UNIVERSITY OF MORATUWA

Faculty of Engineering

Registered Module No: EN3992

INDUSTRIAL TRAINING REPORT

LE Robotics (Pvt.) Ltd.

From: 04/ 01 / 2022 To: 20 / 06 / 2022

Date of Submission:
20 / 06 / 2022

Thalagala B.P.

180631J

Department of: Electronic and Telecommunication Engineering

Preface

This report was composed as partial fulfillment of the requirements of Module EN3992 - Industrial Training, in the curriculum of B.Sc. in Engineering (Electronic and Telecommunication) at the University of Moratuwa, Sri Lanka. The experience and knowledge that I gained during the six months of my industrial training were used and were the inspiration to create this report.

Acknowledgment

I would like to gratefully acknowledge all of the people who helped me to make this six months of special industrial training period a massive success, starting from the point of applying to a company to the point I left the training organization at the completion of six months.

First of all, I would like to express my heartfelt gratitude to Professor Kapila Jayasinghe who was our supervisor for us throughout the six months of the internship period. The advice he provided us with regard to professional engineering practices and ethics was invaluable. In addition to that the directions he provided us to gain the required technical skills required for the allocated project were priceless. I believe the mindset that he built in us, towards working under minimum supervision, will be a massive support for us to thrive in the fast-moving industry.

Next, I would like to express my gratitude toward Miss. Laknie Jayasinghe who was the Engineer in charge of us in our training period. The support she provided us to improve our soft skills as well as technical skills as a professional engineers, is highly appreciated. The support she provided when composing the technical documentation of my allocated task by pointing out the mistakes and the areas of improvement was invaluable and must be mentioned at this point. Moreover, her support in validating the project deliveries at the end of the training period is highly appreciated.

Last but not least, I would like to express my heartiest gratitude to Mr Janka Kulathunga, the manager of the Lanka Electronics research and development section and Mr Aloka Perera, an electronic engineer in LE Robotics (Pvt.) Ltd for being available for us whenever we needed their support.

Contents

Preface 1

Acknowledgment 2

List of Abbreviations 4

List of Figures 5

List of Tables 6

1 Description of the organization and business, its past, present and future 7

1.1 Organization and Business . . . 7

1.1.1 Introduction . . . 7

1.1.2 Services and Products . . . 8

2 Description of familiarization work carried out 10

3 Exposure to systems (HSE, Financial, Administration, Logistics, etc.) 11

4 Project Work 12

4.1 Development of an Object Detection Framework . . . 12

4.1.1 Problem Definition . . . 12

4.1.2 Solution . . . 13

5 Hands on experiences 15

6 Soft Skills Development 16

7 SWOT Analysis of the organization and self 17

8 Conclusion: Own perspective of areas to be improved (of the whole training process including self) 18

Appendices 19

A Guidelines 20

References 21

PDF is clickable

List of Abbreviations

CV Computer Vision

FOV Field of View

OOP Object Oriented Programming

R&D Research and Development

ROI Region of Interest

RPi Raspberry Pi

SCARA Selective Compliance Articulated Robot Arm

SFTP SSH(Secure shell) File Transfer Protocol

SIFT Scale Invariant Feature Transform

SVM Support Vector Machine

UART Universal Asynchronous Receiver/Transmitter

List of Figures

1.1 Logo of the LE Robotics (Pvt.) Ltd. 7
1.2 Model *LE 6 R1149* 6-DOF articulated robot arm[1] 8
1.3 Model *LE 4 R565* 4-DOF Selective Compliance Articulated Robot Arm (SCARA) robot arm[2] 9

4.1 Interconnection between inputs and outputs of the Computer Vision (CV) subsystem 13
4.2 Interconnections between the existing robot controller and the CV subsystem . 14

List of Tables

Chapter 1

Description of the organization and business, its past, present and future

For my special industrial training, I got the opportunity to work as an engineering trainee at LE Robotics (Pvt.) Ltd. located at 100/4, Divulapitiya Road, Minuwangoda, Sri Lanka.It is a local Research and Development (R&D) facility where they work on industrial articulated robot arms and related technologies. This chapter provides an extensive description of the organization and business as well as information about its past, present and future.

1.1 Organization and Business

1.1.1 Introduction

LE robotics (Pvt.) Ltd. is a local R&D facility that has been established by Prof. J.A.K.S. Jayasinghe who is a senior professor in the Department of Electronic and Telecommunication Engineering at the University of Moratuwa in Sri Lanka.

LE robotics (Pvt.) Ltd. is the first in the Sri Lankan market to offer fully customisable robotics solutions 'Made in Sri Lanka' for various automation needs for an affordable price with expertise based in Sri Lanka. In the year 2005, the company designed and manufactured the first custom robotics solution in their affiliated company, Lanka Electronics (Pvt.) Ltd. Since then, they have been developing various robotics solutions and related technologies in the facility.

Figure 1.1: Logo of the LE Robotics (Pvt.) Ltd.

1.1.2 Services and Products

As mentioned previously LE Robotics Pvt. Ltd. provides services and tailor-made products for various automation needs of its customers. When it comes to the services they provide, the following key services can be highlighted.

1. Process Analysis to identify the automation needs and challenges of organizations
2. Product customization to provide the best tailor-made solution for requirements
3. Providing local expertise with ease of access
4. Providing lifetime support for the products

In addition to the services they provide, the following products are manufactured at LE Robotics Pvt. Ltd. R&D of the related technologies of those products is a key activity among the day-to-day activities in the facility.

1. **6 DOF Robots** - Robots with six degrees of freedom (Figure 1.2 depicts such a model)
   - Robotics solutions with the capability to mimic human arm operations
   - Offers the flexibility to provide you with fully customized robotic movements to suit your requirement
   - Around 1 m reach and 0.1 mm placement precision

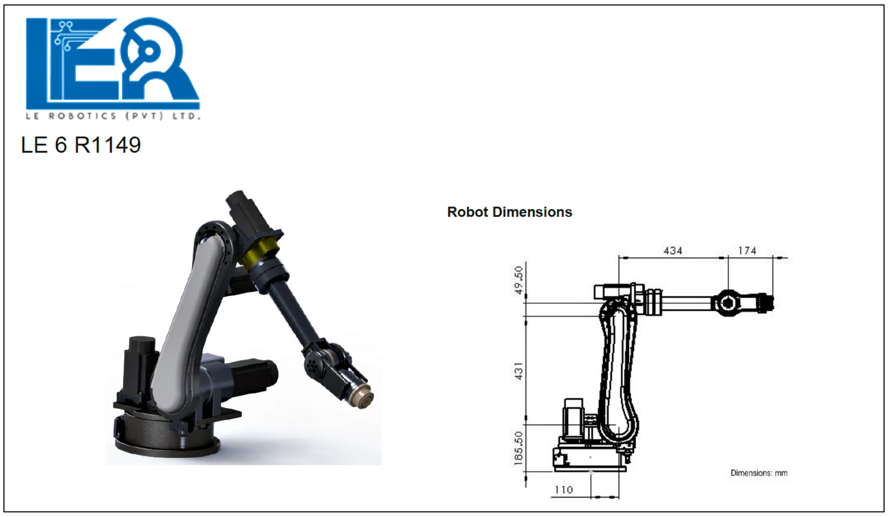

Figure 1.2: Model *LE 6 R1149* 6-DOF articulated robot arm[1]

2. **4 DOF Robots** - Robots with four degrees of freedom (Figure 1.3 depicts such a model)
   - Robotics solutions with superior high-speed performance, high rigidity and high accuracy
   - Array of options with a compact design
   - Around 500 mm reach and 0.1 mm placement precision

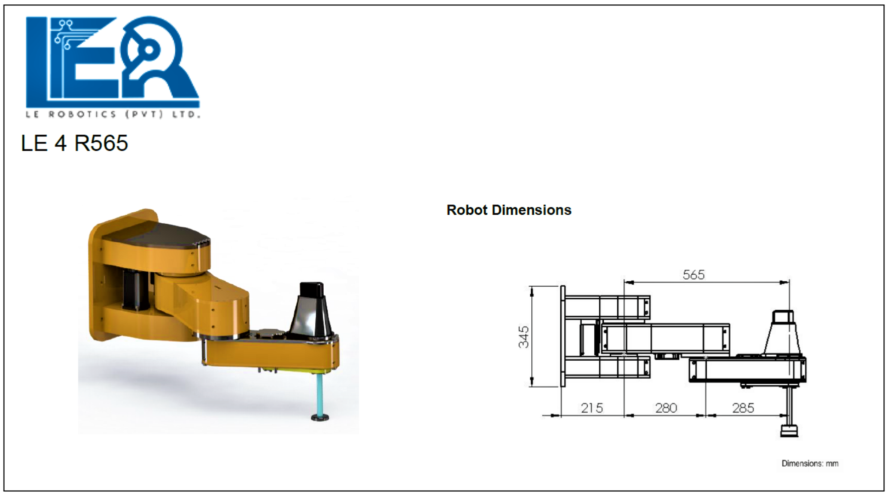

Figure 1.3: Model *LE 4 R565* 4-DOF SCARA robot arm[2]

3. **Custom Made Robots** - Robots designed according to the customer's needs
    - Reach and Payload specifications are possible to be customized as per your process requirements
    - Robotics Solutions to carry out simple pick and place operations

Chapter 2

Description of familiarization work carried out

Chapter 3

Exposure to systems (HSE, Financial, Administration, Logistics, etc.)

Chapter 4

Project Work

By title the project that I was assigned, was ***Machine vision based Real time Motion Planning for an Industrial Articulated Robot Arm***. In simple words it was a project related to an automatic pick and place machine which can be used to pick objects placed on a conveyor belt and pass them to the next stage of processing.

My contribution to that project was to develop the following three aspects of the system.

I. Development of an object detection framework

II. Development of an application to train an object classification model

III. Development of an application for camera calibration

Subsequent sections will thoroughly explain the mentioned sub projects that were undertaken by me during the industrial training period.

4.1 Development of an Object Detection Framework

The first project, that I was assigned as a trainee electronic engineer was related to CV field. In this project, an Object Detection Framework was developed to be deployed in an Automatic Pick and Place Machine. As a summary, the framework is capable of identifying Region of Interest (ROI), detecting and classifying objects, determining location and orientation of objects with respect to a real world coordinate system for grasping (picking). This section explains everything related to the development of that framework.

4.1.1 Problem Definition

Most of the robotic arms used in industrial environments operate in a pre-programmed cycle. When it comes to the way a human does the same task is much different as the path planning for picking an object may change from cycle to cycle because of the perception obtained through human vision. CV is the technology and methods incorporated to mimic the human vision in order to gain the insights about the operating environment of the robotics system.

When it comes to the real time object detection using CV, there is an inevitable trade-off between the accuracy and the speed of the operation. This depends entirely on the used CV algorithms and the computational power of the available hardware. If the robotic system/ arm in interest is not controlled through a dedicated industrial PC with adequate computational resources, the amount of resources that can be allocated to the CV unit becomes limited. This will eventually result in great delays (which is not desirable when it comes to real time operations) to produce the required outputs by processing the acquired images through the associated camera.

Due to the limitations in the resources, initial problem of real time object detection on a moving conveyor was subdivided in to three problems.

- **Case 1:** Detection of objects placed in a ***static environment*** (no conveyor belt is associated). Picking and placing is carried out by the robot in the usual way.
- **Case 2:** Detection of objects placed on a ***non-continuous conveyor belt***. Conveyor belt can be paused when objects are detected and picking and placing is carried out thereafter.
- **Case 3:** Detection of objects placed on a ***continuously moving conveyor belt***. Picking and placing happens while the conveyor is moving.

4.1.2 Solution

As the initial stage of the project, the case 1 mentioned in the Section 4.1.1 was developed. It consisted of developing a CV subsystem for detecting ***stationary objects*** placed in a ***static environment***. In this case no conveyor belt is used and objects are placed in the Field of View (FOV) of the camera.

Figure 4.1 shows the interconnection between inputs and outputs of the developed system. Once the video stream from a camera is fed into the system, it is capable of,

1. Determining the grasping location of an object in a real world coordinate system. Centroid of the 2D view of the object was considered as the grasping location.
2. Determining the gripper's angle. Orientation of object with respect to the positive x direction of the same real world coordinate system was used for this.
3. Determining the class/ type of the detected objects using a Scale Invariant Feature Transform (SIFT) and Support Vector Machine (SVM) based classification algorithm.

and providing them to the main controller of the pick and place machine as requested by it.

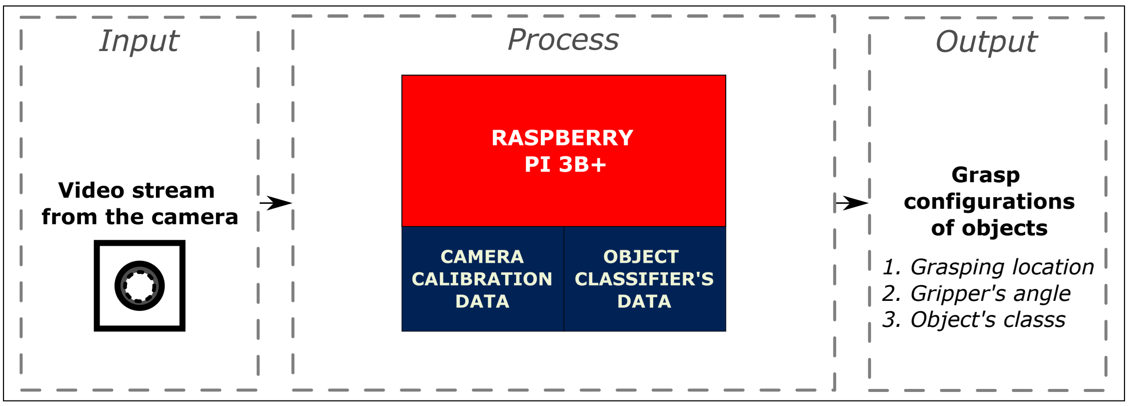

Figure 4.1: Interconnection between inputs and outputs of the CV subsystem

Figure 4.2 depicts the interconnections between the existing robot controller and the newly developed computer vision subsystem. Outputs showed in the Figure 4.1 are provided to the robot controller through a serial communication link built using an Universal Asynchronous Receiver/Transmitter (UART) circuitry. For transferring data to the Raspberry Pi from the working PC, SSH(Secure shell) File Transfer Protocol (SFTP) over Wi-Fi technology was used.

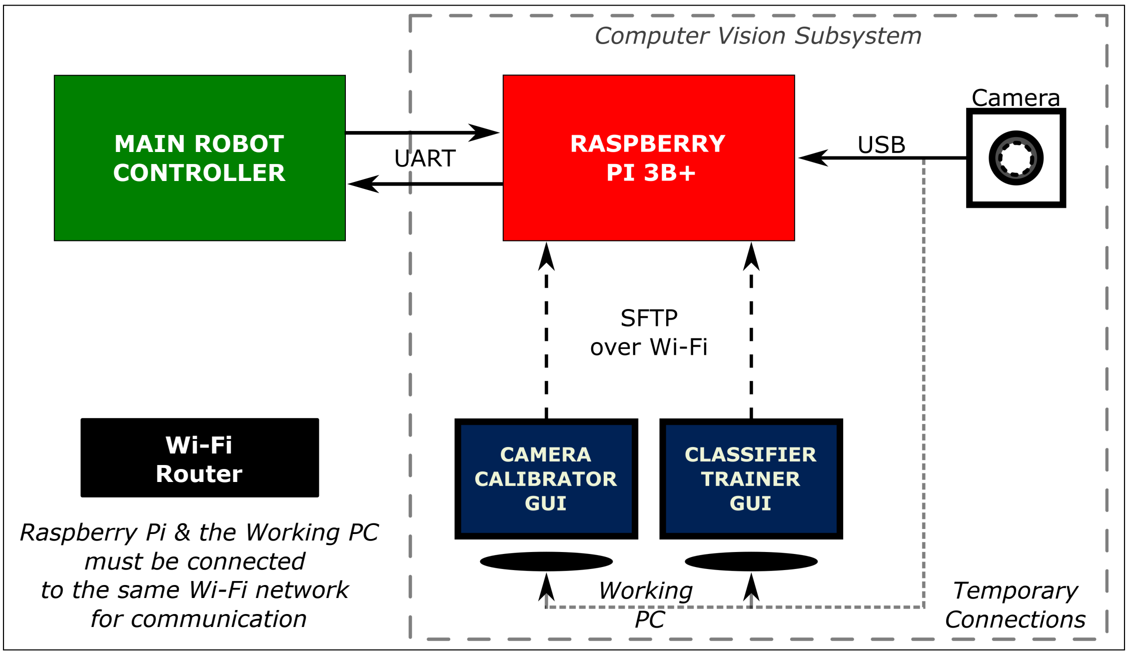

Figure 4.2: Interconnections between the existing robot controller and the CV subsystem

For the implementation of the prototype following third party tools are used.

1. **Raspberry Pi (RPi) 3 B+ Single Board Computer (SBC)**
   Product brief: Online available at `https://datasheets.raspberrypi.com/rpi3/raspberry-pi-3-b-plus-product-brief.pdf`.

2. **Logitech C310 HD Webcam, 720p Video**
   Technical specifications: Online available at `https://support.logi.com/hc/en-us/articles/360023464573-Logitech-HD-Webcam-C310-Technical-Specifications`.

3. **OpenCV open source computer vision library stable release 4.4.0**[3]
   Stable and development releases: Online available at `https://github.com/opencv/opencv`; A pre-compiled version of this library, which is optimized for CV and Deep Learning on Raspberry Pi was used.

4. **Gordon's Arduino wiring-like WiringPi Library for the Raspberry Pi**[4]
   Unofficial Mirror for WiringPi bindings: Online available at `https://github.com/WiringPi/WiringPi`.

Chapter 5

Hands on experiences

Chapter 6

Soft Skills Development

Chapter 7

SWOT Analysis of the organization and self

Chapter 8

Conclusion: Own perspective of areas to be improved (of the whole training process including self)

Appendices

Appendix A

Guidelines

References

[1] LE Robotics - Articulated Robots. http://www.lerobotics.lk/articulated-robots.php. publisher: LE Robotics Pvt. Ltd.

[2] LE Robotics - SCARA Robots. http://www.lerobotics.lk/scara-robots.php. publisher: LE Robotics Pvt. Ltd.

[3] G. Bradski. The OpenCV Library. *Dr. Dobb's Journal of Software Tools*, 2000.

[4] G Henderson. Wiring Pi: GPIO Interface library for the Raspberry Pi. http://wiringpi.com/.