PCB Pick and Place Project

Team JFL

Version 2.0
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Jailine Contreras Marquez, Fernando Zavala-Ortiz, and Lap Nguyen
jailinecontrerasmarquez@my.unt.edu, fernandozavala-ortiz@my.unt.edu, lapnguyen@my.unt.edu.

Preliminary Design Document

Version 1.0

Contents

A. Project Overview

In the semiconductor engineering industry, device testing is one of the important steps. Testing device is necessary to make the whole machine accurate and reliable. Throughout this process, it is really costly and time consuming. To optimize device testing, people can create advanced technology to automate this process. Reducing the human's role in device testing, it can increase the accuracy and reliability of the testing. This also decreases the employee cost and optimizes the speed of this process.

Our team JFL will solve this problem by improving the tracking system to make it easier to access and control. The system includes a camera that can identify the PCB in a particular area. The system will move the PCB location and slow pick up the PCB. Then it will move the PCB and place it on the PCB tray which is the decided target location. The system also has a web framework system that lets people remotely control. This system will be able to precisely place PCBs up to 300mm by 500mm that are under 200g. This system should be made using existing infrastructures.

B. Current Problems and Proposed Solutions

Currently, the process of placing and removing a PCB into a testing tray is a manual process. A person has to pick up a PCB, load it into a test tray and wait until the testing is complete to remove the PCB. The testing can take several minutes to complete, leaving the user idly monitoring the testing machine instead of focusing on different tasks. This project is used to automate the process of picking up the PCB, placing it on the testing tray and removing it once the test is complete. The system will use a camera to identify the location of the PCB and pick it up with the control arm. It will also locate the test tray where the arm will place the PCB for testing. Automating the loading and unloading process will allow the user to focus on different tasks.

We also need to create a web framework for users to control the system remotely. The system needs to use React to form the web front end. This needs to have an easy access interface for users and have enough function to control the system manually.

C. Requirements

1. Functional Requirements

ID	Functional Requirements	Team Member Responsible	Effort (in %)	Verification
FR1	A machine learning model will use the camera to find the location of the fiducial on the PCB.	Fernando Zavala	35%	Test
FR2	A fiducial will be created for the PCB and test tray.	Fernando Zavala	5%	Inspection
FR3	Images of the fiducial should be created and used to train the model.	Fernando Zavala	10%	Test
FR4	A web interface will allow the user to login and start/stop the system.	Jailine Contreras Marquez	20%	Demonstration

FR5	User should have access to camera feed on the interface.	Jailine Contreras Marquez	30%	Demonstration
FR6	Web interface should have a manual override feature where the user should have control of the arm.	Jailine Contreras Marquez	30%	Demonstration
FR7	System should find the PCB by jogging the camera back and forth over a XY axis.	Lap Nguyen	20%	Demonstration
FR8	When the PCB location is identified, the system should lower the arm and pick up the PCB using vacuum	Lap Nguyen	10%	Inspection
FR9	When the test tray location is identified, the system should lower the arm and place the PCB in the test tray.	Lap Nguyen	10%	Inspection
FR10	The mini-PC should control the pick-up arm manually to a precise location.	Lap Nguyen	20%	Test
FR11	The camera should be mounted high enough to have a clear and large image.	Fernando Zavala	15%	Inspection
FR12	A machine learning model will use the camera to find the location of the fiducial on the test tray.	Fernando Zavala	30%	Test

2. Non-Functional Requirements

ID	Non-Functional Requirements	Team Member Responsible	Effort (in %)	Verification
NFR1	The speed for moving the PCB should be 10mm/s.	Lap Nguyen	20%	Test
NFR2	The system must handle PCBs of size 300 mm wide by 500 mm long.	Lap Nguyen	20%	Inspection
NFR3	The PCB lifting mechanism should be capable of lifting up to 200 g.	Fernando Zavala	5%	Inspection

NFR4	The system should pick and place the PCB in 8 seconds.	Jailine Contreras Marquez	10%	Test
NFR5	The system should use the ethernet standard for most communications.	Jailine Contreras Marquez	5%	Inspection
NFR6	The mini-PC should be mounted onto the system.	Jailine Contreras Marquez	5%	Inspection

3. Constraints

a. The budget for the project is $2000
b. The mini-PC needs to fit on the system's control tray
c. Weight of the mini-PC needs to be less than 3 Kg to be mounted on the system
d. This project should be completed on or before April 19th 2024
e. The system consumes 24V to work

A. Specifications

1. Functional Requirements Specifications

ID	Functional Requirement Specification	Team Member Responsible
SFR1	The machine learning model will use tensorflow and keras to find the fiducial on the PCB. Once the model identifies the fiducial, it will send the location to the miniPC which will move the arm and try to center the fiducial.	Fernando Zavala
SFR2	The fiducial for the PCB and test tray will be an image designed in photoshop or similar imaging software. The fiducial should be easy to identify by design and have a centerpoint. It can be created in different sizes for testing the machine learning model to identify it.	Fernando Zavala
SFR3	The training images will be created by taking pictures of the fiducial at different locations in the view of the camera. The Images will then be used to train the machine learning model in FR1.	Fernando Zavala
SFR4	Use react for the web front end to create the website to allow the user access and start/stop system.	Jailine Contreras Marquez

SFR5	Python FastAPI for REST API for the web framework allows the user to access the camera by combining FR1 and FR12.	Jailine Contreras Marquez
SFR6	Implement the process of FR5 to combine software and hardware from FR7-10 to allow the user to override the arm manually.	Jailine Contreras Marquez
SFR7	The camera connects to the mini-PC by the ethernet cable. The camera output and the min-PC input data should be RAW 10 of the current position of the arm with the PCB.	Lap Nguyen
SFR8	When the camera identifies the PCB, the mini-PC communicates with the stepper drives. The system will slowly decrease z coordinate position until the suction cup gets the PCB. The system slowly increases z coordinate position to get back the default position.	Lap Nguyen
SFR9	When the camera controls the arm to the PCB test tray, the mini-PC communicates with the stepper drives. The system will slowly decrease z coordinate position until the suction cup places the PCB onto the test tray. The system slowly increases z coordinate position to get back the default position.	Lap Nguyen
SFR10	The mini-PC connects to one driver and that driver connects to the rest one by one. The system uses the modbus protocol to communicate to each other.	Lap Nguyen
SFR11	The camera will be mounted and adjusted based on the image that it displays. The height needed will be calculated based on the area that it can display. For a larger field of vision, the camera must be higher. However, if it is too high it can give an image that is out of focus. After calculating the height of the camera, the image should be checked to see if it is clear enough to identify objects.	Fernando Zavala
SFR12	The machine learning model will use tensorflow and keras to scan the images of the fiducial on the test tray. The model will identify the fiducial and send the location to the miniPC which will move the arm and try to center the fiducial.	Fernando Zavala

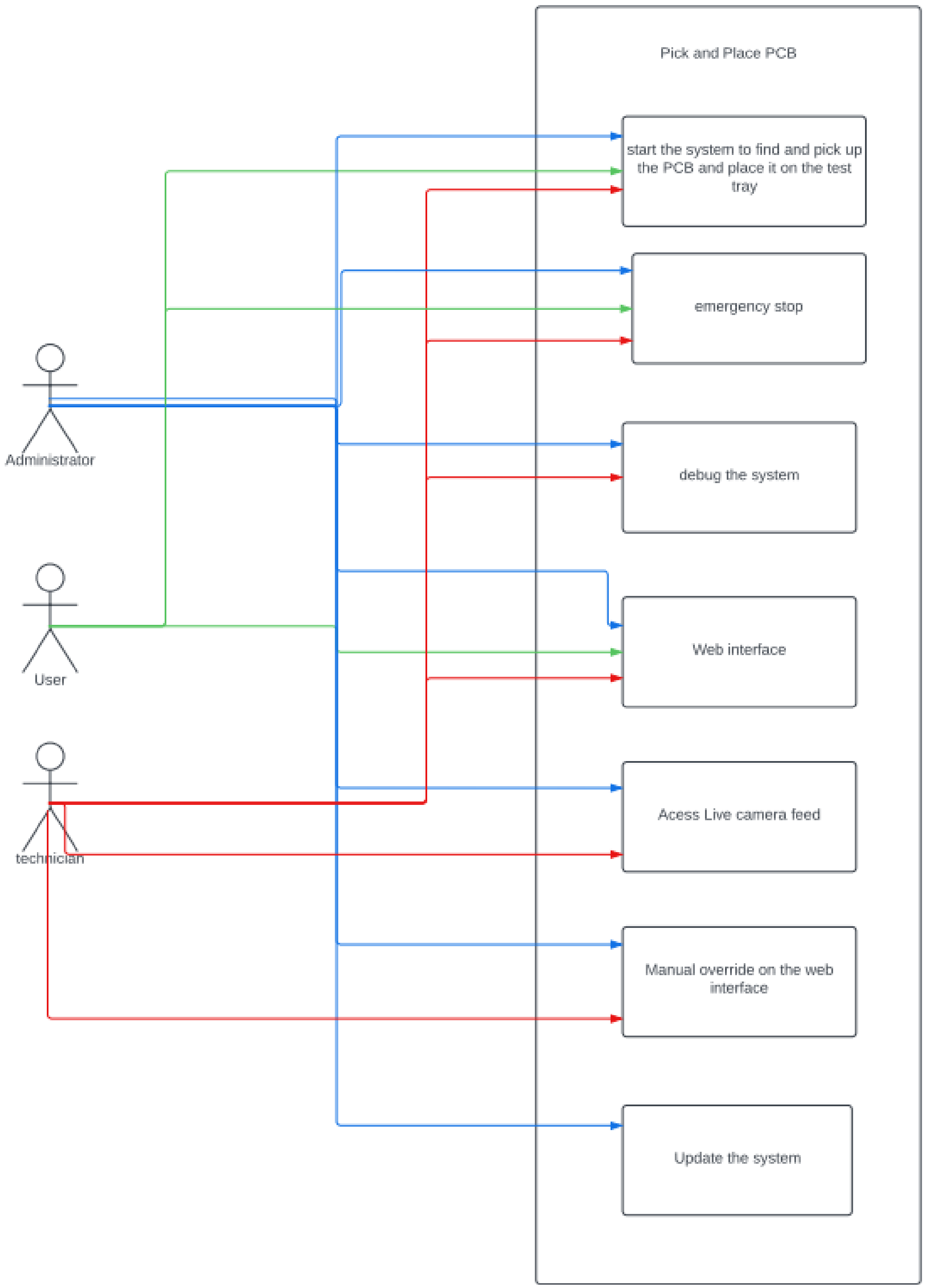
2. Non-Functional Requirements Specifications

ID	Non-Functional Requirement Specification	Team Member Responsible
SNFR1	Test the react of the system with the feedback from min-PC. Then use a delay function to slow the feedback commands from the mini-PC to the pickup arm to get the stable speed. We need to run the system, record the velocity and adjust the speed by adjusting the delay time in time out function.	Lap Nguyen
SNFR2	The pickup arm with the camera on it keeps jogging in a specific area. The area should be big enough for a camera that can accommodate PCBs to size of 300 mm wide by 500 mm long.	Lap Nguyen

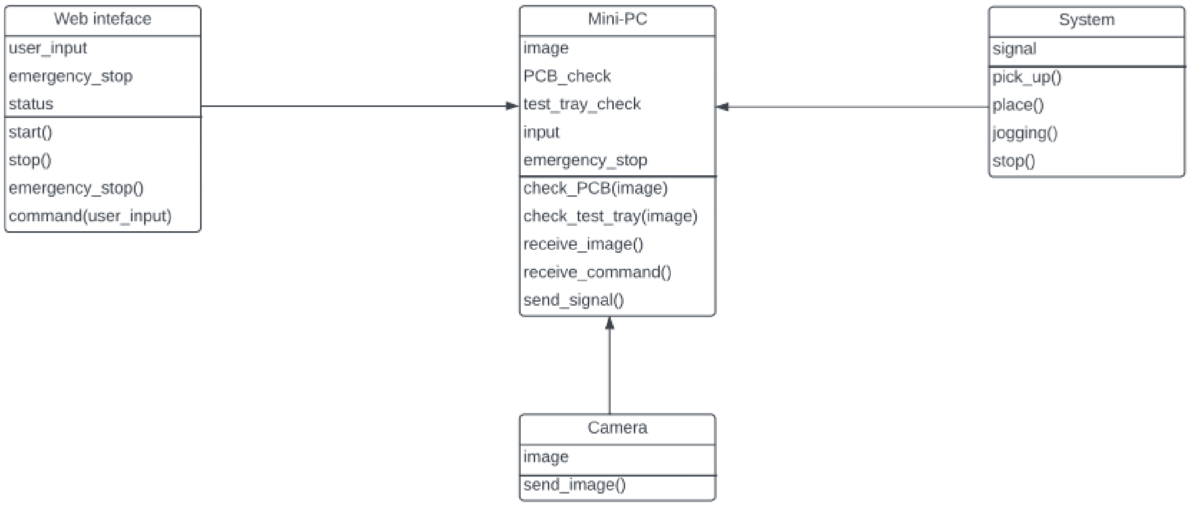
SNFR3	The PCB lifting mechanism will be tested with a PCB that has added weight up to 200g and capable of lifting about 10 cm to clear the test tray pins and allow the mechanism to move the PCB.	Fernando Zavala
SNFR4	Write code to communicate with all movable parts to move with the same speed and to avoid damaging the machine. The code will be based on the previous team parameters.	Jailine Contreras Marquez
SNFR5	Find out if the components can be connected using the ethernet bus; if not, modify or change out cables.	Jailine Contreras Marquez
SNFR6	Build a custom platform from acrylic or polycarbonate using 3D printing as needed.	Jailine Contreras Marquez

A. Preliminary Design

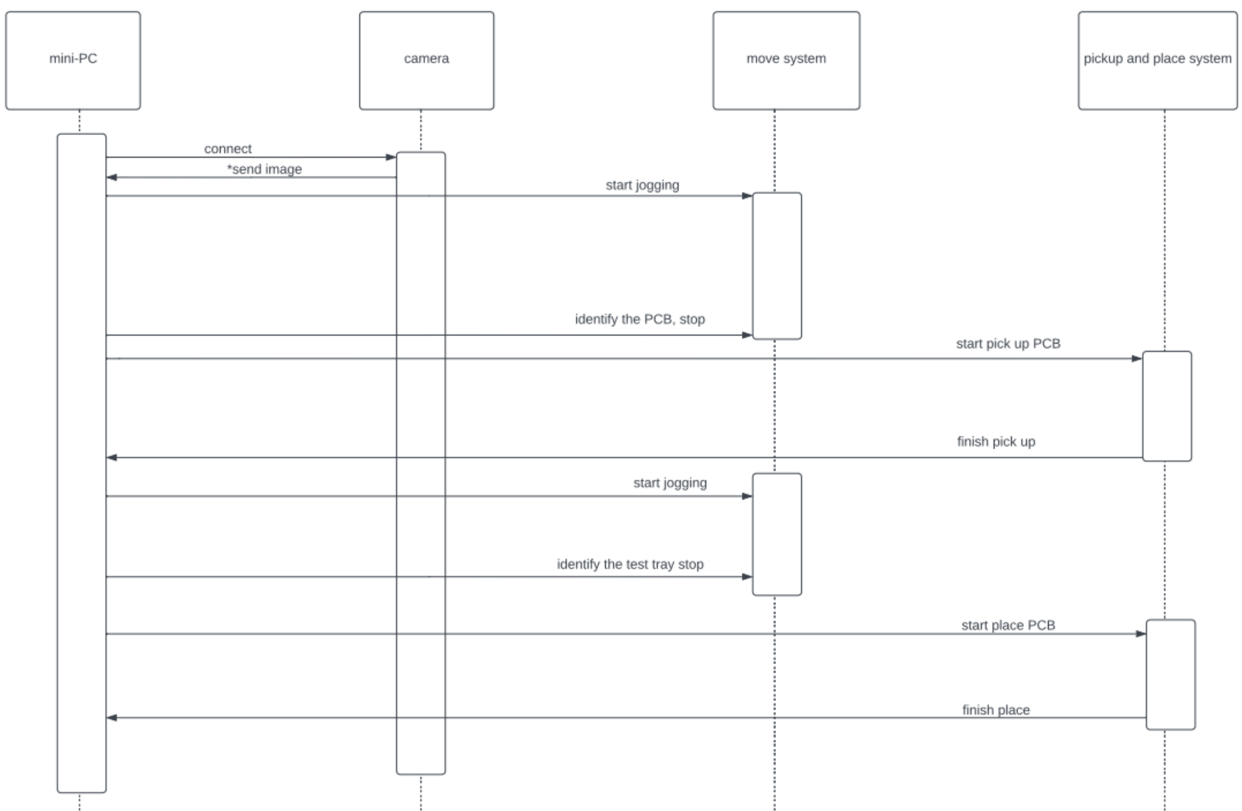
1. Use Case Diagrams



2. Class Diagram



3. Sequence Diagrams



4. State Diagram