# APPLICATION OF SIGNAL PROCESSING TECHNIQUES FOR CHARACTERISATION AND MONITORING OF YARN FAULTS

**VIJAY KUMAR YADAV**

**DEPARTMENT OF TEXTILE TECHNOLOGY**

**INDIAN INSTITUTE OF TECHNOLOGY DELHI**

**AUGUST 2016**

# APPLICATION OF SIGNAL PROCESSING TECHNIQUES FOR CHARACTERISATION AND MONITORING OF YARN FAULTS

by

**VIJAY KUMAR YADAV**

Department of Textile Technology

Submitted

in fulfilment of the requirements of the degree of Doctor of Philosophy

to the


**INDIAN INSTITUTE OF TECHNOLOGY DELHI**

**AUGUST 2016**

**Dedicated to my parents, wife and children**

# Certificate

This is to certify that the thesis titled **Application of Signal Processing Techniques for Characterisation and Monitoring of Yarn Faults** being submitted by Mr. Vijay Kumar Yadav for the award of the degree for Doctor of Philosophy in Textile Technology is a record of bona fide work carried out by him under our guidance and supervision. In our opinion, the thesis has reached the standards fulfilling the requirements of the regulations relating to the degree.

The work presented in this thesis has not been submitted elsewhere, either in part or full, for the award of any other degree or diploma.


**Dr. S.M. Ishtiaque**
Professor
Department of Textile Technology
Indian Institute of Technology Delhi

**Dr. S.D. Joshi**
Professor
Department of Electrical Engineering
Indian Institute of Technology Delhi

**Dr. J.K. Chatterjee**
Professor
Department of Electrical Engineering
Indian Institute of Technology Delhi

# Acknowledgements

At the outset I express my deep gratitude to my supervisors Prof S.M. Ishtiaque, Prof S.D. Joshi and Prof J.K. Chatterjee for guiding me all through the PhD journey, both technically and morally. They have been pillar of strength at many difficult moments during PhD. Without their encouragement and help, it would have been impossible for me to complete this research work.

I wish to express my warm and sincere thanks to Research Committee members, Prof. R. Chattopadhyay, Prof. Apurba Das, and Prof. R.K.P. Bhatt for their valuable suggestions and constructive criticism at different stages during the course of my work.

I would like to thank the Head of Textile Department, Prof. B. K. Behera, for providing all necessary facilities to do my research work and also for allowing me to work in the laboratory after official working hours. I also wish to thank ex-Heads of department, Prof. R. Chattopadhyay, Prof. Kushal Sen and Prof. P. K. Banerjee for their encouragement and support. My special thanks goes for Prof. Vijay Kumar Kothari for his advices and teachings which helped me a lot in moving forward with my doctoral research. He had been a continuous source of inspiration for me through all these years and would remain in future too.

I acknowledge the support received from the laboratory staff of various labs with special reference to Mr. B Biswal (Testing), Mr. Rishi Dagar (Applied Mechanics), Mr. Rajkumar (Computer), Mr. Prathap (Spinning) and Mr. Manoranjan Kundu (Weaving).

I am grateful to M/s Vardhman Group and M/s Alps Industries, for providing the yarn samples required for my research work. My special thanks goes to Mr. Nadeem and Mr. Aamir Saif for

helping me in instrument fabrication and providing their round the clock support. My gratitude also goes to my friends and colleagues with whom I have collaborated during this work Special thanks are due to my friends Dr. Guruprasad, Dr. Naveen Padaki, Dr. Brojeswari Das, Dr. Kausik, Dr. Jagganath, Dr. Swapna Mishra, Dr. Ajit Pattanayak, Dr. Alok Kumar, Dr. Raghunath Reddy, Dr. Shabaridharan, Mr. Navdeep Phogat and Mr. Janmajay Kumar.

I am indebted to Dr. J.V. Rao for providing me the required and unconditional leave from a demanding job at Textile Sector Skill Council, New Delhi. His inspiration has definitely put me a way forward.

I would especially like to thank my family. My wife, Poonam has been extremely supportive of me throughout this entire process and has made countless sacrifices to help me get to this point. My children, Akash and Anand, have continually provided the requisite breaks from studies and the motivation to finish my degree. My brother Satpal, sister-in-law Rajni, niece Riya and nephew Mukul provided that little stress reliving moments and remained a source of inspiration. Thanks to Anu for helping me in the proof reading of the thesis.

My mother Smt. Santra Devi and my late father Shri Deeg Ram Yadav deserves special thanks for their blessings and encouragement. Without such a team behind me, I doubt that I would be in this place today. Finally I thank the Almighty for letting me through all the difficulties.

**Vijay Kumar Yadav**

# Abstract

A continuous image acquisition system to monitor and characterize the yarn faults using two projection views has been successfully designed and developed. The virtual images are captured intermittently using a Leica stereomicroscope mounted with a CCD still camera. Further, the cross-sectional area signal is used to generate a volume signal for fixed band sections along the yarn. Two independent images are filtered using binary image processing technique after converting to a binary image. Binary morphological filtration method is used for processing bi-directional yarn images and to extract the individual yarn images corresponding to two projection views of the yarn. Means of generating 1-D signal are used and extended to determine the length of the faults. Different algorithms for extracting the physical dimensions of the faults are developed. Karhunen–Loève Transformation (KLT) basis for each fault class is formed. Projections of individual realization from the test sample on KLT basis are obtained for each class and Radon projection angle. The average weighted Euclidean criteria is applied using these Euclidean distances. The individual KLT basis developed above is used to extract such eigenvectors explaining only as single class. It is established that the respective fault has different configuration and therefore, makes possible to differentiate the fault on the basis of their configuration. It is established that the faults of a particular class has more than one type of configuration and different terms can be given for different type of sub-classes.

The proposed classification and measurement techniques are used for developing a scheme for characterization of faults which can be used in the ‘offline’ as well as ‘online’ scenario. The DIAMETRIC FAULTS system provides the detailed classification of faults based on their geometric dimensions and presents flexibility to the user to choose the boundary limits for fault

classification. The system is used to compare the characteristics of yarns made on two different spinning systems and on two different opening and carding technologies. Signal processing tools applied to the bi-direction view yarn image have shown new dimension to fancy yarn analysis. The developed system is used for characterizing and deriving constructional parameters of slub yarns.

# Contents

# List of Figures

***Page No.***

***Page No.***

***Page No.***

***Page No.***

***Page No.***

***Page No.***

# List of Tables

***Page No.***

***Page No.***

***Page No.***