter and Outer Diameter of the TYPE1 tyre is 1.4 inch and 0.95inch respectively. Thus the radii are 0.7inch and 0.47inch. The Difference between these two radii is taken as the parameter for feature. The Radii difference is 22.5inch.

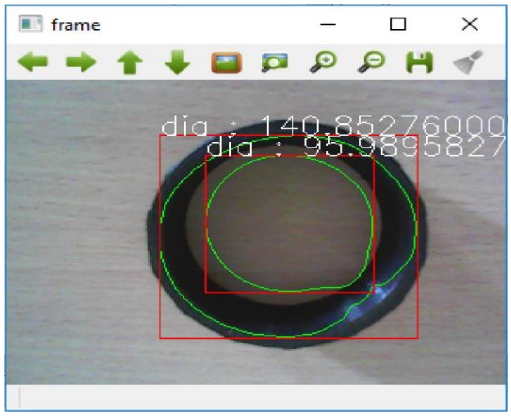


**Fig.4 Type 1 tyre inner and outer diameter**

**b. Tyre TYPE 2**

The Inner Diameter and Outer Diameter of the TYPE2 tyre is 1.75 inch and 0.80inch respectively. Thus the radii are 0.87 inch and 0.40 inch. The Radii difference is 0.47inch.

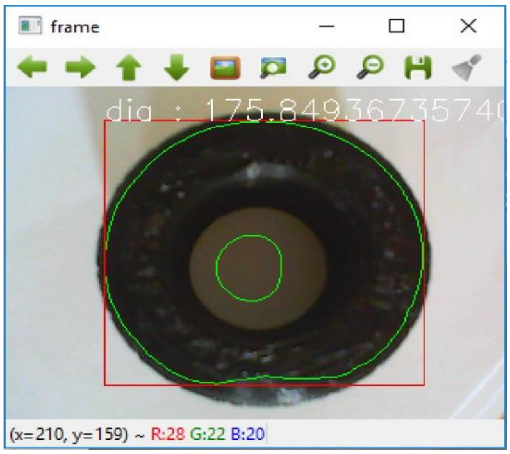


**Fig.5 Type 2 tyre inner and outer diameter**

**c. RESULT FOR MODULE 2**

The Tread Pattern of the tyres are extracted using canny edge detection algorithm.

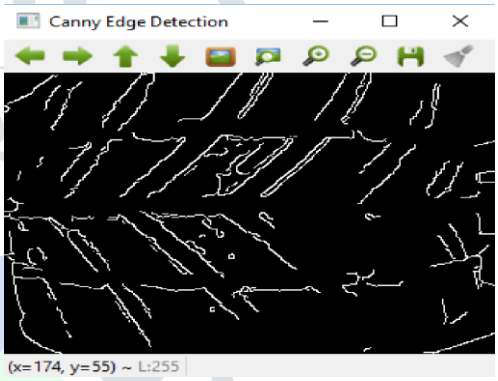


**Fig.6 Tread Pattern**

## VII. CONCLUSION

In today's era, small scale and large scale industries faces common hindrance like shortage of time and workers which leads to inefficient manufacture. Previously the sorting of tyres were done manually either based on weight or based on the diameter. This methodology gives less accuracy since human errors can arise. Also the world is marching towards automation of various processes. So we have automated the sorting of two wheeler curved tyres for Storage keeping Units and uploaded the data into IOT platform.

We implemented the project using GR LYCHEE microprocessor and automated such systems to bring about highest accuracy and less maintenance. A prototype of our work was developed and Miniature tyres of varying radius has been printed using 3D printer. These tyres were used for the successful demonstration of our project. By our proposed algorithm, the tyres of various size can be sorted automatically without any error.

## VIII. FUTURE ENHANCEMENT

The future work might be to implement the solutions in real tyres for practical implementations.

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