FINAL YEAR PROJECT

FYP-1 Final Report

“AutoInspect”

Supervisor :- Dr. Atif Jillani

External Supervisor :- Dr. Kashif Sagher

Group Members

Muhmmad Saqib i190494

Vara Ali i190502

FAST School of Computing

National University of Computer and Emerging Sciences

Islamabad, Pakistan

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Table of Contents

Project Vision Document

Auto-Inspect
Vision Document

Approved by
Dr. Atif Aftab Ahmad Jillani

Prepared by
Vara Ali i190502
Muhammad Saqib i190494

National University of Computer and Emerging
NUCES FAST ISB

Revision History :-

Name	Date	Reason for Change	Version
Vara Ali Muhammad Saqib	23-10-2022	Initial Version	1.0
Vara Ali	24-12-2022	1. Business Positioning is modified by adding a few details . 2. There were various formatting mistakes which were removed .	1.1

1. Introduction :-

1.1. Purpose :-

The purpose of this vision document is to highlight , analyze and to have a better understanding of the high-level system requirements .It focuses on the capabilities needed by the stakeholders , targeted users and to understand why actually these needs exist . It also helps us in identifying and reducing the potential risks caused by the system .

1.2. Scope :-

The vision applies to “AutoInspect” , which is basically an automated inspection technique for the surgical instruments . This system helps the surgical instruments manufacturers to increase the efficiency of their quality assurance departments by providing them with an efficient technological solution employing machine learning and computer vision techniques to ensure the quality of instruments . **Dr. Frigz International** is an original equipment manufacturer in the surgical industry and shall be our main sectoral collaborator for this project . The company shall facilitate in getting defects related to surgical instruments, collection of data sets, and provide feedback for field trials and improving the developed prototype machine and approaches.

2. Positioning :-

2.1. Business Opportunity :-

Pakistan is one of the leading exporters of surgical equipment with exports worth **$359M USD** but this export volume has been affected by quality issues during the recent years . This is because currently most of the inspection related tasks performed to ensure adherence to quality standards in the surgical industry are manual which are more prone to errors . Plus in the coming few years Medical Devices Regulation (MDR) will be imposed on each and every surgical instrument being exported to European Countries .

The European Medical Device Regulation (MDR) is a new set of regulations that governs the production and distribution of medical devices in Europe, and compliance with the regulation is mandatory for medical device companies that want to sell their products in the European marketplace. This naturally creates a need in the market where surgical instrument manufacturers will be looking for a way to get compliant to these regulations along with improving their quality.

2.2. Problem Statement :-

Following table explains problem of a certain user group being targeted by AutoInspect and how the solution being proposed would benefit them.

The problem of	manual eyeball inspection of the surgical instruments in Pakistan
affects	quality of surgical instruments produced by our manufacturing industry
the impact of which	results in inconsistent product quality causing damage to the reputation as well as rejection of export orders . Thus adversely affecting the exports volume of our country.
A successful solution would be	a technological approach employing Computer Vision as well as Machine Learning techniques that ensures pre-shipment grading and thorough inspection of the manufactured instruments .
The current available systems	majorly involves human intervention which makes it prone to more errors and less efficient in terms of accuracy and resource consumption (time & finances) .

Table :- Problem Statement Tabular Explanation

2.3. Product Position Statement :-

Following table explains the value our product AutoInspect will be delivering to its target market customers .

For	Surgical Instrument Manufacturers for their Quality Assurance Department
Who	are looking to improve product quality and consistency by adopting an automated inspection technique
AutoInspect	is an automated inspection technique for the surgical instruments employing ML and Computer Vision
That	helps the surgical instruments manufacturers to increase the quality of their product by providing them with an efficient technological solution
Unlike	manual eyeball inspection technique with involves major human intervention
Our Product	Provides efficient and runtime classification of surgical as faulty or non-faulty plus indicating the type , size and location of the fault .

Table :- Product Positioning Statement Explanation

3. Stakeholders and User Description :-

3.1. Market Demographics Statement :-

The target market includes the surgical instruments manufacturers from Pakistan with the aim to make their quality inspection methodologies more efficient to produce consistent products and export them throughout the world capturing export magnitudes .

3.2. Stakeholders Summary :-

Stakeholders include Instrument Manufacturing Company , Workers , Quality Assurance Department / Analysts and customers of the company . These stakeholders directly or indirectly influence the working and impact of our system as compared to its competitors.

Stakeholders	High Level Goals	Problems
Instrument Manufacturing Company	The company needs as automated system in addition to its workforce to identify the faulty surgical equipments	If the faulty equipments are not identified and separated the entire shipment of exported surgical equipment gets rejected which causes loss to the company
Workers	Workers manually conduct the eyeball inspection of the instruments. An automated system would counter check and verify the existence of faulty or non faulty instruments	Workers might miss any fault because the inspection they conduct is manual
Quality Assurance Department Analysts	The responsibility Quality Assurance Department/ Analysts is that no faulty equipment that has been detected by the system becomes a part of the shipment that has to be exported	Absence of stats generated by the fault detection system makes it difficult for the quality assurance department to analyze which instruments are faulty in the entire batch
Customers	The buyers or customers of the shipments of surgical instruments need to have fault and defect free material	In case of faulty instruments being exported to the customers it might cause fatal consequences .

Table :- Summarizing the Stakeholders

3.3. Stakeholders Profile :-

Stakeholders of our system AutoInspect range from Instrument Manufacturing Company , Workers , Quality Assurance Department / Analysts to the customers of the company .
Following tables explain each and every stakeholder of the company individually .

Stakeholder Name :- Instrument Manufacturing Company	
Description	Industries involved in any type of surgical instruments manufacturing like scissors , needles , knives , blades .
Type	Major stakeholder whose whole factory's reputation and thus the investment is on-stake .
Responsibilities	Ensures that 1. The system has been deployed properly 2. The surveillance of quality analysts and the workers is strict
Success Criterion	1. All the faulty surgical instruments which went pass through the conveyor belt undeflected must be non-faulty 2. The type , size and shape of defects have been computed accurately so that corrective measures could be taken
Involvement	Corrective measures to be decided carefully keeping in view the quality stats generated based on the fault logs containing fault descriptions i.e., is faulty , localize defect , fault size and fault shape

Table :- Instrument Manufacturing Company Description as Stakeholder

Stakeholder Name :- Workers of the Company	
Description	Technicians and workers appointed along the conveyor belt carrying product line and the inspection system
Type	Casual Stakeholder who have minor interest in the accuracy of the system but interested in keeping the process going
Responsibilities	Ensuring that 3. The Inspection system has the desired environment needed for its operation like camera , lightning , calibrations and focus . 4. The surveillance of the product line so that all the surgical instrument i.e., subject in coming right under the focus of camera
Success Criterion	1. Subject is coming right under the focus of the camera 2. Environment i.e., lightning is so adjusted that camera captures each surgical instrument properly
Involvement	1. Adjusting in the environment i.e., camera , light and calibration mounts if needed 2. Correcting the adjustment of the product line if unoriented

Table :- Workers Description as Stakeholder

Stakeholder Name :- Quality Assurance Department	
Description	Analyst from the Quality Assurance Department responsible of analyzing the fault logs & quality stats and deciding the corrective measures
Type	Major stakeholder whose is primarily responsible for the quality consistency and efficiency of surgical instruments produced and exported
Responsibilities	Ensuring that 1. Instruments produced are up-to the mark and of export quality standards are being met .

Stakeholder Name :- Quality Assurance Department	
Description	Analyst from the Quality Assurance Department responsible of analyzing the fault logs & quality stats and deciding the corrective measures
	2. Figuring out the corrective measures in the product line if certain quality issues are being faced frequently .
Success Criterion	1. Instruments being produced are of export standards meeting all the quality standards like Medical Devices Regulations . 2. Corrective measures to amend the product line faults
Involvement	1. Analysis of fault logs and quality stats 2. Adjusting the product line manufacturing processes whenever needed in order to produce consistent quality products

Table :- Quality Assurance Department Description as Stakeholder

Stakeholder Name :- Customers	
Description	Customers of the surgical instruments from wholesale buyers to hospitals and individual doctors depending upon their need of type of surgical instruments and magnitude of the order
Type	Major stakeholder as the surgical instruments are to be used in hospitals by doctors during operations and the faulty instruments can make the situation messy during operation and can have serious consequences
Responsibilities	1. Use of the surgical instruments as guided by the manufacturer 2. Sterilization of the surgical instruments after use plus if the instrument life has expired
Success Criterion	1. Product Quality is up-to the mark as promised by the manufacturer 2. Order is delivered on-time and safe and secure . No damage to the shipment .

Stakeholder Name :- Customers	
Description	Customers of the surgical instruments from wholesale buyers to hospitals and individual doctors depending upon their need of type of surgical instruments and magnitude of the order
Involvement	1. Involved in the purchase of the surgical instruments & that's where the whole process initiates . 2. Use of the surgical equipment on-field

Table :- Customer Description as Stakeholder

3.3. Key Stakeholders and User Needs :-

Stakeholders and needs of different users have been identified in the table as follows ;

Need	Priority	Concern	Current Solution	Proposed Solution
Efficient	High	Faulty instruments might get into the export batches	None	The computational unit ensures to have as minimum false positive as possible so that no faulty instruments gets to pass the inspection phase
Optimized	Moderate	Run-time inspection and conveyor belt grading operations will be adversely affect causing system to fail	None	The testing time for the algorithms being used is made carefully and deliberately low despite the fact that training time might be comprised to high
Repeatability	Moderate	This may affect the accuracy and precision of the inspection system	None	YOLO models being used for training which ensure the repeatability property

Accuracy	Hight	Faulty instruments might get into the export batches or non-faulty instruments might get to re-inspection frequently	None	The ML and Image Processing techniques used and deployed in the computational unit are well judged and test to achieve high accuracy and precision
Easy to Use	Moderate to High	Workers mightn't be able to adjust to the complexity and so the system might fail	Yes existing manual solution is quite easy	Prototype machine consisting of just a camera , calibration mounts and lighting setup . All the computation takes place at the hardware computational unit

Table :- Key Stakeholder and Their Needs

3.4. Alternatives and Competitors :-

1. Manual Inspection method where humans pass each instrument to their eyeball test and search for the possible defects if present but carelessness and limitations of humans make this existing solution much more prone to errors .
2. Fully Automated Inspection System like Industrial Vision UK where we get complex machines and methodologies to ensure 100% accuracy but such systems have extremely high cost , multiplex SOP to use , complex maintenance strategies and the most important one , adjusting to industrial methods and their corresponding potential defects is quite hard to figure out .

4. Product High-Level Architecture :-

Following figure depicts the interactions of different system components to achieve a unified goal of defect detection in surgical instruments .

"AutoInspect"

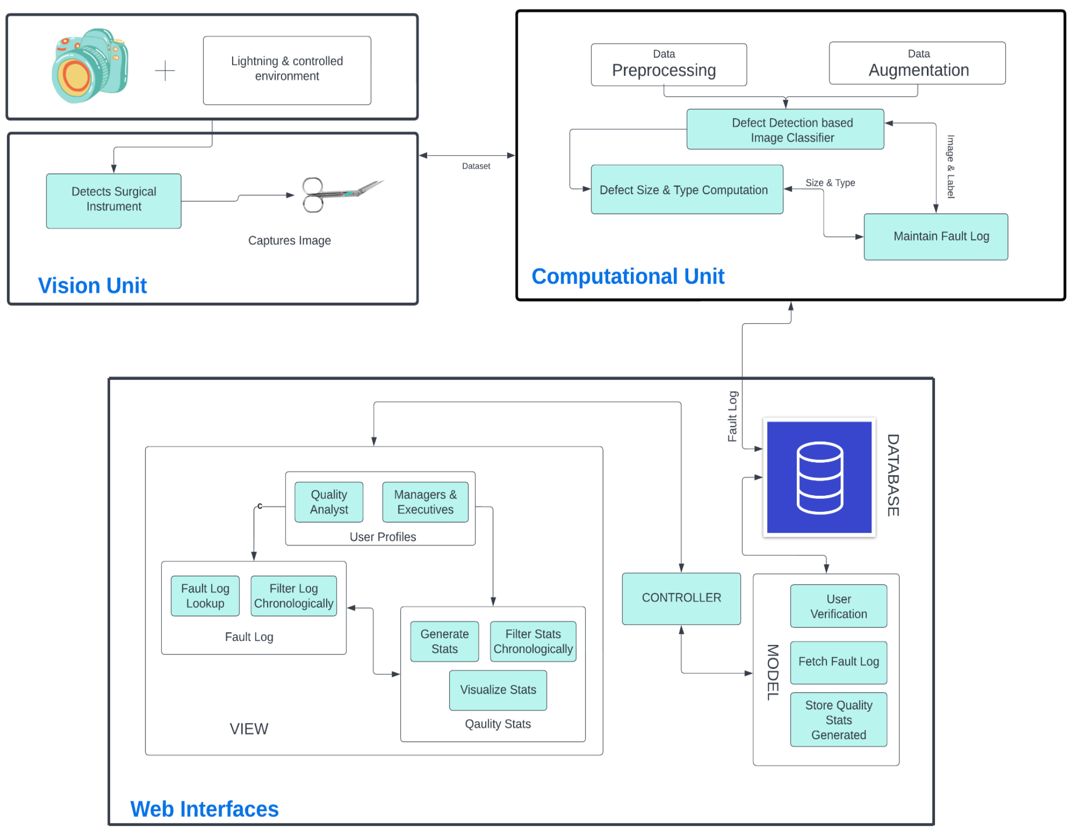

Figure :- AutoInspect High Level Architecture

5. Product Features :-

The list of features our project “AutoInspect” has ;

A. Detect Instrument :-

The system would provide the functionality of detection. Since the system is designed particularly for the surgical instruments it would not capture the image or pre-process it unless it is a surgical instrument.

B. Grade as faulty/ non faulty :-

After the system has detected that the instrument it is being is a surgical instrument it would capture its image and detect if it has any surface level faults.

C. Detect type of fault :-

This is an added feature where the system would localize the fault and tell its type e.g. corrosion, pore, scratch or tuck.

D. Generate & View Stats :-

The system would display the results produced in the form of stats on the web so that any quality assurance analyst can visualize them easily and figure out how many instruments from the batch were faulty and what types of faults were there.

E. Automated Image Acquisition through Prototype :-

A prototype machine is to be developed as a part of this project capable of automated image acquisition . This prototype would be deployed in industry to see if it works well .

6. Constraints :-

There are certain constraints which users and different stakeholders have to consider regarding the working and construction of our product AutoInspect .

1. The system would not be able to detect if the fault is not on the surface level exposed to the camera .
2. The system would not be able to detect the depth of the fault e.g. how deep a pore is
3. The accuracy of the fault detection would be dependent on the camera quality. In case of bad lighting conditions or camera results, the desired results and their accuracy would be affected.

Software Requirement Specifications

Auto-Inspect
System Requirement Specifications

Approved by
Dr. Atif Aftab Ahmad Jillani

Prepared by
Vara Ali i190502
Muhammad Saqib i190494

National University of Computer and Emerging
NUCES FAST ISB

Revision History :-

Name	**Date**	**Reason for Change**	**Version**
Vara Ali Muhammad Saqib	23-10-2022	Initial Version	1.0
Muhammad Saqib	20-12-2022	**1.** Additions in Software and Hardware Requirements **2.** Quality Attributes explained in more details along with mentioning metrics to evaluate them **3.** Removing formatting mistakes in the SRS Document	1.1

1. Introduction :-

1.1. Purpose :-

The purpose of this document is to give an overview of all the functional, non-functional requirements, constraints, stakeholders and all the business aspects of the system AutoInspect.

1.2. Document Conventions :-

Term	**Definition**
The system	AutoInspect
FR	Functional Requirement
NFR	Non-Functional Requirements

1.3. Intended Audience :-

The SRS is intended for developers, project managers, buyers, users, testers, system designers and particularly stakeholders of the system of AutoInspect .

2. Product Scope :-

2.1. Overall Description :-

Our product is capable of classifying / grading a surgical instrument as faulty or non-faulty along with dataset generation for the model training & validation . It would also indicate the type of fault the subject has i.e., breakage ,cracks , pores , corrosion, tucks and scratches . Web-Interface through which the factory's higher authorities will be able to monitor the quality remotely and see quality stats on a daily basis plus the test rig as a prototype for automated image acquisition .

2.2. User Description and Needs :-

Standard users may belong to any demographic group including any gender, nationality that are directly or indirectly related to the production or sales purchase of surgical instruments.

Stakeholders	**Interests**	**Constraints**
Standard User	Needs as automated system in addition to its workforce to identify the faulty surgical equipments	None
Workers	Technicians and workers appointed along the conveyor belt carrying product line and the inspection system	None
Customers	The buyers or customers of the shipments of surgical instruments with the need to have fault and defect free equipment or material	None
Quality Assurance Analyst	The responsibility Quality Assurance Department/ Analysts is that no faulty equipment that has been detected by the system becomes a part of the shipment that has to be exported	None
Designer	The architecture and design of the whole system plus deployment	None

2.3. Product Operating Requirements :-

2.3.1 Software Requirements :-

● Operating System: Windows/MacOS(Web)

● Web browser: Google Chrome for Windows or MacOS.

● Programming language: React, Javascript.

● Web-Technology able to run: React, Javascript.

● Back-End: Cloud Firebase

2.3.2 User Documentation :-

The system will not provide any documentation. Online written and video tutorials will be served when users register to the site.

2.3.3 Assumption and Dependencies :-

1. The user of the site should be acquainted with the very basic English language.
2. The user should have a valid email address in order to register into the website.
3. Central server/Admin of the system must be able to handle all the incoming requests simultaneously.
4. Admin should be registered by the system developers.

2.4. External Requirements and Interfaces :-

2.4.1 User Interfaces :-

Standard users will use the web browser to use the website. Hence, it shall have a login page for users to login into the site. If the user is new to the system he would have to register himself first. After logging into the website the user would be able to upload a captured image of instruments in order to find the faults in them. For the analysis purposes he would have view access to the visualizable stats of the faults generated by the system. He would also be able to view the fault log where all the past fault images would be stored.

2.4.2 Hardware Requirements :-

- Controlled Environment setting with circular style illuminations to control shadows and reflections .
- Vision Unit capable of image acquisition with a beginners DSLR camera OR Android/ iOS camera (10-12 MP) mounted .
- Computational Unit in the form of a mobile or computer that could run computer vision algorithms .

2.4.3 Software Requirements :-

- ***OS on Computational Unit ,*** A platform or an OS installed on the computational unit capable of running Computer Vision Algorithms .
- ***Mobile for Android application ,*** In order to run and test our app the basic requirement is an android mobile phone capable of running Flutter Apps .
- ***Email Interface ,*** This interface shall use SMTP services to authenticate the email addresses used to register for the website.
- ***Captcha Service Interface ,*** Captcha services shall be used for human identification. The user would retrieve a token once it passes the captcha service. The back end would validate the token via a Google api. Front end listens if the human identification is a success or an error. In case of error, the user has to pass through the captcha service again.

3. Functional Requirements & Product Features :-

Following section provides a list of functional requirements for the product by system features, the major services provided by the system.

3.1. Detect Instrument :-

ID :- FR 1

Description :-

The system would provide the functionality of detection. Since the system is designed particularly for the classification of surgical instruments as faulty or non faulty it would not capture the image or pre-process it unless it is a surgical instrument. Hence the basic functionality of the system would be to determine if the object facing the camera is a surgical instrument or not. Only then it will proceed to pre-processing and classification.

Dependencies :- None

3.2. Instrument Classification :-

ID :- FR 2

Description :-

After the system has detected that the instrument it is being is a surgical instrument it would detect if it has any surface level faults. At first, the system would capture the image of the instrument facing the camera. Once the image is captured it will run different pre-processing techniques on it in order to enhance the image quality or to remove noise etc. After the image is ready for the classification the system would run image processing or the machine learning models to check for the faults.

Dependencies :- FR 1

3.3. Indicated Type of Fault :-

ID :- FR 3

Description :-

This is an added feature. After the system has classified the provided instrument as faulty or non faulty in case the instrument is the faulty one the system would further provide the details about the object so that it might be separated from the batch of non faulty instruments depending the type of the fault i.e., if the fault is a tuck, scratch, pore, crack, corrosion etc.

Dependencies :- FR 2

3.4. Compute Fault Dimensions :-

ID :- FR 4

Description :-

The system will be able to compute the size of the fault in centimeters. It would be done after the fault has been detected and localized by the localization function . Calibration would be performed to convert fault size in pixels to the corresponding length in centimeters and hence the user would get the results in the form of basic length measurements i.e, centimeters that is easily understandable by a common man.

Dependencies :- FR 2

3.5. Generate and View Stats :-

ID :- FR 5

Description :-

The system would display the results produced in the form of stats on the web so that any quality assurance analyst can visualize them easily and figure out how many instruments from the batch were faulty and what types of faults were there.

***Dependencies* :-** FR 3 , FR 2 and FR 4

3.6. Automate Image Acquisition :-

ID :- FR 6

Description :-

A prototype machine is to be developed as a part of this project capable of automated image acquisition . This prototype would be deployed in industry to see if it works well. Because the system is basically intended for the industry to automate the inspection process of the surgical instruments.

Dependencies :- None

4. Non-Functional Requirements :-

The non-functional requirements mainly known as quality attributes of our system AutoInspect are explained in detail as following ;

4.1. Performance Requirements :-

The time to draw inference based on an input image and the accuracy of our results are the main performance attributes of AutoInspect .

4.1.1 Scalability :-

System should be able to handle a large amount of data i.e., photos simultaneously. For e.g. handling around multiple agents at the same time.

4.1.2 Accuracy :-

System must provide surety of accurate and precise classification i.e., no faulty instrument gets into the export batches . ML and Image Processing techniques used and deployed in the computational unit must be well judged and tested to achieve high accuracy and precision .

4.1.3 Responsivity :-

The application should be fast enough to classify a particular image in 5 to 6 seconds . Classification functionality should be fast to enable better end-to-end grading on conveyor belts.

4.2. Security Requirements :-

1. Only authenticated users would be allowed to see the fault logs and quality stats on the web interface & reCaptcha or OTP service for each login through an unauthorized device.
2. Hashed passwords will be stored in the database and passwords shall be at least 8 characters, including small character, capital character, number and a special character .

4.3. Software Quality Attributes :-

4.3.1 Usability :-

The prototype i.e., test rig should be simple and clear to be easily used by any user. Fast and zero percent complex SOP , without getting into fuss.

4.3.2 Availability :-

- The system should be available at all times. It should be ensured that there should be minimum or no downtime to ensure better user experience.
- The system should be reliable. It should yield correct results depending on the input that is given so that if a user performs queries for any fault description or quality stat he gets the accurate response.

4.3.3 Testibilty :-

The system shall be testable SQA engineers can test the applications for bugs and incomplete requirements. The types of testing, its schedule and their specifications are listed in the test plan Section 4.

4.3.4 Maintainable :-

The system should be extensible, It should be able to incorporate new features or requirements in the existing requirements In case of errors or bugs identified at the testing level the developers must be able to rectify and enhance the model to tackle the bugs. For the test rig , it should be easily maintainable .

Analysis and Design Artifacts

Auto-Inspect
Analysis and Design Artifacts

Approved by
Dr. Atif Aftab Ahmad Jillani

Prepared by
Vara Ali i190502
Muhammad Saqib i190494

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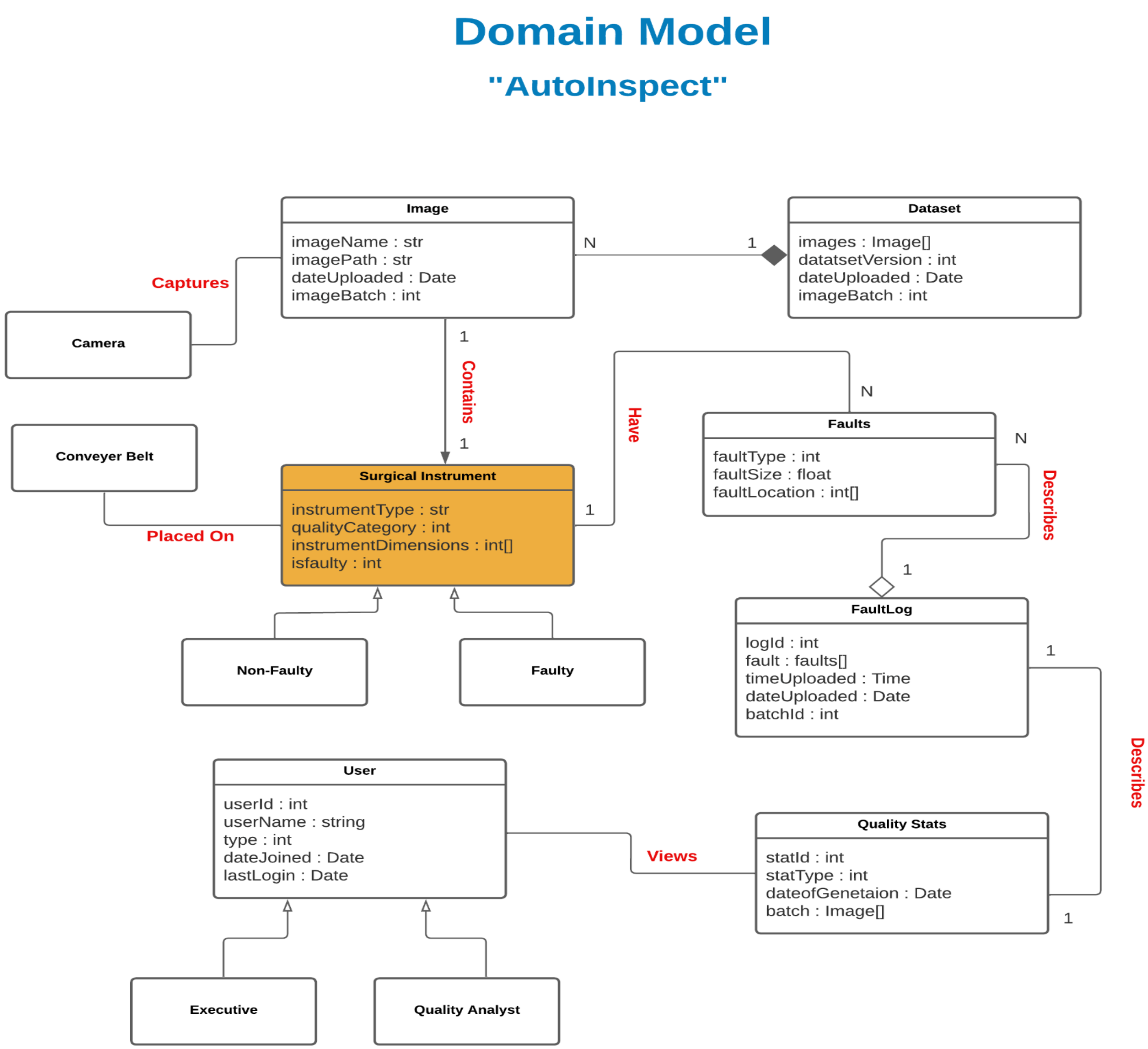
Revision History :-

Name	Date	Reason for Change	Version
Vara Ali Muhammad Saqib	20-10-2022	Initial Version	1.0
Vara Ali Muhammad Saqib	24-12-2022	1. Modifications in Class Diagram 2. Corrections in System Sequence , Sequence Diagrams and Operational Contracts . 3. Addition of development details like ; ● DatasetGeneration ● Annotations and Preprocessing ● Implementation details in form of a PILOT Study	1.1

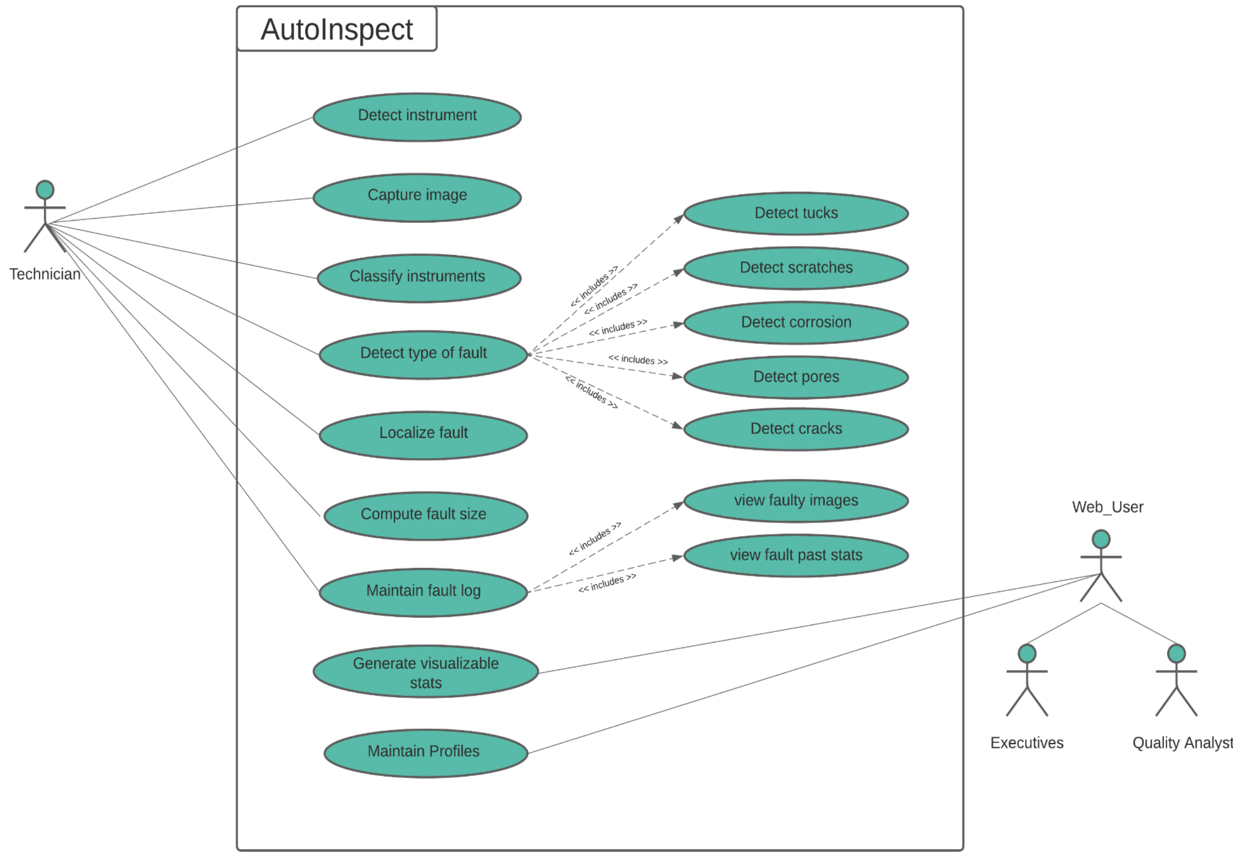
Elicitation & Analysis Phase

1. Domain Model :-



2. Use Cases :-

2.1. Use Case Diagram :-



2.2. High Level Use Cases :-

Use Case ID	UC-01
Use Case Name	Detect the instrument
Actors	Worker
Type	Primary
Description	When the camera is directed at any object to be examined it detects the whether the object is an instrument or not

Use Case ID	UC-02
Use Case Name	Capture Image
Actors	Worker
Type	Primary
Description	When the camera is directed at any object to be examined it scans , determines whether there is an instrument or not plus it decides the type of the instrument

Use Case ID	UC-03
Use Case Name	Classify Instruments
Actors	Worker
Type	Primary
Description	Once the system has recognized and scanned the instrument it would be able to grade whether the instrument has any surface level fault or not

Use Case ID	UC-04
Use Case Name	Detect type of fault
Actors	Worker
Type	Primary
Description	After the system has detected that a particular instrument is faulty it would also be able to detect that if the fault is corrosion, tucks, pores, cracks etc.

Use Case ID	UC-05
Use Case Name	Localize the fault
Actors	Worker
Type	Primary
Description	The system would be able to tell the location of that very fault on the surface of the surgical instrument surrounded by a rectangle to highlight the fault

Use Case ID	UC-06
Use Case Name	Compute fault size
Actors	Worker
Type	Primary
Description	The system would be able to identify the length of the fault given the fault localized image . Calibrations are performed before we compute the size of fault to convert pixels to length notation

Use Case ID	UC-07
Use Case Name	Maintain fault log
Actors	Worker
Type	Primary
Description	The system would be able to maintain a fault log containing the fault localized image , type of fault , size of fault and its shape . The user can access the faulty images and their fault stats

Use Case ID	UC-08
Use Case Name	Generate visualizable stats
Actors	Analyst
Type	Secondary
Description	The system would display the final stats generated from the fault log and the fault description in the form of certain visuals depicting how many instruments of the entire batch are faulty with which type , size and location .

Use Case ID	UC-09
Use Case Name	Maintain Profiles
Actors	Analyst
Type	Secondary
Description	The system would be able to maintain , edit, update the profiles of quality assurance analysts and executives separately

2.3. Expanded Use Cases :-

Use Case ID	UC - 01
Use Case Name	Detect the instrument
Level	User goal
Actors	Instruments Manufacturer Company
Stakeholders and Interests	The company wants to detect whether the object that camera is directed at is a surgical instrument or not

Pre-conditions	1. Camera should be positioned above the object 2. Camera should be active to take a picture
Post-conditions	System has detected whether that object is a surgical instrument without capturing the image
Main success scenario	1. Camera scans the object below it 2. The algorithm on the backend extracts image image information coming through the camera 3. System detects whether the object is an instrument or not based on the extracted image
Alternatives	1. Object is moved forward on the conveyor before the detection of object 2. Image is blurred, detection is not accurate 3. Lights affecting illumination of the image and hence object is not detected successfully
Technology and Data Variation Lists	Camera with quality good enough to get a sharp image
Frequency of Occurrence	Everytime a new object arrives, it needs to be classified

Use Case ID	UC - 02
Use Case Name	Capture Image
Level	User goal
Actors	Instruments Manufacturer Company
Stakeholders and Interests	The company wants to detect what type of surgical instrument is being processed
Pre-conditions	1. Camera should be positioned above the object 2. Camera should be active to take a picture

Post-conditions	System has detected the type of the surgical instrument e.g if it was a scissor
Main success scenario	1. Camera scans the object below it 2. Camera captures the image 3. Image is processed by the machine learning model at the back end 4. System classifies the type of the image
Alternatives	1. Object is moved forward on the conveyor before the detection of object 2. Image is blurred, detection is not accurate 3. Lights affecting illumination of the image and hence object is not detected successfully
Technology and Data Variation Lists	Camera with quality good enough to get a sharp image
Frequency of Occurrence	Everytime a new object arrives, it needs to be classified

Use Case ID	UC - 03
Use Case Name	Classify Instruments
Level	User goal
Actors	Instruments Manufacturer Company
Stakeholders and Interests	The company wants to detect whether the instrument that is being processed is faulty or not.
Pre-conditions	1. Camera should have clicked the picture of the object 2. The object must be a surgical instrument
Post-conditions	System should display the end result of whether the instrument was faulty or not.

Main success scenario	1. Image taken from the camera is fed to the backend machine learning algorithm 2. Backend pre processes the image and extracts image information 3. Machine learning model decides based on the extracted image information of the instrument that whether the image is faulty or not
Alternatives	1. Image information extracted is not accurate because of the blurred image 2. Object is moved forward on the conveyor before the detection of object 3. Lights affecting illumination of the image and hence object is not detected successfully
Technology and Data Variation Lists	Camera with quality good enough to get a sharp image
Frequency of Occurrence	Everytime an instrument is detected, it needs to be classified as faulty or non faulty

Use Case ID	UC - 04
Use Case Name	Detect type of fault
Level	User goal
Actors	Instruments Manufacturer Company
Stakeholders and Interests	The company wants to detect which type of fault is there in the faulty instrument
Pre-conditions	System should have detected that the instrument is faulty

Post-conditions	System should display the end result of whether the instrument was faulty or not.
Main success scenario	1. Instrument image information is extracted 2. The extracted image information is passed to the YOLO algorithm 3. Algorithm detects which type of fault exists in that particular surgical instrument
Alternatives	1. Image information extracted is not accurate because of the blurred image 2. Object is moved forward on the conveyor before the detection of object 3. Lights affecting illumination of the image and hence a defect is missed
Technology and Data Variation Lists	Camera with quality good enough to get a sharp image
Frequency of Occurrence	Everytime a faulty instrument is detected, system needs to tell its fault type

Use Case ID	UC - 05
Use Case Name	Localize the fault
Level	User goal
Actors	Instruments Manufacturer Company
Stakeholders and Interests	The company wants to know where the fault exists on the surgical instrument.
Pre-conditions	System must has identified that the instrument image being processed is faulty

Post-conditions	System should highlight/ point out the place on the surface of the surgical instrument where the fault exists
Main success scenario	1. The back end algorithm identifies the type of fault 2. The algorithm then highlights where the fault exists
Alternatives	Image information extracted is not accurate so the location isn't is not highlighted properly
Technology and Data Variation Lists	Camera with quality good enough to get a sharp image
Frequency of Occurrence	Everytime a faulty instrument is detected

Use Case ID	UC - 06
Use Case Name	Compute fault size
Level	User goal
Actors	Instruments Manufacturer Company
Stakeholders and Interests	The company wants to know the length of the fault on the surface of the surgical instrument.
Pre-conditions	System must has identified that the instrument image being processed is faulty
Post-conditions	System should highlight/ point out the place on the surface of the surgical instrument where the fault exists
Main success scenario	1. The back end algorithm identifies the location of the fault 2. The algorithm then outputs the length of the detected fault
Alternatives	Image information extracted is not accurate so the length of the fault is not calculated accurately

Technology and Data Variation Lists	Camera with quality good enough to get a sharp image
Frequency of Occurrence	Everytime a faulty instrument is detected

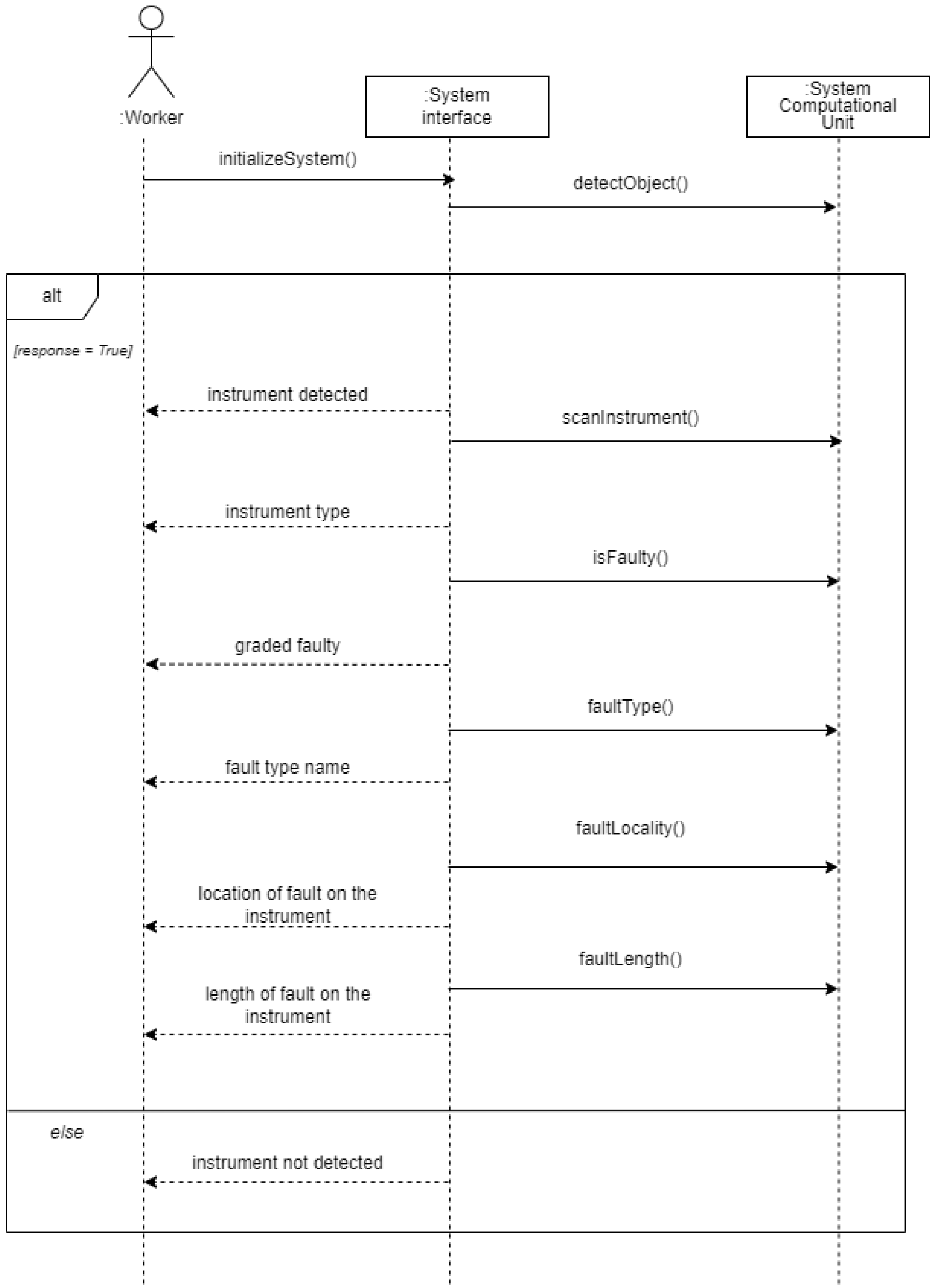
Use Case ID	UC - 07
Use Case Name	Maintain fault log
Level	User goal
Actors	Instruments Manufacturer Company
Stakeholders and Interests	The company wants to maintain a fault log where they view, access and analyze the past faulty pictures along with their stats
Pre-conditions	1. Camera has captured pictures of the instruments 2. System has identified the faulty images
Post-conditions	System must store the results in the form of stats and hence maintain a fault log
Main success scenario	1. Camera captures the image of the instrument 2. System detects if it is faulty or not 3. System generates the details of the fault i.e., its location and length 4. System generates stats of the faults 5. System stores the stats along with the faulty images for the analyst to view and analyze
Alternatives	1. Image of the fault instrument is not saved 2. Fault results are not updated to the fault storage

Technology and Data Variation Lists	Storage for the fault log
Frequency of Occurrence	Everytime a faulty instrument is detected

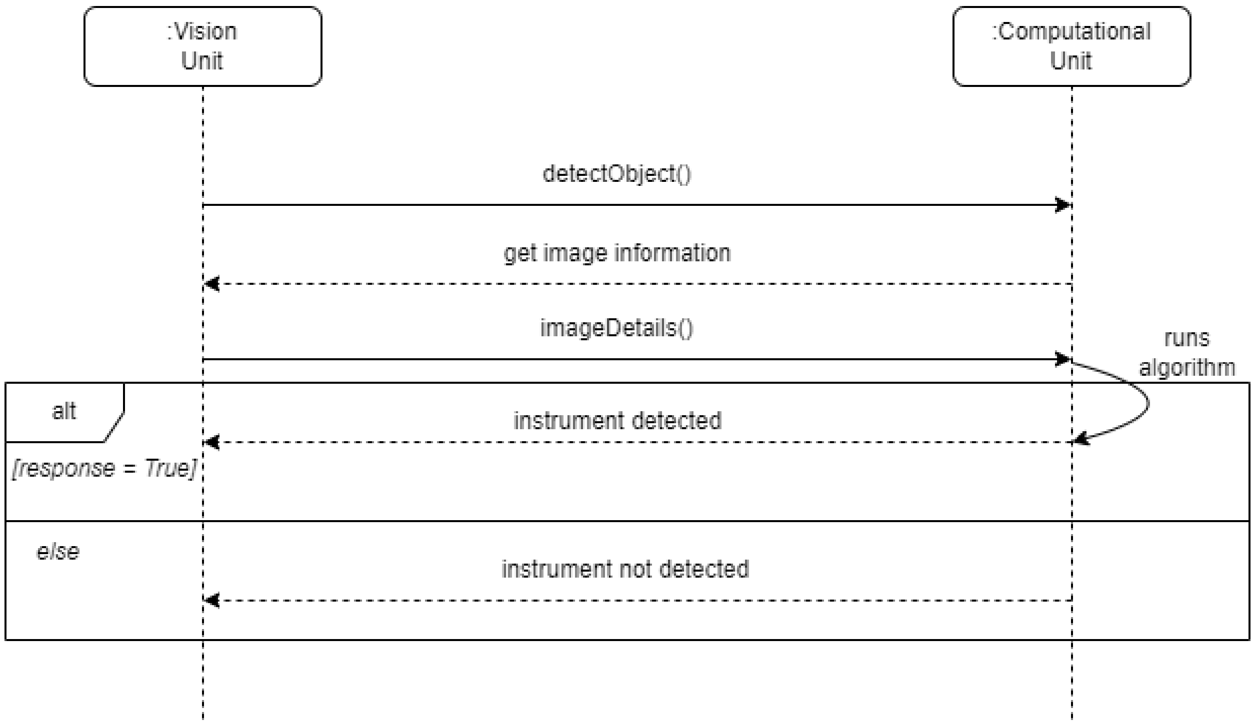
Use Case ID	UC - 08
Use Case Name	Generate Visualizable stats
Level	User goal
Actors	Web_User (Executives & Quality Analyst)
Stakeholders and Interests	The actor wants to view the stats generated by the system
Pre-conditions	System has detected the faulty instruments
Post-conditions	System must generate the results in the form of the visualizable faults
Main success scenario	1. Camera captures the image of the instrument 2. System detects if it is faulty or not 3. System generates the details of the fault i.e., its location and length 4. System generates the results in the form of visualizable faults
Alternatives	Image was not successfully graded and hence inaccurate stats are generated
Technology and Data Variation Lists	Storage for the fault log
Frequency of Occurrence	Everytime a faulty instrument is detected

Use Case ID	UC - 09
Use Case Name	Maintain profiles
Level	User goal
Actors	Web_User (Executives & Quality Analyst)
Stakeholders and Interests	Each web user either executives or quality analyst should have a profile where they could login and analyze the fault logs plus visualize quality stats
Pre-conditions	User Registration
Post-conditions	A profile is maintained for each and every analyst & executive
Main success scenario	1. Allow analyst to have an account 2. Assign analyst an account id and password 3. Provide the required permissions to view the fault log & quality stats 4. Delete and Update account information
Alternatives	
Technology and Data Variation Lists	Database addition , updation & deletion
Frequency of Occurrence	Less Frequent . Used only when addition , updation or deletion of any account is required

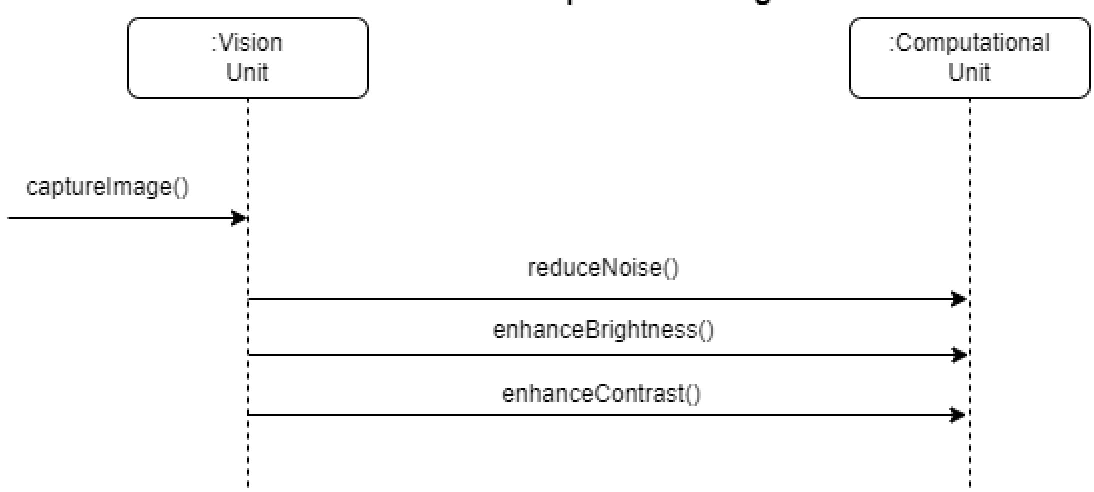
3. System Sequence Diagrams :-



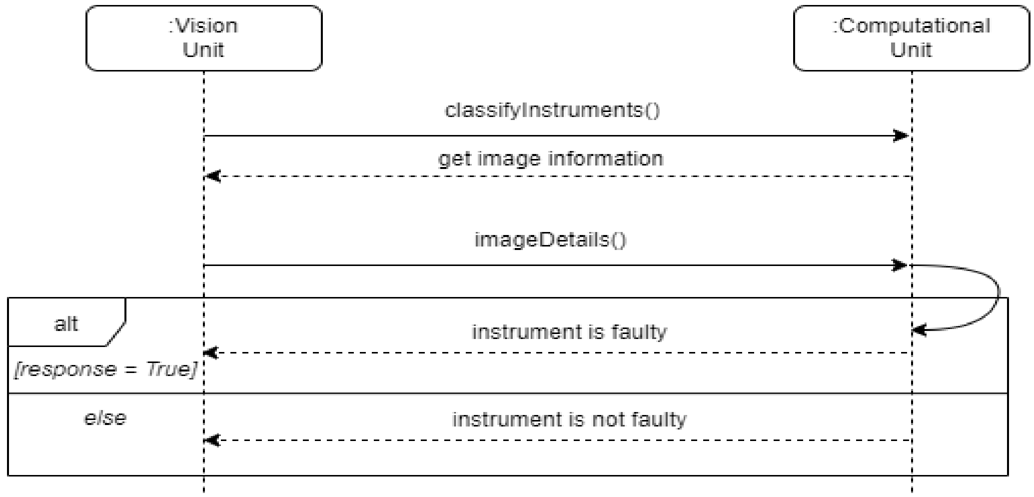
UC - 01 Detect the Instrument



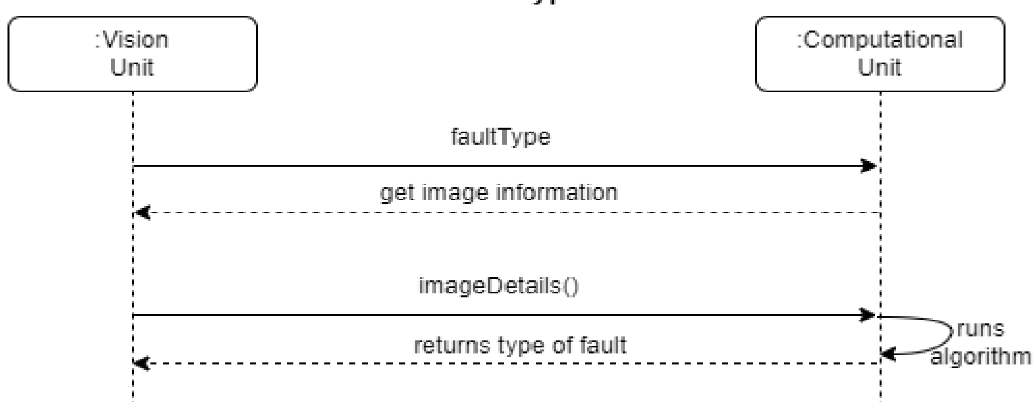
UC - 02 Capture the Image



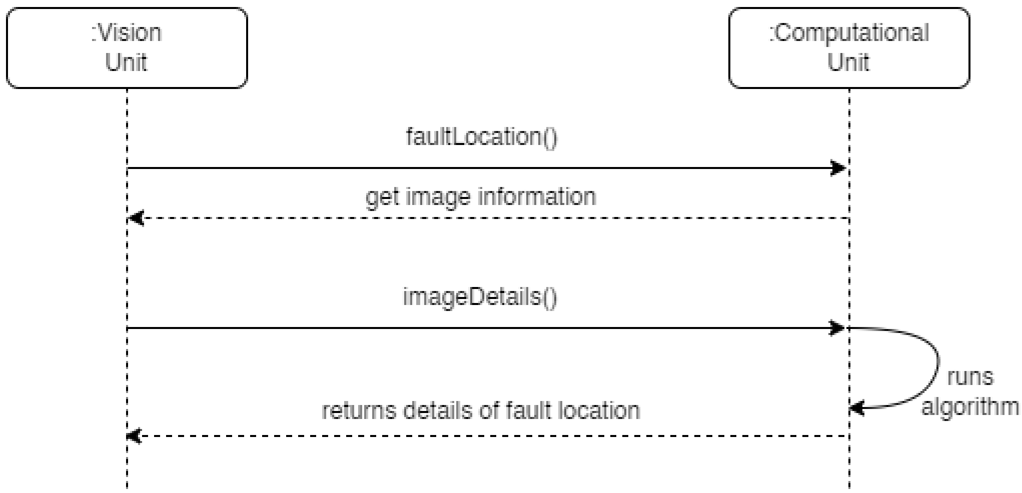
UC - 03 Classify Instruments



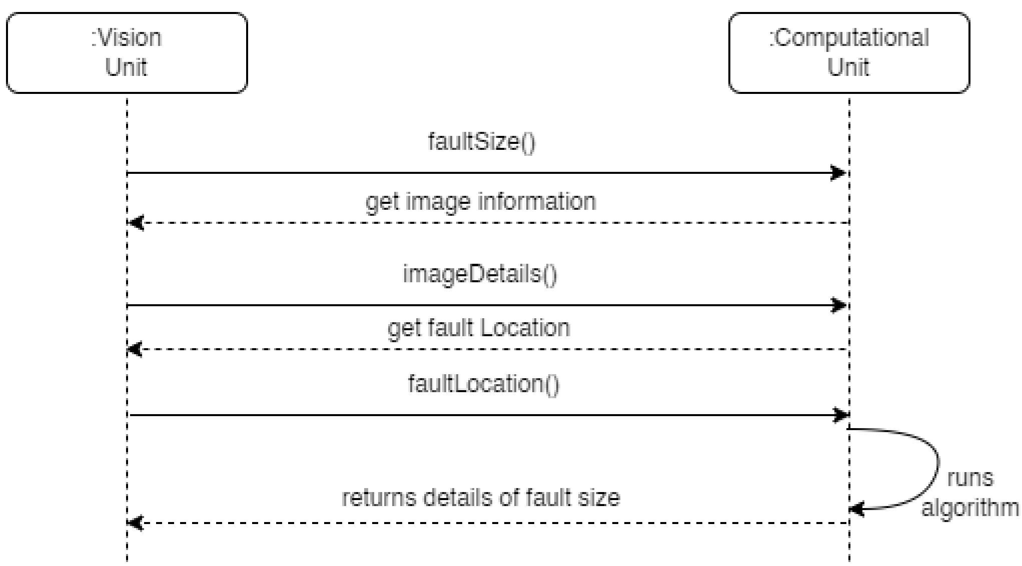
UC - 04 Detect type of fault



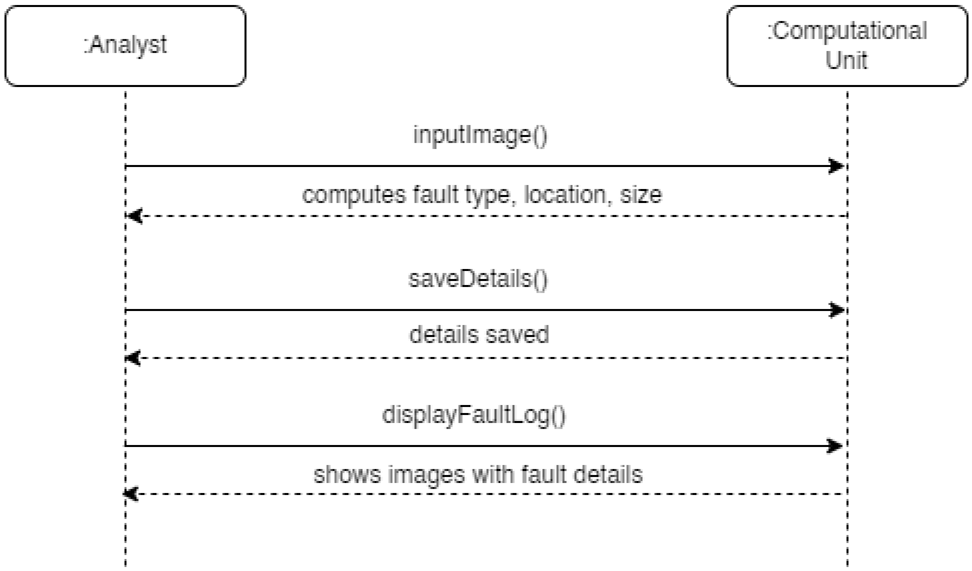
UC - 05 Localize the Fault



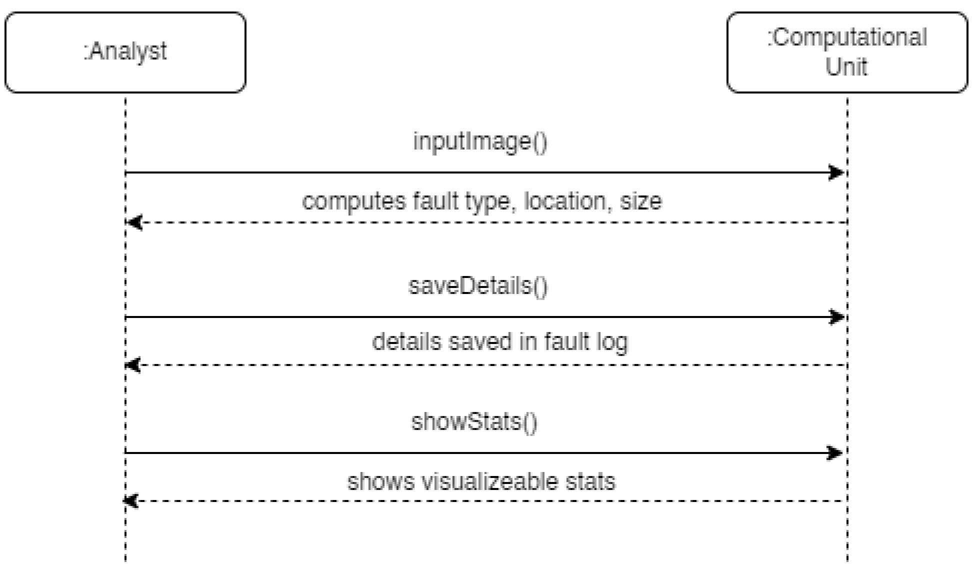
UC - 06 Compute Fault Size

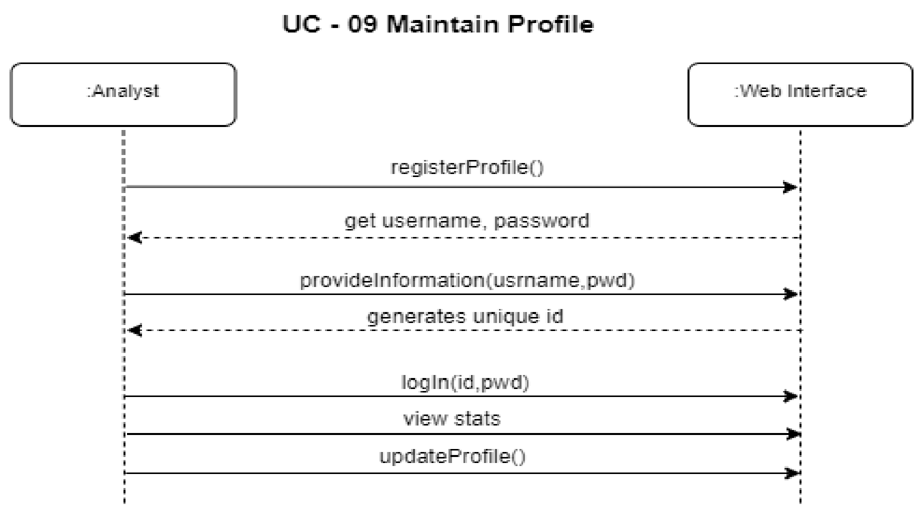


UC - 07 Maintain fault log



UC - 08 Generate Visualizeable Stats





4. Operational Contracts :-

Contract Name : applyAlgorithm()

Name	applyAlgorithm()
Type	System
Responsibility	It applies the fault detection algorithms to the images dataset . Fault detection algorithms include Machine Learning based detection and Image Processing based detection
Cross Reference	Grade as Faulty/ Non faulty (UC - 03)
Output	Algorithm is applied to grade the instruments
Pre conditions	Instrument must be captured by the camera properly with careful lighting setup and calibration mounts
Post Conditions	testModel() function was invoked in the YOLO Model class

Contract Name : displayImage()

Name	displaylmage()
Type	System

Responsibility	Given the index of the image in the dataset array , it displays the image in the images dataset along with its label , filepath and preprocessed image
Cross Reference	Scan the Instrument (UC - 02)
Output	Image is shown in the image dataset
Pre conditions	Instrument must be captured by the camera properly with careful lighting setup and calibration mounts
Post Conditions	1. An image object was created 2. The object was associated with Image dataset

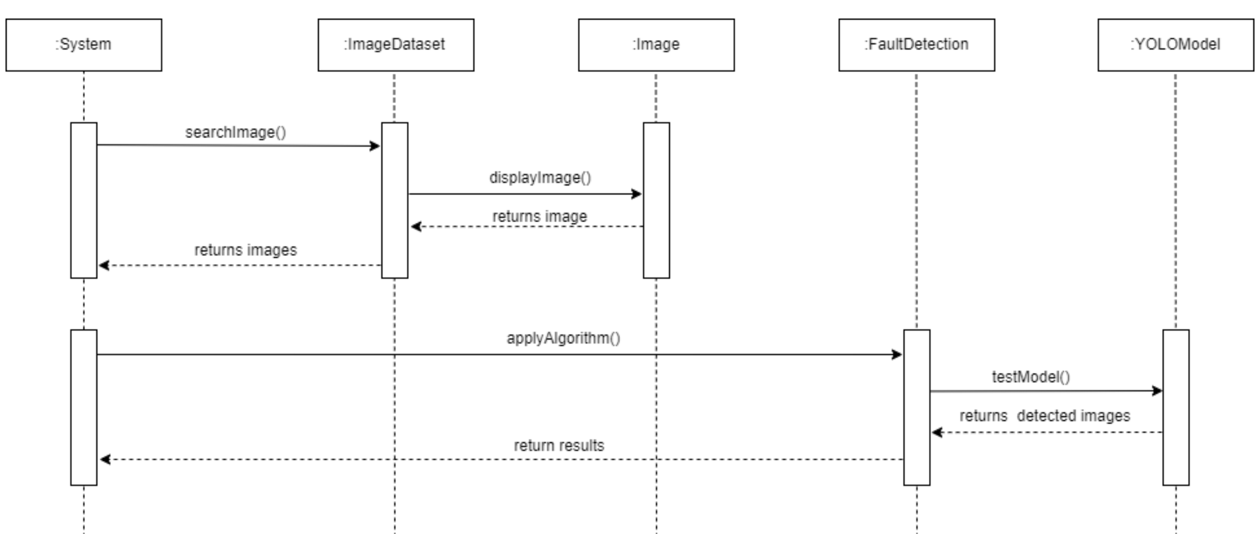
Contract Name: gaussianSmoothing()

Nam	gaussianSmoothing()
Type	System
Responsibility	Its main purpose is to smoothen the image, reducing the effect of noise , reflection and shadows . It applies the algorithm to the images dataset that removes the noise from the image
Cross Reference	Detect the instrument (UC - 01)
Output	Algorithm is applied to remove the noise from the images
Pre conditions	Instrument must be captured by the camera properly with careful lighting setup and calibration mounts
Post Conditions	Image object is created & associated with class processed image

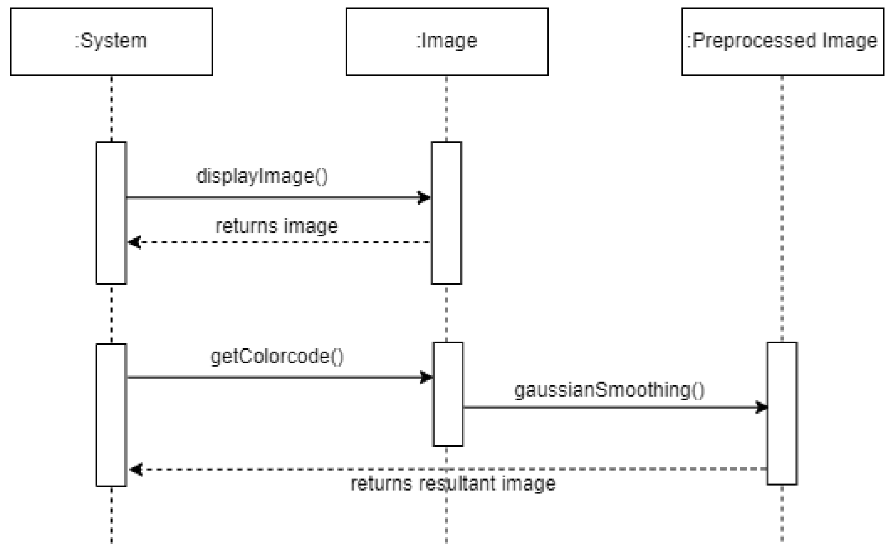
Contract Name: generateStats()

Name	generateStats()
Type	System
Responsibility	It generates the quality stats depicting how many instruments are faulty from the entire batch
Cross Reference	Generate Visualizable stats (UC - 08)
Output	The function would generate visualizable stats on the web interface
Pre conditions	System has detected the faulty instruments along with its type, locality and length
Post Conditions	3. A fault log object was created 4. The object was associated with fault description

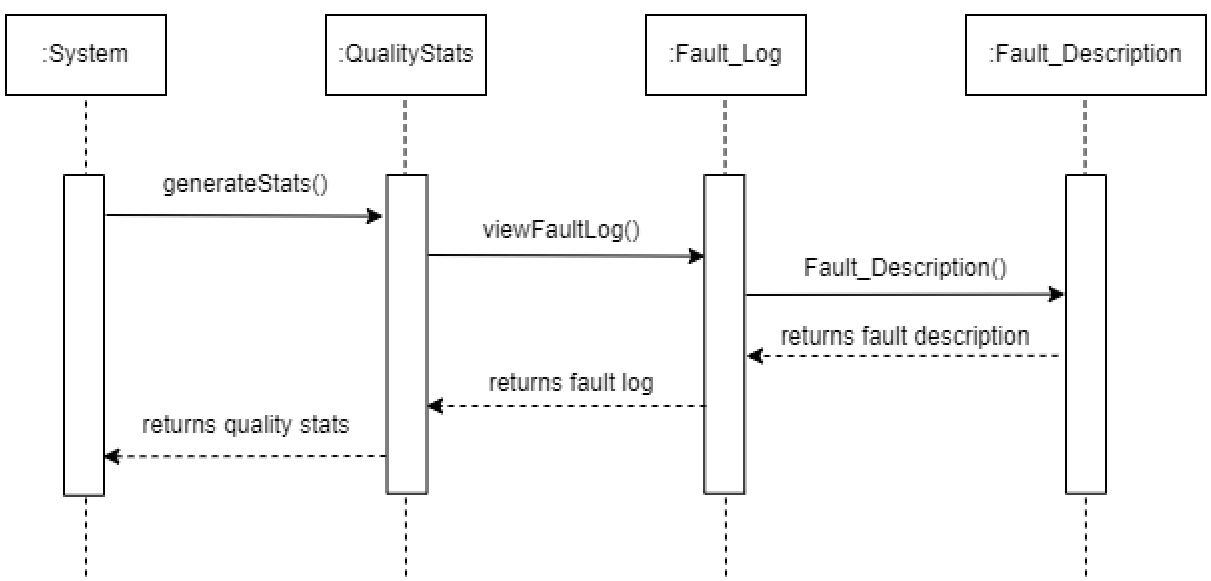
5. Sequence Diagrams :-



applyAlogorithm()

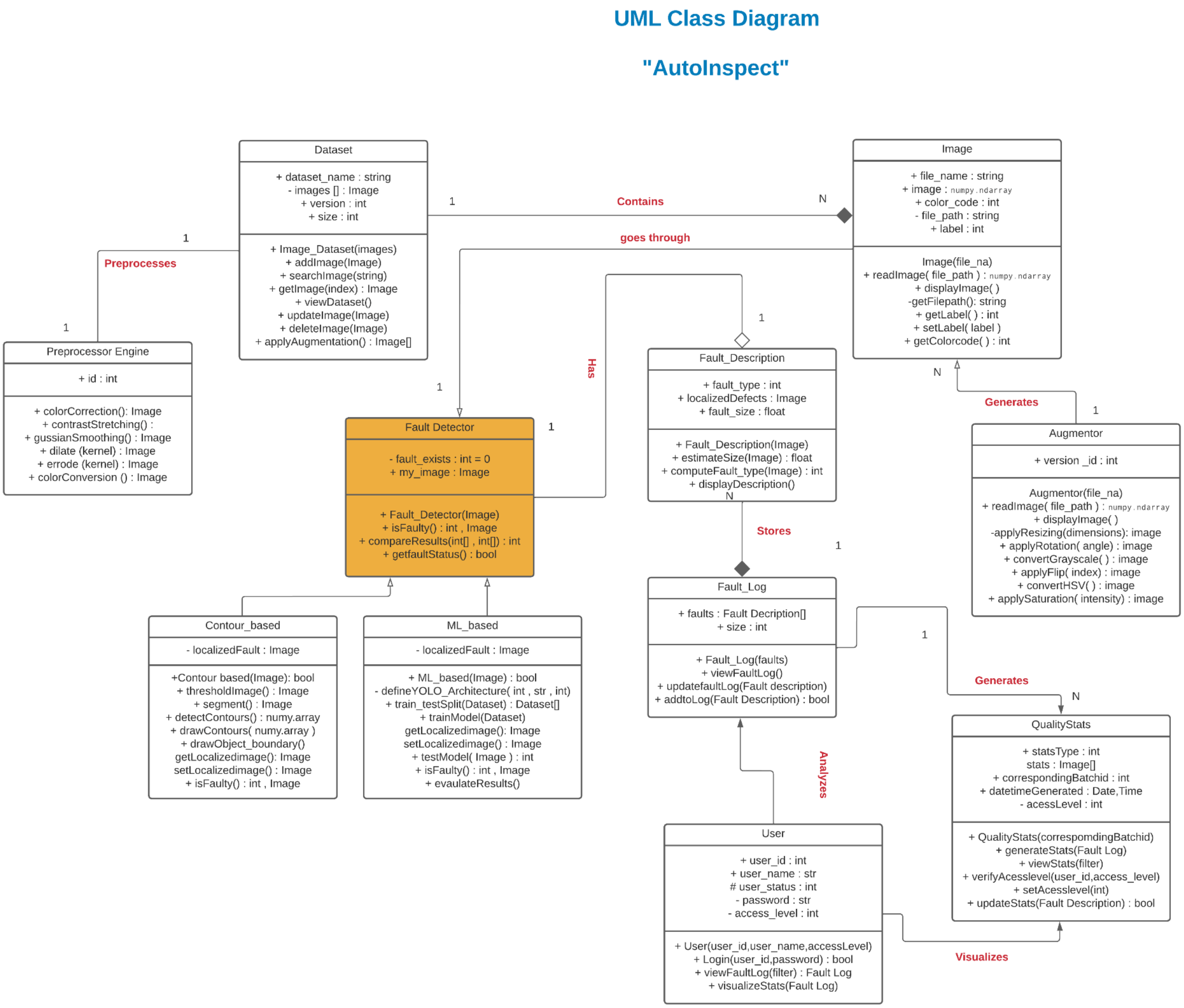


gaussianSmoothing()



generateStats()

6. Class Diagram :-



Design & Development Phase

Inspection jobs that involve searching for little flaws in vast areas can be difficult since any successful system must have a very low false positive rate, and since flaws are uncommon, it might be difficult to gather enough instances to train a classifier or a region-based object detector. Therefore, as part of our study, we must develop algorithms for defect detection and look into various methods of producing photographs of defective surgical tools. In case you missed it, Auto-Inspect has the following features ;

1. Dataset generation for model training & validation
2. Classifying / grading a surgical instrument as faulty or non-faulty
3. Indicating the type of fault the subject has i.e., breakage ,cracks , pores , corrosion, tucks and scratches
4. Web-Interface through which factory's higher authorities will be able to monitor the quality remotely and see quality stats on daily basis
5. Test rig as a Prototype for Automated Image Acquisition

Iteration-wise Division & Progress Tracking :-

Following table indicates the modules of our system which have been implemented completely and the ones which need to be implemented .

Sr. No	Module Name
1.	Dataset Generation ie., Image Acquisition Setup
2.	Image Annotations and Pre-Processing
3.	Defect Classifiers & Defect Localization
4.	Indicating Defect Type and Dimensions (FYP-2)
5.	Prototype Development for Vision Unit (FYP-2)
6.	Web Integration (FYP-2)

→ Completed Modules

The 3 modules which have been developed completely are described in detail as follows ;

1. Dataset Generation for Defected Surgical Instruments :-

The first and the most important thing when it comes to an artificial intelligence and machine learning based solution is the dataset and its goodness . In order to have a reliable , robust , efficient and accurate machine vision model , one needs to have a good dataset . Tracking a surgical instrument during operation and counting surgical instruments after an operation are the research areas where extensive work has been done so far . But defect detection in surgical instruments is still unexplored. That's why , for defect detection we don't have the dataset available for our problem . So , as part of our project , we have generated a defected surgical instruments dataset by configuring an imaging unit along with annotations and preprocessing . We have divided our dataset generation process in two steps of image acquisition and image annotations explained in detail as below ;

1.1. Image Acquisition :-

In image processing and computer vision tasks , image acquisition is the action of retrieving a digital image from a source, usually using hardware systems like cameras, sensors, etc. It is the first and the most important step in the workflow sequence because, without an image, no actual processing is possible by the system. The image that is acquired by the system is usually completely unprocessed. The reliability , robustness and accuracy of image acquisition truly determines the accuracy and efficiency of Machine Learning Model .

In the case of our project , capturing images of surgical instruments which are made up of metals was quite a tedious task because of reflections caused by uneven lighting etc. We had to try multiple options in order to overcome the challenges we faced . Following are the complete details of our image acquisition setup . Before acquiring images, we set certain parameters regarding our imaging system according to the need of our problem on a hit-and-trial basis. Those fundamental parameters include resolution, field of view, working distance, sensor size, and depth of field. Figure 1 illustrates these concepts .

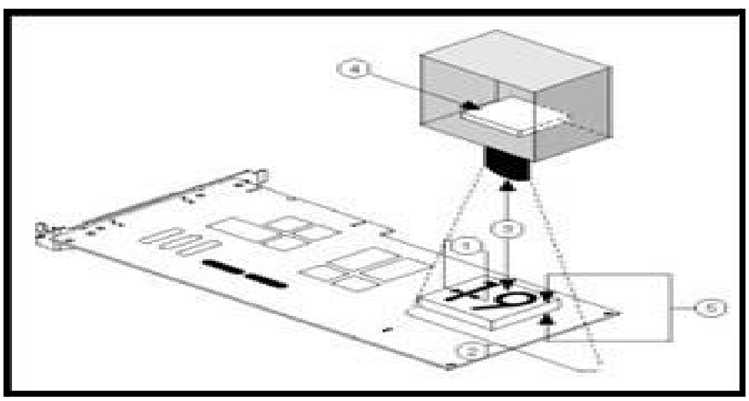


Figure :- Fundamental Parameters Consideration in Image Acquisition

1.1.1 Setup for image acquisition :-

A. Camera :-

Camera constitutes the most important part of our vision unit i.e., taking the light information from a scene and converting it into digital information i.e. pixels . Camera Resolution plays a key role ; the higher the resolution, the more data the system collects, and the more precisely it can judge defects in the subject under consideration . However, more data demands more processing, which can significantly limit the performance of a system . So , there exists a tradeoff . In order to make our dataset generation process more diverse and robust , we have different cameras for image acquisition . Various Android , IOS as well as DSLR Cameras are used for the image acquisition.

B. Photographic Box :-

For capturing images for our dataset , it was very important to have a **controlled environment with a fixed background and both illumination setup** in order to reduce the noise caused by the outside exposure . For this purpose , we used Puluz Light Box with the following features ;

- 【High Brightness】96 high-quality LED light beads are included inside the portable photographic studio, offering sufficient brightness for shooting. A CRI95 color temperature ring light board, built-in stone grain cloth, and an excellent light collecting effect are all features of this picture lighting studio kit.

- 【Multi-angle Shooting】With one front horizontal shooting window and one front vertical shooting window, the photo light box can accommodate various shooting needs. But we have employed a vertical shooting angle.

- 【Multiple Background Options 】Fixed Background providing multiple options like green , white , black , red , yellow and blue etc. whichever is suitable for your problem .

C. Illumination :-

One of the most important aspects of setting up an imaging environment is proper illumination or lighting setup . Images acquired under proper lighting conditions make your image processing software development easier and overall processing time faster. One objective of lighting is to separate the feature or part you want to inspect from the surrounding background by as many gray levels as possible. The second but the most important goal in our case was to control the light in the scene so there are no shadows and reflections .

How did we achieve both of these objectives ? The answer is **Ring Lighting** ; *two 65W LED light diodes fitted in the form of circular rings with adjustable intensities along with butter paper* . Ring lighting is a common style of lighting that, because of its adaptability, may be used in a variety of settings. With the use of those circular light rings, the subject is initially illuminated in order to reveal all of its details; however, shadows and reflections are created when metallic items are exposed to light so closely. Using butter paper, we were able to soften and smooth the light coming from the circular rings, which lessens the shadowing effect as well as reflections brought on by inconsistency in illumination.

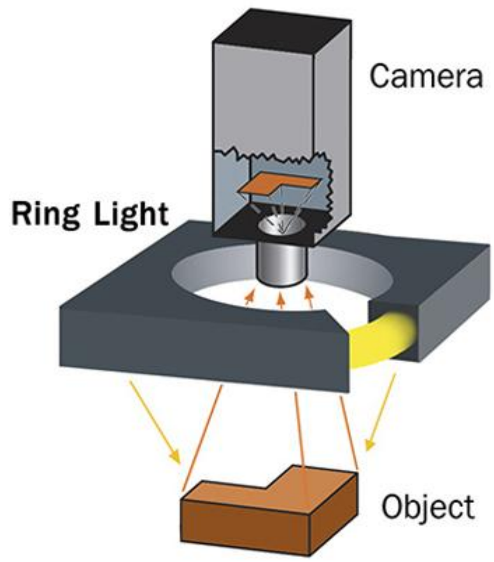


Figure :- Image Acquisition Unit with Ring Lighting Setup

1.1.2. Challenges we faced and their solution :-

Particularly in our case , we faced some challenges during image acquisition despite using a controlled environment discussed briefly in the illumination section . The root cause of all these issues/challenges were uneven lightning and specific geometric shapes of surgical instruments . Following are details of the challenges we faced and how we overcame them.

A. Reflections and Shadows :-

Illumination of the subject for better coverage of defects using circular LEDs installed in the photographic box caused uneven lighting within the box . That uneven lighting inturn gave birth to shadows on some portions of the subject and reflections on the other portions . This is a serious concern for us . If the defect comes in the shadowed or reflected region , it will pass undetected through the conveyor belt producing a lot of False Negatives .

We tried various techniques to solve this issue . One of these was to ignore all these in the image acquisition step and cover them in the preprocessing step but its performance was not up-to the mark . So , we decided to opt a hybrid mode mixing the software and hardware solution ; trying to make the hardware solution as efficient as possible but complimenting it through software techniques .

- Using Butter Paper to smoothen and soften the light from circular LED rings so that there is an even lighting within the box .
- Decreasing the intensity of LED diodes to some extent .
- If the problem still exists in the images , cover it in the pre-processing .

B. 100% coverage of the subject :-

Because of complex geometries , with the use of a single image it is completely impossible to classify a surgical instrument as either faulty or non-faulty . For example , if we have a surgical instrument placed on a table , by visual examination , we can only tell whether the instrument is faulty or not for the surface we could see . What about the surface facing the table ? The possible approaches we had in our mind were ;

1. Frame Extraction from a Video
2. Configuring some sort of a hardware capable of rotation so that the image of the subject under consideration can be captured from multiple angles.

Extraction of frames from a video is quite a computationally expensive as well as time consuming task , so hardware configuration which is tedious to configure but once setup is built , only 4 images taken by rotating the instrument would be enough for complete detection.

1.2. Image Augmentation :-

In order to increase the size of our dataset so that our deep learning model won't overfit on the limited number of samples we have in our dataset , we have used image augmentation techniques . Actually , image augmentation is a technique that is used to artificially expand the data-set. Through image augmentation , we have increased the size of our dataset to 3x .

Figure :- Operations Applied in Image Augmentation

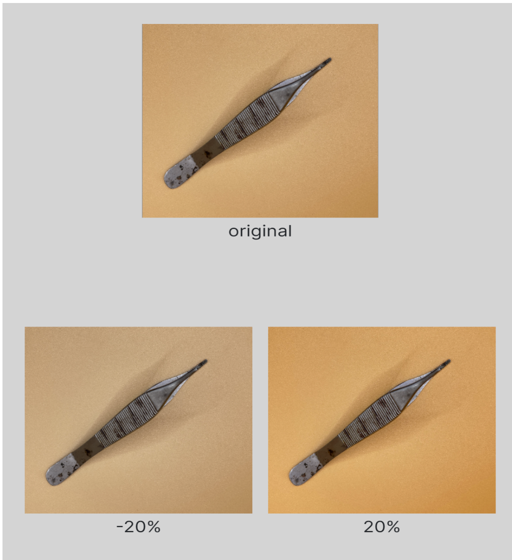


Figure :- Augmentation using Saturation

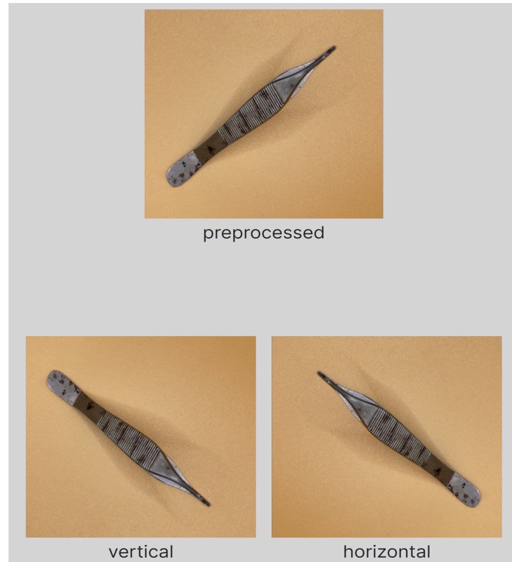


Figure :- Augmentation using Flip

Figure :- Some images from the dataset as representative data

The graphs and charts to summarize the dataset we generated are as follows showing classes wise division of the surgical instruments . Out of 1.3k samples , we have a total of 1,190 considering the fact that we do have more than one annotation in an image where there are more than one faults and for images with no faults , we null annotations .

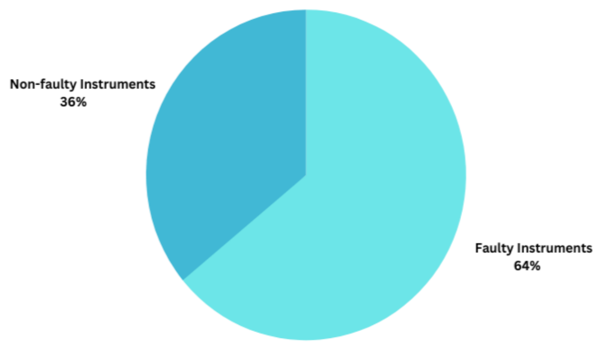


Figure :- Dataset Division Classes-wise

2. Image Pre-Processing Steps :-

Pre-processing has been one of the most important software components of our system . Removal of shadows and reflection ; those which we were unable to cater during the image acquisition step plus making images more suitable to be fed to the model for better learning . These are the pre-processing operations which we have used .

1. Image Resizing
2. Morphological Operations
3. Image Smoothing
4. Saturation and Brightness Correction

3. Image Annotations :-

3.1. Annotation Software :-

We have used **Roboflow** for annotating images captured by our image acquisition unit . A popular tool for many machine learning and computer vision tasks is roboflow. You may import datasets in any annotation format and export to any other, allowing you to spend more time exploring and less time scuffling with one-off conversion scripts. It also offers a simple interface for annotating photos. We were seeking a solution that could provide us the option of polygonal annotations, which is why we chose Roboflow over other tools. Only a few of the other tools offer what we were searching for, however all of them offer bounding box annotation and some additional annotations. We could only annotate images, export in any format, host our dataset, host our computer vision model, etc., on Roboflow.

3.2. Annotation Technique :-

For our model to learn the defect patterns correctly , we decided to input annotated images with key points i.e., defects highlighted . For this purpose , we have used **Polygonal Annotations** in which complex polygons are used instead of rectangles to define the shape and location of the key point in a much more precise way . The reason why we used this type of annotation instead of simple rectangular boxes is because of the fact that defects on the surface of surgical instruments are of variable size and shape .

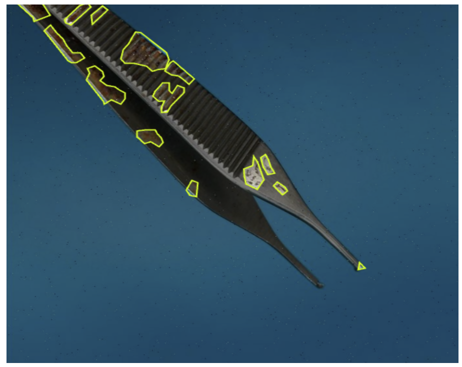


Figure :- Depiction of Polygonal Segmentation

3.3. Annotation Format :-

As far as the annotation format is concerned , we have used **YOLO Format** to export our annotations so that it could be fed to the ML Model . In YOLO Format of annotation , corresponding to each image file a separate .txt file is created containing the coordinates of the polygons we drew during the annotation of the defect classes . There are multiple other annotation formats like COMO JSON , PASCAL VOC XML and TensorFlow TFRecord etc. but we had to train our dataset on YOLOv5s which requires annotated images in YOLO Format . Once we have annotated images , we can export in any format . So , for the future we might be using multiple annotation formats as per our need .

4. Defect Classifier Algorithm :-

For any problem regarding features or information extraction from images or video , we always have two paths to approach our destined solution .

1. Image Processing Based
2. Computer Vision Based

There are certain cases in which image processing based algorithms work well and in some cases computer vision based algorithms perform better depending upon the problem . In our case for defect detection in surgical instruments , we couldn't finalize which approach to go with without testing the approach on our dataset . So , we performed **PILOT Study ,** a small scale preliminary study conducted before any large-scale quantitative research in order to evaluate the potential of each algorithm **,** in order to test the feasibility of all the candidate algorithms on our dataset. All the algorithms and their details analysis is given below ;

4.1 Reference Based Approach :-

This approach belongs to the category of image processing based techniques . In the reference comparison approach, a standard image which is called template will be prepared firstly, and then a surgical instrument that needs to be inspected will be compared with the template to find the unknown defects. Although it is simple and easy to use, there are still a lot of things to keep in mind, such as uneven lighting, erroneous registration, a lot of storage space needed, etc. The issue with this approach is that we must first create a database of reference images and then, each time a test image is received, parse that database to choose an image that would be the best fit to serve as a template for our test image. This process is both time- and computationally-intensive.

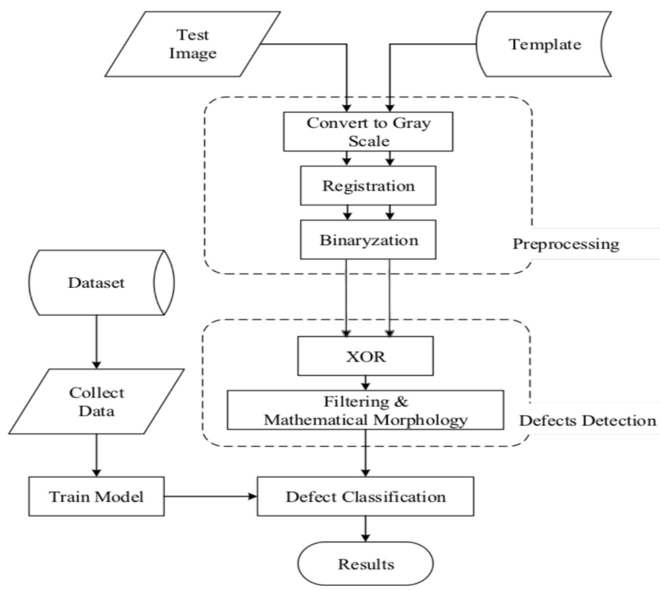


Figure :- Flowchart for reference image based defect detection

4.2. Contour Based Approach :-

This approach also belongs to the category of image processing based techniques . The test image is first pre-processed in order to remove noise and do some corrections . The pre-processed image is then fed to the contour detector which returns all the contours found ; contours can be explained simply as a curve joining all the continuous points (along the boundary), having the same color or intensity. The number of contours found on the surface of defected surgical instruments vary largely from the ones which are un-defected . The problem with this approach is False Positives Rate ; comparatively high rate indicating faults where faults don't even exist .

4.3. Transfer Learning based , YOLOv5 :-

This approach belongs to the category of computer vision based techniques . Transfer learning, in general, refers to a machine learning strategy in which knowledge collected or learnt by pretrained models is reused to increase learning of a related task. YOLO is a method that provides real-time object identification by utilizing neural networks. Among all object detection algorithms, it stands out for its accuracy and quickness. In contrast to earlier versions that were Darknet-based, YOLOv5 is implemented on PyTorch.

We have trained our algorithm on the dataset we generated and in order to make YOLO work best for our problem , we have changed its architecture by freezing certain layers , changing anchor & backbone along with tweaking the hyperparameters so that accuracy and efficiency is maximized . The architectural diagram for YOLOv5 is as follows;

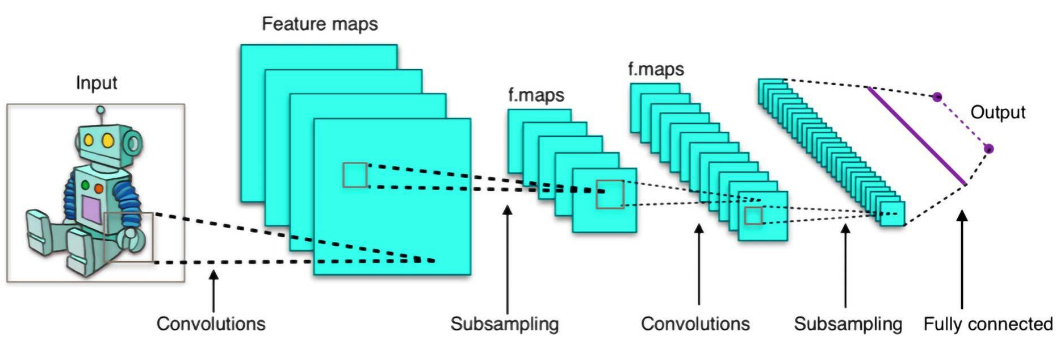


Figure :- Architecture Diagram of YOLO model used

Architectural Changes YOLOv5	Precision / Accuracy	Time to draw inference
Batch Size	Size : 20 Precision : 0.985 Recall : 1	10.9ms taken for inference
Epoch Size	Size 300 Precision: 0.985 Recall: 1	11.0ms taken for inference
Hyperparameters (after 300 evolutions)	(lr0,lrf):(0.01011,0.01)	10.9ms taken for inference

	momentum: 0.937 (default) momentum: 0.94709 (evolved)	10.9ms taken for inference
	warmup_bias_lr: 0.1 (default) warmup_bias_lr: 0.09535 (evolved)	10.9ms taken for inference
	(hsv_h,hsv_s,hsv_v): (0.01726,0.7223,0.40266) (default) (hsv_h,hsv_s,hsv_v): (0.015,0.7,0.4) (evolved)	10.9ms taken for inference
Freezing Layers	0 (best results with no frozen layers)	10.9ms taken for inference
Fitness	0.8851	10.9ms taken for inference
Weights	yolo5s.pt [default]	-
Image Size	640	10.8ms taken for inference

Based on the analysis from the stats of table mentioned above , we can easily draw some conclusions regarding optimal values of hyperparameters as well as overall architecture .

Candidate Algorithms / Feature Description	Brief Description	Accuracy & Inference Time	Limitations
Reference Image Based	In the reference comparison approach, a standard image which is called template will be prepared firstly, and then a surgical instrument that needs to be inspected will be compared with the template to find the unknown defects .	Accuracy in case of reference based approach is **67.4%** . **AND** Time to draw inference on an input image is **11.5 seconds**	Reference Image Orientation Dependent **AND** Time to traverse reference images database makes this approach less efficient

Contour Detection Based	In a contour based approach , the input image is fed to the contour detector which returns all the contours found ; The number of contours found on the surface of defected surgical instruments vary largely from the ones which are un-defected .	Accuracy in case of contour based approach is **74.4%** . **AND** Time to draw inference on an input image is **10 seconds**	FALSE Positive Rate is extremely high . **AND** Tiem to draw inference could still be lessened .
YOLOv5	Using the Transfer Learning approach , we have trained an algorithm on the dataset we generated and in order to make YOLO work best for our problem , we changed its architecture by freezing certain layers , changing anchor & backbone along with tweaking the hyperparameters so that accuracy and efficiency is maximized .	Accuracy in case of contour based approach is **81.0%** . **AND** Time to draw inference on an input image is **4 seconds**	In case of YOLOv5 , time to draw inference is reduced but the accuracy of our system is still compromised and we need to make it up-to our classification objective i.e., **Zero False Negatives .**

5. Technical Workflow :-

1. Image Processing based Classifier :-

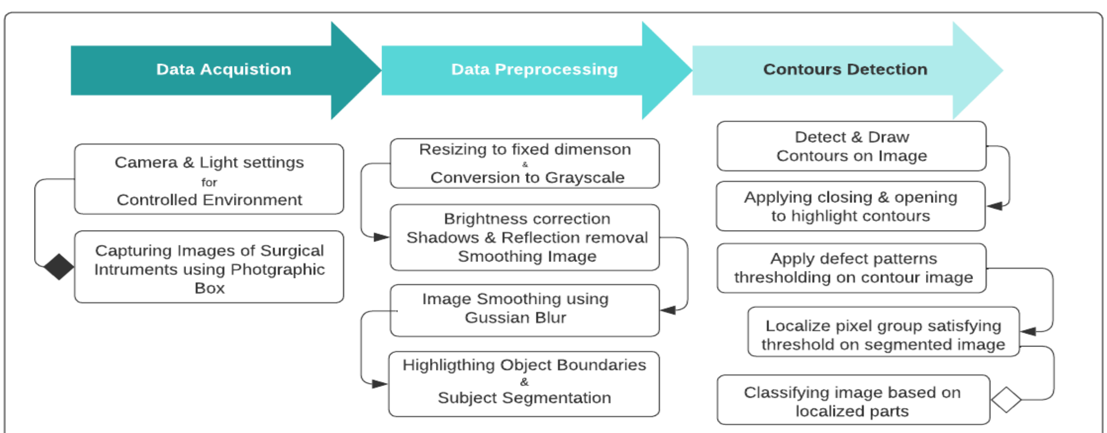


Figure :- Technical Workflow of the proposed Contour based classifier for defect detection

2. Machine Learning based Classifier :-

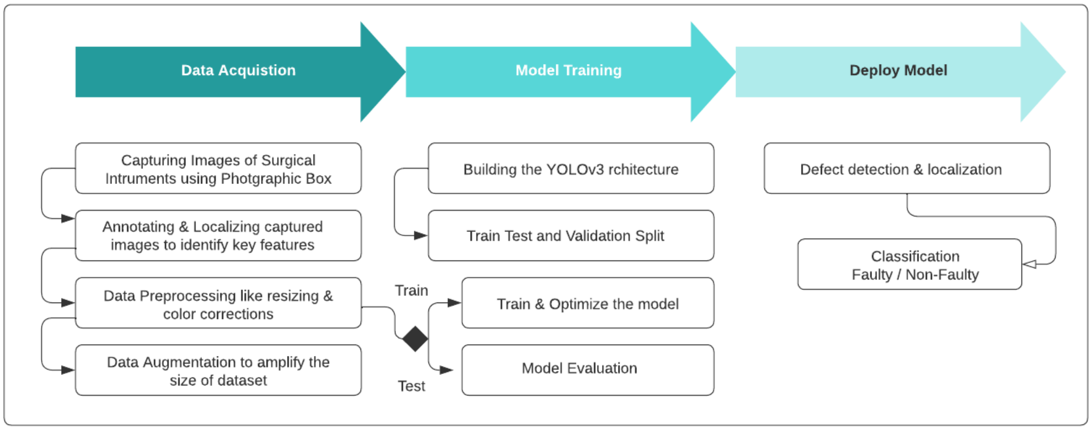


Figure :- Technical Workflow of the proposed ML based classifier for defect detection

Test Plan (IEEE 829 FORMAT)

Auto-Inspect
Test Plan Document

Approved by
Dr. Atif Aftab Ahmad Jillani

Prepared by
Vara Ali i190502
Muhammad Saqib i190494

National University of Computer and Emerging
NUCES FAST ISB

Revision History :-

Name	Date	Reason for Change	Version
Vara Ali	24-12-2022	Initial Version	1.0

1. TEST PLAN IDENTIFIER :-

Master Test plan for F22-018-D-AutoInspect

2. REFERENCES :-

- Vision Document
- Analysis and Design Artifacts
- Software Requirements Specifications

3. INTRODUCTION :-

The purpose of this Software Test Plan (STP) is to develop a test plan to assess all functionalities of the automated system for fault detection of surgical equipment (AutoInspect) V.1.0 for Final Year Project - I.

3.1. Scope

The scope of this test plan includes unit testing of the machine learning model i.e YOLOv5 for the automated system for fault detection of surgical equipment.

4. TEST ITEMS (FUNCTIONS) :-

The testing would mainly cover two areas.

a. Input Validation :-

The YOLOv5 model trains on input data in the form of images. The first item of testing would include how the model behaves if given no input or input in the wrong format than expected to make sure the image pre-processing is robust.

b. Weights Comparison :-

Second item to be tested are the weights. Weights of every layer would be recorded once the model is initialized. Then a dummy dataset would be given and the model is trained for a single epoch. Weights are then compared to those of the already trained model.

c. Pre-Processing Unit :-

The pre-processing unit includes all the operation applied to the images before any defect detection algorithm is applied. All the features that it includes e.g. noise removal, exposure enhancement, color conversions etc would be tested

d. Response Time :-

Another thing to be assessed is the time that the model takes to make an inference/ garde image as faulty or non faulty once a test image is given.

e. **Accuracy of the Decision :-**

The YOLOv5 model being used is responsible for detecting the type of fault in the particular image of the instrument.. The accuracy of prediction of the fault type would be tested.

f. **Custom Model Testing :-**

A custom model based on neural networks developed to classify the instrument would be tested.

5. FEATURES TO BE TESTED :-

1. Robustness of the system even if a wrong image is fed for the fault detection
2. Ability of the system to work on a particular standard in classifying images as faulty/ non faulty .

6. APPROACH (STRATEGY) :-

6.1 Testing Levels :-

Unit testing :- It would be conducted by the project developer. All the necessary documents related to unit testing such as the list of the test cases, inputs, outputs, loopholes identified etc shall be provided once the testing is done.

Adversarial Testing **:-** In order to assess the robustness of the YOLOv5 object detection model adversarial testing has to be performed.

Invariance Testing :- Using a modified input it would be checked that if it has any effect or if it changes the output of the model e.g. sending a differently augmented image to find out if the model still classifies it correctly or not .

6.2 Measures and Metrics :-

After carrying out all the testing procedures following information would be provided by the team:

1. Location of the fault
2. Effect of the fault on the final output
3. Time consumed to rectify the fault

7. ITEM PASS/FAIL CRITERIA :-

Unit Testing :-

Following criteria must be met for the unit test case:

- All the test cases must be complete
- Percentage of minor defects in particular percentage of unit test cases that is acceptable
- Percentage of code covered

Invariance Testing :-
By the completion of invariance testing, the model must be classifying correctly with the accuracy greater than 96%. Below this threshold would mean that the model is failing to generalize rest of the modified input given which is not acceptable for our defect detection system

8. SUSPENSION CRITERIA AND RESUMPTION REQUIREMENTS :-

Testing would be suspended if a fatal error is discovered.

- Model is unable to classify instruments with minor or smaller defects as faulty equipment
- Model is unable to detect the position and location of the fault on the surface of surgical equipment

Such defects in the model must be handled and resolved first and then further testing should be continued. Otherwise it would result in other ghost errors that would be nothing but the result of the errors ignored previously.

9. TEST DELIVERABLES :-

Following items would be delivered by the end of the testing phase

- Test plan document.
- Test cases.
- Test design specifications.
- Error logs and execution logs.
- Problem reports and corrective actions.

One thing that is not a test deliverable is the software itself that is listed under test items and is delivered by the development team.

10. REMAINING TEST TASKS :-

Once major faults are identified rest of the development would be carried out and would be tested accordingly. Every time a new component or feature is added it would be tested separately. Some components that would be added later on and their corresponding testing is listed below.

- Testing the accuracy of detection of type of fault that exists on the particular equipment e.g. if the fault identified is pore, tuck, scratch, crack or corrosion
- Testing the accuracy of location of the fault on the surface of the surgical equipment
- Verification of the prototype of the app and its interface
- Accessing the integration of the model with the app
-

11. STAFF TRAINING :-

1. Training on the application/system.
2. Training for any test tools to be used.

Section 4 also affects this section. What is to be tested and who is responsible for the testing and training.

12.SCHEDULE :-

7th Semester

1. **Mid-I Evaluation**
   Unit test cases of the completed code.
2. **Final Evaluation**
   Unit test cases of the completed code.

8th Semester

1. **Mid-I Evaluation**
   Unit test cases and FSM of the completed code.
2. **Final Evaluation**
   FSM, Unit test cases and integration testing of the completed code.

13. GLOSSARY :-

Used to define terms and acronyms used in the document, and testing in general, to eliminate confusion and promote consistent communication .

Conclusion :-

In a nutshell , 50% modules of the AutoInspect which we have committed as a whole have been implemented and the most important among the completed ones is the defect detection & localization . The requirements specifications , design & analysis artifacts and test plan for all the implemented modules have been added in this report . One can easily compute the size , shape and location of a defect using further processing , once the defect is detected . As far as the web integration and prototype development is concerned , we have started working on our project web integration plus we have also developed an android app for the demonstration of our project . Prototype development for this project will be started after the mid evaluation of the FYP-2 . This sums up our whole FYP-1 plus a brief way forward for our FYP-2 .

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