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Vision-based automatic tool-wear inspection system

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Contents

List of Figures

List of Tables

List of symbols

Maak een lijst van de gebruikte symbolen. Geef het symbool, naam en eenheid. Gebruik steeds SI-eenheden en gebruik de symbolen en namen zoals deze voorkomen in de hedendaagse literatuur en normen. De symbolen worden alfabetisch gerangschikt in opeenvolgende lijsten: kleine letters, hoofdletters, Griekse kleine letters, Griekse hoofdletters. Onderstaande tabel geeft het format dat kan ingevuld en uitgebreid worden. Wanneer het symbool een eerste maal in de tekst of in een formule wordt gebruikt, moet het symbool verklaard worden. Verwijder deze tekst wanneer je je thesis maakt.

b	Breedte	$[mm]$
A	Oppervlakte van de dwarsdoorsnede	$[mm^2]$
c	Lichtsnelheid	$[m/s]$

List of Acronyms

Chapter 1

Introduction

1.1 Situreing

1.2 Problem definition

The steel industry is a big industry in the world and provides lots of jobs. due to high labor costs in western europe and more specific in Belgium, production and manufacturing costs should lower to be able to compete with other big companies around the world. To archive this goal we will take on one step of the manufacturing of steel which is the contol of tools used to carve in the metal.

These tools typically have a base tool and a cutting plane mounted on them which is easily removed when it wears. In the past people had two options to check the wear of these planes:

1. shutting down the whole plant and manually inspect all planes.
2. Replacing all planes on set times.

Although option number one will optimize the lifespan of the planes, it is very time consuming and labor intensive. Option number two is less labor intensive and thus less time consuming but will produce a lot of waste in those planes. Having safety levels there will be a lot of planes trown away even when they are still usable.

A new way of dealing with this problem is based on option one where each plane will be inspected. To speed op this inspection process a camera will be used. And using deep neural networks the amount of wear will be projected.

1.3 How does the tool wear?

The wear of the tool begins with wear on the coating and goes right through the the coating in the base material of the tool. This base material will mostly be carbide due to its strength and heat resistance. Slijtage is te zien in paper: Tool life and wear mechanism of uncoated and coated milling inserts Hier zijn alle slijtage types opgesomd

The carbide used: cemented carbide here the combination with Wolfram called tungsten carbide in short WC Wolfram carbide

more information on: https://www.destinytool.com/carbide-substrate.html

Chapter 2

Literature review

2.1 Verleden

2.1.1

2.1.1.1 Machine Vision System for inspecting Flank Wear on Cutting Tools

machine vision

? discribes a way of using machine vision to inspect flank wear on cutting tools. The process they use is very labor intensive and should be redone when inspecting a new tool. Their steps are ”image acquisition, tool edge detection, highlighting wear region, feature extraction, wear type classification and finally wear measurement.” In our paper we will try to make this process a lot simpler by using deep neural networks which will be trained on different tool types. But we will need more labeled data to be able to perform such a task which may be expensive to create. A accuracy of 7.5 micrometer is achieved.

2.1.1.2 Novel spatial cutting tool-wear measurement system development and its evaluation

laser sensor

? Provides a way to measure tool-wear with a 3D laser profile sensor. This would be more accurate since more data is available to the algorithms. Here tool-wear is divided in two categories: premature tool failure and progressive tool-wear. The premature tool failure ”mostly occurs as sudden and unpredictable breakage of the cutting edge” these types of error’s wont be detected. The progressive tool-wear on the other hand is easier to predict and measure. Here the inability of measuring wear profiles in depth is the main disadvantage of direct measuring methods. The results of this paper are really good, they detect the numbers on the crater wear and nose wear of the tool. This with an accuracy of 1 micrometer.

2.1.1.3 A Review on Applications of Image Processing in Inspection of Cutting Tool Surfaces

–¿ goes out of the range of this paper... summarizes the different inspections which can be done machine vision

? Gives an overview of where image processing is used in the industry. They use a CCD camera to grab images which will be processed. Surfach roughness is another topic interesting for research to determine the wear of tools. This will not be covered in the scope of this paper. Toolwear measurement is done by indirect methods: empirical formulae. And by direct methods: Toolmaker microscope, graduated magnifying lens. To that date (2015) the accuracy of the measurements was 50 microns using vision based inspections. In this paper the accuracy will be pushed even more. Three parameters where used to estimate a degree of tool wear: vizual intensity histogram, image frequency domain content and spatial domain surface texture. Here it is said 40% of all metal removal operations are drilling.

The coating measurement, images taken using confocal scanning laser microscopy (CSLM). Surface defect inspection of cutting tool: coating defects occur onperiphery of cutting tools -¿ are observed as black or white spots in a different surrounding. this is detected using a fluorescent lamp to have highly diffused light

The cost saved by automatic tool inspection is created by: cost of tool inserts, costs associated with non productive periods due to tool replacement.

2.1.1.4 An online optical system for inspecting tool condition in milling of H13 tool steel and in 718 alloy

Creates a nice overview of tests on different materials and different coatings, this gives the reason why it is important to detect toolwear in an early stage to produce as many goed materials as possible

? proposes a setup which will detect the tool wear in-line. Which is the end goal of this research.

2.2 Light reflections on the tools

The next paper is good to get an overview of the light reflection seen in different types of materials and even multi layeres tools. article: New color from multilayer coating applied machining tools based on tungsten carbide insert J. C. Caicedo1

Here is described that the best reflection occurs at the highest wavelength. This translates to the visible color red and will mean that the reflection should be the highest when the lighting is on the top of the spectrum of the camera lens.

The material is best cut with a laser at wavelengths 1030nm and 515nm. This is proved in: article: Fundamental investigations of ultrashort pulsed laser ablation on stainless steel and cemented tungsten carbide is the good removal also a good reflector?

Study of absorption of certain wavelengths by the material. Not as usefull. unless all waves are absorbed by the material and only the rest is lightened. this is in the infrared spectrum so not realy possible with this camera. article: FTIR studies of tungsten carbide in bulk material and thin film samples

Chapter 3

Implementation

3.1 Camera setup

Tests of the setup:

- 3D printing the tool holder
- 3D printing a easy way of photographing many tools in an easy way

Parts of the setup:

1. leds
   (a) 3-4 led lights/strips separately controllable to light from different angles
   (b) with or without extra light on top
2. Wheel with tool mount
   (a) 3D model creation of mount system
   (b) creating wheel to be accurate
   (c) controlling stepper motor to turn just enough to put the next tool in front of the camera
3. Camera mount
   (a) Design to let the camera view different angles
   (b) watch out for lighting

Also a pcb

3.2 Designing a tool holder

During the design process different tool holders are designed to create an optimel camera position and optimal lighting conditions for that setup.

3.2.1 Simple tool holder

test remote second

3.2.2 Wheel holder

First Wheel Holder:

A simple wheel holder which can hold 20 inserts.

used for first tests and did work. Except the tools wern't fixed good enough or they were to hard to remove and insert into the holder.

The holder was printed badly and this made the print cleanup very labor intensive.

Second Wheel Holder:

Created on the base of the first wheel holder, but with an easier way of inserting and removing the tools.

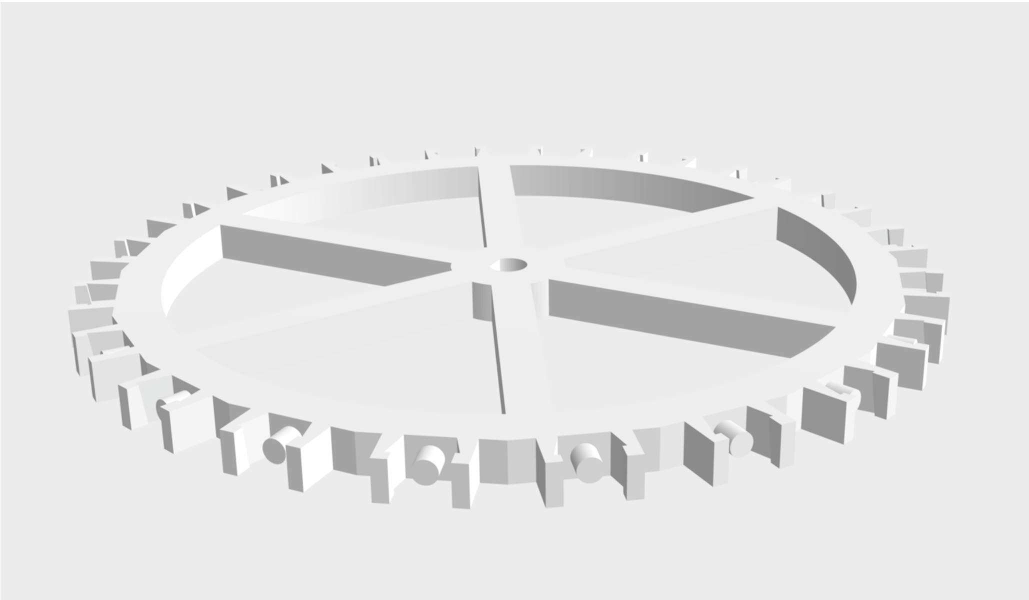
This with a more secure way of holding the tools.

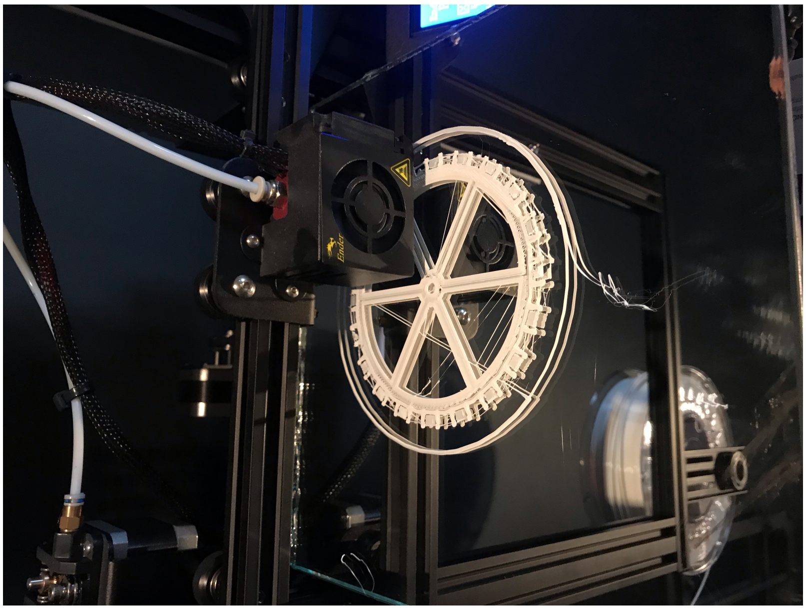
print so no cleanup must be done

3.2.2.1 first wheel holder

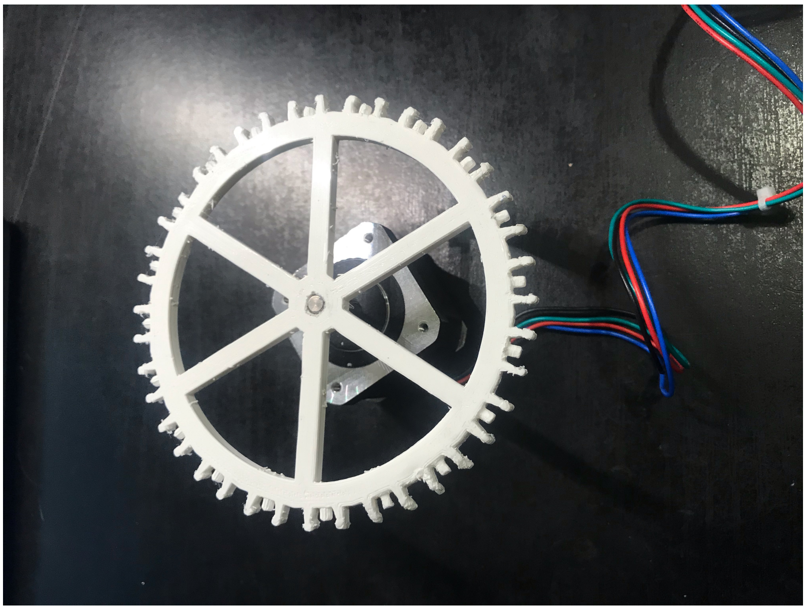
Created vrijdag 13 november 2020

To be able to quickly create a lot of photos in a consistant way, a wheel is designed to mount 20 tools at once; using a stepper motor and a fixed camera and lighting setup the process of taking images would be automated for every 20 tools. The holder will be 3D printed so a few wheels can be made to be able to swap the wheels with new tools for an efficient dataset creation.





After printing the wheel had to be cleared from rest pieces of plastic and had to be tested with a tool, this made it possible to scratch the tool extra hard which would mean the given labels for that tool aren't correct anymore. The tool used is from 3 number 6 36*. the manual removal also means the tools dont sit in the same position in every place on the wheel. This will show in the generated pictures.



This wheel is mounted on a stepper motor with step angle of 1.8 degrees.

We can calculate the accuracy for a wheel with a radius of 5.5cm (measured to the tip of the measured tool)

grad to radials

2*pi/360*1.8= 0.0314159265359

sin(0.031415)*55 = 1.72754081497 mm

this gives an accuracy of 1.72 mm, this is not in the accuracy range that is needed for this project. In order to get the wanted displacement per step the rotations needs to be adjusted with extra gears in the system. A displacement of less than 0.5 mm would be good.

to achieve this the calculations are made backworth:

the required angle

arcsin(0.5/55) = 0.52 degrees

calculate how the gears should relate to each other

1.8/0.52 = 3.46153846154

round this up to 4 and recalculate the displacement per step of the motor

the angle:

1.8/4 = 0.45

2*pi/360*0.45= 0.00785398163397

sin(0.00785398163397)*55 = 0.431964548879mm

This is whithin the needed displacement range.

This needs adjustment of the current design of the wheel holder also a 3d printed footer can be printed so the wheel can circulate vertically which would make the camera and light setup easier.

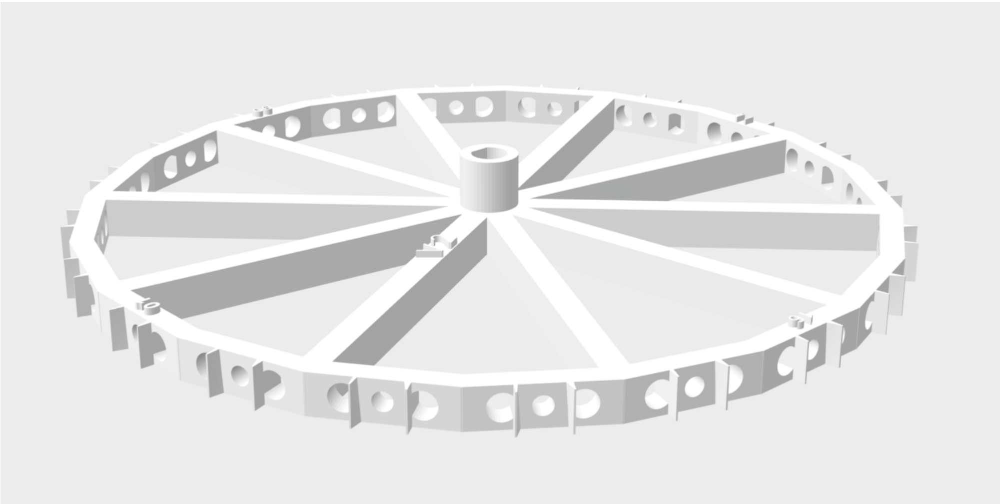
3.2.2.2 Second Wheel Holder

Created vrijdag 04 december 2020

The first wheel holder wasn't good because the inserts where clamped in with the knife side so it was very hard to remove them.

In a new wheel holder the clamps got changed by new clips that can easily be removed and printed again when the design changes.

The inner tube that slides over the motor shaft is made bigger to fit over the motor axis.



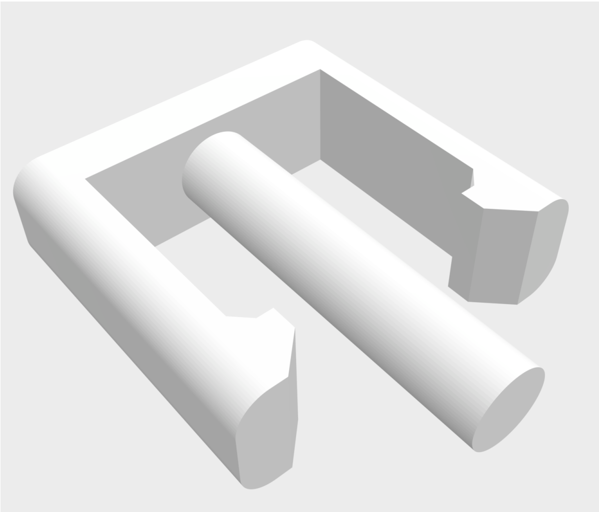
In the wheel there are holes in which the clips fit. The center hole is as big as the hole in the inserts. This keeps the insert from moving round the hole.

The slads between the holes are made to fit the insert perfectly so this doesn't move or shift around.

On the pictures the slads are visible which is not ideal so they will probably have to be adjusted in a future design.

The printing of these wheels was very difficult since it was with another material as we were used to and the print wouldn't stick to the print bed. This made a few bad runs and hours of wasted printing time. At the end 8 wheels of this are printed correctly and were used to create the Birthday dataset and the spaghetti dataset.

The clips looked like this:



3.2.3 Design different lighting solutions

3.2.3.1 Light

Created zaterdag 24 oktober 2020

Different light setups:

1. Desk Lamp
2. white led strips (long)
3. led strip (single led)
4. Color changeable led strip (multiple combined in a matrix)
5. top light (white or colored)

3.2.3.2 Adressable Color Changeable Led Strip

Created Wednesday 28 October 2020

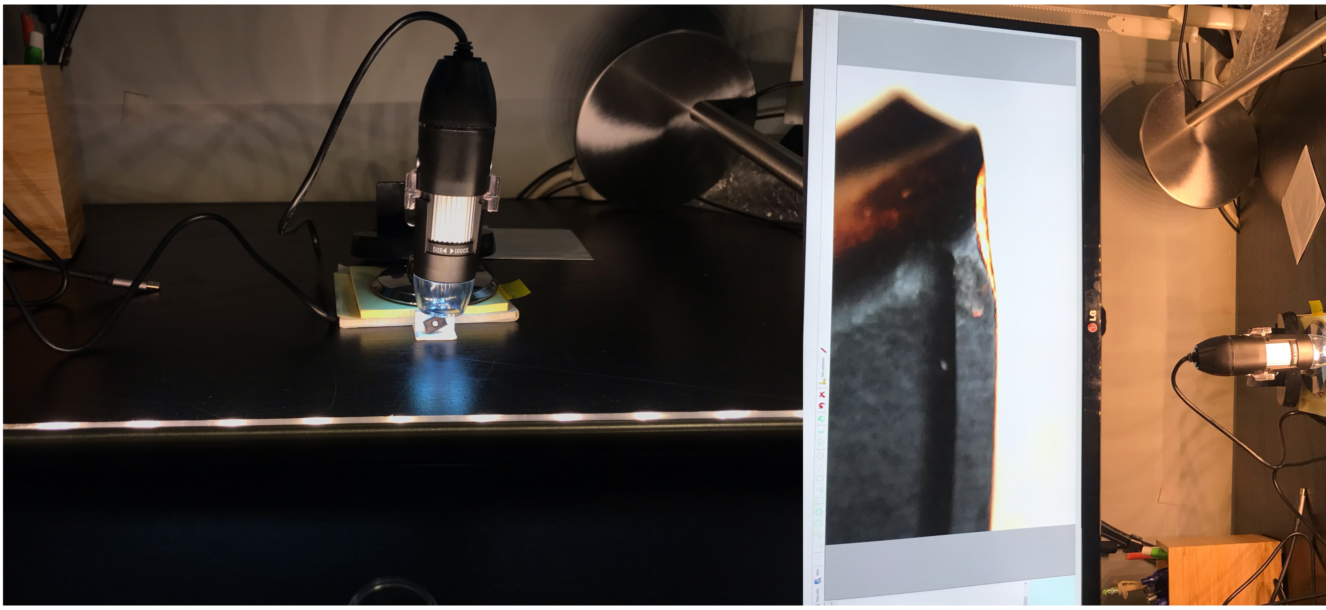
A third option of lighting is playing with the colors of the light. to archieve this a setup will be created with a single adressable light strip where the color and led can be freely chosen.

To assign a color which works best; a study is made to find the wavelengths where the light reflects most on the used materials of the tool. This can be found in Light Reflection

3.2.3.3 Desk Lamp Test

Created Wednesday 28 October 2020

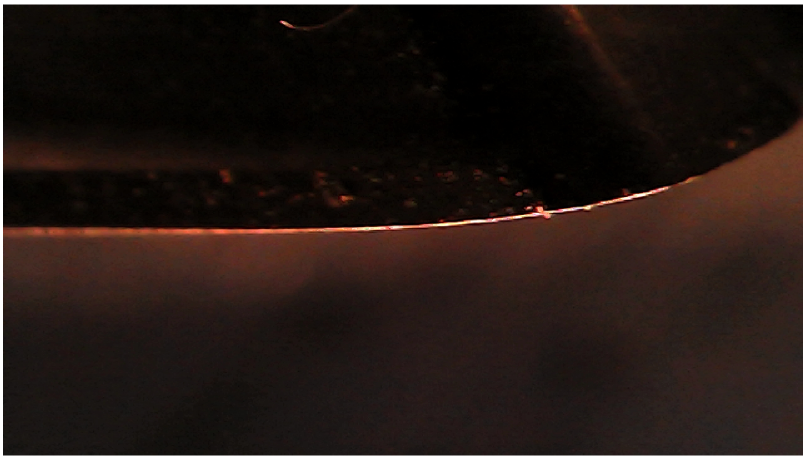
First test using following setup:



This setup was using the top light of the camera. This light was good to be able to adjust the camera. Without the light, the errornous places where more visible. But the desk lamp had to much brightness. Therefor and to test other lighting conditions a led strip will be used for further tests.

The result with this setup can be seen in the above picture on the screen. here can be seen that there is a bright white background behind the tool. In a new setup there will be tried to make the background as dark as possible to make sure only the bad part of the tool is clearly lighted.

The result of this is shown in the following picture where the light is blocked off of the rest of the tool and only the errornous part is lightened. This would be a good start to start creating a dataset.



The color of the desk light set a good gradient of bad vs good sets. White areas are worn very hard while orange is not worn that hard.

By tilting the lamp up and down in a horizontal way, all the areas where ligthtend.

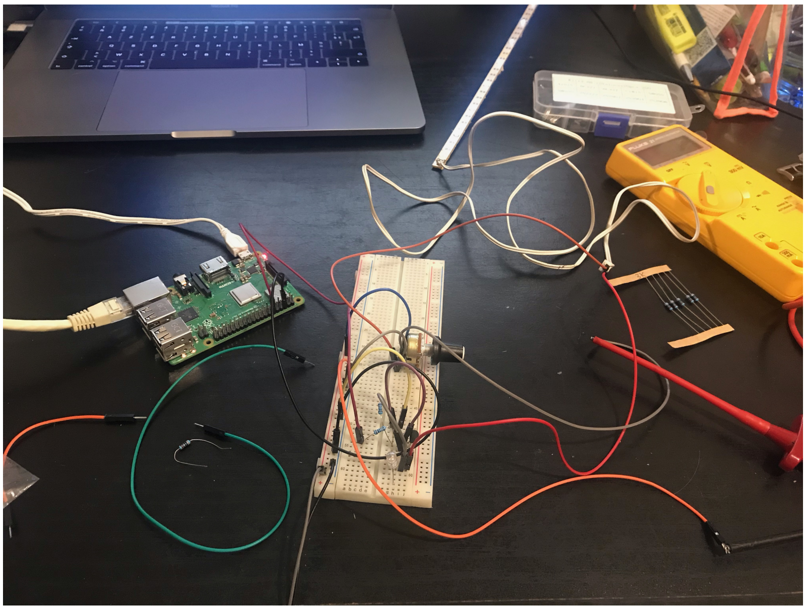
The setup used for this lighting scene is described

3.2.3.4 White Led Strips

Created Wednesday 28 October 2020

A second lighting contition created is the lighting with 3 the same led strips controllable with a raspberry pi.

This was tested using some transistors to create a controllable switching circuit. This didn't work due to the wrong type of transistors. The second option is to control the led strips using proper relays. These will have to be bought separately so is must still be assessed if this is needed.



The setup to test the control of a led strip using a NPN transistor as switch.

3.2.4 Design a way to mount the camera in a desired spot

3.2.4.1 Camera mount

Created Wednesday 28 October 2020

In this page the camera mount will be discussed along the design process of the setup

1. Holder
2. Wheel holder

3.3 Vision Algorithm

3.3.1 Finding an algorithm to test the camera position setup

First there must be found an algorithm that can quickly confirm wether a setup is good or not. This will be done by taking pictures different camera positions with the same lichting. After this the images go trough a simple model and the output is verified with a test set.

This algorithm must be as small as possible to not have to take a lot of pictures to determine wether an algorithm is good or not.

3.4 camera position validation

Created woensdag 18 november 2020

3.4.1 Information

The next data input structure is made:

- 20 train images
- 10 validation images
- 10 test images

These images will go through different algorithms multiple times and the outputs are verified for every different algorithm.

3.4.2 papers

1 A Comprehensive Study on Deep Image Classification with Small Datasets

a short comparison of the amount of convolutional layers to be used in the network (5 is optimal)

- b comparison on datasets: Caltech101, CIFAR10
- c also transfer learning also around 5 convolutional layers is the optimum
- d network architecture
  - 1 from scratch:

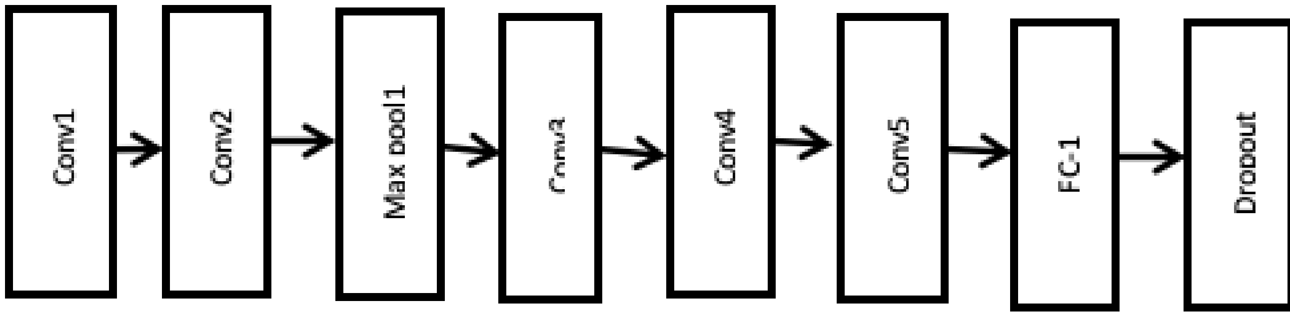


Fig. 4 Proposed CNN architecture for image classification f

2 transfer learning pretrained on VGG16 with imagenet dataset

2 Deep learning for image classifification on very small datasets using transfer learning

- a creation of an image classification network with context of where it comes from
  - 1 alexnet vs googlenet vs vgg and the history
  - 2 displays keras code to create the same models
  - 3 architecture for models is shown
  - 4 niet super interessant gezien hier nog steeds wordt gewerkt op 6000 fotos van katten en honden, wel een indicatie dat deep learning gaat met weinig data

3 https://paperswithcode.com/task/small-data

- a interesting papers with small datasets

4 A survey of the recent architectures of deep convolutional neural networks

- a overview of almost all neural networks with their strengths and weaknesses

5 SDD-CNN: Small data-driven convolution neural networks for subtle roller defect inspection

   a very interesting paper detects faults in bearing rollers.
   b Using very little data
   c results with from scratch training best with SDD-inception v3 and SDD-resnet18
   d SDD-VGG16 gets good results, but with long trainin time

In most seen papers a very low learning rate

0.0005

3.5 Datasets

Created vrijdag 13 november 2020

A separation is made between hand made datasets and automated datasets because they take a very different approach and produce very differing pictures.

3.5.1 Handmade datasets

The following datasets where produced using a microscopic camera to take pictures of single inserts all placed under the camera by hand.

3.5.1.1 initial dataset

The initial dataset where the images made by a microscopic camera at Sirris. These pictures were taken for the measurement of the toolwear. This dataset provided the labels for the first 5 batches labeled with 00x.

3.5.1.2 Second handmade dataset

A second dataset was made to compare the pictures with the previous dataset. This is done to verify the images and the results and to determine what the marker meant. This dataset also handles the first 5 batches labeled with 00x

3.5.1.3 second initial dataset

The second initial dataset was made with the inserts from batches 11 to 19 labeled with 01x. Here the images where taken with the same microscope as the first initial dataset but instead of phtotographing only the one insert at a time; two inserts are photographed per shot.

3.5.2 Automated datasets

First the camera position is discussed and than the datasets are all listed.

3.5.2.1 Camera position

This discussed two setups where on the one the camerea is more pointed to the side of the insert and the other one is pointed more to the top of the insert.

1 1 camera position side dataset

2 2 camera position top dataset

3.5.2.2 created datasets

All created datasets which conduct a few images that are worth processing are discussed here.

1 birthday dataset

   a conducted tests

2 Spaghetti dataset

   a conducted tests

3.6 automated datasets

Created vrijdag 04 december 2020

Divided in a few topics:

- check camera position which will discuss different camera position angles
- created datasets where all fully created datasets will be discussed

3.7 1 check camera position

Created vrijdag 04 december 2020

3.7.1 1 $ 2

In this set there will be defined what the best camera position is for the creation of the dataset. Top view as well as side view will be checked.

3.8 1 camera position side

Created woensdag 11 november 2020

3.8.1 Camera position on the side

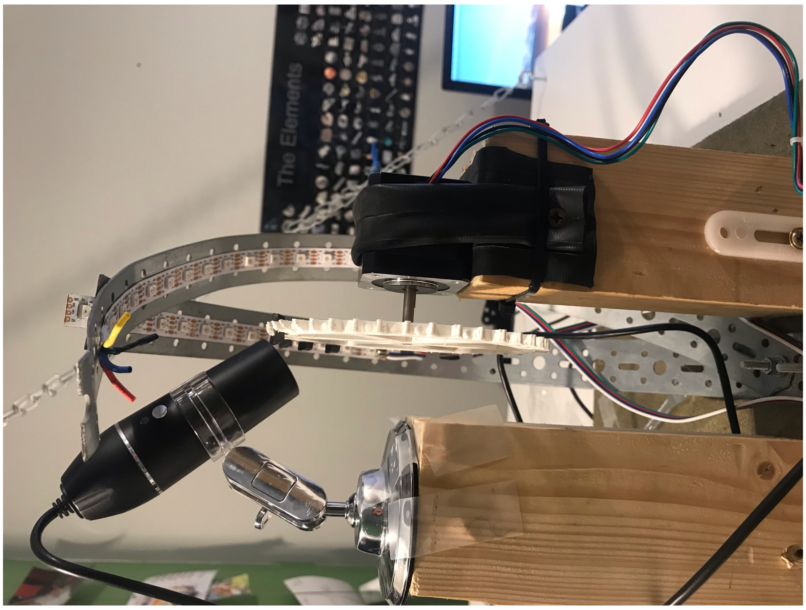
Taken on the first 4 plates of batch 04 with red lighting only from the adressable led strips.

1st light position is made with a setup with two led strips where one image is taken for every set of two led lights.

output is bad. Reflection angle wasn't good.

Results saved in next directory

/Users/larsdepauw/Documents/Lars.nosync/Documents/School/1Ma ing/Masterproef/Images/dataset/-First_automated/camera_zijkant_dual_ledstrip



The images that where taken with this setup are found here:

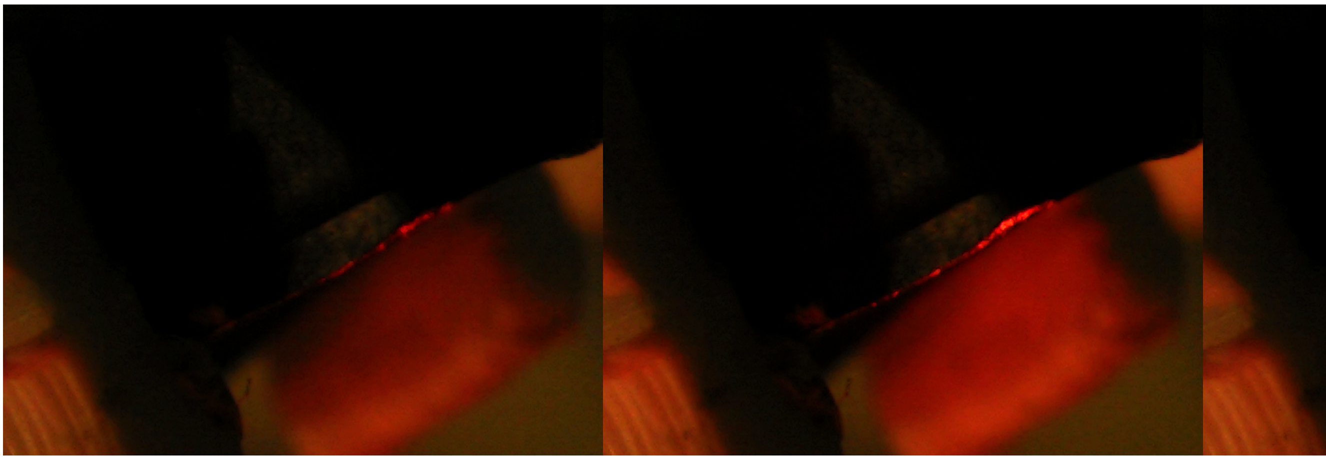
Due to the problems with the arduino communications described here the first dataset wasn't successfull because the leds didn't turn on when the photo's where taken. So the results are all black pictures with al little shadow of the insert caused by the polluting light.

3.8.2 Camera position on the side take two

A delay was entered before sending a command to the arduino to provide the wanted lighting conditions. Although this was a very long process the results are way better than the ones from the first take on this camera setup.

The same setup was used with the camera in the same position. For red led only the following image is the result.

The leds shown here leds 8 through 10. There is a nice lighting of every part of the wear



This lightens the worn area very good. Although th ebackground is lighted as well and makes it harder to only see the worn area. On this we can build the first dataset.

Next the top view was tested

3.9 2 camera position top

Created woensdag 11 november 2020

The same plates where used 04 -> 1until 5.

Every pair of led is lighted separately to generate the photo’s

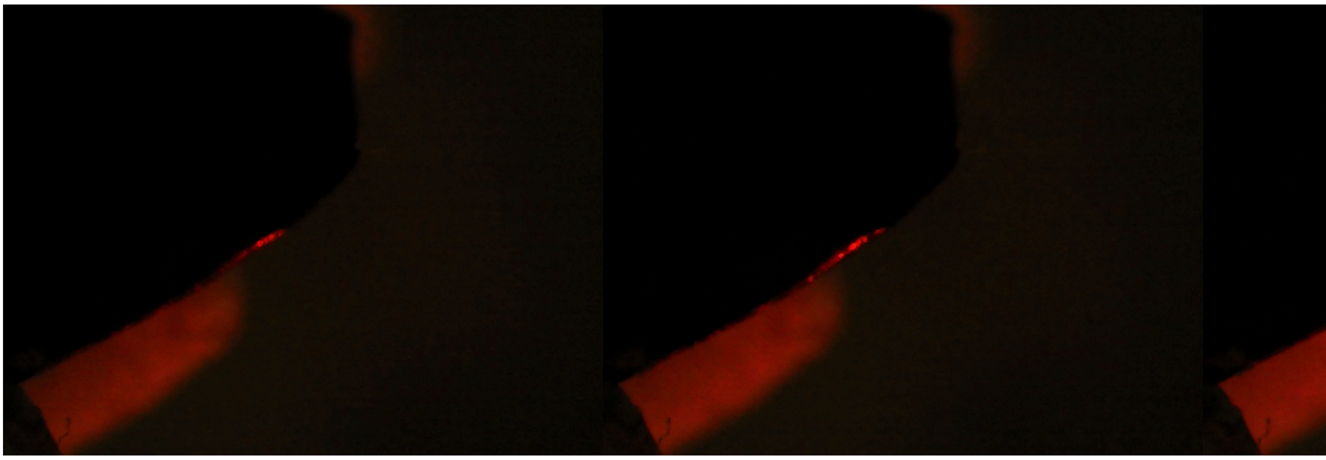
extra documents of the results in the folders images/dataset/.....

3.9.1 Camera position to top

The second test was conducted with the camera mounted a little more to the top of the inserts. This made the reflection from the worn area to the camera better.

The first test results where also all black pictures caused by the same problem as on the first test of camera position side. On a second test this issue was resolved and the following pictures where the result. The issue was resolved by adding enormous amounts of delay for each command sent to the arduino. This made the process take very long (about 1 second per photo).

One picture was taken for every two leds of the strip with red light. for batch number 4 insert 3 with leds 5,6 and 7 turned on.



On this data we can see the leds going up on the insert wear area. Which is what we tried to obtain. Now the leds are mapped to specific positions on the inserts and the amount of leds that need to be turned on for taking pictures can be reduced so no extra time is wasted.

3.10 2 created datasets

Created vrijdag 04 december 2020

The full datasets will be discussed in this page where firstly the dataset is documented and after that the tests that lead to this dataset are discussed.

3.10.1 Birthday dataset

Created a dataset on 27/11/2020 with a part of the given inserts for every possible color and led setting where pictures are taken from two separate led strips and every led one after another. This is done for white, red, green and blue colors.

Done for batch 1 to 11

3.10.2 spaghetti dataset

3.11 1 Birthday dataset

Created woensdag 02 december 2020

On November 27th a new dataset is created where for every plate 91 pictures are taken.

The next pictures are available for the dataset:

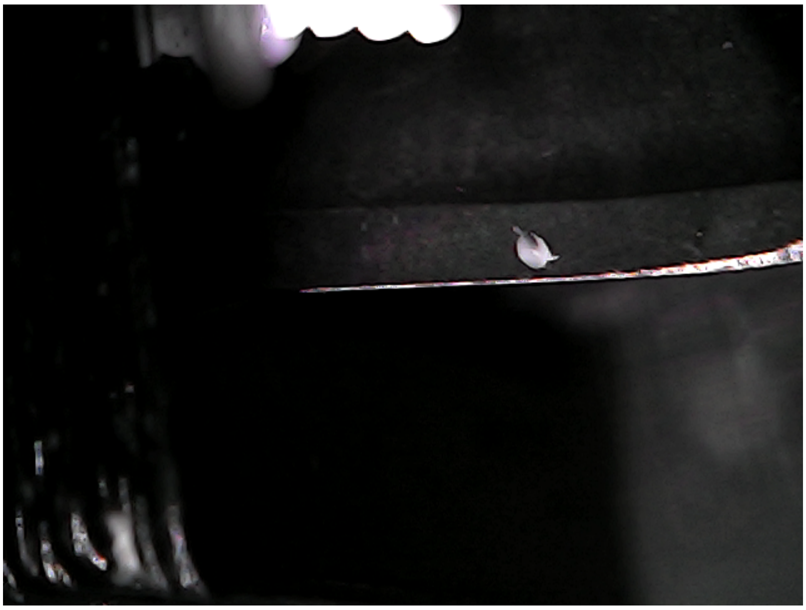
- 1 picture with all leds on white
- 30 pictures with red lighting; 15 of led strip A and 15 of led strip B
- 30 pictures with blue lighting; 15 of led strip A and 15 of led strip B
- 30 pictures with green lighting; 15 of led strip A and 15 of led strip B

The brightness is set to 80% for all lights to make sure to not clip against the top values.

The dataset consists of 120*91 photos of 60 inserts with 120 worn sides. After 120 the quality was evaluated and the red, green and blue colors didn't seem to add more information to the pictures.

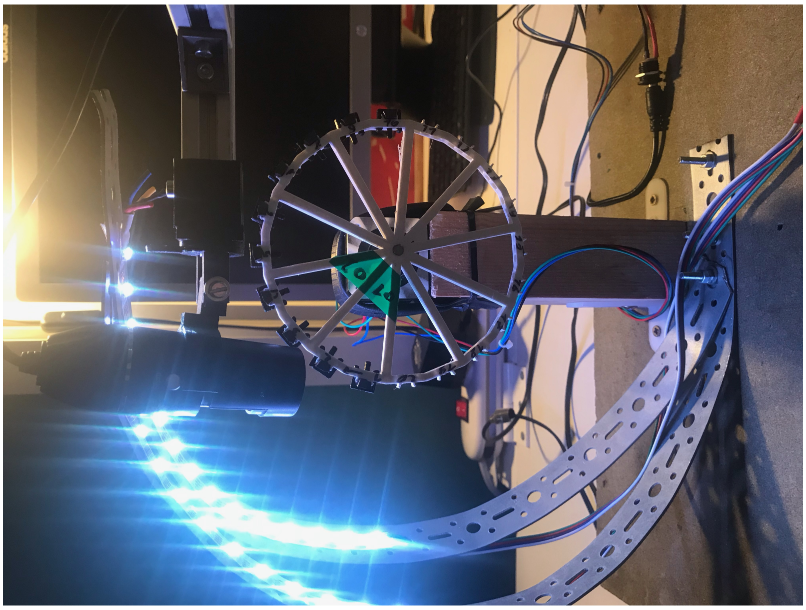
In this dataset, there are some pictures unusable. As some worn areas are not even in the frame. Some to the left side and some to the right side. The placement of the wheel which holds the plates wasn't checkt thoroughly.

Picture 1: batch 3 insert 10 the side without bullet is off to the right side



picture 2: batch 3 insert 10 The side with bullet. Is far off to the left side.

The setup for creating this dataset was as follows:



Here two ledstrips where mounted and pointed at the photographed insert. The inserts where attached to the wheel with black clips 3D printed with PETG. This was shosen above white clips to lower the light reflections into the camera lens. This was a problem in previous setups.

Also a sturdy camera mount was fabricated out off metal profiles and 3D printed parts to get better notice of the placement of the camera opposed to the insert.

The image taking process took about 1 minute per batch because of the amount of pictures taken. Since time was limited and the setup wasn't yet perfect we decided to only run 60 inserts through it. These where from batches 1 to 11.

Sample pictures of this dataset can be found underneath.

For every led one picture is taken. These images can be put together to create images on a full spectrum of leds and take out the best conditions.

This can be done by inserting the images as different channels in the model.

The next pictures are from batch 3 insert 5 with led 6 turned on for both led strips and four colors.

On these pictures we can see only red and white are visible and the B led strip wasn't visible. For this purpose the color of the wheel is changed to Black for less reflections. In the next dataset only white and red will be used for lighting.

3.11.1 Code

The code used to process this data can be found in

3.12 conducted tests before creation

Created vrijdag 27 november 2020

Getting first full dataset with images of all plates

3.12.1 First test

first pictures formatted with

b_xxx_p_xxx_l_xxx.png

-> these images where from last time checking some setups

3.12.2 Second test

formatting

next pictures without changing for different led strips

b_xxx_p_xxx_color_l_xxx.png

3.12.3 Third test

formatting

pictures with full experiments on lid lighting

b_xxx_p_xxx_color_strip_l_xxx_bullet.png

a video is taken here

Here we can see a difference with or without light in the room

reformatted last images to be able to see difference between different leds, bet setup and runs are the same

b_xxx_p_xxx_bullet_l_xxx_color_strip.png

possibly 3 and 4 no bullet wrong

rest went okay just check the batches 3 and 4

3.12.4 Birthday dataset

batch 3 plate 7 no bullet: had restants of 3D print plastic on worn area

batch 3 plate 8 no bullet: is a bit off picture

from here in batch 3 plates go out of sight for no bullet side.

bullet side is going the other way out of sight for batch 3

batch four starts of with bad pictures (also b on the left out of sight and nb on the right side out of sight

from batch 4 plate 7 it is okay again

batch 5 plate 6 no bullet lighting not good

batch 5 plate 6 bullet has string from 3D printing on wear area

batch 11 plate 5 bullet had hair on wear area

3.13 2 Spaghetti dataset

Created vrijdag 04 december 2020

After the Birthday dataset a new dataset was created using the things learned from that. Now the amount of leds driven is reduced to 5 leds. Where led 6 to 11 is used to lighten the inserts.

only the colors white and red are used for this dataset. This was discussed thad the red color could have an influence on the reflection of the carbide of which the inserts are made see light reflection.

3.13.1 Dataset explanation

For every insert, two pictures are taken. One with leds 6 to 11 on red and one with these leds white. This was experimentally found to be the best setting for reflecting the light off the worn area and into the camera.

Turning on a led to much on the upper bounary will lighten the side of the insert which isn't of much use in this paper. Turining on a led to much on the bottom boundary makes the background very bright which supports unnessesary information.

The images are separated in a folder for every insert named with batch number and insert number:

batch_aaa_plate_bbb where aaa is the batch number and bbb is the insert number.

Images are named with their settings, batch number and insert number:

b_aaa_p_bbb_l_006-011_color_bullet.png

where

- aaa is the batch number;
- bbb is the plate number,

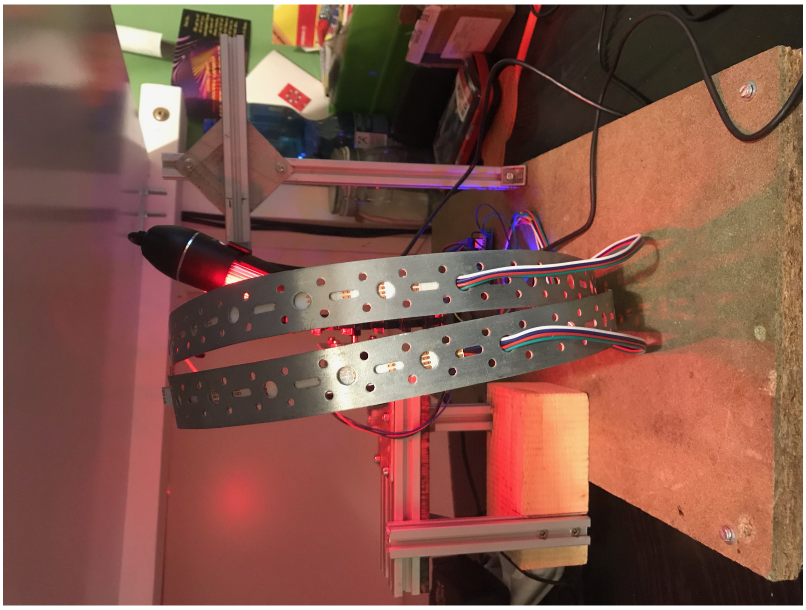
- 006-011 are the leds that turned on at the same time;
- color is the color: red or white
- bullet is the appearance of a bullet on the side of the inset and has values of b for bullet or nb for no bullet.

The dataset inserts consisted of a few different types and coatings.

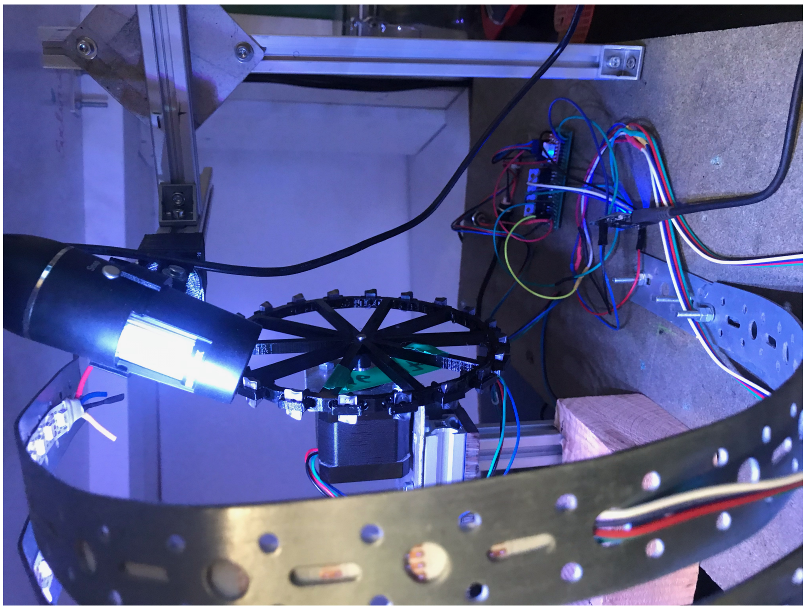
3.13.2 Setup

The setup used is exactly the same as on the Birthday dataset where the camera is positioned as much to the top as possible. This can be seen on the picture:

Here we can see the led strips are a little bit twisted and are positioned very close to each other. This made the reflection better and should result in beter outcome of the algorithm.



The camera angle is kept the same a little to the top and very close to the inserts as seen on the next picture:



Through the whole dataset the direct light coming from other sources eg. the light of the room was blocked to have full control of the lighting conditions.

3.13.3 Results

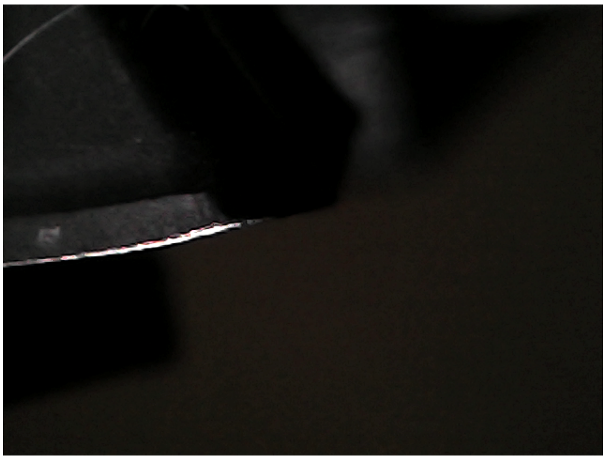
Underneath are some pictures of good examples in the dataset.

Underneath are two pictures of batch 3 insert 6. These where lid with red light on the left and white light on the right. Here is a nice wear shown and lighted. However if we zoom in to the picture the top part of the wear is not lighted that well. We can also see a white piece of the insert holder on the image which is providing som extra difficulties. The discussion of these difficulties will be bespoken in vision algorithm.

Some pictures aren't sharp like the one shown next.

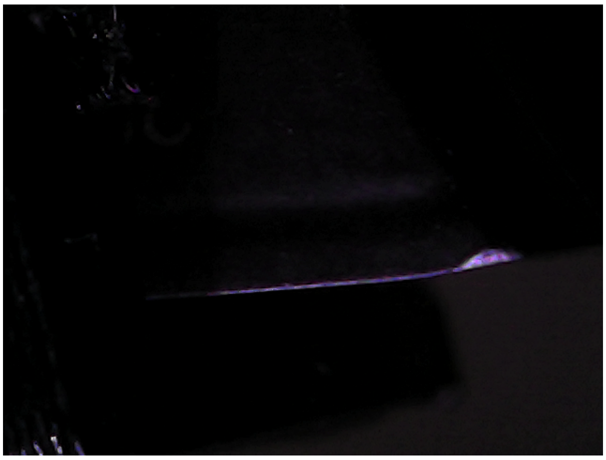
like batch 5 insert 5 withoud bullet.

Different insert types First type are the grey inserts with very visible wear. These are seen in batches 1 to 5 consistently. This type will be called grey inserts.

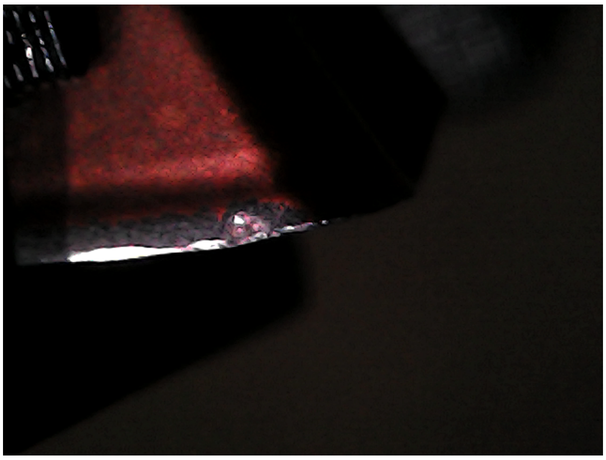


Than there are other inserts in batch 11 which are also grey but have a different shape on the cutting part. These will be called rounded grey inserts.

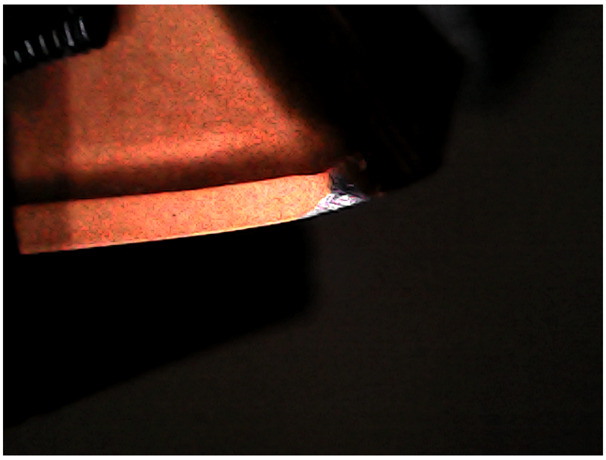
In batch 12 and 13 there are the same shape of inserts but with a black coating which results in way darker pictures as seen here on batch 13 insert 2 no bullet. These inserts are the rounded black inserts.



The next type are copper colored inserts with the rounded shape. Seen in batch 14 insert 5 no bullet.



Than we have inserts with a gold coating and hooked shape. For batch 15 insert 6 no bullet that gives the next picture:



3.14 camera position

Created woensdag 11 november 2020

1st test was with a camera position more to the side of the cutting plates. This resulted in a bad reflection angle since the light came from the wrong side. Documentation of this set is in automated datasets:1 check camera position:1 camera position side

3.15 handmade datasets

Created vrijdag 04 december 2020

3.16 initial dataset

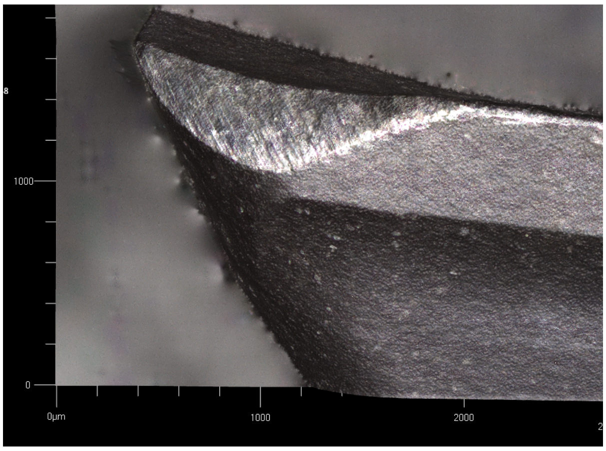
Created vrijdag 13 november 2020

3.16.1 Form

The dataset given where taken with a microscopic camera at Sirris. These images were in good lighting conditions for the measurement, but had a lot of extra "unwanted" features on it. The background was very like the wear and the rest of the tool insert.

Every insert that was measured had a little mark on one side to mark the a and b. Sadly the information about what the marker meant is lost. To find the corresponding values, the inserts where once again put through a microscopic camera and the new pictures where compared against the old ones.

While again checking the inserts out, a new dataset is created since this didn't ask much more time. During this proces there is also a new way of separating the sides of the inserts. There is a bullet at one side on every insert. This is an easy way to recognise a side and wont dissapear like the marker line.



3.17 Second handmade dataset

Created vrijdag 13 november 2020

A second handmade dataset is made to compare with the first dataset and get to know what the stripes mean on the first dataset which was used to measure the wear.

The next setup is used:

The light came primarely from the camera itself which was set in the first brightness setting.

The camera was located at a distance of 2cm between the housing and the measured point on the insert. The housing starts at the black part; not the plexi glass protector.

During the making of this dataset the inserts where labeled with bullet or no bullet. This was not setup this way in the first place; instead there was a marker line on the insert. This marker line is also noted in the labels of the dataset.

An ”s” means it is with a marker line. A

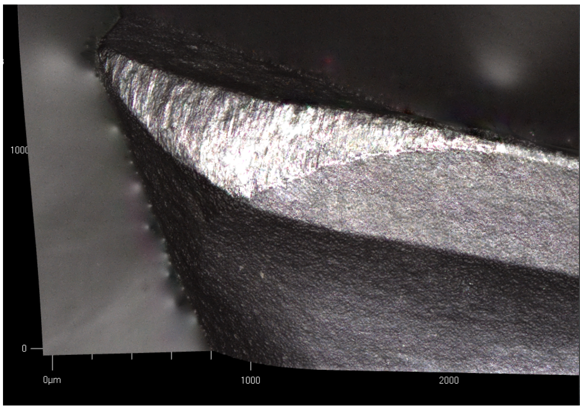
symbol	explanation
s	side with marker line
n	side without marker line
batch number	number specified on the box in which the inserts are kept
plate number	number specified inside the box; this goes from 1 to 10 per batch

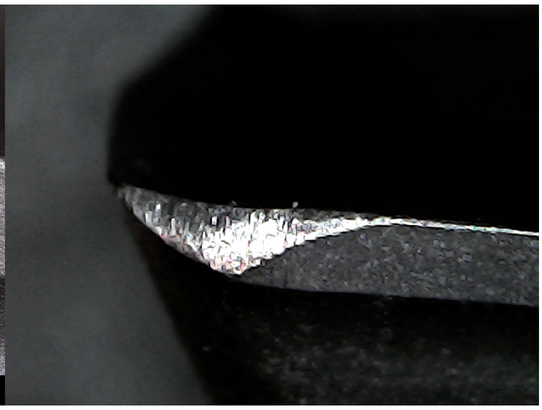
The naming of the dataset is the following

b_<batch number>_p_<plate number>_<identifier of side>

After looking at the pictures of the datasets it can be confirmed that the ’b’ side of the inserts is the side with the mark on.

This can be seen on the folowing two pictures whis correspond. The first one is from the first dataset, the second from the second dataset.





3.18 second initial dataset

Created vrijdag 04 december 2020

With the second number of inserts (batch 11 to 19) another dataset was created for measurement.

Since the photo's where labeled with two inserts at a time; the images taken where not relevant for the data processing and were not saved

The distance for these inserts is measured between the line connecting the two highest points visible on the insert and the outer most point of the wear area.

3.19 Google Colab

3.20 Test Camera Setup

Created woensdag 04 november 2020

To test the camera setup, a binary classification model is made. This model will tell with a treshold of 150 (200 the real treshold but 150 to warn before tool is worn out) wether a tool is good to work with or must be removed from the machine.

This model should be trainable with as less images as possible, preferably 20 because that is the amount of pictures taken in one batch.

3.20.1 Resnet18

First we will try to implement SDD-Resnet18 to classify the few images in good or bad.

3.20.2 nception v3

Than we will implement SDD-inception v3

These described models should perform rather good without any transfer learning.

After the first tests these results can be compared with a transfer learning model.

3.20.3 All Networks

For this all networks test, some networks where tested and an algorithm is created to make it possible to add more networks along the way

3.21 All Networks

Created woensdag 02 december 2020

3.22 All Networks 1

Created woensdag 02 december 2020

All networks 1 can be found here.

3.22.1 Network architectures

This model is used to test different model architectures namely:

- Resnet18
- Alexnet
- VGG11_bn
- Squeezenet
- Densenet

inception v3 didn't seem to work

These models are all relatively small and should provide quite good results for a small dataset.

More on why the models should work can be found here

3.22.2 Dataset

This algorithm had the input of images from the Second handmade dataset which was devided into 3 classes based on their measured wear value.

class	min value (micron)	max value (micron)
good	0	130
medium	130	230
bad	230	â

3.22.3 Results

Results of this notebook are available on wandb as pytorch-TWI_second_handmade

Interesting results will be bespoken here;

Tests for different models:

model name	test accuracy %	validation accuracy%	transfer learning
Alexnet	100	90	yes
VGG11_bn	89	85	yes
Densenet	89	85	yes
Squeezenet	89	85	yes
Resnet18	89	90	no

An overview of the best runs for every model architecture. Since there are only nine test images; the test scores are set to a very high granularity. Further results of this test are to be found on wandb as Testing on first handmade dataset

3.23 All Networks 2

Created vrijdag 04 december 2020

3.23.1 Network architectures

This model is used to test different model architectures namely:

- Resnet18
- Alexnet
- VGG11_bn
- Squeezenet
- Densenet

inception v3 didn't seem to work

These models are all relatively small and should provide quite good results for a small dataset.

More on why the models should work can be found here

3.23.2 Dataset

This algorithm had the input of images from the Second handmade dataset which was devided into 3 classes based on their measured wear value.

class	min value (micron)	max value (micron)
good	0	130
medium	130	230
bad	230	â

3.23.3 Results

Results of this notebook are available on wandb as pytorch-TWI_second_handmade

Interesting results will be bespoken here;

Tests for different models:

model name	test accuracy %	validation accuracy%	transfer learning
Alexnet	100	100	yes
Resnet18	100	95	no
Densenet	100	85	yes
Squeezenet	100	85	yes
VGG11_bn	100	90	no

An overview of the best runs for every model architecture. Since there are only nine test images; the test scores are set to a very high granularity. Further results of this test are to be found on wandb as Testing on first handmade dataset

Trying to sweep over different parameter settings didn't work on my local computer; all runs failed or crashed

3.24 All Networks 3 Birthday

Created vrijdag 04 december 2020

The code for this project is to be found here: TSU_AllNetworks_3_Birthday

3.25 All Networks 4 Spaghetti

Created vrijdag 04 december 2020

The code for this can be found in here: TSU_AllNetworks_4_spaghetti

The report is noted in Spaghetti sweep with TSU_AllNetworks_4_spaghetti This can be transformed into latex without further problems i hope.

3.26 All networks 4 spaghetti first 5 batches

Created vrijdag 04 december 2020

Only the first five batches are analysed in this report to check if the dataset is as good as the dataset created by hand of these batches.

Also the difference is checked between the red and white leds.

3.27 Resnet18

Created woensdag 18 november 2020

In this page we will describe the results and actions taken to get results out of Resnet18

this paper suggests that this is a good architecture for a quite like problem. where a low amount of data is used.

SDD-CNN: Small data-driven convolution neural networks for subtle roller defect inspection

3.27.1 Creating first file

3.27.2 TSU_Resnet18_1

failed to load data, did copy files into correct directories and created dataset class

3.27.3 TSU_Resnet18_2

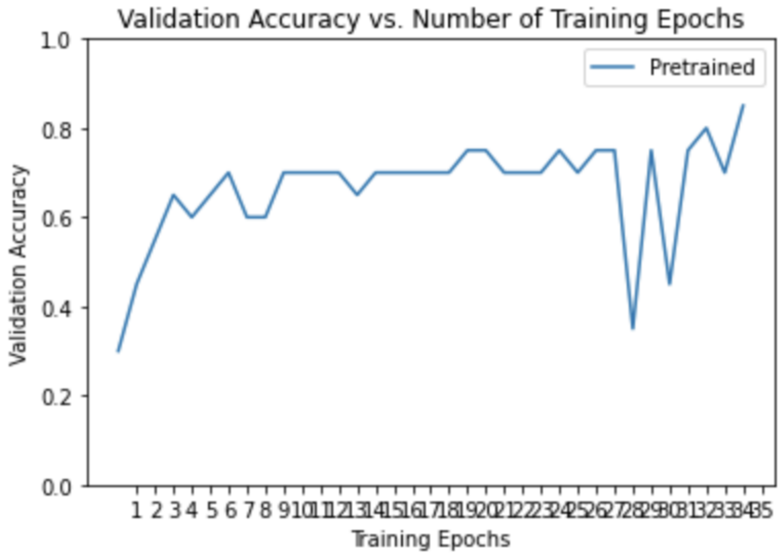
Simpeler method to read in data and not be able to change a lot of things;

next time build dataset class self with the same model.

After that the regression model would be easy

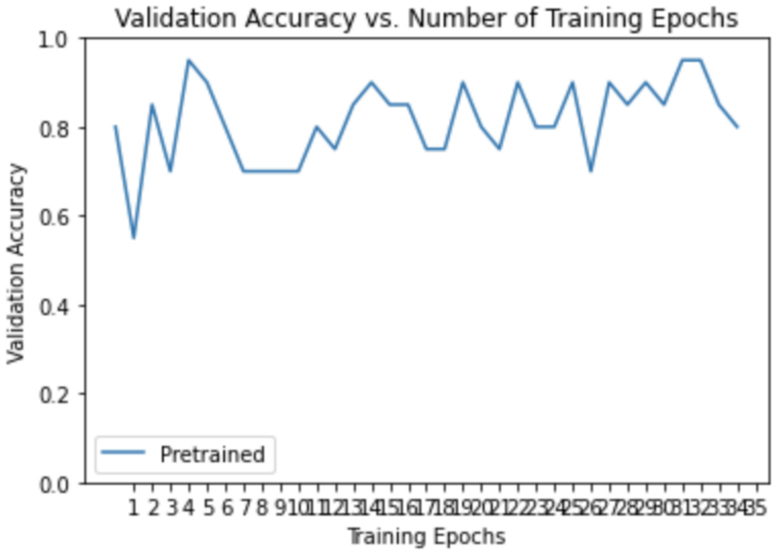
First result of the training.

```
num_epochs: 35
num_classes: 3
batch_size: 12
learning_rate: 0.001
momentum: 0.9
feature_extract: False
```



Tweede test met een aanpassing van de learning rate en een foto van de training set naar test set gebracht

```
num_epochs: 35
num_classes: 3
batch_size: 12
learning_rate: 0.005
momentum: 0.9
feature_extract: False
```



Next time create results file to get nice overview of all results

Chapter 4

Results

Paste result reports here when they are finished

Chapter 5

Conclusion

5.1 Inleiding

De referentielijst bevat de volledige lijst van literatuur en bronnen waarnaar in de tekst wordt verwezen. Door systematisch de referentielijst aan te vullen bij het schrijven van het literatuuroverzicht gaat er achteraf geen tijd verloren aan het opnieuw opzoeken van referenties.

5.2 Referentiestijl

Voor het verwijzen naar informatiebronnen wordt gebruik gemaakt van het numerisch systeem of van het auteur-jaar systeem. Dit kies je door volgend commando in het latex bronbestand aan te passen:

- numerisch (IEEE) : `\bibliographystyle{ieee}`
- alfabetisch (APA) : `\bibliographystyle{apalike}`

Plaats je bronnen in een *bibtex* bestand (evt. via software zoals bv. Jabref Endnote of Mendeley), waarnaar je verwijst vanuit je thesis text a.d.h.v. het commando `\cite`. Enkele links naar nuttige software in deze context:

- JabRef (Open Source)
- Mendeley (Freeware)
- EndNote (Paid license)

Indien je zelf een .bibtex bestand wil aanleggen dien je volgende syntax te volgen voor een tijdschriftartikel:

```
@article{hughes2005,
title={Isogeometric analysis: CAD, finite elements, NURBS, exact geometry
and mesh refinement},
author={Hughes, Thomas JR and Cottrell, John A and Bazilevs, Yuri},
journal={Computer methods in applied mechanics and engineering},
volume={194},
number={39},
pages={4135--4195},
year={2005},
publisher={Elsevier}
}
```

Enkele voorbeelden van het gebruik van bronnen in een tekst (in APA stijl):

Recent werd het Higgs boson experimenteel vastgesteld door Aad et al. **?** (syntax: `\cite{aad2012}`).

Als alternatief voor het discretiseren van een CAD model vooraleer een eindige elementenanalyse te kunnen toepassen, stellen Hughes et al. voor om de nodige elementenformulering rechtstreeks uit de NURBS beschrijving van de CAD geometrie te halen **?** (syntax: `\cite{hughes2005}`). Daarnaast introduceren ze tevens een k-iteratieve procedure als een verfijning van de geldende p- en h-iteratieve procedures in eindige elementen methoden **?** (syntax: `\cite{cottrell2009}`).

Appendix A

Uitleg over de appendices

Bijlagen worden bij voorkeur enkel elektronisch ter beschikking gesteld. Indien essentieel kunnen in overleg met de promotor bijlagen in de scriptie opgenomen worden of als apart boekdeel voorzien worden.

Er wordt wel steeds een lijst met vermelding van alle bijlagen opgenomen in de scriptie. Bijlagen worden genummerd het een drukletter A, B, C,...

Voorbeelden van bijlagen:

Bijlage A: Detailtekeningen van de proefopstelling

Bijlage B: Meetgegevens (op USB)

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