FINAL YEAR PROJECT

Mid Evaluation 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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1. Project Vision :-

1.1 Introduction:-

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 .

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

1.2 Positioning :-

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.

Problem Statement :-

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) .

Product Position Statement :-

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 .

1.3 Stakeholder & User Descriptions :-

Market Demographics :-

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 .

Stakeholders Summary :-

Stakeholders include Instrument Manufacturing Company , Workers , Quality Assurance Department/ Analysts and customers of the company .

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	Absence of stats generated by the fault detection system makes it difficult for the quality assurance department to analyze which

	that has to be exported	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 .

Stakeholders Profiles :-

1.3.1 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., isfaulty , localize defect , fault size and fault shape

1.3.2 Workers

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

1.3.3 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 upto the mark and of export quality standard are being met . 2. Figuring out the corrective measures in the product line if certain quality issues are being faced frequently .

Description	Analyst from the Quality Assurance Department responsible of analyzing the fault logs & quality stats and deciding the corrective measures
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

1.3.4 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 and diposlam of the surgical instruments after use plus if the instrument life has expired
Success Criterion	1. Product Quality is upto the mark as promised by the manufacturer 2. Order is delivered on-time and safe and secure . No damage to the shipment .
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

Key Stakeholders & User Needs :-

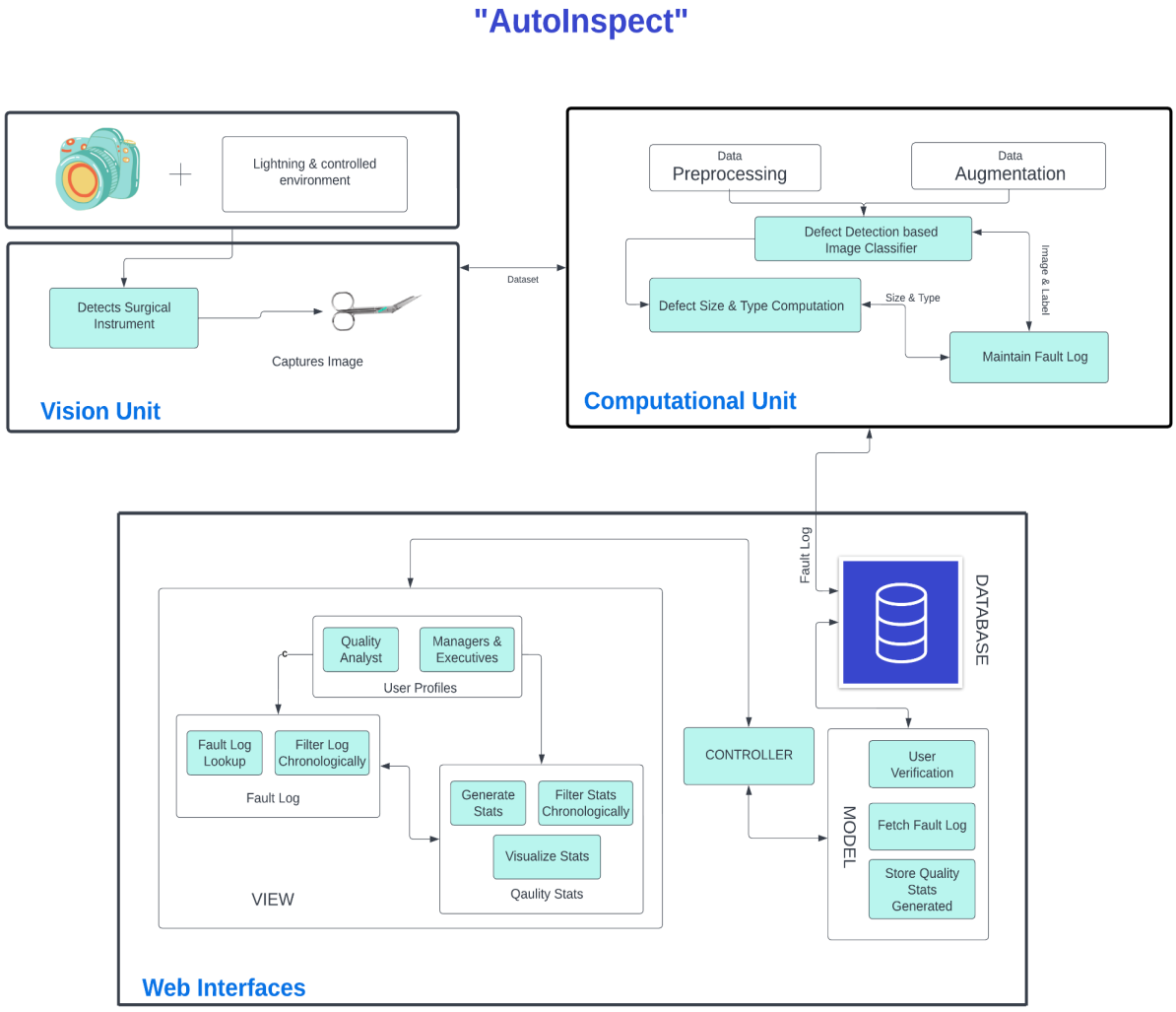
Need	Priority	Concern	Current Solution	Proposed Solution
Efficient	High	Faulty instruments might get into the export batches	None	The computational unit ensures to have as minimum false positive as possible so that no faulty instruments gets to pass the inspection phase
Optimized	Moderate	Run-time inspection 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

Alternatives and Competition :-

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 .

1.4 Product Overview :-

Product Perspective / Architecture :-



1.5 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.

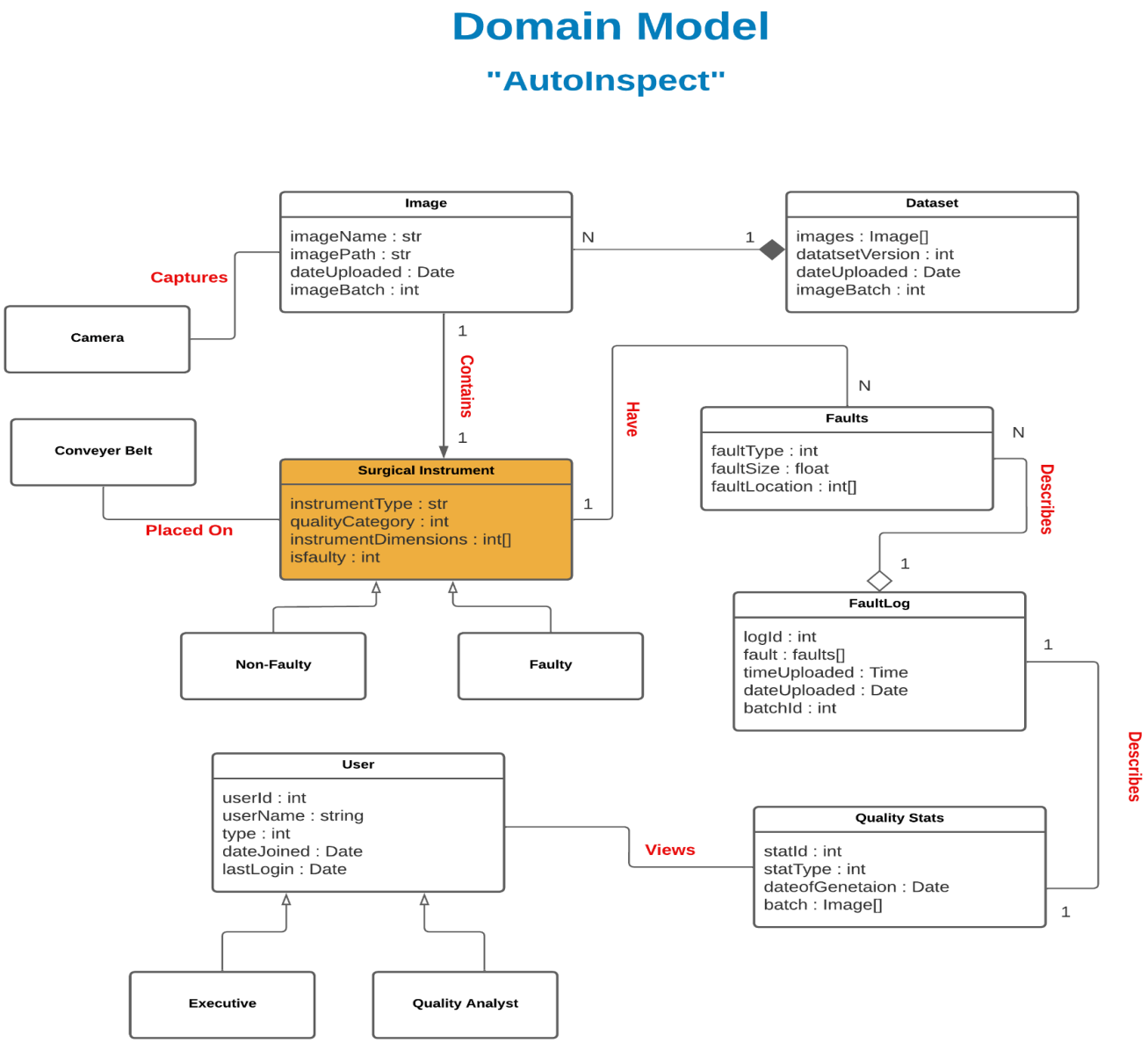
E. Automated Image Acquisition through Prototype :-

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 .

1.6 Constraints :-

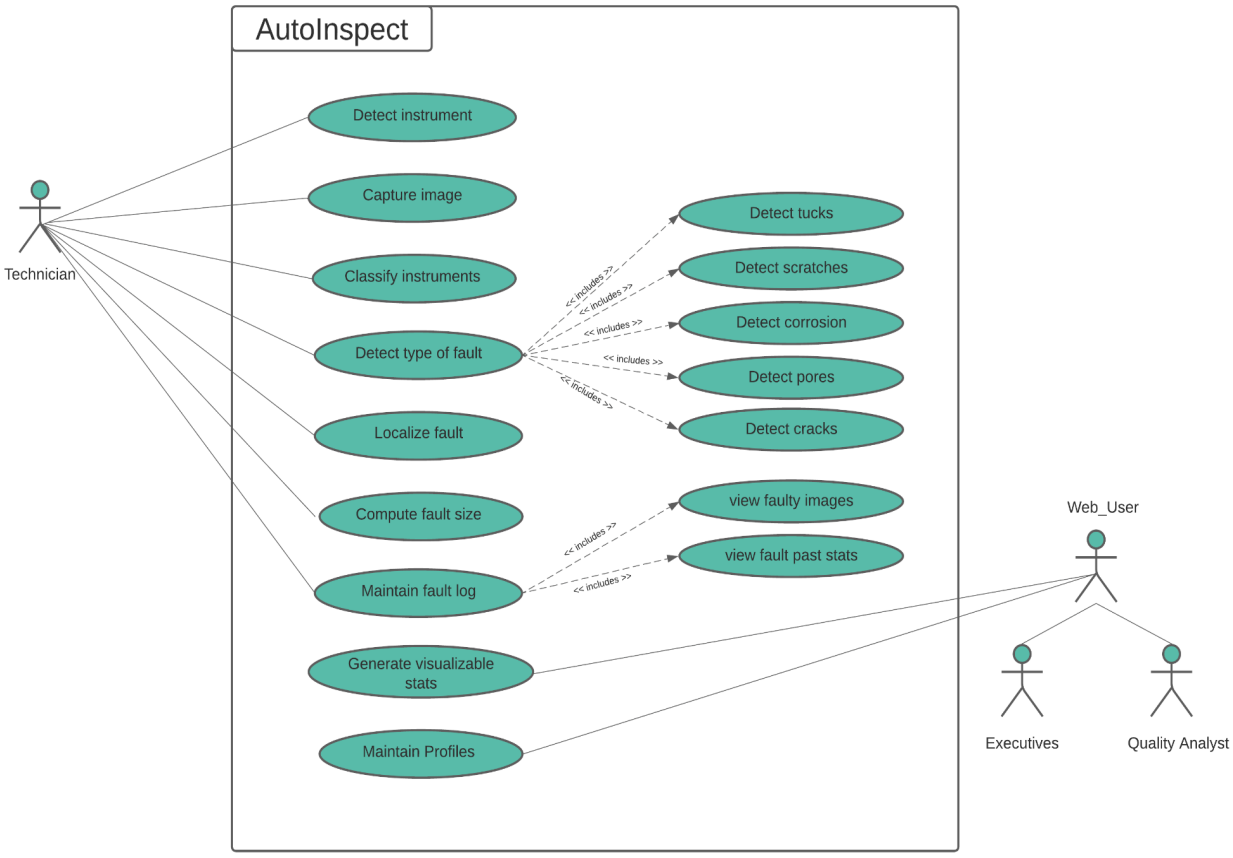
1. The system would not be able to detect if the fault is not on the surface level exposed to the camera .
2. The system would not be able to detect the depth of the fault e.g. how deep a pore is
3. The accuracy of the fault detection would be dependent on the camera quality. In case of bad lighting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

2. Domain Model :-



3. Use Cases :-

3.1. Use Case Diagram :-



3.2. 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

3.3. 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

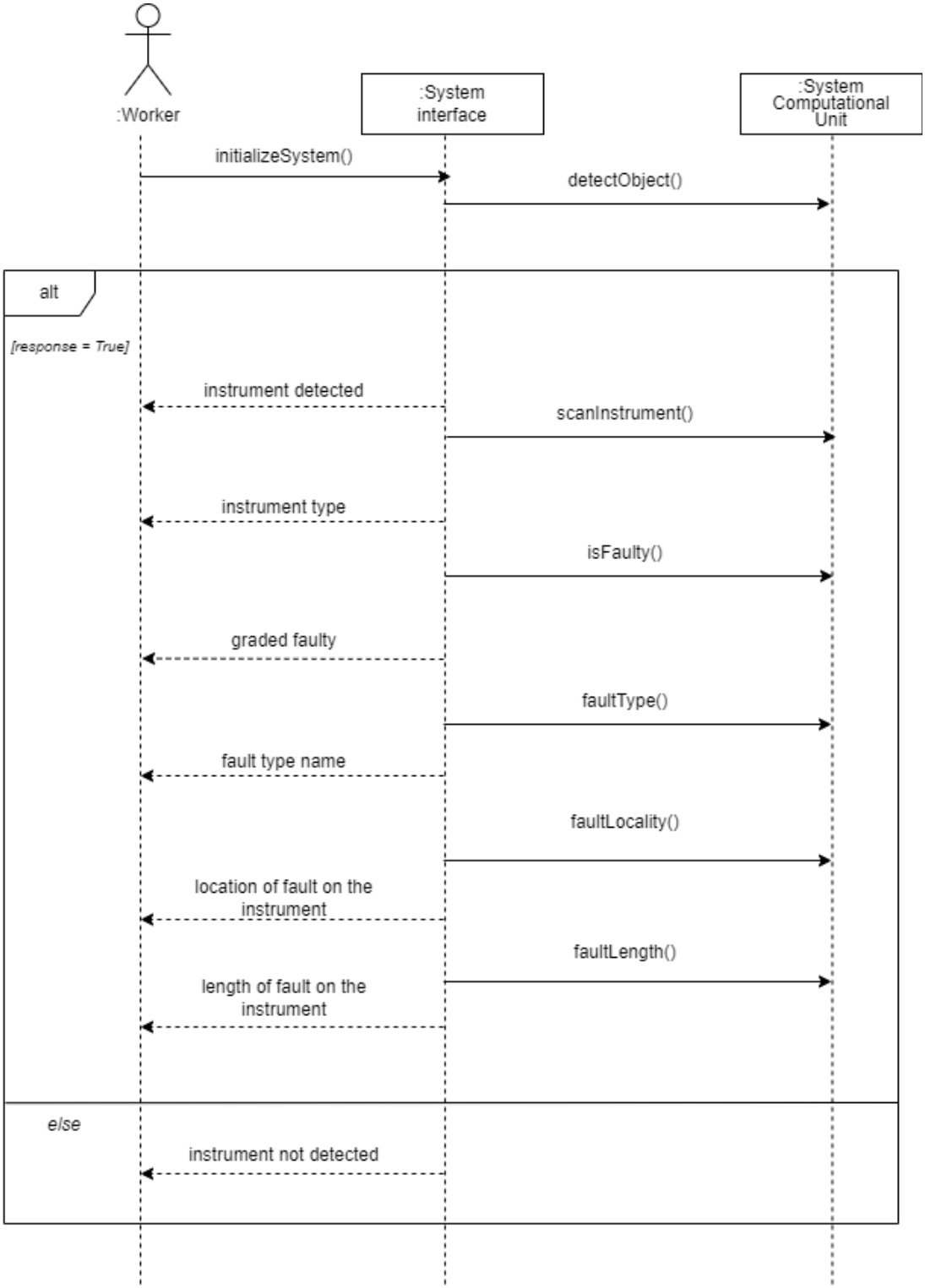
Use Case ID	UC - 07
Use Case Name	Maintain fault log
Level	User goal
Actors	Instruments Manufacturer Company
Stakeholders and Interests	The company wants to maintain a fault log where they view, access and analyze the past faulty pictures along with their stats
Pre-conditions	1. Camera has captured pictures 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

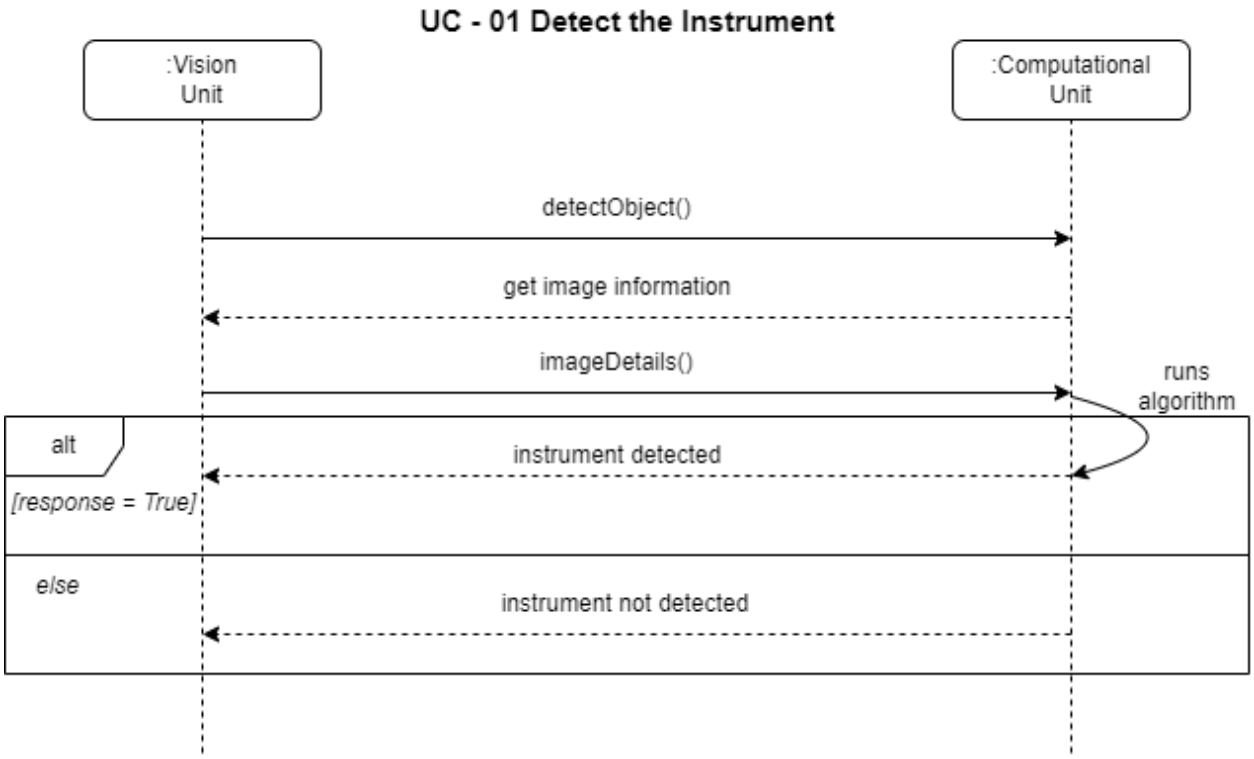
Technology and Data Variation Lists	Storage for the fault log
Frequency of Occurrence	Everytime a faulty instrument is detected

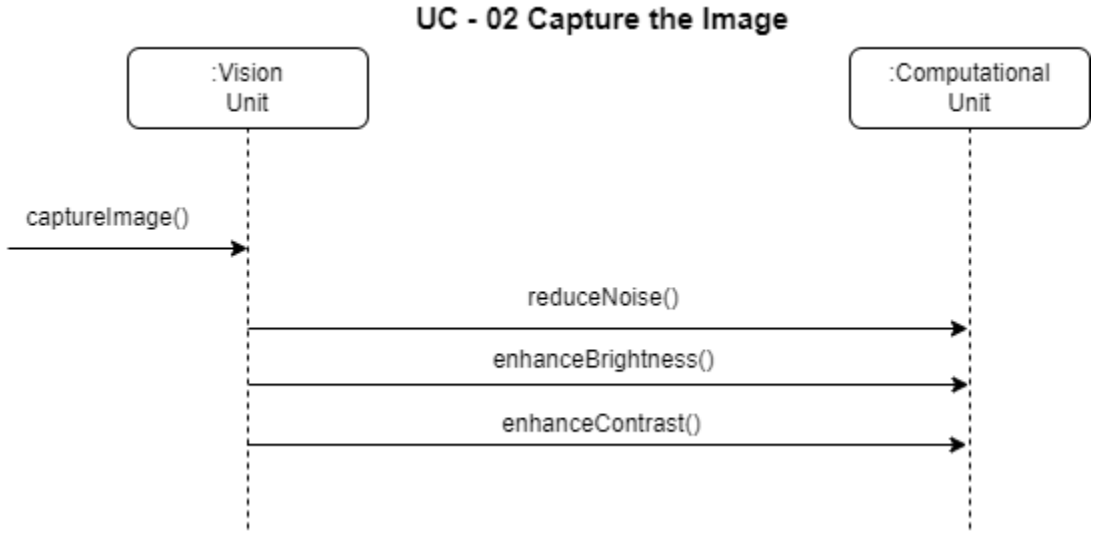
Use Case ID	UC - 08
Use Case Name	Generate Visualizable stats
Level	User goal
Actors	Web_User (Executives & Quality Analyst)
Stakeholders and Interests	The actor wants to view the stats generated by the system
Pre-conditions	System has detected the faulty instruments
Post-conditions	System must generate 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

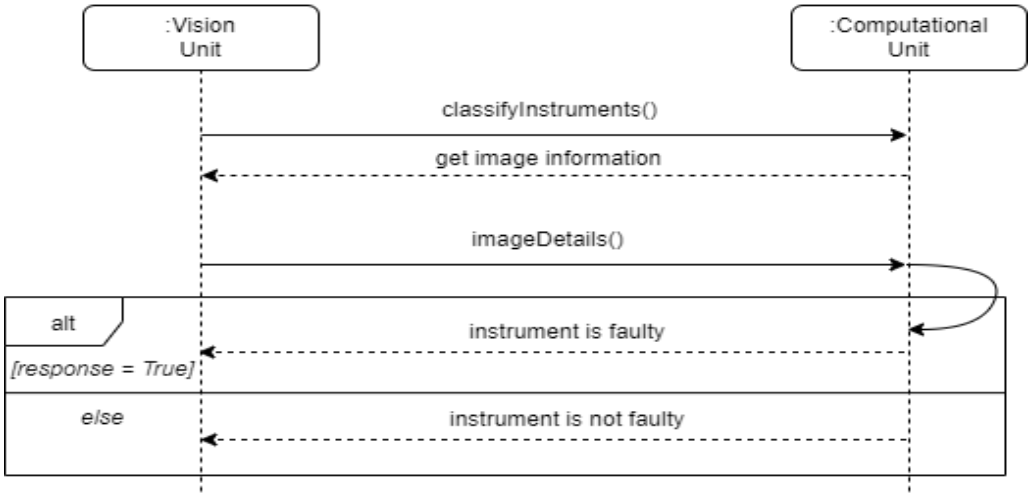
3.4. System Sequence Diagrams :-



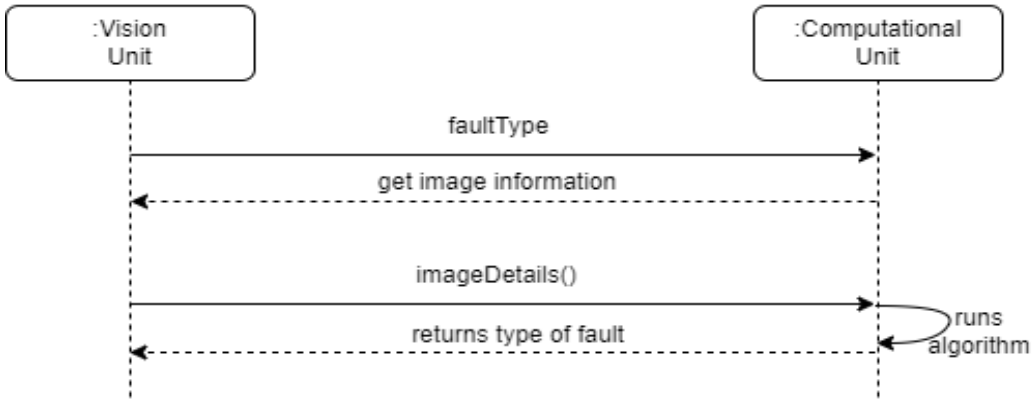

UC - 01 Detect the Instrument
:Vision Unit
:Computational Unit
detectObject()
get image information
imageDetails()
runs algorithm
alt
instrument detected
[response = True]
else
instrument not detected


UC - 02 Capture the Image
:Vision Unit
:Computational Unit
captureImage()
reduceNoise()
enhanceBrightness()
enhanceContrast()

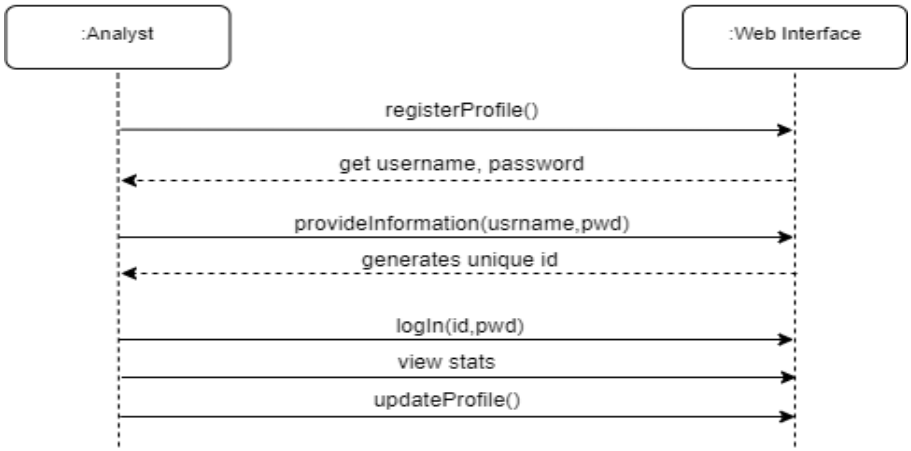
UC - 03 Classify Instruments



UC - 04 Detect type of fault



UC - 09 Maintain Profile



3.5. OperationContracts

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

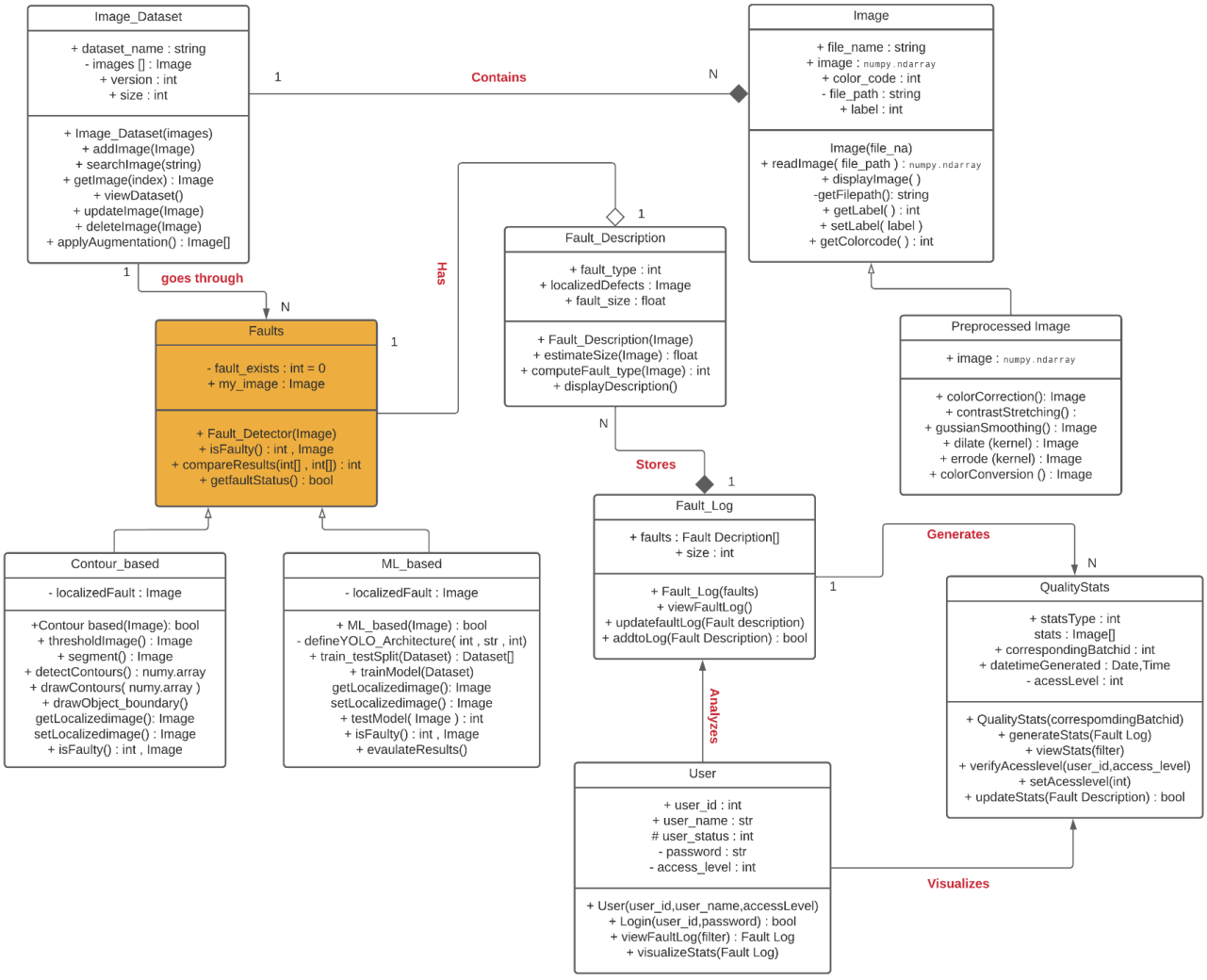
Contract Name: generateStats()

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

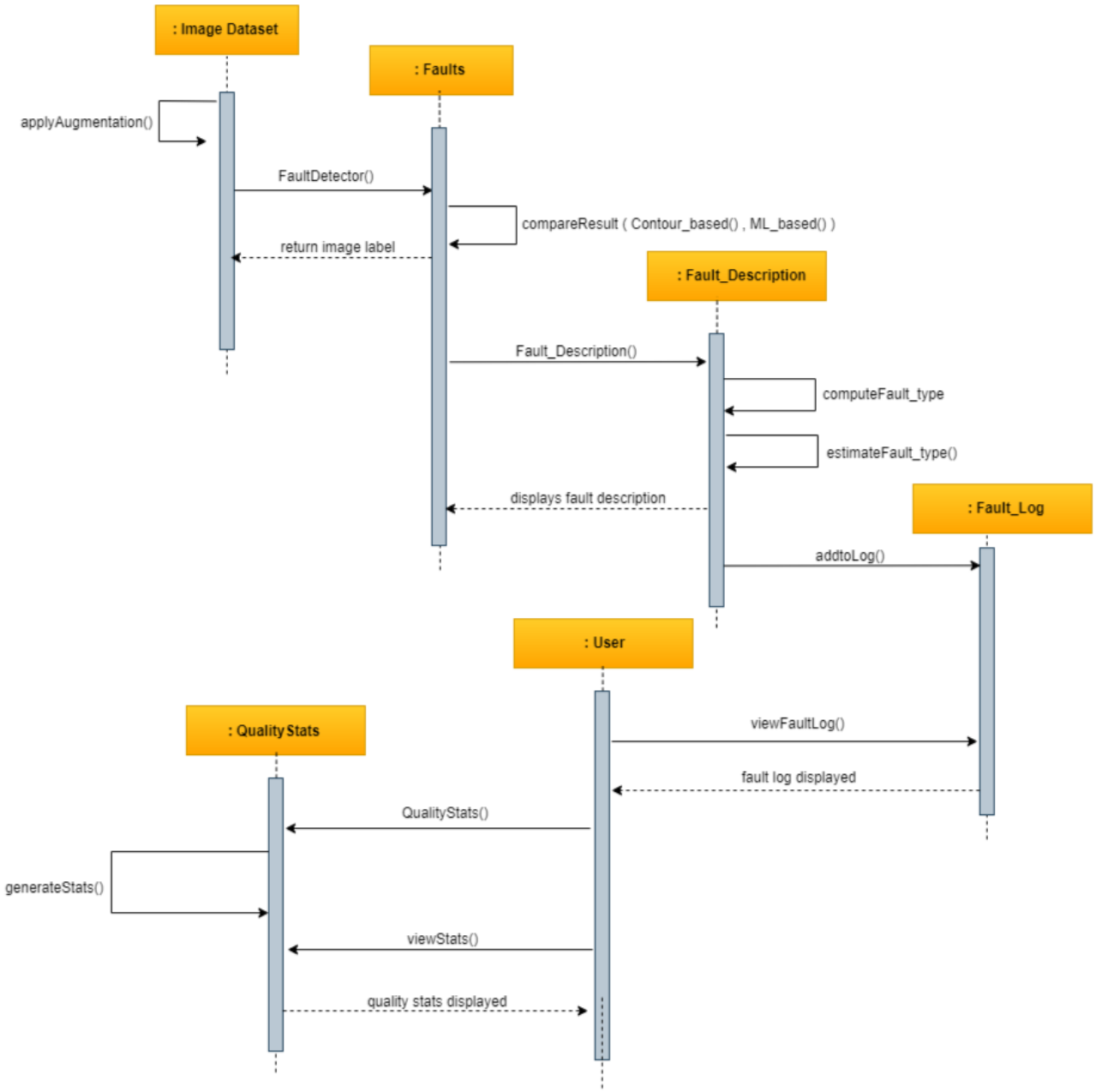
4. Class Diagram :-

UML Class Diagram

"AutoInspect"



5. Sequence Diagram :-



6. System Requirement Specifications:-

6.1 Introduction :-

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.

Document Conventions :-

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

Intended Audience :-

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

6.2 Product Scope :-

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 .

User Classes & Characteristics :-

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.

Standard users are categorized into following groups:

1. **Surgical Instrument Manufacturers** :- Those who own any factory involved in the production of surgical equipment .

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

Operating Requirements :-

6.2.1 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

6.2.2 User Documentation

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

6.2.3 Assumptions 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.

External Requirement Interfaces :-

6.2.1 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.

6.2.1 Hardware Interfaces :-

- Android/ iOS camera (10-12 MP)
- A beginners DSLR camera

6.2.1 Software Interfaces :-

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.

6.3 Product Features :-

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

6.3.1 Detect Instrument :-

***ID* :-** FR 1

***Description* :-**

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.

***Dependencies* :-** None

6.3.2 Instrument Classification :-

***ID* :-** FR 2

***Description* :-**

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

***Dependencies* :-** FR 1

6.3.3 Indicate type of fault :-

***ID* :-** FR 3

***Description* :-**

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

***Dependencies* :-** FR 2

6.3.4 Compute fault size :-

***ID* :-** FR 4

***Description* :-**

The system will be able to compute the size of fault in centimeters after the fault has been detected and localized by the localization function . Calibration is performed to convert fault size in pixels to corresponding length in centimeters.

***Dependencies* :-** FR 2

6.3.5 Generate & 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

6.3.6 Automated Image Acquisition :-

***ID* :-** FR 4

***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.

***Dependencies* :-** None

6.4 Non-Functional Requirements :-

Performance Requirements :-

6.4.1 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.

6.4.1 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 .

6.4.2 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.

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 .

Software Quality Attributes :-

6.4.3 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.

6.4.4 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 if a user performs queries for any fault description or quality stat ..

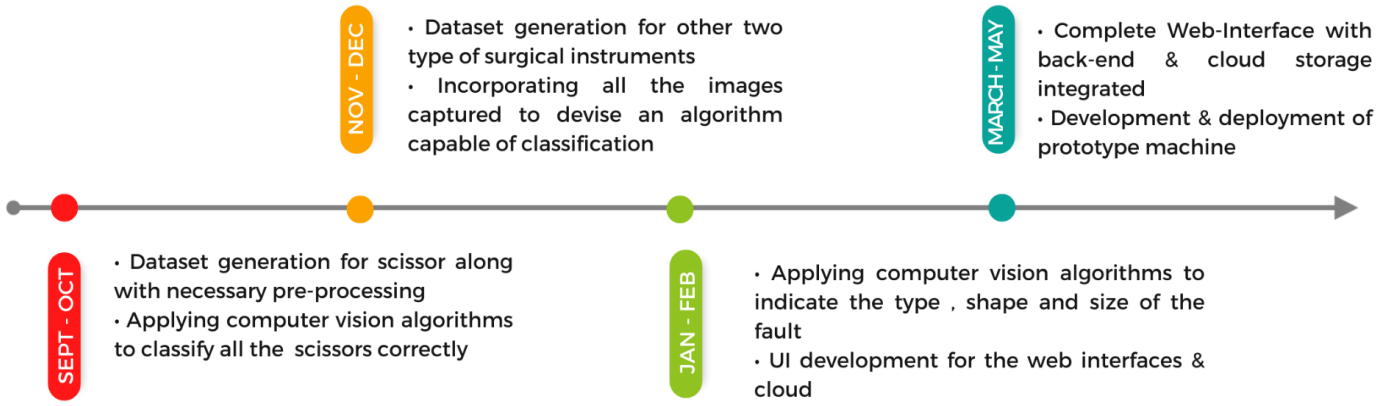
6.4.5 Testability :-

The system shall be testable SQA engineers can test the applications for buggs and incomplete requirements.

6.4.6 Maintainability :-

The system should be extensible, It should be able to incorporate new features or requirements in the existing requirements. For the test rig , it should be easily maintainable .

7. Iteration Plan :-



8. Technical Workflow Diagram :-

1. Machine Learning based Classifier :-

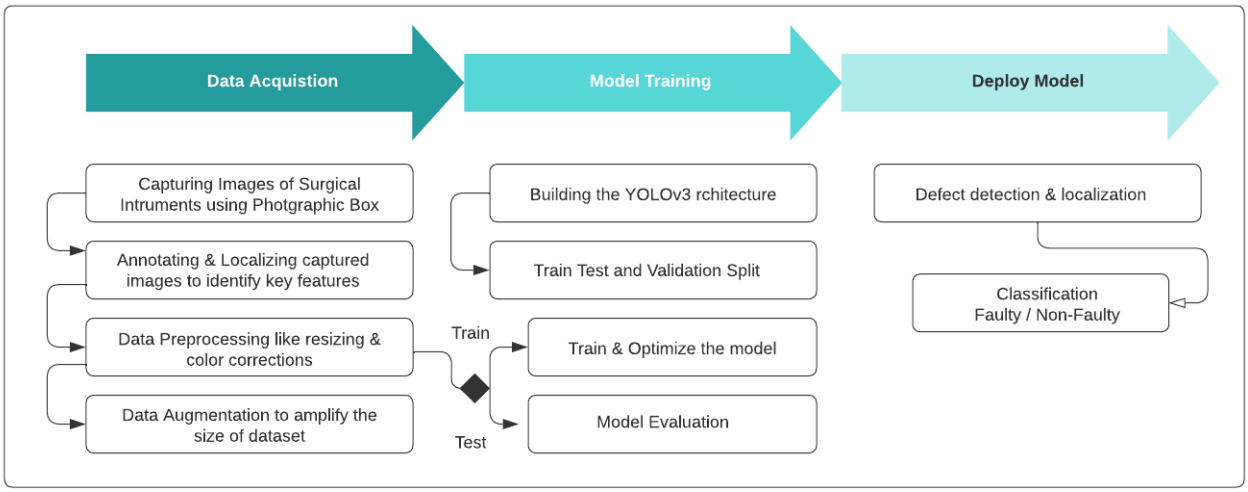


Figure :- Technical Workflow of the proposed ML based classifier for defect detection

2. Image Processing based Classifier :-

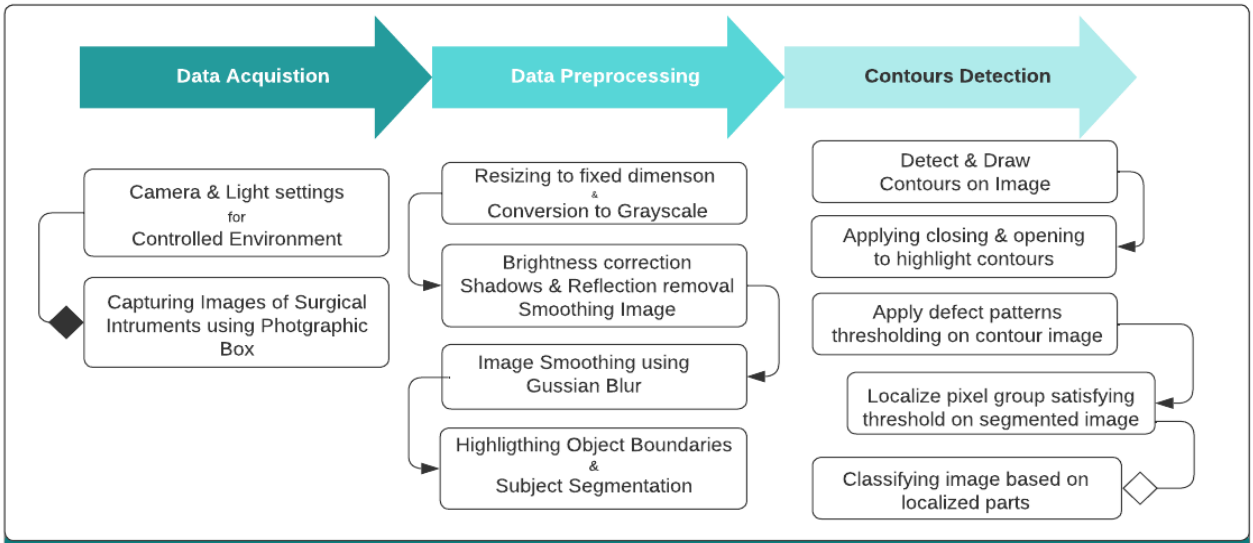


Figure :- Technical Workflow of the proposed Contour based classifier for defect detection