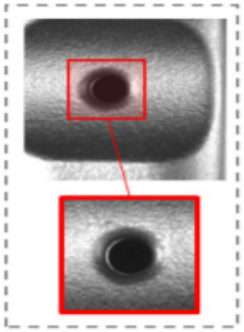
# Boss Technology LTD.

## Image processing for mold damage detection

## Problem definition

- **What is our product ?**



Detecting defects in casting products is often done by human inspection but nowadays, computer vision based techniques can be implemented to carry out the process more efficiently on a large scale. In this report we have experimentally demonstrated.

We have developed a robust tool for early, fast, accurate and automated detection of **defects present in mold** using two computer vision based techniques, Deep Learning and OpenCV and briefly discussed the potential advantages of these techniques over other conventional methods.

- **Who is it for ?**

We are a Mumbai based startup in the field of AI-Manufacturing aiming to redefine the **manufacturing sector in India** and become a strong pillar in providing reliable and accurate **damage detection services.** We plan to enter the B2B market of the Indian manufacturing industry with our defect detection solutions in the early phase of manufacturing like casting.

As with the increase in science there is a lot of evolution in the field of manufacturing and also there is an increased level of competition in the manufacturing market. So in order to grab the attention of consumers the manufacturer must try to increase their production while maintaining the quality. So that's why quality control is an important aspect of modern manufacturing processes.So in order to meet the growing demand for high-quality products the manufacturer must have to think out of box and in current time the use of AI is becoming essential as it reduces the quality checking time and accuracy.

- **Why should they come to us ?**

The implementation of conventional methods to find defects directly affect the default casting rates . This inspection process which uses machine vision has several advantages

compared to the previous quality testing processes. It is much **more productive** and **fully automatic** . So it also **reduces the amount of labour** required for the quality checking process of the mold.

So overall, it will increase the efficiency in manufacturing with more profit.

- ## Customer (End-user) requirement

It's more precise than other conventional methods such as ultrasonic and eddy current testing,laser scanning, and can detect damage on a variety of mold surfaces. Fast, accurate, robust, and reliable defect detection solutions to the manufacturing industry at an affordable price range. Supervisors no longer have to wait for the long quality checking process of the mold in order to do further processing.

- ## Market survey for available solutions

Viking Analytics and iioote (detecting mold), The U.S. Centers for Manufacturing Control and Prevention(mold quality inspection) , Siemens(AI solution in manufacturing)

- ## Key differentiator

We are providing **3 to 4 manufacturing problem solutions** which include defect detection, defect classification, bounding box detection and estimating defect size. Among these the major are bounding box detection and estimating defect size.So first we will check if there is defect or not, and if defect is present then make bounding box around it, and then check if the estimated dimensions are above some threshold or not. If it exists then we will discard the product and send it for further manufacturing.

- ## Unique selling point (USP)

Easy-to-use, multi-problem solution, user-friendly interface to assist companies identify potential defects in mold at early stages. High accuracy (>90%), sensitivity and specificity as compared to conventional methods and other and other available solutions.

- ## Protection of USP

Code encryption and secure and reliable cloud and continuous updation of data for the model Patenting and copyrighting of our startup solutions, and codebase OR keep it as industry secret

- ## Barrier to entry both by you and others

Manufacturing data protection laws and extent of production data and there may be a fear among manufacturing industries that it may reveal their way of production to others. Also there are patents and copyright issues from other startups/companies working in the

field. Due to automation, there is an increase in unemployment of workers which are engaged in the quality checking process.

- ## Business case

At every checkpoint of manufacturing, we will use high quality cameras making $360^{o}$ in order to provide a continuous set of images to our server. Then our model will check for localisation and estimation of defects if it exists and if the defect size is above some threshold then send the alert to the supervisor to discard the product for further manufacturing.

We will provide a year long subscription system to manufacturing factories at a very reasonable cost which will help them to increase their efficiency.

# Technology Landscape

- ## Published Literature

1) Road Damage Detection Using Deep Neural Networks :- **(Hiroya Maeda et al.)**

In this paper they have developed a new, large-scale road damage dataset, and then train and evaluate a damage detection model that is based on the convolutional neural network (CNN) method using object detection frameworks such as Faster R-CNN,YOLO, R-FCN, SSD etc.The dataset contains the eight types of road damage. This model is proposed to identify the type of damage from among the eight types with high accuracy.

2) Edge-Detection for Crack Identification in Bridges :- **(Abdel-Qader et al.)**

In this paper they have detected cracks on a deteriorated bridge and compared the effectiveness of 4 crack detection techniques: : fast Haar transform (FHT), fast Fourier transform, Sobel, and Canny edge detection. They use MATLAB to implement the image edge-detection algorithms and simulated using a sample of 50 concrete bridge images.

3) Using Artificial NN for Detecting Tobacco Leaves :-**(Himer George et al.)**

In this paper a pattern recognition technique was implemented, called Artificial Neural Networks. They used train and testing images of damaged leaves for training the model, and achieved 97% + accuracy.

4) Automatic Localization of Casting Defects with CNN :- **(Max Ferguson et al.)**

In this paper, a defect classification model is trained based on a series of defect images and then uses a sliding classifier method to develop a simple localization model. The localization accuracy and computational performance were evaluated on the GDXray database of X-ray

images.They applied the three object detection architectures to the casting defect detection task i.e. Faster R-CNN , R-FCN and SSD .

5) Mold Quality Inspection using Image Processing :- **(Venkatraman et al.)**

In this research paper image processing for the damage detection is done using OpenCV library in python. Here the basic concept used is to match the similarities of the features of the input image with a certain referenced image and if our image matches with our referenced image(usually defected image) to a certain percentage then we can comment about the presence of the defect in the sample.

6) Method for Defective Casting Products with CNN :- **(Thong Phi Nguyen et al.)**

In this research paper image processing for the damage detection is done using the convolutional neural network algorithm by training the data sets of the conventional casting defects and which makes it possible to detect various types of defects.

- ## Open Libraries

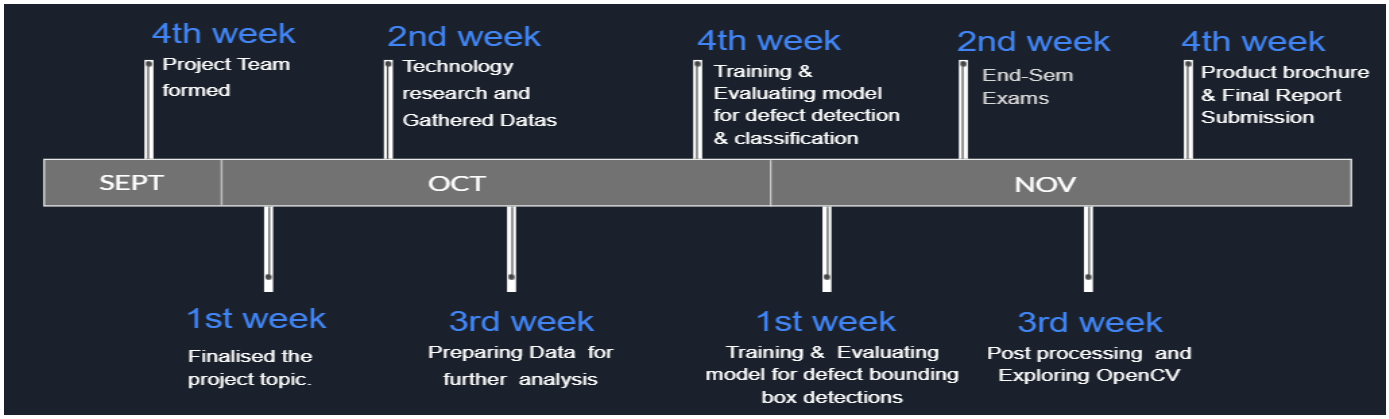
1) Numpy
2) OpenCV ( SIFT and SURF)
3) Matplotlib
4) Keras
5) Imutils
6) PIL(python Imaging Library) by ImageChops

- ## Proprietary libraries

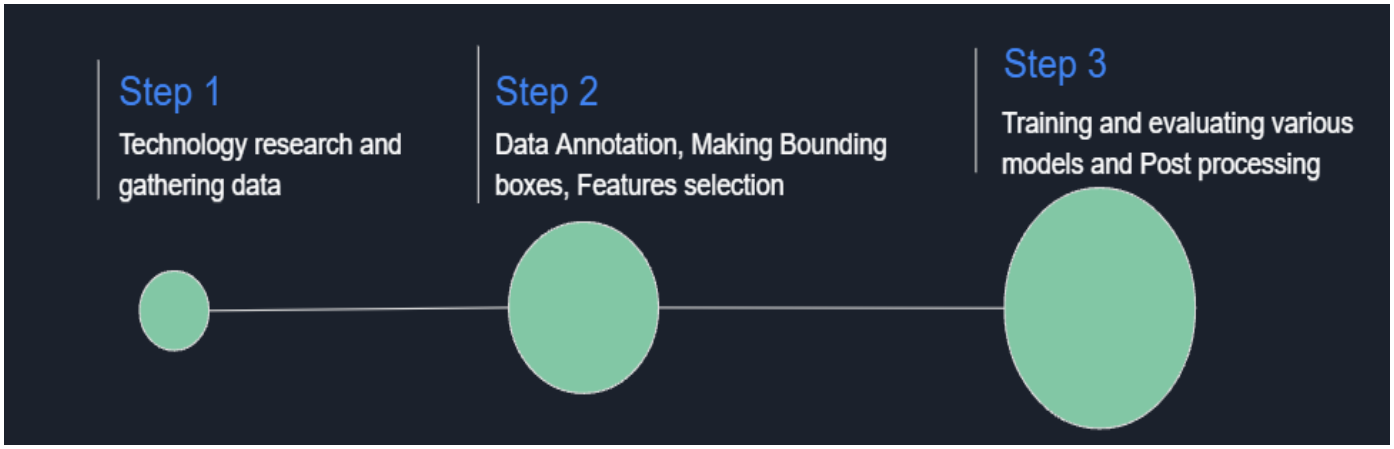
1)Casting product image data for quality inspection

# Project Planning

- ## Timeline



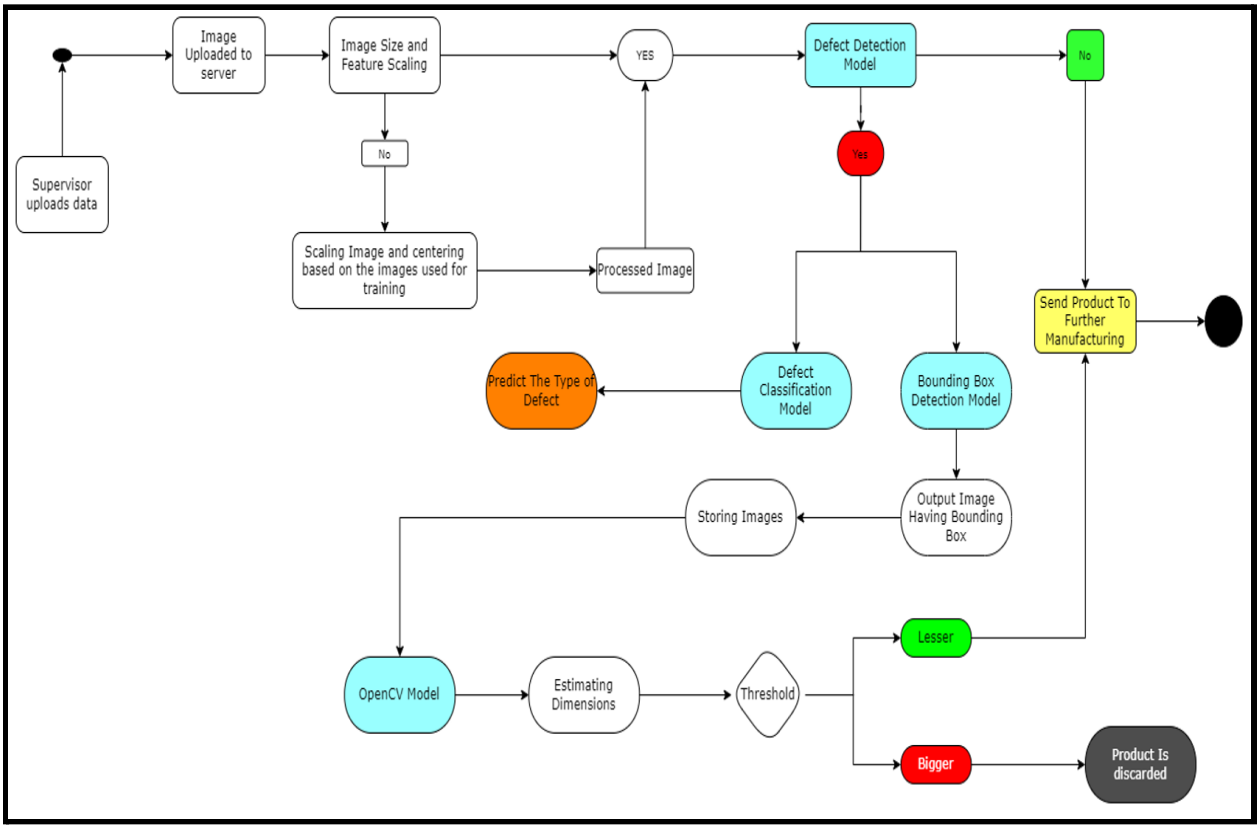
- **Strategy**




- **Rasic chart**

| Tasks Completed | 10/10-16/10 | 17/10-23/10 | 24/10-30/10 | 31/10-6/11 | 14/11-20/11 | 21/11-24/11 |
|---|---|---|---|---|---|---|
| Technology Research | Brijalkumar Prajapati | | | | | |
| Data Gathering | Omprasad Vibhute | | | | | |
| Data Transformation | Sumit Bhong | | | | | |
| Making bounding boxes manually | Samyak Ajmera | | | | | |
| Training and Evaluating model for defect detection and classification | | | Sumit Bhong | | | |
| | | | Brijalkumar Prajapati | | | |
| Training and Evaluating model for defect bounding box detections | | | Omprasad Vibhute | | | |
| | | | Samyak Ajmera | | | |
| Code documentation and Product brochure | | | | | Brijalkumar Prajapati | |
| Marketing Slides and Video | | | | | Omprasad Vibhute | |
| Final Report and OpenCV (if possible) | | | | | Samyak Ajmera | |
| Presentation Slides | | | | | Sumit Bhong | |

# Conceptual design




Our first task to move ahead was to detect if there is damage in the casting mould or if it is good.

So for the detection of the presence of the defect we proposed an inspecting system supported by the deep learning algorithm (CNN). We implemented our model on 6633 training images containing both defected and sound images.

Now that we have detected the presence of defects in a casting mould we need to find what kind of defect is present in the casting mould.The dataset we used had three kinds of defects which included Blowholes , Metallic projections and both blowholes and Metallic projection.So for the classification of these defects again we used our Convolutional Neural Network algorithm with appropriate changes to detect the type of defect. Here we used the same training dataset of 6633 training images to train our model.

After we classified the image as whether it contains a defect or not, the next step is to localize the defect within the image. We annotated around 3000 images containing defective images and trained it using the YoloV3 model (ref: https://pjreddie.com/yolo/ ).

Now after using machine learning we have done some extra work on the OpenCV. We have implemented a series of in-built opencv functions to find differences between 2 images. We then extended this method to find defects in casting products by using 2 similar images with one non defective casting product and the other containing defect. Then using feature matching

methods we figured out the difference between the 2 images which corresponds to the defect. The size of the objects in an image can be found using opencv. The algorithm uses a reference object with known dimensions and evaluates a property called ‘pixel per metric ratio’. We have used a similar concept to estimate defect size in casting products.

# Unit Test report

Our model expects images of products at every checkpoint of manufacturing using high quality cameras making $360^{o}$ in order to provide a continuous set of images to our server. So after uploading an image to the server the image will be pre processed and centralized as per our model and the parameters of image are also feature normalised. We perform data pre-processing with a good enough time on our end so that no discrepancies can come in the time of prediction which then successfully passes all testing parameters required in the code testing part.

After performing these tasks, an image is sent to our first model( defect detection) which will check if the defect exists or not. If it is not defected then we are done and will send the product for further manufacturing but if defected then we will send the image to our second and third model simultaneously which will predict the type of defect and localise the defect. Next we will go for openCV for estimating dimensions and if the defect dimension is avoidable we will send it to further manufacturing and if not then discard.

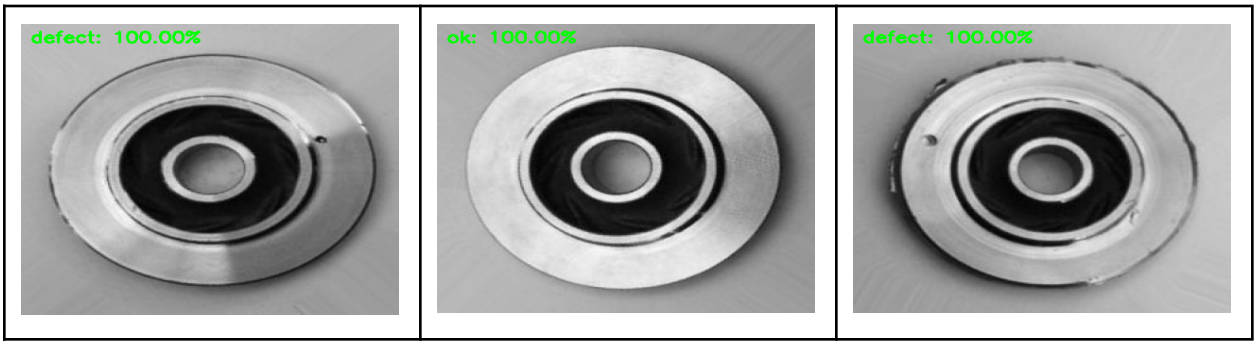
Hence, our model is 4 step unit testing and at each step testing is necessary for further analysis. The testing is done in the above mentioned sequences.

# Model training and testing report

## 1) Defect Detection :-

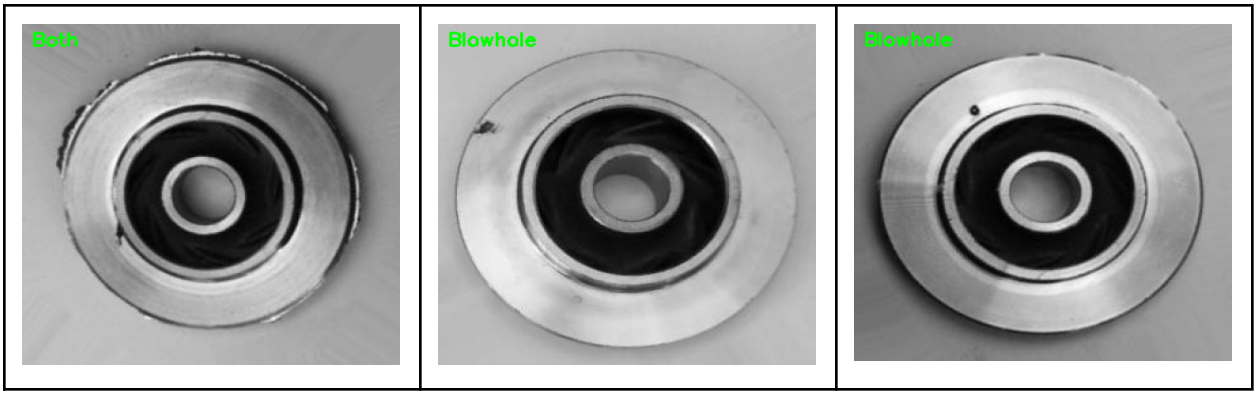
We tested our model and predicted the presence of defects with an accuracy of **92.33%** on the training dataset and an accuracy of **87.34%** on the test dataset.

Given below are some of the predicted images from test dataset with the percentage confidence of accuracy:



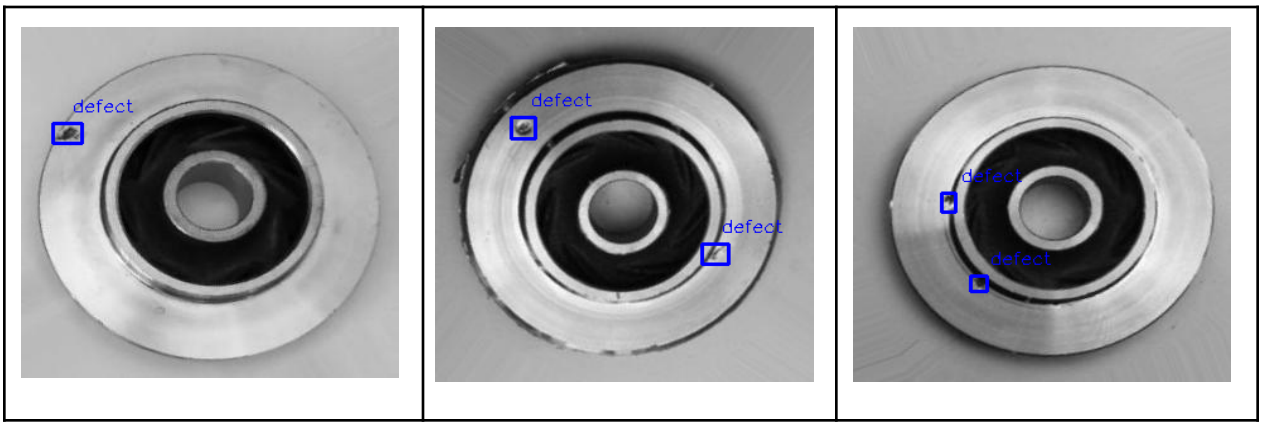
## 2) Defect Classification :-

Here are some of the classified defects in the image test dataset:



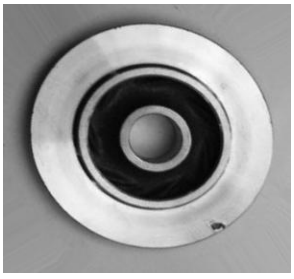
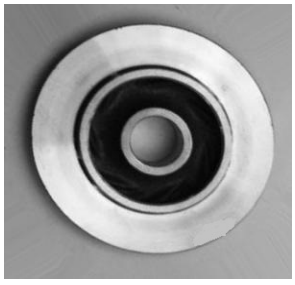
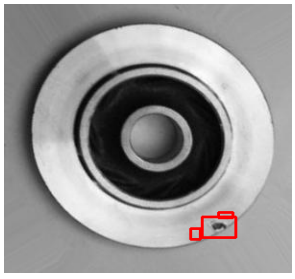

## 3) Bounding Box Detections :-

Using an object detection algorithm to identify and localize the defects is more efficient and reliable as can be seen in the below images. Overall test accuracy of the model was **99%**.



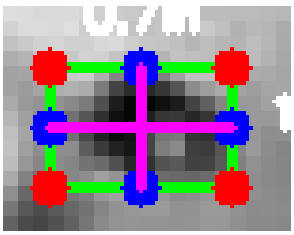

## 4) Open CV Methods :-

### 4.1) Defect detection using feature matching :-

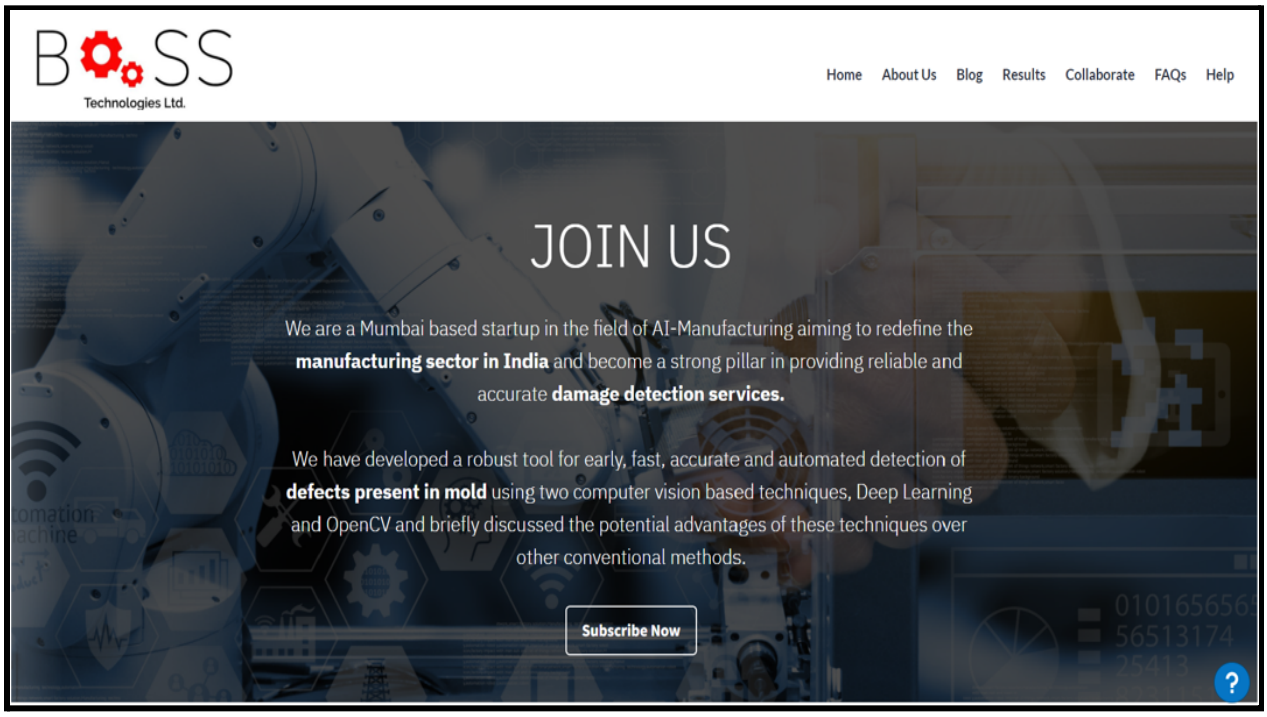
| Defective product | non-defective product | Output of the detection algorithm |
|---|---|---|
|  |  |  |

### 4.2) Estimation of defect size

Following are some results of our implementation :

| | | |
|---|---|---|
| Defect |  |  |

# User Manual and Interface




- **Product description**:

Automated Defect Detection Software for early, fast, accurate and automated detection of defects present in mold using two computer vision based techniques, Deep Learning and OpenCV in manufacturing industries.

- **Intended use:**

This application is mainly intended for the use of manufacturing industries where supervisors no longer have to wait for the long quality checking process of the mold in order to do further processing.

- ## Features/accessories:
    - Fast analysis of defects in the product
    - Save amount of labour required  for the quality checking process
    - Increased efficiency in manufacturing
    - Increased pace in manufacturing
    - Store Manufacturing detailed summary for CEO on our reliable server
    - 24/7 Technical Support, Free Installation
- ## Description of the user interface:

After logging in the software you will be able to see your user id on the top right of the interface. In the top panel, you will see Home, About Us, Result/Report, Collaborate, Blog and Contact Us.

- **Home:** Your main page just after login
- **About Us:** Our startup journey and product information
- **Results:** Contains past results and reports of their production efficiency
- **Collaborate:** Details if you or your organization would like to collaborate with us for supplying data so that we can develop our model with new products
- **Blog:** Connect with our and our partner organization's consultants to discuss the new market of manufacturing and get notified about our model dataset update.
- **Contact Us:** Details of our contact for technical support or other help.
- **Images:** Upload images of products at every checkpoint
- **Defect-status**: Predict if the image is defected or not
- **What-to-do:** Tell if the product is discarded or not

Just below the box, there is an option for next to navigate**.** Further below you will see our different links to connect with us and other things regarding policy, copyright, permissions

- ## Safety warnings:

Our model accepts images of products. We need high quality cameras **making 360º** in order to provide a continuous set of images to our server and must be present at a fixed position at every checkpoint of manufacturing.

- ## Installation instructions:

Since we partner with industries, so supervisores need to install the software from your organization link to connect to your industry server systems.

- ## Steps to use the app:

1. Login with the credentials assigned to you by your industry
2. Once you have logged in you will be able to see the ‘Results’ button in the top right corner. Click on it to view the progress and efficiency of your manufacturing.
3. Choose a previously existing badge input image or enter a new image for a new badge in the ‘center’ box. Use ‘Next’ and ‘Previous’ buttons to navigate across the tabs.
4. After processing the image, our model will give you the details of which product to keep and which product to discard.
5. Based on your accuracy and total final products you may see how much extra new products you have to make in order to complete your desired target.

- **Maintenance information:** Do check server status from your side daily to avoid overloads.
- **Technical Details**: Once you upload the product image under the ‘Image’ tab, the image will be uploaded to our computation server for analysis where we will first predict if the product is defected or not and if it's defected then we capture the defect area from the casting image using a bounding box model. After that further analysis is done using OpenCV by estimating the defect size and to check if this defect size is avoidable or not. Once the process is done, the input image is deleted from the server.

  **NOTE:** If you give us permission from the ‘Collaboration’ tab above, we save the image and also save the final data of where the defect is present and what are its dimensions.

- **Repair information:** If you face any problem, try restarting the app. If it doesn’t help try to contact your industry technical team for any server related problems or check out our self-help videos. If the problem stays, do contact our technical team for assistance.
- **Information on disposal of the product and packaging:** Once you are out of the organization, inform the technical team to remove your access to the system.
- **Data Privacy Concerns:** Privacy is our most important concern. So, server spaces are

specific for each subsystem and industry can buy more spaces based on their need. Once a supervisor from a specific organization signs in, (s)he will be able to see only those data that comes to his/her supervision.

- **Contact details:** For technical assistance contact us at techsupport@bosstechnology.com or reach out to our team