Fabric Defect Detection using Computer Vision

# Summary

This report aims to how computer vision could be used to find defect in narrow fabric. Utilising the open source technologies, OpenCV and TensorFlow to create 3 different inspection techniques and Qt to build a fabric inspection GUI.

\*\*\* pre-processing maybe \*\*\*

The three inspection techniques were all created in python using OpenCV. The first used created and examined histograms generated form the pixel values of the images. The second utilised image morphology and contour finding to look for large objects present in the image. The last method leveraged TensorFlow to build a CNN (Convolutional Neural Network) that was trained on pre labelled defect data obtained from the aitex fabric image database.

A prototype graphical application was then created using the second and third inspection techniques and the report discusses how this would be implemented in a full inspection system. Finally, the report compares the inspection techniques created to human inspection, the current method most companies use. \*\* explain findings \*\*

The report concluded \*\* conclusion \*\*

# Acknowledgements

I would like to thank my assessor \*\*name\*\* and both of my supervisors Amy Lowe and David Head who provided indispensable guidance throughout the project.

I would also like to thank my friends who provided much needed data around human inspection.

Finally I would like dedicate this report to my late father Charles, who inspired the idea for the project. \*\* add more about dad \*\*

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# Chapter 1: Introduction and Background Research

## Introduction

The purpose of this project was to explore how computer vision could be used in fabric defect detection and what advantages it could offer over traditional methods.

This project and report will investigate the effectiveness of different computer vision techniques at locating defects in images of fabrics. To carry out this investigation three different inspection techniques were created, the first two using OpenCV and the last using TensorFlow.

Lastly, a prototype application was created that would be used to automatically inspect a user supplied images using the most effective inspection methods found in the initial stages of the project.

## Fabric

Most fabric / textile is produced through one of a number of processes weaving, knitting, felting, bonding or turfing. Out of these the most common are weaving and knitting which produces most conventional fabrics. Both involve very similar steps, first fibres (synthetic or natural) are spun into yarn which is then converted into fabric using either weaving or knitting (Shaker,2016).

As these two production methods are the most widespread the projects definition of a fabric or textile was limited to those produced by either of these two methods. To understand the problem and what defects can occur, it was important to have a surface level understand of how these production technique’s function.

### Spinning

First fibres are harvested naturally for example flax or are produced synthetically such as polyester. These are then aligned and collected into yarn through the process of spinning, this process varies for natural and synthetic material. Natural fibres can be spun in many ways, but all involve them being twisted, this binds them together to form yarn (Smith, 1969, p. 1).

Synthetic fibres are spun differently, here liquid polymer is extruded though many, densely packed small holes. A cool “quench air” is passed over them to solidify the liquid polymer into long continuous fibres. Variations in the air passed over them also causes fibres to bunch in certain areas binging them together into yarn (Denn, 1983, pp. 179-180).

### Weaving and Knitting

After yarn is created, weaving and knitting are two processes that can be used to convert this yarn into fabric. Weaving is the process of interlacing yarn perpendicularly to each other. The patterns this is done in determine the properties and appearance of the textile (Adanur, 2020, p. 1). Terms used later in the project are warp and weft and they are key when understanding the weaving process. All woven fabric consists of warp and weft yarns, warp yarns are the yarns that run parallel to the edge / selvage of the fabric and are used to form its structure. Weft yarns are those running perpendicular to the edge of the fabric and are interlaced between the warp yarns using a loom (Lord,1982).

Knitting is the second most prevalent for of textile manufacturing. It is achieved by vertically intermeshing loops of yarn (Ray, 2012, p.2). Similarly, to weaving the way in which the loops mesh decides the properties and appearance of the final textile. While they processes differ Both methods aim to produce an ordered and reoccurring structure of yarn.

### Dyeing

Once these textiles are produced most if not all go through some level of processing. This may include dyeing a form of post processing that colours the fabric with a dye or pigment. There are many ways to dye a fabric but the common is the batch dyeing processes. The batch dyeing processes involves a textile being submerged in a large quantity of dye for an extended period, this allows the dye to transfer into the textile (Perkins, 1991, p. 23).

Many other finishing processes can also be applied such as coatings, but these are less prone to producing visible defects and so do merit discussion.

## AITEX Fabric Image Database

This project developed using the AITEX fabric image database( <https://www.aitex.es/afid/> ) and its accompanying article “A PUBLIC FABRIC DATABASE FOR DEFECT DETECTION METHODS AND RESULTS” (Silvestre-Blanes, 2019, pp.363-374). The article explains how the database was created and explores some detection methods. The database consists of 245 images ranging over 7 different types of woven fabric. It contains 140 images of defect free fabric, 20 each type of fabric. With 105 images of defective fabric spread between all 7 fabric and 12 defect types.

Usefully the database also contains 105 mask images for each image of defective fabric, theses mask images match the dimensions of the fabric images (4096×256 pixels). The masks contain only black pixels apart from the pixels that make up the defect, these are coloured white.

### Types of Defects

Now the project has a baseline understanding of how fabric is created and a database to refence from we can assess what defects are produced during the phases of its creation.

The twelve defect types present in the AITEX database are:

* Fuzzy balls. Fuzzy balls are the result of warp yarns that are too small lowering their abrasion resistance allowing fibres to break loose and form fuzz balls. According to cotton works list of defects.
* Neps. Neps are formed by an accumulation of fly and fluff on the machinery used and result in damage the fabrics appearance when dyeing (Nateri, 2014). Often caused in the spinning process.
* Knots. Knots occur in natural or synthetic warp yarns and damage the appearance and tensile strength of the textile. Knots can also refer dead or immature natural fibres (Lim, 2018).
* Crease. A crease is a valley or ridge present in the final fabric caused by folding or improper tension.
* Broken End. A broken end appears as an untied or broken warp end and manifests as horizontal lines in the lines in the fabric. The yarn is usually broken during weaving or finishing processes (Lim, 2018).
* Broken pick. A broken pick defect consists of a broken weft yarn and results in a sudden discontinuity in the weave (Lim, 2018).
* Broken yarn. Broken yarns are breaks in either the warp or weft yarn during the weaving process and result in elongated holes.
* Contamination. Contamination refers foreign objects suck too or woven into the textile. Even if the object is later removed it may have disturbed the weave or cause uneven dyeing.
* Warp ball. A warp ball is caused by a single or multiple warp yarns becoming clumped or entangled.
* Cut selvage. Selvage a is the densely woven edge of a piece of fabric a cut in the selvage can cause a separation in the weave (Lim, 2018).
* Weft Curling. Weft curling Is produced by the use of highly twisted weft yarn as a result it disturbs the pattern of the weave. (<https://textiletutorials.com/types-of-fabric-defects-with-causes-and-remedies/#:~:text=The%20weft%20curling%20defect%20is,the%20surface%20of%20woven%20fabric>.) According to Textile Tutorials.
* Weft Crack. A weft crack results in a narrow streak running in parallel with the weft caused by an absence of weft yarn. According to Textile Sphere.

Calendar

Description automatically generated with low confidence

Figure - (Silvestre-Blanes, 2019)

Figure 1. ROI of 256 x 256 pixels from original images of defective fabrics, with the names used in the database. (a) broken end, (b) broken yarn, (c) broken pick, (d) weft curling, (e) fuzzy ball, (f) cut selvage, (g) crease, (h) warp ball, (i) knot, (j) contamination, (k) nep, and (l) weft craft. ROI, region of interest (Silvestre-Blanes, 2019).

### Importance of Inspection

Fabric inspection is important for a multitude of reasons, the upmost being the prevention of inferior quality product being sold to or used by consumers (Malek, 2013). Inferior or defective product being used or sold can cause a variety consequence for the producer.

Inspection at early stages, straight after weaving, can finically be benefit the producer it stops the offending sections being processed further or being sold to those who will apply finishing processes. Supplying defective fabric is likely to cause animosity directed towards the fabric supplier, worsening customer satisfaction and possibly affecting future revenue.

The garment industry represents one largest purchasers of textiles, they need assurance the raw materials they purchase are defect free. Many of the designer brands will expect or enforce that textiles be inspected before purchase and are unafraid to hold producers accountable, as their clientele expect a level of quality.

Defects are not only cosmetically undesirable many effect the structure of the weave and so can degrade its tensile strength. Ultimately leading to textiles being distributed with a lower tensile strength than advertised, creating the potential for catastrophic failures. For example, it is key that seat belts or ratchet straps have no structural defects.

## Current Inspection Techniques

Currently fabric inspection techniques vary, the majority use human inspection. Human inspection uses workers to scrutinise fabric by hand. The accuracy of human inspection declines over time due monotonous nature of the task. This results in slower, more expensive, and erratic inspection (Chin, 1982).

Many in the industry paired a use of human inspection with inspection using DSP (digital signal processing). DSP would analyse the waveform produced by a sensor pointed at the fabric in controlled lighting. However, most are now moving towards computer vision approaches as they easier to implement and are more capable at inspecting a variety if fabrics.

## Computer Vision

Computer vision is defined as the processes of allowing computers to see the real world (Learned-Miller, 2011). Computer vision has proven key when automating the workplace.

### Deep Learning

## Background research summary

# Chapter 2: Methods

The goal of this chapter is to address the design and implementation of the three inspection techniques mentioned earlier and create the prototype inspection application. All were completed in python utilising OpenCV, TensorFlow and PyQt5.

## Initial Project Decisions

\*\* talk about the scale of the project, decision to just do detection rather than classification. Limited size of data, decision to use that specific data set as opposed to <https://www.kaggle.com/datasets/belkhirnacim/textiledefectdetection> and others, why develop the openCv techniques as well \*\*

This projected was developed using the agile methodology, using sprints to manage milestones. This method suited the project as in any form of inspection results and the times in which they are achieved are not guaranteed. This allowed some area of the project to always be in active development, even during long model training periods or when certain avenues of thought lead to dead ends.

The decision to use the aitex image fabric defect database was the first and largest decision of the project as it informed what detection methods would be perused and how they would be evaluated. There was another choice, the university of

## Sprint 1: Data Preparation and Analysis

### Goals

### implementation

#### Acquiring and Preparing the Dataset

\*\*tiling , edge finding\*\*

#### Image Analysis

### Sprint Review

## Sprint 2: OpenCV Contour Finding

### Goals

### Implementation

#### Image Morphology

### Sprint Review

## Sprint 3: TensorFlow

### Goals

### Implementation

#### CNN

### Sprint Review

## Sprint 4: Gui

### Goals

### Implementation

### Sprint Review

# Chapter 3: Results

# Chapter 4: Discussion

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# Appendix A Self-appraisal

# Appendix B External Materials

# Appendix D User Testing Consent Form

# Appendix F User Manual