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DEFECT DETECTION MODEL

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Contents

Abstract

Existing problem

The American Society of Quality does report that quality-related costs can account for up to 40% of total production revenue for many organizations, and that manual inspection is a major source of inefficiency and inconsistency in quality control in manufacturing.

The reasons cited for the limitations of manual inspection, such as the difficulty of ensuring standard procedures are followed and the potential for human error, are also well documented in the literature.

It is also true that the reliability of manual visual inspection is limited, and that the FMEA inspection process guidelines do account for factors such as operator subjectivity, visual fatigue, and defects that may not be detectable by the human eye. Overall, the information presented in this statement appears to be accurate and supported by industry reports and research.

Motivation

The lack of skilled workforce is a common challenge in many industries, and the use of fully automated inspection solutions can help mitigate this challenge by reducing the need for human involvement in the inspection process.

Tools

Python(Tensor flow, OpenCV,…) On (google colab , jupyter notebook)
Deep Learning (CNN , Vgg).
Computer Vision.
Image Processing.
Flutter.

Background

Motivation

Manufacturing systems and industrial businesses aim to increase productivity while minimizing costs. However, relying solely on human workers to achieve this can be expensive. Although scientific methods can improve productivity, quality control remains a challenge.

Beneficiary

The main beneficiaries of this application are industries, including food and technology, among others.

Main techniques

The problem of inconsistent and inefficient manual inspection can be overcome with AI models using deep learning and computer vision.

Defect detection using CNN is a rapidly growing area of machine vision with applications in numerous industries. By training an AI model on what a product should look like, it can then be given video or photo input and tasked with determining whether a product is defective or not.

CNN is a specialized class of neural network designed for processing data with a grid-like topology, such as images. Digital images are binary representations of visual data, arranged in a grid of pixels with values that determine their color and brightness. CNN typically consists of four layers: a convolutional layer, a pooling layer, a fully connected layer, and a nonlinearity layer.

The convolutional layer uses important computer vision concepts such as parameter sharing and matrix shrinking to process images.

The pooling layer summarizes the output of the convolutional layer and reduces the amount of computation required. There are various methods for pooling, including maximum and average.

The fully connected layer connects neurons in the preceding and succeeding layers through matrix multiplication and bias effects.

Nonlinearity layers, such as sigmoid, tanh, and ReLU, are often used after the convolutional layer to introduce nonlinearity to the activation map and account for the nonlinear nature of images.

Main application

Our main application is designing an AI defect detection model that detects defects in industrial manufacturing. We will design it as a mobile application to serve as a proof of concept.

Problem Definition

The issue of defective products has been a persistent challenge in industry. It cannot be eliminated through the industrial process. Most companies use human resources to do manual inspection. The current manual inspection methods are time-consuming, boring for the workers and not making them gain any skills, and not scalable for high-volume production lines.

This problem can be overcome by an AI-system that should be able to identify various types of defects in a product, including but not limited to cracks, scratches, missing components, and incorrect assembly, with high accuracy and in real-time.

Furthermore, the model must differentiate between defects and normal variations in the products to avoid misclassifying them.

The model should be designed to detect predefined defects in a specific product. Moreover, the solution should be easily integrated with existing production lines and scalable for future growth.

The ultimate goal of this project is to reduce the time and costs associated with manual inspection. The AI-based defect detection system should improve product quality, automate the process of separating defective products, and increase the overall efficiency of the manufacturing process.

Related work

First Project:

MobiDev; Concrete Crack Detection with Unsupervised ML.

Similarities: it detects defective products.

Differences: It is an unsupervised model. It requires human intervention, and The results often have lesser accuracy.

Reference:

https://mobidev.biz/blog/defect-detection-in-manufacturing-with-unsupervised-learning

Second Project:

ML defect detection model based on CNN.

Similarities: Using CNN with two stages, the first stage determines the location of defects while the second stage creates error masks for each specific error location.

Differences: The cost of the required equipment for laser detection remains significantly high, while our method is cheaper.

Reference:

https://www.sciencedirect.com/science/article/pii/S2214860421001305

Third Project:

Machine Learning Based Intelligent Defect Detection System.

Similarities: The approach involves pre-processing images using OpenCV, training the program with CNN, and implementing generative adversarial by max pooling. Python is used in the testing stage.

Differences: It uses the overall architecture of the GAN-based detection system (by using GAN-based samples maker).

Reference:

https://www.researchgate.net/publication/327647709_Study_on_Machine_Learning_Based_Intelligent_Defect_Detection_System

Fourth project:

STRUCTURE DEFECT DETECTION USING MACHINE LEARNING ALGORITHMS

Similarities: using CNN to train the model on the dataset and to improve the accuracy of CNN.

Differences: We use a CNN with two stages forming overlapping capture areas to reduce the likelihood of a crack lying on the boundary of the individual scans going undetected. Additionally, we are training region-based convolutional neural networks to detect various types of defects.

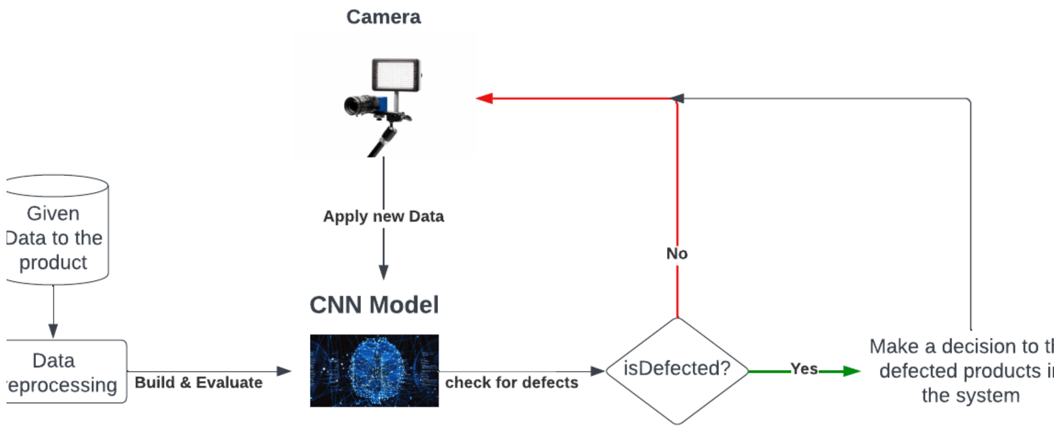
Reference:

https://patents.google.com/patent/CA3056498A1/en

Project specifications

System architecture

Diagram:

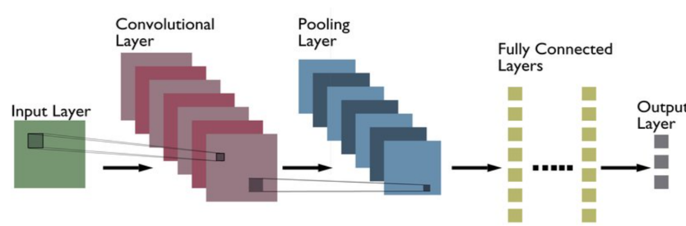


Machine Learning Stages:

- Collecting Data (Images Dataset).
- Preparing the Data (Preprocessing to the images).
- Choosing a Model.
- Training the Model.
- Evaluating the Model.
- Making Predictions.

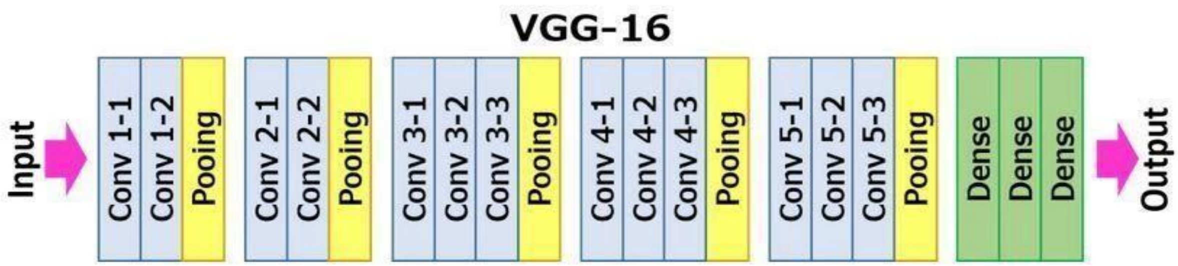
CNN Layers:

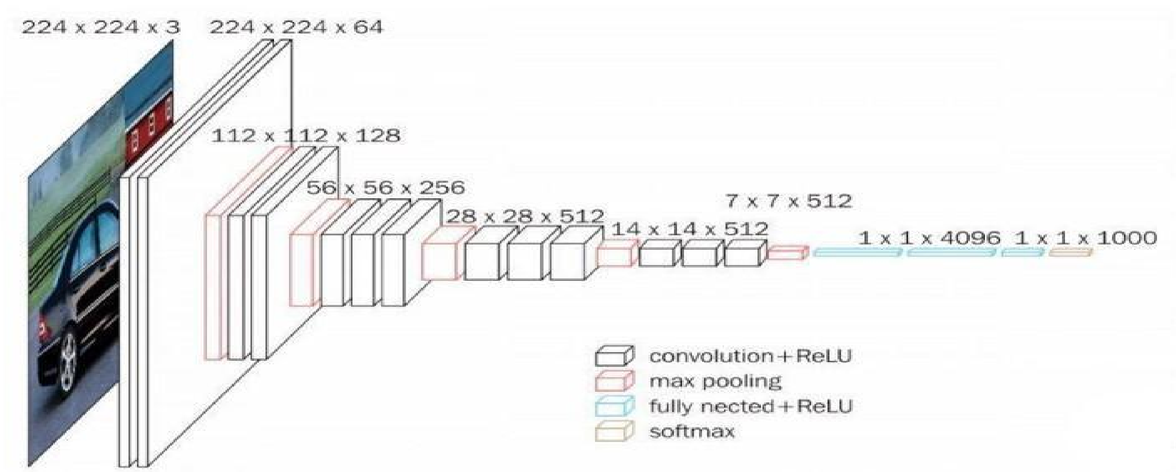
- Input layer.
- Convolutional layer (Convo, ReLU).
- Pooling layer.
- Fully connected layer.
- Output layer.



CNN Architecture (VGG16)

Visual Geometry Group
- It is a successful architecture applied on CNN for classification that has known numbers of layers in the network and get good results in the competition applied to the ImageNet Dataset.





Stakeholders

- Factory workers: Using the model to check the products for defects improves product quality.
- Factory owner: Check the workers using the model and assess the impact of the project on the model's performance.
- Product expert: Can differentiate between defective and good products and interact with the model.
- Team members: Fix bugs or update the model and evaluate its performance to make it more successful.

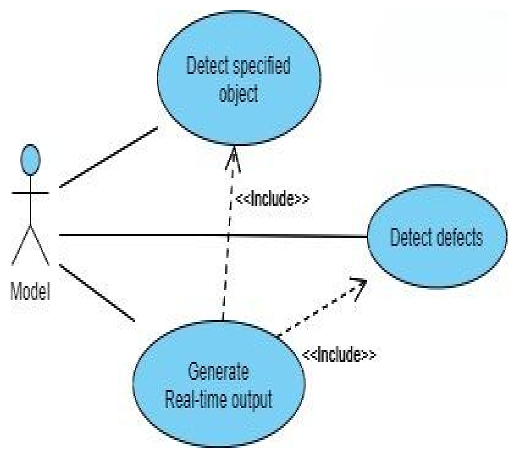
Functional Requirements

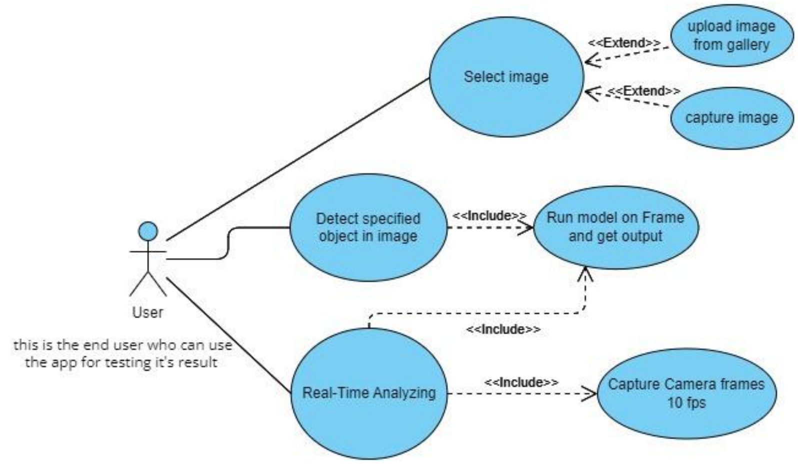
- Detects the defects in the image of the product.
- Real time detection of the defect.
- Defect Detection using video of the product.
- Using video as frames to apply the model.
- Output feedback on the quality of the products.

Non-functional Requirements

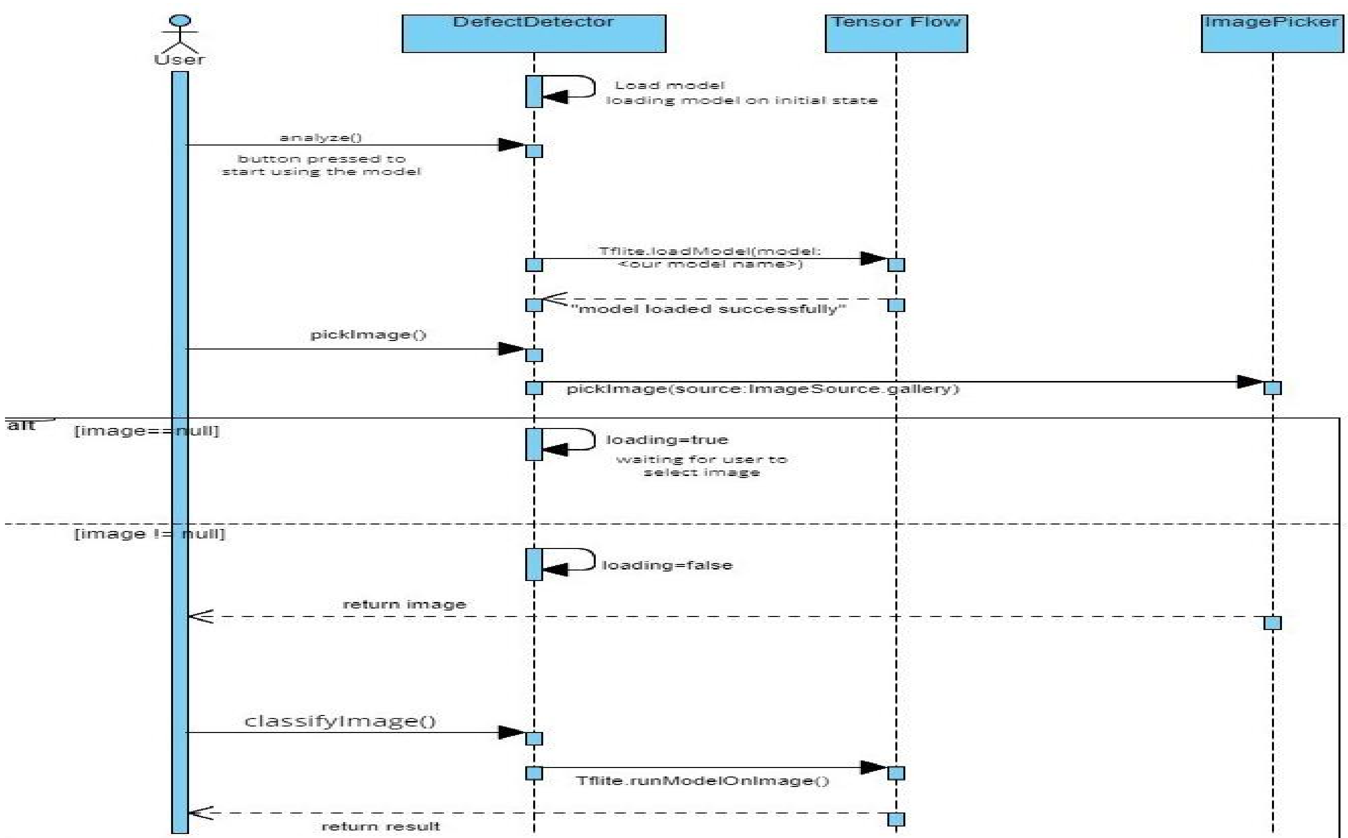
- Easy to use: The system can be used with just one click by uploading an image or video.
- High performance: The model is selected to ensure high accuracy and validation.
- Usability: Factories can save money on manual inspection and reduce the workload for workers.
- Scalable: The system can be expanded to detect additional types of defects as needed.

Use Case Diagram





Sequence Diagram

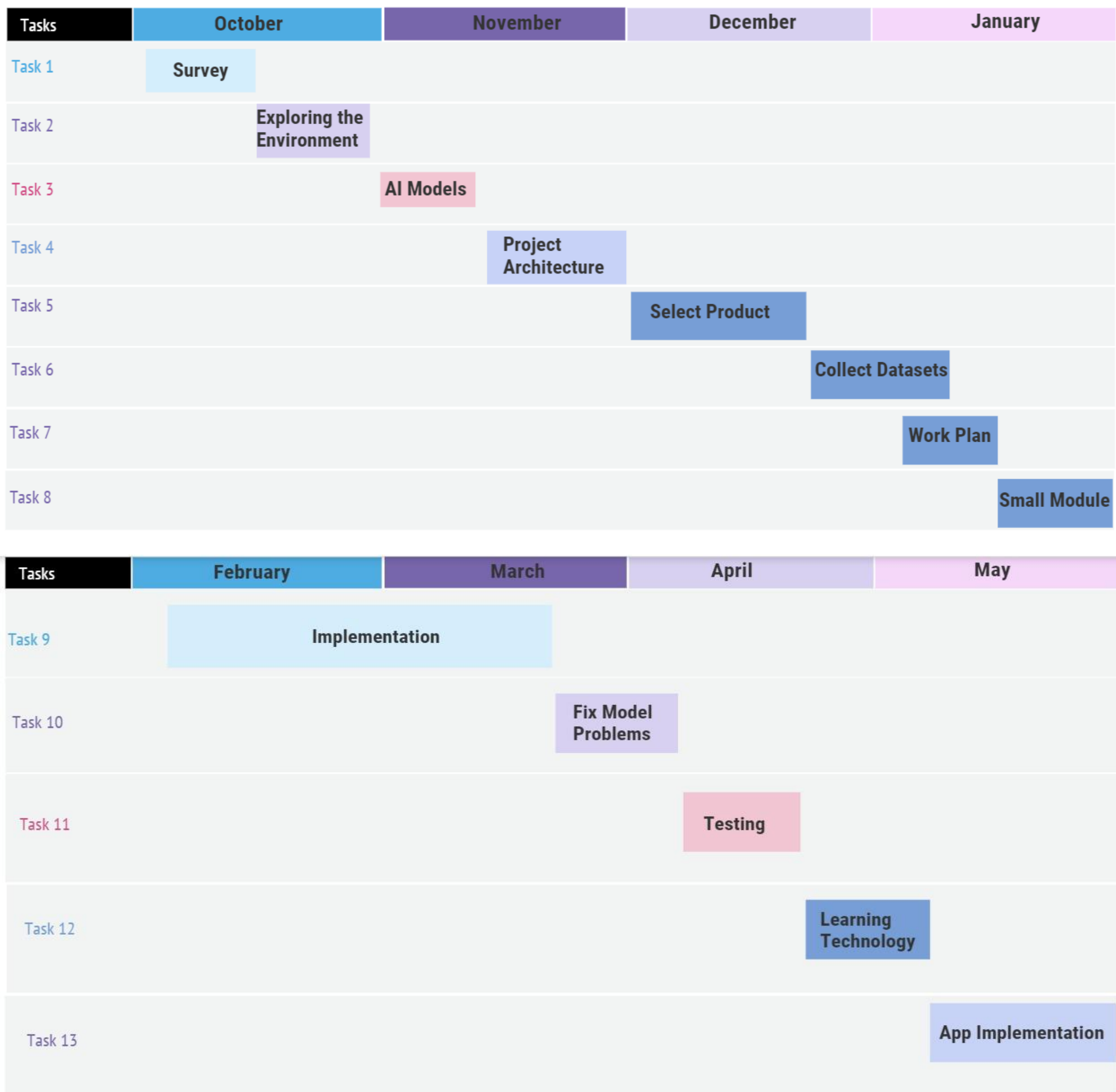


Time Plan

Task	Task Title	Task Description	Task Status
1	Survey	Conducting a survey to determine which project to work on.	Completed
2	Exploring the Environment	Exploring the environment of AI projects.	Completed
3	AI Models	Learning the development of Ai Models using python and different ml algorithms..	Completed
4	Project Architecture	Conducting research to determine a suitable architecture for the project.	Completed
5	Select product	We searched for some of products, and we choose the best product to implement our model on	Completed
6	Collect Datasets	Collecting the proper datasets for the project.	Completed
7	Work plan	Writing the work plan for the next period.	Completed
8	small module	Implementing a module to explore the process of dealing with live video and generating real-time output.	Completed
9	Implementation	Implementing and training the model.	Incomplete
10	Fix Model Problems	addressing any bugs and taking steps to prevent overfitting if there are unexpected results.	Incomplete
11	Testing	Testing and evaluating the model.	Incomplete

12	Learning Technology	learning how to develop a mobile app using Flutter and Dart.	Incomplete
13	App Implementation	Develop a mobile app and deploy the model to simulate the IOT system.	Incomplete

Gantt Chart:



Mobile Application UI