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A Project Report On

# DETECTION OF MULTIPLE DEFECTS ON DISK BRAKES USING CNN

**By**


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# C E R T I F I C A T E

**This is to certify that *Mr. Anurag Biswas Exam No B190574210*, *Mr. Kaif Ali Gaur Exam No B190574245*, *Ms. Vaishnavi Patil Exam No B190574326*, *Ms. Ritika Singh Exam No B190574363* have successfully completed the Project Stage-II entitled *DETECTION OF MULTIPLE DEFECTS ON DISK BRAKES USING CNN* under my supervision, in the fulfillment of Bachelor of Computer Engineering of Savitribai Phule Pune University.**

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# Abstract

**Inspection of brake components is very essential to detect the damaged manufactured parts before it is assembled in any vehicle. Manual inspection of brakes is extremely difficult since most of defects are very minute and cannot be identified by human eyes. Therefore, automatic inspection of manufactured brakes is indispensible to prevent failure of brakes and accidents. Previously, various research articles perform inspection of brake through conventional image processing and traditional image processing algorithms. However, these techniques are capable of identifying a single fault only and are less robust to detecting numerous faults. Further, the existing techniques hardly localize the exact location of faults in the surface of brake. In order to over these drawbacks, in this research we utilize deep learning object detection algorithms namely Single Shot Detector and Faster RCNN to identify and localize the exact location of fault on the brake surface. Furthermore, the proposed system is capable to detect different types of faults in a single algorithm and is robust to brake's material surface, environmental and lightening factors. The deep learning algorithms are trained using transfer learning on custom collected dataset. The proposed algorithms deliver an accuracy of 95.64 percent.**

**Key words :Disk Brakes errors , fault detection, convolutional neural networks, image analysis.**

# List of Abbreviations

**The next list describes several abbreviations that will be later used within the body of the document**

$CNN$ **Convolutional Neural Network**

$RCNN$ **Region Based Convolutional Neural Network**

$SVM$ **Support Vector Machine**

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# Chapter 1

# INTRODUCTION

**Automotive manufacturing assembly tasks are built upon visual inspections such as scratch identification on machined surfaces, part identification and selection, etc, which guarantee product and process quality. Solution identifies the defects (Holes, Casting error) on the disc brakes with the confidence score. The given dataset has defective and non defective images. The defective disc brake images are first labelled with defect boundary and defect type. A deep neural network model is trained on the training data on test data. we utilize deep learning object detection algorithms namely Single Shot Detector and Faster RCNN to identify and localize the exact location of fault on the brake surface. Furthermore, the proposed system is capable to detect different types of faults in a single algorithm and is robust to brake's material surface, environmental and lightening factors. We will create a User interface where an individual can upload the images of his/her disk brakes for verification that the disk brake is viable and its life isnt over. The uploaded images can be further stored in a database connected to the interface which will be saved in a cloud storage (eg. AWS buckets). These images can be further used to train the dataset to improve its accuracy and precision. 4Ps of our Project:**

1. **People: Developers, Surveyors, Field experts, Colleagues**
2. **Product: Product is a ML model, capable of being scalable and flexible which includes a user end website/ simple application.**
3. **Process: Steps involved in development and implementation phase.**
4. **Project: Testing and reviewing feedback to eliminate errors with consultation from guide and industry experts.**

## 1.1 Overview

**As the traffic increases so does the possibility of accidents. A large number of accidents are caused due to brake failures. Brake failure can be avoided by timely analysis of these brakes (most popularly in use, disk brakes) to identify the casting errors and wear and tear deformities that result in the decline in safety of the vehicle. The appearance is enough to determine the level of damage to the brakes for a batch of a huge number of disk brakes that are manufactured in an automobile parts industry. This project will increase in its efficiency with given input and is extremely helpful in situations of physical restraint due to remote locations.**

## 1.2 Motivation

Brakes are the very important part in any transportation vehicle and it is highly important that the developed brake parts are of good standard to stop any accidents. According to the recent survey, it is saddening to know that largest number of accidents in the world occurs in India. In 2017 alone, there were 147913 accidents on road, in which 48764 were on 2 wheelers, 26869 happened on cars, 20457 happened to people walking on roads and 3559 were on cycles. Approximately, 400 people die everyday on our Indian roads due to different types of accidents. Based on the analysis done by the National Highway Traffic Safety Administration (NHTSA), it is observed that 22 percent of fatal accidents happen due to brake failure. This shows that one of the primary reasons for road accidents is failure of Brakes. Therefore, it is very crucial that all the developed brakes are of good quality without any defects and damages.

## 1.3 Problem Definition and Objectives

To detect multiple defects on disk brakes with accuracy and confidence score using CNN. The project is aimed to design a website with the basic versions of the following features:

1. To detect cracks and holes in disk brakes
2. To calculate percentage of affected area by visual inspection
3. To calculate confidence score and accuracy
4. To calculate percentage of faulty disc brakes in a batch

## 1.4 Project Scope and Limitations

- Efficient Disk Brake Quality Control: This project focuses on optimizing the quality control process for disk brakes through the application of a deep neural network (DNN) model. The primary objective is to enhance the assessment of brake quality while minimizing the expenditure of time and resources.
- Robust Dataset and Training: The DNN model is trained using a substantial dataset consisting of 5 classes, each representing common apparent defects found in disk brakes, including cracks, dents, scratches, rust, and smears. With a total of 500 epochs and 1000 images per class, the model is exposed to a diverse range of data, enabling it to learn complex patterns effectively.
- Optimized Testing and Deployment: To gauge the model's effectiveness, a rigorous 7:3 dataset split is employed, with 70
- Resource-Efficient Quality Control: By automating the quality control process using computer vision and DNN technology, this project aims to reduce both the time and cost traditionally associated with manual inspections. This not only enhances efficiency but also contributes to the overall quality and safety of disk brakes used in automobiles.

Limitations:

1. Limited Diversity: limited model's ability to identify less common or nuanced defects.
2. Overfitting Risk: The model may perform well on training data but poorly on new, unseen data.

3. Deployment Challenges: Implementing the model in real-time manufacturing environments may face technical and logistical challenges, including hardware requirements and integration into existing systems.

## 1.5 Methodologies of Problem solving

- The proposed methodology aims to develop a robust system for the detection of errors in disk brakes using machine learning techniques. This process involves several key phases: data collection, preprocessing, training, testing, and the integration of multiple components, including a graphical user interface (GUI) and a SQL database. Here is a detailed description of each phase:
- Data Collection and Preprocessing: The initial step involves gathering a dataset of images representing various states of disk brakes. These images serve as input to the machine learning system through a GUI. To prepare this dataset, rigorous preprocessing is performed. This includes the removal of noisy and blurry image portions and resizing or rescaling the images to ensure uniformity. These preprocessing steps are crucial for optimizing the quality of input data for subsequent analysis.
- Training the Dataset: Once the dataset is appropriately preprocessed, it undergoes a training phase. Feature extraction plays a pivotal role in this step, where relevant features such as edges and size characteristics are extracted from the images. These extracted features are instrumental in the classification process. Subsequently, segmentation techniques are applied to divide the images into multiple parts, enhancing the model's ability to discern specific defects. For classification, support vector machines (SVM) and convolutional neural networks (CNN) are employed. SVM and CNN algorithms are chosen for their effectiveness in categorizing and labeling image features. The model is trained to create a 70 percent accurate representation.
- Testing: The testing phase evaluates the model's performance, employing the remaining 30 percent of the model's capacity. During testing, the system takes images as input, and the model processes these images to identify errors in disk brakes. However, specific evaluation metrics used to measure the accuracy and usability of the system are not detailed in the provided information, necessitating further clarification.
- Proposed System Components: The proposed system comprises multiple components, including machine learning models, a GUI, and an SQL database. The machine learning model is responsible for defect detection, while the GUI serves as the user interface, enabling data input and result visualization. The SQL database likely stores and manages datasets and results, facilitating data transmission and retrieval.
- In summary, this methodology outlines a comprehensive approach to error detection in disk brakes. It leverages machine learning techniques, preprocessing, and feature extraction to create a robust model. Furthermore, it incorporates user-friendly components like a GUI and a database for seamless interaction and efficient data management. However, further details on evaluation metrics and mathematical models are essential for a complete understanding of the system's capabilities and performance.
- Libraries used for the project includes OpenCv, imutils, scipy, NumPy. We have used OpenCv for image processing functionalities. It is an open-source library, some functionalities of imutils used in project are shown (for displaying images) and resize.

**The scipy (scientific python) package is used for importing distance metrics i.e., Euclidean distance, NumPy (numerical python) is used for working with arrays.**

# Chapter 2

# LITERATURE SURVEY

**The overarching objective of this project is centered on the utilization of machine learning algorithms to effectively identify manufacturing errors present in disk brakes, with a specific emphasis placed on the discernment of minute openings and crevices that possess the potential to inflict significant damage upon these critical components, rendering them unsuitable for their intended purpose. The capacity to accurately segregate and classify defective disk brakes from their high-quality counterparts is of paramount importance in the realm of automotive engineering and safety assurance.**

**In pursuit of this goal, the project places considerable value on the analysis and assimilation of prior research endeavors that have delved into the multifarious approaches adopted for the purpose of error detection within the domain of disk brakes. These research papers offer invaluable insights into the diverse methodological paradigms employed, their empirical validity, and the extent of their efficacy in furnishing the requisite outcomes. Thus, it is imperative to embark upon a comprehensive exploration of these antecedent investigations.**

**In [1], the fused model (SVM+ANN) incorporates two commonly used machine learning approaches through the use of fuzzy logic. The proposed ambiguous choice system has outperformed the previous system in accuracy, achieving a score of 94.87.**

**In [2], a validated RF-SMA-SVM model was created. Based on the experimental findings, the suggested method outperforms the SVM method based on other optimization algorithms in terms of prediction accuracy and performance stability while filtering out the important variables with strong discriminatory power.**

**In [3], The study used a variety of classifiers, such as Decision Tree (DT), Support Vector Machine (SVM), Random Forest (RF), K-Nearest Neighbor (KNN), Naive Bayes (NB), Multiple Perceptron (MP), J48 Trees, and Logistic Regression (LR) classifiers. In comparison to other classifiers, the proposed ensemble classifier beat individual classifiers in performance evaluation, achieving the best accuracy of 94**

**In [4], The four separate MSVM kernel functions of the support vector machine's MSVM model were used to categorize the six significant circumstances. For six sensor scenarios, the RBF kernel model provides the highest classification accuracy. The classification outcomes and statistical measurements were applied to the RBDT-MSVM model's evaluation. The overall accuracy of the categorization was 92.8571that an MSVM classifier with an RBF kernel function and RBDT is a top candidate for fault diagnosis of water quality monitoring equipment.**

**In [5], In order to accurately assess the patients' heart-disease status, the suggested HDPM**

**was created and developed for the Heart Disease Clinical Decision Support System. The patient data, together with additional diagnosis data, were acquired by the HDCDSS and sent to a secure web server. After being transmitted, the data was saved in MongoDB, which can efficiently deliver a prompt answer. The patient's current heart disease status was then determined using the proposed HDPM, and the results were then communicated back to the HDCDSS's diagnosis result interface. A statistical review was also provided to support the model's significance. Experimental outcomes showed that the suggested model performed better than leading models and earlier study findings, with accuracy up to 95.90respectively.**

**In [6], By using RBF-SVM decision classification and covariance matrix Cholesky decomposition, an effective method for blind spectrum sensing at low SNRs is described. An established SVM classification model is easily used to make the decision. The actual decision threshold has a self-learning capability based on the SVM, which successfully distinguishes signals from sounds. In terms of computational complexity, the suggested approach performs better than the traditional MME scheme. Simulation findings show that the suggested technique performs better than traditional detection ones, especially at low SNRs, demonstrating its potential for 5G communications.**

**In [7], Regarding data imputation and sample diagnosis, the suggested CKD diagnostic methodology is workable. The integrated model could reach a sufficient level of accuracy after KNN imputation was used to impute missing values in the data set without supervision. So, it is hypothesized that using this technology to really diagnose CKD would produce favorable results. Unfortunately, only 400 samples of the available data were used in the model-building procedure because of the constraints imposed by the requirements. As a result, the model's ability to generalize may be constrained.**

**In [8], To distinguish AD from HC, a machine learning classifier based on SVM was created. The outcomes demonstrated that examining the spatiotemporal information of the body joints as it changed while being captured by a Kinect V.2 camera yielded significant features from several TUG test subtasks. The SVM classifier's average accuracy and F-score were 97.75evaluated using five-fold cross-validation, and 98.68leave-one-subject out cross-validation. Their results confirmed the possibility of the thorough analysis of TUG utilizing a Kinect V.2 camera and machine learning as a simple and affordable complementary tool for the detection and routine quantitative assessment of AD in clinical or home settings.**

**In [9], A stacked SVM-based expert system was suggested to help with the diagnosis of heart failure. While the second SVM model served as a prediction model, the first SVM model was utilized to remove unnecessary characteristics. It was demonstrated that the suggested strategy outperformed eleven well-known methods that were already in use in the literature and other cutting-edge machine learning models. Also, it was noted that the strength of the suggested model outperforms the standard SVM model by 3.3effective in terms of time complexity. because the predictive model's training period is shortened. So, it can be inferred from the dataset's results that the suggested expert system can help doctors diagnose heart failure by improving their decision-making process.**

**In [10], The investigation on the identification and categorization of lamination flaws in the power transformer core was reported in this publication. Using a 15 kVA transformer, experimental results from a prior study were used. The conclusions are as follows.**

1. **For the detection purpose, where two classes were taken into consideration, SVM, KNN, and DT classifiers provided a good accuracy rate of around 82**

2. **The SVM method produced an accuracy rating for the categorization of 84.26KNN and DT classifiers, it was 84.04particular, for the DT method, the classification process was sensitive to data decomposition.**

3. **It was discovered that, in comparison to other classes, the insulating lamination fault exhibits a good accuracy rate. For this class, higher precision and recall were attained.**

Table 2.1: Literature Review

| **Sr. No** | **Paper Name/Year** | **Author/YOP** | **Strengths** | **Limitations** |
|---|---|---|---|---|
| 1 | Model based fault detection and diagnosis | Harald Straky, Marco Muenchhof Rolf Isermann Publication:2021 | The model was used for fault detection and diagnosis scheme; A correlation analysis method is used which is able to discern and diagnose air enclosures and leakages. | Can not detect force balance at the particular piston which allows to locate the fault |
| 2 | Multi-stream convolutional neural network-based fault diagnosis for variable frequency. | John Grezmaka, Jianjing Zhanga, Peng Wanga, Robert X. Gao Publication:2020 | The model was used for fault detection and diagnosis scheme; A correlation analysis method is used which is able to discern and diagnose air enclosures and leakages. | Can not detect force balance at the particular piston which allows to locate the fault |
| 3 | Using Deep Learning to Detect Defects in Manufacturing: A Comprehensive Survey and Current Challenges | Authors: Jing Yang, Shaobo Li, Zheng Wang, Hao Dong, Jun Wang, and Shihao Tang Publication:2021 | Automatic defect detection technology not only adapts to an unsuitable environment but also works in the long run High precision and efficiency. | Can not design defect information feedback technology that is based on defect detection technology. |

| Sr. No | Paper Name/Year | Author/YOP | Strengths | Limitations |
|---|---|---|---|---|
| 4 | A Study of Data Mining Methods for Prediction of Personality Traits | Authors: Helly. N. Desai , Prof. Rakesh Patel Publication:2020 | Fault detection and diagnosis of induction motors in variable frequency drive (VFD) applications Minimizing unexpected downtime, material waste and equipment damage | The relative amount of positive or negative relevance between sensor inputs is different for each speed. |
| 5 | Failure of Friction Brake Components against Rapid Braking Process | Authors: Mufti Reza Aulia Putraa, Pandu Sandi Pratamab, Aditya Rio Prabowo Publication:2021 | The use of a good braking system will provide safety and comfort in its use. | A better cooling system can maintain the performance of a braking system |

**Table 2.1 shows the literature review table.It contain the paper title,author name,strength,limitation of twelve papers.**

# Chapter 3

# SOFTWARE REQUIREMENTS SPECIFICATION

**In previous chapter the literature survey is summarized. A software requirements specification is the basis for entire project. It's used to provide critical information to multiple teams - development, quality assurance, operations, and maintenance. Using the SRS helps to ensure requirements are fulfilled. And it can also help you make decisions about your product's lifecycle — for instance, when to retire a feature. In this chapter SRS is framed to identify requirements for the whole system.**

## 3.1 Assumptions and Dependencies

**Assumptions are the presumptions made regarding the project while implementing it. Dependencies are the necessary elements needed for the project to work. This section will mention the Assumptions and Dependencies required for this project.**

## 3.2 Assumptions

**The assumptions in this project are as follows.**
- **User provides correct input format.**
- **System gives a number of violations correctly after processing frames.**

## 3.3 Dependencies

**The dependencies in this project are as follows.**
- **A Correct Input format (Image)**

## 3.4 Functional Requirements

**A Deep Neural Network model for getting the apparent errors using an image is presented in this work, motivated by the necessity of improving the process of evaluating quality of disk brakes with resource (time and cost). The selected algorithms were trained for 500 epochs with 1000 images in each Class. Cracks, dents, scratches, rust and smear the classes**

taken for consideration. The training and test dataset are split in the ratio 7:3 for testing purposes. This project can be implemented for real time datasets of automobile parts manufacturing companies.

### 3.4.1 System Feature 1

This system will provide accurate object detection.

### 3.4.2 System Feature 2

Based on the obtained faults, identify the type of fault (crack, hole)

### 3.4.3 System Feature 3

Identify number of faults and percentage of disc brake that is damaged.

## 3.5 External Interface Requirements

The requirements section of hardware includes minimum of 100 GB hard disk and 4 GB RAM with 1 GHz or higher speed. The primary requirements include a memory of 1 GB for the application of Python and MySQL (If required). The user interface of this program is the common Windows interface, nothing additional is required. Deep Neural Networks for the prediction of apparent errors in disk brakes. It can quantify the types and percentage of errors from the input image presented via the user interface in the form of a website. The data is then fed through the model to be able to detect errors and display them individually with the type to the user. This data is stored in the model's database to increase further accuracy of the model.

### 3.5.1 Hardware Interfaces

The hardware should have following specifications:

- Ability to read gallery
- Ability to exchange data over network
- Keypad (in case touchpad not available)
- Continuous power supply
- Ability to connect to network
- Ability to take input from user
- Ability to validate user.

### 3.5.2 Software Interfaces

Anaconda Navigator: Anaconda is an open-source distribution of the Python and R programming languages for data science that aims to simplify package management and deployment. Package versions in Anaconda are managed by the package management system, conda, which analyzes the current environment before executing an installation to avoid disrupting other frameworks and packages.The Anaconda distribution comes with over

250 packages automatically installed. Over 7500 additional open-source packages can be installed from PyPI as well as the conda package and virtual environment manager. It also includes a GUI (graphical user interface), Anaconda Navigator, as a graphical alternative to the command line interface. Anaconda Navigator is included in the Anaconda distribution and allows users to launch applications and manage conda packages, environments and channels without using command-line commands. Navigator can search for packages, install them in an environment, run the packages and update them.

## 3.6 Non-Functional Requirements

### 3.6.1 Performance Requirement

- System can produce results faster on 4GB of RAM.
- The performance of the functions and every module must be well. The overall performance of the software will enable the users to work efficiently. Performance of encryption of data should be fast. Performance of the providing virtual environment should be fast Safety Requirement. The application is designed in modules where errors can be detected and easily. This makes it easier to install and update new functionality if required.
- The system will be available 100% of the time. Once there is a fatal error, the system will provide understandable feed back to the user.

### 3.6.2 Safety Requirements

- The application is designed in modules where errors can be detected and fixed easily. This makes it easier to install and update new functionality if required.

### 3.6.3 Security Requirements

- For the security purposes and to avoid illegal use of the system, while using this application user must do following things:
  - At the time of deploying this software user have to register to system.
  - To use software user have to login and logout each time.

### 3.6.4 Software Quality Attributes

- Adaptability: This software is adaptable by all users. Availability: This software is freely available to all users. The availability of the software is easy for everyone.
- Maintainability: After the deployment of the project if any error occurs then it can be easily maintained by the software developer.
- Reliability: The performance of the software is better which will increase the reliability of the Software.
- User Friendliness: Since, the software is a GUI application; the output generated is much user friendly in its behavior.
- Integrity: Integrity refers to the extent to which access to software or data by unauthorized persons can be controlled.

- **Security:** Users are authenticated using many security phases so reliable security is provided.
- **Test ability:** The software will be tested considering all the aspects.

## 3.7 System Requirements

### 3.7.1 Software Requirements(Platform Choice)

1. **Jupyter-Notebook:** Its an IDE used for the computing various aspects in different programming languages. Data cleaning, data transformation, numerical simulation, modeling, visualization, machine learning.
2. **Pandas:** It's a package in python useful for scientific computation. It's a strong N-dimensional collection entity. It consists of tools for integrating C/C++. Useful for operating on linear algebra, Fourier transform, and random number capabilities.
3. **Tensorflow:** TensorFlow is an end-to-end open source platform for machine learning. It has a comprehensive, flexible ecosystem of tools, libraries and community.
4. **Scikit-learn:** It's a machine learning open source library supporting support vector machine. Regression and clustering via clubbing similar objects together.
5. **Scipy:** It's a package build on numpy for scientific and technical computations. It has functions for optimization.
6. **Pillow:** It's a open source library supporting the image manipulation. It provides the ease to access different types of formats of the image files. It is supported in Windows, Linux OS.
7. **Torch:** Package supporting tensor computations and the deep learning computations adding with a powerful Graphical Processing Unit support.
8. **Torchvision:** The package comprises of popular datasets, architectures also the common image transformations methodologies.

### 3.7.2 Hardware Requirements

1. **Disk Space:** Minimum disk space of 500 GB is expected for computations and storage means.
2. **Processori5 CPU @1.60 GHz 1.80 GHz, 32-bit x32 OR 64-bit x64 processor is preferable.**
3. **Memory:** 4 GB RAM and above , .
4. **Display:** 1600 * 900 minimum display resolution for better display

## 3.8 Analysis Models: SDLC Model to be applied

SDCL Waterfall model is being depicted by our system.

- The initial stage is requirement analysis stage here the data is being gathered which is to be provided as an input to the system.
- Second stage is the design stage where all the UML diagrams are created.

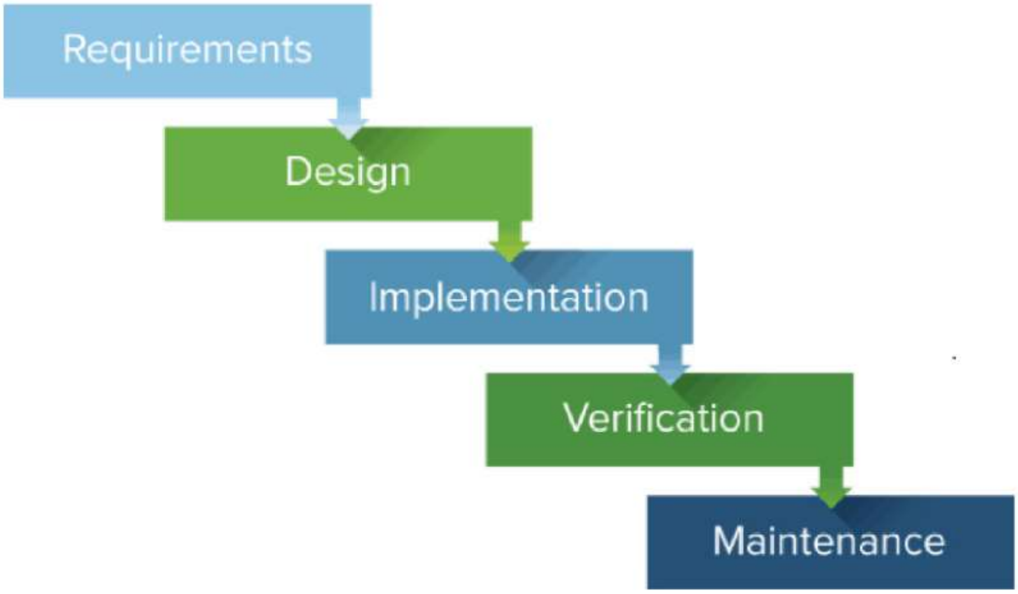


Figure 3.1: Waterfall Model

- **Third stage is the coding stage in which the system performs its main functionality of mapping of the classes and getting the exact prototype.**
- **Testing is done in the fourth phase in order to test the text and image-based outputs.**
- **In the maintenance phase it's the last phase wherein the system has to depict and showcase errors.**

# Chapter 4

# SYSTEM DESIGN

**The third chapter described the study of Software requirement specification. It included functional requirements, non-functional requirements, hardware and software requirements, external requirements, system requirements. This SRS needed to be represented into pictorial form for better understanding. This chapter is about system design. It would provide an insight into the system architecture and also the various underlying that the model would make use of.**

## 4.1 System Architecture

**Data collection :- 1) First of all we provide images of disk brakes as a dataset to the machine which are input using GUI. We have to modify or prepare that dataset, for that next step is pre-processing. 2) Preprocessing :- In Pre-processing phase, in that removing the noisy and blurry part of the dataset, and re-scale, resize the image dataset. 3) After preprocessing of dataset, next phase is trained that dataset. For that, dataset goes through feature extraction classification. Train the dataset :- In this process we train the dataset by following steps. 1)Feature extraction :- In Feature extraction extract the features like edges, size etc. from dataset. Extract the features for classifications. After Feature Extraction next step is segmentation. 2)Segmentation :- In segmentation we divide image in multiple parts. Then after the all steps done, next phase is classification . We used classifier for the classification. 3)Classification :- We used SVM/CNN algorithm for the classification. Classification is process of categorizing and labelling groups of pixels or vectors within an image based on specific rules.After all the training phase done Machine create model i.e. trained model. It is 70 percent model. Testing :- Testing is 30 percent model. We give input as image for testing. Then model can goes to testing phase and then provide the output to user. Output is to detect errors in disk brakes. The architecture of the system is as shown in Figure 4.1.**

## 4.2 Mathematical Model

**Fig.4.2 shows the mathematical model of our system.**

- **Set Theory:**

**Let S be the Whole system S=I,P,O**
**I-input**

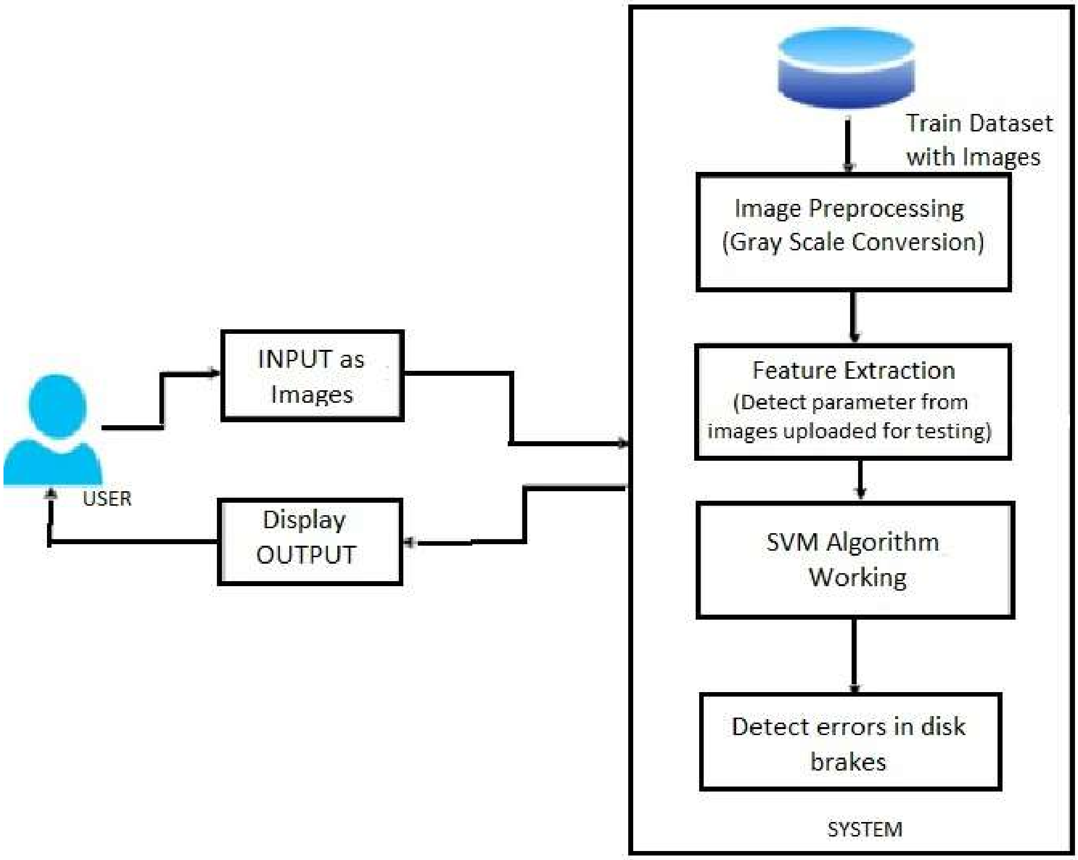


Figure 4.1: System Architecture

**P-procedure**
**O-output**
**Input( I)**
**I= Dataset as a Images/Individual Image of Disc Brake**
**Where,**
**Procedure (P),**
**P=I, System Using Perform the Operation and Predict the Personality.**
**Output(O)**
**O= Casting errors, Life and validity of disc brakes**

**Success if:**

- **error detected accurately.**
- **type of error detected accurately.**

**Failure if:**

- **More time consumption by the system.**
- **Hardware failure.**
- **Software failure.**

Given a training dataset $D = \{x_i, y_i\}_{i=1}^{m}$ where $x_i \in \Re^d$, $y_i \in \{+1, -1\}$, SVM classifies with an optimal separating hyperplane, which is given by:

$$D(x) = w^T x + b \qquad (1)$$

When working with data non-linearly separable, this hyperplane is obtained by solving the following quadratic programming problem:

$$\mathrm{Min} \frac{1}{2} w^T w + C \sum_{i=1}^{m} \xi_i$$
$$\text{s.t. } y_i(w^T x_i + b) \geq 1 - \xi_i, \ \ \xi_i > 0 \ \ for \ \ i = 1, \ldots, m \qquad (2)$$

Figure 4.2: Mathematical Model

- **Improper network connection.**

**Space Complexity:**

**The space complexity depends on size of dataset .bigger dataset and more accurate results mean more space complexity.**

**Time Complexity:**

**If system has n records then, the time complexity of checking the records is O(1) in best case and O(n) in worst case.**

**E=end of program**

**T = Failures and success conditions.**

## 4.3 Data flow Diagram

**A figure 4.3 and 4.4 shows data-flow diagram (DFD) is a way of representing a flow of a data of process or a system (usually an information system). The DFD also provides information about the outputs and inputs of each entity and the process itself.**

### 4.3.1 Data flow diagram level 0:

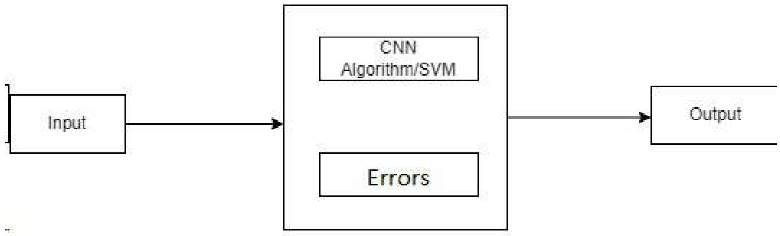


Figure 4.3: DFD Level 0

### 4.3.2 Data flow diagram level 1:

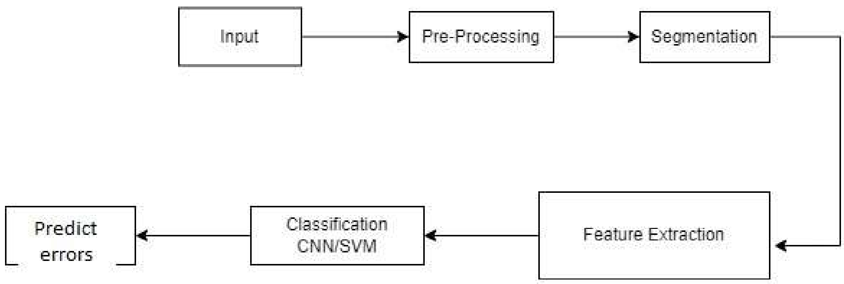


Figure 4.4: DFD Level 1

## 4.4 Use Case Diagram

**The figure 4.5 shows Use Case Diagram is shown in the above figure. There will be one primary actor or one secondary actor. The primary actor is User and the use cases like select image, Display error, Display violation alert message, Display information about type of error.On the other side the secondary actor database select the database.**

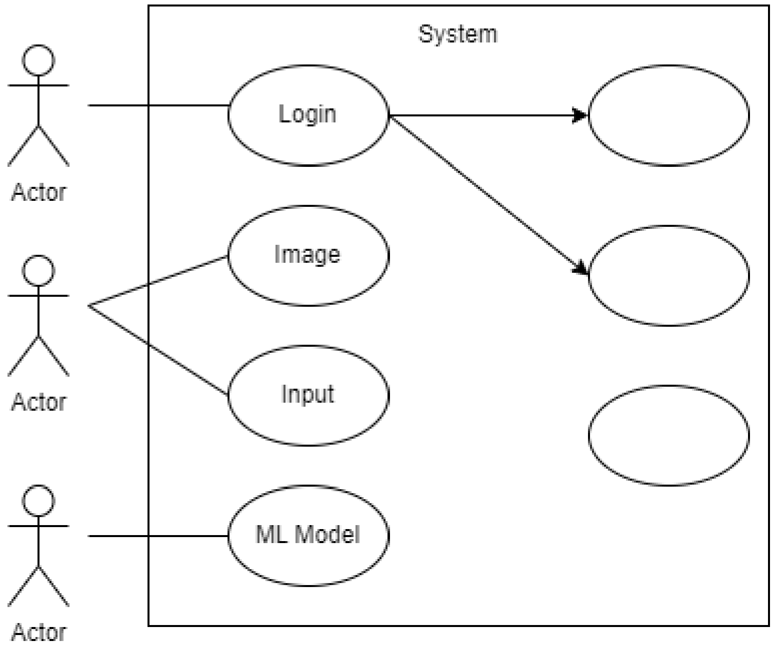


Figure 4.5: Use case Diagram

## 4.5 Sequence Diagram

**The Sequence diagram of the system is shown in the fig 4.6. High-level interaction between active objects in a system is visualized using sequence diagram. The sequential flow of system and the exchange of messages between the object is shown. Active Objects/Actors in the sequence diagram are User, Web Portal, Database System.**

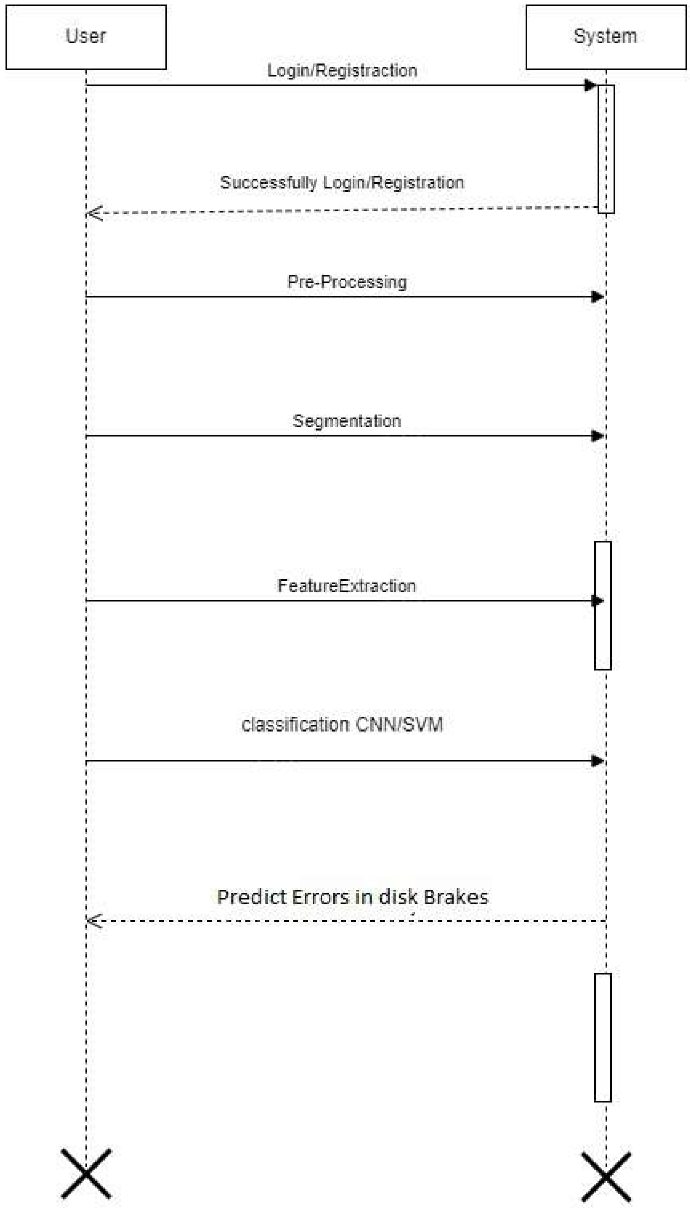


Figure 4.6: Sequence Diagram

## 4.6 Activity Diagram

**The figure 4.7 shows the flow of control in the system and shows the steps involved in the execution of a use case. User Activity decides the flow of the control. Activities has predefined flow and execute as per the conditions.**

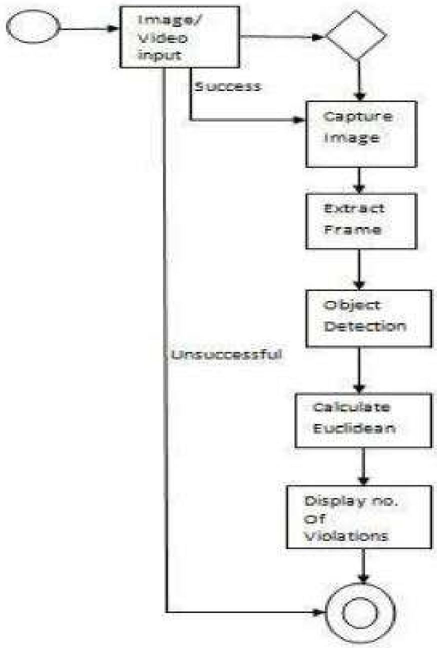


Figure 4.7: Activity Diagram

## 4.7 Communication Diagram:

**The figure 4.8 shows Communication Diagram of Social distance detector system shown in above figure.In the above figure communication between different modules with the flow of data is displayed.Firstly communication between user and the system is take place and data is flow from user to image processing module and next communicate to object detection to calculate distance for checking result.**

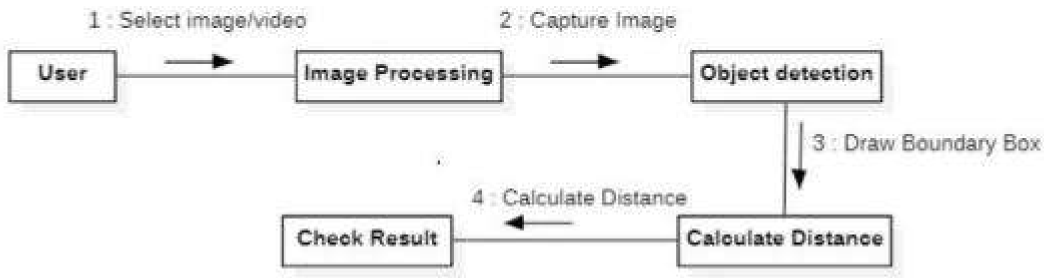


Figure 4.8: Communication Diagram

## 4.8 Component Diagram:

**The figure 4.9 shows a Component diagram. A component diagram is used to break down a large object-oriented system into smaller components, so as to make them more manageable. It models the physical view of a system such as executables, files, libraries, etc. that resides within the node.A component is a single unit of the system, which is replaceable and executable. The implementation details of a component are hidden, and it necessitates an interface relationship between components of system.**

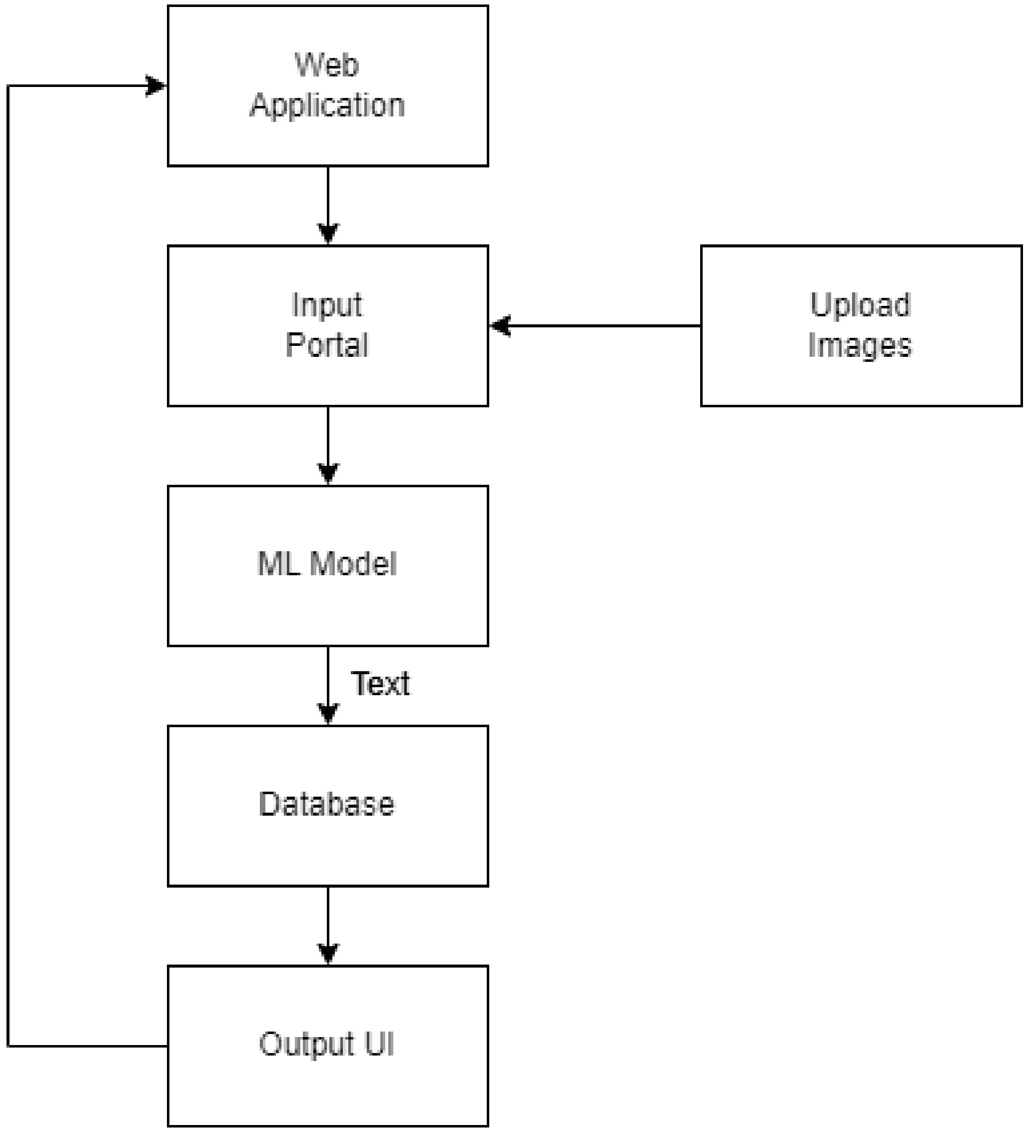


Figure 4.9: Component Diagram

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# Chapter 5

# PROJECT PLAN

## 5.1 Project Plan

### 5.1.1 Project Estimate

#### Project Resources

**Project resources include people involved, expenditures etc. Hardware like Processor , RAM,hard disk, and Softwares like Windows OS, Python kit etc**

### 5.1.2 Risk Management

#### Risk Identification

**1. Security Information and Event Management(SIEM):Analyzeandcor- relate large amounts of real-time data from network and security de- vices to manage external and internal security threats, improveincident response time and compliancereporting.**
**2. Application Log Monitoring: Improve analysis of application log data to better manage system resource utilization, security issues, and diag- nose and preempt production applicationproblems.**
**3. Network Intrusion Detection: Monitor and analyze network traffic to detect, identify, and report on suspicious activity orintruders.**
**4. FraudDetection:Usepattern/anomalyrecognitiononlargervolumes and variety of data to detect and prevent fraudulent activities by ex- ternal or internalparties.**
**5. Risk Modelling: Improve risk assessment and associated scoring by building sophisticated machine learning models on Cloud that can take into account hundreds or even thousands of indicators.**

#### Risk Analysis

**The risks for the Project can be analyzed within the constraints of time and quality. Table 5.1 shows the Risk Analysis table.It shows the Risk,Probability and Mitigation of risk.**

Table 5.1: Risk Analysis

| Risk | Probability | Mitigation |
|---|---|---|
| It takes longer than proposed to learn the new technologies | Low | 1. Advanced concepts are learnt on need-to-know basis and basic features are prioritized which are required for the implementation<br>2. Rescheduling of the project plan to accommodate any delay |
| Some technical problem arise during implementation | Low | Help from developer community from various blogs and forums can be taken |

### 5.1.3 Project Schedule

**Project Task Set**

**Major Tasks in the Project stages are:**

- **Task 1:Requirement Gathering**
- **Task 2: Literature survey**
- **Task 3: Mathematical modeling**
- **Task 4: Feasibility testing**
- **Task 5: UML diagrams**
- **Task 6: Database design**
- **Task 7: GUI design**
- **Task 8: Functionality implemented**
- **Task 9:Testing**
- **Task 10:Reporting**


Figure 5.1: Time Line Chart

### 5.1.4 Team Organization

**1. Kaif Ali Gaur. Project Leader**

**2. Anurag Biswas. Tester**

**3. Vaishnavi Patil, Ritika Singh . Domain Expert**

**4. Kaif Ali Gaur. Developer**

**Guide Prof. Mr. Shrikant A. Shinde**

# Chapter 6

# PROJECT IMPLEMENTATION

## 6.1 Overview of Project Modules

1. **User can register with personal information**
2. **User should provide login information**
3. **User should select image to be tested**
4. **System will apply the algorithm**
5. **No of errors, percentage of defected disc brake and types of defects will be identified.**

## 6.2 Tools and Technologies Used

1. **Python is a widely used high-level programming language first launched in 1991. Since then, Python has been gaining popularity and is considered one of the most popular and flexible server-side programming languages.**

   **Select Version of Python to Install The installation procedure involves downloading the official Python .exe installer and running it on your system.**
2. **Download Python Executable Installer**
3. **Open your web browser and navigate to the Downloads for Windows section of the official Python website.**
4. **Search for your desired version of Python. At the time of publishing this article, the latest Python 3 release is version 3.7.3, while the latest Python 2 release is version 2.7.16.**
5. **Select a link to download either the Windows x86-64 executable installer or Windows x86 executable installer. The download is approximately 25MB.**
6. **Run the Python Installer once downloaded**
7. **MySQL Database**

Microsoft SQL Server is a relational database management system developed by Microsoft. As a database server, it is a software product with the primary function of storing and retrieving data as requested by other software applications which may run either on the same computer or on another computer across a network (includ- ing the Internet). Microsoft markets at least a dozen different editions of Microsoft SQL Server, aimed at different audiences and for workloads ranging from small single-machine applications to large Internet-facing applications with many concur- rent users.

1. Jupyter-Notebook: Its an IDE used for the computing various aspects in different programming languages. Data cleaning, data transformation, numerical simulation, modeling, visualization, machine learning.
2. Pandas: It's a package in python useful for scientific computation. It's a strong N-dimensional collection entity. It consists of tools for integrating C/C++. Useful for operating on linear algebra, Fourier transform, and random number capabilities.
3. Tensorflow: TensorFlow is an end-to-end open source platform for machine learning. It has a comprehensive, flexible ecosystem of tools, libraries and community.
4. Scikit-learn: It's a machine learning open source library supporting support vector machine. Regression and clustering via clubbing similar objects together.
5. Scipy: It's a package build on numpy for scientific and technical computations. It has functions for optimization.
6. Pillow: It's a open source library supporting the image manipulation. It provides the ease to access different types of formats of the image files. It is supported in Windows, Linux OS.
7. Torch: Package supporting tensor computations and the deep learning computations adding with a powerful Graphical Processing Unit support.
8. Torchvision: The package comprises of popular datasets, architectures also the common image transformations methodologies.

## 6.3 Algorithm Details

The fused model (SVM+ANN) incorporates two commonly used machine learning approaches through the use of fuzzy logic. The proposed the ambiguous choice system has outperformed the previous system in accuracy, achieving a score of 94.87

Based on the experimental findings, the suggested method outperforms the SVM method based on other optimization algorithms in terms of prediction accuracy and performance stability while filtering out the important variables with strong discriminatory power. In [3], The study used a variety of classifiers, such as Decision Tree (DT), Support Vector Machine (SVM), Random Forest (RF), K-Nearest Neighbor (KNN), Naive Bayes (NB), Multiple Perceptron (MP), J48 Trees, and Logistic Regression (LR) classifiers. In comparison to other classifiers, the proposed ensemble classifier beat individual classifiers in performance evaluation, achieving the best accuracy of 94

### 6.3.1 Algorithm Steps

- **Sense the environment**
- **Learn the faults in disc brakes using unsupervised dataset**
- **Data gathering from user**
- **Data transmission by front end GUI to backend ML model.**
- **SVM and RCNN find the errors in disk brakes.**
- **Errors displayed using visual means like graphs and pie charts**
- **Performance measures used to show accuracy and usability of units.**
- **Results obtained added to the supervised dataset for fine-tuning.**
- **Check performance parameters and calculate result**

# Chapter 7

# SOFTWARE TESTING

## 7.1 Software Testing

### 7.1.1 Types of Testing

**The following are the different types of testing: Unit testing Unit testing refers to tests that verify the functionality of a specific section of code, usually at the function level. In an object-oriented environment, this is usually at the class level, and the minimal unit tests include the constructors and destructors. These types of tests are usually written by developers as they work on code white-box style, to ensure that the specific function is working as expected. One function might have multiple tests, to catch corner cases or other branches in the code. Unit testing alone cannot verify the functionality of a piece of software, but rather is used to assure that the building blocks the software uses work independently of each other. Unit testing is also called component testing.**

White Box testing : **White-box testing is a method of testing software that tests internal structures or workings of an application, as opposed to its functionality (i.e. black-box testing). In white-box testing an internal perspective of the system, as well as programming skills, are required and used to design test cases. The tester chooses inputs to exercise paths through the code and determine the appropriate outputs. This is analogous to testing nodes in a circuit testing. Using white box testing method, software engineer can derive test case that: Guarantee that all independent paths within module have been exercised at least once. Exercise all the logical decisions on their true or false sides. Execute all loops on the boundaries and within their operational bounds. Exercise internal structure to insure their validity. While white-box testing can be applied at the unit, integration and system levels of the software testing process, it is usually done at the unit level. It can test paths within a unit, paths between units during integration, and between subsystems during a system level test.**

Black Box testing: **Black-box testing is a method of software testing that tests the functionality of an application as opposed to its internal structures or workings (see white-box testing). Specific knowledge of the applicationâAZs code/internal structure and programming knowledge in general is not required. Test cases are built around specifications and requirements, i.e., what the application is supposed to do. It uses external descriptions of the software, including specifications, requirements, and design to derive test cases. These** tests can be functional or non-functional, though usually functional. The test designer selects valid and invalid inputs and determines the correct output. There is no knowledge of the test objectâAZs internal structure. Black box testing attempts to find error in following categories: Incorrect and missing function,Interface errors, Errors in data structures or External database accesses, Behavior or performance error ,Initialization and termination.

Integration testing : The purpose of integration testing is to verify functional, performance, and reliability requirements placed on major design items. These âAIdesign itemsâAI, i.e. assemblages (or groups of units), are exercised through their interfaces using Black box testing, success and error cases being simulated via appropriate parameter and data inputs. Simulated usage of shared data areas and inter-process communication is tested and individual subsystems are exercised through their input interface

Top-Down approach : A top-down approach (also known as step-wise design) is essentially the breaking down of a system to gain insight into its compositional subsystems. In a top-down approach an overview of the system is formulated, specifying but not detailing any first-level subsystems. Each subsystem is then refined in yet greater detail, sometimes in many additional subsystem levels, until the entire specification is reduced to base elements. A top-down model is often specified with the assistance ofâAI black boxesâAI, these make it easier to manipulate. However, black boxes may fail to elucidate elementary mechanisms or be detailed enough to realistically validate the model.

Bottom-up approach [20]: A bottom-up approach is the piecing together of systems to give rise to grander systems, thus making the original systems sub-systems of the emergent system. In a bottom-up approach the individual base element of the system are first specified in great detail. These elements are then linked together to form larger subsystems, which then in turn are linked, sometimes in many levels, until a complete top-level system is formed. This strategy often resembles a âAIseedâAI model, whereby the beginnings are small but eventually grow in complexity and completeness. However,âAI organic strategiesâAI may result in a tangle of elements and subsystems, developed in isolation and subject to local optimization as opposed to meeting a global purpose.

### 7.1.2 Test cases and Test Results

A strategy outlines what to plan, and how to plan it. A successful strategy is your guide through change, and provides a firm foundation for ongoing improvement. Unlike a plan, which is obsolete from the point of creation, a strategy reflects the values of an organization - and remains current and useful. When an organization tests its products or its tools, it tries to compare them against its expectations and values. By its nature, testing introduces change as problems are identified and resolved. A test strategy is necessary to allow these two impulses to work together. Furthermore, testing can never be said to be ‘complete’, and a core skill in testing is the justified management of conflicting demands; without a strategy, these judgements will be inconsistent to the point of failure.

Software development is a creative process. A test strategy is a vital enabler to this process keeping focus on core values and consistent decision-making to help achieve desired goals

**with best use of resource. A good strategy stands as a clear counter to reactive, counter-productive test approaches.**

Table 7.1: Test cases

| TC ID | Description | Expected Output | Actual O/P |
|---|---|---|---|
| 1 | User should add personal information for registration | User registration is done and OTP will be send to user account | User get information for login on email id. |
| 2 | User should able to receive the password if the password is forgotten | User should receive the email when forgot password is clicked" | User got the email. |
| 3 | User should able to change password | User once login can change password | User is able to change password |
| 4 | Login to the account | user should be able to login into the system | User is logged in |
| 5 | Upload the image | image will be converted to matrix for testing | Algorithm provides results in form of errors |
| 6 | Register user and login | If username and password are matched then log in. | username and password are matched. Resultant image is displayed |

**Table 7.1 shows the Test Cases table.It contains a total of six test cases. Table contains test case ID, description, expected output and actual output.**

# Chapter 8

# RESULTS


Figure 8.1: Home page

**Figure 8.1 shows the home page of our system. This is the main page of our website. Here users can find the hyperlinks to other pages.**

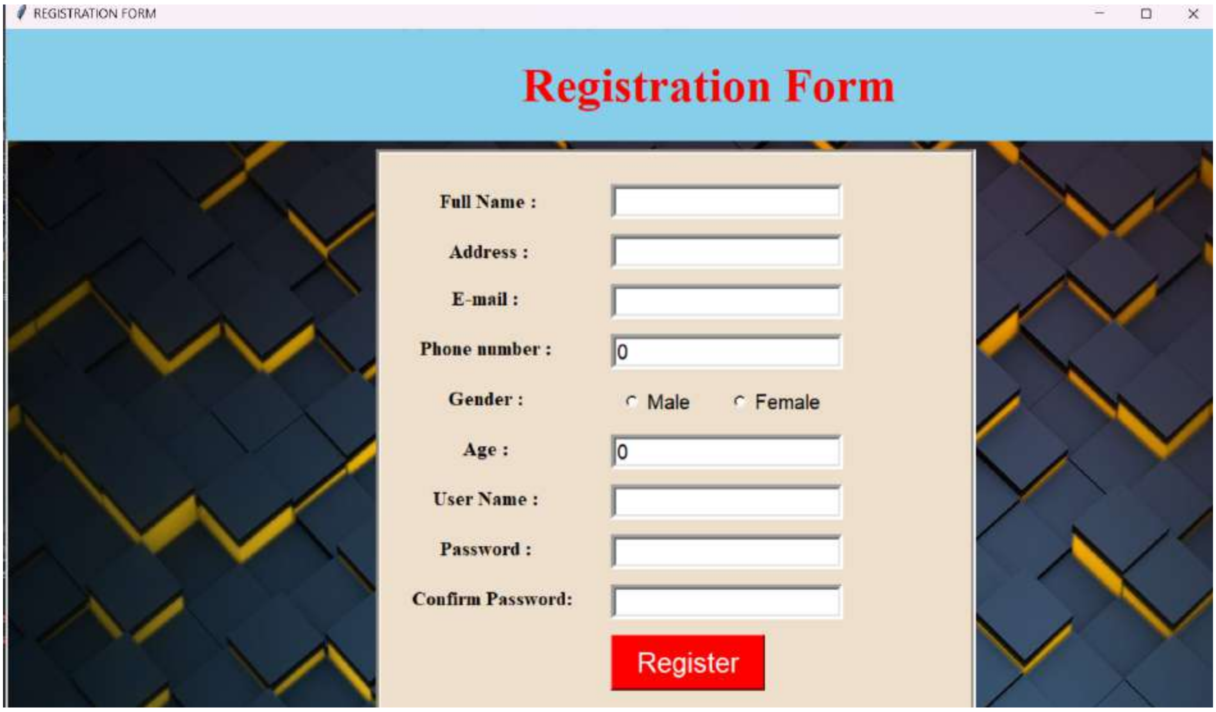


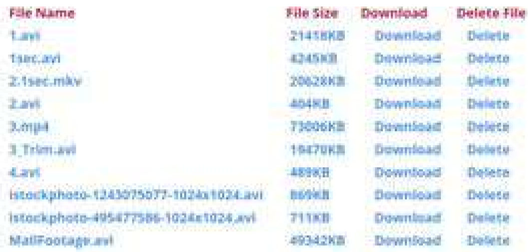

Figure 8.2: Registration Page

**Figure 8.2 shows the Registration page. After clicking on the Registration tab, the registration form is opened. Then user should enter the required information for registration.**


Figure 8.3: Login Page

**Figure 8.3 shows the Login page. After registration user can log into the system using a registered mail ID. A password is required for login, the password is sent to the registered email id.**


Figure 8.4: Upload file Page



| File Name | File Size | Download | Delete File |
|---|---|---|---|
| 1.avi | 21418KB | Download | Delete |
| 1sec.avi | 4245KB | Download | Delete |
| 2.1sec.mkv | 20628KB | Download | Delete |
| 2.avi | 404KB | Download | Delete |
| 3.mp4 | 73006KB | Download | Delete |
| 3_Trim.avi | 19470KB | Download | Delete |
| 4.avi | 489KB | Download | Delete |
| istockphoto-1243075077-1024x1024.avi | 869KB | Download | Delete |
| istockphoto-495477586-1024x1024.avi | 711KB | Download | Delete |
| MallFootage.avi | 49342KB | Download | Delete |

Figure 8.5: Download Output Page

**Figure 8.6 shows the upload file window. Users can upload the images or the entire dataset.The user must select the file from the device and then click on the upload button.**

**Figure 8.7 shows the history and processed files. The user can view and download the output.**

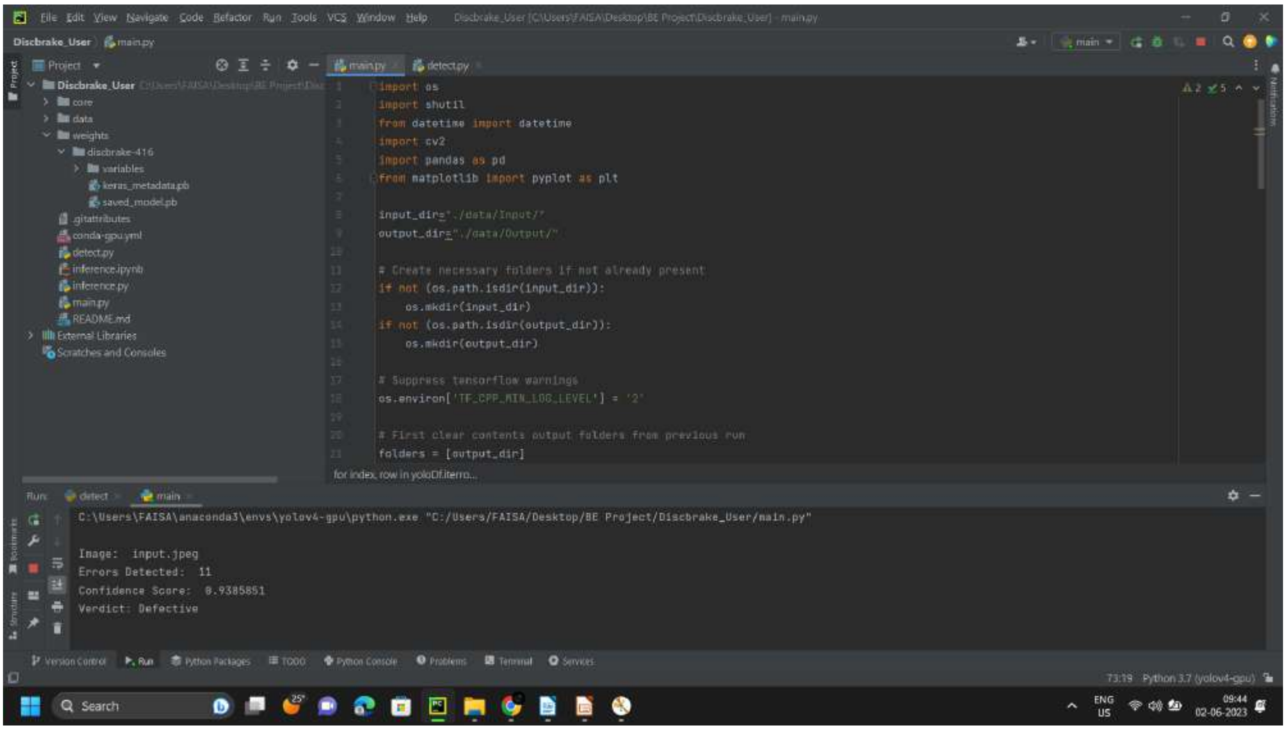


Figure 8.6: IDE interface

**Figure 8.8 shows the PyCharm IDE interface. The user can see how many errors are detected from input and how long it takes to process each image.**

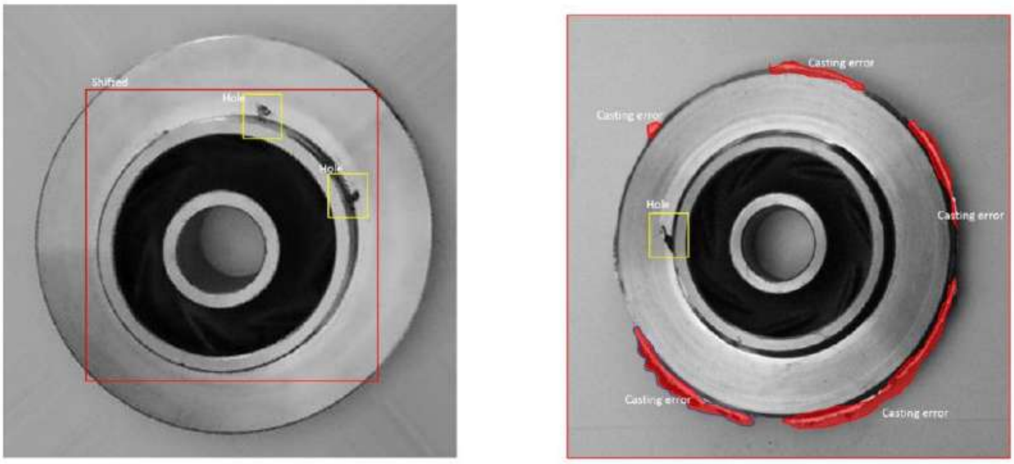



Figure 8.7: Output of Image

**Figure 8.11 shows the final output of the image.**

# Chapter 9

# CONCLUSIONS

## 9.1 Conclusions

**We can train and test the model on datasets from various sources. And feed certified datasets from automobile manufacturing companies for analysis in further stages. We can create a GUI interface for individual users to test particular images to check whether the disc brakes of their vehicles are safe enough to keep functioning. Each individual error can be displayed in a separate image output. CNN-based approaches have shown promising results for defect detection on brake disks. These approaches have the potential to improve the efficiency and accuracy of traditional inspection methods. However, there is still room for improvement, especially in more rah in CNN models that can handle a wide range of Henke disk defects.**

## 9.2 Future Work

**This model and approach is going to be quite useful as a primary addition to the assembly line of disc brake manufacturing companies. It will also be useful for safety testing of old as well as new units.**

## 9.3 Applications

**In this section the applications of the project will be discussed which are as follows:**

- **Automobile industry**
- **Finding safe disk brakes to avoid faulty results.**

# Appendix A

# Appendix: Assignments

**Detection of multiple defects on disk brakes using CNN**

## A.1 Mathematical Model

**Fig.A.1 shows the mathematical model of our system.**

## A.2 Mathematical Model

Given a training dataset $D = \{x_i, y_i\}_{i=1}^{m}$ where $x_i \in \Re^d$, $y_i \in \{+1, -1\}$, SVM classifies with an optimal separating hyperplane, which is given by:

$$D(x) = w^{T}x + b \quad (1)$$

When working with data non-linearly separable, this hyperplane is obtained by solving the following quadratic programming problem:

$$\text{Min} \frac{1}{2} w^{T}w + C \sum_{i=1}^{m} \xi_i$$
$$\text{s.t. } y_i(w^{T}x_i + b) \geq 1 - \xi_i, \ \ \xi_i > 0 \ \ for \ \ i = 1, \ldots, m \quad (2)$$

Figure A.1: Mathematical Model

- **Set Theory:**

**Let S be the Whole system S=I,P,O**
**I-input**
**P-procedure**
**O-output**
**Input( I)**
**I= Dataset as a Images/Individual Image of Disc Brake**
**Where,**
**Procedure (P),**
**P=I, System Using Perform the Operation and Predict the Personality.**

**Output(O)**
**O= Casting errors, Life and validity of disc brakes**

**Success if:**

- **error detected accurately.**
- **type of error detected accurately.**

**Failure if:**

- **More time consumption by the system.**
- **Hardware failure.**
- **Software failure.**
- **Improper network connection.**

**Space Complexity:**
**The space complexity depends on size of dataset .bigger dataset and more accurate results mean more space complexity.**
**Time Complexity:**

**If system has n records then, the time complexity of checking the records is O(1) in best case and O(n) in worst case.**

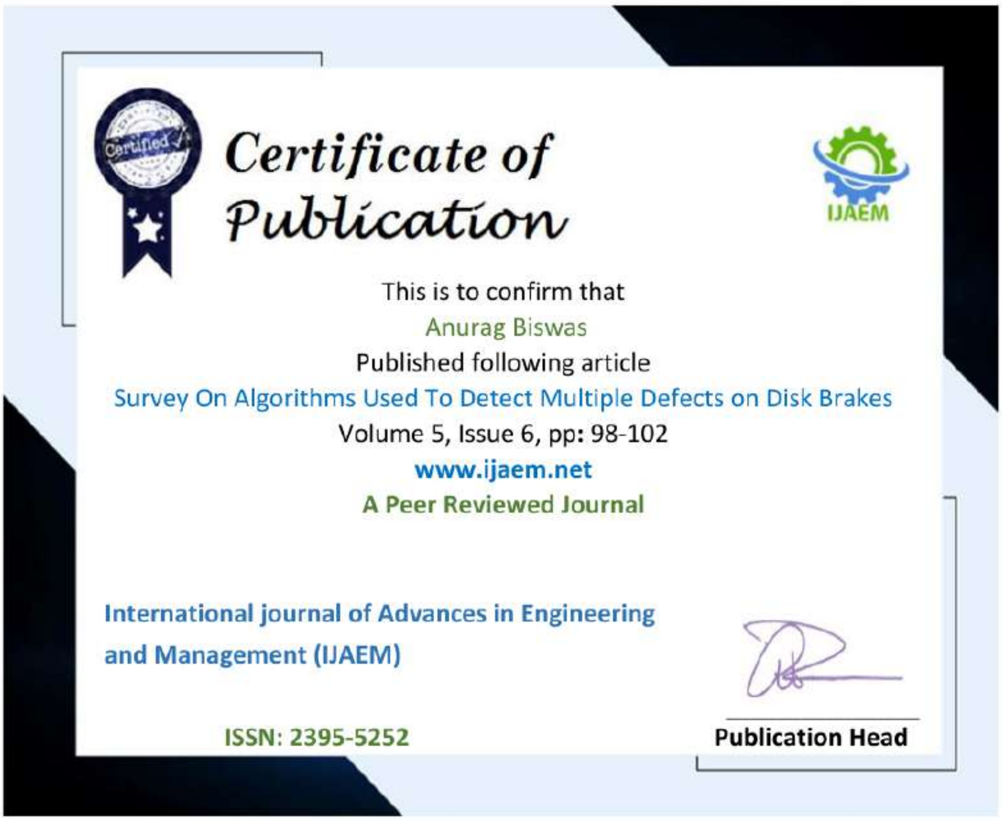
**E=end of program**
**T = Failures and success conditions.**

# Appendix B

# Appendix: Publications

**[1] Shrikant A. Shinde, Anurag Biswas, Kaif Ali Gaur, Vaishnavi Patil, Ritika Singh, "Survey on Algorithms Used to Detect ultiple Defects on Disk Brakes" International Journal of Advances in Engineering and Management(IJAEM)**
**Volume 5, Issue 6, July 2023,**
**DOI:ISSN: 2395-5252.**

**[2] Shrikant A. Shinde, Anurag Biswas, Kaif Ali Gaur, Vaishnavi Patil, Ritika Singh, "Detection of Multiple Defects On Disk Brakes Using CNN" International Journal of Advances in Engineering and Management(IJAEM)**
**Volume 5, Issue 6, July 2023,**
**DOI:ISSN: 2395-5253.**



Certificate of Publication

This is to confirm that

Anurag Biswas

Published following article

Survey On Algorithms Used To Detect Multiple Defects on Disk Brakes

Volume 5, Issue 6, pp: 98-102

www.ijaem.net

A Peer Reviewed Journal

International journal of Advances in Engineering and Management (IJAEM)

ISSN: 2395-5252

Publication Head

Certificate of Publication

This is to confirm that

Kaif Ali Gaur

Published following article

Survey On Algorithms Used To Detect Multiple Defects on Disk Brakes

Volume 5, Issue 6, pp: 98-102

www.ijaem.net

A Peer Reviewed Journal

International journal of Advances in Engineering and Management (IJAEM)

ISSN: 2395-5252

Publication Head

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This is to confirm that

Ritika Singh

Published following article

Survey On Algorithms Used To Detect Multiple Defects on Disk Brakes

Volume 5, Issue 6, pp: 98-102

www.ijaem.net

A Peer Reviewed Journal

International journal of Advances in Engineering and Management (IJAEM)

ISSN: 2395-5252

Publication Head

Certificate of Publication

This is to confirm that

Vaishnavi Patil

Published following article

Survey On Algorithms Used To Detect Multiple Defects on Disk Brakes

Volume 5, Issue 6, pp: 98-102

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International journal of Advances in Engineering and Management (IJAEM)

ISSN: 2395-5252

Publication Head

International Journal of Advances in Engineering and Management (IJAEM)
Volume 5, Issue 6 June 2023, pp: 98-102 www.ijaem.net ISSN: 2395-5252

# Survey On Algorithms Used To Detect Multiple Defects on Disk Brakes

1. Mr. Shrikant A. Shinde, 2. Anurag Biswas, 3. Kaif Ali Gaur, 4. Vaishnavi Patil, 5. Ritika Singh
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Date of Submission: 01-06-2023 Date of Acceptance: 10-06-2023

**ABSTRACT—** The Convolutional Neural Network (CNN) is a kind of network architecture for deep learning algorithms and is specifically used for image recognition and tasks that involve the processing of pixel data. There are other types of neural networks in deep learning, but for identifying and recognizing objects, CNNs are the network architecture of choice.
Support Vector Machine or SVM is one of the most popular Supervised Learning algorithms, which is used for Classification as well as Regression problems. However, primarily, it is used for Classification problems in Machine Learning.
The goal of the SVM algorithm is to create the best line or decision boundary that can segregate n-dimensional space into classes so that we can easily put the new data point in the correct category in the future. This best decision boundary is called a hyperplane.
**Keywords:** Machine - Learning algorithms, Regression, Fault Detection.

## I. INTRODUCTION

The automotive industry has been constantly evolving, and the demand for more reliable and safer vehicles has increased. Disk brakes are an essential component of the vehicle's braking system. However, disk brakes are prone to wear and tear, leading to defects that can result in brake failure.

Traditional methods of inspecting brake disks are time-consuming and often not accurate. Therefore, the development of an automated system that can detect multiple defects on disk brakes using CNN (Convolutional Neural Networks) can be of great importance. This survey paper aims to review the recent developments in the field of disk brake defect detection using CNN.

## II. RELEVANCE

Several research works have been conducted in the field of disk brake defect detection using CNN. In 2017, Gao et al. proposed a CNN-based method for defect detection on brake disks. The proposed method consisted of two CNNs: one for the detection of the brake disk region and the other for defect detection. The method achieved a high accuracy rate of 97.4%.

In 2018, Xu et al. proposed a deep learning-based approach for defect detection on brake disks. The proposed method utilized a pre-trained ResNet-50 model and achieved an accuracy rate of 98.3%. The method was also evaluated on real-world data, and the results showed that it outperformed traditional methods.
CNN Brake Defect Detection:

In 2019, Zhang et al. proposed a multi-task learning approach for defect detection on brake disks. The proposed method consisted of two tasks: brake disk region detection and defect

International Journal of Advances in Engineering and Management (IJAEM)
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detection. The method achieved an accuracy rate of 98.9% for brake disk region detection and 96.9% for defect detection.

In 2020, Wang et al. proposed a novel approach for brake disk defect detection using a two-stage CNN. The first stage detected the brake disk region, and the second stage detected defects within the brake disk region. The proposed method achieved an accuracy rate of 99.2% on the test dataset.

Convolutional Neural Networks (CNN) are a type of deep neural network that can automatically extract features from images. CNNs have been widely used in the field of computer vision for object detection, classification, and segmentation. In recent years, CNNs have also been used for defect detection in various industrial applications.

## III. MOTIVATION

Brakes are a very important part of any transportation vehicle and it is highly important that the developed brake parts are of good standard to stop any accidents. According to a recent survey, it is saddening to know that the largest number of accidents in the world occurs in India. In 2017 alone, there were 147913 accidents on the road, of which 48764 were on 2-wheelers, 26869 happened on cars, 20457 happened to people walking on roads and 3559 were on cycles. Approximately, 400 people die every day on our Indian roads due to different types of accidents. Based on the analysis done by the National Highway Traffic Safety Administration (NHTSA), it is observed that 22 percent of fatal accidents happen due to brake failure. This shows that one of the primary reasons for road accidents is the failure of Brakes. Therefore, it is crucial that all the developed brakes are of good quality without any defects or damages.

## IV. RELATED WORK

In [1], the fused model (SVM+ANN) incorporates two commonly used machine learning approaches through the use of fuzzy logic. The proposed ambiguous choice system has outperformed the previous system in accuracy, achieving a score of 94.87.

In [2], a validated RF-SMA-SVM model was created. Based on the experimental findings, the suggested method outperforms the SVM method based on other optimization algorithms in terms of prediction accuracy and performance stability while filtering out the important variables with strong discriminatory power.

In [3], The study used a variety of classifiers, such as Decision Tree (DT), Support Vector Machine (SVM), Random Forest (RF), K-Nearest Neighbor (KNN), Naive Bayes (NB), Multiple Perceptron (MP), J48 Trees, and Logistic Regression (LR) classifiers. In comparison to other classifiers, the proposed ensemble classifier beat individual classifiers in performance evaluation, achieving the best accuracy of 94%.

In [4], The four separate MSVM kernel functions of the support vector machine's MSVM model were used to categorize the six significant circumstances. For six sensor scenarios, the RBF kernel model provides the highest classification accuracy. The classification outcomes and statistical measurements were applied to the RBDT-MSVM model's evaluation. The overall accuracy of the categorization was 92.8571%. We may infer from the results above that an MSVM classifier with an RBF kernel function and RBDT is a top candidate for fault diagnosis of water quality monitoring equipment.

In [5], In order to accurately assess the patients' heart-disease status, the suggested HDPM was created and developed for the Heart Disease Clinical Decision Support System. The patient data, together with additional diagnosis data, were acquired by the HDCDSS and sent to a secure web server. After being transmitted, the data was saved in MongoDB, which can efficiently deliver a prompt answer. The patient's current heart disease status was then determined using the proposed HDPM, and the results were then communicated back to the HDCDSS's diagnosis result interface. A statistical review was also provided to support the model's significance. Experimental outcomes showed that the suggested model performed better than leading models and earlier study findings, with accuracy up to 95.90% and 98.40% for datasets I and II, respectively.

In [6], By using RBF-SVM decision classification and covariance matrix Cholesky decomposition, an effective method for blind spectrum sensing at low SNRs is described. An established SVM classification model is easily used to make the decision. The actual decision threshold has a self-learning capability based on the SVM, which successfully distinguishes signals from sounds. In terms of computational complexity, the suggested approach performs better than the traditional MME scheme. Simulation findings show that the suggested technique performs better than traditional detection ones, especially at low SNRs, demonstrating its potential for 5G communications.

In [7], Regarding data imputation and sample diagnosis, the suggested CKD diagnostic methodology is workable. The integrated model could reach a sufficient level of accuracy after KNN imputation was used to impute missing values in the data set without supervision. So, it is hypothesized that using this technology to really diagnose CKD would produce favorable results. Unfortunately, only 400 samples of the available data were used in the model-building procedure because of the constraints imposed by the requirements. As a result, the model's ability to generalize may be constrained.

In [8], To distinguish AD from HC, a machine learning classifier based on SVM was created. The outcomes demonstrated that examining the spatiotemporal information of the body joints as it changed while being captured by a Kinect V.2 camera yielded significant features from several TUG test subtasks. The SVM classifier's average accuracy and F-score were 97.75% and 97.67%, respectively, when evaluated using five-fold cross-validation, and 98.68% and 98.67% when evaluated using leave-one-subject out cross-validation. Their results confirmed the possibility of the thorough analysis of TUG utilizing a Kinect V.2 camera and machine learning as a simple and affordable complementary tool for the detection and routine quantitative assessment of AD in clinical or home settings.

In [9], A stacked SVM-based expert system was suggested to help with the diagnosis of heart failure. While the second SVM model served as a prediction model, the first SVM model was utilized to remove unnecessary characteristics. It was demonstrated that the suggested strategy outperformed eleven well-known methods that were already in use in the literature and other cutting-edge machine learning models. Also, it was noted that the strength of the suggested model outperforms the standard SVM model by 3.3%. The suggested approach is also effective in terms of time complexity. because the predictive model's training period is shortened. So, it can be inferred from the dataset's results that the suggested expert system can help doctors diagnose heart failure by improving their decision-making process.

In [10], The investigation on the identification and categorization of lamination flaws in the power transformer core was reported in this publication. Using a 15 kVA transformer, experimental results from a prior study were used. The conclusions are as follows.

1. For the detection purpose, where two classes were taken into consideration, SVM, KNN, and DT classifiers provided a good accuracy rate of around 82%.

2. The SVM method produced an accuracy rating for the categorization of 84.26%. For KNN and DT classifiers, it was 84.04%. In particular, for the DT method, the classification process was sensitive to data decomposition.

3. It was discovered that, in comparison to other classes, the insulating lamination fault exhibits a good accuracy rate. For this class, higher precision and recall were attained.

## V. LITERATURE SURVEY

| Sr. No | Title | Author/ YOP | Strength | Weakness |
|---|---|---|---|---|
| 1. | Harald Straky, Marco Muenchhof Rolf Isermann Publication:2021 | Model based fault detection and diagnosis [1] | The model was used for fault detection and diagnosis scheme; A correlation analysis method is used which is able to discern and diagnose air enclosures and leakages. | Can not detect force balance at the particular piston which allows to locate the fault |
| 2. | John Grezmaka, Jianjing Zhanga, Peng Wanga, Robert X. Gao Publication:2020 | "Multi-stream convolutional neural network-based fault diagnosis for variable frequency. "[2] | The model was used for fault detection and diagnosis scheme; A correlation analysis method is used which is able to discern and diagnose air enclosures and leakages. | Can not detect force balance at the particular piston which allows to locate the fault |
| 3. | Authors: Jing Yang, Shaobo Li, Zheng Wang, Hao Dong, Jun Wang, and Shihao Tang Publication:2021 | "Using Deep Learning to Detect Defects in Manufacturing: A Comprehensive Survey and Current Challenges "[3] | Automatic defect detection technology not only adapts to an unsuitable environment but also works in the long run High precision and efficiency. | Can not design defect information feedback technology that is based on defect detection technology. |
| 4. | Authors: Helly. N. Desai , Prof. Rakesh Patel Publication:2020 | "A Study of Data Mining Methods for Prediction of Personality Traits " | Fault detection and diagnosis of induction motors in variable frequency drive (VFD) applications Minimizing unexpected downtime, material waste and equipment damage | The relative amount of positive or negative relevance between sensor inputs is different for each speed. |
| 5. | Authors: Mufti Reza Aulia Putraa, Pandu Sandi Pratamab, Aditya Rio Prabowo Publication:2021 | 'Failure of Friction Brake Components against Rapid Braking Process " | The use of a good braking system will provide safety and comfort in its use. | A better cooling system can maintain the performance of a braking system |

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## V. CONCLUSION

In conclusion, CNN-based approaches have shown promising results for defect detection on brake disks. These approaches have the potential to improve the efficiency and accuracy of traditional inspection methods. However, there is still room for improvement, especially in more rah in CNN models that can handle a wide range of Henke disk defects.

## REFERENCES

[1]. Raheja J L, Kumar S and Chaudhary A 2019 Fabric defect detection based on GLCM and Gabor filter: A comparison. Optik, 124(23) 6469-6474.

[2]. Aarthi T, Karthi M and Abinesh M 2021 Detection and analysis of surface defects in metals using wavelet transform International Journal of Scientific and Research Publications 3(6) 147-158.

[3]. Sadeghi M and Memarzadehzavareh F 2020 Flaws detection in steel plates Using Gabor Wavelet. Life Science Journal 10(2s).

[4]. Chen, J.; Li, C. Prediction and Control of Thermal Scratch Defect on Surface of Strip in Tandem Cold Rolling. J. Iron Steel Res. Int. 2015, 22, 106–114. [CrossRef ]

[5]. Rodionova, I.G.; Zaitsev, A.I.; Baklanova, O.N.; Kazankov, A.Y.; Naumenko, V.V.; Semernin, G.V. Effect of carbon steel structural inhomogeneity on corrosion resistance in chlorine-containing media. Metallurgist 2016, 59, 774–783.

[6]. Amaya, J.; Lelah, A.; Zwolinski, P. Design for intensified use in product–service systems using life-cycle analysis. J. Eng. Des. 2014, 25, 280–302.

[7]. Detection Of Multiple Defects On Disk Brakes Using CNN

[8]. Wang, T.; Chen, Y.; Qiao, M.; Snoussi, H. A fast and robust convolutional neural network-based defect detection model in product quality control. Int. J. Adv. Manuf. Technol. 2018, 94, 3465–3471

[9]. Kandpal, L.M.; Park, E.; Tewari, J.; Cho, B. Spectroscopic Techniques for Nondestructive Quality Inspection of Pharmaceutical Products. J. Biosyst. Eng. 2015, 40, 394–408.

[10]. Li, B.; Cobo-Medina, M.; Lecourt, J.; Harrison, N.; Harrison, R.J.; Cross, J.V. Application of hyperspectral imaging for nondestructive measurement of plum quality attributes. Postharvest Biol. Technol. 2018, 141, 8–15.

[11]. Amar, M.; Gondal, I.; Wilson, C. Vibration spectrum imaging: A novel

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[13]. Shrikant A. Shinde, Bhavesh Patil, Mrunali Ghate, Poonam Shinare, Ajay Patil, "Skin Burn and Skin Cancer Detection using Image Processing ", International ResearchJournal of Engineering and Technology, Vol 9, Issue 6, June 2022.

[14]. Shrikant A Shinde, Shailaja N Uke, "Transmission Policies for Data Aggregation using Cooperate Node in Wireless Sensor Networks" IJSR Vol 6, Issue 1, Jan 2017

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# Detection Of Multiple Defects On Disk Brakes Using CNN

1. Mr. Shrikant A. Shinde, 2. Anurag Biswas, 3. Kaif Ali Gaur, 4. Vaishnavi Patil, 5. Ritika Singh

*Department of Computer Engineering*

*Sinhgad Institute of Technology and Science, Narhe, Pune, Savitribai Phule Pune University*

Date of Submission: 01-06-2023 Date of Acceptance: 10-06-2023

**ABSTRACT—** The Convolutional Neural Network (CNN) is a kind of network architecture for deep learning algorithms and is specifically used for image recognition and tasks that involve the processing of pixel data. There are other types of neural networks in deep learning, but for identifying and recognizing objects, CNNs are the network architecture of choice.

Support Vector Machine or SVM is one of the most popular Supervised Learning algorithms, which is used for Classification as well as Regression problems. However, primarily, it is used for Classification problems in Machine Learning.

The goal of the SVM algorithm is to create the best line or decision boundary that can segregate n-dimensional space into classes so that we can easily put the new data point in the correct category in the future. This best decision boundary is called a hyperplane.

**Keywords:** Machine - Learning algorithms, Regression, Fault Detection.

## I. INTRODUCTION

The automotive industry has been constantly evolving, and the demand for more reliable and safer vehicles has increased. Disk brakes are an essential component of the vehicle's braking system. However, disk brakes are prone to wear and tear, leading to defects that can result in brake failure.

Traditional methods of inspecting brake disks are time-consuming and often not accurate. Therefore, the development of an automated system that can detect multiple defects on disk brakes using CNN (Convolutional Neural Networks) can be of great importance. This survey paper aims to review the recent developments in the field of disk brake defect detection using CNN.

Inspection of brake components is very essential to detect the damaged manufactured parts before it is assembled in any vehicle. Manual inspection of brakes is extremely difficult since most of defects are very minute and cannot be identified by human eyes. Therefore, automatic inspection of manufactured brakes is indispensible to prevent failure of brakes and accidents. Previously, various research articles perform inspection of brake through conventional image processing and traditional image processing algorithms.

However, these techniques are capable of identifying a single fault only and are less robust to detecting numerous faults. Further, the existing techniques hardly localize the exact location of faults in the surface of brake. In order to over these drawbacks, in this research we utilize deep learning object detection algorithms namely Single Shot Detector and Faster RCNN to identify and localize the exact location of fault on the brake surface. Furthermore, the proposed system is capable to detect different types of faults in a single algorithm and is robust to brake's material surface, environmental and lightening factors. The deep learning algorithms are trained using transfer learning on custom collected dataset.

## II. RELATED WORK

In [1], the fused model (SVM+ANN) incorporates two commonly used machine learning approaches through the use of fuzzy logic. The proposed ambiguous choice system has outperformed previous system in accuracy, achieving a score of 94.87.

In [2], a validated RF-SMA-SVM model was created. Based on the experimental findings, the suggested method outperforms the SVM method based on other optimization algorithms in terms of prediction accuracy and performance stability while filtering out the important variables with strong discriminatory power.

In [3], The study used a variety of classifiers, such as Decision Tree (DT), Support Vector Machine (SVM), Random Forest (RF), K-Nearest Neighbor (KNN), Naive Bayes (NB), Multiple Perceptron (MP), J48 Trees, and Logistic Regression (LR) classifiers. In comparison to other classifiers, the proposed ensemble classifier beat individual classifiers in performance evaluation, achieving the best accuracy of 94%.

In [4], The four separate MSVM kernel functions of the support vector machine's MSVM model were used to categorise the six significant circumstances. For six sensor scenarios, the RBF kernel model provides the highest classification accuracy. The classification outcomes and statistical measurements were applied to the RBDT-MSVM model's evaluation. The overall accuracy of the categorization was 92.8571%. We may infer from the results above that an MSVM classifier with an RBF kernel function and RBDT is a top candidate for fault diagnosis of water quality monitoring equipment.

In [5], In order to accurately assess the patients' heart-disease status, the suggested HDPM was created and developed for the Heart Disease Clinical Decision Support System. The patient data, together with additional diagnosis data, were acquired by the HDCDSS and sent to a secure web server. After being transmitted, the data was saved in MongoDB, which can efficiently deliver a prompt answer. The patient's current heart disease status was then determined using the proposed HDPM, and the results were then communicated back to the HDCDSS's diagnosis result interface. A statistical review was also provided to support the model's significance. Experimental outcomes showed that the suggested model performed better than leading models and earlier study findings, with accuracy up to 95.90% and 98.40% for datasets I and II, respectively.

In [6], By using RBF-SVM decision classification and covariance matrix Cholesky decomposition, an effective method for blind spectrum sensing at low SNRs is described. An established SVM classification model is easily used to make the decision. The actual decision threshold has self-learning capability based on the SVM, which successfully distinguishes signals from sounds. In terms of computational complexity, the suggested approach performs better than the traditional MME scheme. Simulation findings show that the suggested technique performs better than traditional detection ones, especially at low SNRs, demonstrating its potential for 5G communications.

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In [9], A stacked SVM-based expert system was suggested to help with the diagnosis of heart failure. While the second SVM model served as a prediction model, the first SVM model was utilized to remove unnecessary characteristics. It was demonstrated that the suggested strategy outperformed eleven well-known methods that were already in use in the literature and other cutting-edge machine learning models. Also, it was noted that the strength of the suggested model outperforms the standard SVM model by 3.3%. The suggested approach is also effective in terms of time complexity. because the predictive model's training period is shortened. So, it can be inferred from the dataset's results that the suggested expert system can help doctors diagnose heart failure by improving their decision-making process.

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2. The SVM method produced an accuracy rating for the categorization of 84.26%. For KNN and DT classifiers, it was 84.04%. In particular for the DT method, the classification process was sensitive to the data decomposition.
3. It was discovered that, in comparison to other classes, the insulating lamination fault exhibits a good accuracy rate. For this class, higher precision and recall were attained.

## III. PROPOSED METHODOLOGY

### A. Overview

Data collection :-

1) First of all we provide images of disk brakes as a dataset to the machine which are input using GUI. We have to modify or prepare that dataset, for that next step is pre-processing.

2) Preprocessing :- In Pre-processing phase, in that removing the noisy and blurry part of the dataset, and re-scale, resize the image dataset.

3) After preprocessing of dataset, next phase is trained that dataset. For that, dataset goes through feature extraction classification.

Train the dataset :- In this process we train the dataset by following steps.

1) Feature extraction :- In Feature extraction extract the features like edges, size etc. from dataset. Extract the features for classifications. After Feature Extraction next step is segmentation.

2) Segmentation :- In segmentation we divide image in multiple parts. Then after the all steps done, next phase is classification . We used classifier for the classification.

3) Classification :- We used SVM/CNN algorithm for the classification. Classification is process of categorizing and labelling groups of pixels or vectors within an image based on specific rules. After all the training phase done Machine creates model i.e.

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trained model. It is 70 percent model.

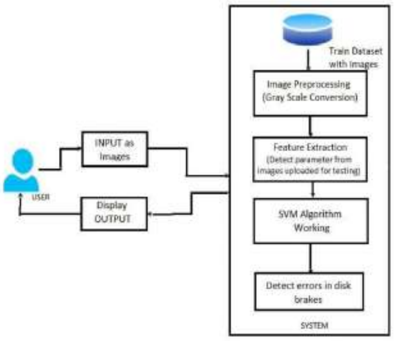
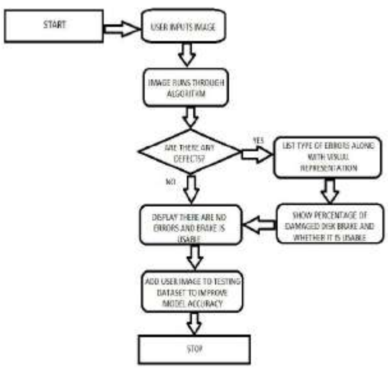



**Figure 1:** Proposed system architecture

Testing :- Testing is 30 percent model. We give input as image for testing. Then model can goes to testing phase and then provide the output to user. Output is to detect errors in disk brakes.

**B. Proposed System**

The proposed system contains ML, Model, GUI and SQL database.




*Algorithm 1: Proposed Algorithm*

1. Sense the environment
2. Learn the faults in disc brakes using unsupervised dataset
3. Data gathering from user
4. Data transmission by front end GUI to backend ML model.
5. SVM and RCNN find the errors in disk brakes.
6. Errors displayed using visual means like graphs and pie charts
7. Performance measures used to show accuracy and usability of units.
8. Results obtained added to supervised dataset for fine tuning.
9. Check performance parameters and calculate result

**C. Mathematical Model**

A mathematical model of the proposed system is given below-

1. Set Theory :-
2. Let S be the Whole system S={I,P,O}
3. I-input
4. P-procedure
5. O-output
6. Input( I)
7. I={ Dataset as a Images/Individual Image of Disc Brake}
8. Where,
9. Images -¿ Image
10. Procedure (P),
11. P={I, System Using Perform the Operation and Predict the Personality.}
12. Output(O)
13. O={ Casting errors, Life and validity of disc brakes }

**4. Experimental Setup Assumptions :**

1. The application is interfaced with high speed internet connectivity.
2. The system recovers automatically in case of any failure.

**Dependencies :**

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1. DB SqlLite3 database is used for the storage of user information.
2. System is an interface provided to predict the errors present in disk brakes.
Software Interfaces

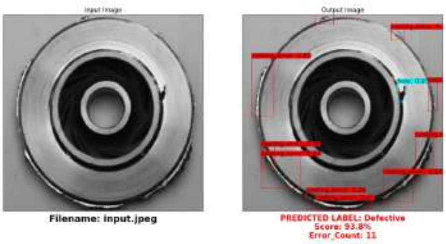
**Operating System:** Windows 10

**IDE:** Pycharm ,Spyder

**Programming Language :** Python

**Communication Interfaces:**
• Anaconda Navigator
• Spyder

### 5. Results and Discussion




As per the Image above the ML model is able to recognize casting defects and wear and tear defects in the given disc brake that are not visible to the naked eye. The Result obtained is labelled with the type of error and percentage of defectiveness. The resultant image is then further fed back into the training dataset to improve its efficiency and accuracy for future inputs.

### 6. Conclusion and Future Scope

In conclusion, CNN-based approaches have shown promising results for defect detection on brake disks. These approaches have the potential to improve the efficiency and accuracy of traditional inspection methods. However, there is still room for improvement, especially in more rah in CNN models that can handle a wide range of henke disk defects.

### 7. Acknowledgment

The authors would like to thank the publishers, researchers for making their resources available and teachers for their guidance. We also thank the college authority for providing the required infrastructure and support. Finally, we would like to extend a heartfelt gratitude to friends and family members.

### 8. References

[1] Raheja J L, Kumar S and Chaudhary A 2019 Fabric defect detection based on GLCM and Gabor filter: A comparison. Optik, 124(23) 6469-6474.

[2] Aarthi T, Karthi M and Abinesh M 2021 Detection and analysis of surface defects in metals using wavelet transform International Journal of Scientific and Research Publications 3(6) 147-158.

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[5] Rodionova, I.G.; Zaitsev, A.I.; Baklanova, O.N.; Kazankov, A.Y.; Naumenko, V.V.; Semernin, G.V. Effect of carbon steel structural in homogeneity on corrosion resistance in chlorine-containing media. Metallurgist 2016, 59, 774–783.

[6] Amaya, J.; Lelah, A.; Zwolinski, P. Design for intensified use in product–service systems using life-cycle analysis. J. Eng. Des. 2014, 25, 280–302.

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[9] Kandpal, L.M.; Park, E.; Tewari, J.; Cho, B. Spectroscopic Techniques for Nondestructive Quality Inspection of Pharmaceutical Products. J. Biosyst. Eng. 2015, 40, 394–408.

[10] Li, B.; Cobo-Medina, M.; Lecourt, J.; Harrison, N.; Harrison, R.J.; Cross, J.V. Application of hyper spectral imaging for nondestructive measurement of plum quality attributes. Postharvest Biol. Technol. 2018, 141, 8–15.

[11] Amar, M.; Gondal, I.; Wilson, C. Vibration spectrum imaging: A novel

[12] Shrikant A. Shinde, Sakshi Bondre, Priyanka Parmar, Khushboo Patil, Pratiksha Yewalkar, "An Social Distance Violation Detector System", International Journal of Innovative research in Engineering, Vol 3 , Issue 3, PP 191-195, May-June 2022.

[13] Shrikant A. Shinde, Bhavesh Patil, Mrunali Ghate, Poonam Shinare, Ajay Patil, "Skin Burn and Skin Cancer Detection using Image Processing ", International ResearchJournal of Engineering and Technology, Vol 9, Issue 6, June 2022.

[14] Shrikant A Shinde, Shailaja N Uke, "Transmission Policies for Data Aggregation using Cooperate Node in Wireless Sensor Networks" IJSR Vol 6, Issue 1, Jan 2017

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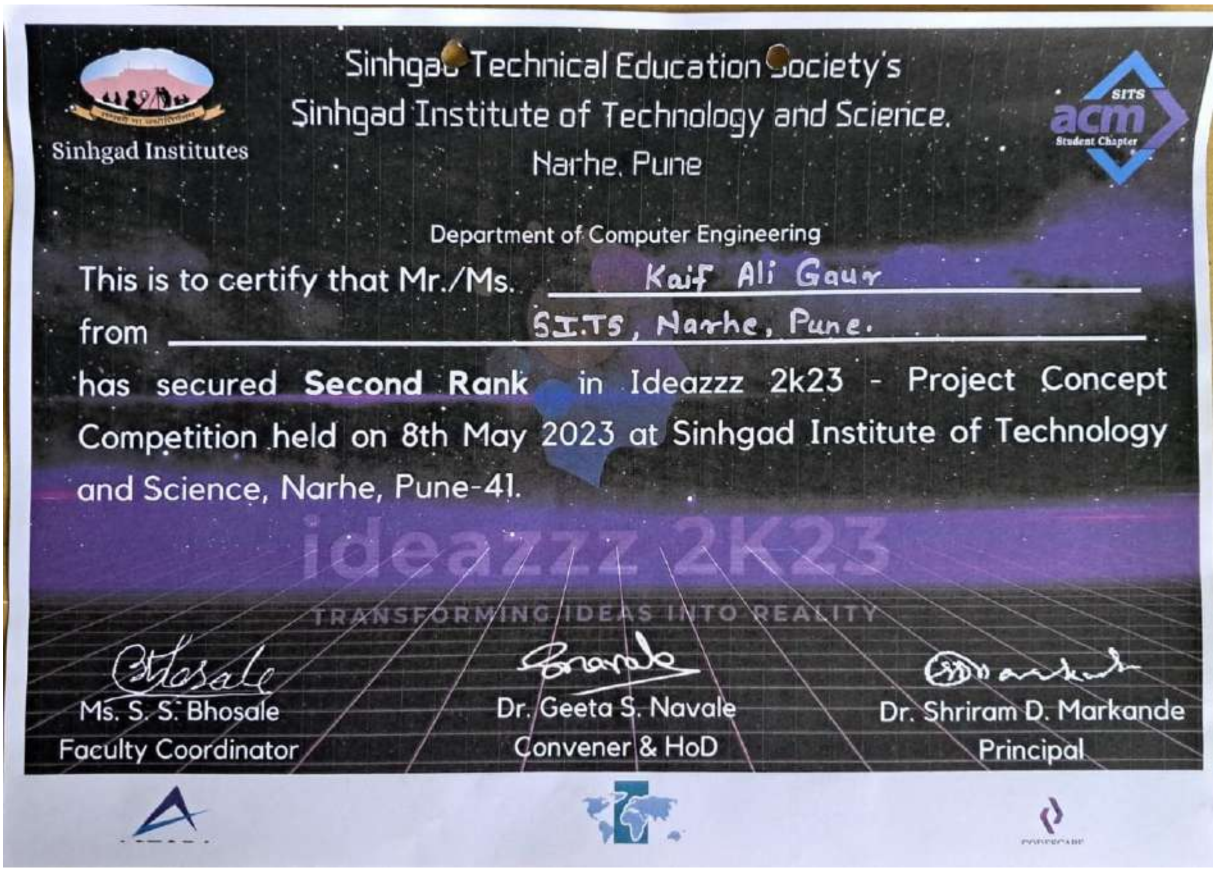
# Appendix C

# Appendix: Certificates

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Department of Computer Engineering

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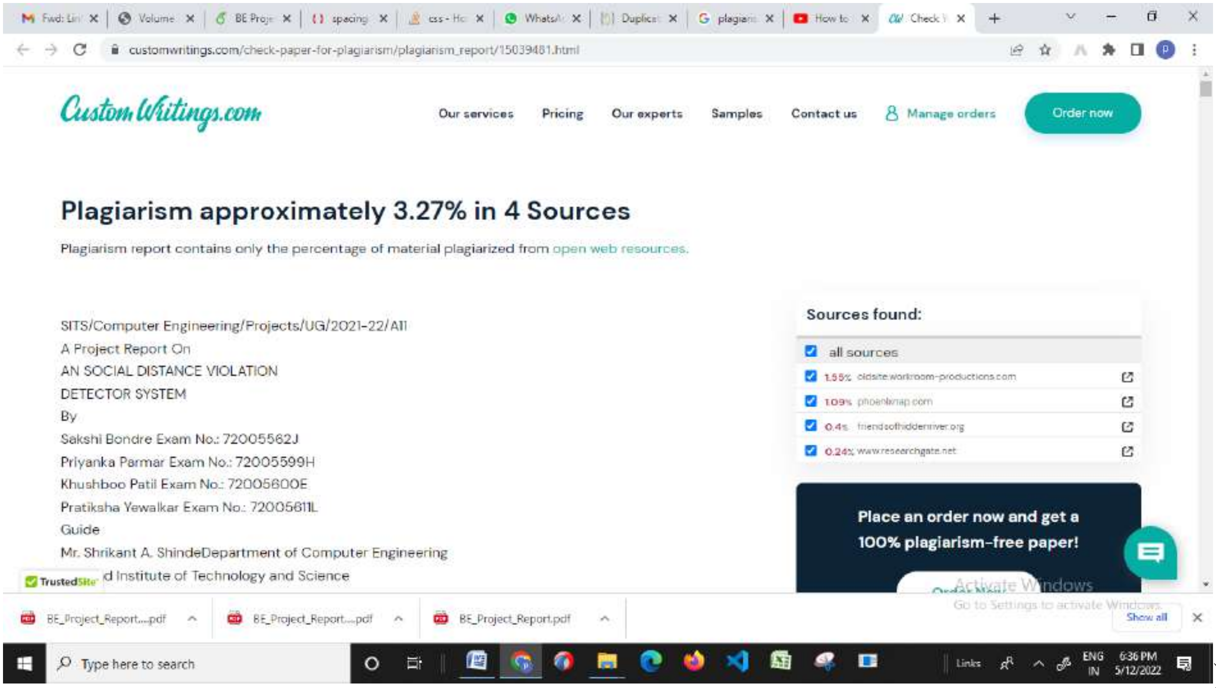
# Appendix D

# Appendix: Plagiarism Report



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