

Master Thesis



Czech
Technical
University
in Prague

F3

Faculty of Electrical Engineering
Department of Measurements

Analysis of the textile fibers unevenness in frequency domain

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Field of study: Sensors and Instrumentation

Subfield: Cybernetics and Robotics

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Acknowledgements

Děkuji.

Declaration

Prohlašuji, že jsem předloženou práci vypracoval samostatně, a že jsem uvedl veškerou použitou literaturu.

V Praze, 15. May 2016

Abstract

To be done.

Keywords: digital signal processing,
textile defects, unevenness

Supervisor: Ing. Jakub Parák

Abstrakt

To be done.

Klíčová slova: zpracování digitálního
signálu, textilní vady, nerovnoměrnost

Překlad názvu: Analýza periodických
vad textilních vláken ve frekvenční
oblasti

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Chapter 1

Introduction

Textile manufacturing has always been important industry field. Major part of this industry is formed by process called spinning, where twisting strands of fibers together form yarn. The modern spinners - textile machines, that execute process of spinning - have been significantly improved and now they reach high level of automation. This allows not only faster and cheaper production but also more focus on quality of the produced textile yarn.

Quality of the yarn could devaluate the final product by creating defects, such as a rapid changes in color or thickness etc., in textile material. Even with modern technologies it is still impossible to produce yarn without any defects. We can't prevent yarn defects by carefully selecting and preprocessing fiber, because some defects can be created by spinning process itself. Out of many types of defects this thesis is focused on analysis of yarn unevenness (also called yarn irregularity). This is describing yarn with a diameter that is not even along it's length, but it is changing it's value periodically. We can measure this defect in the form of mass variation per unit length.

Designed system is not aiming to improve quality of spun yarn, but to monitor quality (specifically unevenness) of produced yarn during the spinning process. Due to this monitoring it is possible to stop spinning process if defective yarn is detected. This allows the operator to resolve the issues that caused it, e.g. by replacing spinner fiber source with new one and reconnecting different yarn endings.

The project - described in this thesis - has been made in cooperation with company Rieter CZ s.r.o, who provided the device requirements, critical measurement data and other important information. The goal of the project was to research and develop an algorithm for analysis and detection of yarn unevenness by using spectrograms and to design an embedded system capable of measuring diameter of yarn while fulfilling the required time constraints and implement detection algorithm to it. System is required to be controlled by ARM M4 microcontroller. Thus the algorithm has to be implemented in a way that takes in consideration memory and computational limitation of such microcontrollers.

Very important specification was requirement to analyse quality of two textile fibre types: the yarn and the sliver. Where sliver is the input textile fibre for the spinning process and the yarn is it's final product. The both of

which has significant physical differences. Mainly they differ in size, because yarn diameter is usually in range of micrometers and sliver diameter is in range from millimeters to centimeters. The diameter of the sliver is measured on combing machine, which precedes the spinning process. This requires different measuring system and filtration processing, therefore two systems and algorithms were designed for quality analysis of each fibre type. Their core content is equal but there are some major differences, which are described later in this thesis. The most significant difference is that processing of signal representing sliver diameter requires much more advanced techniques of digital signal processing. This is necessary due to strong presence of periodical artefacts on sliver diameter caused by machine preprocessing. This type of diameter fluctuations have to be distinguished from the actual sliver unevenness, which is task for complicated digital filtration in frequency domain.

Chapter 2

Teoretical Introduction

Before the process of software and hardware development could begin, detailed theoretical research had to be done. Topics of the research include textile manufacturing, combing process, spinning process and textile fiber defects to understand better device requirements. Another step of research was focused on digital signal processing techniques that could be used on the project, mainly spectrogram estimation and it's calculation using Fast Fourier Transform, together with possible filtration algorithms. Another research topic was aimed to cover embedded systems and specifically micro-controller usage and it's limitations

2.1 Textile Engineering

Goal of textile manufacturing is to make fabric from textile fibers, which can be then used for clothes. This process can be separated in several stages:

- Preparatory Processes - prepares the textile fiber for spinning process by blending, carding and combing,
- Spinning - fibres are spun into yarns,
- Knitting or Weaving - yarns becomes fabric,
- Finishing - fabric is transformed into clothes etc.

In regards to the topic of this thesis only two - the spinning and combing processes - are described.

2.1.1 Textile Fibers

Fibers are the basis for all textiles. We distinguished the two main types: natural fibers and synthetic fibers. The natural fibers are:

- Cotton - from the cotton plant,
- Linen - from the flax plant,
- Wool - from sheep and
- Silk - from silkworms.

Examples of widely used synthetic fibers are:

- Viscose - from pine trees and petrochemicals,
- Acrylic, nylon and polyester - from oil and coal.

were used in detection of yarn defects - optical, mechanical or even chemical. [3]

2.2.1 State of Art

2.3 Digital Signal Processing

Largest part of work on this project is oriented on digital signal processing. Usage of modern advanced algorithms from this field allowed to design projected device in the first place. This section covers the most important algorithms that are used in this project.

Digital signal processing is an area of science and engineering that has developed rapidly over the past 40 years as a result of significant advances in digital computer technology. Today, many of the signal processing tasks that were conventionally performed by analog means are now realized by less expensive digital hardware. [2] To perform the processing digitally, there is need for conversion between analog signal and digital signal. This is done by interface called analog-to-digital (A/D) converter, which yields a digital signal as it's output that is appropriate as an input to the digital processor. [2, 1]

2.3.1 Discrete Fourier Transform

To perform frequency analysis on a discrete-time signal $x[n]$, we convert the time-domain sequence to an equivalent frequency-domain representation. This conversion is obtain by Discrete Fourier Transform that can be algebraically formulated as follows.[2, 1]

Given N consecutive samples $x[n], 0 \leq n \leq N - 1$ of a periodic or aperiodic sequence, the N -point Discrete Fourier Transform(DFT) $X[k], 0 \leq k \leq N - 1$ is defined by

$$X[k] = \sum_{n=0}^{N-1} x[n] e^{-j \frac{2\pi}{N} kn}. \quad (2.1)$$

Given N DFT coefficients $X[k], 0 \leq k \leq N - 1$, we can recover the N sample values of sequence $x[n], 0 \leq n \leq N - 1$ using Inverse Discrete Fourier Transform (IDFT) given by

$$x[n] = \frac{1}{N} \sum_{k=0}^{N-1} X[k] e^{j \frac{2\pi}{N} kn}. \quad (2.2)$$

If $x[n]$ has infinite duration, the frequency samples $X[2\pi k/N], k = 0, 1, \dots, N - 1$ correspond to a periodic sequence $x_p[n]$ of period N , which is an aliased version of $x[n]$. When the sequence $x[n]$ has finite duration of length $L \leq N$, then $x_p[n]$ is simply a periodic repetition of $x[n]$.

■ 2.3.2 Fast Fourier Transform

■ 2.4 Digital Processing Techniques

■ 2.4.1 Spectrograms

■ 2.5 Embedded systems and microcontrollers

■ 2.5.1 Embedded systems

■ 2.5.2 ARM M4

Chapter 3

Practical Implementation

3.1 Description of Algorithm for Unevenness Analysis

3.1.1 Flowchart Diagram

3.2 Description of Designed System

3.2.1 Block Diagram

3.3 Implementation of Software

3.3.1 Filtration

3.3.2 Detection of Defects

3.3.3 Automatic Evaluation

3.3.4 Example of Designed Application

3.4 Implementation of Hardware

3.4.1 Electronic Circuits Design

3.4.2 Description of possible sensors

3.4.3 Designed Prototype



Chapter 4

Conclusions

Proof. 8 Bla

- 1. Blo

□



Appendix A

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název práce

Analýza periodických vad textilních vláken ve frekvenční oblasti

Analysis of the textile fibers unevenness in frequency domain

katedra obhajoby

katedra měření

obor

<neurčen>

Nesouhlasí obor práce s oborem studijní plánu studenta!

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[4] Katalogové listy jednotlivých komponent a součástek.

pokyny

1. Seznámit se s problematikou vad textilních vláken a spřádných strojů
2. Navrhnout systém pro detekci vad textelních vláken
3. Navrhnout implementaci filtračního detekčního a detekčního algoritmu ve frekvenční oblasti
4. Implementovat softwarovou knihovnu s navrženým algoritmem pro mikrokontrolér
5. Experimentálně otestovat navržený systém s implementovaným algoritmem

zadavatel

spolupráce s Rieter CZ s.r.o.

vytištěno: 28.11.2015 14:04:00

vytiskl: Parák Jakub Ing.