National University of Computer and Emerging Sciences

Textile PLM Automation

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Abstract

The Project Lifecycle Management of day-to-day operations within the textile industry can be redundant, inefficient, and slow. A product was required for factories to run seamlessly and concurrently in order to keep track of day-to-day tasks more efficiently. The requirements were presented after careful consideration and indulgence within the operations of the PLM of a common textile factory and the proposed solution of digitizing the entirety of the process aims to improve the industry as a whole. We shall be using the help of digital images to serve as a visual aid to break down textile orders into segments in an attempt to bring modularity and hence efficiency to the entire process. Once an image has been uploaded by a worker in the factory, the managers up the hierarchy can approve or suggest amendments to the order. This brings the entirety of workers within the factory on the same page in terms of production, which was a constant struggle before the digitization of the factory.

Executive Summary

The material business faces difficulties in dealing with its item lifecycle executives processes, which can prompt wasteful activities, postpones showcasing, and inflated costs. This undertaking means computerizing PLM processes for the Textile Industry by fostering a product arrangement that incorporates item plan, creation arranging, and inventory management.

The product arrangement will give a concentrated stage that smooth out the whole PLM process, from idea plan to definite creation. The stage will take into consideration cooperation between various groups and partners, including creators, specialists, and providers, to guarantee consistent correspondence and information sharing.

The venture's goals are to expand the productivity and exactness of PLM processes, diminish lead times, and limit blunders and modifications. The product arrangement will use cutting-edge innovations, for example, computerized reasoning and AI to robotize dull assignments and give bits of knowledge into item execution and market patterns.

This will effectively mean that the entirety of long term and bulk orders will be produced more seamlessly and efficiently reducing the overall cost of the project and making it a lot smoother for the workers of the factory to complete in a timely manner. The project expands this further by introducing innovative ideas to further strengthen the process entirely.

We also propose to explore the automation of approving a particular stage of production by adding image recognition within the software in order to automatically process the order so that minimal human effort is required to track the PLM. This will serve as great innovation across the industry and will effectively expand the horizons of the textile industry as a whole.

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Chapter 1: Introduction

As digitization in various broad horizons lead to change in multiple industries, the textile industry has still been deprived of technological solutions to further strengthen the industry as a whole. The concurrency, parallelity, and dependency of the current systems used in the textile industry for PLM ceases to live up to the standards of the modern age. This project aims to solve the PLM structure of a typical textile factory.

The document shall be visiting the proposed solution, the requirement of the solution, and how the solution shall be helping solve the existing inefficiency in the textile industry. This document shall be dealing with technical aspects of the project including the functional requirements, the GUI, hardware and software requirements, test-cases, constraints, dependencies, high level diagrams, etc. The document shall exist from the start to finish of this project in order to be referred to by the developers and stakeholders at all times.

1.1 Purpose of this Document

The intended purpose of this document is to formally depict the scope of the PLM Automation Software. The document at hand shall be used by developers to refer to the functionality of the project as a whole. The document also exists to serve as a reference for all stakeholders and outside critiques as to learn the nature of the project, the problem at hand, the requirements of the problem, the proposed solution, and how the proposed solution aims to fix the problem effectively. This document shall be referred to from the start of the project till the deployment of the project and shall continue to exist in case of any future amendments to the scope of the software.

1.2 Intended Audience

The intended audience of this document ranges from the stakeholders of the factory, the developers assigned to this project, the upper management of the factory that the product shall be developed for, as well as any concerned party involved in the development of the PLM Automation system. The document shall serve as a set of guidelines for the entirety of the project and shall be referred to whilst developing the software.

1.3 Definitions, Acronyms, and Abbreviations

PLM: Product Lifecycle Management
Odoo: An over-the-counter solution for Business Management
SAP: An over-the-counter solution for Business Management
GUI: Graphical User Interface

Chapter 2: Project Vision

2.1 Problem Domain Overview

The day-to-day tasks operated in the textile industry, more particularly in a factory that deals with production can be immensely redundant and challenging. The existing practice of maintaining orders manually is an inefficient way and needs to be replaced by a more elegant and effective solution to ensure that the regular activities of the factory are more productive. Orders for the factory are received in large quantities and it can be incredibly hard to keep track of several hundred orders when there is no proper digitized solution for the entire process.

To keep everything and everyone on the same page during the entirety of the PLM process becomes nearly impossible for the textile factory owners, which is why the proposed solution is required to introduce concurrency and efficiency within the scope of the factory to make large orders seamless and fluent.

2.2 Problem Statement

The major issue being faced in the textile industry is the efficient management of PLM. This is the major problem that we shall be attempting to solve with the solution proposed in this document by trying to integrate concurrency and fluency in the PLM of the automation industry to tackle large bulk orders with ease.

2.3 Problem Elaboration

Currently the factories in the textile industry rely heavily on manual PLM to get their orders out of production and into the hands of the customers, this process is slow and ineffective as many textile factories deal with large volumes of orders which are hard to maintain in a manual database and are inefficient to work with in terms of the quality of the product.

With a proposed digital solution, we can not only automate the process of the PLM, but we can also integrate an image detection system which can help improve the quality of the orders digitally which will be a vast improvement over the current system at hand. Currently it is immensely hard for the workers of the factory to be on the same page with each other as there is no sense of integrity due to the lack of a centralized domain that controls the PLM of the order.

2.4 Goals and Objectives

The goals and objective of the project are simply to introduce a layer of efficiency, concurrency, parallelity, and integrity within the PLM operations of the textile industry. This can be achieved through the digitization of the PLM operations of the factory as proposed in this document.

2.5 Project Scope

For the current project at hand, the scope of the project is limited to the digitalization of the textile industries PLM, this means that the software shall be dealing with orders from the day they are taken into the factory till the day that the order is ready to be collected by the customer. However, the product deals with taking images of certain parts of production for it to be approved and for everyone to be on the same page while producing the order.

The first part of the project pertains to manually taking images of the products lifecycle and furthermore manually approving the images (to be done by an administrator). However, once

this methodology is successfully installed within the factory, a phase two of the project deals with automatic detection of the images that have been uploaded to the system, and using image recognition, automatic approval of the orders can be performed.

Further improvements can be made to the scope of the project by integrating cameras to production belts for auto capturing of images as well as automatic approval of these orders. But this improvement is an idea to be explored at a later stage.

2.6 Sustainable Development Goal (SDG)

The scope of the project exists to introduce a new standard for innovation and fluency in the textile industry by providing a platform that is smooth, seamless, and efficient to manage the PLM of the day-to-day tasks handled in the industry. We aim to provide a set infrastructure to help solve the redundancy and lack of concurrency in the industry by providing an elegant and sophisticated solution for the digitization of the PLM of the textile industry. The project aims to do this by introducing innovations like image recognition and digital order tracking to maintain a set standard of fluency in the operations of the factory.

2.7 Constraints

Although the project aims to solve maybe problems in concurrency and efficiency of the factory as a whole, however, due to the entire PLM of a textile product being immensely diverse and complex, it is not possible to have a complete digitization in the entirety of the factory as the scope of this project.

As discussed in the document earlier, the project is divided into two phases, where the second phase seeks the automated approval of images for the detection of the textile products. However, the scope is limited till here as the integration of cameras within the machinery of the factory falls beyond the scope of this project and introduces a new layer of complexity in the grand scheme of things. This project only correlates with the software side of digitization which falls under the nature of computer science development, however, for the complete automation of the factory, the project will have to move its domain from computer science to become a core engineering project.

2.8 Business Opportunity

The opportunity for this project in terms of business development is vast and can be explored greatly as the textile industry is indeed a blooming industry that is believed to be one of the few industries that won’t cease to exist as the future of technology unravels. The textile industry of Pakistan moreover is one of the biggest textile industries of the world, and with the industry having great potential of local and international business opportunities, digital technology can greatly influence the textile industry as a whole with providing more concurrency and fluency to the outdated practices being followed today.

Many large players in the textile industry still rely on manual PLM and the introduction of a software of the nature of this project could be a game changer for many well-established brands that are struggling to maintain their PLM.

2.9 Stakeholders Description/ User Characteristics

The stakeholders in the project shall be the owners of the factory existing in the textile industry for which this software is being developed. It is the owner that shall benefit from the output of the solution as the solution aims to provide a global solution for the textile industry at large.

There shall be two distinct user classes that exist within the application.

- **User**: These shall be the workers of the factory that will be entering data into the application and maintaining progress of the PLM
- **Admin**: The admin will be one of the managers of the factory. The admin will be the one who can update order requirements, view, and approve the images that the users have uploaded in the application.

2.9.1 Stakeholders Summary

The stakeholders of the project are of course the owners of the factories in the textile industry. They are big business owners that value efficiency and saving time by having elegant and sophisticated methodologies to go about their day-to-day tasks and will surely appreciate the innovation introduced within their factories in terms of the digitization of their PLM using image recognition and digital order tracking facilities.

2.9.2 Key High-Level Goals and Problems of Stakeholders

The key goal of the project is to reduce redundancy and save the time and efforts of all parties involved during the PLM of any product within the textile industry. The issue arises for the stakeholders as they are the managers of big businesses that deal with large orders in bulk. And the current method they implement for the PLM is slow and inefficient. This would be a game changer for the factories in the industry if they are able to manage their PLM automatically thanks to the application proposed in this document.

Chapter 3: Literature Review / Related Work

3.1 Definitions, Acronyms, and Abbreviations

SAP: An over-the-counter business management system
Odoo: An over-the-counter business management system

3.2 Detailed Literature Review

3.2.1 SAP

3.2.1.1 Summary of the research item

SAP (Frameworks, Applications, and Items) is a worldwide programming organization that creates venture asset arranging (ERP) programming frameworks for organizations in different enterprises. SAP programming arrangements offer organizations a scope of instruments to oversee business tasks, including finance, HR, obtainment, store network the executives, and creation arranging. SAP's ERP programming gives organizations constant information examination and bits of knowledge that assist with further developing efficiency, diminish functional expenses, and improve direction.

In the material business, SAP can be a significant device for overseeing item lifecycle the executives (PLM) processes. SAP's ERP programming can assist material organizations with overseeing item plan, creation arranging, stock administration, and production network the executives in a concentrated stage. With SAP's product, organizations can smooth out their PLM processes, decrease lead times, and limit blunders and improve. SAP's high-level examination and bits of knowledge can assist organizations with settling on information driven choices, enhance creation processes, and further develop item quality. By utilizing SAP's ERP programming, material organizations can increment functional proficiency, lessen the expenses, and upgrade their seriousness on the lookout.

3.2.1.2 Critical analysis of the research item (Strengths and Weaknesses)

While SAP as a proposed solution is an effective tool and an industry leader for business management across the globe, it can be an immensely expensive and costly solution to implement as well as extremely time consuming to completely transform the operations of your day-to-day tasks using a solution as vast as SAP. In essence, business owners usually have to hire specialized resources to manage the transformation and maintenance of the application which makes the solution an inelegant and inconvenient one in comparison to the proposed solution of a tailor-made solution in the textile industry.

3.2.1.3 Relationship to the proposed research work

While the PLM and order management, as well as concurrency and efficiency issues can be handled seamlessly through SAP, a new feature of innovation being introduced in the proposed solution is the automation of approval of textile products using image recognition which is something that SAP cannot provide in the textile industry.

3.2.2 Odoo

3.2.2.1 Summary of the research item

Odoo is an open-source ERP programming that gives organizations a scope of instruments to deal with their tasks, including finance, HR, stock administration, and store network the executives. Odoo's product is profoundly adjustable and can be custom fitted to meet the particular necessities of organizations in different ventures, including the material business. Odoo's secluded construction permits organizations to pick the modules they need and add or eliminate modules as their business needs change.

In the material business, Odoo can be a valuable device for overseeing item lifecycle the board (PLM) processes. Odoo's ERP programming furnishes organizations with a unified stage for overseeing item plan, creation arranging, stock administration, and inventory network the board. With Odoo's product, material organizations can smooth out their PLM processes, decrease lead times, and further develop item quality. Odoo's product likewise furnishes organizations with cutting edge examination and bits of knowledge that assist them with pursuing information driven choices and streamline their creation processes. By utilizing Odoo's ERP programming, material organizations can increment functional productivity, lessen expenses, and improve their seriousness on the lookout.

3.2.2.2 Critical analysis of the research item

Odoo is an elegant solution to the PLM problems of the textile industry and even a solution that was proposed as an interim solution whilst the production of the tailor-made software is completed. However, the issue with implementation of Odoo in the long-term effects is that it is an incredibly vast software and most of the features provided are unrelated to the business requirements presented at hand. This overcomplicates the situation which is why it is not an elegant solution to the problems of PLM in the textile industry.

3.2.2.3 Relationship to the proposed research work

Similar to SAP, Odoo also cannot provide us with the automation of approval of textile products using image recognition which is an innovative feature we wish to explore within the scope of this project. Similarly, the over complication of implementing Odoo is ineffective and not recommended for this problem.

3.3 Literature Review Summary Table

Table 1: Similar Products

This is a summary of the products that correlate to the scope of the product we are trying to develop.

No.	Name, reference	Inventor	Year	Input	Output	Description
1.	SAP	SAP SE	1972	Organizational Data	PLM Management	SAP is an elegant solution for business management implemented by large multinational

						companies across the globe.
2.	Odoo	Fabien Pinckaers	2005	Organizational Data	PLM Management	Odoo is another solution for business management that is implemented largely by various industries.

3.4 Conclusion

Conclusively, whilst PLM softwares are not new in the market, a tailor-made solution for the textile industry is still the need of the market right now as the existing solutions aren't feasible enough to be implemented as a long-term solution in the market. Furthermore, existing solutions don't provide a platform for innovation as a tailor-made solution would by exploring new ideas and incorporating creativity into the industry in a digital manner of speaking.

Chapter 4: Software Requirement Specifications

4.1 List of Features

System will be providing following features.

- **Centralized Data Management:** The system should provide a centralized platform for storing and managing all product- related data, including design, material, costing, and production information.
- **Workflow Automation:** The system should automate key processes such as product design, approvals, sampling, and production. This will help to reduce errors, speed up the development process, and improve overall efficiency.
- **Collaborative Platform:** The system should enable collaboration between different teams, such as design, merchandising, and production. This can be achieved through features such as real-time messaging, commenting, and file sharing.
- **Integrated Material Management:** The system should include a material management module that enables users to track and manage all aspects of material sourcing, procurement, and inventory.
- **Customizable Dashboards and Reports:** The system should provide customizable dashboards and reports that enable users to quickly access and analyze product-related data. This can help to identify potential issues and opportunities for improvement.
- **Mobile Accessibility:** The system should provide mobile accessibility, allowing users to access the system from anywhere, at any time, and on any device.

4.2 Functional Requirements

The functional requirements are given below.

- **Workflow Management:** The system should be able to manage the workflow of the product development process, from ideation to launch. This includes managing tasks, approvals, and notifications to stakeholders.
- **User Management:** The software should provide user management capabilities, including access controls, permissions, and authentication, to ensure the security and privacy of the product data.
- **Supply Chain Management:** The system should be able to manage the supply chain, including supplier management, procurement, and inventory management.
- **Reporting and Analytics:** The system should provide real-time reporting and analytics to support decision-making, such as product performance, costs, and profitability.
- **Integration:** The PLM system should integrate with other enterprise systems, such as ERP, CRM, and CAD systems.
- **User Access and Security:** The system should provide user access control and security to protect sensitive product information.

4.3 Quality Attributes

Quality attributes the system will be having are the following.

- **Security:** The system should ensure the security and privacy of data related to textile production, particularly sensitive information like designs and pricing.
- **Usability:** The system should be intuitive and easy to use, particularly for non-technical users like designers and production managers.
- **Interoperability:** The system should be able to integrate with other software applications and systems used in textile production, such as ERP systems, design software, and inventory management systems.

- **Accessibility:** The system should be accessible to all users, including those with disabilities, and comply with accessibility standards.
- **Compliance:** The system should comply with relevant regulations and standards related to textile production, such as environmental, social, and safety standards.

4.4 Non-Functional Requirements

Following are the non-functional requirements.

Performance: The system should perform efficiently and quickly, particularly when managing large volumes of data related to textile production.

Scalability: The system should be scalable to accommodate changes in business requirements and growth in the textile production processes.

Reliability: The system should be always reliable and available to users, with minimal downtime or disruptions to business operations.

Flexibility: The system should be flexible and customizable to meet the specific needs of the textile production process and the different stakeholders involved.

Maintainability: The system should be easy to maintain and update, particularly when changes are needed to accommodate new business requirements or technology updates.

4.5 Assumptions

Following are the assumptions are made:

- The project assumes that all data related to the textile production process is available, including designs, materials, inventory, sales, and production data. If some data is not available, it could impact the project's effectiveness.
- The project assumes that all stakeholders, including designers, manufacturers, suppliers, and customers, will participate in the project and provide input where needed. If some stakeholders are not willing or able to participate, it could impact the project's success.
- The project assumes that all the necessary software and hardware technologies required for the project are compatible with each other and can integrate seamlessly. If there are any compatibility issues, it could impact the project's effectiveness.
- The project assumes that all the necessary regulations related to textile production, including environmental, social, and safety standards, are understood and adhered to. If there are any regulatory compliance issues, it could impact the project's effectiveness.
- The project assumes that the level of automation required to manage the textile production process is well understood and agreed upon by all stakeholders. If there is a misalignment in understanding, it could impact the project's success.
- The project assumes that the PLM system can integrate with other software systems used in textile production, such as ERP systems, design software, and inventory management systems. If there are any integration issues, it could impact the project's effectiveness.
- The project will require training for operators and maintenance personnel to ensure proper use and maintenance of the automation system.
- The project will be integrated with existing production systems and processes to improve overall efficiency.
- The project will require regular maintenance and updates to ensure optimal performance and prevent breakdowns.
- The automated production process may require some regulatory approvals and certifications before being implemented in the production facility.

4.6 Hardware and Software Requirements

Following are the hardware and software requirements.

4.6.1 Hardware Requirements

The hardware requirements for the development and deployment of the system are as follows.

- A computer with 8 Gigabytes or more RAM.
- Stable internet connection

4.6.2 Software Requirements

We shall be requiring a few software for the deployment of the software:

- An Operating System (Windows 10)

For the development of the project, we shall be using the following:

- Frontend - React Native
- Backend - NodeJS
- Database - MySQL

4.7 Use Cases

4.7.1 Login

<table>
<tr><td>Name</td><td colspan="3">Login</td></tr>
<tr><td>Actors</td><td colspan="3">Admin, Customer</td></tr>
<tr><td>Summary</td><td colspan="3">The user shall provide their email and password on the login form and after successful verification, redirect the user to the home page.</td></tr>
<tr><td>Pre-Conditions</td><td colspan="3">The user must be in the database records either added by any of the authorized users or added manually by a developer.
The user must not already be logged in.</td></tr>
<tr><td>Post-Conditions</td><td colspan="3">The user’s session is successfully established and shall be redirected to the home pages.</td></tr>
<tr><td>Special Requirements</td><td colspan="3">None</td></tr>
<tr><td colspan="4">Basic Flow</td></tr>
<tr><td colspan="2">Actor Action</td><td colspan="2">System Response</td></tr>
<tr><td>1</td><td>The user opens the login page.</td><td>2</td><td>The login page is displayed asking for email and password.</td></tr>
<tr><td>3</td><td>The user enters valid email and password.</td><td>4</td><td>The system verifies the email and password, establishes a session for the user and redirects the user to the home page.</td></tr>
<tr><td colspan="4">Alternative Flow</td></tr>
<tr><td>3</td><td>The user enters invalid email or password.</td><td>4-A</td><td>The system responds with an error message: Incorrect email or password entered.</td></tr>
</table>

4.7.2 Order Tracking

Name	Order Tracking		
Actors	Customer		
Summary	Customer clicks on tracking button and will get information about the order he has placed; at what stage it is now.		
Pre-Conditions	Customer must be logged in using his credentials		
Post-Conditions	Customer will know at what stage his order is.		
Special Requirements	None		
Basic Flow			
Actor Action		**System Response**	
1	Customer clicks on tracking button	2	Order tracking page is displayed.
Alternative Flow			
1	Customer clicks on homepage button	2-A	System navigates to the homepage.

4.7.3 Order Modification

Name	Order Modification		
Actors	Admin		
Summary	Verifies that notifications are sent when changes are made to product data.		
Pre-Conditions	Customer asked for changes in order.		
Post-Conditions	Notification sent to customer if change has been made in his order by admin.		
Special Requirements	None		
Basic Flow			
Actor Action		**System Response**	
1	The admin commits changes in order details.	2	As admin committed change, notification is sent spontaneously to customer
Alternative Flow			
1	Admin changes some other customer order details	2-A	The system sends notification to that customer instead of one who asked for it.

4.7.4 Delete Order

Name	Order Deletion		
Actors	Admin, Customer		
Summary	Customer's order is get deleted if he generates request for its deletion and it is accepted by admin.		
Pre-Conditions	Customer must be logged in.		
Post-Conditions	Active order gets deleted by Admin.		
Special Requirements	None		
Basic Flow			
Actor Action		**System Response**	
1	The customer opens the login page.	2	The login page is displayed asking for email and password.
3	The customer enters valid email and password.	4	The system verifies the email and password, establishes a session for the user and redirects the user to the home page.
5	Customer generates order deletion request.	6	After acceptance by admin, system deletes the order from active orders list.
Alternative Flow			
5	Customer clicks on Add button.	6-A	The system navigates to add order page.

4.7.5 Order Completion Request

Name	Order Completion Request
Actors	Company Employee
Summary	Final step for completion of any active order is uploading of picture of final product and they will be uploaded on system for verification.
Pre-Conditions	Final product is ready for approval for deliver.
Post-Conditions	Product can be supplied to customer.
Special Requirements	None
Basic Flow	

Actor Action		System Response	
1	Employee uploads the product pictures for verification.	2	System sends the request to Manager for approval.
Alternative Flow			
1	Employee doesn't upload the picture in specified time.	2-A	The system responds with a warning message: *Please upload pictures on time*

4.7.6 Order Completion Confirmation

Name	Order Completion Confirmation
Actors	Admin/Manager
Summary	For order ready to be deliver, it gets confirmation from admin or manager.
Pre-Conditions	Pictures of the product must be uploaded on system.
Post-Conditions	Product can be supplied to customer.
Special Requirements	None

Basic Flow			
Actor Action		**System Response**	
1	Manager/Admin approves the pictures.	2	System marks the current active order completed.
Alternative Flow			
1	Manager/Admin disapprove the pictures.	2-A	The system sends notification to employee: *Product is not ready to deliver*.

4.8 Graphical User Interface

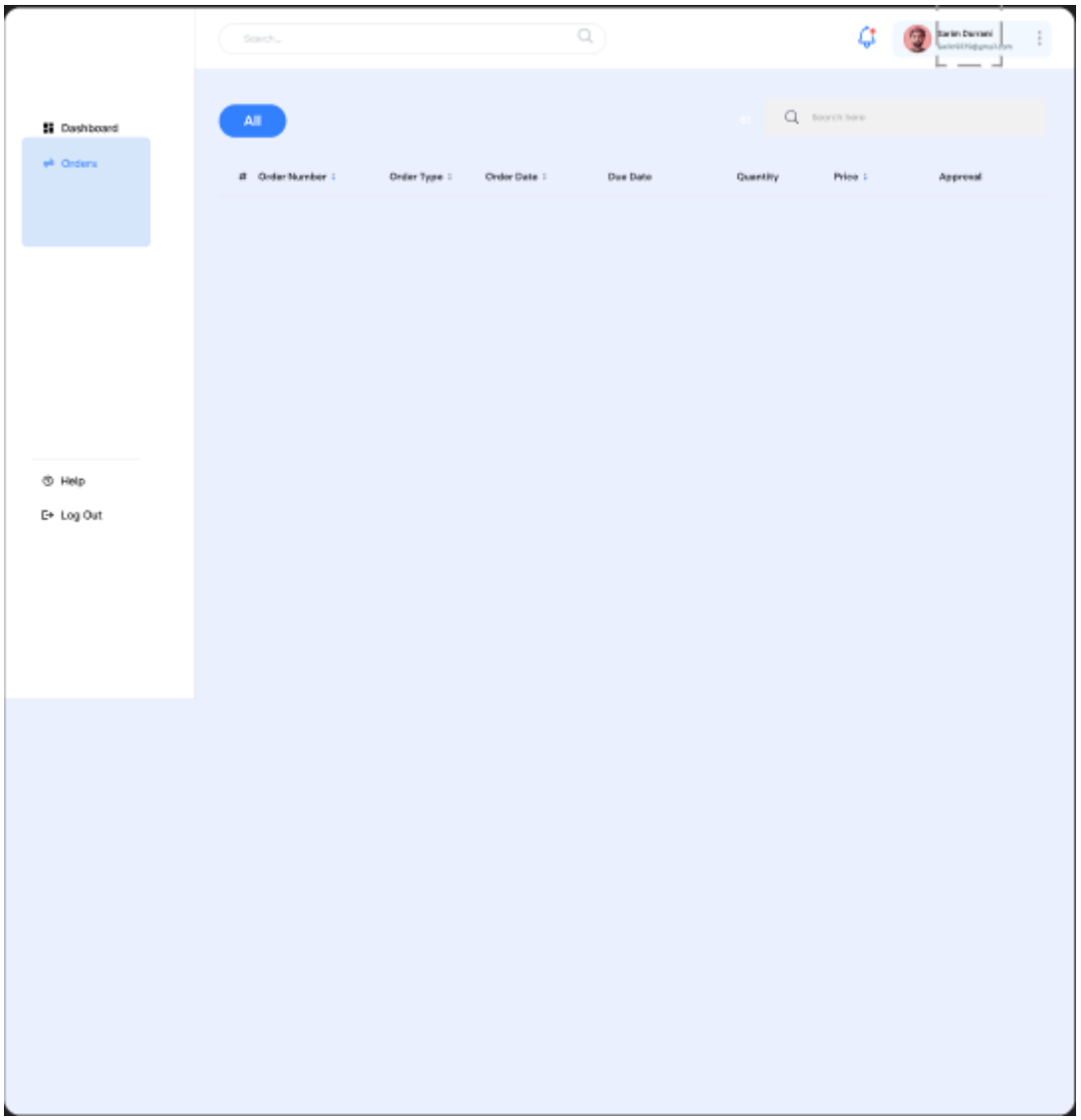


Figure 1: Orders List Page

This is the screen where all the current orders will popup that are in the pending list.

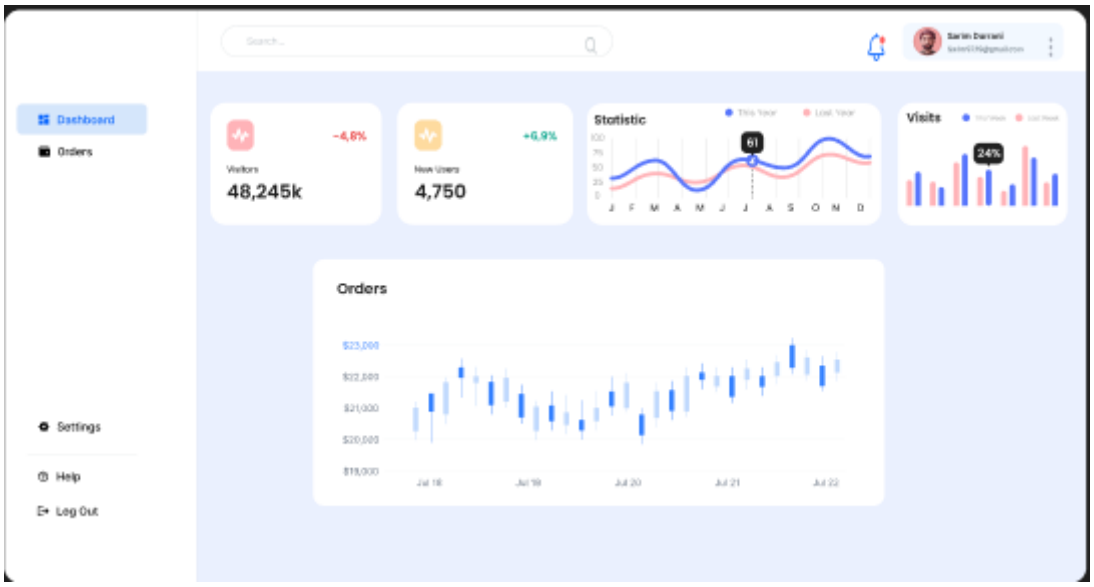
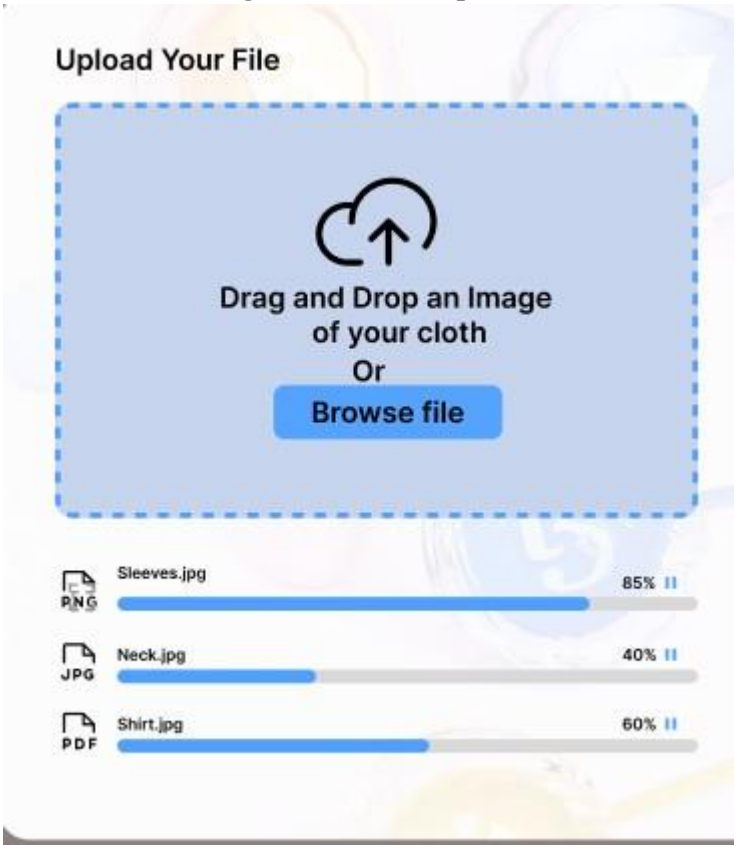


Figure 2: Dashboard

This is the basic dashboard from where users can get an overview of day-to-day tasks.

Figure 3: Picture Upload



This screen shall be used to upload images for further verification of the part of the order inthe textile PLM.

4.9 Database Design (*if required*)

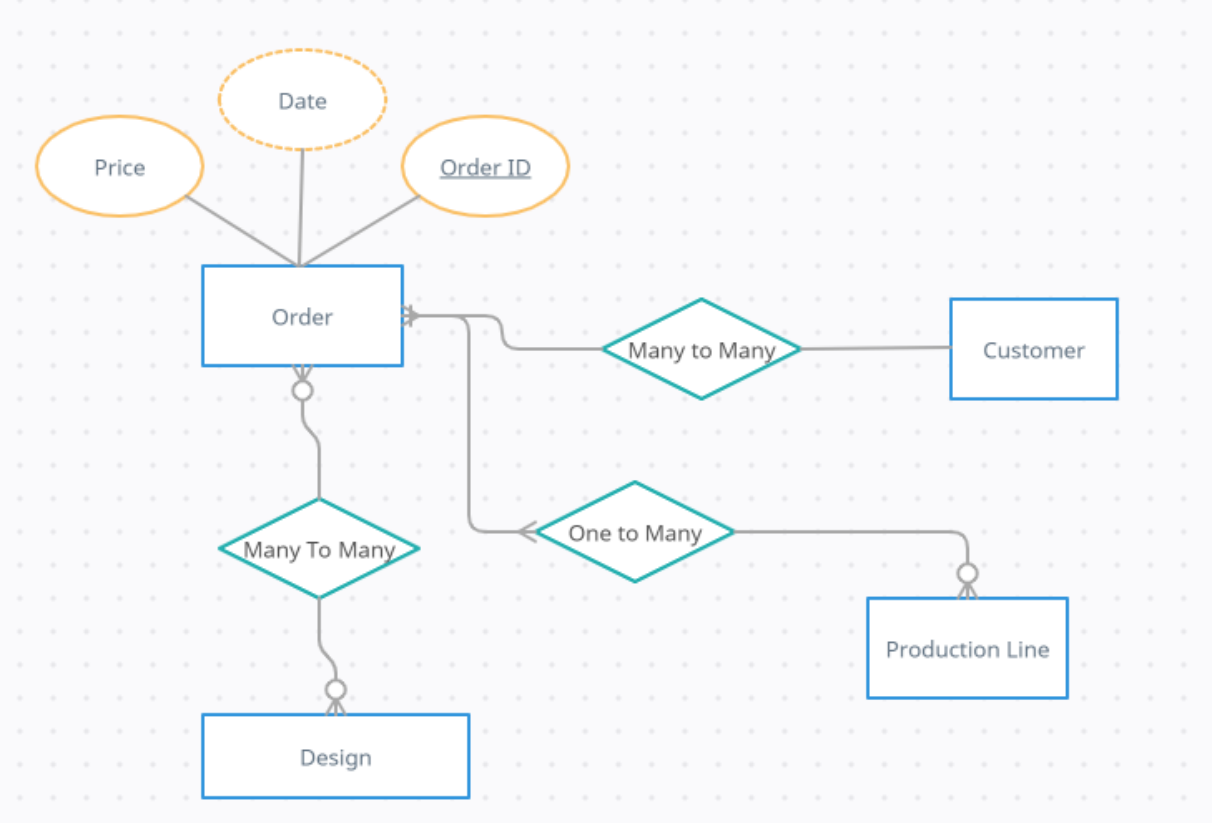
Table 2: DB Table

Table showing different SQL tables that will be used in database.

Tables	Attributes
Product	ID, Name, Description, Price, Category
Production Line	ID, Name, Description, Capacity
Order	ID, Date, Status, Customer Name, CustomerID
Customer	CustomerID, Name, Address, Number
Design	ID, Name, Description, FileLocation, Thumbnail

4.9.1 ER Diagram

Figure 4: ER Diagram



ER Diagram of the Textile PLM System

4.9.2 Data Dictionary

Field Name	Description
CustomerID	Refers to the customers unique identifier.
DesignID	Refers to the Designs unique identifier.
Description	A short description of what the product is.
Thumbnail	A small image of the products picture.
OrderID	Refers to the orders unique identifier.
ProductID	Refers to the Products unique identifier.
FileLocation	Where the image of the product is saved.

4.10 Risk Analysis

1. Technical Risks
    - Integration of the new system can be a challenge as many compatibility issues or data synchronization problems may arise.
    - Data security will also be a concern as you take the entire PLM process digitally.
2. Operational Risks
    - Employee resistance to change could be a factor that leads to the failure of the project.
    - The management's dependency on the current methodology will be challenged as a new process is implemented.
3. Financial Risks
    - Implementation of a tailor-made software as well as the development of the project will incur financial costs.

Chapter 5: High-Level and Low-Level Design

As far as the high-level description of the software goes, we shall be splitting the software into two major segments:

1. The user side.
2. The factory side.

The user side shall enable the customer to place an order that will directly be linked to the main database. Whilst the factory side of the software shall be managing the PLM of the factory's operations during the entirety of the order.

In terms of low-level design, one singular database shall be used making use of MongoDB to ensure that the database is concurrent with both the factory side and user side of the application. The general low level and high-level flow of the application is discussed in detail within this chapter.

5.1 System Overview

The system shall be divided into the user side and the factory side.

As part of the user side, the customer shall be able to:

1. Select what product he/she wants to have made from the factory.
2. Select the quantity of the product required.
3. The system shall allocate a date of completion automatically upon receiving the order.
4. The system shall allocate a price for the product to be received upon completion.
5. The system shall generate a unique ID for the order once order is placed.

The factory end of the software shall:

1. Receive order as well as the unique ID for the order.
2. An Admin shall be able to move an order from “Upcoming Orders” to “Pending Orders”.
3. Factory users shall be able to update the status of the orders and upload images pertaining to that order.
4. Only the Admin shall be able to approve or disapprove orders once uploaded by factory users.
5. Upon approval, the application shall move the order from “Pending Orders” to “Completed Orders”.

5.2 Design Considerations

Since the user side of the application is aimed to be provided to the untrained user, we shall be providing drop down options for the simplicity of both the user interface and database management. We shall be segregating the factory side of the application into three parts.

- Upcoming Orders
- Pending Orders
- Completed Orders

Furthermore, the factory end of the application shall be persisting of two user classes, namely, the admin and the user. Only the admin shall have the ability to transfer an order from any of the order classes to any other class. Similarly, only an admin can approve or disapprove of an order in order for it to make it to the list of completed orders.

5.3 Assumptions and Dependencies

We shall be working under the assumption that the customer that shall place orders (the user side of the application) is a complete layman and hence we shall be providing drop down options for the placement of orders with automatic generation of unique ID, rate, and date, in accordance to the quantity and complexity of the order that has been placed.

Furthermore, only an approved admin on the factory side of the application shall be able to approve and disapprove the orders that are to be placed.

We shall be working with an object oriented approach in order to further implement the AI model for the automatic recognition of the images of the textile products. The primary dependency upon the entire application is that the images of the textile products currently need to be manually uploaded in order to be verified by the application. Furthermore, the right to approve/disapprove the order shall stay with the admin until the applications AI model can produce a high enough accuracy to work as a standalone application.

5.3.1 General Constraints

Generally, the application as a whole has many constraints to be considered in the grand scheme of things upon the implementation of the software in the textile industry.

- The user that shall be placing the order on the application shall have access to the internet and a web browser (Preferably Chrome/Firefox/Edge/Safari).
- A lack of a huge training model for the AI model.
- Hesitance from the factory workers to move to a digital system.
- Hesitance from the upper management of the factory towards digital systems.
- Parallel running of manual system and digital system till the digital system is adopted wholly.
- A camera is required in order to upload images to the application of the products.
- A strong network/internet connection shall now be required within the factory.
- Security requirements to keep the integrity of the factory's data intact.
- Memory management for the system could be an issue as many various images of the products have to be uploaded.
- The application shall perform seamlessly without any hindrances in the flow of the software.
- Admin verification as well as user accounts need to be maintained.

5.3.2 Goals and Guidelines

The primary goals of the application are to digitize the PLM of the textile industry hence the requirement of simplicity is the most important. Furthermore, since the application is focusing on image processing to ensure the integrity of the orders that are going to be coming out of the factory, a huge memory constraint is what needs to be catered to. Lastly, since this software is the first of its kind and implemented within a factory that is not immensely familiar with PLM tools, a heavy emphasis should be on the UI/UX of the application. We shall be focusing on:

- The KISS principle ("Keep it simple stupid!")
- Effective memory management all the while keeping the application fast and snappy.

- A neat clean interface that is easy to pick up and effective to use.

Since we are planning to add implementation of an image training model within the application the memory management issue is a big one as our training model not only has to be accurate with the results it provides but also needs to be performed in a timely manner in order for the PLM application to be effective in the long run.

5.3.3 Development Methods

Since we are talking about developing a client end as well as a factory end application that caters to future artificial intelligence enhancements and a limitless scope, we shall be observing a strict object oriented approach in order to seamlessly diversify and expand our code in the future.
The object oriented methodology shall enable us not only to observe the primary concepts of abstraction, inheritance, polymorphism, and encapsulation, rather it shall also empower us to expand our code upon further improvements within the industry to ensure a long lasting and solid application is made.

5.4 System Architecture

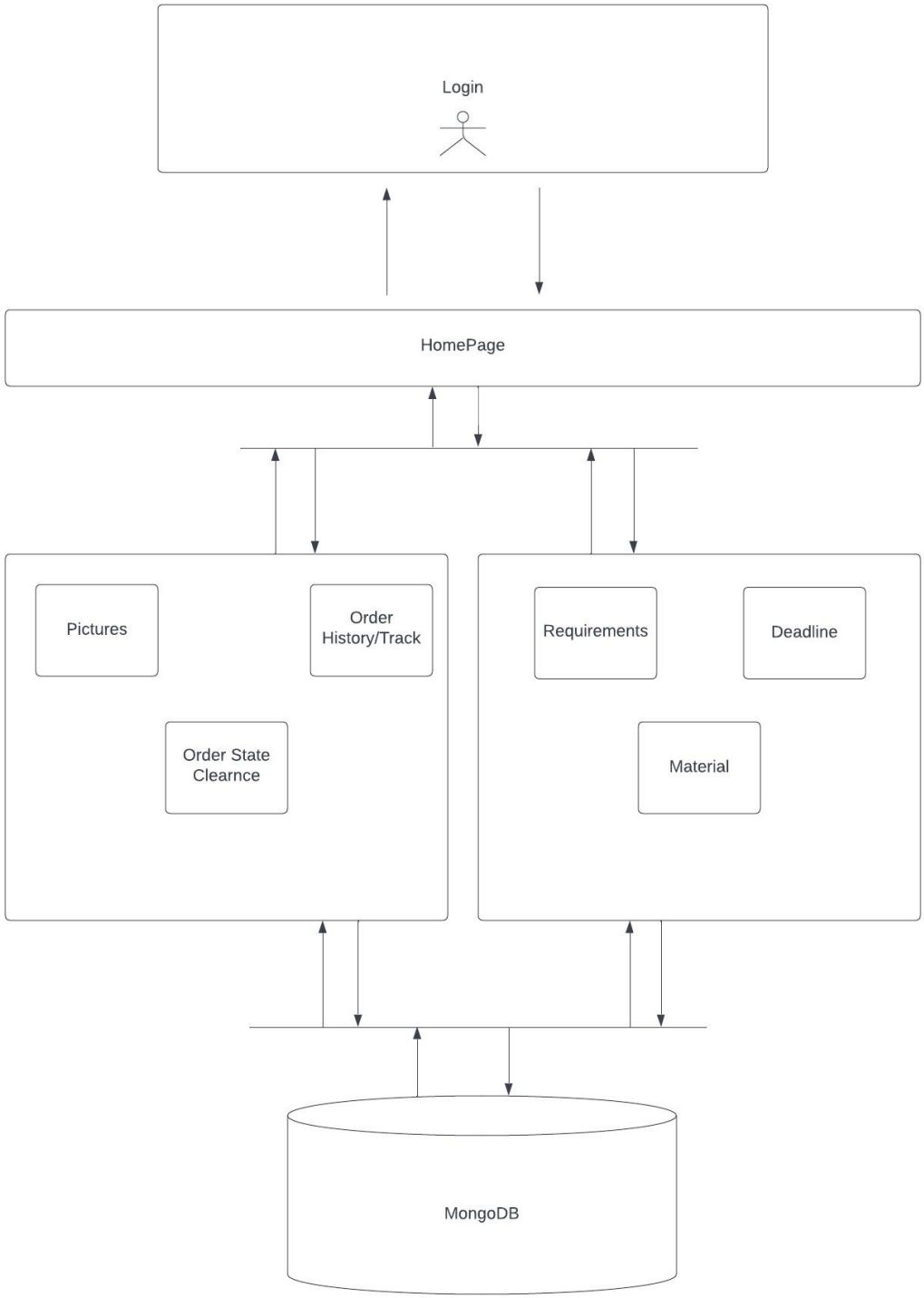


Figure 5: System Architecture
Architectural Diagram of Textile PLM Automation as a whole.

5.4.1 Subsystem Architecture

5.4.1.1 Order Placement

Figure 6: Order Subsystem
Block of Order through where client will be placing orders.

5.4.1.2 Approval of Images

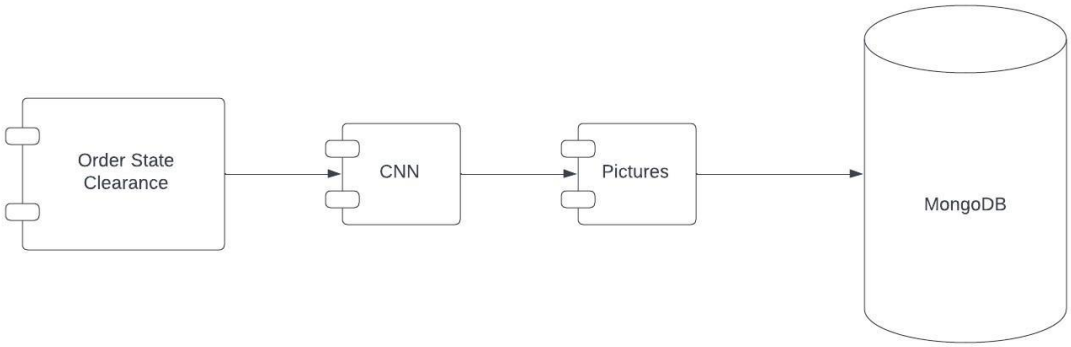


Figure 7: Image Approval
Figure shows how the images will be approved by system via CNN Model.

5.4.1.3 PLM Management

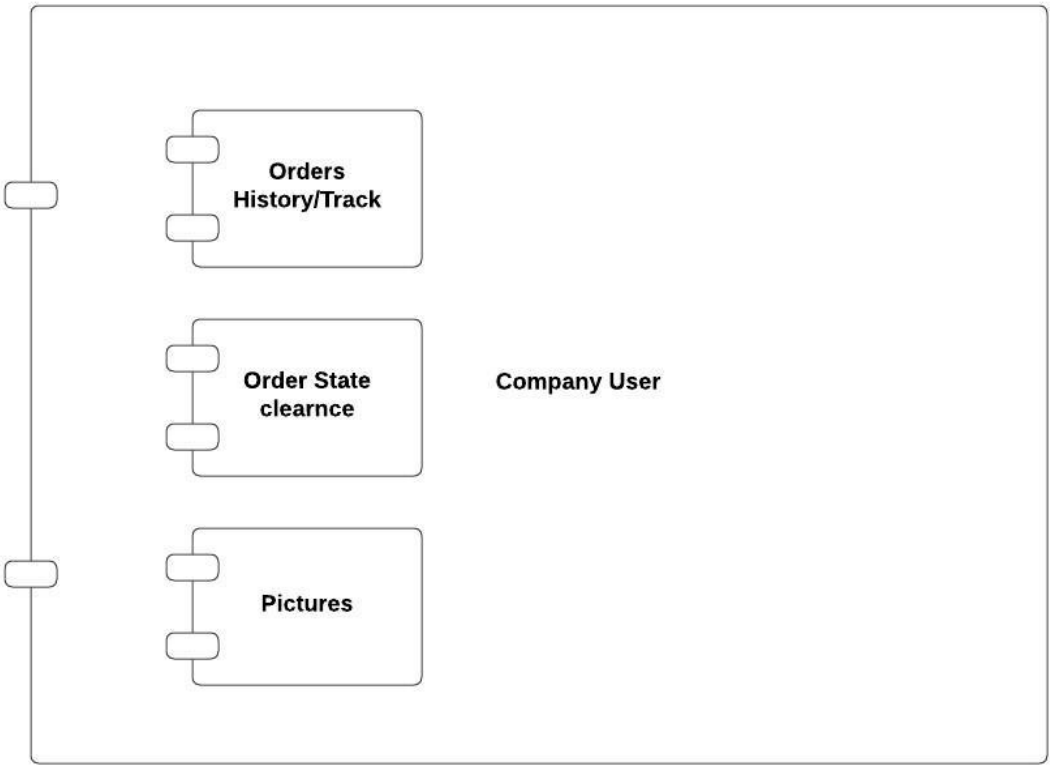


Figure 8: Company User Block
What options will a company user will have.

5.5 Architectural Strategies

Speaking in terms of architecture we have segregated the application into two basic sides, the user end and the factory end.
The user end of the application is supposed to accept orders and store them into the database whilst updating it on the factory end as an "Upcoming Order". The user end will require a customer to login using their email address and password before being eligible for placing an order.

The second part of the application is what the factory workers see. This segment is further broken down into three types of orders:

- Upcoming Orders
- Active Orders
- Completed Orders

5.5.1 The User End

The user end of the application is required to be as user friendly and smooth as possible as it simply just gathers information for a particular order and processes it within the application.
It also works for generating a unique ID for the order.
The goal is to set-up the user end of the application with drop down menus and automatically generated itineraries to make it easy for the customer to place an order.

5.5.2 Factory End

The factory end of the application segregates the orders into three aspects, Pending Orders, Active Orders, and Completed Orders. Only an admin has the right to move these orders from one category to another. Furthermore, Users (workers) of the factory can upload images of the order when it is in Active Orders and can request for admin approval to henceforth complete the order. Only an admin can approve the order.

5.6 Domain Model/Class Diagram

5.6.1 Customer

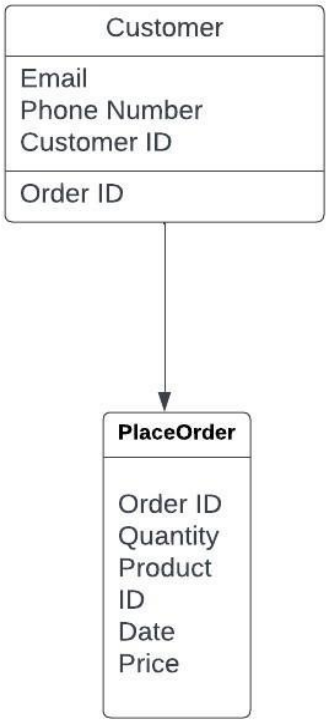


Figure 9: Customer Model
Class Diagram of the Customer Model.

5.6.2 Factory

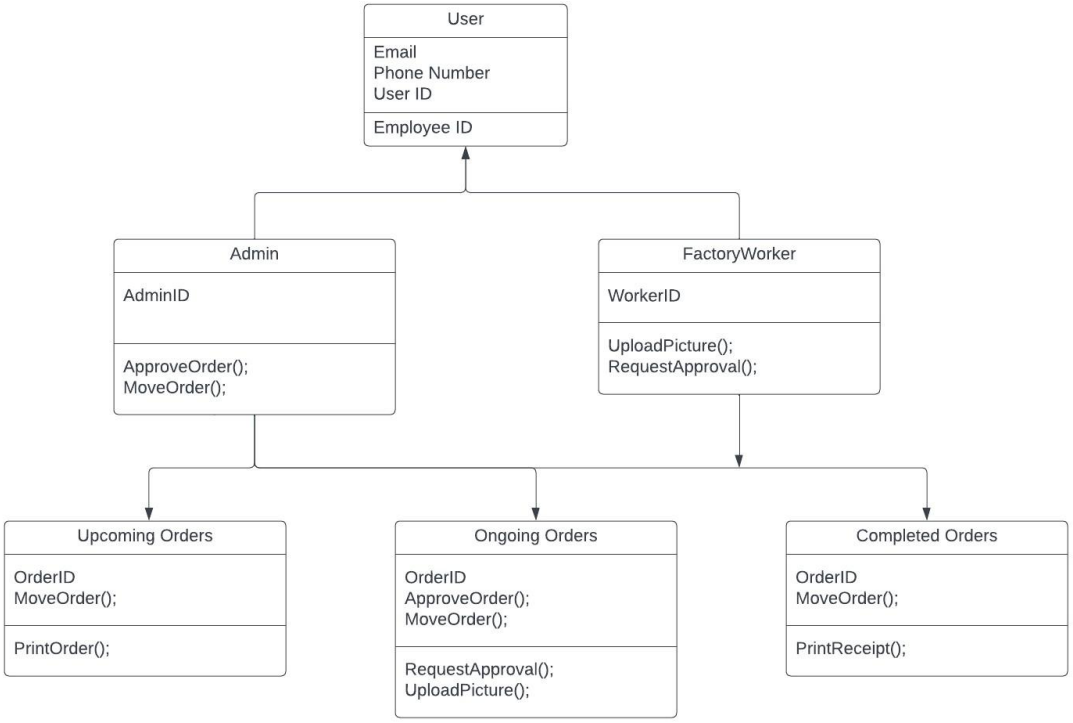


Figure 10: Factory Model
Class Diagram of the Factory Model

5.7 Sequence Diagrams

5.7.1 Customer Sequence

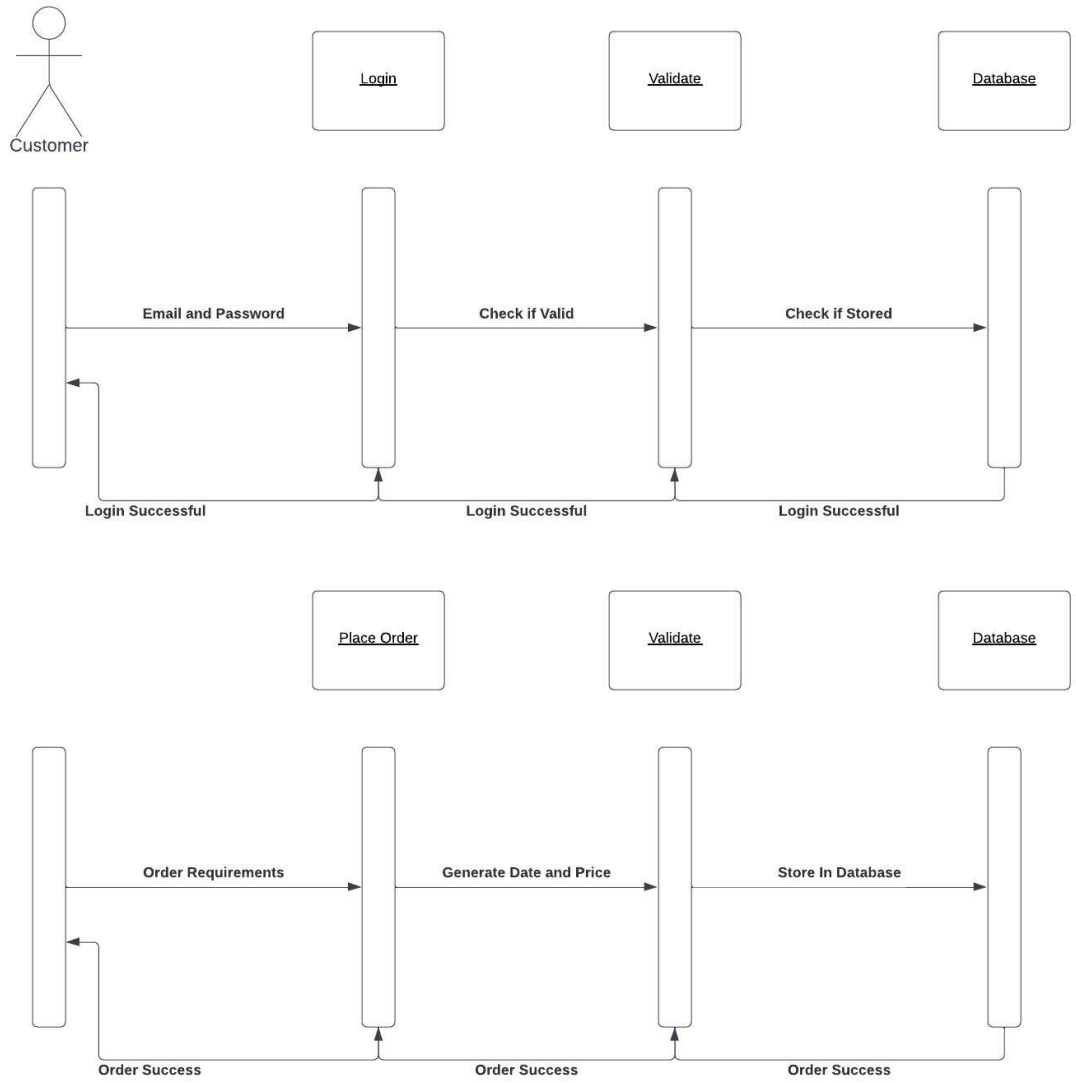


Figure 11: Customer Sequence Diagram

Diagram shows the sequence in which customer will be interacting.

5.7.2 Factory Worker Sequence

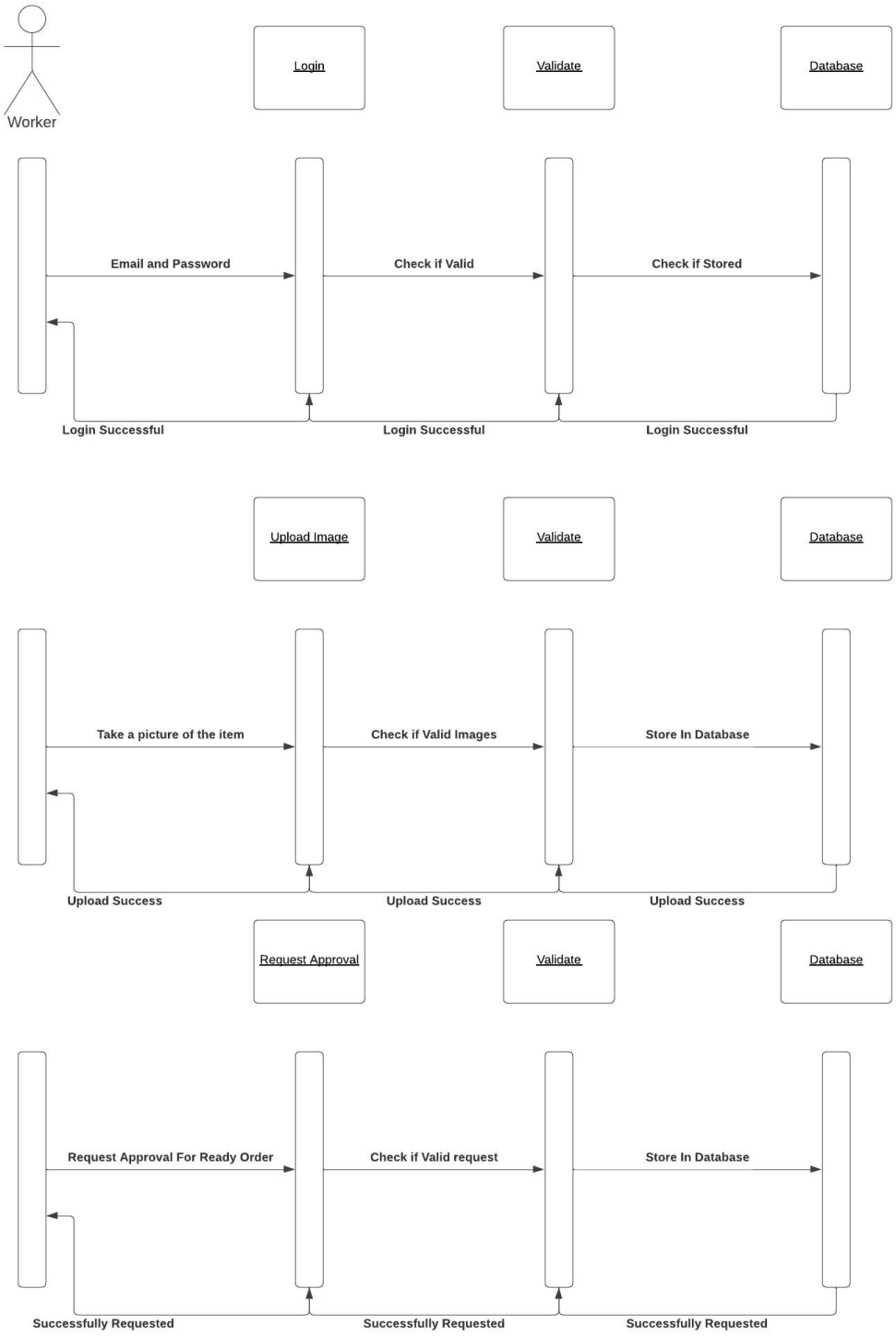


Figure 12: Factory Worker Sequence Diagram

Diagram shows the sequence in which factory worker will be interacting.

5.7.3 Admin

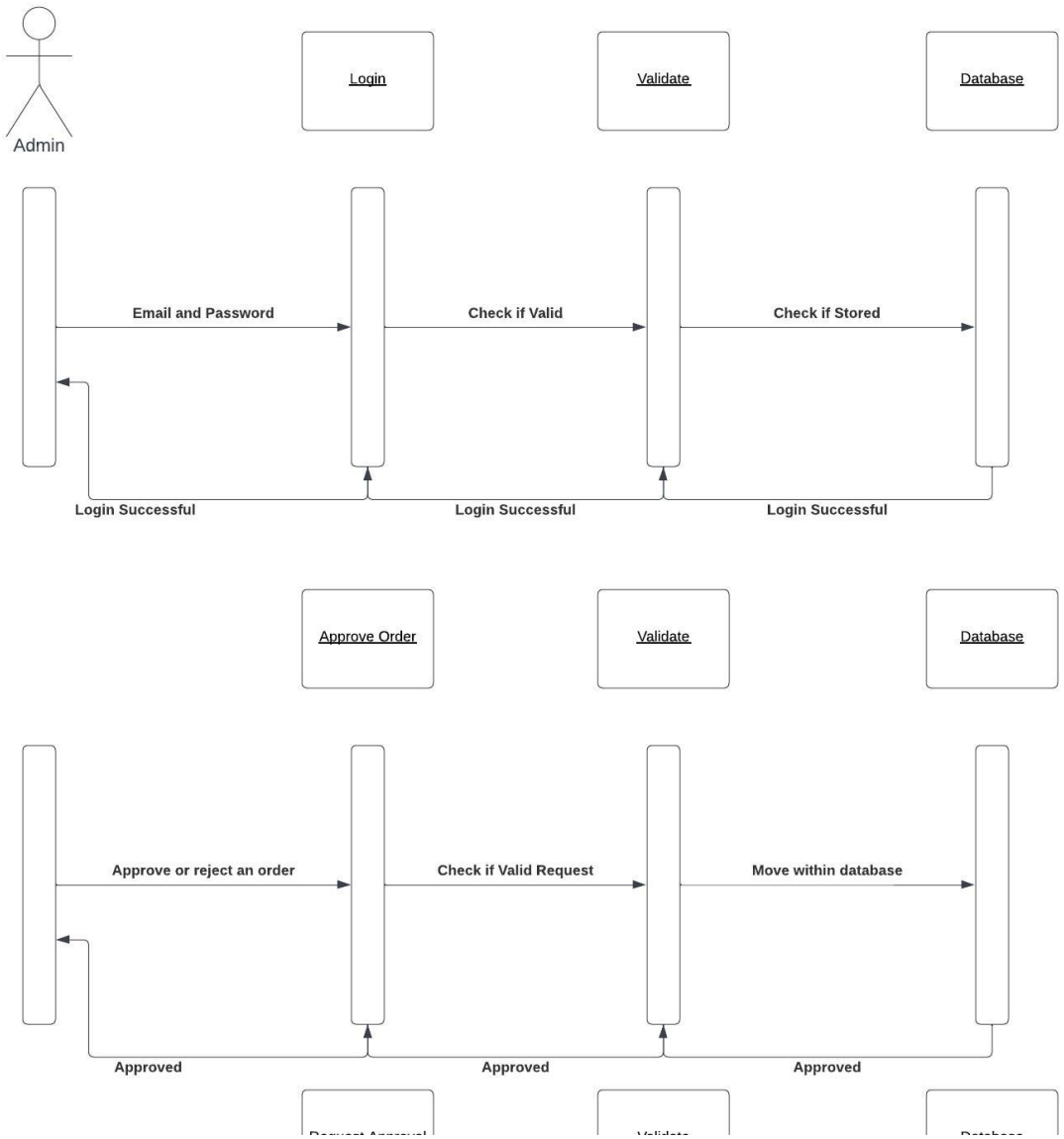


Figure 13: Admin Sequence Diagram

Diagram shows the sequence in which admin from factory will be interacting.

5.8 Policies and Tactics

As implementation of the PLM system within the factory is just considered as phase 1 of our project, we shall be keeping in mind some policies for the further upgradation of our project in order to implement phase 2 (The image model training) aspect of the project. For this we have to cater memory constraints as well as train an effective data model that not only accurately depicts the products coming out of the factory but also can be integrated into the application as we move along with the maturity of the project.

Similarly, as discussed earlier, the user that shall be using this application to place orders is assumed to be a complete layman hence we shall be incorporating drop down menus and user friendly environments for the ease of this application.

5.8.1 Image Training

Training of the images will be done using Python and will be well versed with a diverse dataset in order to attempt to get a high enough accuracy for the model to be used within the textile industry. In lieu of a future upgradation to Artificial Intelligence we shall be developing the native application using diverse and versatile programming languages so that the integration of the training model can occur seamlessly with the already existing application. We shall also be using a secure database to keep all our data in line for any future upgradation of the project.

5.8.2 Simplicity for the User

As mentioned above, the user that shall be working day to day with this application is not a technical person and henceforth will require a clean and well-versed environment to work with in order for the application to be successfully implemented within the factory. We shall be providing drop down menus and automatically generated itineraries wherever possible to keep the entire process as simple and friendly as possible.

Chapter 6: Implementation and Test Cases

6.1 Implementation

The second phase of the project is deeply focused on the machine learning aspect of the application. The application simply prompts for images and yields an output of “Approved” or “Not Approved” with respect to the dataset that it has been trained upon.
The dataset is a highly relevant one that has been clustered and gathered directly from operational factories within the industry and hence the yielded output is an immensely desirable one.

For the ease of this purpose, we have created a front-end that effectively collects the images from the user and furthermore displays the desired output of the image. The core focus however is on the machine learning algorithm implemented in this regard that effectively takes those images as an input and matches it across its trained dataset to calculate an accurate response.

6.1.1 Product Lifecycle Management (PLM)

As far as the surface level of the application is concerned, without adding much sophistication to the system, we have integrated a simple feature with respect to ODOO, to manage our currently pending and completed orders to keep the entirety of the textile factory on the same page in terms of current orders that the factory is working on.
Admins are able to add new orders to the list of pending orders and are also enabled to move any order from the current pending list and move it into the list of completed orders.

6.1.2 Image Interface

We have worked on an interface within the application that lets us gather and collect images that are required to be approved by the system. This feature allows the user to upload images that are relevant with respect to the application. A side feature that we have been working on to go along with the image interface is the ability to install a camera on the conveyer belt inside the factory to collect real time images to be further sampled and shortlisted as an approved piece or not.

6.1.3 Automatic Approval

Once an image has been highlighted to be sent for approval within the application, the application takes a short while to make the final judgement on whether or not the piece of cloth should be approved or not. This works in respect to the model that we have trained that is given a minimum pass rate on what items exist without any defects and are hence ready for approval. The system shall generate the output “Approved” or “Not Approved” on the front-end side of the application.

6.2 Test Cases

6.2.1 Register

Textile PLM			
Registration			
Test Case ID:	*1*	**QA Test Engineer:**	*Ahsan-Ul-Haq*
Test case Version:	*1*	**Reviewed By:**	*Sarim Durrani*
Test Date:	*1/11/23*	**Use Case Reference(s):**	*Registration*
Revision History:	-		
Objective	*User Should be able to register and account into the system with their employee ID.*		
Product/Ver/Module:	*PLM Application*		
Environment:	*System is up and running. User is not logged in.*		
Assumptions:	*The first time an employee is booting up the system.*		
Pre-Requisite:	*System is running.*		

Step No.	**Execution description**	**Procedure result**
1	*User presses on register button*	*Registration form opens up*
2	*User presses register after entering details*	*Registration Successful*
☐ *Passed*		

6.2.2 Login

Textile PLM			
Login			
Test Case ID:	*2*	**QA Test Engineer:**	*Ahsan-Ul-Haq*
Test case Version:	*1*	**Reviewed By:**	*Sarim Durrani*
Test Date:	*1/11/23*	**Use Case Reference(s):**	*Login*
Revision History:	-		
Objective	*User Should be able to log in to their account*		
Product/Ver/Module:	*PLM Application*		
Environment:	*System is up and running. User is not logged in.*		
Assumptions:	*The first time an employee is booting up the system.*		
Pre-Requisite:	*System is running.*		

Step No.	**Execution description**	**Procedure result**

1	*User Enters his credentials and clicks on login*	*Login Successful*
☐ *Passed*		

6.2.3 View Pending Orders

Textile PLM			
View Pending Orders			
Test Case ID:	*3*	**QA Test Engineer:**	*Ahsan-Ul-Haq*
Test case Version:	*1*	**Reviewed By:**	*Sarim Durrani*
Test Date:	*1/11/23*	**Use Case Reference(s):**	*PLM*
Revision History:	-		
Objective	*User Should be able to view all the currently pending orders*		
Product/Ver/Module:	*PLM Application*		
Environment:	*System is up and running. User is logged in.*		
Assumptions:	*User is Logged in.*		
Pre-Requisite:	*System is running.*		

Step No.	**Execution description**	**Procedure result**
1	*User presses view pending orders button*	*List of pending orders pops up*
☐ *Passed*		

6.2.4 View Completed Orders

Textile PLM			
View Completed Orders			
Test Case ID:	*4*	**QA Test Engineer:**	*Ahsan-Ul-Haq*
Test case Version:	*1*	**Reviewed By:**	*Sarim Durrani*
Test Date:	*1/11/23*	**Use Case Reference(s):**	*PLM*
Revision History:	-		
Objective	*User Should be able to view the list of completed orders*		
Product/Ver/Module:	*PLM Application*		
Environment:	*System is up and running. User is logged in.*		
Assumptions:	*The User is Logged in. User is an Admin.*		
Pre-Requisite:	*System is running.*		

Step No.	**Execution description**	**Procedure result**
1	*User presses on View Completed Orders button*	*List of all the completed orders should pop up.*
☐ *Passed*		

6.2.5 Add a new order

Textile PLM			
Add Order			
Test Case ID:	*5*	**QA Test Engineer:**	*Ahsan-Ul-Haq*
Test case Version:	*1*	**Reviewed By:**	*Sarim Durrani*
Test Date:	*1/11/23*	**Use Case**	*PLM*

		Reference(s):	
Revision History:	-		
Objective	*User Should be able to add a new order into the list of pending orders*		
Product/Ver/Module:	*PLM Application*		
Environment:	*System is up and running. User is logged in.*		
Assumptions:	*User is an Admin*		
Pre-Requisite:	*System is running.*		
Step No.	**Execution description**	**Procedure result**	
1	*User presses on add new order button*	*New Order Form opens up*	
2	*User Enters Details and presses add new order*	*The system generates the order and adds it to the list of "Pending Orders"*	
☐ *Passed*			

6.2.6 Move an Order

Textile PLM			
Move an Order			
Test Case ID:	*6*	**QA Test Engineer:**	*Ahsan-Ul-Haq*
Test case Version:	*1*	**Reviewed By:**	*Sarim Durrani*
Test Date:	*1/11/23*	**Use Case Reference(s):**	*PLM*
Revision History:	-		
Objective	*User Should be able to move orders from pending orders into completed orders*		
Product/Ver/Module:	*PLM Application*		
Environment:	*System is up and running. User is logged in.*		
Assumptions:	*User is admin*		
Pre-Requisite:	*System is running.*		
Step No.	**Execution description**	**Procedure result**	
1	*User clicks on the checkbox ahead of the order that we want to select*	*The system highlights the order(s)*	
2	*User presses move to completed button*	*System takes all the highlighted orders and moves them into completed orders.*	
☐ *Passed*			

6.2.7 Upload an Image

Textile PLM			
Upload an Image			
Test Case ID:	*7*	**QA Test Engineer:**	*Sarim Durrani*
Test case Version:	*1*	**Reviewed By:**	*Ahsan-Ul-Haq*
Test Date:	*1/11/23*	**Use Case Reference(s):**	*Image Recognition*
Revision History:	-		
Objective	*User should be able to successfully upload an image for testing.*		
Product/Ver/Module:	*PLM Application*		
Environment:	*System is up and running. User is logged in.*		

Assumptions:	*User is logged in.*	
Pre-Requisite:	*System is running.*	
Step No.	**Execution description**	**Procedure result**
1	*User presses on the upload button*	*System prompts user to select an image from the secondary storage*
2	*User selects the image*	*The image should be loaded into the system now*
☐ *Passed*		

6.2.8 Request Image Approval

Textile PLM			
Request Approval			
Test Case ID:	*8*	**QA Test Engineer:**	*Sarim Durrani*
Test case Version:	*1*	**Reviewed By:**	*Ahsan-Ul-Haq*
Test Date:	*1/11/23*	**Use Case Reference(s):**	*Image Recognition*
Revision History:	-		
Objective	*Request the model to mark the uploaded image as either approved or Not Approved*		
Product/Ver/Module:	*PLM Application*		
Environment:	*System is up and running. User is logged in.*		
Assumptions:	*User is logged in, image has been uploaded.*		
Pre-Requisite:	*System is running.*		
Step No.	**Execution description**	**Procedure result**	
1	*User presses on request approval button.*	*The AI model runs and sees if the image passes the validity test.*	
2		*Output is generated in either "Approved" or "Not Approved"*	
☐ *Passed*			

6.2.9 An Image that should be approved

Textile PLM			
Imaged (Should be approved)			
Test Case ID:	*9*	**QA Test Engineer:**	*Sarim Durrani*
Test case Version:	*1*	**Reviewed By:**	*Ahsan-Ul-Haq*
Test Date:	*18/11/23*	**Use Case Reference(s):**	*Image Recognition*
Revision History:	-		
Objective	*We enter an image that we know should be approved to see if the system agrees.*		
Product/Ver/Module:	*PLM Application*		
Environment:	*System is up and running. User is logged in.*		
Assumptions:	*The image should be approved.*		
Pre-Requisite:	*System is running.*		
Step No.	**Execution description**	**Procedure result**	
1	*User presses on request approval button*	*The system uses the AI model to depict whether to approve or not.*	

2		*The system displays "Approved"*
Comments: We added an image that we knew should yield the output "Approved"		
☐ *Passed*		

6.2.10 An Image that should be Not Approved

Textile PLM			
Image (Should not be approved)			
Test Case ID:	*10*	**QA Test Engineer:**	*Sarim Durrani*
Test case Version:	*1*	**Reviewed By:**	*Ahsan-Ul-Haq*
Test Date:	*18/11/23*	**Use Case Reference(s):**	*Image Recognition*
Revision History:	-		
Objective	*We are going to upload a defected image that should get Not Approved.*		
Product/Ver/Module:	*PLM Application*		
Environment:	*System is up and running. User is logged in.*		
Assumptions:	*The image is defected*		
Pre-Requisite:	*System is running.*		
Step No.	**Execution description**	**Procedure result**	
1	*User presses on Request Approval button*	*The system uses the AI model to depict whether to approve or not.*	
2		*"Not Approved" is displayed*	
Comments: We added an image that we knew should not be approved by the system.			
☐ *Passed*			

6.3 Test Metrics

As this is an application that deals with Artificial Intelligence and Machine Learning. Our test metrics are also surrounding false positives, false negatives, F1 Score, and Accuracy.

6.3.1 PLM

Metric	**Purpose**
Number of Test Cases	10
Number of Test Cases Passed	10
Number of Test Cases Failed	0
Test Case Defect Density	0
Test Case Effectiveness	100%

6.3.2 Image Recognition

Metric	**Purpose**
Number of Training Images	50

Number of Test Images	500
False Positives	13
False Negatives	17
Accuracy	94%

Please note that these numbers are relevant to the current model and are subject to change for the final application/presentation.

Chapter 7: User Manual

7.1 User Registration

- From the home page, find the registration button displayed adjacent to the login button.
- Click on the button that says registration to open up the registration page.
- Enter your details along with your employee ID and E-mail address and Phone Number.
- Once you have entered all the details ensure that the information you have provided is correct.
- Click on the “Register” button on the bottom of the page.
- Remember your employee ID as well as the password you have created on the previous page.

7.2 Login

- From the home page, find the login button displayed adjacent to the registration button.
- Enter your employee ID and Password.
- Ensure that the details you have entered are correct.
- Click on the login button to have you redirected to the employee panel.

7.3 Upload a Photograph

- Ensure that you are logged in to the platform.
- From the home dashboard, navigate to the “Upload a Photograph” button on the left hand side of the screen.
- Click on the button to have you redirected to the upload a photo page.
- Click on the “Upload” button on the center of the screen, then select the photograph you want to upload.
- The photograph will now be uploaded into the system.

7.4 Request approval of Photograph

- Once you have uploaded a photograph, locate the button that says “Request Approval”
- Click on the button and wait till the system generates an output.
- The screen will now display if the photograph you have entered is compliant against our requirements or not.

7.5 View Pending Orders

- Make sure that you are logged in to the system.
- Locate the “View Pending Orders” button on the left hand of the screen.
- Click on this button and the system will redirect you to the page where all active orders currently reside.

7.6 View Completed Orders

- Ensure that you are logged in to the system.
- Locate the “View Completed Orders” button on the left hand side of the screen.
- Click on this button and the system shall redirect you to the page where all previously completed orders reside.

7.7 Move Pending Orders to Completed Orders

- Open the “Pending Orders” pages.
- Click on the checkbox ahead of the order you want to relocate.
- Once you have selected all the orders you want to relocate, click on the “Move to Completed” button on the bottom of the screen.
- The selected orders should be now moved to the completed orders page. (Please note that an admin access is required to complete this task).

7.8 Add a New Order

- Ensure that you are logged in to the system.
- Click on the “Add Order” button on the left hand side of the screen.
- Enter the details of the new order in the form that has opened up.
- Click on “Add Order” button at the end of the page.

Chapter 8: Conclusion and Future Work

Phase two of the implementation of PLM Automation saw us delve heavily into the world of machine learning and image recognition. We greatly explored synthetic dataset creation as well as worked on hand-on data provided directly from functional factories in the local industry, for which we are extremely thankful.

Our AI model has been trained with relevant and exact images provided directly from the industry on real-world samples, hence performance of the image recognition model is highly relevant in the grand scheme of the project. To lay the project down simply, a user can now upload an image into the system and have it checked for defects automatically. This was a process that was previously monotonous within the industry and required many man hours to perform. The integration of the recognition model in factories will ensure a seamless and highly accurate result yielded in the future.

As far as future work is concerned, the project is far from over. The next step is the engineering aspect of the project, which is the installation of fixed cameras above the textile belts that can generate output using our data model in real time. Real time response of the approval or disapproval of a part of textile can also be converted into an efficient manner to automatically discard scrap in the factory by applying efficient engineering techniques.

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