INDUSTRIAL INTERNSHIP TRAINING AT

MULTITEK TECHNOLOGIES, DELHI

VIT®

Vellore Institute of Technology

(Deemed to be University under section 3 of UGC Act, 1956)

Internship Report

Submitted in partial fulfilment of Bachelor of Technology in Electronics and Instrumentation Engineering at Vellore Institute of Technology, Vellore

Submitted By

Vinayak Sharma

19BEI0084

September, 2022

CERTIFICATE

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MULTITEK TECHNOLOGIES

TO WHOMSOEVER IT MAY CONCERN

This is to certify that **Mr. Vinayak Sharma** has completed his internship in **Automated Vickers Testing** at **Multitek Technologies**, Delhi, from **23/05/2022** to **22/06/2022**.

He has worked on a project titled **Automated Vickers Testing**. This project was aimed at building automated digital methods of calculating the Vickers hardness of a material. As part of the project, he has worked on:

- an Open CV-based method of computing hardness
- a .NET application to interface a digital microscope camera and provide a user interface
- a Flutter app that provides similar functionality on various platforms (specially Linux on ARM)

During his internship he has demonstrated his skills with self-motivation to learn new skills. His performance was commendable and he was able to complete the project on time.

We wish him all the best for his future endeavours.

Multitek Technologies

Ms. Sarita Sharma

CEO

ACKNOWLEDGEMENT

Firstly I would like to thank the SELECT school for granting me the permission to pursue this internship.

This internship opportunity proved to be very beneficial in acquiring various technical skills and professional development in general.

Furthermore I would like to thank Multitek Technologies to providing me with this opportunity to intern at their esteemed company and guiding me compassion all the way through. I am very thankful that I got to learn a lot of skills through this hands on work experience.

Sincerely,

Vinayak Sharma

ABOUT THE COMPANY

Multitek Technologies was formed by the unification of multiple leading companies for materialography, metallography and hardness testing. They supply instruments, complete laboratories, software and consumables. They take pride in the highest quality, flexibility and innovation displayed in their work.

Certifications like **EN ISO 9001:2015** and **NABL Accreditation** are testament to their promise of quality and perfection.

They actively work with other esteemed organisations like Tata Motors, Maruti Suzuki, Honda, Hero, New Holland, Ashok Leyland, VE Commercial Vehicles, Oerlikon Graziano, TAFE, JSL, Shriram Piston, NBC, SONA, to name a few.

STUDY PROJECT REPORT

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2. Theory
3. Equipment Overview
4. Technology Stack
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7. Flutter
8. Calibration Procedures
9. Day Wise Record of Activities
10. Conclusion

Scope of Work / Objective

The scope of work for this internship is singular project based. A project is decided upon discussion with the technical head of the firm, and the primary objective is to complete the project whilst learning the required technical and professional skills.

The project for this internship was decided as “Automated Vickers Testing”. The following were the outlined objectives for this project:

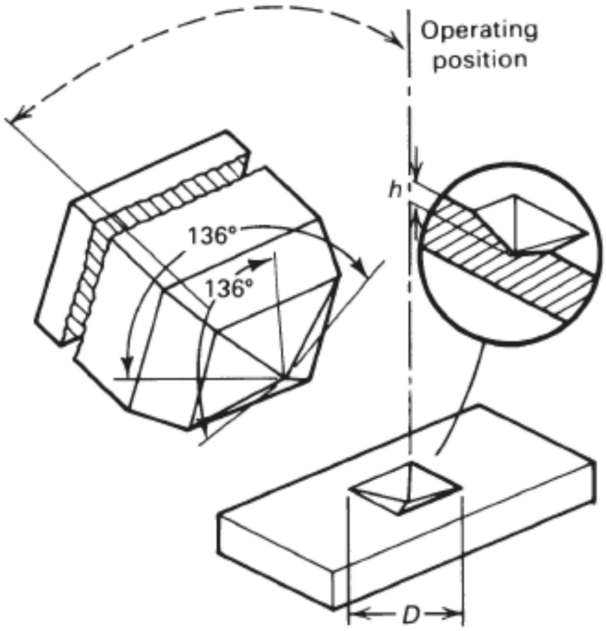
1. To develop an automated system that determines the Vickers Hardness of a material using a Microvicker and an attached Microscope camera.
2. To develop a User Interface for the control of the said system
3. To explore deployment on a single board computer with integrated touch screen controls.

Theory / Introduction

Microvickers Testing

Metal hardness is a characteristic that determines the surface wear and abrasive resistance. The ability of a material to resist denting from impact is related to hardness as well as a material's ductility. A hardness test is typically performed by pressing a specifically dimensioned and loaded object (indenter) into the surface of the material you are testing. The hardness is determined by measuring the depth of indenter penetration or in this case, by measuring the size of the impression left by an indenter.

Robert L. Smith and George E of the United Kingdom developed the Vickers Hardness Test in 1925, which was then published by ASM International. It employs a square-based pyramidal shaped indenter made from diamond.

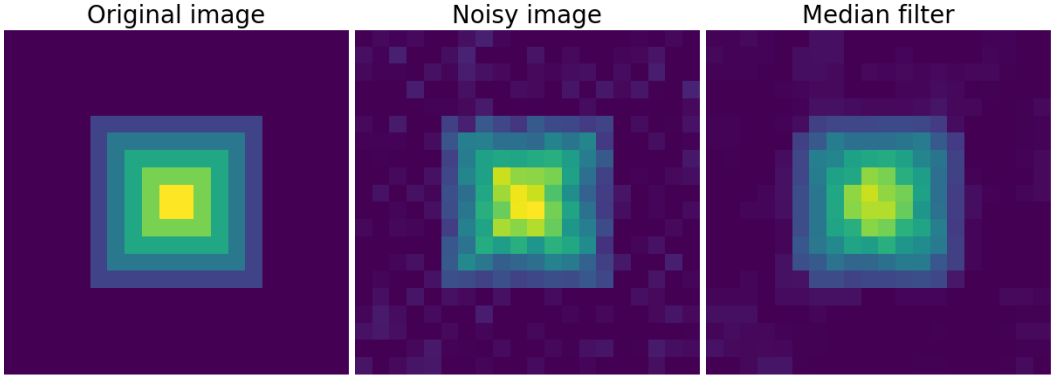


Thresholding

Thresholding is the simple process of converting a coloured / grayscale image into a black and white image. It involves setting a thresholding point, that separates a channel into two parts. Any value lesser than the threshold is now considered 0 or black and any value higher than the threshold is now considered 1 or white. Thresholding is used to, 1. Reduce the number of channels in an image to 1, which makes the processing simpler and faster, and 2. Removes the faint details and emphasises the prominent ones.

Noise Reduction

Noise reduction is the process or set of processes that filters distortion or unwanted information from an image. In this case, a Median Filter is used, as it has the potential to remove noise while preserving edges.

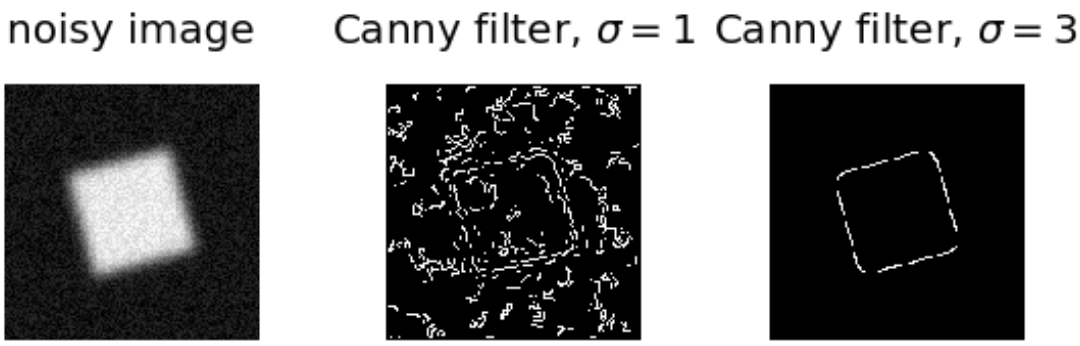


Sobel Operator

The Sobel operator is used for its ability to highlight edges. It does so using a discreet differentiation operator, computing an approximation of the gradient of the image intensity function.

Canny Edge

Canny edge is an edge detection operator that uses a multi-stage algorithm to detect edges. The stages are: noise reduction; gradient calculation; non-maximum suppression; double threshold; and edge tracking by hysteresis.

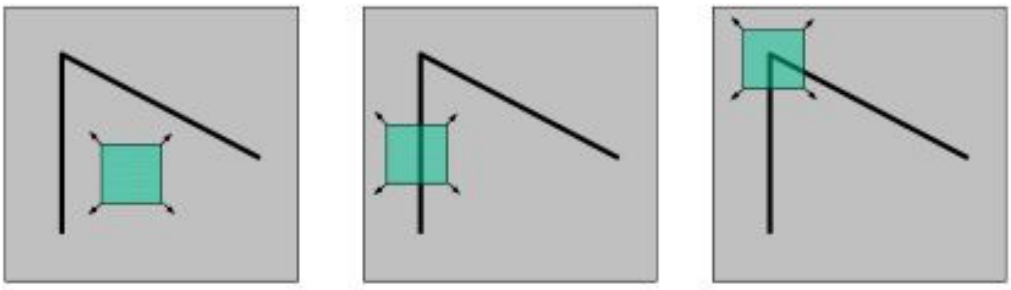


Laplacian Operator

The Laplacian operator too can detect edges. Since the 2nd derivative of the pixel density at an edge is zero, the Laplacian operator can be used to calculate the same for a 2D image by taking the derivative in both dimensions.

Harris Corner Detector

Harris Corner Detector is a corner detection operator that is commonly used in computer vision algorithms to extract corners and infer features of an image. Harris' corner detector takes the differential of the corner score into account with reference to direction directly, instead of using shifting patches for every 45-degree angles, and has been proved to be more accurate in distinguishing between edges and corners.

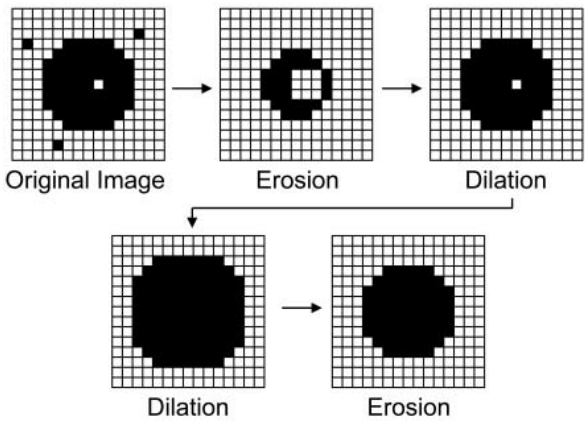


Region of Interest (ROI)

A region of interest (ROI) is a portion of an image that you want to filter or operate on in some way. You can represent an ROI as a binary mask image. In the mask image, pixels that belong to the ROI are set to 1 and pixels outside the ROI are set to 0 .

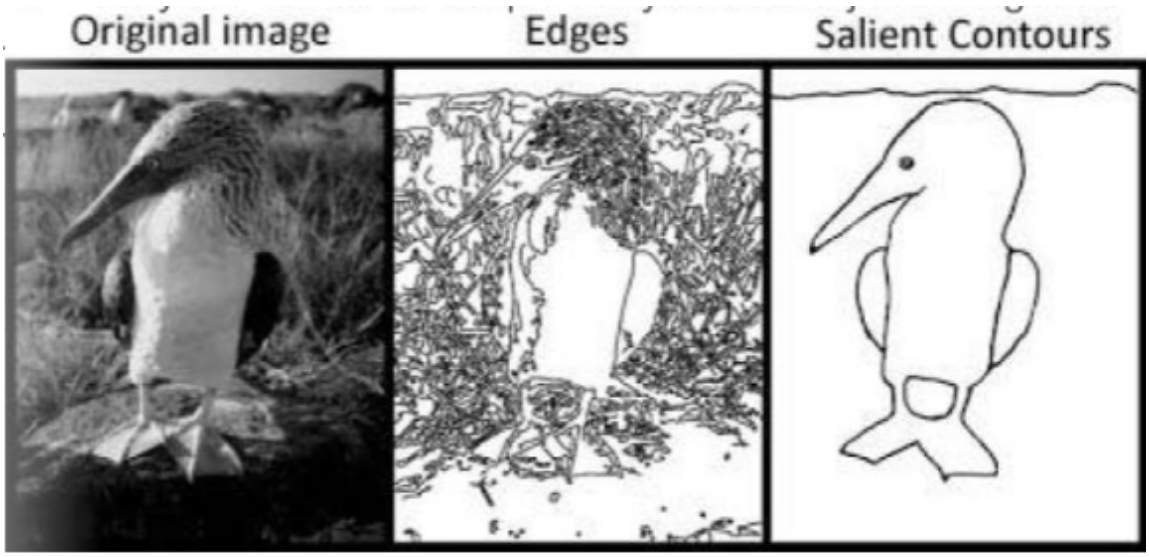
Dilation and Erosion

Dilation and erosion are basic morphological operations. Dilation adds pixels to the boundaries of objects in an image, while erosion removes pixels on object boundaries. The number of pixels added or removed from the objects in an image depends on the size and shape of the *structuring element* used to process the image. In these operations, the state of any given pixel in the output image is determined by applying a rule to the corresponding pixel and its neighbours in the input image.



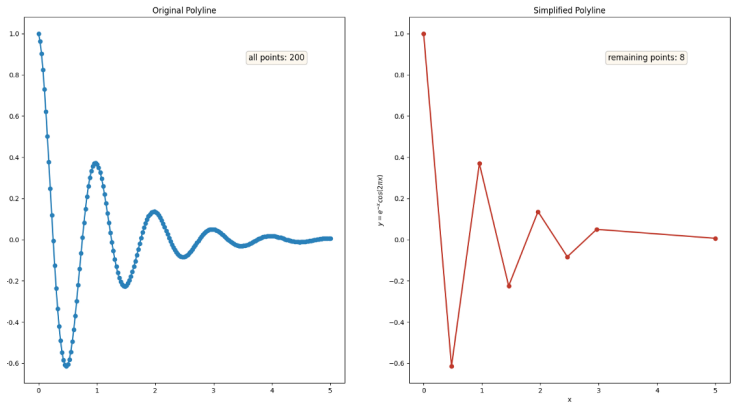
Contours

When we join all the points on the boundary of an object, we get a contour. Typically, a specific contour refers to boundary pixels that have the same colour and intensity.



Ramer–Douglas–Peucker Algorithm

The purpose of the algorithm is, given a curve composed of line segments, to find a similar curve with fewer points. The algorithm defines 'dissimilar' based on the maximum distance between the original curve and the simplified curve. The simplified curve consists of a subset of the points that defined the original curve.



Equipment Overview

Micro Vickers Hardness Tester

A micro vickers hardness tester applies a stored dead weight on to a sample via a diamond based indenter. The equipment has control for the applied weight and optics to view the microscopic image of the formed indent. The device also contains two micrometers that move physical crosshairs on a transparent film which allows an operator to calculate the dimensions of the formed indent. These dimensions can then be used to obtain the hardness of the sample using a simple formula: $HV = 1.854\frac{F}{D^2}$.

Where F is the applied load and D is the average of length of diagonals.

Microscope Camera

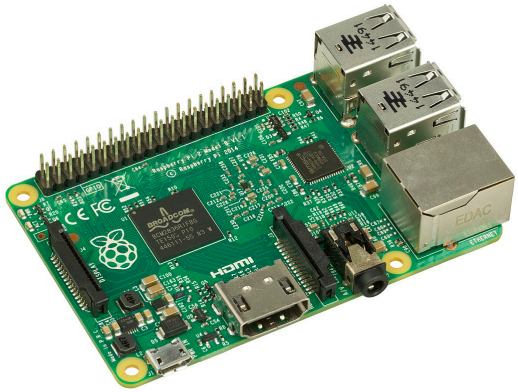
A microscope camera can be attached to a micro vickers hardness tester using a camera port that reflects light off of a semi-coated mirror. Light then travels through a reduction lens and finally reaches the camera's sensor. Most cameras connect using the USB interface that can then be used to obtain the frame buffer.

Processing and Interaction Devices

The final piece of software needs to run a machine that can process realtime images, display them and allow the user to interact as well.

There are two broad classifications to be made here:

1. Single Board Computers (SBCs): These are small boards with integrated sac and memory. These usually run on ARM processors and have touch screen support. These tend to house weaker processors and hence aren't very good at processing images at a higher refresh rate but are compact and power efficient.



2. Personal Computers (PCs): These are full fledged computers that run on either x86 or x86_64 architecture. They have keyboard, mouse and external display support for interaction. These are great at processing images at near real time speeds but are much bigger in size and require additional power budgets.

Technology Stack

The task at hand was to create an application that can display the current frame buffer from the microscope camera for the user, provide required controls for the user, use the frame buffer to automatically calculate the hardness of the sample and finally display the result to the user. The two approaches that I have taken to accomplish this task is as follows:

1. A native app based on .NET framework:

The .NET framework allows us to create MFC applications for the windows x86/x64 based machines. It is also a great fit for this project along with “Emu CV” which is an Open CV wrapper for C#. Furthermore, proprietary camera hardware can also be interfaced due to wide adoption of this framework.

2. A cross platform app using Flutter:

The Flutter framework provides great out of the box functionality that is particularly important for this project like, ARM support on linux hosts, built-in touch screen support, inter-op functionality with languages like C and python that allows us to use Open CV.

Methodology

Open CV

Open CV stands for Open Source Computer Vision. It is an one source library that includes hundreds of computer vision algorithms and related tools. It is currently maintained as a C++ API though various ports and wrappers exist which makes it the most available Computer Vision API today.

For this project, we will be using “Emu CV” which is a wrapper for .NET, in the .NET app and the Open CV API for python for the Flutter app. Both the APIs provide the same methods for us to use which guarantees the same output regardless of the platform though performance differs.

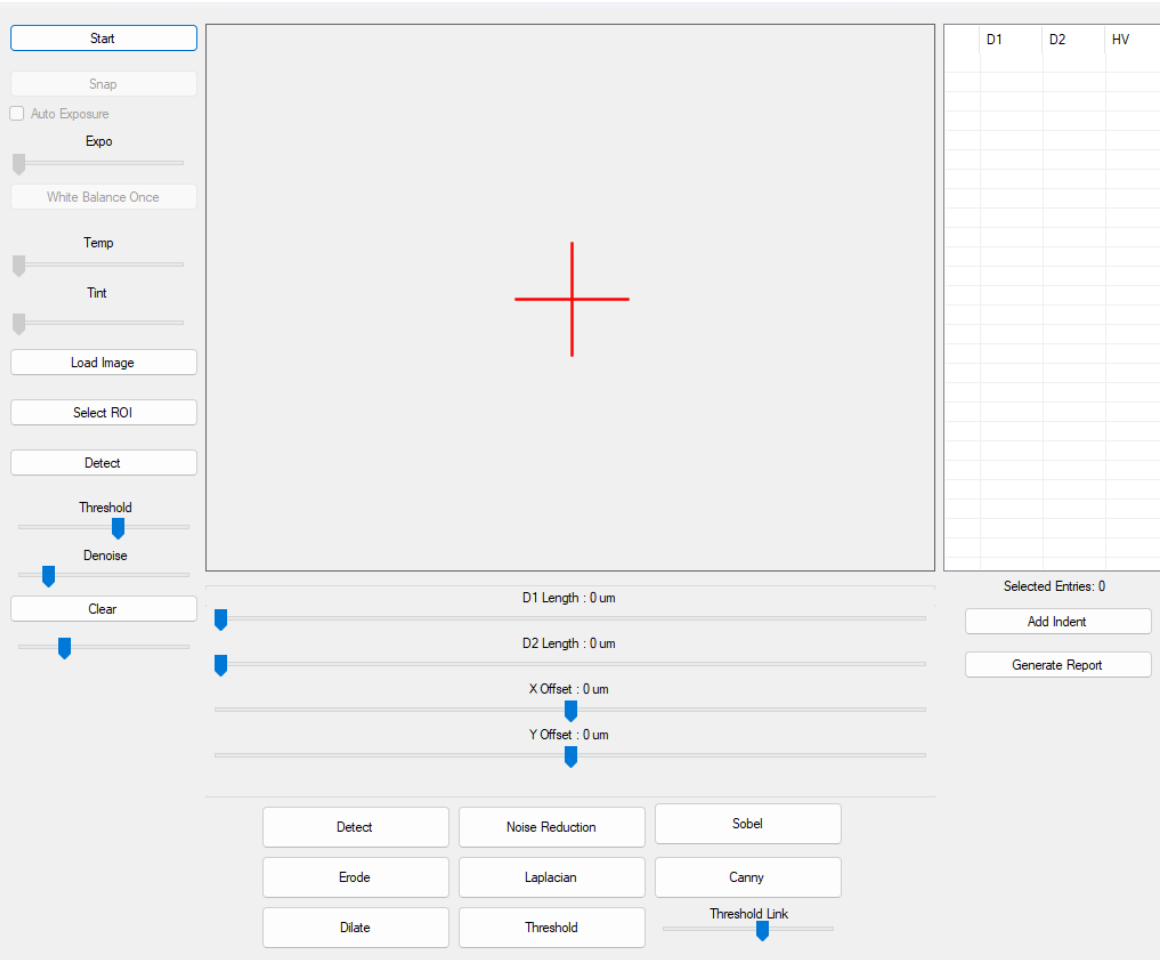
The step by step algorithm employed is as follows:

1. Threshold
2. De-Noise
3. ROI Extraction
4. Find Contours
5. Shape Approximation
6. Diagonal Pixel Length Measurement
7. Pixel to Distance conversion
8. HV Calculation

.NET Framework

The .NET Framework app directly interfaces with a proprietary camera to obtain a frame buffer and then uses Emgu CV to detect the indent and calculate its dimensions. These dimensions are then used to calculate the hardness value and display it to the user. The app also provides manual sliders to calculate the indent. It also has provisions to alter basic camera controls like white balance and exposure.

As an additional feature, the app can interoperate with Microsoft Word to generate reports based on predefined templates. The report can include multiple consecutive readings and also specific information like the make and model of the hardness tester or the dead weight used for the test etc.

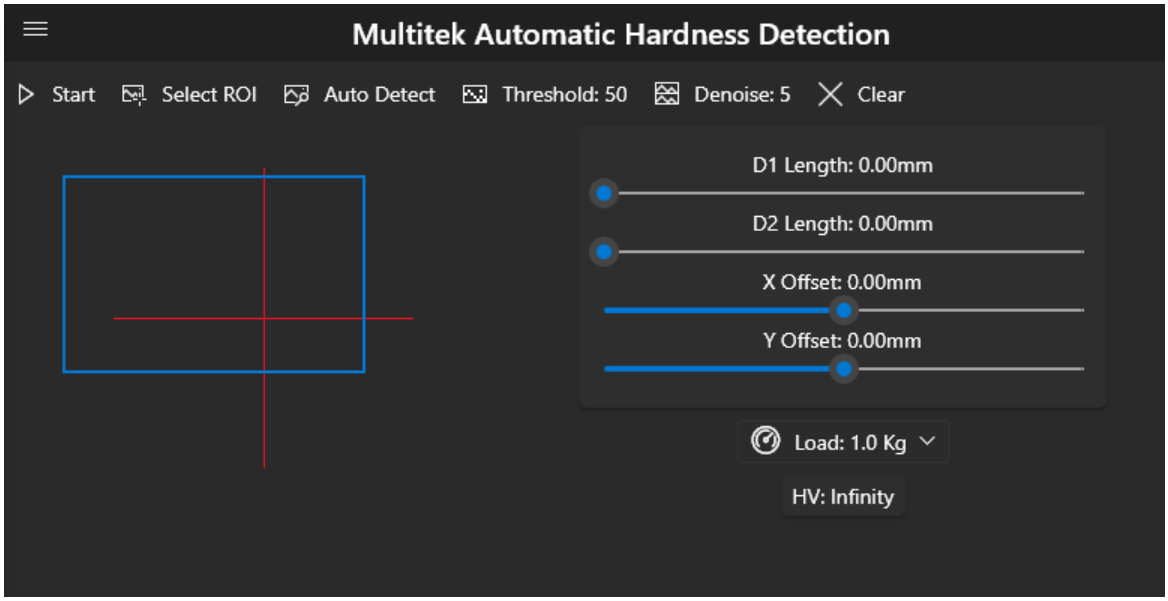


Flutter Framework

The flutter framework produces cross platform apps with a modern look. The UI for the app follows the latest Fluent UI design language provided by Microsoft. It interoperates along with Python which utilises Open CV to fetch frames and maintain a frame buffer on disk which the Flutter app reads from and displays on screen.

The same stack is used again to detect indents with Open CV with the settings passed as arguments to a python script.

The cross platform nature of both flutter and python allows us to run the developed application on virtually any hardware. For this project, single board computers running Linux on ARM were on a focus. Tests were run on a Raspberry Pi 3 B+ which managed to pull about 10 frames per second while fetching the frame buffer from disk.



Calibration Procedures

1. Pixel to Distance Mapping:

An optical scale is kept under a lens of the microvicker and its image is captured using the camera at various resolutions. The distance spanning the entire image is measured and compared with the resolution to calculate the pixel to distance ratio.

$$ratio = \frac{total\_measured\_distance}{total\_number\_of\_pixels}$$

The same process is repeated for both the axes and at different magnification levels.

2. Calibration Factor

The hardness tester too needs calibration. It is performed by obtaining an indent on standard master block and manually calculating the length of the diagonals of the formed indent. The hardness value is then calculated and a correcting factor is found by comparing the obtained value with the standard value.

$$ratio = \frac{obtained\_hardness}{standard\_hardness}$$

Day Wise Record of Activities

Date	Activity
23/05/22	Company Tour and Demonstration of active projects
24/05/22	Selection of Project, declaration of terms and conditions
25/05/22	Sanctioning of work computer, allotment of microvickers tester and camera
26/05/22	Demonstration of Micro Vickers Hardness Tester, Hands on trials with sample blocks
27/05/22	Demonstration of calibration procedures
30/05/22	Discussion on project objectives, software specification, compatibility
31/05/22	Research on existing solutions, open source projects
01/06/22	Workstation setup with .NET Framework, Emgu CV
02/06/22	Basic UI development using Visual Studio
03/06/22	User controllable crosshairs for manual measurements
06/06/22	Understanding proprietary camera sdk, running samples/tests
07/06/22	Integrating proprietary camera drivers for windows and C# API to show frame buffer
08/06/22	Update canvas to show frame buffer and crosshairs, camera settings for WB, and Exposure
09/06/22	Implementing Thresholding, Demonising, Saving FB, Reading FB
10/06/22	Implementing & applying combinations of Sobel, Canny Edge and Laplacian
13/06/22	Measuring pixel to distance ratio with master block and optical scale
14/06/22	Word Interop for reports, ROI, Erode, Dilate
15/06/22	Testing in real-time with samples
16/06/22	Preparing workstation for Flutter and Python, Preparing RPi for Flutter
17/06/22	Basic UI development using the Flutter Framework, ROI
20/06/22	Developing scripts for writing frame buffer to disk and reading in flutter app
21/06/22	Translating C# scripts to python for interop with flutter, RPi Deployment
22/06/22	Final testing and demonstration

Conclusion

This one month internship opportunity at Multitek Technologies was great for work based learning and professional development. I experienced the practical difficulties of working with proprietary hardware and software solutions, the unexpected challenges of real life projects and more importantly the ways to overcome these.

Though this internship, I was able to learn the following technical skills:

1. Working of a Micro Vickers Hardness Tester.
2. Calibration of a Micro Vickers Hardness Tester.
3. Using proprietary drivers and SDKs to implement custom solutions.
4. Implementation of Emgu CV with the .NET Framework.
5. Interop of Microsoft Word with the .NET Framework.
6. Deploying and testing cross platform apps for Linux on ARM.
7. Python interop with Flutter.

All in all it was a wonderful experience of the joy of learning and building something new.