

## Conclusion

The subjective evaluation of many fibrous structures is common and stands as a problem in the textile industry where it causes a great deal of dependency on the human operator and prevents the automation of the applied evaluation method. The lack of automation results in a heavy laborious work load that might affect the product at many levels:

- Quality *fluctuation* as a result of the dependence on the human element
- Lack in *understanding* the studied phenomenon; because of the lack of information about it which is usually collected through some measurement experiments. Once the measurement being automated, a lot of experiments can be carried out and enough information can be collected about the phenomenon of study
- Processing of information is usually performed in a *black-box system* with no clarity about the process

It is fortunate that the current advancement in computer science and technology, on the hardware and software levels, allow addressing these problems in a different way. Computer vision, for instance, allows the digitization of the physical objects and aims at understanding the digital model with a high level of intelligence. This level of intelligence can be achieved through the soft-computing algorithms which are based on the accumulation of different branches of science such as physiology, sociology, philosophy, mathematics..., etc. The work introduced in this thesis aimed at utilizing these tools in solving some of the current problems in fibrous materials at different levels; where yarns, fabrics at production, and fabrics at the end use were investigated.

Highlights of the work introduced in this study are summarized below:

- For the study of the yarn internal structure and geometry, the Chan-Vese (CV) model was utilized to detect the actual contours of both the yarn and its constituent fibers. The detected yarn contour allows the use of the actual yarn cross-sectional shape which differs from the approximated circular contours that are considered in the conventional methods for calculating the yarn packing density. By considering the actual yarn contour (rather than its circular approximation), the measured packing density using the introduced method is expected to be faster and more reproducible than the traditional methods of calculating the packing density. The method we suggested in this work is the first in literature to implement an active contour method (such as Chan-Vese) for studying the yarn internal structure and it significantly reduces the time for measuring the yarn packing density compared to the traditional methods of measurement. Also, the introduced method is not limited to studying the yarns but it can be extended to segment different fibrous structures and calculate their porosity and packing density.

- Our DiaLib® method introduced in this work is a new and simple method that is computationally inexpensive and can handle massive amount of images within a reasonable time. The data obtained from the applied algorithm were found to be significantly comparable to the commercial available instruments such as Uster evenness tester. The developed analysis was capable of detecting the short term, the long term, and the periodic variations of yarn diameter. To the best of our knowledge, this work is the first to process the images of continuous long length of yarns to allow its time-series treatment. The developed data-treatment algorithm is also powerful enough to handle data collected from the image analysis method or to handle the raw data that might be obtained from the commercial measuring instruments and standardize the results with a transparent explanation.
- Our introduced machine prototype for detecting and classifying the fabric faults was associated with computer vision algorithms at a high level of imitating the visual inspection of the human operators. The machine is capable of running at suitable speeds and the system was trained on identifying a relatively high number of fabric faults categories. A direct and hierarchical classification approaches were considered where the hierarchical approach aimed at reducing the processing time. Results introduced in this study are promising and may allow the application of the introduced techniques in real time fabric inspection systems because of the high successful classification rate and the relatively short processing time.
- The implementation of the principal component analysis (PCA) allows the dimensionality reduction of the input feature dataset without sacrificing the amount of information in the original dataset which enhanced the processing time. In this work on fabric fault detection, we considered a large set of features that composes of statistical as well as spectral features (using FFT). The performance of the network that was implemented after the application of the PCA surpasses the performance of the other network in all aspect of characterization.
- In our work on the objective fabric pilling evaluation, a comprehensive review of the available literature methods was done, for the first time, with a categorization of the published work. The literature survey showed some shortcomings of the current research in the field which led to the introduction of our two papers on fabric pilling. Our purpose was to introduce an integrated system that utilizes the best practices in the four main stages of the evaluation process and our suggested system was able to implement fast and efficient techniques for pills segmentation and quantization. The system also introduces a new stochastic method for creating sampling dataset that is large enough to suite the training and testing processes required in building the applied artificial intelligent classifiers.
- Similarly, the work on the objective pilling evaluation in woven fabrics introduces for the first time the *image textural features* as measures for the fabric surface. Creating a feature dataset from the available Standard images with enough size for training the soft

computing algorithms is challenging due to the limited number of those Standard images. To deal with this issue, a new approach was suggested to mimic the noise that interferes with the fabric surface during its digitization. Hence, a user-friendly pilling evaluation system that integrates the processes of fabric surface digitization, pilling segmentation, quantization, and classification was implemented. The system was able to classify woven fabric samples according to their surface texture with a high degree of correlation to the traditional methods of pilling evaluation.

Finally, the algorithms presented in this work are heading in the direction of *improving*, *simplifying*, *automating*, and *reducing* the time required for the current evaluation methods. Nevertheless, this work can only be considered as few steps in that direction and the future is full of opportunities for further development.

