B.E FOURTH YEAR ELECTRONICS AND TELECOMMUNICATIONS ENGINEERING PROJECT REPORT ON

INSPECTION OF MECHANICAL JOB USING IMAGE PROCESSING AND DEEP LEARNING

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CERTIFICATE

This is to certify that the project report entitled

INSPECTION OF MECHANICAL JOB USING IMAGE PROCESSING AND DEEP LEARNING

Submitted By

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Is a bonafide work carried out by them under the supervision of Prof. **M.M.Patil** it is approved for the partial fulfilment of the requirement of University of Pune for the award of the Third year of Bachelor of Engineering (Electronics and Telecommunication).

This Mini-project and Seminar report has not been earlier submitted to any other Institute or University for the award of any degree or diploma.

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Place: Pune

Date: External Examiner

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ACKNOWLEDGEMENT:

It gives me an immense pleasure to submit this report on **" MECHANICAL JOB INSPECTION USING IMAGE PROCESSING AND DEEP LEARNING ".**I have tried my level best to represent this topic into compact and to the point framework.

I truly express my deepest thanks to all the people who have given their precious time and encouragement and my guide **Prof. M. M. PATIL** for the patience she showed me during the process of preparation of the report from the initial conception to the final presentation and all the staff of E&TC department. I would like to thank from the core of my heart to our H.O.D of E&TC department **Prof. K.M. GAIKWAD** for being constant pillar of support, during the preparatory stages.

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ABSTRACT:

The increase in demand for industrial automation in the manufacturing industry has exposed the significance of machine vision in quality inspection and process monitoring. Contrary to stylus instruments, the computer vision systems have the advantages of being non-contact. In the present study a novel technique has been reviewed to explore various applications of Image processing inspection of cutting tool surfaces. Measurement and inspection of Surface roughness, Tool wear, Tool profile, Thickness of coating done on tool and Surface defects are all reviewed in this paper which will help in developing a specialized inspection system particularly for inspection of machining tools alone in reduced production cost.

Chapter 1

INTRODUCTION:

1.1 Motivation:

Computer vision systems are widely implemented in automatic inspection systems. The quality management of mechanical parts in industries is vital for appropriate job selection. Defect detection should be done in the pre-production stage ensuring quality control. Real time inspection using manual labour is inadequate, time consuming and non-consistent. Hence there is a need for a system which is built for automatic defect detection which will help in finding out if a particular job can be used or not, such that it avoids human errors and is comparatively accurate. The system builds a computer vision system which detects the defective objects by comparing it with a preferred image from the database. This paper makes use of an overhead camera mounted at specified height which sends recorded images to the Raspberry Pi. Pattern recognition is performed to identify the defective objects. It identifies the surface irregularities such as chipped surface or missing teeth from the and thereby helps in identifying a useful job from a non-useful one.

1.2 Problem Statement:

The aim of our project is build a device which will inspect the produced mechanical jobs and inform the operator whether the job is completed, ready to use or is incomplete and cannot be used. The device will reduce the required human effort and error.

1.2 Objective of proposed work:

The Objective of the proposed work is to inspect the mechanical job and detect whether the given job is good or not.
Authorities regarding the same

- Avoids the human error caused by the manual labour.
- It is the best way to increase the effectiveness, efficiency and coverage for job selection.
- By defect detection we can ensure the quality of the mechanical job at the pre-processing stage.
- Companies that implement these techniques benefit from shorter production time for products and also can ensure a good quality product.

Chapter 2

LITERATURE REVIEW:

Appropriate mechanical job selection and quality management are growing in importance in industrial development and production. The decentralized production of components by suppliers means that tight specifications have to be met to ensure problem free assembly in final production, resulting in a high quality final product. Test engineers strive to catch defects before the product is released but they always creep in and they often reappear, even with the best manual testing process. Image processing is the best way to increase the effectiveness, efficiency and coverage for job selection. Typical features such as hole patterns as well as borders, sharp edges, elongated holes can be measured with Quality Control using Image Processing (QCUIP). The full surface component measurement enables a simple good GO/NO GO statement. It also shows the deviation for a fast evaluation of processing. This means early detection of potential problems so that processes can be corrected in a timely manner, resulting in lower production cost and efficient quality control. Companies that implement these techniques benefit from shorter production time for products. Companies remain competitive because they help their customer to go from idea to product faster, optimize production Workflow and minimize rejects while production is running.

Chapter 3

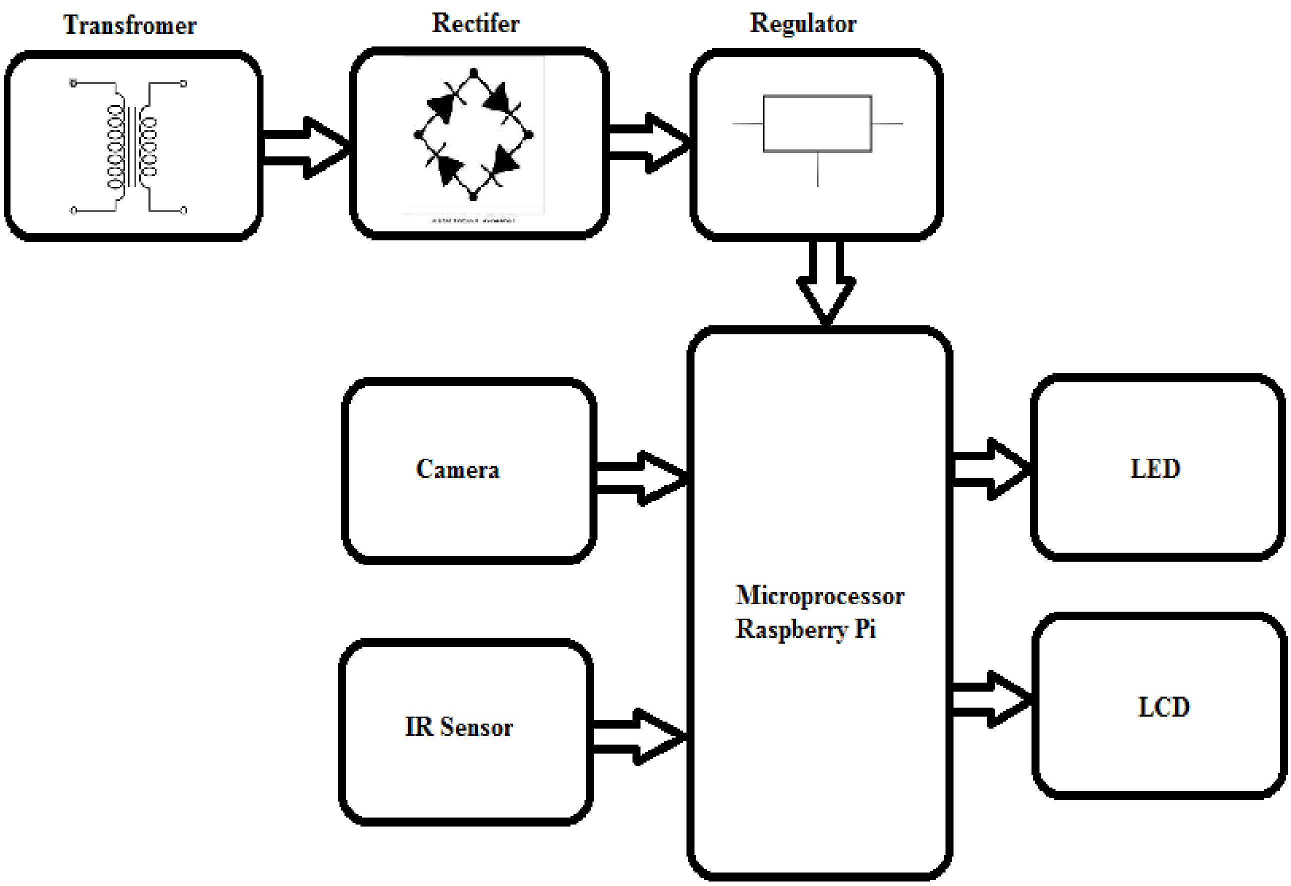
Project Description:

3.1 Introduction:

Computer vision systems are being extensively used in industrial solutions these days, especially in developing image based automatic inspection systems. It integrates image processing techniques to solve real world problems. These systems are mainly used for quality assessment in industries. Mechanical parts are the fundamental units in manufacturing of machineries. Basic components like gears and metal sheets are important in the design and manufacturing sector. Gears are most commonly used in rotating machineries. They are used in transfer of velocity and torque from one shaft to another. Though inexpensive, an inappropriate job usage which results in its failure can disturb the complete production in a plant results in production losses. Hence mechanical job detection is vital and should be accurate. Surface defect is one of the most crucial causes which affect the performance of metal sheets. It often arises as a result of systematic process problems, such as partially damaged machinery or metallurgical drift which might not be visible to the human eye and this leads to poor quality job selection. Thus, the early detection of defects can also have a direct cost benefit in terms of saving of time as well as to prevent rejection from being generated in large quantities, in downstream. Geometric defects detection such as cracks, scratches, holes can help in correct job selection which can be implemented using thresholding for edge-detection techniques. The visual detection by human eyes is not accurate in massive production. Thus Automatic Quality control becomes an important part in industries during the manufacturing process. Thus, defective parts need to be identified in the pre-production stage and segregated. Manufacturers can attain a higher order of accuracy and convenience, as it gives freedom from human errors related to labour.

Digital image processing is used to extract various features from images. This is done by computers automatically without or with little human intervention. This synopsis deals with integration of pattern recognition techniques into an automatic test system for data acquisition and classification in order to detect whether the particular job is correct or not by analysis of mechanical faults.

3.2 BLOCK DIAGRAM:



3.3 Working

Digital Image Processing techniques are employed to verify almost all the products that are coming out of the product line. This is executed using the following steps.

- Image Classification

  This is the first step in the process of mechanical job inspection. Here, we create a dataset for each mechanical job using a camera. This gives us a total of seven datasets each consisting of about a hundred images.

- Data Labeling

  In this process manually label the input data so that the Deep Learning algorithm can eventually learn to make the predictions on its own. The objective at this point will be to identify the mechanical job under inspection by comparing it with the available images stored in the datasets.

- CNN

  By using convolution neural network aka CNN, type of objects in an image can be detected with ease. In order to achieve this, we execute the following steps:-

1. Convolution Operation

   Convolute input image with feature detector, number of matching points which gives feature map. We create many feature maps to obtain our first convolution layer.

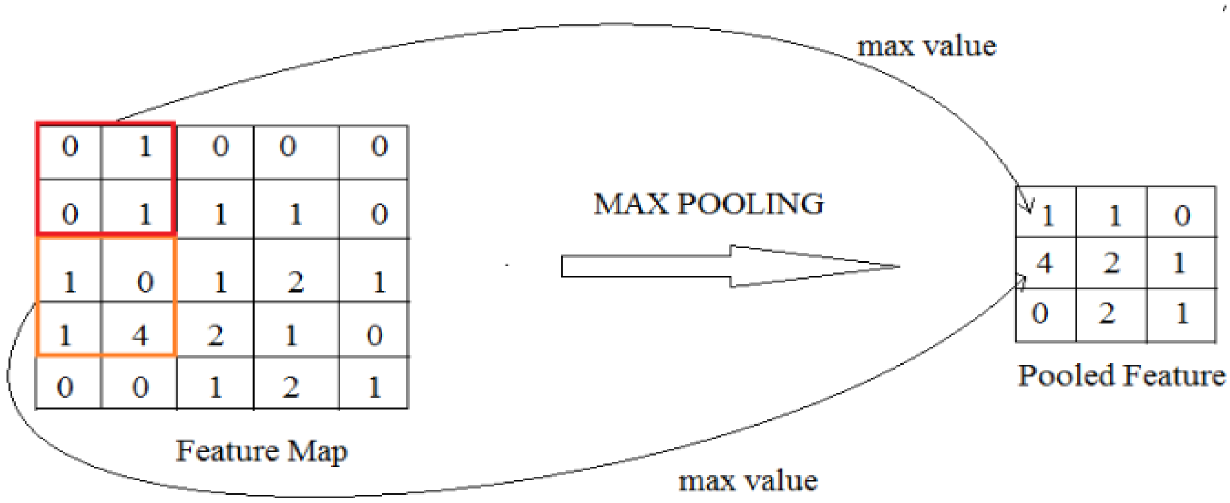
$$(f * g)(t) \triangleq \int_{-\infty}^{\infty} f(t-\tau)g(\tau)\,d\tau.$$

2. ReLU Layer

   The main purpose of applying rectifier transform is to increase the non-linearity in our network.

3. Pooling

   Pooling is also called as downsampling, for our system we are using max pooling. The main purpose of max pooling is to extract important features from the feature map.



4. Flattening

    Flattening is converting the data into a 1-dimension array for inputting it to the next layer. Flattening transforms a two-dimensional matrix of features into a vector that can be fed into a fully connected neural network classifier.

    Full connection

    A fully connected layer also known as the dense layer, in which the results of the convolutional layers are fed through one or more neural layers to generate a prediction label.

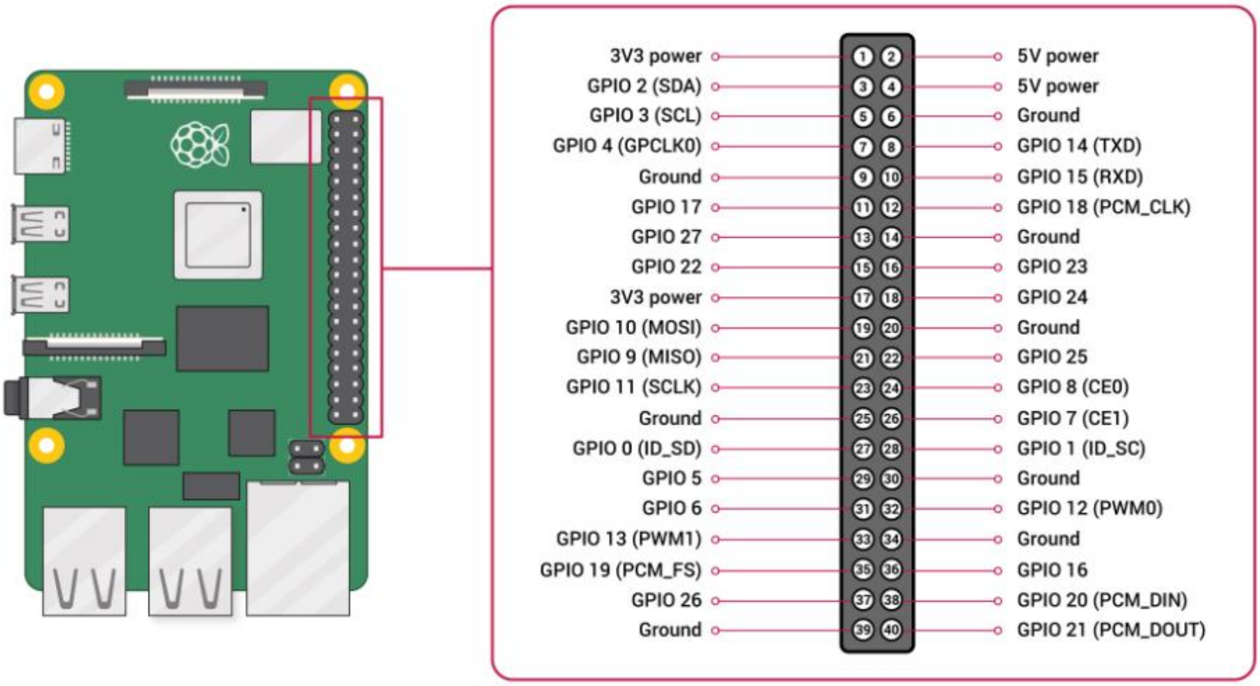
    Softmax and cross entropy

    After the labels are generated, we employ the soft max and cross entropy function in which the final probabilities of each label is determined. Higher the probability, higher is the accuracy of mechanical job inspected.

- DIMENSIONS INSPECTION/VALIDATION

    Finally the image is subjected to some threshold operations wherein the dimensions of the mechanical job is calculated and then compared with the expected dimensions. If the calculated dimensions matches with the expected dimensions then the mechanical job is considered to be error free which gets displayed on the LCD and by glowing of an LED.

3.3 Raspberry Pi 3B+ Pinout:



3.4 Features:

The Raspberry Pi 3 Model B+ is the final revision in the Raspberry Pi 3 range.

- Broadcom BCM2837B0, Cortex-A53 (ARMv8) 64-bit SoC @ 1.4GHz
- 1GB LPDDR2 SDRAM
- 2.4GHz and 5GHz IEEE 802.11.b/g/n/ac wireless LAN, Bluetooth 4.2, BLE
- Gigabit Ethernet over USB 2.0 (maximum throughput 300 Mbps)
- Extended 40-pin GPIO header
- Full-size HDMI
- 4 USB 2.0 ports
- CSI camera port for connecting a Raspberry Pi camera
- DSI display port for connecting a Raspberry Pi touchscreen display
- 4-pole stereo output and composite video port
- Micro SD port for loading your operating system and storing data
- 5V/2.5A DC power input
- Power-over-Ethernet (PoE) support (requires separate PoE HAT)

3.5 Pin description:

A GPIO pin designated as an input pin can be read as high (3V3) or low (0V). This is made easier with the use of internal pull-up or pull-down resistors. Pins GPIO2 and GPIO3 have fixed pull-up resistors, but for other pins this can be configured in Voltages

Two 5V pins and two 3V3 pins are present on the board, as well as a number of ground pins (0V), which are unconfigurable. The remaining pins are all general purpose 3V3 pins, meaning outputs are set to 3V3 and inputs are 3V3-tolerant.

Outputs

A GPIO pin designated as an output pin can be set to high (3V3) or low (0V).

Inputs

A GPIO pin designated as an input pin can be read as high (3V3) or low (0V). This is made easier with the use of internal pull-up or pull-down resistors. Pins GPIO2 and GPIO3 have fixed pull-up resistors, but for other pins this can be configured in software.

More

As well as simple input and output devices, the GPIO pins can be used with a variety of alternative functions, some are available on all pins, others on specific pins.

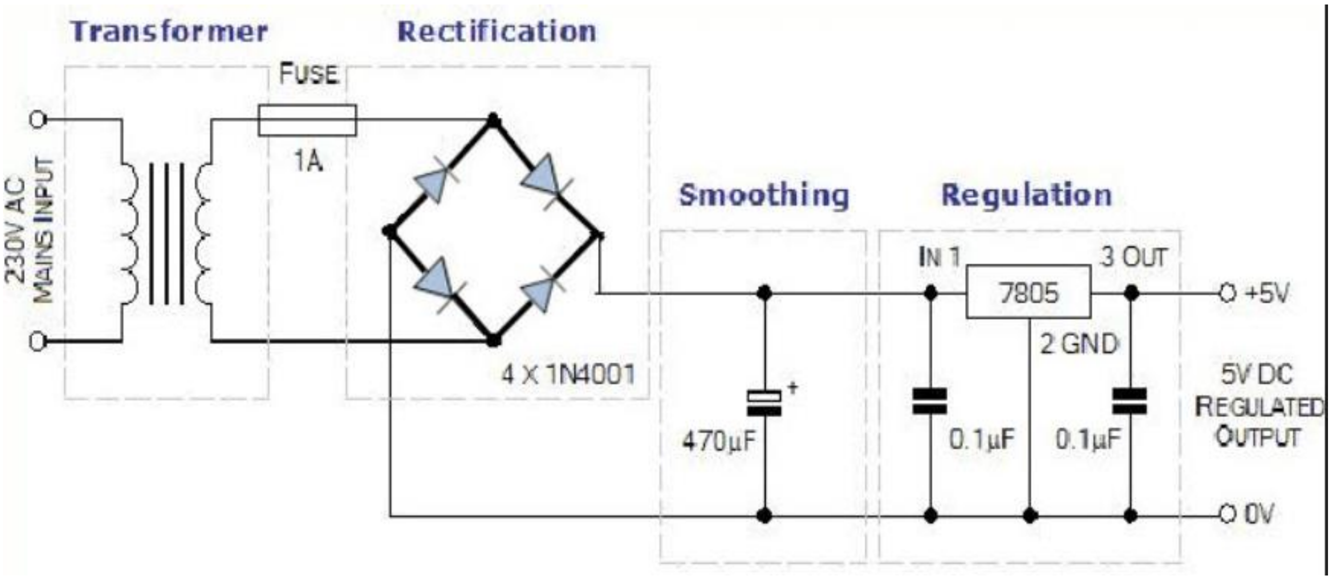
- PWM (pulse-width modulation)
  - Software PWM available on all pins
  - Hardware PWM available on GPIO12, GPIO13, GPIO18, GPIO19
- SPI
  - SPI0: MOSI (GPIO10); MISO (GPIO9); SCLK (GPIO11); CE0 (GPIO8), CE1 (GPIO7)
  - SPI1: MOSI (GPIO20); MISO (GPIO19); SCLK (GPIO21); CE0 (GPIO18); CE1 (GPIO17); CE2 (GPIO16)
- I2C
  - Data: (GPIO2); Clock (GPIO3)
  - EEPROM Data: (GPIO0); EEPROM Clock (GPIO1)
- Serial
  - TX (GPIO14); RX (GPIO15)

3.6 Power Supply:

The basic step in the designing of any system is to design the power supply required for that system. The steps involved in the designing of the power supply are as follows,

1. Determine the total current that the system sinks from the supply.
2. Determine the voltage rating required for the different components.

The bridge rectifier and capacitor I/p filter produce an unregulated DC voltage which is applied at the I/P of 7805.As the minimum dropout voltage is 2v for IC 7805, the voltage applied at the input terminal should be at least 7 volts .nC1 (470 µf / 65v)is the filter capacitor and C2 and C3 (0.1u f) is to be connected across the regulator to improve the transient response of the regulator. Assuming the drop out voltage to be 2 volts, the minimum DV voltage across the capacitor C1 should be equal to 7volts (at least).



POWER SUPPLY

3.7 CAMERA MODULE

A camera module is an image sensor integrated with a lens, control electronics, and an interface like CSI, Ethernet or plain raw low-voltage differential signalling.

An image sensor or imager is a sensor that detects and conveys information used to make an image. It does so by converting the variable attenuation of light waves (as they pass through or reflect off objects) into signals, small bursts of current that convey the information. The waves can be light or other electromagnetic radiation. Image sensors are used in electronic imaging devices of both analog and digital types, which include digital cameras, camera modules, camera phones, optical mouse devices, medical imaging equipment, night vision equipment such as thermal imaging devices, radar, sonar, and others. As technology changes, electronic and digital imaging tends to replace chemical and analog imaging.

The two main types of electronic image sensors are the charge-coupled device (CCD) and the active-pixel sensor (CMOS sensor). Both CCD and CMOS sensors are based on metal–oxide–semiconductor (MOS) technology, with CCDs based on MOS capacitors and CMOS sensors based on MOSFET (MOS field-effect transistor) amplifiers. Analog sensors for invisible radiation tend to involve vacuum tubes of various kinds, while digital sensors include flat-panel detectors.

3.8 IR SENSOR

IR sensor is an electronic device, which emits the light in order to sense some object of the surroundings. An IR sensor can measure the heat of an object as well as detects the motion. Usually, in the infrared spectrum, all the objects radiate some form of thermal radiation. These types of radiations are invisible to our eyes, but infrared sensor can detect these radiations. The emitter is simply an IR LED (Light Emitting Diode) and the detector is simply an IR photodiode.Photodiode is sensitive to IR light of the same wavelength which is emitted by the IR LED. When IR light falls on the photodiode, the resistances and the output voltages will change in proportion to the magnitude of the IR light received.

There are five basic elements used in a typical infrared detection system: an infrared source, a transmission medium, optical component, infrared detectors or receivers and signal processing. Infrared lasers and Infrared LED’s of specific wavelength used as infrared sources.

The three main types of media used for infrared transmission are vacuum, atmosphere and optical fibers. Optical components are used to focus the infrared radiation or to limit the spectral response.

Types of IR Sensor

There are two types of IR sensors are available and they are,

- Active Infrared Sensor
- Passive Infrared Sensor

Active Infrared Sensor

Active infrared sensors consist of two elements: infrared source and infrared detector. Infrared sources include the LED or infrared laser diode. Infrared detectors include photodiodes or phototransistors. The energy emitted by the infrared source is reflected by an object and falls on the infrared detector.

IR Sensor Working Principle

There are different types of infrared transmitters depending on their wavelengths, output power and response time. An IR sensor consists of an IR LED and an IR Photodiode, together they are called as PhotoCoupler or OptoCoupler.

IR Transmitter or IR LED

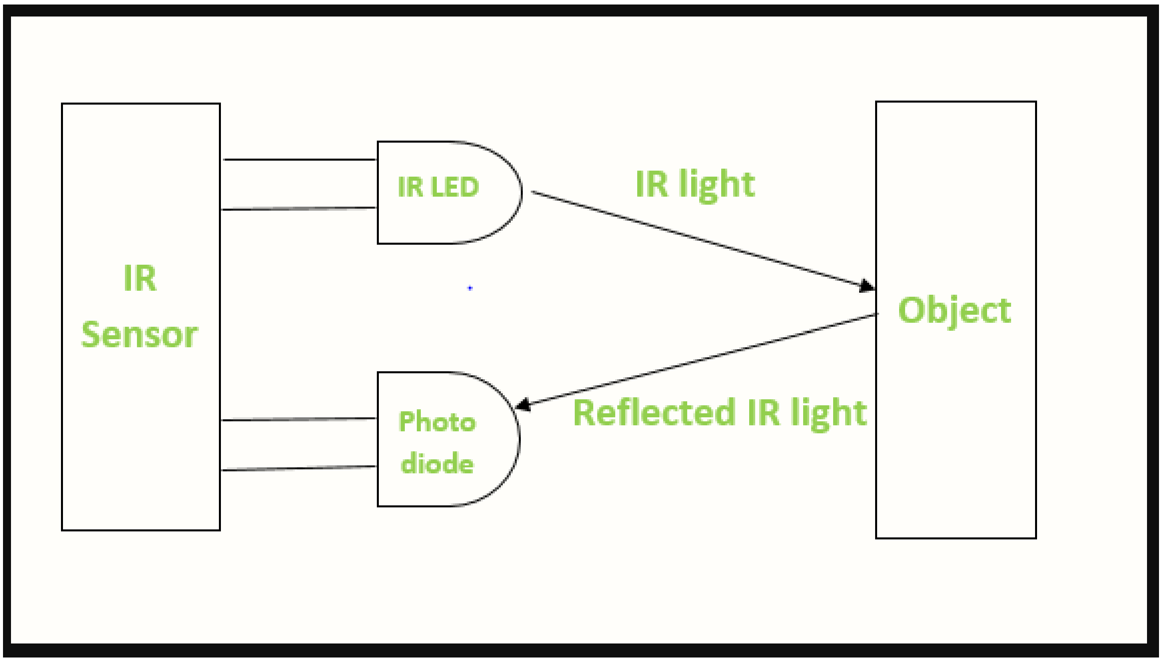
Infrared Transmitter is a light emitting diode (LED) which emits infrared radiations called as IR LED’s. Even though an IR LED looks like a normal LED, the radiation emitted by it is invisible to the human eye.

IR Receiver or Photodiode

Infrared receivers or infrared sensors detect the radiation from an IR transmitter. IR receivers come in the form of photodiodes and phototransistors. Infrared Photodiodes are different from normal photo diodes as they detect only infrared radiation. Below image shows the picture of an IR receiver or a photodiode, Different types of IR receivers exist based on the wavelength, voltage, package, etc. When used in an infrared transmitter – receiver combination, the wavelength of the receiver should match with that of the transmitter.

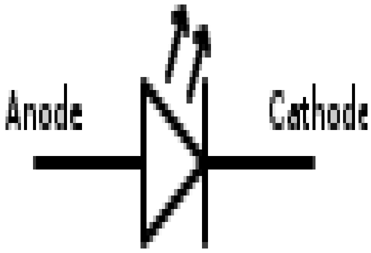
The emitter is an IR LED and the detector is an IR photodiode. The IR photodiode is sensitive to the IR light emitted by an IR LED. The photo-diode's resistance and output voltage change in proportion to the IR light received. This is the underlying working principle of the IR sensor.

When the IR transmitter emits radiation, it reaches the object and some of the radiation reflects back to the IR receiver. Based on the intensity of the reception by the IR receiver, the output of the sensor defines.



3.9 LED's:

A light-emitting diode (LED) is a semiconductor light source. LEDs are used as indicator lamps in many devices, and are increasingly used for lighting. A light-emitting diode (LED) is a semiconductor light source. LEDs are used as indicator lamps in many devices, and are increasingly used for lighting. The LED is based on the semiconductor diode. When a diode is forward biased (switched on), electrons are able to recombine with holes within the device, releasing energy in the form of photons. This effect is called electroluminescence and the colour of the light (corresponding to the energy of the photon) is determined by the energy gap of the semiconductor. An LED is usually small in area (less than 1 mm^2).



Characteristics:

Following are the characteristics of LEDs:

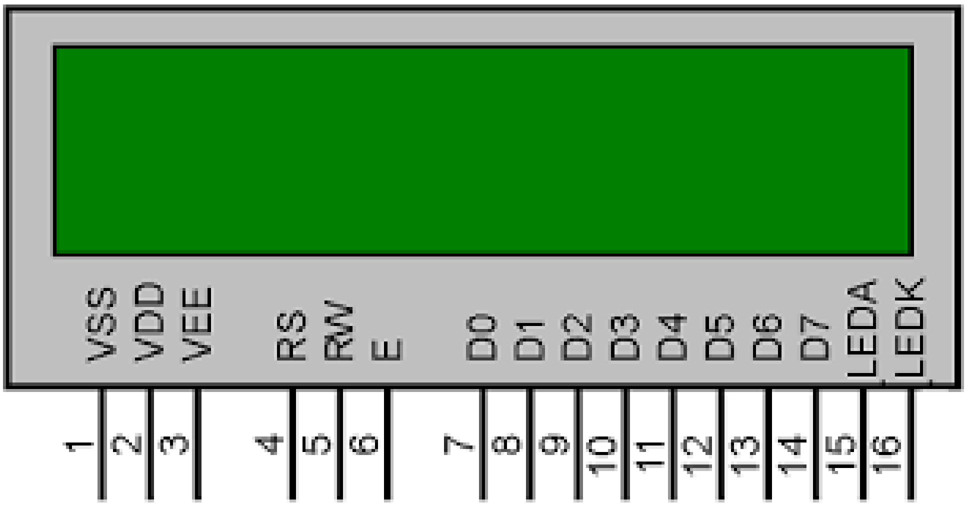
- Low working voltages and currents.
- Less power consumption.
- Very fast action.
- Small size and weight.
- Emission of monochromatic light.
- Extremely long life.

3.10 LCD Display (16*2):

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on.

A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers namely Command and Data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD. Click to learn more about internal structure of a LCD.

Pin Diagram:



Pin Description:

PIN NO.	FUNCTION	NAME
1	Ground(0V)	Ground
2	Supply voltage:5V (4.7V – 5.3V)	VCC
3	Contrast adjustment; through a variable resistor	VEE
4	Selects command register when low; and data register when	Register Select

	high	
5	Low to write to the register; High to read from the register	Read/Write
6	Sends data to data pins when a high to low pulse is given	Enable
7	8-bit data pins	DB0
8		DB1
9		DB2
10		DB3
11		DB4
12		DB5
13		DB6
14		DB7
15	Backlight V_{CC} (5V)	Led+
16	Backlight Ground (0V)	Led-

Pin no 15 and 16 are used for backlight control of LCD

LCD Commands =>The LCD's internal controller accept several commands and modify the display accordingly. These commands would be things like:

- Clear screen
- Return home
- Shift display right/left

The 44780 standard requires 3 control lines as well as either 4 or 8 I/O lines for the data bus. The user may select whether the LCD is to operate with a 4-bit data bus or an 8-bit data bus. If a 4-bit data bus is used, the LCD will require a total of 7 data lines. If an 8-bit data bus is used, the LCD will require a total of 11 data lines. The three control lines are **EN**, **RS**, and **RW**.

Chapter 4

Software Description

4.1 Spyder:

Spyder is an open source cross-platform Integrated Development Environment (IDE) for scientific programming in the Python Language. Spyder integrates with a number of prominent packages in the scientific Python stack, including Numpy, SciPy, Matplotlib, Pandas, IPython, SymPy and Cython, as well as other open-source software. It is released under the MIT license.

Spyder uses Qt for its GUI and is designed to use either of the PyQt or Pyside Python bindings.QtPy, a thin abstraction layer developed by the Spyder project and later adopted by multiple other packages, provides the flexibility to use either backend.

Features

1) An editor with syntax highlighting, introspection, code completion
2) Support for multiple IPython Consoles
3) The ability to explore and edit variables from a GUI
4) A Help pane able to retrieve and render rich text documentation on functions, classes and methods automatically or on-demand
5) A debugger linked to IPdb, for step-by-step execution
6) Static code analysis, powered by Pylint
7) A run-time Profiler to benchmark code
8) Project support, allowing work on multiple development efforts simultaneously
9) A built-in file explorer, for interacting with the filesystem and managing projects
10) A "Find in Files" feature, allowing full regular expression search over a specified scope
11) An online help browser, allowing users to search and view Python and package documentation inside the IDE
12) A history log recording every user command entered in each console
13) An internal console, allowing for introspection and control over Spyder's own operation

4.2 OpenCV:

OpenCV (*Open Source Computer Vision Library*) is a library programming functions mainly aimed at real-time computer vision. Originally developed by Intel, it was later supported by Willow Garage then Itseez (which was later acquired by Intel). The library is cross platform and free for use under the open source Apache 2 License. Starting with 2011, OpenCV features GPU acceleration for real-time operations.

Applications:

1) 2D and 3D feature toolkits
2) Egomotion estimation
3) Facial Recognition System
4) Gesture Recognition System
5) Human Computer Interaction(HCI)
6) Object Detection
7) Segmentation and Recognition

4.3 Keras:

Keras is an open-source software library that provides a Python interface for artificial neural networks. Keras acts as an interface for the Tensorflow library.Keras contains numerous implementations of commonly used neural-network building blocks such as layers, objectives, activation function, optimizer and a host of tools to make working with image and text data easier to simplify the coding necessary for writing deep neural network code. In addition to standard neural networks, Keras has support for convolutional and recurrent neural networks. It supports other common utility layers like dropout, batch normalization and pooling.

Keras allows users to productize deep models on smartphones (IOS and Android), on the web, or on the Java Virtual Machine .It also allows use of distributed training of deep-learning models on clusters of Graphics Processing Unit(GPU) and Tensor Processing Unit(TPU).

Chapter 5

5.1 Advantages:

1. Real time inspection using manual labour is inadequate, time consuming and non-consistent. It avoids the human error caused by the manual labour during the inspection of mechanical jobs and hence it is more accurate.
2. Image processing is the best way to increase the effectiveness, efficiency and coverage for job selection. Typical features such as hole patterns as well as borders, sharp edges, elongated holes can be measured with Quality Control using Image Processing (QCUIP).
3. By defect detection we can ensure the quality of the mechanical job at the pre-processing stage. This means early detection of potential problems so that processes can be corrected in a timely manner, resulting in lower production cost and efficient quality control
4. It detects the defective objects by comparing it with a preferred image from the database. As the object is compared with the preferred image it can scrutinize the object properly and thus giving us fruitful results.
5. Companies that implement these techniques benefit from shorter production time for products and also can ensure a good quality product.

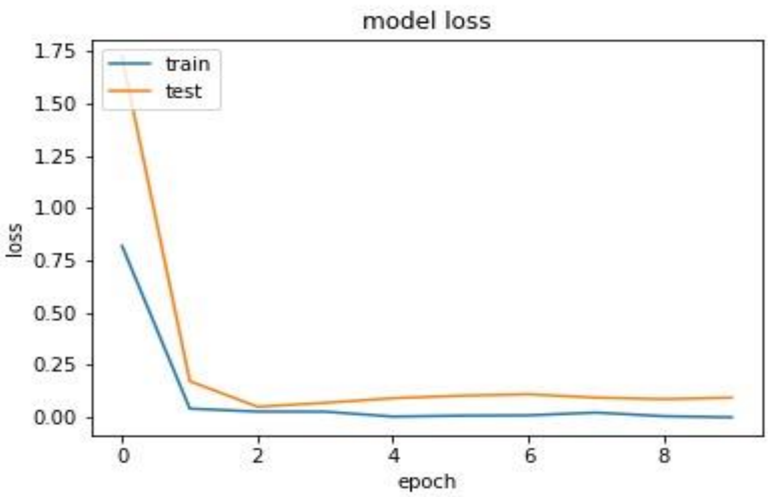
5.2 Limitations:

1. It requires very large amount of data in order to perform better than other techniques.
2. It is extremely expensive to train due to complex data models. Moreover deep learning requires expensive GPUs and hundreds of machines. This increases cost to the users.

5.3 Results:

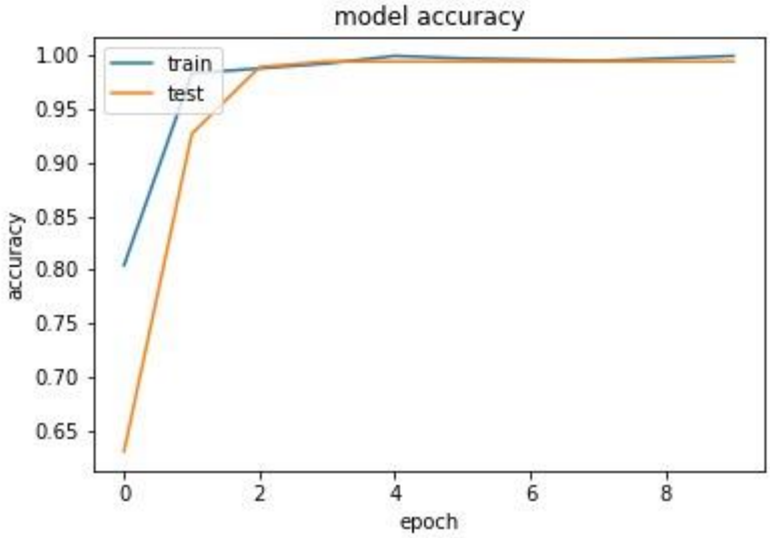
Model Loss:

A loss is a number indicating how bad the model's prediction was on a single example. If the model's prediction is perfect, the loss is zero; otherwise, the loss is greater. The goal of training a model is to find a set of weights and biases that have low loss, on average, across all examples.



Modal Accuracy:

Model accuracy is defined as the number of classifications a model correctly predicts divided by the total number of predictions made. It's a way of assessing the performance of a model, but certainly not the only way.



5.3 Conclusion:

We have developed this project for an industry to fulfil their need of having a computer vision to verify objects for error identification. We have explained in detail all concepts of object verification using image processing and why it is so important in that field. Our analysis showed that the main aim was to inspect the objects in order to rectify any human errors that might have occurred in manufacturing that object. We are trying to develop a system which will capture images of a completed mechanical job from all the angles using a camera, the system will then compare the images with the reference images that have already been stored in the system to ensure that the finished product does not have any minute errors. We are using python and raspberry pi to develop our system so that its operation becomes more efficient and reliable. This project will help to minimize the differences between similar finished mechanical jobs and thus will increase the overall quality of the jobs at a lower cost.

5.4 Future Scope:

1. Use of better algorithm, processor, camera will make the process faster and accurate.
2. Improving the training and testing will improve the efficiency of the device.
3. Adding more convolution will also increase the performance of the device.
4. Over fitting and underfitting can be reduced to increase accuracy and efficiency
5. More hidden layers and dense layers can be added to train the model more efficiently.

5.5 References:

1. Kah W. Ng and Kee S. Moon, Measurement of 3-D Tool Wear Based on Focus Error and Micro-Coordinate Measuring System, Decision and Control, 1998. Proceedings of the 37th IEEE Conference, Volume: 3.
2. B. Dhanasekar and B. Ramamoorthy, Evaluation of Surface Roughness Using an Image Processing and Machine Vision System, Journal Metrology Society of India, Vol.21, No.1,2006, pp, 9-15.
3. Moreels, P., Perona, P.,: Evaluation of Features Detectors and Descriptors Based on 3D Objects. 73(3), 263–284 (2007).
4. Jenn-Yih Chen, Bean-Yin Lee, Kuang-Chyi Lee, Zhao-Kai Chen, Development and Implementation of a Simplified Tool Measuring System, Measurement Science Review, Volume 10, No. 4, 2010, pp, 142-146.
5. Jain, T, Meenu, Automation and Integration of Industries Through Computer Vision Systems. International Journal of Information and Computation Technology. 3(9), 963-970 (2013).