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Quality control of fiberglass profiles using machine vision

May 2020

NTNU

Norwegian University of Science and Technology
Faculty of Information Technology and Electrical Engineering
Department of ICT and Natural Sciences

Bachelor's thesis

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Preface

This bachelor thesis is written by four students from Automation Engineering at NTNU in Aalesund and is the last major assignment before graduating as engineers spring 2020. All students have previous experience in the field of electronic systems. Two of us used to worked with automated systems, while the other two worked with offshore electrical installations.

The choice of project was based on our Interests in technology and development. Today, most companies have to focus on higher quality in a demanding marked. With the help of new technology we will therefore develop a functional prototype that Vello Nordic can apply to enhance their quality control.

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- Beijer Electronics norge
- Berggård Amundsen & Co AS

Summary

Vello Nordic produces composite profiles for doors and windows using pultrusion technology. Producing these profiles is challenging due to the small margin of error. During the production different reasons could lead to errors in the profile. Controlling the quality of the finished products are demanding and difficult. Therefore, Vello aim to enhance their quality control by examining how an automated quality control with machine vision could improve their current control.

In order to improve their current control, a functional prototype was designed and created by applying machine vision. Image captured where processed to extract geometrical data and accentuate the structure of the profile. Furthermore, a graphical user interface and a program for controlling the complete system were developed. To complete it, a mechanical construction was designed to hold the necessary equipment.

Examination and testing of different components led to the final solution. A range of different equipment like cameras, lenses and lighting were tested, whereas the production line was examined in order to reach the satisfying mechanical solution

As a result of the study, a functional working prototype were developed and applied in Vello's production. Vello found this prototype to be satisfying as it shows accurate dimensional measurements and it is easier for Vello to inspect the fiber mat than earlier.

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Terminology

FOV Field of view, the area of sight for the camera.

AOV Angle of view, the angle of sight for the camera.

DUT Data unit type, describes a user-specific data type.

POU Program Organization Unit, where the source code for your controller is written.

Fieldbus Industrial computer network protocols.

Notation

W Watt

min Minutes

mm millimeter

nm nanometre

bpp Bit per pixel

bpc Bit per channel

Abbreviations

Gnd Ground in electrical circuits

DC Direct current

GUI Graphical User Interface

HMI Human machine interface

TCP Transmission Control Protocol

IP Internet Protocol

BOM Bill of material

I/O Input and output

OS Operating system

USB Universal Serial Bus

PSU Power supply unit

LED Light emitting diode

RGB Red, blue and green

FTP File transfer protocol

PLC Programmable logic controller

Scada Supervisory Control And Data Acquisition

CCD Charge-Coupled Device

CMOS Complementary Metal-oxide Semiconductor

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Chapter 1

Introduction

Vello Nordic specializes in producing composite framing for windows and doors in the building industry using pultrusion technology[51]. Vello manufactures products by firstly pulling threads and mats of fiberglass through a chemical bath, followed by them being guided through a temperature regulated mold, and lastly cut into desired lengths.

The pultrusion technology is not immaculate, there are several challenges. The fiber mat is one of those challenges, as the fiber mat can get folded when it enters the mold. The folded mats leads to a decreased mat width, which results in weak profiles. Secondly, the pulling-tool can be twisted, only a few millimeters may result in unevenly distributed wall thicknesses. Finally, if there is not applied enough fiber in a corner or a lip, the corner becomes weak and the lip will be to small or non-existing. All these challenges leads to defect profiles and therefore waste.

Vello Nordic wants to explore the possibilities of applying machine vision in their quality control. With machine vision their goal is to remove the uncertainties in their quality control, which today is done manually. Vello want to be able to verify and document each produced profile. Previously Vello had been in contact Amatec AS and together they conducted some tests to explore the possibility of using their machine vision equipment to perform the inspection. However, no further work had been done and Amatec agreed to join the project as a partner offering to lend necessary equipment.

This study aim to examine how machine vision can be used to improve the quality control at Vello. The study examines how camera technology can be applied to measure geometrical dimensions on fiberglass profiles to a certain degree of accuracy. Also how different light and filters can help accentuate the fiber mat in the profiles. To achieve this a graphical presentation of the results including a program for controlling the complete system needed to be developed. It was also required to design and build a mechanical construction to hold necessary equipment.

1.1 Background

Companies continuously seek new and innovative technology in order to compete in today's competitive market [43]. Increasing productivity and decreasing the use of resources are in focus as businesses apply new and innovative automation technology in their productions [43].

Businesses like Vello Nordic utilizes automation technology in order to increase production productivity and the consistency of its products, as well as it points out issues which again minimizes the risk of defected products. Minimizing defects are important as defects often leads to several inconveniences like increased workload, material consumption and tear on machines. By reducing products with defects, one is optimizing the workload as well as minimizing the consumption of materials. Ultimately, the aim is to decrease the company's production cost to stay competitive in the market. Increasing automation productivity has been of interest at Vello Nordic for several years. The company is now looking for external assistance to increase its productivity, which this study is a result of.

1.1.1 Introduction of Vello Nordic

Vello Nordic AS is a Norwegian company located in Skodje and manufactures composite product using pultrusion technology. The company was established in 1965 and is today owned by the Spilka-group. Vello's pultrusion technology has the opportunity for tailoring material combinations to meet the requirement's and specifications for the final product that the costumer demands.[51]

1.2 Objectives

In order to make a functional prototype of a quality control which uses machine vision, the following actions will be taken:

1. Implement vision system for the image analysis provided from Amatec. This is to be able to inspect the profile on the production line and extract the necessary data with sufficient

precision.

2. Select and document difference between the cameras, optics and the lighting applied.
3. Make a mechanical test concept which will be applied when testing different camera equipment including necessary illumination.
4. Develop a graphical user interface for controlling the system. The functionality needed for the HMI panel is visualization of image analysis, an alarm and recipe system.
5. Create a mechanical model for mounting the vision equipment on the production line.
6. Implement a PLC for controlling:
 - Vision system
 - communication
 - logging of data
7. Build an electrical cabinet for the required hardware.
8. Writing a report to document the work and results.

1.3 Limitations

The choice regarding hardware where limited to the provided equipment from Vello Nordic AS and our partners Amatec AS. Amatec gave us access to Omron's machine vision system while Vello Nordic had already decided on the PLC for this assignment, this means that there might be limitations in the hardware.

1.4 Outline

The thesis is structured as follows.

Chapter 2 - Theoretical basis: Describes the theories the project is based on.

Chapter 3 - Method and Materials: Description of the methodology and materials used in this project.

Chapter 4 - Result: Present the results achieved during the project and describes these.

Chapter 5 - Discussion: A summary of the results are taken under consideration and discussed.

Chapter 6 - Conclusion: Conclusion of the project is made and recommendations for further work are presented.

Chapter 2

Theoretical basis

2.1 Machine vision

Machine vision is how the machine can perceive the environment with the use of a digital camera and a computer. By using machine vision a machine can solve complex problems without human interaction [46].

2.2 Digital image processing

Digital image processing concerns with the manipulation of digital images by using a computer and is a subcategory of digital signal processing. Manipulation of the images are done by processing digital images through algorithms. Algorithms used in digital image processing are made by taking concepts and techniques from areas such as statistics, theoretical computing, AI and information theory. [26]

The following sub sections gives a theoretical background which the image processing algorithms used are based on.

2.2.1 Calibration

Calibration is used to correct for camera tilt and image distortion due to the lens. This can be done using a point pattern where the software itself is trained to look for certain points. The point pattern can look like figure 2.1. The number of points and the distance between them are set in the software. Then the software compensates for distortion by aligning the points in the image. This operation removes distortion caused by the lenses. [4]

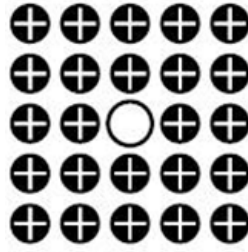


Figure 2.1: Example of calibration plate

2.2.2 Edge detection

The standard method to search for edges in an image is by using a 2x2 or 3x3 convolution matrix on the input image. Multiplying this convolution matrix (derivative kernel) with the pixel values in the image, will result in the images derivatives. However, it is possible to use a larger derivative kernel and get better approximation of the derivatives, but larger masks often lead to loss of details. There are several ways to use the images derivatives to search for edges, the approaches are divided into two categories. One using first order derivatives and the other one using second order derivatives.

The first order edge detection uses derivative from the input image. By using the first derivative, it is possible to find directional change in color or intensity in an image. There are a lot of different methods used in computer vision, image processing and machine vision. The most popular are Sobel, Roberts and Prewitt. [21]

The second order edge detection uses the second order derivative from the input image. By using the second derivatives, it is possible to calculate the zero crossings in the image. The zero crossings capture the local minimum and maximum of pixel values. This approach is often used with a smudging filter, because it is sensitive to noise. Some of the popular second derivative edge detection methods are Laplacian, Laplacian of Gaussian(LoG) and Difference of Gaussian(DoG). [5]

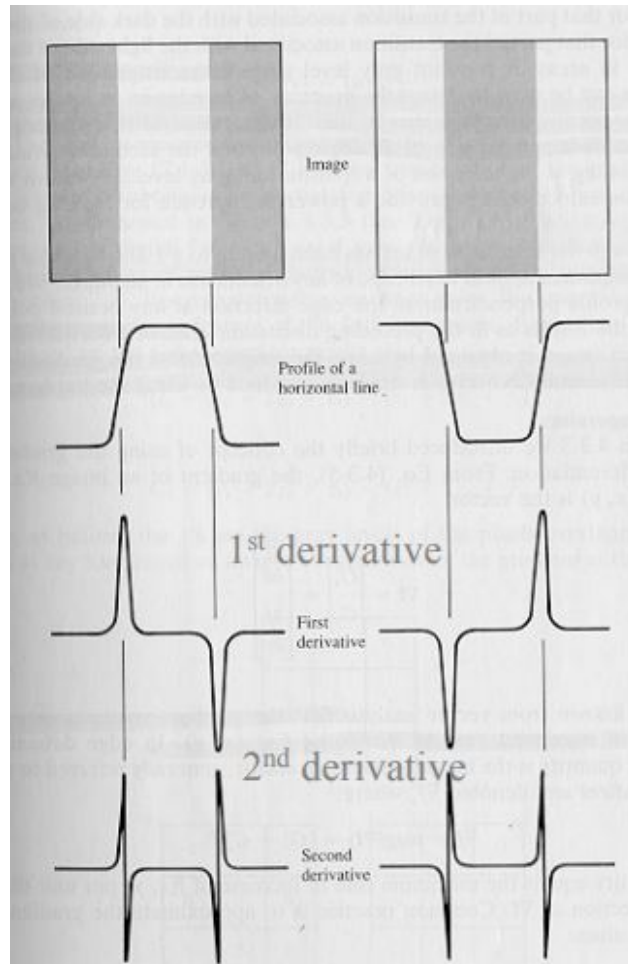


Figure 2.2: 2d visualization of an edge in an image [47]

2.2.3 Grayscale filter

A simple grayscale filter transforms a color image to a monochrome image. When the filter is applied to the image, a mathematical function iterates over every pixel in the image. The mathematical conversion can be done differently in the varicosity of greyscale filters. However, luminosity filter function reads the amount of red, blue and green (RGB) there are in the pixel. Each color then gets multiplied with defined constants. The luminosity filter is like a weighted average filter and have the following formula: $Y = 0.2126R + 0.7152G + 0.0722B$ [45]". [32]

2.2.4 Image background suppression

Background suppression is a filter that constrain the pixels RGB values. Normal parameters in this filter are common upper and lower limits for the RGB colors or individual limits for each of them. The constrained values are then normalized to RGB output values between 0 and 255.[4]

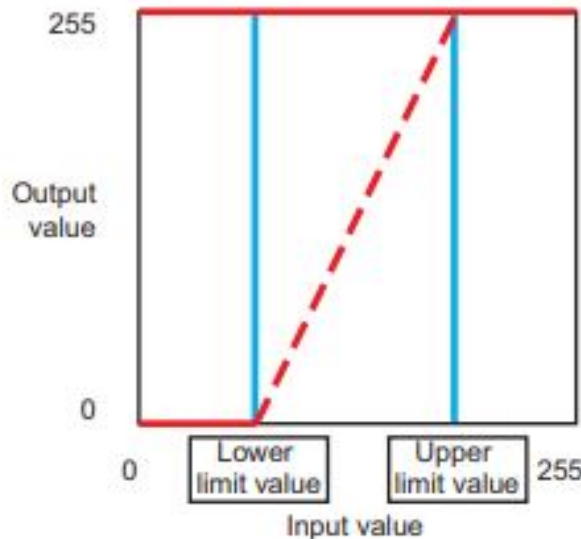


Figure 2.3: Visualization of one constrained color. [4]

2.2.5 Position compensation

This algorithm uses specified reference coordinates to compensate the position of the captured image. Specified references can be an edge, area or a figure, which represent the object. After obtaining the object references, a transformation of pixel coordinates is performed. In results, the positional deviation of the object can be corrected. [4]

2.3 Digital camera

Digital camera is a hardware device where the image is recorded on an image chip consisting of photosensitive electronic components. The chip captures the intensity and color of the light that hits the chip and stores it as pixel data in a digital memory, the chip could be an CCD or

CMOS unit.[44]

CCD

Charge coupled device is built up of rows and columns of pixels that produce potential wells from a clock signal applied. These potential wells store and transport charge packets. The charge packets are made up of electrons which are produced by the photoelectric component. The pixels are defined by the gate silicon surface gates structure. By applying a voltage in a time varying sequence to the gates, the charge shifts to an output amplifier. Then external components convert the output sequence into a digital image. [36]

CMOS

Complementary Metal-oxide Semiconductor is built up of rows and columns of light sensitive pixels. The pixels consist of a photo diode and numerous control transistors. The photo diode is the light sensitive component in CMOS. Photo-carries are collected and stored by the photo diode. Meanwhile, the transistor is used to control the exposure time, convert charge to voltage and control the readout sequence.[7]

2.3.1 Camera resolution

The resolution of a camera is how many horizontal and vertical pixels the camera sensor has (H x V). When using a camera to measure a object, the smallest feature to measure should cover a minimum of two pixels [33]. Higher resolution results in smaller physical pixel size, if the camera sensor has a fixed size.

$$Resolution = \frac{FOV}{smallestFeature} \cdot 2 \quad (2.1)$$

Equation 2.1 calculates the desired resolution. Use the same unit's for FOV and smallest feature in the equation and resolution will be provided in pixels.

2.4 Digital image

A digital image is built by a two-dimensional array of pixels. Each pixel has a coordinate to where it belongs in the image. The coordinate is represented by the image x-axis and y-axis. Looking just at one pixel, it is a square which contains some variables who becomes its color. A pixel is the smallest element in an image. [35]

When talking about digital images, they're pixels comes in different flavors. There is binary image, which is just white and black pixels. Meanwhile, the grayscale image components consist of a scale of intensity. Finishing off with the color image, which its pixels holds three variables. The three variables are an intensity of red, blue and green. [18]

Normal features that's often mentioned about a digital image is resolution and color depth. Resolution is how many pixels the image is constructed by, more pixels in an image results in more details and is measured in mega pixels (MP). Colour depth is how many bits per pixel (bpp) there is. A low number of bits per channel (bpc) results in less color depts, while a high bpc. leads to deeper colors. For example, a grayscale image has normally 8-bpp, while a color image has 16-24 bpp. (6-8 bpc) [18].[23]

2.5 Optics

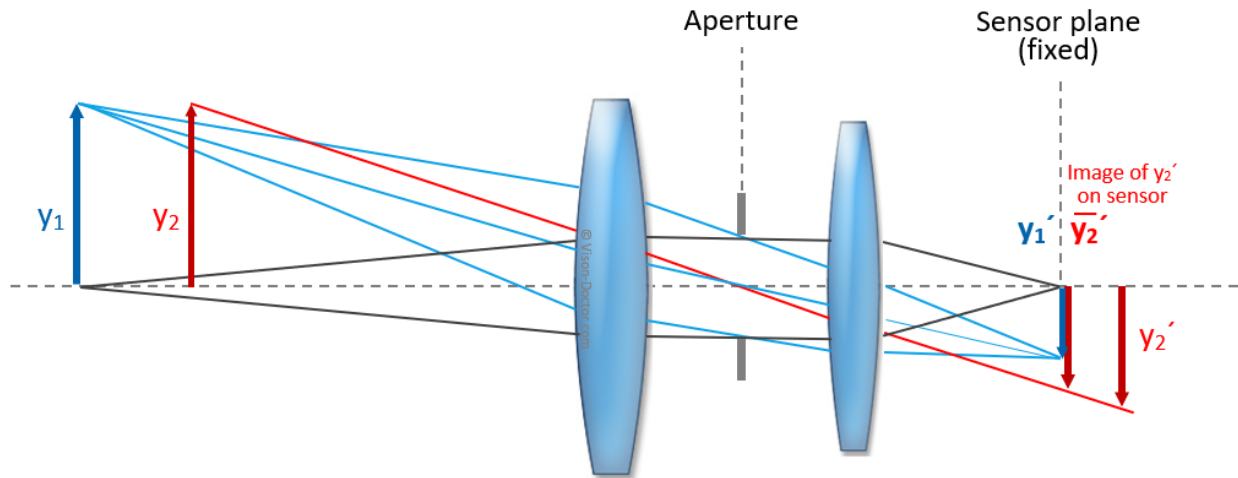
Different lenses are needed for different situations. The two lenses described in this section is entocentric and telecentric lenses.

Aperture and focus are mechanical settings can be adjusted in a lens. The aperture determine how much light the lens lets through. Focus is the sharpness of the image. When an image is in focus all light from the object in question converges. [8]

2.5.1 Entocentric Lens

Entocentric lens has a fixed aperture angle of the optics towards the object and towards the sensor. This makes objects closer to the optic center appear bigger than equal sized objects

further away. Entrocentric lenses will suffer from geometric distortion, this will get worse with smaller focal length. Figure 2.4 shows how a entrocentric lens is built up and how distance affect the object size. [53]

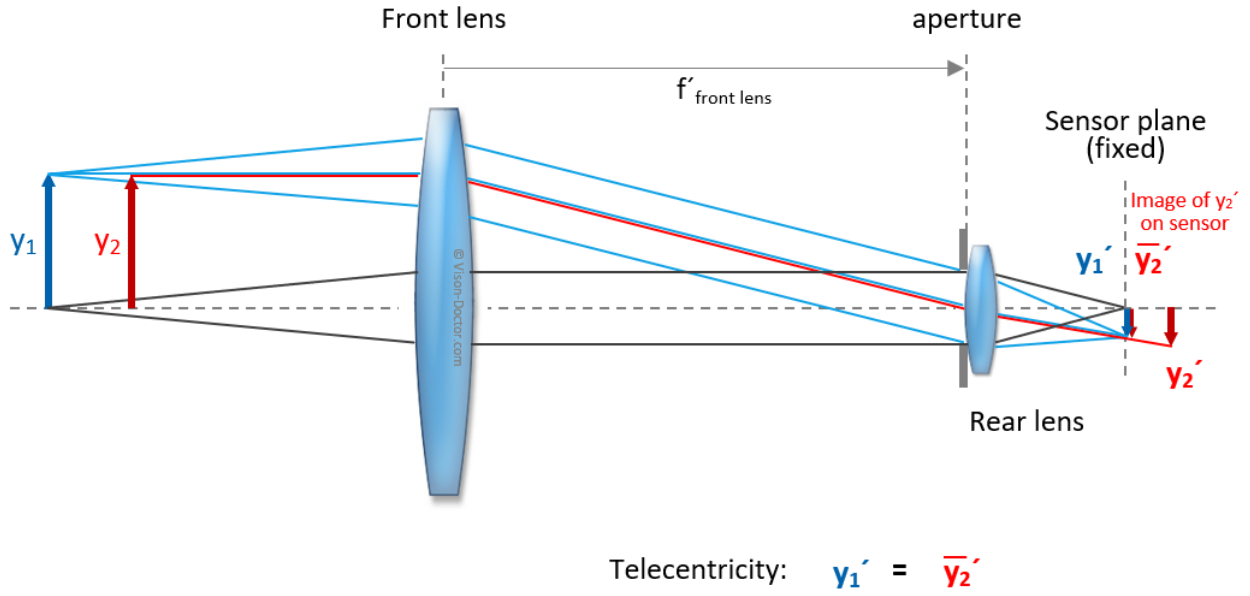


Entocentric lens: more distant object is imaged smaller on the sensor as when it is closer to the camera

Figure 2.4: Entocentric lens build up [53]

2.5.2 Telecentric Lenses

Telecentric lens is built in such a way that prevents any geometrical distortion. This makes telecentric lenses optimal for high accuracy measuring tasks. This is because every part of the image is depicted in parallel to the optical path. Telecentric lenses must be the same size as the object in the picture. This will often result in a larger lens compared to an entosentric lens. Telecentric lenses has the advantage that even if the object is moved inside of the telecentric range, the measured sections do not vary in the image. [54] Figure 2.5 shows this and how the telecentric lens is built.



Objects of the same size y_1 and y_2 with different working distances are depicted with the same size on the sensor plane.

Figure 2.5: Telecentric lens build up [54]

2.5.3 Field of view calculation

To calculate the Field of view, the angle of view (AOV) needs to be calculated. This can be accomplished with the knowledge of the focal length and the sensor size of the camera. By looking at figure 2.6 we can apply trigonometry to the right angle triangle that consist of focal length, sensor horizontal/2 and AOV/2. By solving the equation for AOV we get equation 2.2.

$$AOV[^\circ] = 2 \cdot \arctan\left(\frac{SensorHeight[mm]}{2 * FocalLength[mm]}\right) \quad (2.2)$$

When the angle is known, the calculation of the field of view can be proceeded. This is accomplished by applying trigonometry on the right angle triangle consisting of FOV/2, working distance and AFOV/2. By solving the equation for FOV, we get the equation 2.3.

$$FOV[mm] = 2 \cdot WorkingDistance[mm] \cdot \tan\left(\frac{AOV[^\circ]}{2}\right) \quad (2.3)$$

[19]

2.5.4 Field of view

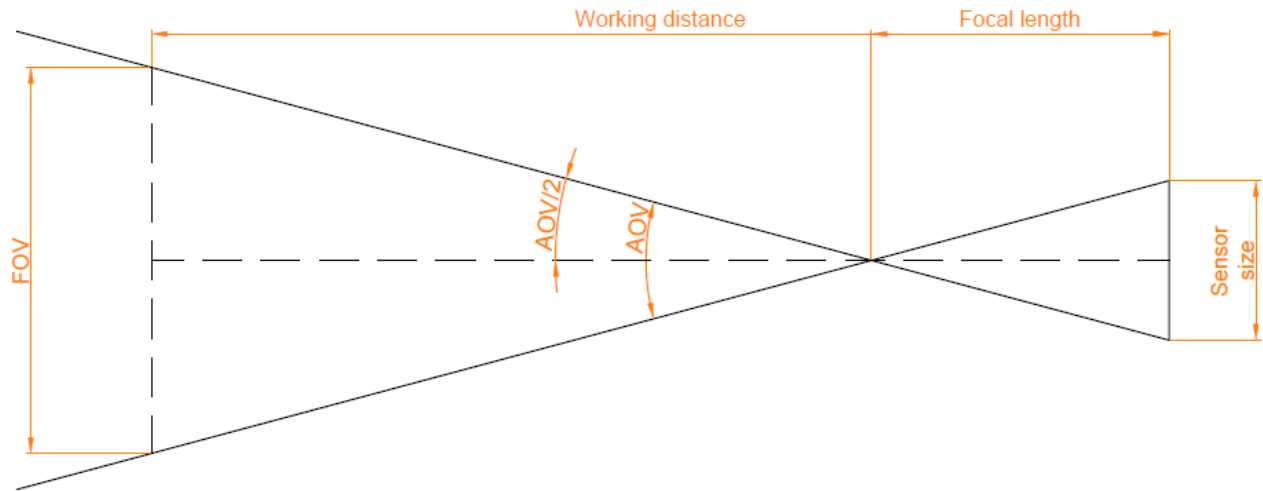


Figure 2.6: FOV

2.5.5 Optical filter

An optical filter is a physical lens which is mounted on the end of the camera lens. The filter's task is to prevent specific or specific group of wavelengths of light to penetrate it. The filters are usually categorized in two groups, which is absorptive and dichroic filter. An absorptive filter has different layers of coating over a transparent glass lens, which absorb the unwanted wavelength. Meantime, a dichroic filter lens is built up with precise thickness of coating, which are designed to reflect undesired wavelength of light. [52]

While generally speaking of filters, there are some named specifications. For example, lowpass and highpass filters. But working with optical filter, these are called shortpass and longpass. When using a shortpass filter, short wavelength of light penetrates the lens. While a longpass filter lets long wavelength through. There is also a bandpass filter which is basically a shortpass and a longpass filter put together. The bandpass filter lets a specified range of wavelength pass through the filter. [52]

2.6 Lighting

2.6.1 Electromagnetic Spectrum

Inside the electromagnetic spectrum, electromagnetic waves can be classified according to their wavelength. This classification is known as the electromagnetic spectrum. Wavelength shorter than the visible spectrum are UV, X rays and gamma rays. These radiations can be harmful for living organism, caused by the short wavelength.[49]

On the right side of the visible spectrum there is IR, microwave and radio waves. These kinds of radiation are not known to be harmful for living organism. Figure 2.7 below shows the electromagnetic spectrum. [34]

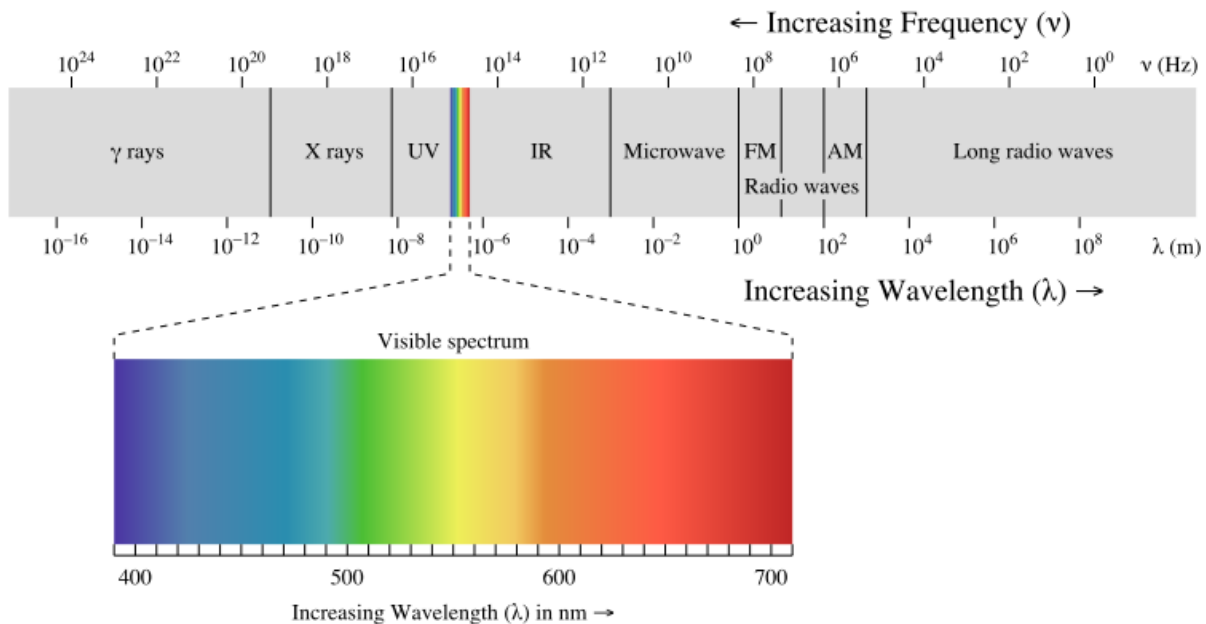


Figure 2.7: Electromagnetic spectrum [34]

2.6.2 Visible spectrum

The visible spectrum lies in the range from 400-780nm and can be observed with the naked eye. The range starts from 400nm with the color violet and ends at 780nm with the color red. Figure

2.8 shows the different colors in the visible spectrum. [6]

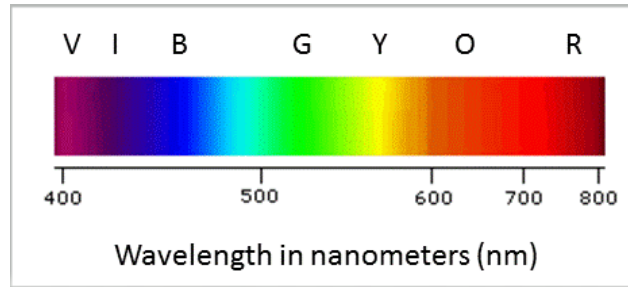


Figure 2.8: Visible spectrum [6]

2.6.3 Near infrared spectrum

Near infrared range lies in the spectral range from 780 - 2500nm. It is not visible for the naked eye and require a camera that can handle that spectral range [6]. Since the wavelength is longer for IR light than UV and the visible spectrum, the IR light is capable to penetrate deeper in materials and generates fewer surface reflection [55]. Figure 2.7 shows that near infrared spectrum is after the visible spectrum in the electromagnetic spectrum.

2.7 Accuracy

Accuracy refers to the degree of proximity of the measurement to a specified true value [27]. Accuracy is high if the measurement is close to the true value. Figure 2.9 illustrates accuracy in a graph with a value against probability density and figure 2.10 illustrates the accuracy together with precision.

2.8 Precision

Precision is an expression of the standard deviation of the normal distribution, it is used as a description of random errors [30]. If repeated measurements under unchanged conditions produces the same results, then precision is high. Figure 2.9 illustrates precision in a graph

with a value against probability density and figure 2.10 illustrates the precision and accuracy together.

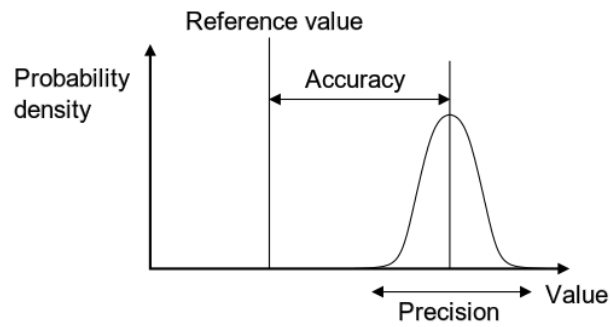


Figure 2.9: Accuracy and precision graph

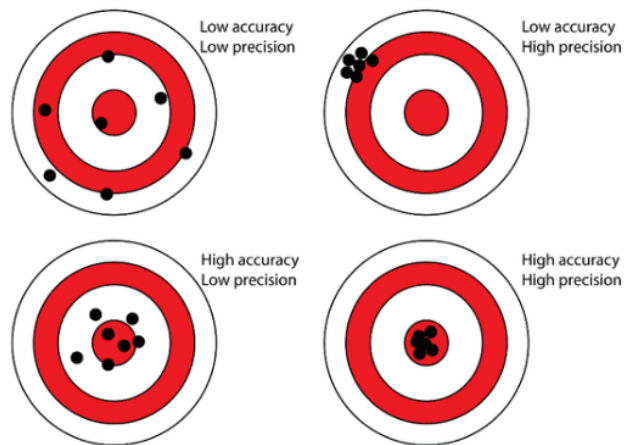


Figure 2.10: Accuracy and precision illustration

Chapter 3

Materials and methods

This chapter is divided into three parts, first part will give an insight and explanation of the method and material used during development. Secondly the software used during the project period is explained. Lastly how the project has been organized and how the work has been carried out.

3.1 Machine vision

One of the main factors for thesis success is the ability to inspect the quality of the profile. To accomplish this, machine vision with a digital camera is used.

3.1.1 Omron machine vision

Omron machine vision system is based on an industrial PC with their own software, FZ-panda. The software is based on flowchart programming where predefined algorithms are used by placing them into the flowchart. Omron machine vision FH controller has the possibility to connect up to 8 cameras and has a 4 core high speed CPU. It also supports EtherCAT, Profinet, Serial communication and Ethernet/IP. [\[40\]](#)

3.1.2 FZ-panda

FZ-panda is a software developed for the vision system by Omron. The software provides a graphical user interface for the programming of the vision application. In this project, the software version 6.31 is used.

This section gives an description of the tools used in the software FZ-Panda. Descriptions below is from the reference manual [4].

Scan edge position

Scan edge position is used to detect edges based on changes in color inside the measurement region. This tool specifies the x and y-positions of the detected edge. Physical values in mm can also be retrieved by turning on the calibration parameter.

Main parameters to tune scan edge position are edge level and number of measured points. The edge level specifies the color threshold for detecting an edge. By tuning this, the sensitivity of the scan edge position is changed. The parameter, number of measured points changes how many measurements are performed inside the search region. Average values from the measurements are calculated to get the x and y-position.

Shape search III

Shape search III is a function for recognising different shapes. When a new image is applied, the algorithm estimate its correlation, position and orientation relative to the reference figure. Before the function can be used, the function must be trained with a reference image. Algorithms generate a reference shape, position and orientation from the reference image. Its recommended to train the model in the work environment to get the best result.

The main parameters to adjust the shape search is candidate level(LV) and correlation judgement. Candidate LV sets the threshold to detect candidate points in a rough search. Parameter correlation judgement sets the correlation limit for the judgement.

Position compensation

Position compensation is used to compensate for different positioning of an object. It uses coordinates from previous processing units like shape search. The coordinates of the object are compared with the specified coordinates. Then, the object is compensated so the objects coordinates matches the specified coordinates.

There are several different compensating methods used in the position compensation. The most used is 1 unit scroll, this method compensate the image based on a reference position retrieved from either edge detection or shape search.

Camera image Input FH

To capture an image from the camera to the controller, a camera image input tool is needed. The camera image input FH is specific for the FH controller. This processing item is also responsible for storing the image captured from the camera.

In camera setting, it is possible to change shutter speed and gain for the camera. The shutter speed and gain is adjusted to the specified camera. For example a FZ-SC5M should use a shutter speed from 20-100.000 μ s and gain from 0-230.

It's also possible to change white balance by adjusting the colors red, green and blue. These three colors can be adjusted separately to achieve the desired color balance needed for the application in hand.

Calculation

The calculation function works like a calculator, where different variables and values can be used to solve simple math. Additionally, the limits for each feature on the profile can be set remotely with EtherCAT by setting the upper and lower limits on the judgement condition on each calculation.

From calculation there is two output variables for each unit that is of interest, which is result and judgement. Result shows the resulting calculation, and judgement shows if the result is within the limits.

Fieldbus data output

Fieldbus data output is used to set up which data to send with fieldbus to an external device. Fieldbus data output is setup in system settings, here the type of fieldbus and the format of the

data is set.

Result display

Result display has functionality to graphically present the measurement result. By using display value, display circle and display line, it is possible to make a graphical presentation of the measurements. The judgment section makes it possible to display the result, only when the result is not approved. The result is displayed on the image so it is easy to interpret the results.

Precise calibration

The Precise calibration tool uses point pattern calibration. Precise calibration corrects for camera tilt, distortion created by the camera lens and calibrates measurement result to actual dimensions. This does not compensate for distance and angle.

The calibration is done by taking a picture of a calibration plate (FZD-CAL 3D Calibration tool). Properties of the calibration plate like number of points, color and distance between points are inserted to the precise calibration. Based on the inserted properties, the calibration algorithm calculates the calibration parameters.

3.1.3 Camera hardware

For the project 2 different kinds of cameras was tested to find the most suitable.

Table 3.1 shows a list of the cameras and controller used during this bachelor project.

Component	Description	Supplier	Manufacturer
FH-3050-20	FH vision controller, standard, Intel Core i7, 4 core type, 8 camera, NPN&PNP	Amatec AS	Omron
FZ-VS3 2M	cable for FZ/FH camera 2m straight plug	Amatec AS	Omron
FZ-SC5M2	FH/FZ CCD camera, high resolution 5M pixel, color 2/3"	Amatec AS	Omron
FH-SC02	FH camera, high resolution 2M pixel, color	Amatec AS	Omron

Table 3.1: List of cameras and controller used

3.1.4 Lighting

A light source had to be used in the inspection of the profile. Two different kinds of lights was tested for the inspection. A LED light that emitted light in the visible spectrum explained in 2.6.2 and a IR light that emitted light in the infrared spectrum explained in 2.6.3. Each light is controlled by a light controller that makes it possible to adjust the power of the lights.

Table 3.2 is an complete list of the light equipment used for this project.

Component	Description	Comment
PD3-5024-3-PT	Light controller	Digital control unit, for LED Light, input 24 V DC
FL-STC25	Light controller	Lighting for Image Processing
LDR2-90IR2-850	Infrared circular light	Adopts LEDs with a peak wavelength of 850 nm
HLDL2-300X45IR-DF-W	Infrared bar light	Emits infrared light with a peak wavelength 860 nm
FL-DR90W	Ring ODR-light	90/50mm, wide area model, white LED, IP20
FL-XC5	Cable for light	Extension standard cable, 5m
FCB-5	Cable for light	Extension cable for CCS 24 V lighting, 5 m

Table 3.2: Light equipment used in the bachelor project

Surroundings

The light source in the production local where the quality control system is to be installed, uses white LED light. The type of light source is Glamox GIR LED 11000Lm HF 85W [28]. White light from LED's is usually made by a blue LED with yellow phosphor covering it [16]. This results in wavelength shown in figure 3.1. However, the quality control system needs to have its own light to illuminate the profiles and suppress the surrounding light.

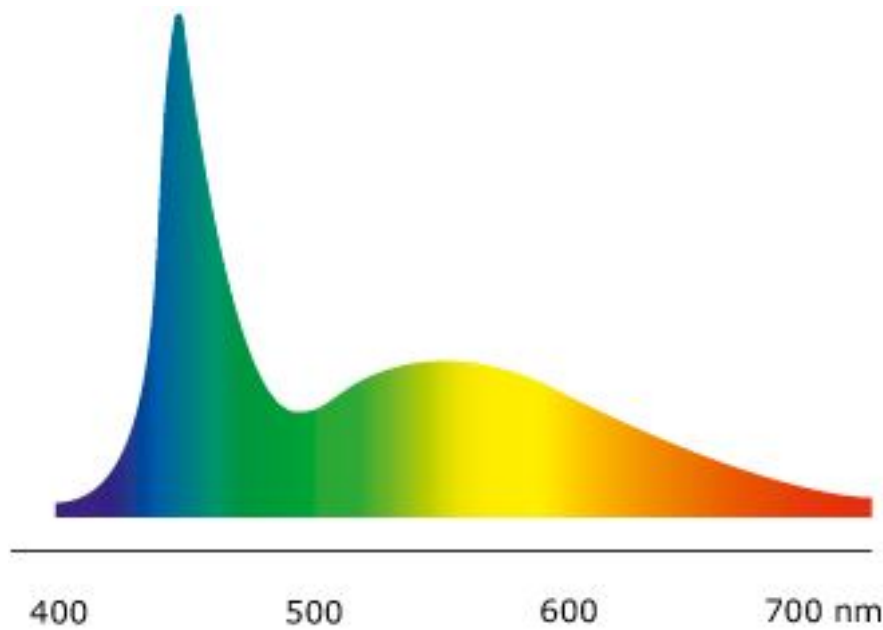


Figure 3.1: The spectrum of the white led light (used as reference for comparisons) [29].

In the production local, there are several windows in the roof where sunlight can come through. Sunlight contains a wide range of wavelength [31]. To consider filtering out this light becomes difficult. Therefore, the best way to keep the sunlight out of the area, is to shield it out.

3.1.5 Optics

The lenses mounted on the camera is a Omron product made specifically for Omron cameras. The lens has to be selected based on the working distance and FOV. When deciding what kind of lens to use, it is important to note the different properties of each lens. Each lens is suited for use in different applications.

When the right kind of lens is chosen, it must be set up correctly. There is two settings that is important, the aperture and the focus. These are tuned with trial and error by setting an object at the working distance adjusting the two until you have a clear and sharp image.

Table 3.3 shows the different lenses used in this project.

Order code	Product details
3Z4S-LE VS-1214H1	Camera low-distortion lens, 12mm, C-mount
3Z4S-LE VS-1614H1N	Camera low-distortion lens, 16mm, C-mount
3Z4S-LE VS-2514H1	Camera low-distortion lens, 25mm, C-mount

Table 3.3: List over lenses used

3.1.6 Mechanical filter

A polarizing filter was mounted on the camera to further enhance the contrast in the image. The filter is mounted in front of the lens by using the threads at the end. A side benefit of mounting a filter is avoidance of contamination on the lens, like dust from the saw.

Product name: 3Z4S-LE SV-PL305, Polarizing filter.

3.2 Control devices

There are two control devices used in this project. A Beijer X2 Control 15 and an Omron FH 3050-20 vision controller. There is also used a Wago 750-354 etherCAT coupler to handle inputs and outputs.

3.2.1 Beijer X2 Control 15

The main controller in the system is a Beijer 15" HMI with iX runtime and CODESYS soft control. iX Runtime 3.10.10 in the controller is responsible for running the HMI application and is using

version 2.40 SP4. The CODESYS soft control is running version 3.5.13.30_4 and the image on the device is using build version 693.



Figure 3.2: Beijer X2 Control 15

3.2.2 Omron FH 3050-20 Vision controller

Image processing is done with the Omron Fh 3050-20 Vision controller running FZ-panda [3.1.2](#). The controller is a industrial computer running Windows Embedded Standard and has built in interfaces for: *EtherCAT, Ethernet, USB, Parallel I/O, Encoder Interface, Monitor Interface, SD Card, Serial Communication RS-232C, PROFINET, EtherNet/IP*



Figure 3.3: Omron FH

In the project the following are used:

EtherCAT is used as the communication protocol between the Vision controller and the PLC.

Ethernet for sending the data and image over FTP.

USB used to connect:

- mouse
- keyboard
- external storage

SD-Card as a storing device.

3.2.3 Wago 750-354

WAGO fieldbus coupler built for connecting the modular WAGO I/O system to the EtherCAT fieldbus [56]. To this fieldbus coupler there are connected two I/O modules, the:

- 750-430, digital input module with eight channels, it receives control signal from sensors.
- 750-530, digital output module with eight channels, transmits control signals to the connected actuators.

3.3 Design and modelling

The main focus for designing the construction is building a lightweight product that is easy to mount on the production line. Started with identifying the problematic element and made an overall plan for the solution.

The design of the mechanical constructions are to be designed using Autodesk Fusion 360 3.10.6 because it provides a solution for sharing projects between members and is free for students.

The material for building test setups and the final solution is aluminium. There are two distinct reasons for choosing aluminium over steel, it is light weight and easy to rework with available equipment. Steel and stainless steel is considered to be harder to rework and would require different machines[38].

3.3.1 Mechanical test setup

The test setup used during testing period at NTNU was built at Amatec by components donated and borrowed from them. This setup is not a part of the product to be developed. Its only a necessity for testing equipment provided at the beginning.

When building the first mechanical test setup there where two distinct reasons why it was built this way

- a test setup should be easy to adjust
- should be possible to mount additional equipment without major rebuild.

A complete table over component used is included in Appendix F. In figure 3.4 an image of the 3D model is shown.



Figure 3.4: Image of the test setup CAD model

Figure 3.5 is an image of the built test setup used for testing the different camera hardware and settings.

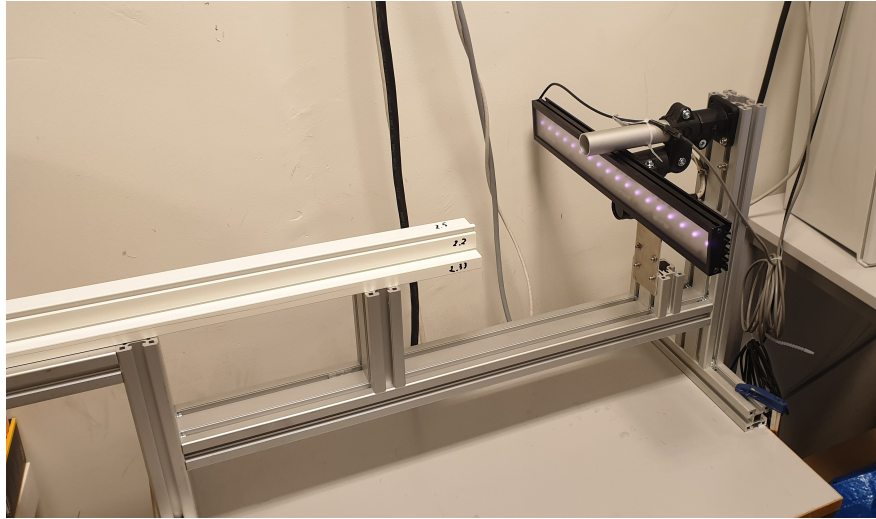


Figure 3.5: Image of the built test setup

3.4 Testing

In order to test the inspection related to the geometry of the quality control, there will be pre-formed tests to verify the accuracy and precision of the system.

By doing these tests there will be generated data from measured features. Data will thereby be extracted and saved to a csv file. The data will be analyzed using Excel and MatLab to verify accuracy and document the precision. In each test a minimum of 100 images will be taken in one run to reduce the margin of error and improve the statistical data.

Test moving

The profile will be pushed forward on the production line where the sensor will trigger the camera and an image will be taken.

Test standstill

Profile will be held in place at the trigger position during production and the data will be collected. This is done to create data to compare against the moving profile data, which is the critical test.

Test sideways

In this test the profile will be moved in the direction perpendicular to the axis of motion during

production. The test is done to highlight the effects of the profile not being positioned properly.

Test late trigger impact

This test is used to document and visualize the effect of the image being captured to late, due to errors such as latency and speed of the production.

This test will be done in five steps, the difference between the steps is the distance from the trigger position to the position of the profile. The interval is set to 1mm and 100 images will be taken for each interval, the test will start at 5mm and end at 1mm.

3.5 Evaluating test data

To evaluate the data generated from testing, different methods must be applied for the different measurements. Methods below are developed to document the performance of the system.

3.5.1 Evaluate accuracy

Data generated using the method test moving 3.4 is used to determine the accuracy of the measurements. To evaluate the accuracy, the average value of the measurements are compared with the actual value of the feature. The difference between the average and the actual value is the measurements accuracy. The actual value is provided with a digital caliper 3.9.1. To calculate the average value, equation 3.1 is used.

The features are divided into three groups and evaluated separately. The first group is measurements under 4mm, the second group is for measurements over 4mm and the last group is measurements of angles. This is to evaluate the systems capability of measuring the different type of measurements separately.

$$\bar{x} = \frac{1}{N} \sum_{i=1}^N x_i \quad (3.1)$$

3.5.2 Evaluate precision

To evaluate the precision, the standard deviation is calculated. When n measurements of the population is known, an estimate of the population standard deviation σ can be calculated. Equation 3.2 shows how to calculate the sample standard deviation, S .

The features are divided in the same tree groups as in 3.5.1. The average value of the standard deviation is represented as the result for the different groups.

$$S = \sqrt{\frac{\sum (x - \bar{x})^2}{n - 1}} \quad (3.2)$$

3.5.3 Evaluate late trigger impact

To evaluate the effect of late trigger impact, the average value of the data generated with 0mm to 5mm displacement is compared. The difference in the average value show the effect of the displacement lead to.

3.5.4 Evaluate test sideways

To document the effect of displacement in y direction, the data from test sideways 3.4 are used. The mean values of the measurements from 0mm to 20mm displacement are compared. Difference between the measurements shows the effect of displacement.

3.6 Trigger delay calculation

Estimation of delay in triggering sequence, delay from when profile triggers the sensor to an image is captured. The delay is estimated by summing the longest response time for each factor.

In the calculation we have taken the following parts into consideration:

1. response time of the sensor

2. input filter of the Wago 750-530 input card
3. update rate interval of Wago internal bus
4. cycle interval EtherCAT
5. cycle interval PLC task
6. processing rate on vision controller

To calculate the effects of the processing time delay, the production speed must also be known. The production speed of the profile is maximum 800 mm/min.

3.7 Communication protocols

In this project there are used 2 communication protocols, these are:

- FTP
- EtherCAT

These were used based on the available interfaces on the hardware provided from Vello Nordic and Amatec.

3.7.1 FTP

FTP stands for file transfer protocol and is a protocol for sending and moving files. FTP has its strength in sharing files across different types of computers and is a reliable solution for transferring files [25].

3.7.2 EtherCAT

The EtherCAT stands for Ethernet Control Automation Technology and is a fieldbus communication based on ETHERNET, it is designed for industrial automation applications and its a

real-time protocol. The protocol is characterized by high performance and flexible topology architecture [24]. EtherCAT uses the master slave principle in communication.

The EtherCAT is available as a fieldbus on the PLC, WAGO 750-354 and the Omron FH 3050-20 Vision controller. In the setup of the master there is several different settings to adjust. The main settings are:

- Autoconfig master/slave, if enable the addresses are set by the master and the devices are configured automatically.
- Source Address, the network interface to use.
- Cyclictime, the time between each cycle of the EtherCAT frame.

3.8 Electrical cabinet and components

The materials used in the electrical cabinet were mainly composed of components borrowed at Amatec AS, the PLC was supplied by Vello Nordic and some components where borrowed at NTNU. How the components are connected can be seen in the electrical drawings in Appendix [P](#).

3.8.1 Fuses

Fuses used in the control cabinet was selected based on the equipment connected. The two fuses used is type C-characteristic 6 and 10 ampere.

3.8.2 Power supplies

The power supply unit (PSU) used in the control cabinet is a book type rated to supply 480 W at 24V DC. DIN rail attachment for easy mounting and push-in terminal for rapid connection. It also has under voltage alarm to warn if the consumption is to high [41].

Consumption calculation

The power supply has to be able to supply enough current and the correct voltage to each of the connected devices. In this control cabinet, only one PSU is needed because all the connected devices are rated at 24V DC.

Table 3.4 shows the maximum rated consumption of the components connected.

Component	Ampere
Beijer PLC X2 Control 15	1.3 A
Omron FH 3050-20*	6.8A
Wago 750-354 ethercat coupler	0.7A
Wago 750-430 Input card	0.1A
Wago 750-350 Output card**	4 A
CSS PD3-5024-3-PT***	2.17A

Table 3.4: Current consumption

* This is maximum consumption when 4 cameras is connected.

** 0.5 Ampere per channel max.

*** This is the maximum consumption when 3 lights are connected.

3.8.3 Bill of material electrical cabinet

Table 3.5 gives an overview over the components used during both the test setup and the final mechanical solution, note the Omron vision controller and the light controller is not included because it's mentioned in their respective sub categories.

Component	Description	Quantity	Supplier	Manufacturer
Beijer X2 Control 15	X2 control panels combine industrial HMI and CODESYS PLC	1	Vello Nordic	Beijer

PT 2,5 - 3209510	Feed-through terminal block	10	Amatec AS	Phoenix contact
PTV 2,5-PE - 1078963	Ground modular terminal block	2	Amatec AS	Phoenix contact
CLIPFIX 35 - 3022218	Quick mounting end clamp for NS 35/7,5 DIN rail	5	Amatec AS	Phoenix contact
PTFIX 18X1,5-NS35 BU	Distribution block, bridged internally	1	Amatec AS	Phoenix contact
PTFIX 18X1,5-NS35 RD	Distribution block, bridged internally	1	Amatec AS	Phoenix contact
PTFIX 18X1,5-NS35 GN	Distribution block, bridged internally	1	Amatec AS	Phoenix contact
Din Rail	Slotted, 35 x 7,5 mm	1m	Amatec AS	Weidmuller
LK4 40040	Slisset kanal, type LK4 40x40	2m	Amatec AS	Rehau
iC60H 2P 6C	Circuit breaker	1	Amatec AS	Schneider
iC60H 2P 10C	Circuit breaker	1	Amatec AS	Schneider
750-354 ethernet coupler	I/O module	1	NTNU	Wago
750-430 Input card	Wago input card	1	NTNU	Wago
750-530 Output card	Wago output card	1	NTNU	Wago

Table 3.5: Bill of material electrical cabinet

3.8.4 Trigger sensors

Sensors used for triggering the image capturing sequence is listed in table 3.6.

Type	Description	Quantity	Supplier
E3Z-LT81 2M	Fotocelle, sender-mottaker Laser, 60m, kablet, PNP utgang	1	Amatec AS
E39-S65A	Slissedecksel for presisjonsdeteksjon for E3Z-T, 0.5mm diameter	1	Amatec AS
S8VK-S48024	DIN skinne montering, 1-fas 100-240VAC forsyning, 480W 24VDC	1	Amatec AS
E3Z-LL81 2M OMS	Fotocelle, bakgrunnsavblending Laser Sensor, 20-300mm, kablet, PNP utgang	1	Amatec AS

Table 3.6: Sensors and necessary accessories

E3Z-LT81 2M uses sender and receiver in pairs. This means that the sender sends the laser beam signal and the receiver reads the laser beam. This makes the system more reliable in changing surroundings [3].

E3Z-LL81 2M OMS uses the principle of background suppression, this means it more affected by changing background [3]. Principle for this kind of sensor is:

1. sensor sends a signal
2. signal is reflected back by an object
3. if the reflected signal changes, the sensor triggers

3.9 Hardware tools

3.9.1 Caliper

A caliper is used for measuring the physical measurements of the profile, it is important to know the exact measurement of the profile for calibration of each measurement. It is used a digital caliper to achieve higher accuracy. The caliper used has an accuracy of 0.03mm and a resolution of 0.01mm [17].

3.10 Software tools

In this section a detailed explanation of the software used during the project, both for developing and organizing the project work.

3.10.1 Codesys

The PLC application is programmed in Codesys V3.5 SP13 Patch 3 and is compiled to run on a target running CODESYS control 3.5.13.30_4.

Codesys support the use of enumeration, which is a data type defined by the user. Enumeration values are used for identifiers of global constants in the entire project [10].

Structures combines different variables into one logical unit. The variables can be of different data types [11]. A structure is declared by creating a new DUT object and selecting structure.

Task configuration is used to define the task's for executing the programs in the application [20].

The task needs the following parameters:

- name, the name of the task.
- priority, if several tasks are ready for processing at the same time, then the one with the highest priority is run first.
- type, determines what condition starts the task
 - cyclic-interval, the task is run at a set interval
 - freewheeling, the task is run as fast as possible.
 - event, internal or external event triggers the start of the task

Devices used in Codesys are described by installing device description file for each device. These files are based on the IEC standard and uses XML. From the vendors one downloads the XML file. By installing these files, the device can be inserted into the application and their functions are available for use.

Programming languages PLC

The PLC programming environment supports the IEC 61131-3 standard when it comes to languages one can choose to program in. The languages used in programming this PLC is:

- Structured text, ST
- Ladder diagram, LD,

3.10.2 iX Developer

iX Developer is used to develop the HMI application in this project. iX Developer is a licensed software from Beijer Electronics. In this project, version 2.40 SP4 is used [14].

This software provides the functionality for:

- data logging
- recipes
- trends
- alarms

The program has built in graphics and vector-based symbols that can be inserted into the screen [13]. These symbols are used to build the buttons, text field and numeric displays on the screen allowing the operator to interact with the system.

iX Developer is open for specialized designed functionality, which can be achieved using C# scripting and .NET framework components [12]. C# modules can be imported or made creating customized functions [15]. By importing third party objects and .NET assemblies, functionality can be further expanded.

Tag exchange

The PLC and the HMI is both running on the same hardware from Beijer Electronics, this means that communication between them is done internally via local ethernet. Codesys has a communication protocol named CoDeSys ARTI which is made for this purpose. The ARTI driver is a polling driver, the driver polls the variables exposed from the Symbol configuration in CODESYS at a set interval [2].

OpenNETCF FTP library

OpenNETCF has developed a library for FTP communication that is supported to run on .NET Compact Framework. The library can be added as an assembly in IX developer and used in script modules or in the script sections in the screens.

Recipe system

IX developer provides a built-in recipe system. The purpose of the recipe system is to update multiple variables and save different variations of these variables. The methods provided by the recipe system used in this project is listed below.

- **SaveRecipe**

The method SaveRecipe saves the values of the recipe tags to the selected recipe. Which recipe to save is selected by the pop-up dialog window or by using a string to defining the specific recipe as an argument.

- **LoadRecipe**

The method LoadRecipe loads a recipe and updates the recipe tags according to the loaded recipe. Which recipe to load is selected by the pop up dialog window or by using a string to defining the specific recipe as an argument.

- **ExportRecipe**

The method ExportRecipe exports the saved recipes in the recipe system to the specified csv file.

- **ImportRecipe**

The method `ImportRecipe` imports the saved recipe from the csv file to the recipe system.

- **DeleteRecipe**

The method `DeleteRecipe` deletes an existing recipe. The recipe to be deleted is either selected from the pop-up dialog, or given as an argument to the method.

3.10.3 VS-studio

Microsoft Visual Studio is an IDE for Microsoft's .NET platform. Visual Studio has support for several different programming languages including *C#* [39].

VS-Studio is used for developing the .Net application for transferring images but also for developing code to run on the HMI.

3.10.4 FZ-Simulator

The FZ-Simulator is a simulator for the FZ-Panda software used on the FH-controller. The simulator offers all functionality as the FZ-panda, except for the possibility of communication and capturing a image. To use the FZ-simulator it is recommended to have an image taken from the FH-controller. It is also possible to import a file to the simulator. [1]

The simulator is used so each task can be divided between more than one person and work can be done more effective. Also makes it possible to work from home with the vision system.

3.10.5 Trello

Trello is a web-based application for keeping control and oversight of tasks that are done or needs work on. It is possible to create own boards and invite people to the given board, this makes it good for group projects. Each task gets it's own card inside a board, each card can have assigned group members, deadline date, comments, checklists and file attachments. [50]

3.10.6 Autodesk Fusion 360

Fusion 360 is a free CAD software for personal and educational use. The software is cloud based and offers easy solutions for group cooperation.[\[9\]](#)

3.10.7 X2ImageLoader_build693

X2 Image Loader is a software for making a image to setup the X2 controller or to transfer a panel image to another image, can either be set up with SD-card or USB-stick. The software is made by Beijer them self.

3.10.8 Overleaf

Overleaf is a program for writing LaTeX code. Overleaf is a web browser app and is free to use and helps make it easier to write LaTeX code. LaTeX is a programming language that is used for technical and scientific writing. LaTeX provides good source handling in compliant with scientific report writing. Overleaf also gives the possibility to write collaborative without any problems with merging conflicts. [\[42\]](#)

3.10.9 Matlab

Matlab is a software developed by MathWorks and is designed for engineers and scientists. It is a programming platform that uses a matrix-based language. The program is used to analyze data, develop algorithms, create models and applications. There is also support for downloading apps and using built-in mathematical functions. [\[37\]](#)

Matlab is in this project used for data analysis and plotting graphs for report.

3.10.10 iX Runtime

iX Runtime is a software from Beijer Electronics and is pre-loaded in every operator panel on delivery [22]. This software is made for running the application programmed in iX Developer on the target hardware.

3.11 Production specification

The profiles produced are drawn with the tolerances standard NS-ISO 2768-1-medium. This standard sets tolerances for linear and angular dimensions without individual tolerance indications [48].

3.12 Project Organisation

There is one project leader and one secretary. The leader's main responsibility is to oversee the progress of the sub tasks and the overall progress of the project. He is also the main contact person and is responsible for delegating work if necessary. Secretary is the deputy in charge if the leader is unavailable. The secretary will send out meeting invitations including progress report and other relevant documents. After each meeting, the secretary writes a meeting report.

A flat organization will be practiced when a decision needs to be taken and the group members needs to come to an agreement.

3.12.1 Organizing

To organize the development of the project, a gantt diagram is used as the overall organizing tool. Every sub part in this diagram is specified and has one accountable person for every given task. The member with the responsibility needs to keep track of the progress and make sure the task is completed within the deadline. The member shall also report the progress to the project leader and inform about any deviations. Complete gantt diagram can be found in Appendix B.

Work distribution

The work distribution is mainly done in the software Trello [3.10.5](#). Trello gives an overview of the daily tasks and helps to keep track of the projects progress. One can clearly see what each member is working on, which results in simpler collaboration.

To distribute the different tasks included with a project, three boards were used. These boards were:

1. Bachelor tasks, which includes sub tasks from the Gantt diagram. This board was changed along the way, as the project needed other chores. This gives full control of the progress, available work and an illustration of remaining work.
2. Report writing, this board was used as to organize and distribute the writing of the report.
3. Miscellaneous, mainly used in the preliminary report and at the start of the project.

Thesis writing

Blackboard provides a structured template for bachelor reports which is used in this report. The template follows the recommended structure for a technical report and is written in Overleaf [3.10.8](#).

3.12.2 Reporting

Reporting progress of the project will be done by writing a progress report biweekly. This report contains information about what we have been working on and the progress of the work. It will also include a section about deviations and problems encountered during the given period. Finally a conclusion and recommendation for further work will be written. A screenshot from Trello is included to give the management group insight in the work distribution for the upcoming weeks.

3.12.3 Meetings

The group has internal meetings biweekly where the progress made in the last two weeks are discussed. A status report is also written during this meeting. Objectives for the next two weeks are planned and tasks are distributed amongst the members.

Meetings with the management group is scheduled Mondays every other week. The participants are the advisors and the contact persons at Vello Nordic. A key point in these meetings are the status reports where the progress is discussed, and the management group can give feedback and eventually support.

Before every meeting, a notice is sent including the status report and other relevant documentation such as pictures from the project. The notice also includes an agenda for the meeting. At the start of every meeting, the attendances have a possibility to add additional agenda items that they want to bring up for discussion.

After every meeting the group had a sit down discussing the meeting and the secretary wrote a meeting report summarizing the meeting. These reports were sent to all the persons invited to the meeting and other relevant persons.

In Appendix [D](#) all the notice for the meetings is included and in Appendix [E](#) meeting reports are included, giving insight in discussions and the development of the project.

Chapter 4

Result

This chapter presents and describes the results achieved during the project.

4.1 Machine vision

4.1.1 Camera hardware

This section deals with the choice and results regarding the different camera hardware that were tested for the machine vision system.

There were tested 2 different cameras for the project, see table [3.1](#) for details.

2MP camera

The first camera that where tested was a 2MP 2040x1088 camera, the requirement for FOV is minimum 100mm in both directions. Because there are less pixels in the height, FOV in the height direction is set to 100mm. The smallest feature that the camera can measure are calculated by using equation [2.1](#).

$$SmallestFeature = \frac{100mm}{1088} \cdot 2 = 0,184mm \quad (4.1)$$

5MP camera

A 5MP 2448x2044 pixel CCD camera was also tested. The FOV in the height direction was set to 100mm. Calculation [4.2](#) shows that the camera had a high enough resolution for the precise calculation needed. Since there is more pixel diagonally than vertical the FOV becomes 120mm x 100mm. This camera was chosen for use in the project.

$$SmallestFeature = \frac{100mm}{2448} \cdot 2 = 0.082mm \quad (4.2)$$

4.1.2 Optics

For the project there were tested 3 different camera lenses, a 12mm lens, a 16mm lens and a 25mm lens, see table 3.3 for specifications.

The three lenses tested all provided a sharp image with a FOV of 100mm. The differences between the lenses are working distance and distortion they add to the image. Short working distance causes more shadows and larger distortion with the same FOV. Distortion is a result of using entrocetric lenses but is reduced at higher focal lengths.

Adjustment of camera optics

When adjusting the lens setting the focus was to have a powerful light source and keep the aperture of the lens big, this lowered the impact other light sources had in the image. Focus is adjusted to obtain a sharp image. The focus is adjusted by trail and error and must be adjusted depending on the lens that is used.

4.1.3 Calculated working distance

The working distance is calculated based on the chosen camera, lens and FOV. Table 4.1 shows the calculated working distance of the different cameras and lenses with a vertical FOV of 100mm. Equation 2.2 and 2.3 are used to calculate the working distances.

Focal length/Camera	2MP	5MP
12mm	200.67mm	169,01mm
16mm	267.56mm	225.35mm
25mm	418.06mm	352,11mm

Table 4.1: Calculated working distance with FOV height of 100mm

4.1.4 Lighting

In this section, the result of the different light sources will be presented.

Circular white LED

Circular white LED light gave clear edges on the profile, but the fiber mat inside the profile was nearly invisible. Surrounding light in the environment impacted the image causing disturbances. This caused unwanted shadows and varying light intensity in the image.

Figure 4.1 shows an image taken with the circular white led light.

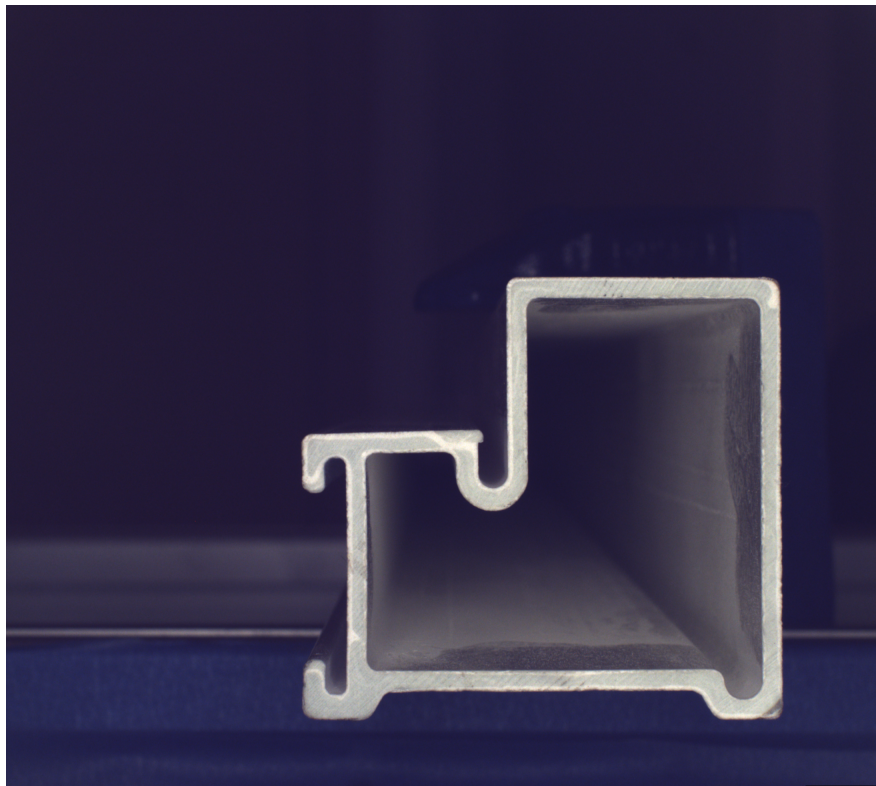


Figure 4.1: Raw image taken with circular white LED light

IR light bar

IR light bar gave clear edges on the profile and the fiber mat inside the profile was accentuated. Since the light source was a bar, it was not possible to evenly light up the profile, this made the

result of the image inconsistent. Figure 4.2 shows an image taken with the IR bar.

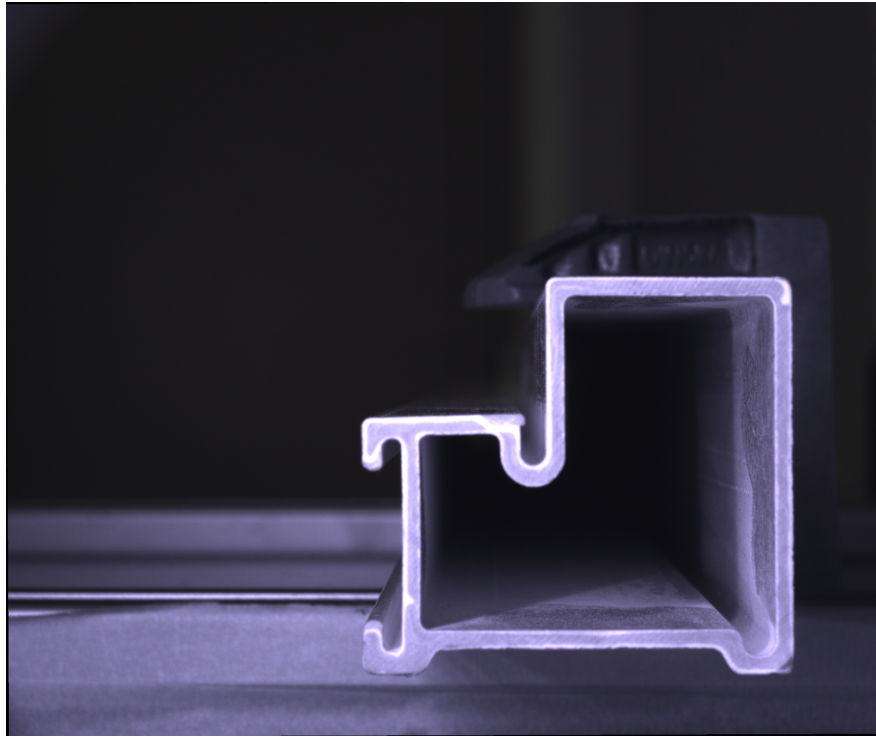


Figure 4.2: Raw image taken with IR bar

Circular IR light

The circular IR light accentuated edges on the profile and the fiber mat inside the profile. Intensity of the light was more intense in the middle of the FOV due to the curvature of the light. At desired working distance, the light had focus in the the middle of the FOV. This made the lighting on the profile a bit uneven, but still the whole FOV was illuminated. The light source is affected by the environment in the same way as 4.1.4, since they have the same wavelength in their light. Figure 4.3 shows an image taken with the circular IR light.

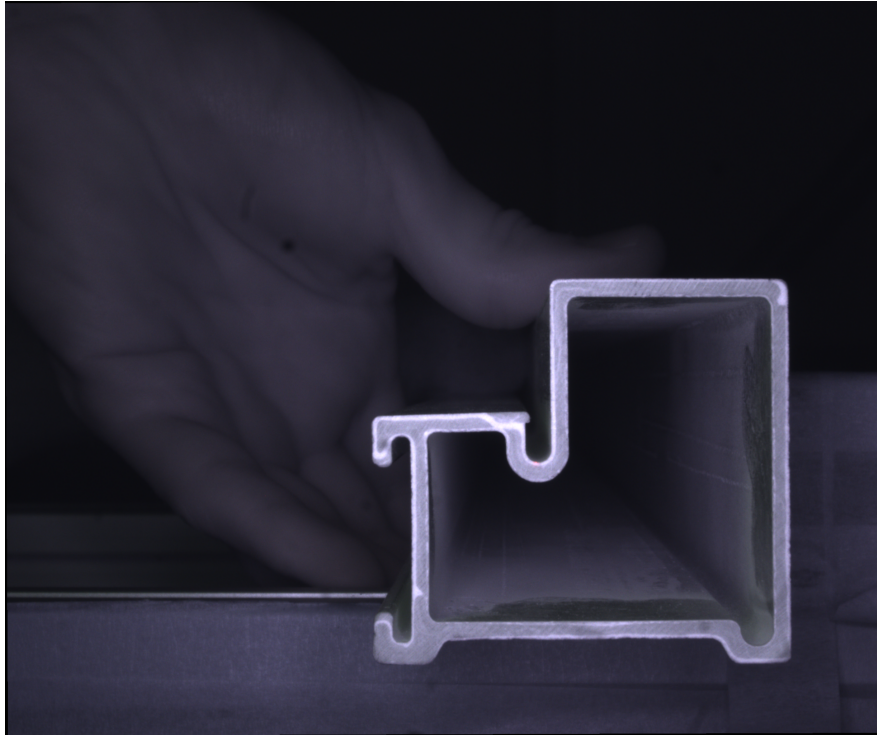


Figure 4.3: Raw image taken with circular IR light

4.1.5 Vision controller flow

Figure 4.4 shows the main flow of the Omron vision controller. The section will present the result for the main parts of the image analysis.

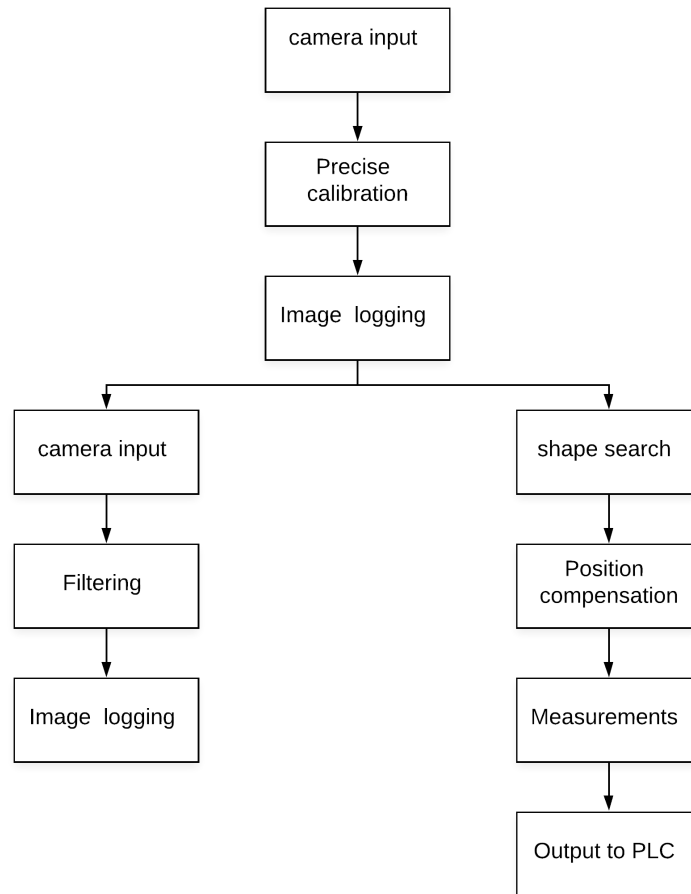


Figure 4.4: Flowchart image processing

4.1.6 Calibration and position compensating

Calibration of the images are preformed to transform pixel values to real dimensions as well as compensate for distortion in the image. To achieve this, Precise Calibration tool [3.1.2](#) is used. The result for Precise Calibration is a corrected image that can be used to extract details with precision.

When the image is corrected, the profiles position is located using Shape Search 3. The algorithm searches for the profile based on a registered model of the specified profile. The registered model is defined when creating a new profile type in the vision software. When the profile's position is located, the tool calculates the correlation factor against the model. Shape search 3 managed to locate the profile position and check that the profile is of the correct type using the

correlation factor.

Position coordinates from Shape search 3 is used to compensate for the position's variance in the direction perpendicular to the production. The reason for compensating the image is to move the profile to the same location every time in the image, this way the tools used later in the flow can have the same static position. Position Compensation tool is used to perform the task, and the result is that minor deviation in position of the profile, does not affect further processing. The effects on accuracy due to position compensation is shown here [4.2.4](#).

Figure 4.5 shows shape search in use. The boxes in the image is where the model is found, and on the bottom right the correlation between the found and the registered model is shown. Correlation between 95-100% means that the system is correctly configured and there are not any structural faults or missing features.

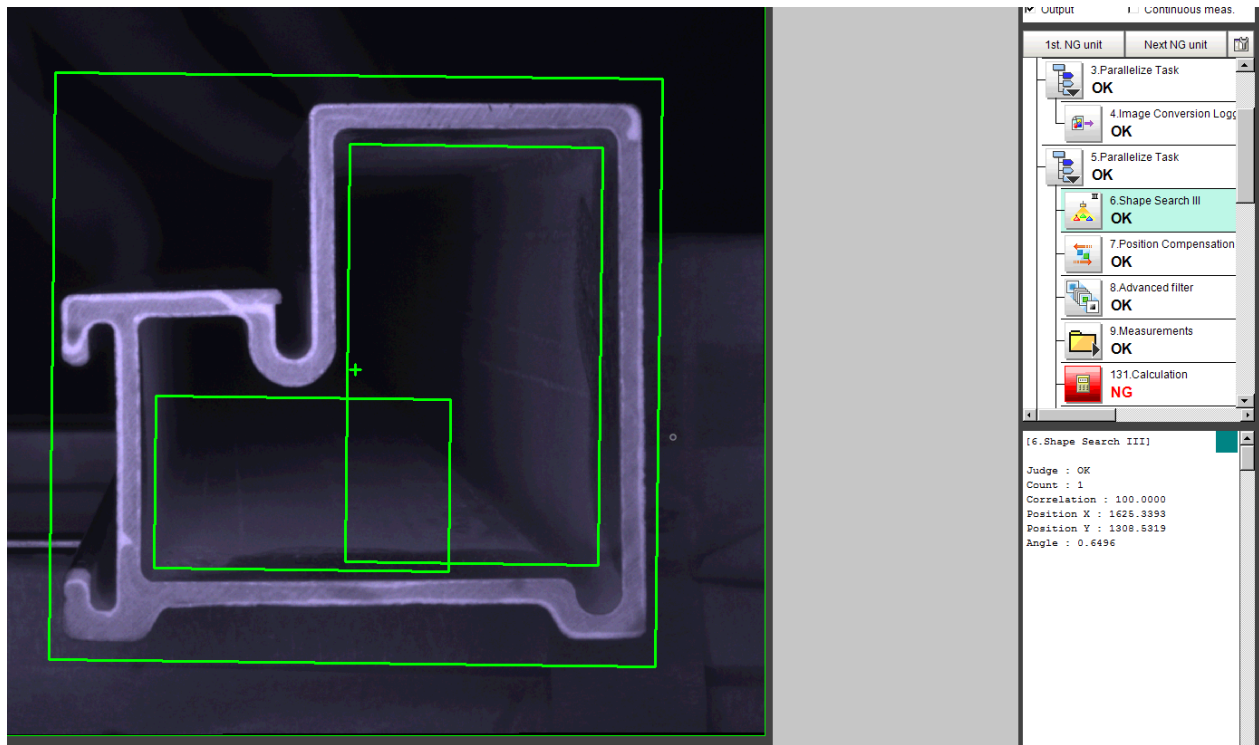


Figure 4.5: Shape search

4.1.7 Feature measurement

To measure a feature Scan edge position is used in pairs to perform a measurement. Scan edge tool is positioned in the image where one wants to measure. Each scan edge position is adjusted separately to find the edge on the feature as precisely as possible. This is done by having a profile where each feature measurements is known. Figure 4.6 shows the scan edge position in use on a profile.

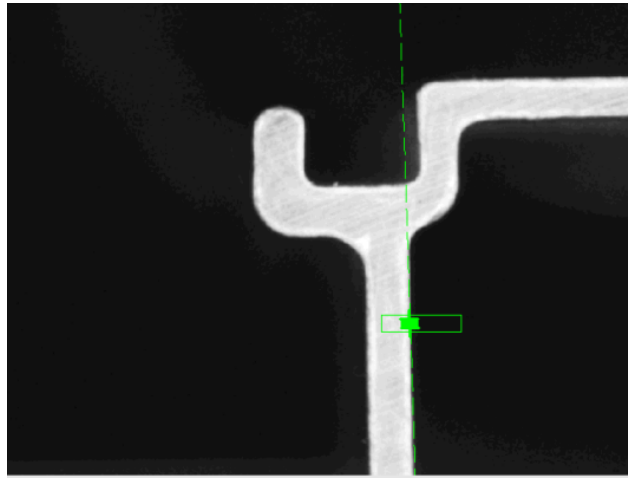


Figure 4.6: Scan edge

When two edges are found the Calculation tool is used to calculate the dimension of a feature. In the calculation unit the tolerances for the specific feature is known and based on this a system variable of the specific feature is set.

4.1.8 Accentuation of fiberglass mat

To accentuate the fiber mat, several different methods were tested. The Advanced filtering tool is used to achieve these results. In this tool there are combined different filter combinations to accentuate the fiber mat. The result from the different approach are described.

Extract edges 5x5

Figure 4.7 shows the result with an extract edges filter with a 5 x 5 matrix. To the left on the image, the fiber mat is visible as the small black line inside the profile with bright green edges. On the rest of the profile the fiber mat is placed adjacent to the edge and is therefore more difficult to separate and make visible.

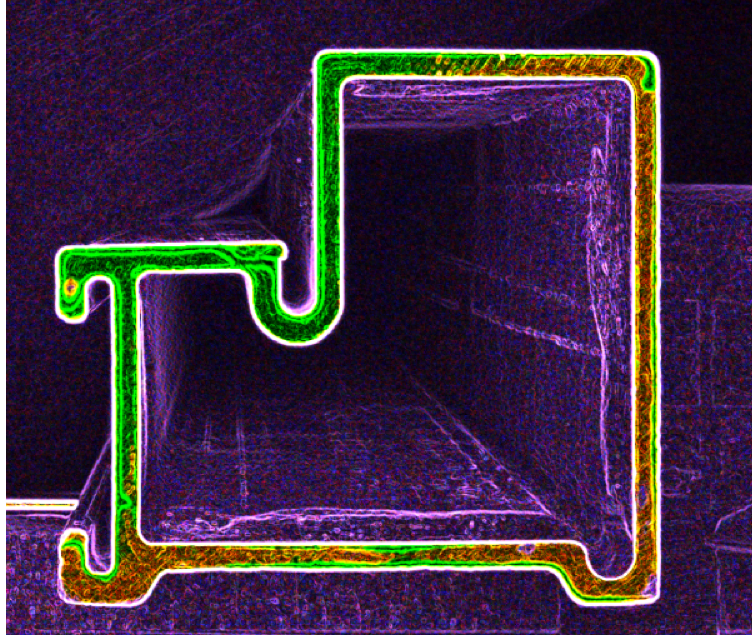


Figure 4.7: Extract edges

Background suppression

Figure 4.8 shows the result from using a background suppression filter 2.2.4. This filter suppresses colors outside the selected range of colors. By applying this filter, the fiber mat becomes visible. Experience from testing shows that the filter requires a unique intensity or color of the mat.

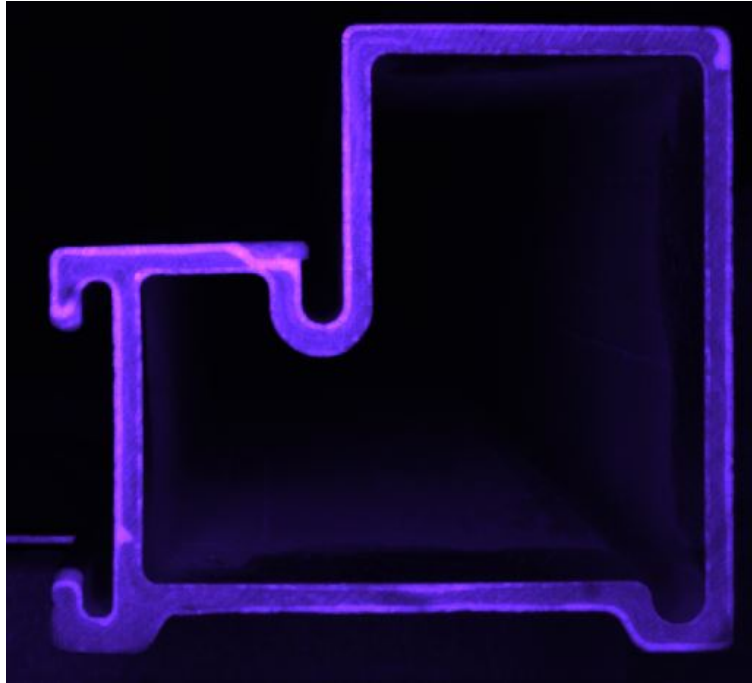


Figure 4.8: Background suppression

Background & extract edges 3x3

A combination of background suppression and extract edges with a 3 x 3 matrix in a was also tested to accentuate the fiber mat and the result from this is shown in figure [4.9](#).

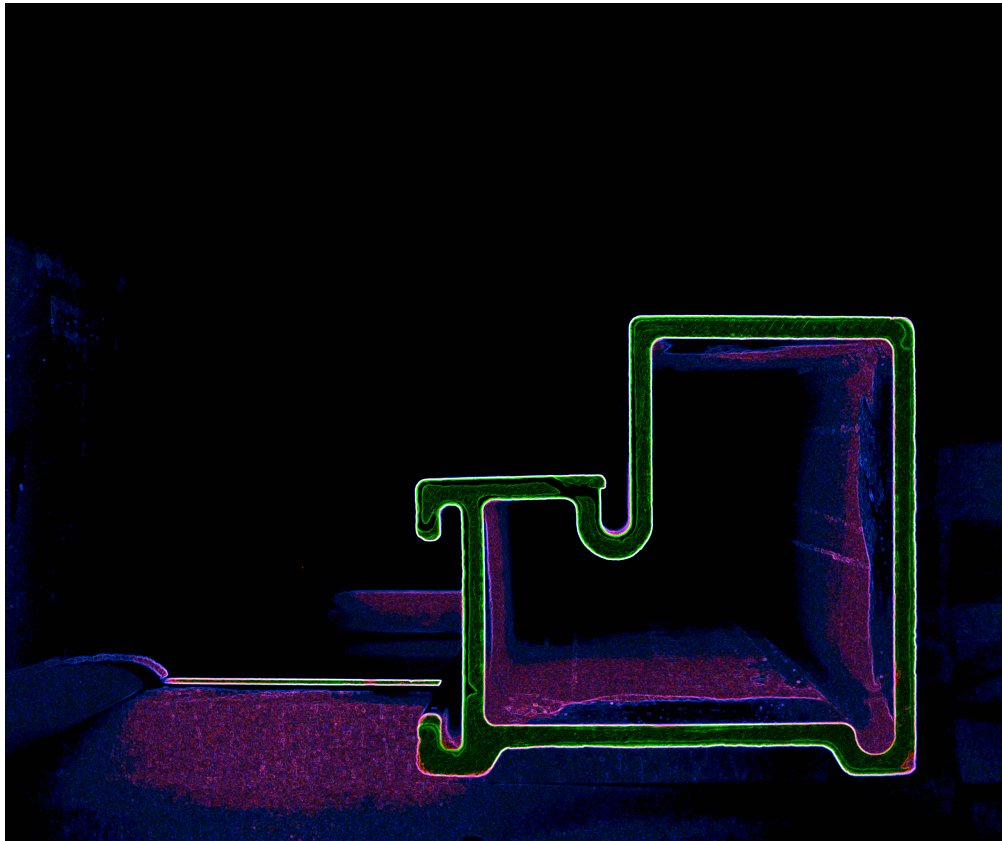


Figure 4.9: Background suppression and extract edges

4.1.9 Highlighting error

To highlight when an error occur, the result display tool is used. Result display gives a graphical presentation of the faults detected on the profile. It uses system variables to determine if there is a fault to be displayed. Each measured feature is set up graphically when configuring a new scene and is shown when a calculation judgment is negative. Figure 4.10 show how a fault is presented to the user. The figure indicates that the distance between the red lines is 52.31mm.

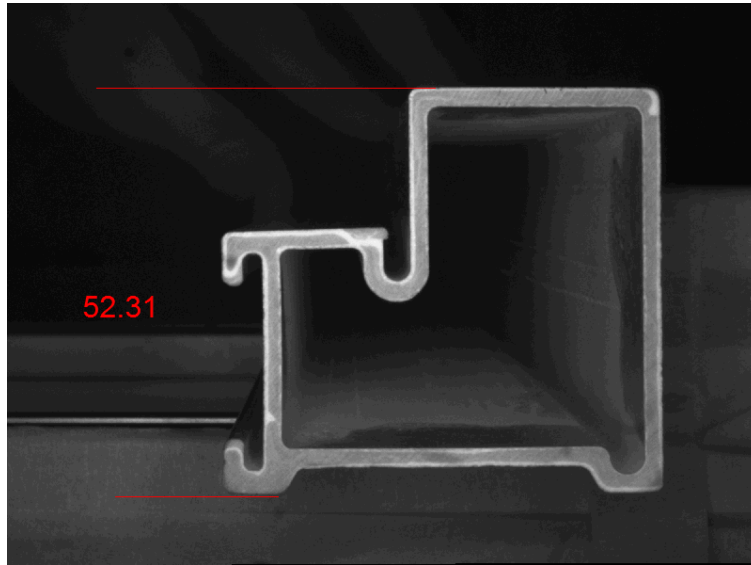


Figure 4.10: Result display

4.1.10 Logging

The software on the vision computer is configured to log two different images using image conversion logging and a third image is logged using the .Net application developed [4.6](#). These three images are logged so that they can be sent to the operator panel for visualization.

1. **rawImage**, this is an unfiltered image
2. **filteredImage**, this image is filtered to highlight the fiber mat as good as possible for the operator to inspect.
3. **resultImage**, this image highlights the features that are not within tolerance.

There is also set up the possibility to log the raw image directly to a network drive where one can chose between logging every image or only NG (NOT GOOD). The NG reflects if the features are within their specified tolerance.

4.1.11 Setup of new profile

When setting up a new kind of profile in the vision system every measurement needs to be calibrated and aligned to the correct position. The alignment and calibration of each measurement is done graphically. See setup manual for more detailed information in Appendix N.

4.1.12 Cost of hardware

The cost of the vision equipment from Omron is given in table 4.2 below. These are only the cost of hardware where no configuration or other necessities are included.

In table 4.2 only the cheapest Vision controller is used, this controller is able to perform as needed in this project. The camera is also changed compared to the one used in the project, the reason for changing the camera is due to the cost of a high resolution CCD camera compared to a CMOS.

To be able to choose the best suited controller one must have a plan over the whole quality control in the production. This must be known to be able to calculate which controller is most suitable.

Type	Product description	Price
FH-1050	FH vision controller, standard, Intel Celeron, 2 core type, 2 camera, NPN&PNP	58,000
FH-SC04	FH camera, high resolution 4Mpixel, color, 1" CMOS - (only for FH controller)	54,600
3Z4S-LE VS-2514H1	camera low-distortion lens, 25mm , C-mount	4,183
3Z4S-LE SV-PL305	Polarizing filter for 30.5mm lens.	365
FZ-VS3 5M	cable for FZ/FH camera 5m straight plug	4,951

Table 4.2: Cost of Omron vision hardware

4.2 Accuracy and precision

During the test at Vello Nordic's facility we conducted the four different tests described 3.4. These tests provide the data used in the calculations.

Figure 4.11 shows a drawing of the profile used for testing. The different features are marked with a letter identifier. These identifiers are refereed to later in the report.

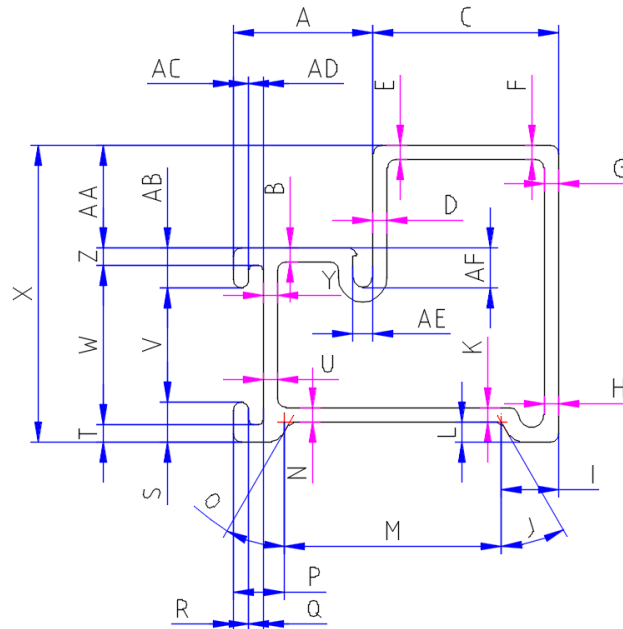


Figure 4.11: Drawing of test profile

4.2.1 Evaluating accuracy

To evaluate accuracy, the method described in section 3.4 is used. Mean values of the measurements are compared with the actual values.

Table 4.3 show the results of the features with lengths under 4mm. All the features are within the range of accepted result, except feature L. The average error of the small features under 4mm are 0.016mm.

Feature	Actual	Measured	Error
B	2.57mm	2.573mm	0.003mm
D	2.47mm	2.466mm	-0.004mm
E	2.54mm	2.538mm	-0.002mm
F	2.54mm	2.543mm	0.003mm
G	2.44mm	2.438mm	-0.002mm
H	2.43mm	2.419mm	-0.011mm
K	2.55mm	2.547mm	-0.003mm
L	3.35mm	3.527mm	0.177mm
N	2.50mm	2.499mm	-0.001mm
Q	2.51mm	2.523mm	0.013mm
R	2.72mm	2.669mm	-0.051mm
T	3.06mm	3.059mm	-0.001mm
U	2.45mm	2.443mm	-0.007mm
Y	2.46mm	2.451mm	-0.009mm
Z	2.99mm	2.986mm	-0.004mm
AC	2.73mm	2.729mm	-0.001mm
AD	2.54mm	2.536mm	-0.004mm
AE	3.51mm	3.502mm	-0.008mm
AG	2.81mm	2.820mm	0.010mm

Table 4.3: Mean values of features under 4mm

Table 4.4 shows the results of the measurements of the features with length over 4mm. All of the features have an error under 0.1mm. The average error is 0.017mm.

Feature	Actual	Measured	Error
A	24.40mm	24.402mm	0.002mm
C	32.54mm	32.509mm	-0.031mm
S	7.17mm	7.168mm	-0.002mm
V	19.87mm	19.845mm	-0.025mm
W	28.03mm	28.021mm	-0.009mm
X	52.34mm	52.343mm	0.003mm
AA	18.20mm	18.165mm	-0.035mm
AB	7.07mm	7.038mm	-0.032mm
AF	6.95mm	6.965mm	0.015mm

Table 4.4: Mean values of features over 4mm

Table 4.5 contains measurement data of the measured angles of the profile. The angles of the physical profile were not measured due to lack of measurement equipment. The actual value is therefore taken from the drawing of the profile. Both measurements are out of the accepted range tolerance of 0.5° . The average error is 3.5083° .

Feature	Actual	Measured	Error
J	30.00°	31.038°	1.038°
O	30.00°	35.978°	5.978°

Table 4.5: Mean values of angles

4.2.2 Evaluating precision

Table 4.6 shows the average standard deviation of the three groups.

Group	Mean standard deviation
Length <4mm	0.0030mm
Length >4mm	0.0108mm
Angles	0.2300°

Table 4.6: Standard deviation of feature groups

4.2.3 Measurements of another profile

Another profile of the same type was also tested with the method testing moving described in 3.4. Because the system is calibrated with profile A, testing with another profile is necessary to test the system's ability to measure different profile of the same type. Figure 4.12 illustrates and compares the measurements from profile A and profile B. The first plot shows the error based on the measured value and the actual value for both the profiles. The second plot shows the standard deviation of the measurements for both the profiles. Average error of the length measurements of profile B is 0.0767mm. Profile B has a greater average error of the lengths compared to profile A, which has an average error for the lengths of 0.0166mm.

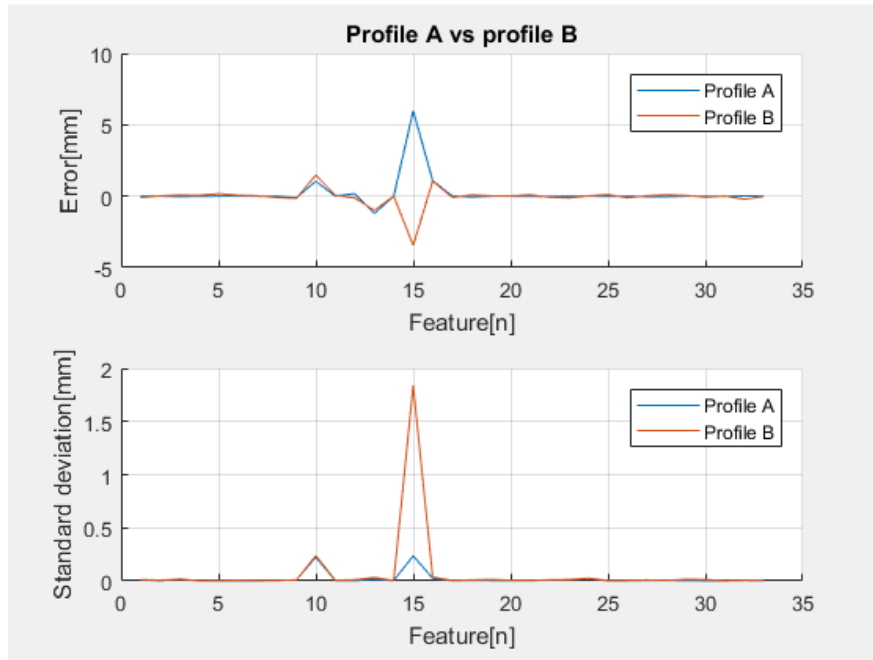


Figure 4.12: Profile A vs Profile B

4.2.4 Effect of displacement sideways

The results from the test method described in 3.4 testing sideways is conducted to document the effects on accuracy when simulating sideways displacement. Figure 4.13 shows the effect on feature C while figure 4.14 shows the effect on feature N. Figures 4.13 and 4.14 shows that different measurements are affected differently due to displacement.

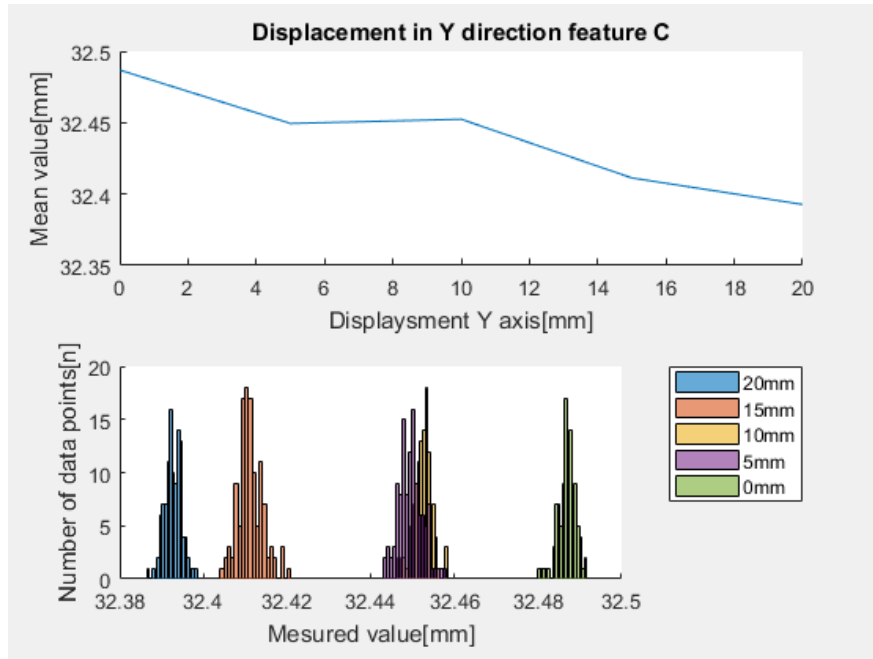


Figure 4.13: Displacement in Y direction feature C

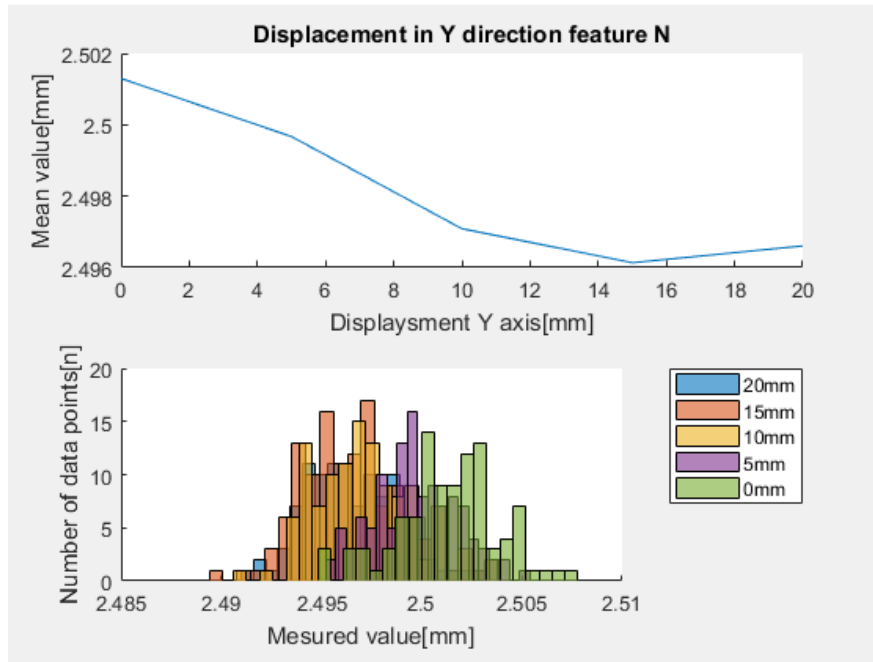


Figure 4.14: Displacement in Y direction feature N

4.2.5 Effect of late trigger impact

The test performed according to test late trigger impact in 3.4 shows the effect of displacement in the X direction caused by late triggering. Displacement in the X direction has an impact on all measured dimensions. The effect on the measured value differs as seen in figure 4.15 where feature E is shown compared to figure 4.16 where feature X is shown.

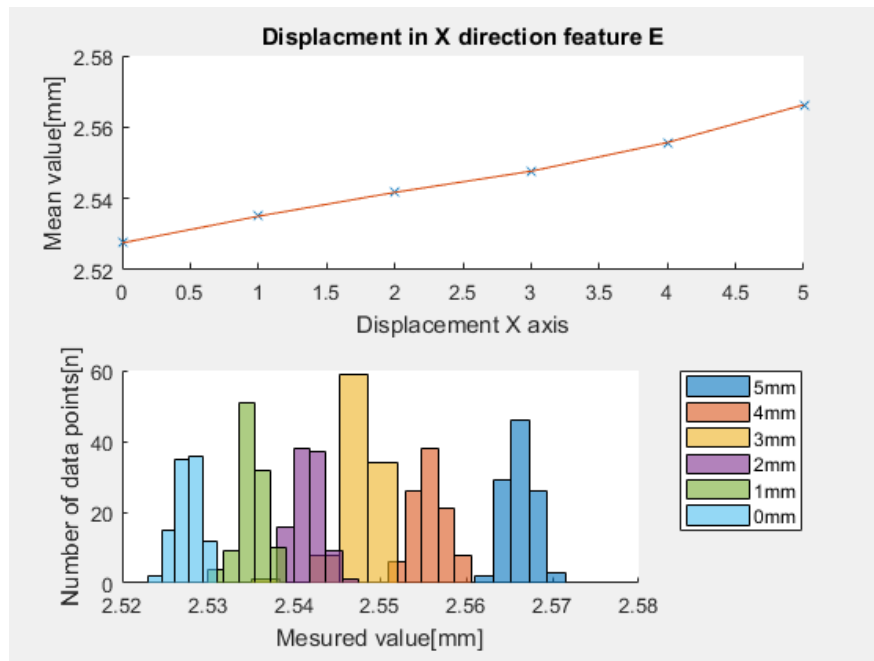


Figure 4.15: Displacement in X direction feature E

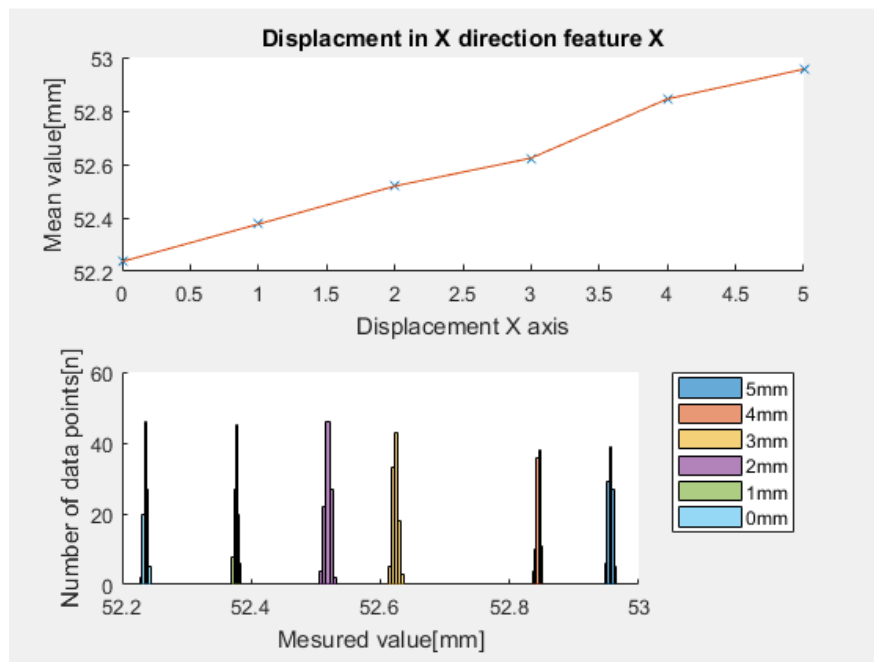


Figure 4.16: Displacement in X direction feature X

4.3 PLC

As the main controller in the project the PLC has several different tasks to perform. Its main job is to control the sequence in the image capturing and sending the results to the HMI. The PLC has the IP 192.168.1.10 during this project and is available on port B of the Beijer X2 Control unit. The image capturing sequence triggers the camera as required and retrieve the data sent from the vision computer. When new data is received the PLC converts it and sends the data to the HMI application. The PLC program takes care of notifying the HMI when a new image is ready to be presented.

When a new profile is selected in the HMI recipe system the PLC is responsible to take the new profile data and update the scene data in the vision software, this is done over EtherCAT using the program `setProfileVision`.

The data from the quality inspection that should be saved to the database is ready in the PLC. To automatically update this data, privileges and setup of structure needs to be implemented.

4.3.1 Function block

There are used several different function block in the program, some are standard and included in CODESYS while two are result from the project.

fbChangeScene is a function block programmed in structured text used for changing the scene and group on the vision computer. It uses the global variable representing the vision computer to achieve this by altering the correct parameters in a sequence.

fbSetUntiData function block used to alter the unit data of the calculation tool in the vision software. By changing the unit data one can adjust the upper and lower limit of the calculation.

4.3.2 Program

There are three main program's in the PLC software that is developed. These are responsible for carrying out the task of the PLC has. These are:

- **equipmentControl** program to control the external devices connected at the inputs and outputs.
- **measureProfile** program with a sequence for triggering and retrieving the results from the vision controller.
- **setProfileVision** program used for changing parameters and setup in the vision software based on the profile selected in the HMI.

4.3.3 Task Configuration

Task configuration is used to organize and run the different programs in the PLC application. In the project there are two tasks, the main task and EtherCAT task. The main task has priority one and is run every 4ms. It has three calls to different POU:

- equipmentControl
- measureProfile
- setProfileVision

The EtherCAT_Task is run every 4ms and is prioritized as one, meaning highest priority. This task is responsible for running the EtherCAT communication.

4.3.4 Structures

Structure, or struct are used in the PLC to make the program more transparent by combining several variables with different data types into one logical unit.

sCamera is a struct used to represent all the data included in the communication between the PLC and Omron FH Vision controller.

sFeature used to hold all the necessary information of one feature on the profile.

sHMI includes all the basics variables to control the program with the HMI.

sMeasurement contains one value from the inspection.

sProfile represents a complete profile with all of its data.

sResults used inside the sCamera to collect all measurements from vision pc in one collection.

4.3.5 Enumeration

Enumeration is used to abstract the value of constants in the project making it easier to read and understand.

- **eCaseMeasure** used in the program for controlling the sequence of inspecting the profile.
- **eCaseProfileVision**, for controlling the sequence of changing the setup in the vision software.
- **eCaseSetUnitData** for controlling the sequence of editing the tool's unit data in the vision software.
- **eCommandDataEtherCat** used to abstract constants values used in communication with the vision controller.
- **eCommandGet** to abstract constants values used in reading data from the vision controller.
- **eCommandSet** to abstract constants values used in setting data in the vision controller.
- **eSceneChangeCase** used to control the sequence of a scene change.

4.3.6 Global variables

Global variables are used to communicate between the different parts of the PLC software. There are four different list of global variables, this is done to separate the different variables in the project.

- **gvHMI** this list holds the variables used in communication with the HMI.
- **gvIIO** this list holds the variables used for the inputs and outputs.

- **gvlProfileRecipes** this variable list holds the loaded profile and dummy profile data used for testing.
- **gvlVisionSystem** variable list where the camera variables are stored.

4.3.7 Communication with HMI

The data exchange between the PLC and HMI is done by use of a proprietary communication protocol Codesys Arti. The variables that should be available are set in the Symbol configuration as explained in [3.10.2](#). These variables are as follows:

- gvlHMI
 1. HMI
 2. loggingImageFileName
 3. resultMeasurement
- gvlProfileRecipes
 1. loadedProfile

4.4 HMI

4.4.1 Description of screens

The finished HMI screens are explained in detail below.

Quality control

Quality control is the main screen for the vision quality control system. From this screen, the operator navigates to the other screens concerning the quality control, as well as the alarm screen. The screen itself provides the operator with general information about the profiles measured. To the left on the screen, there is a list that consist of measurement results. By selecting a measurement from this list, the image belonging to this measurement is displayed to the right, one

can chose between raw image, filtered image and result display. The list has a dedicated column which reflects the result from the inspection and also has the possibility to sort the measurements based on this.

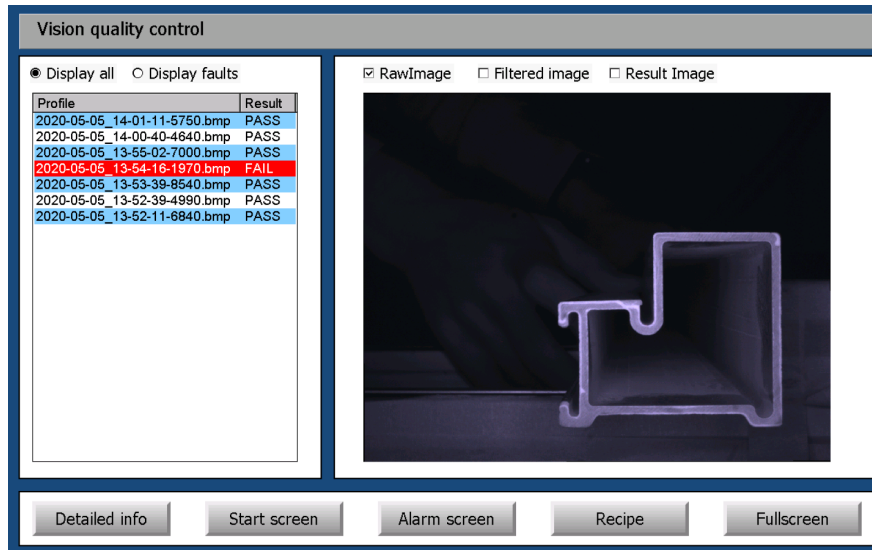


Figure 4.17: Quality Control Screen

Result details

This screen has more detailed information regarding the measurements done for the selected profile, the screen can be opened from the Quality screen. It contains a list of all the measurements performed of the profile with the associated tolerance and target value. Measurements with deviation that's more than the required tolerance is marked with a red background and "FAIL" in the result column. In the feature column, every measurement has a letter identifier. Every letter has a corresponding letter in the drawing of profile in the right of the screen.

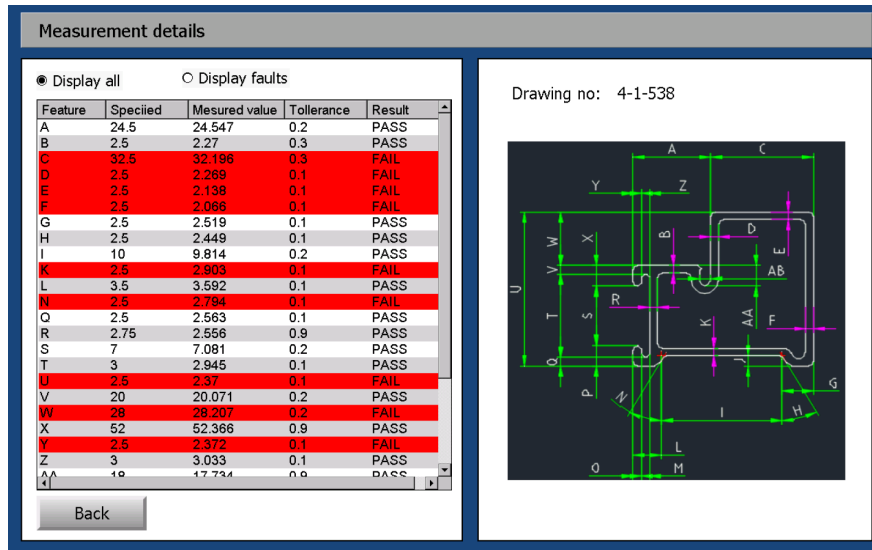


Figure 4.18: Quality Control Screen

Recipe menu

The purpose of the recipe screen is to manage and select recipes. When the “Load recipe” button is pressed, a list of saved recipes is presented in the middle of the screen. By selecting one of the recipes, the recipe is loaded, and corresponding tags are updated. To create a new recipe, the buttons “New recipe” or “Copy recipe” is used. The “New recipe” button creates a new recipe with all values set to zero and the “Copy recipe” button makes a copy of the already loaded recipe with a new recipe ID. To edit values on the loaded recipe, the button “Recipe edit” is used. This opens the edit recipe screen for editing. Buttons for creating new recipes and editing recipes is password protected. This requires a user with administrator privileges to be logged on to the system.

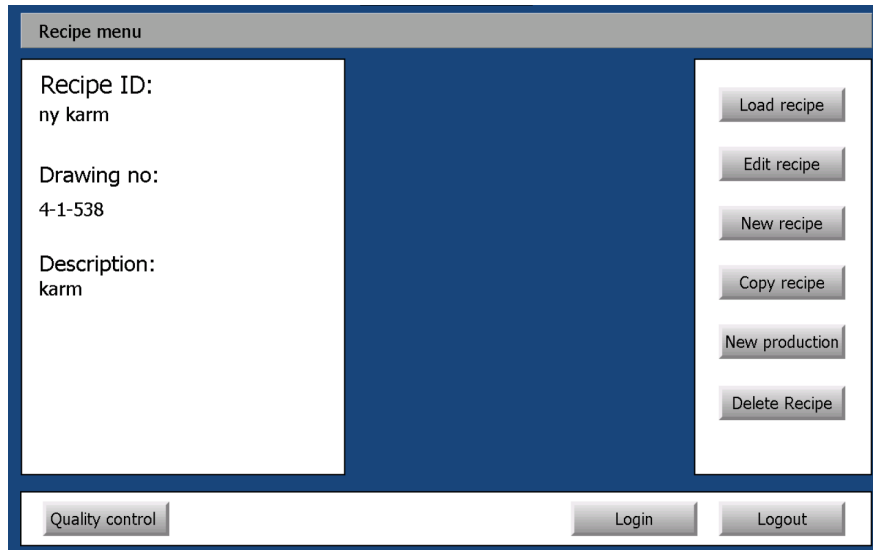


Figure 4.19: Recipe menu Screen

Recipe edit

To edit an already loaded recipe, the recipe edit screen is used. The screen displays a list of all the measurements done for this recipe. The parameters specified, tolerance, scene-unit and Data number can be edited from here. This is done by selecting one of the features and using the edit section in the bottom of the screen. The editing of the numbers has a check for correct format. If the numbers have an incorrect format, the user gets informed. Editing of the drawing number, group number, Scene number and description is done in the segment on the right-hand side. To confirm the changes the button “Done” is pressed. If the button “Cancel” is pressed, all the changes done is discarded.

Identifier	Value	Tolerance	Scene-unit	Data number
A	24,5	0,2	131	0
B	2,5	0,1	131	1
C	32,5	0,3	131	2
D	2,5	0,1	131	3
E	2,5	0,1	131	4
F	2,5	0,1	131	5
G	2,5	0,1	131	6
H	2,5	0,1	131	7
I	10	0,2	131	8
J	-1	100	131	9
K	2,5	0,1	131	10
L	3,5	0,1	131	11
M	-1	100	131	12
N	2,5	0,1	131	13
O	-1	100	131	14

Figure 4.20: Recipe edit Screen

4.4.2 Recipe system

The built in recipe system provided by IX developer described in 3.10.2 is used to store different types of profiles. A recipe called RecipeProfile is made for holding values regarding a specific type of profile. The values are specified value, tolerance and values concerning the setup in the vision controller.

To realize the functionality described in the recipe edit screen, methods from the recipe system are used. Figure 4.21 shows a flow chart illustrating how its implemented. The button OK edits the selected feature. The internal tags corresponding to the selected feature are updated if the format of the new values are correct. When the button Done is pressed the drawing number, scene number, group number and description is checked for correct format and updated. After that, the method SaveRecipe is called to save the values of the internal tags to the recipe system. When this is complete, the method ExportRecipe is called to export the recipe system to a csv file and the PLC is notified that changes has been done to the tags. The Button Cancel discards all changes done. This is done by calling the method LoadRecipe. By loading the recipe, the values in the recipe system will be written over the internal tags and eventual changes will be discarded.

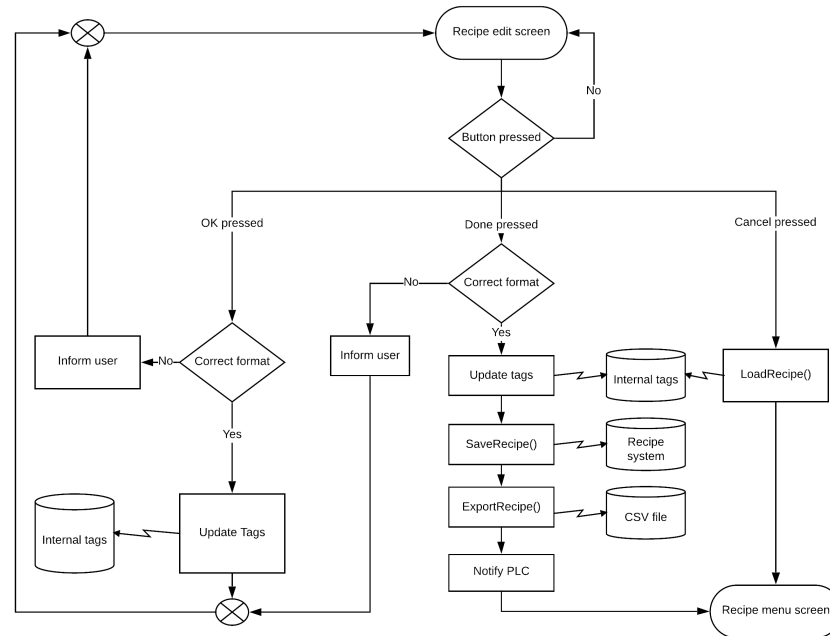


Figure 4.21: Flow chart for editing recipes

4.4.3 Triggering Alarm

When a measured profile is out of its range of accepted result, an alarm is triggered. To manage the alarm's, Beijer's own built in alarm handling system is used. When one or more of the measured features is out of its accepted tolerance, an alarm is generated. The alarm is immediate set as an inactive alarm which means that the occurrence is no longer present. This causes the alarm to always be inactive. The alarm still needs to be acknowledged from an operator. The alarm appears in the alarm viewer along with other generated alarms. Alarm viewer supports several built-in features such as logging filtering and acknowledge.

4.4.4 Saving profile information

To retain the information of the measured profiles after a power cycle, the information needs to be stored. Because some of the serialization methods are not supported by dot net compact, saving the instance must be performed in an alternative way. By writing the information to a txt file in a specified format, retrieving the information can be accomplished by implementing an

algorithm that retrieving the information according to the format from the txt file and creating the instances based on the information.

4.4.5 HMI settings for tag exchange

Figure 4.22 shows the settings in iX Developer which enabled to communication between the HMI and PLC applications

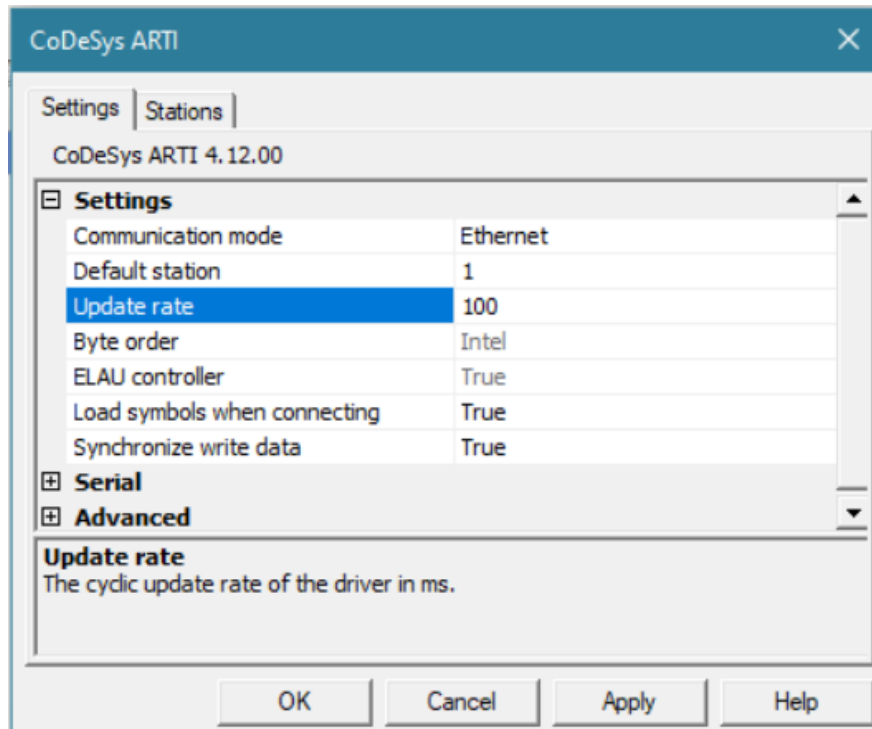


Figure 4.22: Settings in iX Developer Tag exchange

4.5 EtherCAT coupler

The Wago EtherCAT coupler is used for receiving signals and controlling actuators. There are two different cards connected to the EtherCAT coupler, one input and one output card. To the input card connected the signal from the laser sensor connected. There are two signals connected to the output card, these are:

- the light controller, this is used for turning on and off the light.

- an air valve, used for turning on and off the pressured air.

4.6 Image transfer application

The images generated from the vision controller must be transferred to the HMI panel. Different solutions have been developed to accomplish this task with different results.

There was first attempted to use the HMI panel to retrieve the images from the FTP server located in the vision controller. Because the standard library's for ftp transfers is not supported, a third-party library was used. This solution was able to find and download the image to the HMI panel. The time spent for finding the newest image generated and downloading an image was around 50 seconds.

There was also implemented an application programmed in .NET Framework running on the vision controller. The application can be started automatically when the vision controller turns on by using Windows task scheduler. The application runs on .Net Framework 3.5, standard library's are supported. The application developed is event driven. Event's trigger when files or directories are created in the folder where the images are to be stored. When the event occurs, the application finds the newest generated images and transfers these images to the HMI-panel FTP server. The solution also managed to get the result display 3.1.2 by taking a screenshot of the screen and sending it to the FTP server.

4.7 Communication result

Figure 4.23 shows the systems main data flow. On each line where data is exchanged the communication protocol between each hardware is included. The figure also includes details about the IzP, MAC and EtherCAT address setup on the different hardware.

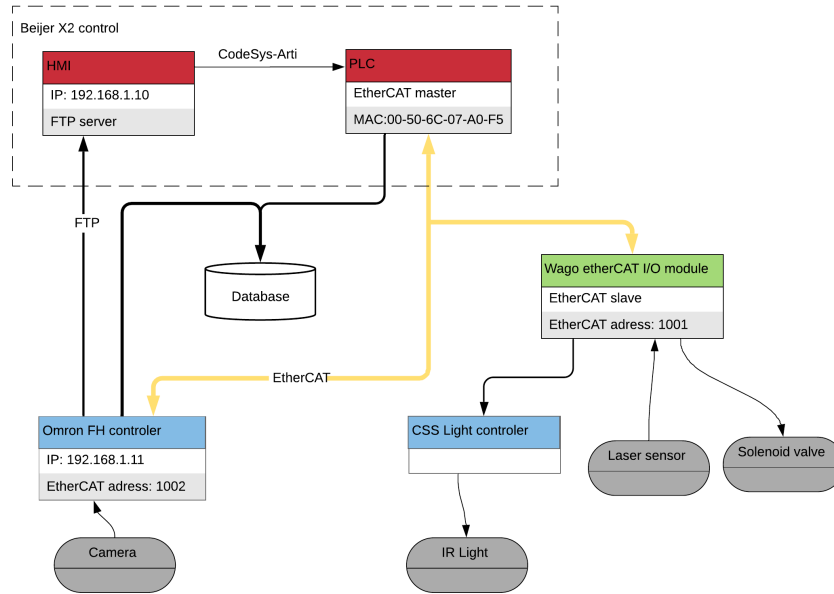


Figure 4.23: Data flow

4.7.1 Device communication

The three control devices has a functioning communication system allowing the applications to communicate as intended.

EtherCAT communication is used to communicate with the Omron FH controller and the Wago coupler where the PLC is the master. The PLC is set to configure the slave devices address and other parameters. The cycle time is set to 4ms meaning the frames on the EtherCAT is sent every 4ms. This take advantage of the EtherCAT high speed making the trigger commands to send from the PLC happen with minimal delay. Figure 4.24 shows a simplified communication diagram for the EtherCAT.

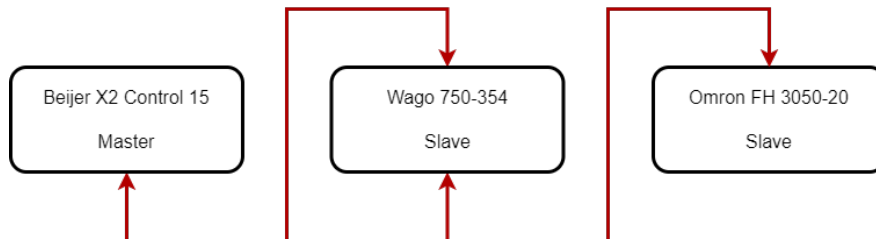


Figure 4.24: Diagram illustrating the EtherCAT communication

FTP communication is used for moving the files on the hard drive connected to the vision controller to the HMI. The HMI has a built in FTP server, FTP communication is used to transfer the images from the vision controller to the HMI. Figure 4.25 shows the communication diagram for the FTP.

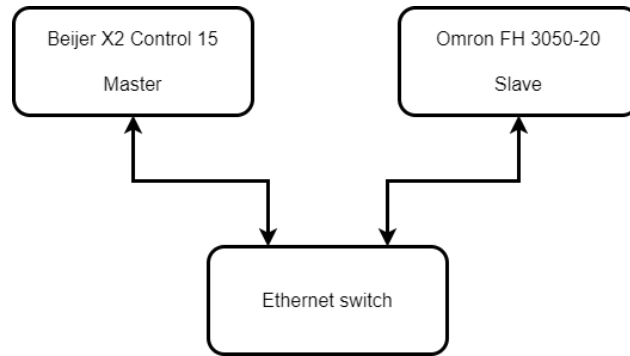


Figure 4.25: Diagram illustrating the FTP communication

4.8 Mechanical

This section presents a walk through of designing and building of the mechanical solution for mounting of the camera hardware. The equipment were to be mounted a line 5 at Vello Nordic, since there is production at this machine on a daily basis there was built a simple model to simulate the mounting.

Following an iterative design process, a solution was chosen that can work to prove the concept of camera based quality control. This process involved many redesigns in Fusion 360 to achieve a desired result, the redesigns helped to avoid flaws and errors.

The custom parts where manufactured at Stranda Stålindustri where the parts was cut on a laser and bent using a bending machine. While the extruded aluminum profiles where cut and re-worked at Amatec. The aluminum profiles were cut using a special saw made for this purpose.

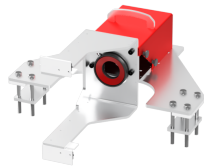
4.8.1 Mechanical solution

There were several important criterion's achieved in the solution:

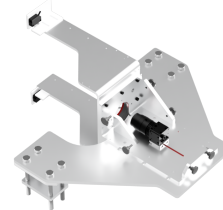
1. Easy mounting on the production line, compensates for the product produced have different length.
2. Fine adjustment in position of the camera to achieve the correct FOV.
3. Mounting the camera in correct position while providing cover from the surroundings and without obstructing the FOV.
4. Mounting of the light source without blocking the FOV for the camera and illuminating the profile.
5. Mounting for photoelectric laser sensors, the sensor is mounted at a desired distance without blocking the FOV.
6. Reduced ambient noise, reduces vibration from saw and pulling tower.

4.8.2 Image of 3D model

Figure 4.26a shows the front view of the complete CAD model and figure 4.26b shows the CAD from the rear where the cover is removed displaying the camera.



(a) Front view 3D-model



(b) Cover removed, camera exposed 3D-model

4.8.3 Mechanical BOM for solution

Table 4.7 gives an overview over the main mechanical parts, nuts and bolts are not included.

Explanation to each part can be found below table 4.7.

Name	Quantity	Thickness[mm]	Material
Base	1	8	Alu
Base Mounting Clamp	2	8	Alu
Camera Mount	1	6	Alu
Camera Mount Side Support	2	8	Alu
Camera Bottom Adjustment Cover	1	2	Alu
Camera Cover	1	2	Alu
Camera Cover Handle	1	8	Alu
Rear Cover Mount	1	8	Alu
Sensor Bracket	1	6	Alu
Sensor Bracket Side Stiffener	1	8	Alu
Sensor Mount UP & DW	1	4	Alu
Shim	1	8	Alu

Table 4.7: BOM for mechanical solution

4.8.4 Mechanical parts

Drawing of the mechanical parts in DXF format is included in Appendix K.

Below each part made in the CAD software will be explained in detail.

Base

The part named base is the base of the whole construction made in 8mm aluminum. This part is meant to be mounted to the C-profiles on the production line at Vello Nordic. Holes for mounting of the other parts in the construction are also made. The holes are slotted so one can slide the camera plate that will be mounted on the top sideways.

Base Mounting Clamp

Plate in 8 mm aluminum for clamping the base plate to the production line. Threaded holes for 10mm bolts.

Camera Mount

This is a key part in the design, it has many functions such as:

1. Threaded M8 holes for mounting it to the Base.
2. Slotted hole for mounting the camera, with the slotted hole sliding the camera forward and backwards is possible.
3. Hole for the Side support.
4. Designed so that the circular light can be screwed in place.
5. Threaded M8 holes and other necessity's for mounting the Sensor bracket.

Camera Mount Side Support

Part made for strengthening and stiffening the Camera mount bracket. It is mounted by drilling holes in the part based on the holes in the Camera Mount. Threaded M5 holes for mounting of the Camera Cover.

Camera Bottom Adjustment Cover

Plate made in 2mm aluminum for protecting the camera and reducing contamination, holes for mounting it on the Base.

Camera Cover

Housing for the camera to reduce the dust from the production affecting the quality of the image and also protecting the camera equipment from physical impacts. Holes for mounting the handle at top making it easy to remove.

Camera Cover Handle

Handle is made in 8 mm and it's function is to make the Camera Cover easy to remove. Threaded M4 holes is used for mounting it to the cover.

Rear Cover Mount

Bracket is 8 mm for mounting of the cover to the Camera Mount. Threaded M5 holes for locking the cover in place.

Sensor Bracket

Main sensor bracket for holding the sensor at the correct distance from the camera. The sensors need to perfectly align with each other and this bracket is responsible for holding them. Five holes for screwing the bracket onto the Camera Mount. There are also holes for mounting of the Sensor Bracket Side Stiffener.

Sensor Bracket Side Stiffener

Purpose of this part is to stiffen and reduce vibrations in the sensor bracket. Stiffening is important so that the sensors stay perfectly aligned and reducing vibration is important so that the sensors trigger properly.

Sensor Mount

Made from extruded aluminum angle bracket. Responsible for mounting the sensor on the Sensor Bracket. Slotted holes for adjusting the position of the part on the Sensor Bracket, and 2 holes for the sensor mount.

Shim

Plate in 8mm aluminum for adjusting the height of the base relative to the production line. Two holes for the mounting $\varnothing 10.2$.

4.8.5 Lens protection

The solution for avoiding particles from the production, especially dust from the saw compressed air was used. This was done by mounting:

- a pressure regulator for adjusting the pressure
- a valve for turning on and off the air output
- a tube for distributing the air evenly inside the cover

This solution creates a low over pressure reducing the amount of dust and other contamination entering inside the cover.

4.8.6 Built mechanical solution

In image 4.27 the aluminum parts are mounted together while image 4.28 all the additional equipment is also mounted.

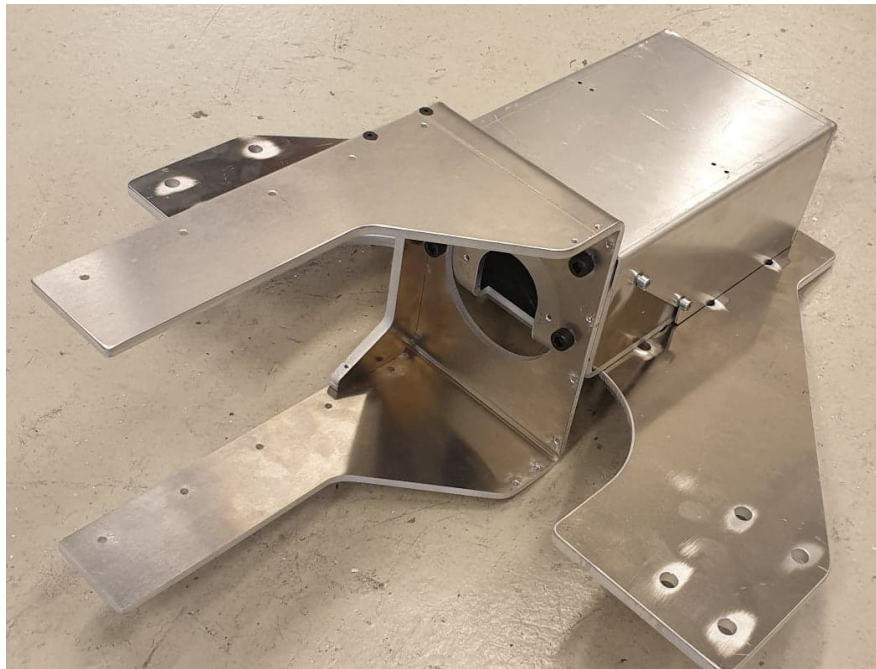


Figure 4.27: Aluminum parts screwed together

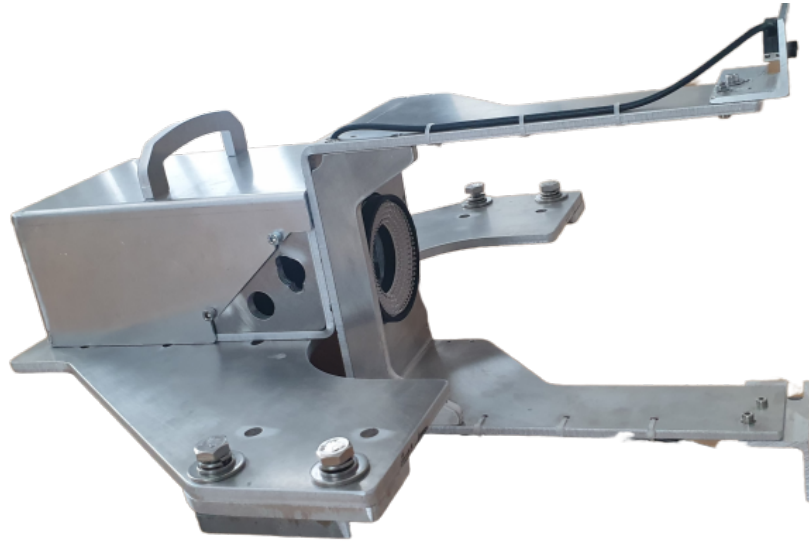


Figure 4.28: All necessary equipment mounted

4.8.7 Cost of parts

Mechanical parts used in the project is gifted from different providers. Amatec has calculated an estimate for the cost to around 16.000,- this include the raw material, bending, threading and grinding.

4.9 Electrical cabinet

Electrical cabinet is built as described [3.8](#) which is used to house the control components and power supplies.

4.9.1 Trigger mechanism

To trigger the system when a profile is in correct position for capturing an image there where tested the two different sensors as listed in table [3.6](#).

E3Z-LL81 2M OMS the sensor triggered as intended, due to using background suppression instead of sender and receiver it is more exposed to changing surroundings.

E3Z-LT81 2M triggered the system as intended, uses sender and receiver and is not affected by changing surroundings. This sensor also had the ability to mount precision covers reducing the radius of the laser spot making the trigger more precise.

4.9.2 Trigger mechanism delay

This section shows the results from the calculation based on method 3.6 that deals with the delay in the image capturing sequence.

In calculation we have taken into consideration:

- 1ms response time sensor*
- 3ms input filter Wago 750-530 input card
- 1ms + 1 ms jitter update rate interval Wago K-bus
- 4ms cycle interval EtherCAT
- 4ms cycle interval PLC task
- 4ms cycle interval EtherCAT
- unknown processing rate Vision controller **

*In this calculation the specification for the Omron E3Z-LT81 2M is used. ** This is unknown but due to configuration of Omron controller.

This gives a total of 17-18 ms delay plus the unknown processing delay on the vision computer. The maximum delay is set to 25ms including the unknown processing rate of the Vision controller. Taking this into consideration, the profile has moved a maximum of 0.3mm.

4.10 Mounting on test jig

To test the mechanical construction during development, a test jig was built using extruded aluminum profiles. This was built to replicate the production line at Vello. Mounting the camera

fixture to this construction provided a testing place with similar surroundings as at the production line. Figure 4.29 shows an image of the testing areas used at the later stage in the project.

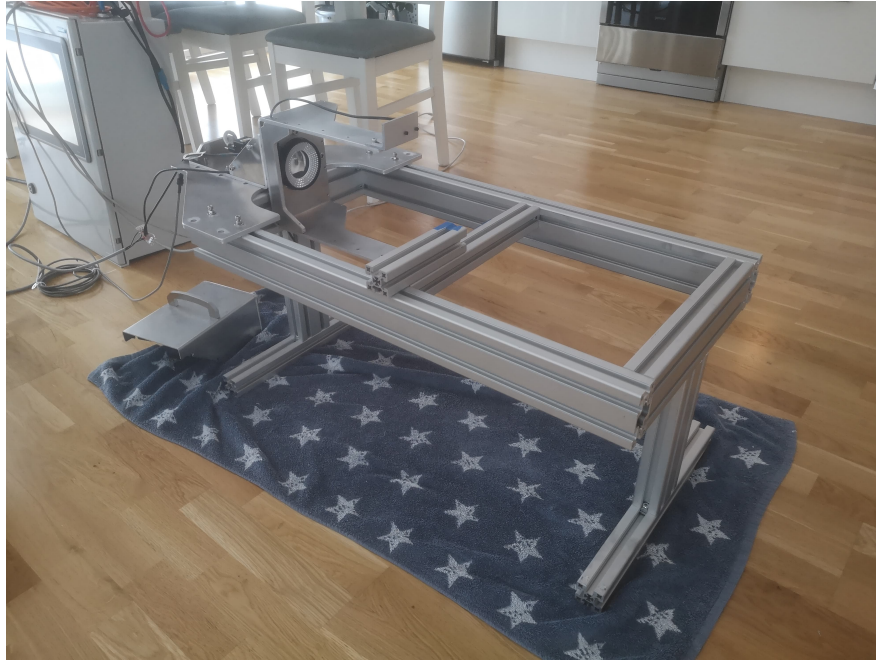


Figure 4.29: Construction mounted on test jig

4.11 Test mounting at Vello 01.04

At the first of April the equipment was test mounted at the production line, this test was conducted to reveal any problems related to the position of the camera. Figure 4.30 shows the test mounting.

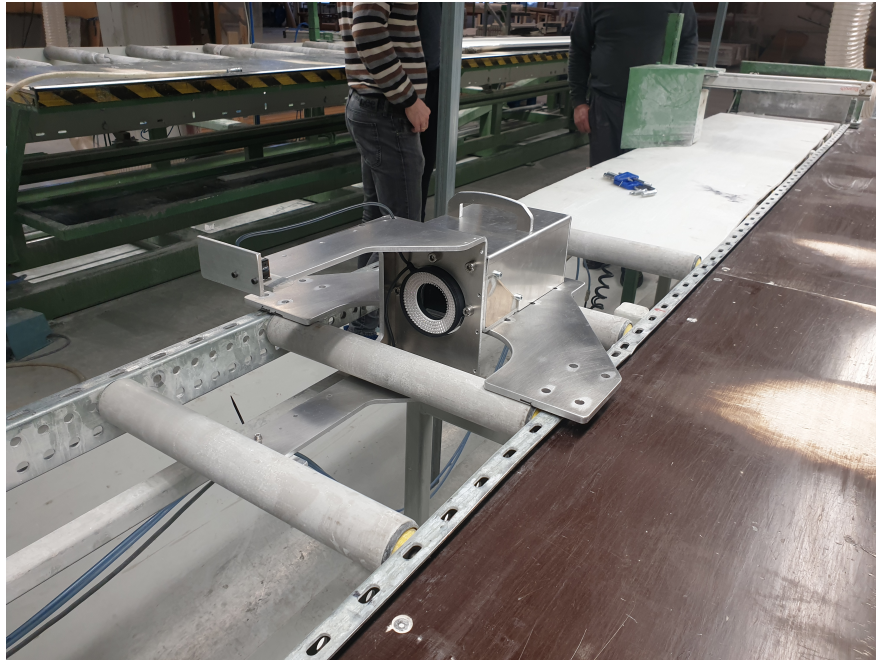


Figure 4.30: Test mounting at Vello

Mounting the mechanical component to the production line showed that the base part has the mounting holes in the correct place. The shim was not yet produced therefore the height of the camera was lower than planned. Temporary shim was used to verify that when these are in place the position is as planned.

4.12 Test at Vello 30.04

On the 30.04.2020 it was conducted a manual test at the production line at Vello Nordic's facility. At this test we logged all the data necessary to validate the accuracy and visualize the enhancement of the fiber mat. The complete system was tested to verify the software solutions, testing how the it worked in a production environment. The construction for fixating the position of the profile was yet not built. This construction should help positioning the profile in the direction perpendicular to the motion of the profile produced. Therefor there was mounted to boards help guide the profile.

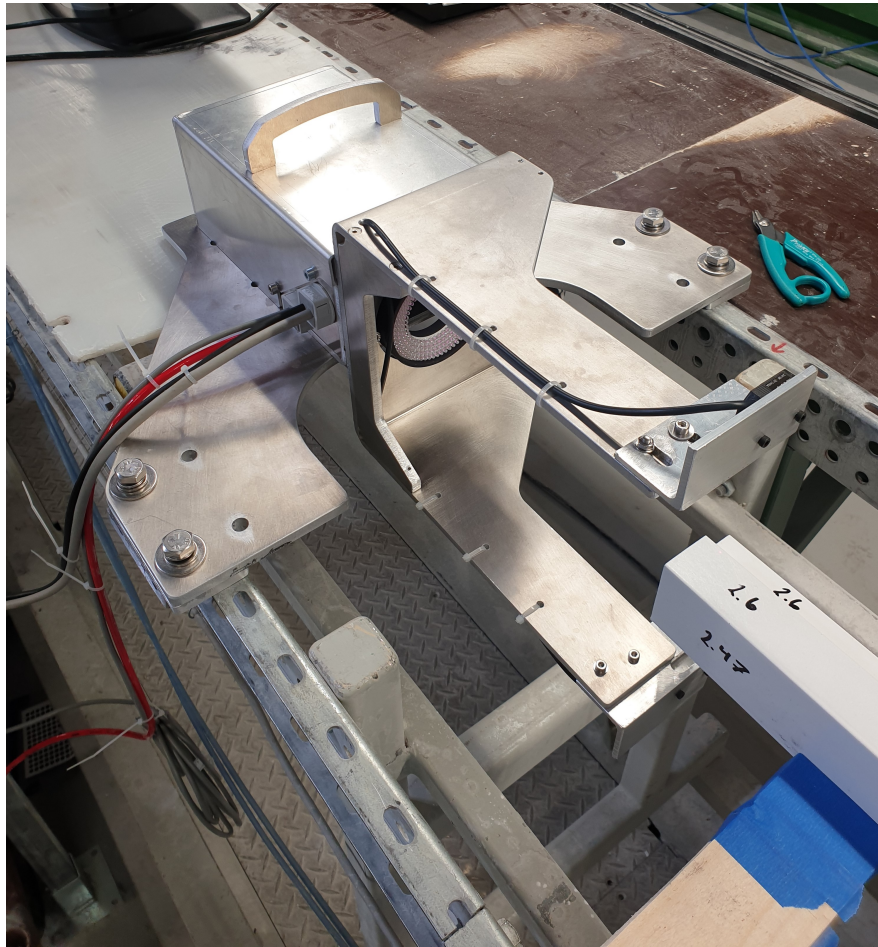


Figure 4.31: Picture taken during the first test at Vello Nordic

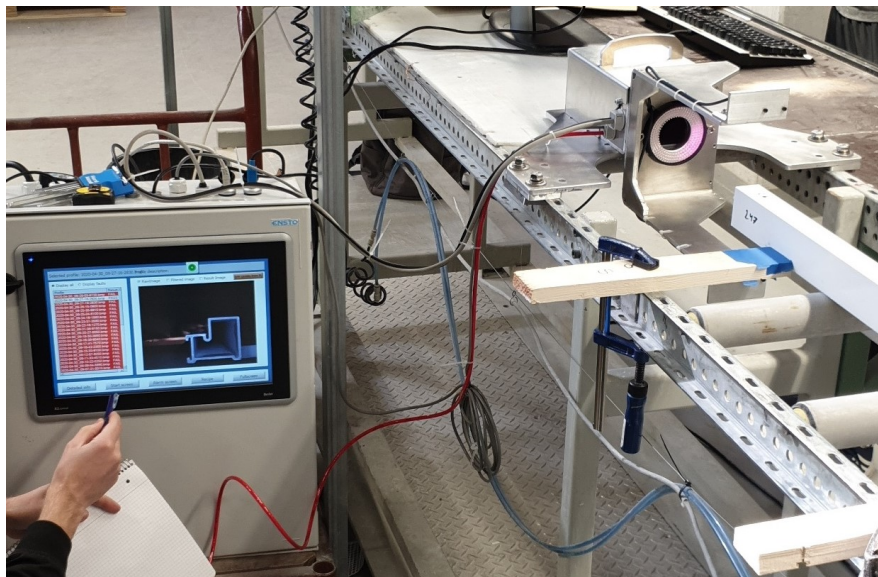


Figure 4.32: Picture taken from the test at Vello Nordic

Chapter 5

Discussion

A summary of the results are taken under consideration and discussed in this chapter.

5.1 Machine vision

5.1.1 Camera

Result [4.1.1](#) shows that our 5MP camera has high enough resolution to achieve a FOV of 100 x 100 mm and a theoretical accuracy under 0.1mm. These results shows that we have achieved a theoretical accuracy that meet the requirements set by Vello Nordic. The 5MP camera has a rectangular FOV, making it ideal for the production as the profiles are usually wider than they are tall. tall

For further work it should be tested if a CMOS camera can achieve the same accuracy as a CCD camera, because a CCD camera as we used are usually more expensive than CMOS.

5.1.2 Lenses

Three lenses where tested for this application, as result [4.1.1](#) shows they all are capable of providing a sharp image of the profile. The difference lies in the working distance required to have a FOV to reach the correct theoretical accuracy. Results from testing shows that the lenses with a low focal length adds more shadows to the image. These shadows are due to the angle of view and the use of entrocentic lens [2.5.1](#). The recommended focal length from our point of view is the 25mm lens. The 25mm lens provide a convenient working distance, low distortion and low light interference in the image.

If Vello Nordic is satisfied with a FOV of 100 x 100mm, it is recommended to consider a telecentric lens 2.5.2. These lenses does not add any distortion or side effects as an entrocetric lens does. Downside of telecentric lens is that they are more expensive and larger in size.

5.1.3 Illumination

There are two main objectives for the lighting to be considered, it should evenly illuminate the profile and suppress the surrounding lighting at Vello 3.1.4.

The circular white LED illuminated everything evenly and good, yet it did not accentuate the fiber mat as good as with IR lights which can be seen in result 4.1.4. Because of the performance in enhancement and it is so easily effected by the surroundings, this light was not suitable for the application. The disturbances in the images where caused by the wave length in the white led lies within the same range as lighting used at Vello. 3.1.4.

The IR bar did not illuminate the whole profile evenly because of the shape and placement of the bar, but it did accentuate the fiber mat inside the profile as result 4.1.4 shows. Since the light was unevenly spread on the profile, it was difficult to do image processing. Most image processing algorithms are applied to the whole image. When the image is unevenly illuminated, the algorithms will result in different result trough the image. Also the physical size of the IR bar made it difficult to use. This made also the IR bar unsuited for the final solution.

The Circular IR light gave the best overall result. It illuminated the profile almost as evenly as the Circular white LED and accentuated the fiber mat as good as the IR beam. The reason it did not illuminate as evenly as the circular white LED is due to the curvature of the light as explained in result 4.1.4.

The IR light can be affected by sunlight because it contains around 40% IR [31], this can create some unwanted shadows. However, since the production line is in the middle of the factory with only a few windows, this is not a big problem. Even with the small drawbacks with the circular IR light had, it provided the best result and therefore it was the most suitable for the final solution.

Improvements for the illumination source would be a flat circular IR light that would distribute the light evenly on the profile.

5.2 Images analysis

5.2.1 Calibration and position compensation

The results from position compensation 4.1.6 shows that we are able to use Precise Calibration 3.1.2 to calibrate the images. Extracting data from the images becomes easier because the software converts dimensions to mm and not pixels. This is better for comparing the measured dimensions against the drawing without any further conversion.

Correlation value from Shape Search 3.1.2 help us determine if the basic shape of the profile is correct. Using this tool allows us to warn the operator that the basic shape of the profile is incorrect, without this the system could be perceived by the operators as unstable, because the measurements would be unreliable.

Compensating in deviation of the profiles position has on one side made it possible to measure all the features without having to relocate the tool as they are graphically set with coordinates in the image. On the other side, the compensating has decreased the accuracy as seen in results from testing 4.2.4.

5.2.2 Measurement performance

The results presented in 4.2 shows us that the measurements are quite accurate for measuring lengths. With an average error of 0.016mm for measurements under 4mm and 0.017mm for measurements over 4mm. This is within the requirement of accuracy. Even though one of the features didn't have the specified accuracy, we can conclude that the system meets the requirement of 0.1mm accuracy. None of the angles are measured within the required accuracy of 0.5° we can therefore conclude that the system is not capable of measuring the angles of this type of profile with the required accuracy.

Calculations of standard deviation shows that the system is able to reproduce its measurements in a sufficient way for the lengths measurements. The standard deviation is larger for the features over 4mm which is because the measured values are larger. The standard deviation for the

angle measurements tells us that the system is not able to reproduce angle measurements.

When comparing the test results from profile A against profile B, one can see that the measurements of profile A is more accurate than the measurements of profile B. This is because the system are calibrated and tuned with profile A. The measurements are still within the requirements of 0.1mm.

Measurements taken with the profile displaced in x direction shows that the effect can make the measured values exceed the required accuracy. The most likely reason for displacement in the x direction is delay in the trigger mechanism. In section 4.9.2, the maximum estimated displacement due to the trigger delay is estimated to 0.3mm. To evaluate the effect of this we can observe the data from 1mm displacement compared to 0mm. The difference between them is only 0.025mm, the difference equals only 1/4 of the required accuracy. We can therefor conclude that displacement due to delay of the trigger mechanism does not have a huge impact compared with the required accuracy.

The results from the test done with displacement in the Y axis 4.2.4 shows that this has an impact on the measurements. For some of the features, the difference between 0mm and 20mm was greater than the required accuracy. We can conclude that the system is vulnerable for displacement of the profile in the Y direction. Vello Nordic is planning to build a guiding system to improve this problem in the future.

5.2.3 Fiberglass mat enhancement

To accentuate the fiberglass mat inside the profile, our final solution used the circular IR light 4.1.4 together with different kinds of filter as result 4.1.8 shows. All the different filters provided a decent result in highlighting the mat, yet there are some differences.

Using extract edges filter accentuated the fiber mat in a clear and distinct way, but when the fiber mat was close to the edge, the edge filter matrix risk smudging the fiber mat into the edge of the profile. As a result of this it was hard to determine if the fiber mat was present or not.

Background suppression produced good results as the result shows but is more prone to disturbances. Slight change in the chemicals would affect the filter as it requires a unique color or

intensity to work and therefore not recommended to be used alone.

The key element in the fiber mat accentuation is correct illuminating, our circular light was curved making the light unevenly distributed. This had a major disadvantage as it prohibited us from using a higher light intensity even though the light was capable of it.

Suggestion for improvements

There are many different combinations of filters and settings that may be changed for accentuate the fiber mat that we have not yet tried. Further test with the adjustment of the white balance in the camera and different filters could make it easier to filter out the fiberglass mat. We recommend to:

1. Switch to a flat IR light as opposed to a curved like the one used.
2. Try to implement artificial intelligence to explore the possibility of automatic detection of faults by using machine learning.

5.3 Software

The HMI panel has a functional user interface to display the results of the image processing. Some of the details in the images vanishes due to the resolution of the screen. However, errors in the profiles are clearly notified to the operator with text and color indication in addition to triggering of an alarm as requested from Vello. The recipe system for selecting the type of profile provides an easy solution for selecting, adding and editing different profile types. If the user want different tolerances of the same profile, a new recipe has to be made.

The .Net application running on the vision controller was preferred over the solution on the HMI panel. This is because, the .Net application is performing the task of transferring the images in a faster and more stable way. The .Net application has also the functionality to get hold of the result display.

To get the result display from the vision controller, screenshot and cropping are used. For this to

work, the layout in the vision controller must be adjusted according to the cropping algorithm. This kind of setup is exposed to several inconvenience, first the screen capture procedure is dependent on the layout of the vision controller always is configured in the same way. Secondly, if the vision controller is to control multiple cameras this setup can only capture one of the images.

The results from 4.3 provided the PLC with the tool to carry out its tasks as desired. Though we did not test logging to their Scada system, the sequence along with the data is ready. The only thing left to do is to add a database push that sends the data to their database.

5.3.1 Suggestions for improvements

When the programs for the quality control is implemented in the PLC controlling the complete machine, evaluation of the CPU load can reveal if the cycle time can be reduced to lower latency further.

Using a full version framework instead of compact version when developing the user interface, displaying results from the image processing can be performed in a better way. This makes it possible to use classes for ftp transfer in the GUI application and replace the .Net application for transferring images. Another benefit is the possibility to use a screen with higher resolution. This can increase the amount of details seen in images.

5.4 Mechanical

Construction is deemed as satisfactory based on the results 4.8.1. The construction provided a good way of capturing images at the desired place and time as shown in result from test mounting 4.11 and in the result from the manual test 4.12. Using 3D modelling proved valuable in time saving when mounting the construction together. Though none of the group members has any prior experience with this kind of 3D modelling, we are very pleased with the outcome. This can be used as a prototype for further testing of the quality inspection.

Full production test without monitoring the system could not be done since Vello did not build

the mechanical system for guiding the profile as needed.

5.4.1 Further improvements

Some redesign might be smart to further improve the solution:

- Make it even less responsive to sunlight. This can be done by:
 - Making the upper part of the sensor bracket wider, this would also have a side benefit of making the bracket stiffer.
 - Adding a cover to the sensor bracket on the right side when viewed from behind.
- Making the camera housing little bigger to make more room for cables and cable entry points.
- Consider the possibility for the camera solution to also be the one to guide the profile to the correct position.

5.5 Experience

5.5.1 Method of development

Chosen development method was scrum with two week sprints. Two week sprints were used since this seemed appropriate for this project and it fit well as we have status meetings every other week.

On one hand, this kind of development method has worked fine, as it clearly says which tasks is expected to be done in each sprint. On the other hand, due to lack of experience it has been hard to plan the amount of work we would get done in the two week sprints. As a result of this sprints were not planned as good as it should have been.

As an overall plan we used a Gantt diagram to plan the whole project, setting goals for when the different parts of the project was expected to be done. The Gantt diagram was not updated

as regularly as it should have been. On one side, this did not affect us much, because we used Scrum as the method of development. On the other side, a more regular update of the Gantt diagram would have helped us plan the Scrum sprints better.

5.5.2 Group work

Working hours were set in the preliminary report, setting a framework for when each member is expected to be working on the project. In this kind of project, we thought meeting up at school was the best way to reach the goals we had set for the project. The need for testing with the physical hardware was also a reason to meet up at the school.

This framework worked out nicely and helped the group work more structured and persistent.

5.5.3 Work process

Every member had at least one main task assigned on the Gantt diagram. This gave a clear work plan from the start. Even if each member had a specific main task to do, all members collaborated and help each other when needed. This made sure every member had something to do throughout the whole project.

5.5.4 Distribution of work

To distribute the work, we used Trello as mentioned in [3.12.1](#). Trello was a helpful tool during the project by helping us distribute the work.

In the beginning of the thesis, each sprint was well planned in Trello. Planned and assigned tasks in Trello, gave a clear insight in upcoming tasks. Due to somewhat bad planned sprints in the middle of the project period, the Trello board became a bit cluttered as it was not updated as regularly as it should have been. But after internal meetings, we cleaned the boards and added all the relevant task back in as a group. This helped us get back on track with the organizing, and Trello became a very helpful tool.

When the Corona situation occurred and we were forced to leave the school, updating and using

Trello was important to help us continue our work accordingly to the plan.

Chapter 6

Conclusions

It is vital for companies to continuously seek new and innovating technology to compete in the globalized market, as customers demand and expect quality products. Vello Nordic's focus has been on reducing defects by improving the quality inspection in order to increase productivity. Hence the importance and motivation to improve their quality inspection by examining machine vision.

Vello has now a possibility to improve today's quality control of fiberglass profiles. Results show that by capturing images of a profile's cross section, one can extract geometrical dimensions with a documented accuracy. Furthermore, with correct illumination of the profile, the fiber mat is accentuated for inspection and even more with digital filtering. A distinguishable fiber mat makes the inspection more precise and simpler to conduct. Previously, inspection and measurements were done manually once every hour. Now the company is able to inspect the geometry and fiber mat on an HMI screen by looking at the data gathered by our system. This is beneficial as the company now can confirm the quality of each product.

For further development there are two elements we would recommend to further develop. First, technologies such as artificial intelligence should be considered to further explore the possibilities for automated inspection of the fiber mat. Secondly we would recommend to change the device for the image presentation as the Beijer HMI is not designed for this purpose and therefore has limited functionality.

The group considers the project as a success and a valid project to fully implement in production. A project of such size has been a valuable learning experience for all of us, where we have learned both new technical skills and project management.

Bibliography

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Appendices

A Preliminary report



Department of ICT and
Natural Sciences

Quality control of fiberglass profiles using industrial vision-system

COURSE CODE: IE303612

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Preliminary report

Faculty of Information Technology and Electrical Engineering

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Chapter 1

Introduction

Vello Nordic is a company that produces different types of fiberglass profiles for different uses. Quality of the profiles are today inspected manually, not all defects are easy to spot manually with the naked eye. Vello Nordic want's an automatic quality control of the profiles using an industrial vision system. Vello Nordic is owned by Spilka International and they have been in contact with Amatec for supplying equipment and expertise to solve this task.

Our main goal is to capture and analyze images of fiberglass profiles using a vision system. It is desirable to analyze newly produced profiles and control them for any deviations. Since quality control is difficult to do manually and operators have limited time to preform the control, several weak profiles are produced. This results in more waste and defective products delivered to the costumer.

The purpose of this report is to uncover and define tasks related to the bachelor thesis. The bachelor thesis should revolve around creating a complete system for quality control of the fiberglass profiles.

CONCEPTS

Vision-System Computer based systems with camera for image processing

GUI Graphical User Interface, makes it possible to interact with a computer

HMI Human Machine Interface, makes it possible to interact with the machine

Gantt A chart used to illustrate a project's schedule.

PLC Programmable logic controller

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Chapter 2

Project organization

2.1 Project group

Student	Student id	Tlf	Mail
Lars Berge	484220	45480990	lb@stud.ntnu.no
Even Årekol	484224	48053662	evenaar@stud.ntnu.no
Jarl Eirik Heide	484227	99427532	jarlehei@stud.ntnu.no
Ole-Kristian Ytterland	484226	92648523	olekrisy@stud.ntnu.no

Table 2.1: Project group

2.1.1 Assignments for the project group - organization

To keep track of the work, the group use a gantt diagram where every task is specified. Every main task has a person responsible for the given task. The member with the responsibility needs to keep track of the progress and make sure the task is completed within the deadline.

For keeping track of more daily tasks we will use Trello. Trello is a tool where you can keep track of tasks that has to be done, what is started and what is done. This will help the group keep track of the tasks needed to be done on a daily basis.

The table [2.2](#) shows the project roles in the bachelor thesis:

Name	Role
Lars Berge	Project leader
Even Årekol	Project secretary
Jarl Eirik Heide	Project engineer
Ole-Kristian Ytterland	Project engineer

Table 2.2: Project roles

2.1.2 Assignments for the project manager

- Main contact person
- Delegate tasks when necessary
- Responsible for progress

2.1.3 Assignments for Secretary

- Secondary contact when necessary
- Responsible for meetings (invitations, report writing)

2.1.4 Assignments for other members

- Each member is responsible for completing the tasks he has been assigned
- Each member is obligated to work on the thesis Mon-Fri from 9-15. See section on Group norms
- Each member must log all the work done

2.2 Management-group

Table [2.3](#) shows the advisors for the bachelor thesis.

Name	Description	Tlf	Mail
Arne Styve	Assistant Professor	90560299	asty@ntnu.no
Webjørn Rekdalsbakken	Associate Professor	70161246	webjorn.rekdalsbakken@ntnu.no

Table 2.3: Project advisors

Table 2.4 shows the contacts with the employer Vello Nordic.

Name	Tlf	Mail
Terje Bergset	90672405	Terje.Bergset@spilka.com
Bjørn Stafset	98263234	Bjorn.Stafset@spilka.com

Table 2.4: Contacts employer Vello Nordic

Supervisors and contacts form the management group for the project.

Chapter 3

Agreements

3.1 Agreements with employer

The project for Vello Nordic has not needed a contract, but later we will discuss whether or not we should write a non-disclosure agreement.

3.2 Workplace and resources

The main workplace for the project will at the start of the project be at the university's lab. Work will be done at university's lab until we have a functioning prototype. After this is achieved, we will do field testing and further development at Vello Nordic facilities.

Vello Nordic will cover all the expenses for the project. It has been agreed that Amatec AS will lend the necessary camera equipment. If components or parts have to be purchased, the contact persons at Vello Nordic shall be informed.

The project group also has the opportunity to use Amatec's areas for mechanical and electrical work when needed.

3.3 Group norms - rules of cooperation - attitudes

Group work hours:

Table [3.1](#) shows the ideal working hours for the group.

Work hours	Time
Core-time	9-15 Mon-Fri
Ideal work-time	8-16 Mon-Fri

Table 3.1: Working hours

Group norms:

- Work hours should be logged on a daily basis
- Industry 4.0 is prioritized as the lectures are mandatory
- Group meeting and write bi-weekly progress reports for management group
- Progress meeting with advisors every other Monday
- If a group member cannot be present during core time, the group shall be informed
- If a task proves to be difficult to carry out as planned, the group will be informed and a new plan will be prepared together
- Reaching deadline is important, all members must be willing to work overtime to reach the desired goals.

Team's Attitude:

- Communicate often
- Ask for feedback
- Confront frustrations
- Show appreciation
- Lead by example
- Positive attitude

3.3.1 Work guidance as an automation engineer

When working as an automation engineer it is important to strive after new and innovative solutions. Considering how fast the technology develops it is important to research and adapt to new technologies. By doing so, one secures further development and understanding. One must always try to improve the solution and always work towards optimizing the solution.

Chapter 4

Project description

4.1 Thesis problem - goal - purpose

Vello Nordic produces glass fiber profiles for different use. Today, the quality of the profiles is manually inspected by the operator. The purpose for this bachelor thesis is to make an automated system for controlling the quality of the profile and detect faults. By developing a system using a camera with filters and lights, relevant data can be extracted from the picture and be compared with the requirements to detect which profiles is defect. In this way Vello Nordic improves quality of their products and produce less defect profiles.

4.2 Project specification

In this section, the specifications regarding the project are described. The project specification are specifying the requirements to fulfil the thesis problem. The specifications are made in cooperation with Vello Nordic to meet their requirements and expectations.

4.2.1 Error detection with vision system

One of the main goals is to develop a system capable of detecting faults in different types of profiles. One way to accomplish this is by using picture processing with different combinations of lights and filtering. Methods for detecting faults and weaknesses in the profile based on the filtered image must also be developed.

Because Vello Nordic produces several types of glass fibre profiles, it is important that the system is developed in such a way that requires minimal changes and adjustments due to the different

profile types.

Parameters that should be controlled:

- Size and geometry of the profile. The profile has specified lengths and thickness as well as radius of corners and edges. These features must be compared with the desired values with the required tolerance.
- Quality of the hardening process. When the profile is made, there could be an error in the hardening process which causes weakness in the profile, this can lead to delamination and cracks in the profile.
- Displacement of the fibre cloth. In some cases, the fiber cloth in the profile twists and makes curls. This results in a weakness in the product.
- Crack in the profile detected from the cross section.

Figure 4.1 shows a section of a profile drawing with example of profile parameters. These marked spots are only example of features to inspect. The features and the requirements for the profile to inspect is decided by the drawing provided by Vello Nordic.

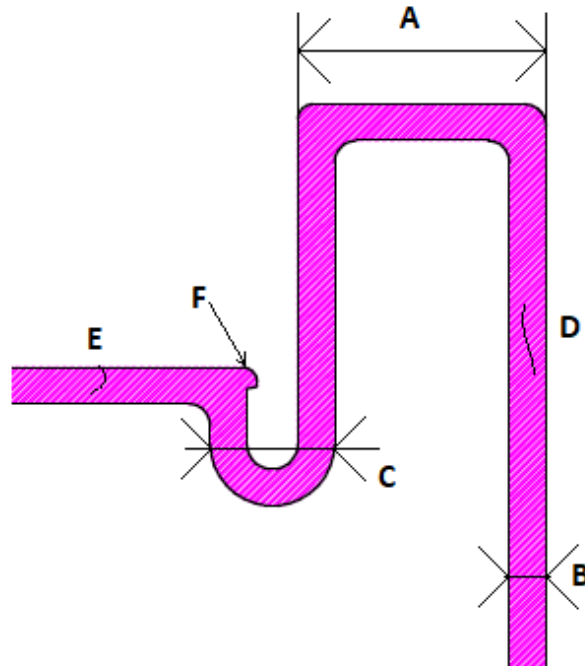


Figure 4.1: Example of profile parameters

Table 4.1 gives an short description of the features to inspect on the profile.

Parameter	Explanation
A	Control the length of specified features
B	Check the width of desired areas of the part
C	Control the radius of the curve
D	Check for delamination of the profile
E	Check for cracks in the profile
F	Control desired features in the profile

Table 4.1: Explanation of the different features to verify

4.2.2 Mounting of camera

The camera must be mounted so that one captures as much detail as possible. The camera should be mounted so that it faces the cross section of the profile. There are several aspect one must take under consideration when choosing the mounting position of the camera. Contamination of the lens is one aspect one must have under consideration. If the camera is mounted in the a area with a lot of dust, counter measures must be taken to avoid this.

If it turns out that one has to mount a camera with an actuator, one must investigate how to do this. Evaluation of the different possible methods and selecting the equipment. There must also be written a program to control the positioning equipment. There's a risk of the profile colliding with the camera. Risk evaluation and measures to reduce this risk is therefore important.

4.2.3 Complete control system

To control the complete system, a PLC with integrated HMI specified by Vello Nordic must be used. When the system operates with the desired quality, the PLC program is added to the PLC used for controlling the machine itself. The control system should control the sequence for controlling the camera and notify the operator if a fault occurs. The control system should also include other functionality needed to meet the requirements for the project.

4.2.4 Logging of data

Vello Nordic uses Ignition as top system in their production facility. Data gathered in the quality control system shall be sent to their database for logging.

4.2.5 Visual presentation of picture

A screen mounted next to the machine shall be used to view detailed information of the results from picture processing. Information displayed could be pictures with and without filter, type of error and visually presenting where on the profile the fault is located.

4.2.6 Profile type detection

A profile identification number exist for every unique profile type in the database has information about the requirements for that specific profile. Therefore, a control of the produced profile should be implemented. A system that recognize the profile type based on the picture taken with the vision system shall be developed. The profile identification number inserted by the operator are compared with the identified profile from the recognition system. If the profiles don't match, the operator must be alerted.

Table 4.2 gives an graphical presentation of the project specification and also an visualization of the how the task are prioritized

Must have	Should have	Could have
Error detection	Presentation of picture	Profile type detection
Mounting of camera		Check for cracks in profile
Control system		
Logging of data		

Table 4.2: Project specification

4.2.7 If time permits

If the development of the project goes faster than planned, one can investigate the possibility of detection of longitudinal errors in the profile.

4.3 Method for development

In this project the development method scrum will be used. The definition of scrum is “Scrum (n): A framework within which people can address complex adaptive problems, while productively and creatively delivering products of the highest possible value.”. Scrum employs an iterative approach to optimize value and control risk [1].

In the scrum model there is specific roles. A scrum team is built up with a product owner, scrum master and the development team. Teams are self-organizing and cross-functional. Self-organizing means that the team can choose which work technique they will work with to reach the goal rather than being told how to work from outside of the team. Being cross-functional means that the team has the expertise to accomplish the work given without depending on others outside of the team [1].

A sprint is a smaller work period and we will use two week sprint. In each sprint there will be decided a smaller sub goal to be reach for each sprint. Sprint review will be done after each sprint where we will conclude if the goal has been reached, what problem we encountered and if we are on the right direction in conjunction with the main task. Sprint planning will be done after each 2 weeks sprint. Having smaller goal will help us reach our end goal easier and will give us better possibilities to change direction so we are working on the right tasks.

4.4 Information gathering

A crucial part of the project is to find relevant information about picture processing form different papers. First part of the project will be dedicated to research and information gathering. Coursing in the equipment chosen will also be an alternative to obtain information. Relevant documentation

revolving around picture processing can be found in different bachelor thesis.

4.5 Risk analysis

In the risk analysis it is setup a 5x5 matrix. The matrix shows the likelihood 1-5 for the risk to happen and 1-5 for the consequence. Figure 4.2 shows the risk analysis we preformed, it is also included in the appendix.

With a risk analysis we can analyze and visualize the probability of an event to occur and the consequences of the event. This way one can reveal events that could delay the progress and jeopardize the project overall result.

	Severity of consequences				
Frequency of incident	Very low severity	Low severity	Medium severity	High severity	Very high severity
Very high frequency					
High frequency		- Short term illness			- Destruction of hardware
Medium frequency		- Limitations in vision system regarding visual representation	- Acquiring hardware - Contact persons not available	- Injuries when working - Production area not available/not in use	
Low frequency			- Internal disagreement - Work overload	- Functional electrical system - Supervisors not available - Limitations in vision system	
Very low frequency				- Software licenses	- Unable to capture picture - Long term illness

Figure 4.2: Risk Analysis example image

The figure 4.3 shows the risks that we considered in the risk analysis.

Special risk for this project	Risk value	Description	Mitigation strategy	Contingency strategy
Distortion of images	20	Hardware is broken.	Properly planning of work and testing of functions.	Replace new hardware
Injuries when working	12	Physical injuries	Properly planning the work before execution	Introduce new HSE measures to prevent new cases
Production area not available/ not in use	12	For some reason the production area is not available	Early planning together with Vello Nordic when we want to test	Continue testing at NTNU, collect more test data from Vello Nordic.
Acquiring hardware	9	Not able to providing necessary parts in time	Ordering parts early. Using standard equipment	Change the equipment that was intended to be used.
Contact persons not available	9	Contact persons at Vello Nordic not available	Early planning of meetings	Discuss the situation at the progress meetings
Functional electrical system	8	We are dependent on a functioning electrical system	Carefully selection of electrical parts.	Acquire new components.
Limitations in the vision system	8	Not supporting the required functionality	Early testing of equipment.	Switch vision system
Supervisors not available	8	Supervisors are not available	Early planning of meetings	Discuss the situation at the progress meetings
Short term illness	8	Group members have a short term illness	Hygiene and not contaminating others when sick	Work extra hours and work from home when sick.
Limitations in vision system regarding visual representat	6	Vision system may not support the required functionality	Examine features and limitations early.	Solve the problem using other systems
Internal disagreement	6	There are internal disagreement regarding the solution method	Open and respectful discussion regarding the tasks.	Include supervisors in the discussion.
Work overload	6	To much work to reach deadlines	Properly planning. Evenly distribute the workload	Reduce the goal of the bachelor thesis
Long term illness	5	Group members have a long term illness	Hygiene and not contaminating others when sick	Work extra hours and work from home when sick, change work plan
Unable to capture picture	5	For some reason we are not able to capture image.	Planning placement of camera	Redo placement of camera
Software licenses	4	Not getting the required licenses	Early planning of needed software	Use other software to solve problem

Figure 4.3: Risk description example image

Color description

- Red is high risk and is an event that results in larger outcomes and results a major impact on the implementation of the project.
- Yellow is medium risk and is an event that may result in critical outcomes and adversely affect project implementation.
- Green is low risk and is an event that results in less critical outcomes and does not have a major impact on the implementation of the project.

4.6 Main activities in further work

4.6.1 Picture processing with vision system

Gathering information and get familiar to the vision system. Find methods to detect faults in the profile by applying different combinations of filters and lighting's. The system should detect fault in size, delamination of glass fibre and displacement of the fibre cloth inside the profile. Another topic to make a test protocol and preform this to validate and detect eventual faults in the developed system.

4.6.2 Mechanical construction for mounting the camera

Design and build a mechanical construction for mounting of the camera. The saw that's cutting the profile produces lots of dust and are close to where the camera should be mounted. For this reason, the system should have a way of avoiding getting dust on the camera lens.

4.6.3 Control system

The purpose of this activity is to make a fully automated system for quality control. This should be the main controller in the quality control. Among things it should control the camera and the lightning required for the camera to operate as desired. It is also responsible for evaluating the data received from the camera controller and act according to these. The control system should

include methods for warning the operator if an fault occurs. The control system might also need to control positioning of the camera if the mechanical construction has moving parts.

4.6.4 Electrical design

Designing an electrical system with the components and wiring needed to realize the design for both the mechanical construction and the control system. There should also be created electrical drawings and other relevant documentation for this system.

4.6.5 Visual representation of image data

A screen with information about the result of the picture processing should be mounted near the production for the operator to see. The information on the screen should present more precise information about the result and an indication of what parameter triggered the fault.

4.6.6 Recognition of profile type

Develop a system for recognizing profile types and compare it with the inserted profile ID. This should work as an extra control of the operator has inserted the right profile type ID.

4.7 Schedule / Timetable

4.7.1 Main project plan

The main project plan is developed in excel using a gantt diagram. The gantt diagram is divided into main task witch contains sub tasks that is needed to to complete for the main task to be considered finished. The main tasks has been distributed so that each member of the group has the main responsibility for at least one main task. the sub tasks is not assigned to anyone yet, but will be distributed when needed. The main project plan is included in the appendix because of it's size.

4.7.2 Project control assets

For project control the team will be using Gantt diagram and Trello. We will also be logging our daily progress on the time sheet.

4.7.3 Development assets

For software development we need the following software:

- Sysmac Studio
- iX Developer
- CODESYS

4.7.4 Internal control

An internal control is a procedure by which an organization's resources are directed, monitored, and measured[2].

Internal control is done in several separate steps, first part of the internal control is the biweekly progress reports. These reports will help point out and emphasize the important parts in the project and keep the project on track. We will be using the gantt diagram to keep track of our progress and assigning new tasks. Through this diagram every member and supervisor will have full control over the progress. The supervisors will also be given access to our SharePoint and by this they will have the information and opportunity to discuss the content in our meetings.

Before a task can be marked complete, certain criteria needs to be checked. It must be properly executed so it won't cause problems later. The task must also give good and reliable results.

4.7.5 Decision making process

Decision regarding the project will be decided by the group together in consultant with the advisor. The advisors will be included in the discussion in the next scheduled meeting. Crucial

decisions regarding the project will be taken together with the provider of the thesis Vello Nordic and advisor. If we find ourselves in the situation where we must limit our goals due to time, we will use the project specification to help aid what goals to cancel. First and foremost, we will cancel objectives that are on the “could have” list.

Chapter 5

Documentation

5.1 Reports and technical documents

Every step in the process will be documented to remember everything for the main report. We will write biweekly reports to keep our supervisor and contact persons at Vello Nordic updated, and we will also write time sheet with comments after each workday. The main bachelor report will be started early so that we will have control that everything used gets included in the report.

All code should be documented well from the start so cooperation is easier in case multiple member work on the same, or if someone needs to take over a part of the coding. All code should also have version control. Version control will be accomplished by usage of file structure in a common storage area.

5.1.1 Data and information storage

The group has set up an sharepoint where all the data and information related to the bachelor thesis will be stored. When the bachelor is done Vello Nordic will have the opportunity to copy what's wanted. The management group will be invited to join the sharepoint area.

Chapter 6

Scheduled Meetings and Reports

6.1 Meetings

6.1.1 Meetings with the management group

Every other week there will be a meeting with the management group. The management group consist of the bachelor group, project advisors and our supervisor from Spilka International. The supervisor is not obligated to attend to every meeting. A status report will be sent to supervisor and contact persons before this meeting and will be the agenda.

If someone considers updating the project specification or any other changes that affects the thesis, it must be brought up in the meeting with the management group and be discussed. The project leader will lead these meetings, and the secretary is responsible to invite all members and writing meeting reports.

6.1.2 Project meetings

There will be periodic internal meetings on every Friday. In this meeting the group should discuss the project work and report progress. Problems that occurs can be discussed and solved jointly. After the project meeting, everyone should have good knowledge of the whole project status and have insight about the next upcoming week.

6.2 Periodic reports

Every other week the group will write a status report. The purpose of this is to keep the group and our partners updated with the project progress. Periodic reports is one of the topics on the progress meetings. The report should contain what's accomplished in the last two weeks, including a short plan for the two next ones. The group can document their work in terms of deadlines, for example when a task is finished or if a scheduled task is being delayed. Delayed tasks should be documented properly, why it became a problem and how it's being solved.

Chapter 7

Deviation management

It is important to manage any deviations in expected standards in the development of a system. If the project progress does not go as planned the group will try to solve this by working additional hours to meet the desired deadlines set in the gantt-diagram. If this is not sufficient the group will try to find a different path to solve the specific task without affecting the result of the projects end result.

Scheduled procedure for changes:

1. Group discusses the possible ways to solve the deviation
2. Discuss the solution with supervisors
3. Approving of the solution with management group

The group leader is responsible for the overall progress of the project. Each member of the project is delegated their own tasks, of which the member is responsible for progress and results. The group leader should follow up the progress at the weekly group meeting.

Chapter 8

Prerequisites for implementation

Equipments	Supplier	Thoughts
Camera	Delivered by Amatec/Omron	We need a fully operational Vision-system, which includes camera, lens, light equipments and a Vision-controller. The idea is to test the Vision-system in our university laboratories, and then evaluate if the equipment is suitable for it's purpose.
Lens		
Vision-controller		
Light equipment		
Control cabinet	Vello or Amatec?	A suitable cabinet to mount electrical equipment.
PC-screen	Borrowed or bought by Vello	A Screen to present the filtered and unfiltered image. Should be industrial because it will be placed in production area.
Power supplies	Borrowed or bought by Amatec/Omron	To power Vision-system and the PLC.
IO modules	Bought or borrowed by Vello	For controlling desired lights, and reading sensors.
Miscellaneous coupling materials	Bought by Vello or Amatec	Miscellaneous coupling materials.
Actuator	Bought by Vello or borrowed by Amatec	To control the cameras position.
PLC	Bought or borrowed by Vello	We want it to be purchased or borrowed a separate PLC that we can use throughout the project.
License for PLC	Vello	If the software requires a license.
Test profiles	Borrowed by Vello	Test profiles from line 5.

Table 8.1: Equipment requirements

Appendix

A Gantt diagram

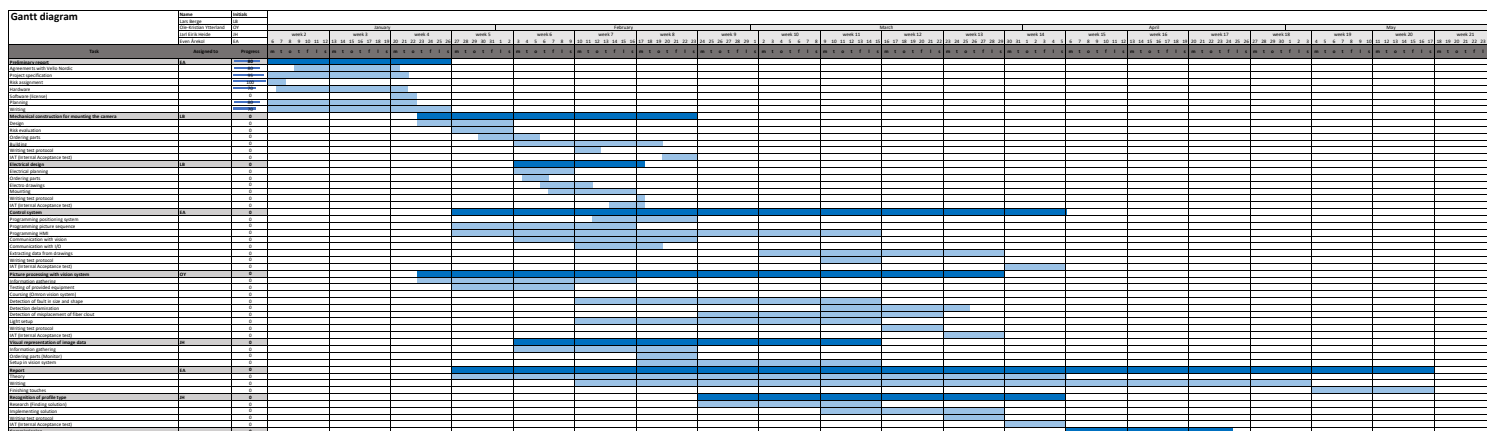
B Progress report 17.01.2020

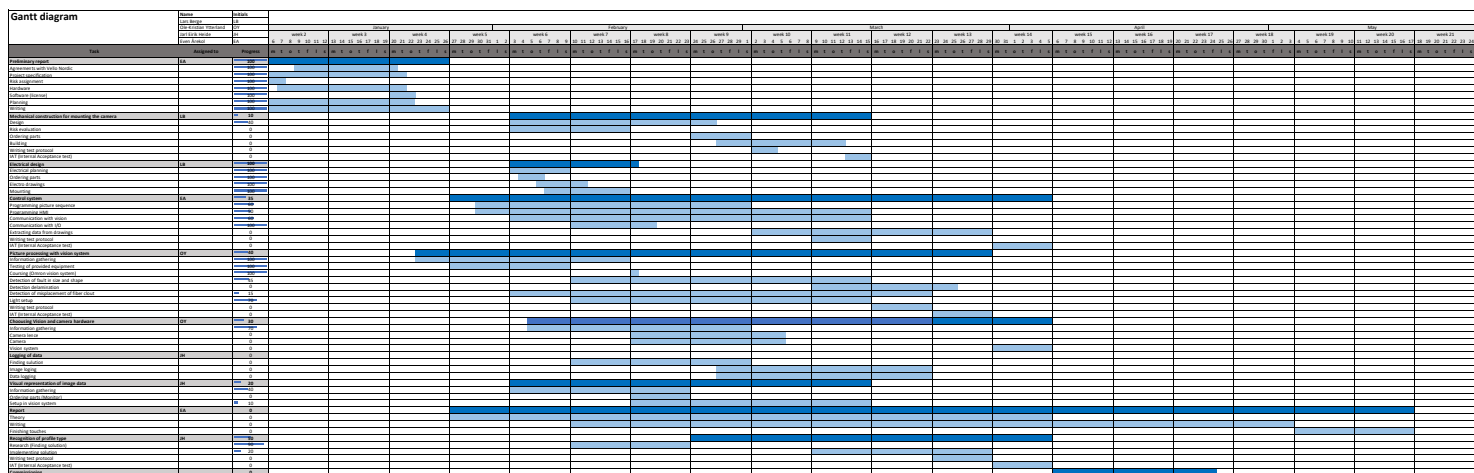
C Risk analysis

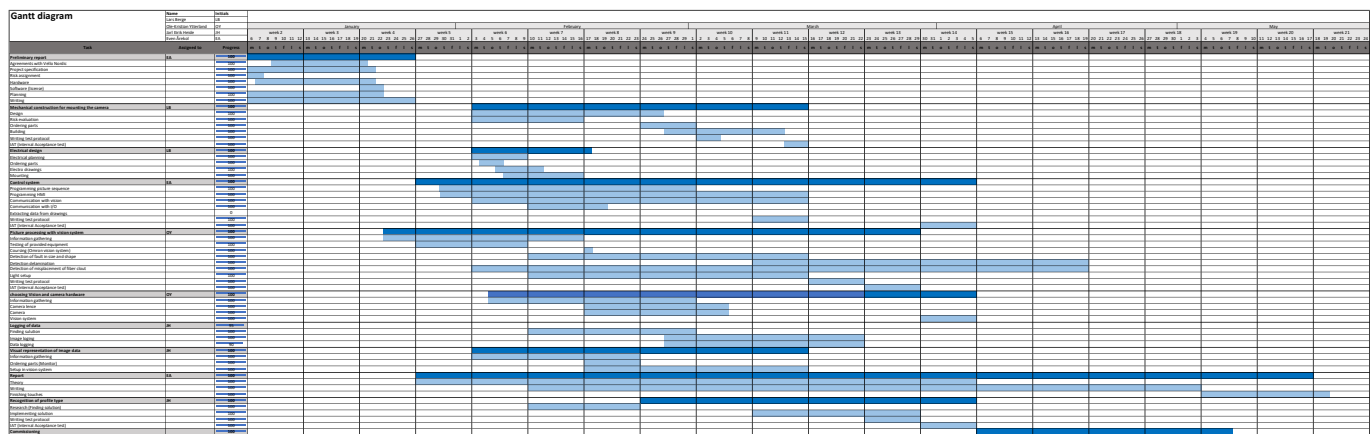
Bibliography

- [1] Ken Schwaber, Jeff Sutherland. The scrum guide — scrum.org, 2017. URL <https://www.scrumguides.org/docs/scrumguide/v2017/2017-Scrum-Guide-US.pdf#zoom=100>. [Online; accessed 21-January-2020].
- [2] Wikipedia contributors. Internal control — Wikipedia, the free encyclopedia, 2019. URL https://en.wikipedia.org/w/index.php?title=Internal_control&oldid=906086640. [Online; accessed 14-January-2020].

B Gantt diagram







C Progress reports

PROJECT STATUS REPORT

PROJECT

REPORT DATE	NAME ON PROJECT	DONE BY	REPORT NUMBER
17. januar 2020	Quality control of fiberglass profiles using industrial vision-system	Bachelor group Vello	[1]

STATUS SUMMARY

Preliminary report almost completed, will be finished next week.

- Some details to be decided in the meeting

Working on acquiring vision hardware from Amatec.

In the following week we will finish up the preliminary report and get a quick introduction on the vision system.

Each member will start with his delegated assignment in the next week.

DEVIATION

Nothing to report

PROJECT OVERVIEW

PLANNED TASKS	% PROGRESS	DUE DATE	ASSIGNED TO	STATUS
Preliminary report	80	26.01	Even Årekol	Ongoing

TASK PERFORMED	NOTES	DATE

CONCLUSIONS/ RECOMMENDATIONS

Work with the preliminary report is going well and we have not encounter any major obstacles.

PROJECT STATUS REPORT

PROJECT

REPORT DATE	NAME ON PROJECT	DONE BY	REPORT NUMBER
31. januar 2020	Quality control of fiberglass profiles using industrial vision-system	Bachelor group Vello	[2]

STATUS SUMMARY

First draft of preliminary report handed in, no feedback from supervisors yet.
Got all our equipment and starting to get familiar with it. Most equipment needs some time to get used to.
Built a control cabinet and set up workstations at NTNU tunglab, after agreement with Anders Sætersmoen.
Next we will build a testing rig for camera and lighting, continue testing and researching the subjects.
Mandatory lectures in week 5, therefor we had limited time to work on bachelor that week.

DEVIATION

Nothing to report

PROJECT OVERVIEW

PLANNED TASKS	% PROGRESS	ASSIGNED TO	STATUS
Picture processing	5	OY	Started
Control system	10	EÅ	Started
Electrical design	70	LB	On going
Mechanical construction	5	LB	Started

TASK PERFORMED	NOTES	DATE
Preliminary report	Still needs approval from supervisors	22.01.2020
Built control cabinet	Done	28.01.2020

CONCLUSIONS/RECOMMENDATIONS

Work is going well and we don't see any big obstacles in the upcoming weeks.

PROJECT STATUS REPORT

PROJECT

REPORT DATE	NAME ON PROJECT	DONE BY	REPORT NUMBER
18. februar 2020	Quality control of fiberglass profiles using industrial vision-system	Bachelor group Vello	3

STATUS SUMMARY

First week has been used on Industrial 4.0.

Have been testing and gotten familiar with the equipment's we have been provided with. Worked on specifying physical properties and measurements for vision system, like field of view, working distance and accuracy of measurements. Found methods that's suitable for our project. With cooperation with Omron, an instructor has held a small course on their Vision System for our group. Working on design for mounting of camera and light source, since the camera needs to be centered on the profile.

DEVIATION

Had some problems with etherCAT communication but worked it out by resetting Beijer PLC and HMI and had to set up everything from scratch. Ordered a new circular IR light with Omron, delivery time is 3 weeks but is not confirmed yet. But for testing purpose we will make do with the IR light bar we have now.

PROJECT OVERVIEW

PLANNED TASKS	% PROGRESS	DUE DATE	ASSIGNED TO	STATUS
Mechanical construction for mounting camera	10%	15.03	LB	Prepared
Control System	35%	05.04	EA	Started
Picture processing	40%	29.03	OY	Started
Recognition of profile type	50%	06.04	JH	Started

TASK PERFORMED	NOTES	DATE
Electrical design	Done	16.02.20
Testing of Vision System	Done	16.02.20
Coursing Vision System	Done	17.02.20

CONCLUSIONS/RECOMMENDATIONS

We have now gathered a lot of information and can start making programs for use and trying to generalize the program for more than one profile true the PLC and HMI recipe. We will also need to get the maximum size for the profile we are going to analyze so we can determine the final field of view, and therefore decide necessary hardware.

PROJECT STATUS REPORT

PROJECT

REPORT DATE	NAME ON PROJECT	DONE BY	REPORT NUMBER
28. februar 2012	Quality control of fiberglass profiles using industrial vision-system	Bachelor group Vello	4

STATUS SUMMARY

In the past two weeks, we have been working with displaying images from the vision system on the Beijer HMI-panel. There has been some struggles with the communication from the Beijer HMI-panel to the FTP-server. More work on the FTP communication is needed.

There has also been worked with etherCAT communication for presentation of result and logging of data from a csv file through an FTP server. A solution to present the result on the HMI-panel need to be implemented.

The Image processing has moved forward and we have managed to calibrate the camera. The measurement shows to be to be precise measurements of the profile. We have also received a new lens from Omron with longer focal length. This is to test if we can get even better measurements with a longer focal length because of less distortion.

The circular IR lights has a delivery date 18 Mars. We have also ordered a new photocell for more precise capturing of picture. We had a meeting with Vello-Nordic where we discussed the requirements of the size and tolerance for the profiles. We also discussed the mechanical solution for mounting the.

DEVIATION

Encountered some problems with the Beijer panel and FTP server, but we have solved the main problems. We have also struggled with reading csv files from the FTP server, needs more work to solve. Because of etherCat is used between PLC and Vision-controller there are some problems regarding what data that could be sent between them.

PROJECT OVERVIEW

PLANNED TASKS	% PROGRESS	DUE DATE	ASSIGNED TO	STATUS
Image processing	50%	29.03	OY	Started
Control System	45%	05.04	EA	
Visual representation of image data	20%	15.03	JH	Started
TASK PERFORMED			NOTES	DATE

CONCLUSIONS/RECOMMENDATIONS

Keep work on getting precise measurements of the profile and testing with different lens. Look into how to read data from a csv file through the FTP server. Take a final decision and program how to present result from the image processing.

PROJECT STATUS REPORT

PROJECT

REPORT DATE	NAME ON PROJECT	DONE BY	REPORT NUMBER
13. april 2020	Quality control of fiberglass profiles using industrial vision-system	Bachelor group Vello	5

STATUS SUMMARY

After last progress meeting we have been working on a solution for presenting faults graphically so they are easy to spot. We have found one solution for this problem that should be fine to implement.

We have Implemented the functions needed in the HMI to fulfill the visual presentation of the result presented at the last status meeting. There have been some problems with the FTP communication between the vision controller and the HMI panel. We're trying to avoid using the third-party FTP library by mapping the FTP server in the HMI as a network drive in the vision controller. This is still not achieved, and further work is needed.

We have created and tested a recipe system that is built in iX Developer for controlling which profile is in production and changing the settings according to this.

There is still some work left on controlling and using all the possible features that the vision-controller has regards to the etherCat communication.

DEVIATION

The government decided the March 12 to close all schools in the country due to the corona virus. This means that we can't work at the school's lab as planned. The equipment is currently moved to Ole-Kristian's apartment.

We have had some trouble with the third-party FTP library. We're working with a solution to avoid using the library. There are some problems regarding exchange of data from PLC to Omron controller, we are trying to figure out what is causing this problem, we have been in contact with Omron support without any help, they are also trying to fix the issue.

CONCLUSIONS/RECOMMENDATIONS

Despite the corona virus he is optimistic in completing the bachelor thesis as planned but some deviation with testing is expected.

We're planning to work individually from home and meet at Ole Kristian if someone needs to access to the equipment.

The next two weeks, we will work on communication between the vision controller and HMI and writing on the bachelor report.

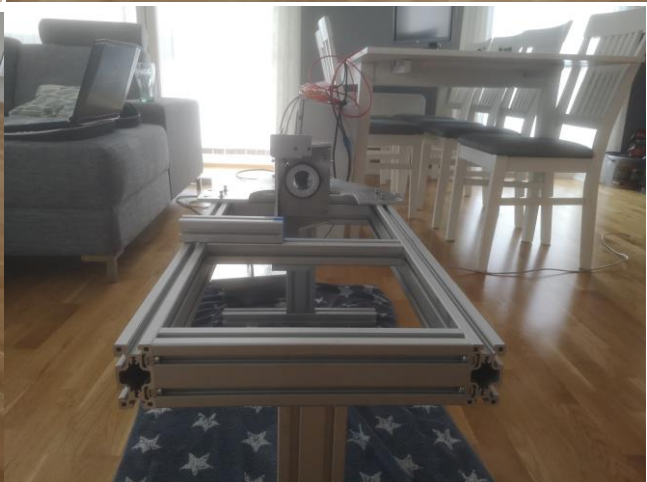
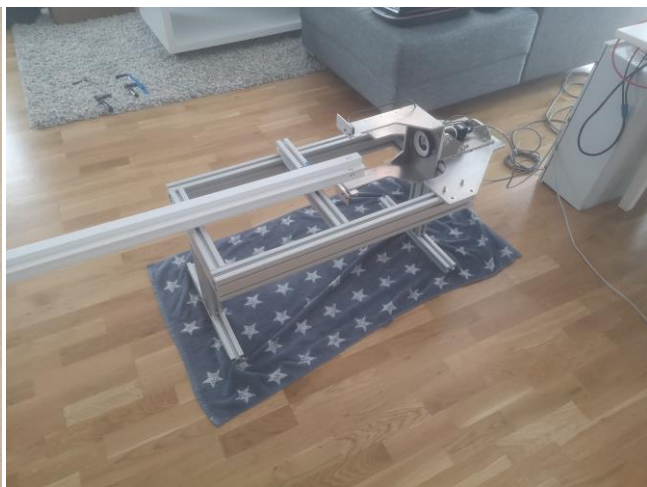
PROJECT STATUS REPORT

PROJECT

REPORT DATE	NAME ON PROJECT	DONE BY	REPORT NUMBER
27. mars 2020	Quality control of fiberglass profiles using industrial vision-system	Bachelor group Vello	6

STATUS SUMMARY

Mechanical build, the mechanical solution is built only minor work left on this before its done. As one can see on the picture below a testing area for it has also been built. The initial tests are promising, and it look like the construction has meet its criteria.



Report, due to corona a large portion of the time has been spent on planning and writing the thesis report. A large portion of the theory and method is written.

The work has primarily been done separate and we have only been at Ole-Kristian place when we have had concrete work to perform.

A dot NET application is developed for transferring images from the FH vision controller to the HMI. The application is also supposed to get the result image with visual representation of fault. The application is not complete, and further testing is needed.

Below there is a print screen from the program Trello where we plan future tasks. We are planning to be done with all the tasks in the "Bachelor oppgaver" list. These are the remaining tasks to prepare the solution for testing in the production line at Vello Nordic.

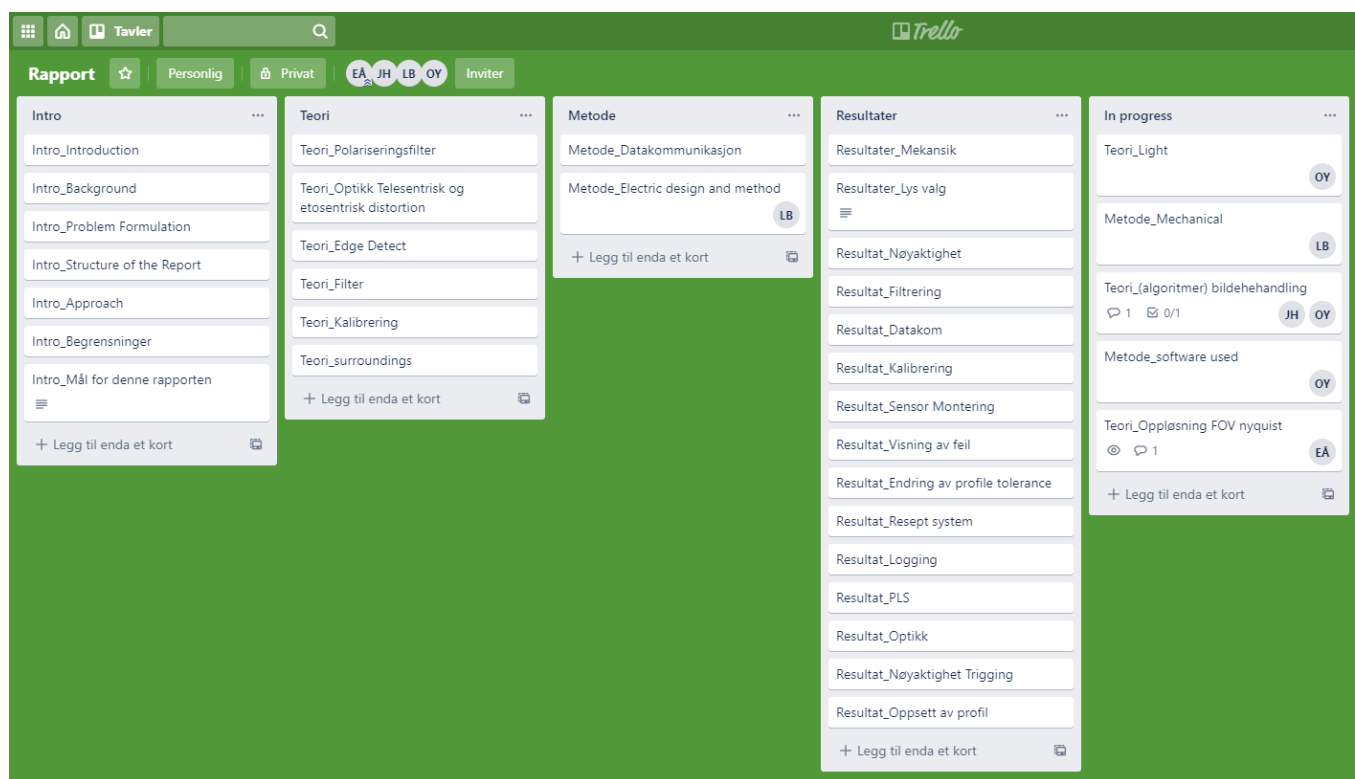


Figure 1 Tasks for the bachelor report

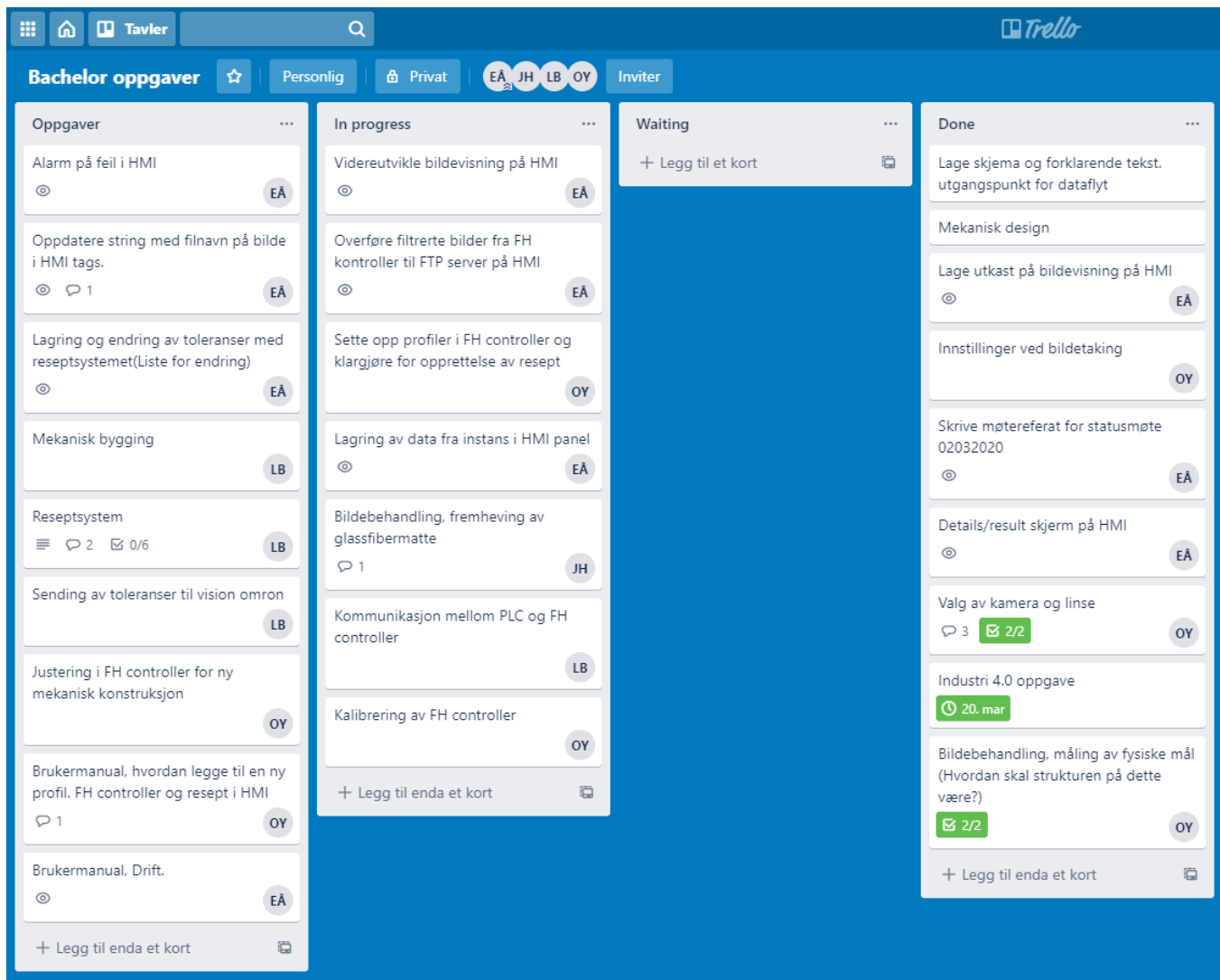


Figure 2 Tasks for the project

DEVIATION

The dot NET application was missing the libraries. There was a problem with installing the new library's because there was not enough storage space on the vision controller. This was solved by using an older version framework 3.5. There were still some problems uploading the image to the HMI panel. This need further work.

CONCLUSIONS/RECOMMENDATIONS

Work has been going well despite the corona virus and we only see minor problems related to it. Devotions can happen due to the virus at a later time in the project.

We are still planning to work individually from home and meet at Ole Kristian if someone needs to access to the equipment.

In the next period we will work on the tasks assigned to us at Trello. When we have some spare time, we will work on the report.

PROJECT STATUS REPORT

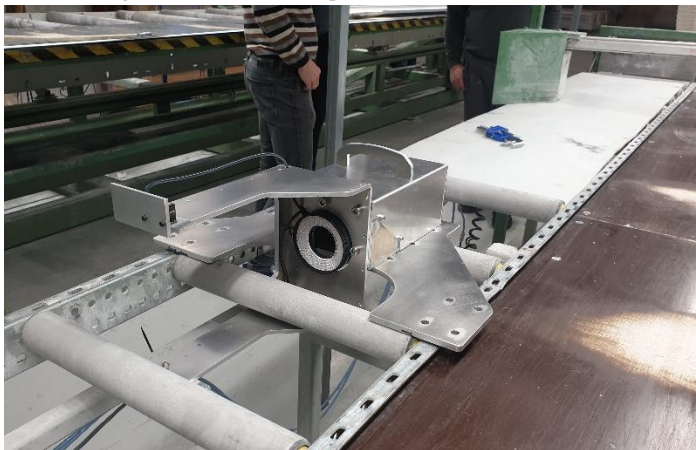
PROJECT

REPORT DATE	NAME ON PROJECT	DONE BY	REPORT NUMBER
24. april 2020	Quality control of fiberglass profiles using industrial vision-system	Bachelor group Vello	7

STATUS SUMMARY

This status summary will report the last four weeks in the project due to the Easter holiday.

- The mechanical solution is now done, and we have been a trip to Vello to check if we have covered and avoided any flaws in the design.



- We now have a functioning system for transferring the images to the HMI. This includes RAW image, filter image and the image with the faults highlighted.

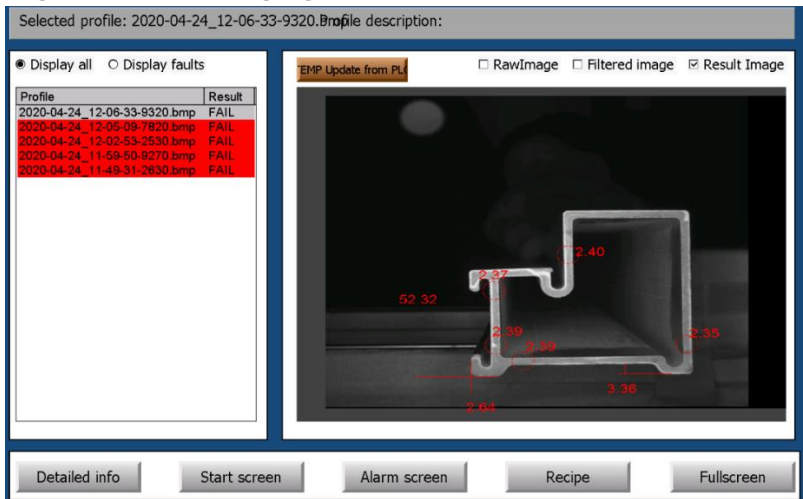


Figure 1 Main screen for vision quality control (The orange "TEMP update from PLC" button is temporary for debug)

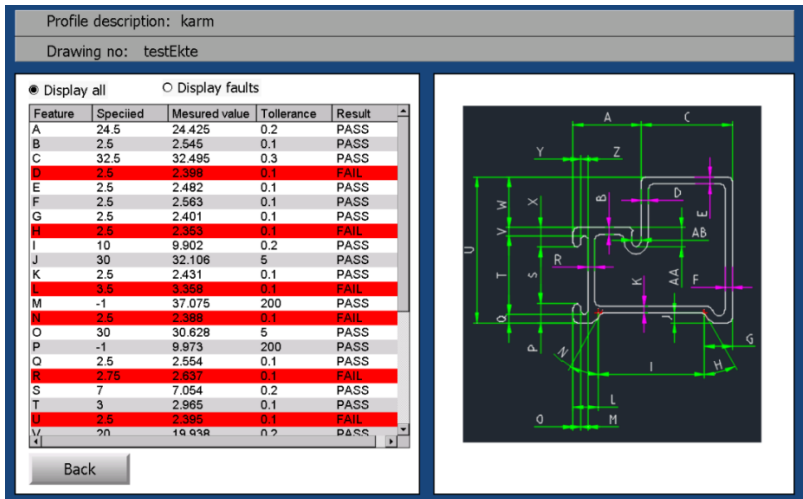


Figure 2 Details result screen

- The recipe system is almost complete and working as intended, it is only missing some features before its complete.

Figure 3 Selecting recipe screen (The orange "Import" button is temporary for debug)

Identifier	Value	Tolerance	Scene-unit	Data number
A	24,5	0,2	138	0
B	2,5	0,1	138	1
C	32,5	0,3	138	2
D	2,5	0,1	138	3
E	2,5	0,1	138	4
F	2,5	0,1	138	5
G	2,5	0,1	138	6
H	2,5	0,1	138	7
I	10	0,2	138	8
J	30	1	138	9
K	2,5	0,1	138	10
L	3,5	0,1	138	11
M	-1	0	138	12
N	2,5	0,1	138	13
O	30	1	138	14
P	-1	0	138	15
Q	2,5	0,1	138	16

Figure 4 Edit recipes screen

- We have started working on an operator manual where the operation of the system is explained.
- Work on the report is going as planned and we feel comfortable with the progress.
- One Friday 24.04 we had a meeting with Vello to get united on the goals for this project and update them on what we have accomplished. The last discussion was about testing at Vello, in the next two-week Vello will only be producing the carbon cable at line ten. This means that testing on line five can have some limitations, this is an agenda item and will be discussed further there.
- Corona is still affecting the way we work, but we are only seeing minor problems due to the situation

DEVIATION

The development of the lists in the HMI application has taken considerably longer time than expected but is now solved.

CONCLUSIONS/RECOMMENDATIONS

The group is feeling confident that we will be done on time and that the only thing left to plan is the testing at Vello, there is still some things left to complete before this, but these are only minor tasks.

The group will continue its work and handle the corona situation as good as possible and keep up the work.

PROJECT STATUS REPORT

PROJECT

REPORT DATE	NAME ON PROJECT	DONE BY	REPORT NUMBER
8. mai 2020	Quality control of fiberglass profiles using industrial vision-system	Bachelor group Vello	8

STATUS SUMMARY

We have completed two tests at Vello, one manual test and one live test.

- The manual test was done to collect data to check our system accuracy and precision
- The production test is considered as a success, we proved that our solution worked.

The report and documents related to this is the only remaining part before the completion of the project.

DEVIATION

Nothing to report.

CONCLUSIONS/RECOMMENDATIONS

Report is the main priority for the rest of the project period.

D Meeting notices

Notice

Progress meeting

Date: 20.01.2020	Place: Norwegian Maritime Competence Center Borgundvegen 340, 6009 Ålesund
Time: 14.00	Meeting nr: 1

Invited:
Arne Styve
Webjørn Rekdalsbakken
Bjørn Stavset
Terje Bergset
Even Årekol
Lars Berge
Jarl Eirik Heide
Ole-Kristian Ytterland

Agenda

1 APPROVAL OF NOTICE

Approving the notice and its agenda items. Additional agenda items should be mentioned here.

2 REVIEW OF PROGRES REPORT

Discussing the progress for the last two weeks based on the progress report.

3 REVIEW OF TENTATIV PRELIMINARY REPORT

Feedback from the management group on the preliminary report. Focus on project specification.

4 METHOD FOR DEVELOPMENT

Discussing method for development. Agile vs waterfall.

5 PROCEDURE FOR ORDERING PARTS

Making a procedure for ordering parts.

6 PROCEDURE FOR ACCESS TO VELLO NORDIC

How should the project group get access to Vello Nordic.

Notice

Progress meeting

Date: 31.01.2020	Place: Norwegian Maritime Competence Center Borgundvegen 340, 6009 Ålesund
Time: 14.00	Meeting nr: 2

Invited:
Arne Styve
Webjørn Rekdalsbakken
Bjørn Stavset
Terje Bergset
Even Årekol
Lars Berge
Jarl Eirik Heide
Ole-Kristian Ytterland

Agenda

1 APPROVAL OF NOTICE

Approving the notice and its agenda items. Additional agenda items should be mentioned here.

2 REVIEW OF PROGRES REPORT

Discussing the progress for the last two weeks based on the progress report.

3 REVIEW OF PRELIMINARY REPORT

Feedback from the management group on the preliminary report.

Notice

Progress meeting

Date: 18.02.2020	Place: Norwegian Maritime Competence Center Borgundvegen 340, 6009 Ålesund
Time: 14.00	Meeting nr: 3

Invited:
Arne Styve
Webjørn Rekdalsbakken
Bjørn Stavset
Terje Bergset
Even Årekol
Lars Berge
Jarl Eirik Heide
Ole-Kristian Ytterland

Agenda

1 APPROVAL OF NOTICE

Approving the notice and its agenda items. Additional agenda items should be mentioned here.

2 REVIEW OF PROGRES REPORT

Discussing the progress for the last two weeks based on the progress report.

3 NON-DISCLOSURE AGREEMENT

Feedback from Vello Nordic about NTNU's NDA.

4 PRESENTATION OF IMAGE PROCESSING

Presentation of the processed image on a second screen

5 REQUIREMENTS FOR PROFILE INSPECTION

Discussing the accuracy of the camera, Field of view and Tolerance for the profiles.

6 DISCUSSION OF FURTHER WORK

Discuss the plan for the further work.

7 PURCHASING NEW LASER SENSOR

Approval for buying a new laser sensor for detecting the profile

8 GENERAL DISCUSSION

Other relevant topics not included above.

Notice

Progress meeting

Date: 2.03.2020	Place: Norwegian Maritime Competence Center Borgundvegen 340, 6009 Ålesund
Time: 14.00	Meeting nr: 4

Invited:
Arne Styve
Webjørn Rekdalsbakken
Bjørn Stavset
Terje Bergset
Even Årekol
Lars Berge
Jarl Eirik Heide
Ole-Kristian Ytterland

Agenda

1 APPROVAL OF NOTICE

Approving the notice and its agenda items. Additional agenda items should be mentioned here.

2 REVIEW OF PROGRES REPORT

Discussing the progress for the last two weeks based on the progress report.

3 PRESENTATION OF GUI SOLUTION

The project group presents their solution for displaying the image on the Beijer HMI screen. The solution needs to be discussed.

4 GENERAL DISCUSSION

Other relevant topics not included above.

Notice

Progress meeting

Date: 16.03.2020	Place: Skype
Time: 14.00	Meeting nr: 5

Invited:
Arne Styve
Webjørn Rekdalsbakken
Bjørn Stavset
Terje Bergset
Even Årekol
Lars Berge
Jarl Eirik Heide
Ole-Kristian Ytterland

Agenda

1 APPROVAL OF NOTICE

Approving the notice and its agenda items. Additional agenda items should be mentioned here.

2 REVIEW OF PROGRES REPORT

Discussing the progress for the last two weeks based on the progress report.

3 VISUALIZATION OF FAULT

The project group presents their solution for visualize faults occurred.

4 TESTING AT VELLO NORDIC

Are there any restriction regarding testing at Vello Nordic due to the corona virus.

5 LOGGING

The project group are going to present their solution for logging images and measurements. There are also some questions regarding what data to log and where to log.

6 BACHELOR REPORT

Questions regarding the bachelor report.

7 GENERAL DISCUSSION

Other relevant topics not included above.

Notice

Progress meeting

Date: 29.03.2020	Place: Skype
Time: 14.00	Meeting nr: 6

Invited:

Arne Styve
Webjørn Rekdalsbakken
Bjørn Stavset
Terje Bergset
Even Årekol
Lars Berge
Jarl Eirik Heide
Ole-Kristian Ytterland

Agenda

1 APPROVAL OF NOTICE

Approving the notice and its agenda items. Additional agenda items should be mentioned here.

2 REVIEW OF PROGRES REPORT

Discussing the progress for the last two weeks based on the progress report.

3 TESTING AT VELLO NORDIC

How does the possibility for testing looks like in the future weeks?

4 GENERAL DISCUSSION

Other relevant topics not included above.

Notice

Progress meeting

Date: 27.04.2020	Place: Skype
Time: 14.00	Meeting nr: 7

Invited:

Arne Styve
Webjørn Rekdalsbakken
Bjørn Stavset
Terje Bergset
Even Årekol
Lars Berge
Jarl Eirik Heide
Ole-Kristian Ytterland

Agenda

1 APPROVAL OF NOTICE

Approving the notice and its agenda items. Additional agenda items should be mentioned here.

2 REVIEW OF PROGRES REPORT

Discussing the progress for the last two weeks based on the progress report.

3 TESTING AT VELLO NORDIC

Discussing the possibility for testing in the future weeks.

4 GENERAL DISCUSSION

Other relevant topics not included above.

Notice

Progress meeting

Date: 11.05.2020	Place: Skype
Time: 14.00	Meeting nr: 8

Invited:

Arne Styve
Webjørn Rekdalsbakken
Bjørn Stavset
Terje Bergset
Even Årekol
Lars Berge
Jarl Eirik Heide
Ole-Kristian Ytterland

Agenda

1 APPROVAL OF NOTICE

Approving the notice and its agenda items. Additional agenda items should be mentioned here.

2 REVIEW OF PROGRES REPORT

Discussing the progress for the last two weeks based on the progress report.

3 PROJECT COMPLETION

Discussion regarding completion of the project. Make sure Vello Nordic gets all information and data needed.

4 GENERAL DISCUSSION

Other relevant topics not included above.

E Meeting reports

Meeting report

Date: 20.01.2020	Place: NTNU
Time: 14.00	Meeting nr: 1

Invited: Arne Styve Webjørn Rekdalsbakken Terje Bergset Bjørn Stafset Even Årekol Lars Berge Jarl Eirik Heide Ole-Kristian Ytterland	Attended: Arne Styve Webjørn Rekdalsbakken Terje Bergset Bjørn Stafset Even Årekol Lars Berge Jarl Eirik Heide Ole-Kristian Ytterland
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1 APPROVAL OF NOTIC

Agenda item:

Approving the notice and its agenda items. Additional agenda items should be mentioned here.

Discussion:

No new topics proposed.

Conclusion:

Notice was approved.

2 REVIEW OF PROGRES REPORT

Agenda item:

Discussing and approving the progress report.

Discussion:

The progress report was read. Most of the discussion of the progress is described in topic nr 3 "review of tentative preliminary report".

Conclusion:

No comments on the progress.

3 REVIEW OF TENTATIV PRELIMINARY REPORT

Agenda item:

Discussing the tentative preliminary report.

Discussion:

Some of the contact information in the preliminary report was wrong and must be corrected. There was also requested more detailed contact information for the participant of the project. The project group will execute these changes for the next draft of the preliminary report

The preliminary report should include some pictures of the profile to illustrate the topic in a better way. Terje and Bjørn are sending some drawings to use in the report.

Detection of cracks in the cross section should also be included in the project specification. Detection of cracks in the length direction should be included as "could have".

The section «Positioning of camera» should be rewritten. The section should imply that the camera must be mounted in a way that gives a desired result.

The risk analysis in the preliminary report should only be focusing on the risks that effects the progress of the project and the bachelor itself. There should also be included mitigation and contingency. Mitigation is measures done before the projects starts to reduce the risks. Contingency is procedures made if the risk evaluated occurs.

Logging and sending data to the database should be included in the project specification with the "must have" priority.

There should be implemented Routines for storing files and documents. The project group have a OneDrive share point where all the files and documents are stored. A written specified routine should be included in the preliminary report. There was also decided that the management group should have access to the share point account.

Møre Kontroll are going to make a new control system for the machine. It is therefore helpful at some point to have a meeting with them.

Conclusion:

The project group are executing the changes discussed in the meeting. A new draft of the preliminary report is sent to the management group as soon as the next draft is done.

4 METHOD FOR DEVELOPMENT

Agenda item:

Discussing method for development.

Discussion:

Arne Styve suggested to use an iterative Development method called Scrum.

Conclusion:

The project group takes this in consideration and evaluation of which development method should be used. This must be documented in the preliminary report.

5 PROCEDURE FOR ORDERING PARTS

Agenda item:

Discussing and making a procedure for ordering parts.

Discussion:

When the project group needs to order parts, this should be done through Amatec. An offer is sent to Bjørn and Terje and must be accepted before ordering. If Amatec is not price Competitive, ordering from another place should be considered.

Conclusion:

Procedure described over.

6 PROCEDURE FOR ACCESS TO VELLO NORDIC

Agenda item:

How should the project group get access to Vello Nordic?

Discussion:

The project group informs and agrees with Bjørn or Terje when visiting Vello Nordic. When the commissioning starts, it is important that the project group informs Vello Nordic early when they are going to mount and test the system. This is for planning when there is production on line 5.

Conclusion:

Procedure is discussed. Visits are planed continuously.

Meeting report

Date: 03.02.2020	Place: NTNU
Time: 14.00	Meeting nr: 2

Invited: Arne Styve Webjørn Rekdalsbakken Terje Bergset Bjørn Stafset Even Årekol Lars Berge Jarl Eirik Heide Ole-Kristian Ytterland	Attended: Arne Styve Webjørn Rekdalsbakken Terje Bergset Even Årekol Lars Berge Jarl Eirik Heide Ole-Kristian Ytterland
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1 APPROVAL OF NOTICE

Agenda item:

Approving the notice and its agenda items. Additional agenda items should be mentioned here.

Discussion:

No new topics proposed.

Conclusion:

Notice was approved.

2 REVIEW OF PROGRES REPORT

Agenda item:

Discussing and approving the progress report.

Discussion:

The progress report should be better documented and include more information about the last two weeks progress. The progress itself should also be better documented with for example an updated gantt diagram.

Routines for storing programming data should be better defined.

The project group showed some pictures of the current test setup and some images of a filtered picture.

Visualization on a separate screen was discussed. How this is developed should be decided.

Conclusion:

The project group are taking the comments about the progress report in consideration and improve this for the next report.

Routines for storing programming data are to be clearly defined.

Different possibility's for visualizing the filtered image for the operator are to be considered by the project group.

3 REVIEW OF PREMINILARY REPORT

Agenda item:

Feedback from the management group on the preliminary report.

Discussion:

The management group was satisfied with the preliminary report. Webjørn had a comment about the use of the word picture instead of image.

Conclusion:

The project group will take Webjørn's advise and change the word picture to image.

Meeting report startup meeting

Date: 09.01.2020	Place: Vello Nordic, Skodje
Time: 13.00	Meeting nr: N/A

Invited: Terje Bergset Arne Styve Bjørn Stavset Jiregna Hirko foggi Lars Einar Riksheim Even Årekol Lars Berge Jarl Eirik Heide Ole-Kristian Ytterland	Attended: Terje Bergset Bjørn Stavset Jiregna Hirko foggi Lars Einar Riksheim Even Årekol Lars Berge Jarl Eirik Heide Ole-Kristian Ytterland Kåre Bjørlykhaug
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1 PARTICIPANTS IN THE PROJECT

Agenda item:

Clearly define who's a part of the project. Both project group and control group

Discussion:

There were decided that Terje Bergset and Bjørn Stavset becomes a part of the control group representing Vello Nordic. They were informed of biweekly status meeting.

Conclusion:

Project group: Even Årekol
Lars Berge
Jarl Eirik Heide
Ole-Kristian Ytterland

Control group: Arne Styve
Webjørn Rekdalsbakken
Terje Bergset
Bjørn Stavset

2 DEFINING THESIS PROBLEM

Agenda item:

Defining the thesis problem. A suggestion is provided by the project group.

Discussion:

Error detection of cross section

Error detection based on picture taken of the cross section is the most important part of the project. The goal is that the system manages to detect error automatically based on the features bellow. The features are compared with ideal values given by the DWG drawings of the specific profile. The goal is to make a general method of detecting errors that can be used for different profiles with minimum individual adjustments.

Features to be evaluated:

Geometry

- Shape
- Wall thickness
- Angles
- Radius

Delaminating

Displacement of fiber cloth

Error detection of surface

Error detection based on picture taken of the surface was decided to not be a part of the main task. The main focus should be in error detection of cross section. Error detection could be implemented if time allows it.

Recognition of profile type

Detection of type and product id based on picture taken as a control.

Complete control system

One of the main goals is to make a complete system for automatically taking picture, positioning of the camera and notify the operator if an error has occurred.

Components and equipment

Camera and lights systems are borrowed from Amatec.

It is preferred from Vello Nordic to use a specific combined PLC and HMI from Beijer. The specific system is the same as the system used in the machine today and it's the new standard for Vello Nordic. The purpose of this is to implement the complete program in the PLC for the machine.

Conclusion:

Based on the information from the meeting, the project group will write a document with clearly defined goals and issues to be solved. The document will be sent to the control group as soon as possible.

3 DEFECTIVE PROFILES FOR TESTING

Agenda item:

The project group need some defective profiles to test the system.

Discussion:**Conclusion:**

Defective and nondetective profiles for testing are provided by Vello Nordic when needed

Meeting report

Date: 02.03.2020	Place: Norwegian Maritime Competence Center Borgundvegen 340, 6009 Ålesund
Time: 14.00	Meeting nr: 4

Invited: Arne Styve Webjørn Rekdalsbakken Terje Bergset Bjørn Stafset Even Årekol Lars Berge Jarl Eirik Heide Ole-Kristian Ytterland	Attended: Arne Styve Webjørn Rekdalsbakken Terje Bergset Even Årekol Lars Berge Jarl Eirik Heide Ole-Kristian Ytterland
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1 APPROVAL OF NOTICE

Agenda item:

Approving the notice and its agenda items. Additional agenda items should be mentioned here.

Discussion:

The project group wanted to buy a digital caliper, the topic was added and discussed.

Conclusion:

Notice was approved.

2 REVIEW OF PROGRES REPORT

Agenda item:

Discussing and approving the progress report.

Discussion:

The project group informed about the last two weeks progress. Arne commented that the time for taking a picture should be documented.

Conclusion:

The project group will document the time for taking a picture.

3 PRESENTATION OF GUI SOLUTION

Agenda item:

The project group presents their solution for displaying the image on the Beijer HMI screen. The solution needs to be discussed.

Discussion:

The project group presented their solution for presenting the result of the quality control. Terje, Arne and Webjørn was satisfied with the result, but they proposed some improvements for the solution.

The profiles should not be deleted after inspection but rather have a acknowledge indication for the profiles that have faults. There was purposed that the HMI panel should have a connection to the database to get accesses to all the images.

Another improvement was to implement a filter for the profile list and the measured feature. With this, the operator gets a better overview of the profiles that have faults.

The last improvement that where purposed was to implement a visual representation of the fault occurred on the displayed image.

Conclusion:

The delete button are removed and replaced with a way to mark the profile with acknowledge. How many images the HMI should have access to needs to be decided. The project group will try to find solutions for the other improvements and implement these.

4 DIGITAL CALIPER

Agenda item:

The project group needs a digital caliper to verify the measurement from the vision system.

Discussion:

The digital caliper can be bought by the lab engineer.

Conclusion:

The project group contacts the lab engineer.

Meeting report

Date: 16.03.2020	Place: Skype
Time: 14.00	Meeting nr: 5

Invited: Arne Styve Webjørn Rekdalsbakken Terje Bergset Bjørn Stafset Even Årekol Lars Berge Jarl Eirik Heide Ole-Kristian Ytterland	Attended: Arne Styve Terje Bergset Even Årekol Lars Berge Jarl Eirik Heide Ole-Kristian Ytterland
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1 APPROVAL OF NOTICE

Agenda item:

Approving the notice and its agenda items. Additional agenda items should be mentioned here.

Discussion:

No new topics proposed.

Conclusion:

Notice was approved.

2 REVIEW OF PROGRES REPORT

Agenda item:

Discussing and approving the progress report.

Discussion:

The project group informed about the last two weeks progress.

Conclusion:

No comments about the last two weeks progress.

3 VISUALIZATION OF FAULT

Agenda item:

The project group presents their solution for visualize faults occurred.

Discussion:

The project group informed that there are some problems regarding exporting the image marked with the faulted measurements.

Conclusion:

The project group will try to get around the problem and exporting the image to the HMI as planned.

4 TESTING AT VELLO NORDIC

Agenda item:

Are there any restriction regarding testing at Vello Nordic due to the corona virus.

Discussion:

Terje informed that there are currently some restrictions regarding visitors at Vello Nordic. There will not be likely to get access in the next two weeks due to the combination of the corona virus and production of the carbon shielded coax cable.

After the two weeks, testing at Vello Nordic may be possible but the current situation must be taken under consideration.

Conclusion:

When the system is ready for testing, the project group informs Terje Bergset and plan for testing according to the current situation.

5 LOGGING

Agenda item:

The project group are going to present their solution for logging images and measurements. There are also some questions regarding what data to log and where to log.

Discussion:

The current solution is to map the storage area as a network drive in the vision controller.

Conclusion:

A meeting to plan how the logging should be and what to store is needed.

6 BACHELOR REPORT

Agenda item:

Questions regarding the bachelor report.

Discussion:

Arne informed about how the structure of a bachelor report should be. Terje requested a user manual for how to operate the system.

Conclusion:

The project group will make an user manual and include this as an appendix in the bachelor report.

Meeting report

Date: 30.03.2020	Place: Skype
Time: 14.00	Meeting nr: 6

Invited: Arne Styve Webjørn Rekdalsbakken Terje Bergset Bjørn Stafset Even Årekol Lars Berge Jarl Eirik Heide Ole-Kristian Ytterland	Attended: Arne Styve Terje Bergset Even Årekol Lars Berge Jarl Eirik Heide Ole-Kristian Ytterland
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1 APPROVAL OF NOTICE

Agenda item:

Approving the notice and its agenda items. Additional agenda items should be mentioned here.

Discussion:

No new topics proposed.

Conclusion:

Notice was approved.

2 REVIEW OF PROGRES REPORT

Agenda item:

Discussing and approving the progress report.

Discussion:

The project group informed about the last two weeks progress.

Conclusion:

No comments about the last two weeks progress.

3 TESTING AT VELLO NORDIC

Agenda item:

Are there any restriction regarding testing at Vello Nordic due to the corona virus.

Discussion:

Terje informed that there were some restrictions due to the corona virus, but testing can be performed with precautions.

Conclusion:

Testing can be performed but must be planed well in advanced.

4 GENERAL DISCUSION

Agenda item:

Are there any restriction regarding testing at Vello Nordic due to the corona virus.

Discussion:

Terje proposed a meeting regarding the scope of the project.

Conclusion:

A meeting will be planed in the following week.

Meeting report

Date: 27.04.2020	Place: Skype
Time: 14.00	Meeting nr: 7

Invited: Arne Styve Webjørn Rekdalsbakken Terje Bergset Bjørn Stafset Even Årekol Lars Berge Jarl Eirik Heide Ole-Kristian Ytterland	Attended: Arne Styve Terje Bergset Bjørn Stafset Even Årekol Lars Berge Jarl Eirik Heide Ole-Kristian Ytterland
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1 APPROVAL OF NOTICE

Agenda item:

Approving the notice and its agenda items. Additional agenda items should be mentioned here.

Discussion:

The project group added a new agenda topic regarding feedback on the bachelor report.

Conclusion:

Agenda topic "Feedback on bachelor report" was added.

2 REVIEW OF PROGRES REPORT

Agenda item:

Discussing and approving the progress report.

Discussion:

The project group informed about the last four weeks progress. Some questions were asked about the HMI. The questions were responded and clarified. Terje requested the filtered image of the profile.

Conclusion:

The project group will send a filtered image for the control group to see.

3 TESTING AT VELLO NORDIC

Agenda item:

Discussing the possibility for testing in the future weeks.

Discussion:

Terje informed that the earliest possible live test with production was 11.may. The project group will take an evaluation when the times come if they will preform a live test. This can be challenging because the due date for the bachelor report is 9 days later.

Manual testing will be possible in week 18. The project group arranged for manual testing Thursday 30.may.

Conclusion:

The project group preforms manual testing at Vello Nordic Thursday week 18.

4 FEEDBACK ON BACHELOR REPORT

Agenda item:

The project group wanted to deliver drafts of the bachelor report to Arne and Webjørn for feedback.

Discussion:

There was planned to get feedback on the report, 6. May and 13. May. Draft of the report are delivered during Monday, 4 and 11 of May.

Conclusion:

The project group delivers a draft during Monday, 4 and 11 of May.

Meeting report

Date: 11.05.2020	Place: Skype
Time: 14.00	Meeting nr: 8

Invited: Arne Styve Webjørn Rekdalsbakken Terje Bergset Bjørn Stafset Even Årekol Lars Berge Jarl Eirik Heide Ole-Kristian Ytterland	Attended: Arne Styve Webjørn Rekdalsbakken Terje Bergset Bjørn Stafset Even Årekol Lars Berge Jarl Eirik Heide Ole-Kristian Ytterland
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1 APPROVAL OF NOTICE

Agenda item:

Approving the notice and its agenda items. Additional agenda items should be mentioned here.

Discussion:

No new topics proposed.

Conclusion:

Notice was approved.

2 REVIEW OF PROGRES REPORT

Agenda item:

Discussing and approving the progress report.

Discussion:

The project group informed about the last four weeks progress. Both manual testing and live testing went as planned.

Conclusion:

The project group will work with completing the bachelor report.

3 PROJECT COMPLETION

Agenda item:

Discussion regarding completion of the project. Make sure Vello Nordic gets all information and data needed.

Discussion:

Terje requested list with components used in the project and user manual for the system.

Conclusion:

Project group will deliver all the data to the Teams site as discussed. The list with the components are included in the bachelor report.

4 GENERAL DISCUSSION

Agenda item:

Other relevant topics not included above.

Discussion:

Conclusion:

We thank you for the cooperation in this project.

Meeting report startup meeting

Date: 09.01.2020	Place: Vello Nordic, Skodje
Time: 13.00	Meeting nr: N/A

Invited: Terje Bergset Arne Styve Bjørn Stavset Jiregna Hirko foggi Lars Einar Riksheim Even Årekol Lars Berge Jarl Eirik Heide Ole-Kristian Ytterland	Attended: Terje Bergset Bjørn Stavset Jiregna Hirko foggi Lars Einar Riksheim Even Årekol Lars Berge Jarl Eirik Heide Ole-Kristian Ytterland Kåre Bjørlykhaug
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1 PARTICIPANTS IN THE PROJECT

Agenda item:

Clearly define who's a part of the project. Both project group and control group

Discussion:

There were decided that Terje Bergset and Bjørn Stavset becomes a part of the control group representing Vello Nordic. They were informed of biweekly status meeting.

Conclusion:

Project group: Even Årekol
Lars Berge
Jarl Eirik Heide
Ole-Kristian Ytterland

Control group: Arne Styve
Webjørn Rekdalsbakken
Terje Bergset
Bjørn Stavset

2 DEFINING THESIS PROBLEM

Agenda item:

Defining the thesis problem. A suggestion is provided by the project group.

Discussion:

Error detection of cross section

Error detection based on picture taken of the cross section is the most important part of the project. The goal is that the system manages to detect error automatically based on the features bellow. The features are compared with ideal values given by the DWG drawings of the specific profile. The goal is to make a general method of detecting errors that can be used for different profiles with minimum individual adjustments.

Features to be evaluated:

Geometry

- Shape
- Wall thickness
- Angles
- Radius

Delaminating

Displacement of fiber cloth

Error detection of surface

Error detection based on picture taken of the surface was decided to not be a part of the main task. The main focus should be in error detection of cross section. Error detection could be implemented if time allows it.

Recognition of profile type

Detection of type and product id based on picture taken as a control.

Complete control system

One of the main goals is to make a complete system for automatically taking picture, positioning of the camera and notify the operator if an error has occurred.

Components and equipment

Camera and lights systems are borrowed from Amatec.

It is preferred from Vello Nordic to use a specific combined PLC and HMI from Beijer. The specific system is the same as the system used in the machine today and it's the new standard for Vello Nordic. The purpose of this is to implement the complete program in the PLC for the machine.

Conclusion:

Based on the information from the meeting, the project group will write a document with clearly defined goals and issues to be solved. The document will be sent to the control group as soon as possible.

3 DEFECTIVE PROFILES FOR TESTING

Agenda item:

The project group need some defective profiles to test the system.

Discussion:**Conclusion:**

Defective and nondetective profiles for testing are provided by Vello Nordic when needed

Meeting report

Date: 05.02.2020	Place: Vello Nordic
Time: 08.30	Meeting nr: N/A

Invited: Webjørn Rekdalsbakken Terje Bergset Bjørn Stafset Sverre Andre Blindheim Edvard Dyb Even Årekol Lars Berge Jarl Eirik Heide Ole-Kristian Ytterland	Attended: Terje Bergset Bjørn Stafset Sverre Andre Blindheim Edvard Dyb Even Årekol Lars Berge Jarl Eirik Heide Ole-Kristian Ytterland
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1 DISCUSSION

Agenda item:

Discussion the challenges with implementing the vision system with the application developed by Møre Kontroll and the solution for mounting the camera on the line.

Discussion:

Before the meeting, an inspection of line 5 was done. Here we were looking at the sequence and mechanics of the process. There was also taken some pictures to inspect later.

The PLC and HMI program must be implemented with Møre Kontroll in the end. Before the vision system is finished and tested properly, the two systems are held separate. There was discussed how to implement the HMI scenes to combine the two programs as easy as possible.

A screen for visualizing the result of the image processing was discussed. Both having a separate screen and displaying the image on the HMI was discussed. No clear conclusion was made.

Physical placement of the camera was inspected and discussed. One solution was to mount the camera with a photocell at the end of the line. The mechanical construction must be designed in such way that it can be easily moved to produce different lengths.

Conclusion:

The project group keep develop the vision application with combining the two applications in the end in mind.

The project group are also trying to display the image from the vision system on the Beijer HMI display. Other methods to display the image are also taking into consideration.

The placement of the camera is assumed to be mounted at the end of the production line. For mounting of the camera and sensor, a prototype is made to complete the testing. Mechanics from Vello Nordic can provide a permanent construction for mounting the camera.

Meeting report

Date: 27.02.2020	Place: Vello Nordic Håhjem, 6260 Skodje
Time: 13.00	Meeting nr: na

Invited: Terje Bergset Bjørn Stafset Jiregna Hirko foggi Kåre Bjørlykhaug Even Årekol Lars Berge Jarl Eirik Heide Ole-Kristian Ytterland	Attended: Terje Bergset Jiregna Hirko foggi Kåre Bjørlykhaug Even Årekol Lars Berge Jarl Eirik Heide Ole-Kristian Ytterland
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1 REQUIRMENTS FOR QUALITY AND HARDWARE

Agenda item:

Quality requirements / Resolution / Size of profiles to be inspected

Discussion:

Kåre Bjørlykhaug informed about how the quality control today is done. The group informed of requirement for hardware given the FOV for the camera. The FOV for the camera is decided by the resolution and the tolerance on the profile.

Discussing of how large the profile to inspect should be, it has decided that we should define the maximum FOV and in the report document the requirement for hardware depending on FOV.

Conclusion:

We concluded that we should use the hardware borrowed by Amatec and work with the FOV this gives us given the tolerance of 0.1 mm.

In the bachelor report there will be a section regarding accuracy and field of view.

2 MOUNTING OF EQUIPMENT ON THE PRODUCTION LINE

Agenda item:

Discussing and planning how to mount the equipment on the production line.

Discussion:

The group explained how much deviation in the placement of the profile the vision system can handle.

An inspection at the production line was done and different solutions was discussed. The group will only plan the mounting of the camera equipment, Vello Nordic will design and build the necessary guides for the profile.

Conclusion:

The group will make a draft on how they plan to mount the camera and necessary equipment.

Vello Nordic will discuss and plan the guiding mechanism.

F BOM test setup

Mechancial test setup

This list gives an overview of the components used in mechancial test setup

Component	Description	Quantity	Supplier
40x40 Alu profile, length 300 mm	Lower beam 1	1	Amatec AS
40x40 Alu profile, length 300 mm	Lower beam 2	1	Amatec AS
40x80 Alu profile, length 740 mm	Main beam	1	Amatec AS
40x80 Alu profile, length 423 mm	Equipment beam	1	Amatec AS
40x80 Alu profile, length 63 mm	support beam 5	1	Amatec AS
40x80 Alu profile, length 63 mm	support beam 5	1	Amatec AS
40x80 Alu profile, length 140 mm	support beam 2	1	Amatec AS
40x80 Alu profile, length 260 mm	support beam 4	1	Amatec AS
40x80 Alu profile, length 300 mm	support beam 3	1	Amatec AS
Lightbracet	Custome made from aluminum, by group	1	Amatec AS
Angle bracket	Custome made from aluminum, by group	1	Amatec AS
Base plate	Custome made from aluminum, by group	1	Amatec AS
K80118ACSR18R18	Angle bracket for tube	1	Amatec AS
8220301_L0220_1_0.095	Tube	1	Amatec AS
K30018ACSR18__FS-KU_12-18	Profile mounting bracket	1	Amatec AS
E3Z-LL81 2M OMS	Fotocelle, bakgrunnsavblending Laser Sensor, 20-300mm, kablet, PNP utgang	1	Amatec AS

G HMI source code

HMI source code located in folder [G](#) in attached zip file.

H Backup Vision software

Backup of Vision software located in folder [H](#) in attached zip file.

I PLC source code

PLC source code located in folder [I](#) in attached zip file.

J .NET source code

.NET source code located in folder [J](#) in attached zip file.

K Mechanical drawings

Mechanical drawings located in folder [K](#) in attached zip file.

L Mechanical 3D models

3D models located in folder [L](#) in attached zip file.

M Complete bill of material

Complete BOM for hardware located in folder [M](#) in attached zip file.

N User manual

User manual is located in folder [N](#) in attached zip file.

O Time sheets

Time sheets for the project group is located in folder [O](#) in attached zip file.

P Electrical drawing

Electrical drawing for the cabinet is located in folder [P](#) in attached zip file.