Extended Abstract
6th PLATE 2025 Conference
Aalborg, Denmark, 2-4 July 2025

Test less, better, faster, cheaper.

Anaïs Dahan[a,b], Romain Benkirane [a], Thierry Scaglia[b], Sébastien Thomassey[a]
a) Univ. Lille, ENSAIT, ULR 2461 - GEMTEX - Génie et Matériaux Textiles, F-59000 Lille, France
b) Petit Bateau, Troyes, France

Keywords: Durability; Lifespan; Textile testing; Clustering; Textile industry.

Introduction

One of the major challenges faced by the textile industry is addressing its socio-environmental impact. To tackle this, various strategies derived from circular economy and eco-design have been identified as potential levers:

- Consumption changes through new business models (Fletcher 2012),
- Care (Laitala and Klepp 2020)
- Price perception in relation to sustainability (McNeill et al. 2020; Pires et al. 2024; Wakes et al. 2020),
- Physical durability of products (Degenstein et al. 2020; Fletcher 2012; Wakes et al. 2020).

These approaches offer significant opportunities for mitigating environmental damage, improving resource efficiency, and promoting sustainability throughout the entire lifecycle of textile products (UNEP 2023). However, each face has specific and significant challenges that require collaboration among producers, governances and consumers (UNEP 2023; Pichon et al 2022)

Focusing on physical durability, it is assumed that the evaluation methodologies currently available are based on established frameworks, which could theoretically be implemented. However, these frameworks rely on a variable number of tests depending on product category (from 4 to 20) (AFNOR 2025; European Commission 2021). Considering the size of a collection, it's clear that this represents a significant challenge. The need to perform individual tests for each item within a large textile collection makes the practical implementation of these frameworks both resource-intensive and time-consuming. This complexity underscores the importance of developing more efficient methodologies to facilitate the adoption of physical sustainability measures in the textile industry.

In this context, a central question emerges: for a high number of references, how to simplify and to optimize the process of assessing the physical durability, while guaranteeing relevant and reliable results?

This study proposes a methodology to optimize the durability assessment of textile considering:

- the number of redundant tests
- the number of fabric references to be tested.

This approach aims to identify key features that enable the performance to be predicted, offering a scientifically robust yet practical solution to support manufacturers in their pursuit of more sustainable production.

Methodology

The proposed methodology relies on a clustering-based approach to predict quality test results. In the following, data collection, processing, clustering and prediction are explained.

Data collection

This work is based on the case study of a knitwear manufacturer. A fashion knitted garment is made from: knitting, dyeing, finishing and dressmaking. Given the diversity of yarns and the process parameters, a high variety of process combinations can arise. Thus, a single yarn reference can be used in several scenarios, a single knitted fabric can incorporate different yarns, etc. (Figure 1). At the dressmaking level, a single knitted fabric may be used for the development of multiple designs, while a single design may be created from various fabric references.

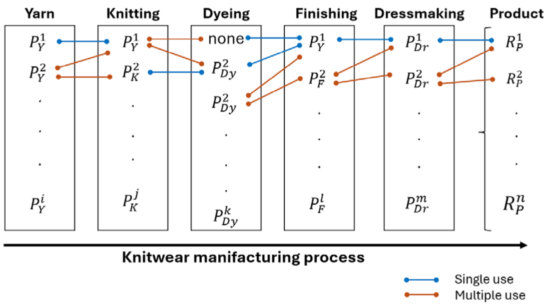

Figure 1. Variety of manufacturing processes for knitted textile products

Features	Type
Knitting structure	Categorical
Structure specification	Categorical
Knit type	Categorical
Mechanical finishing	Categorical
Wool	Numeric
Synthetic	Numeric
Cotton	Numeric
Flax	Numeric
Viscose	Numeric
Elastane	Categorical
Organic cotton	Categorical
Recycled synthetic	Categorical
Knit cut	Categorical
Knitting machine diameter	Numeric
Fabric width	Numeric
Fabric weight	Numeric
Gauge	Numeric
Number of needles on knitting machine	Numeric
Number of knitting feed	Numeric
Yarn count	Numeric
Yarn color (natural, dyeing or mottled)	Categorical
Yarn treatment	Categorical
Twisting	Categorical
Spinning	Categorical
Yarn CSR	Categorical

Table 1. Raw knitwear features

A persistent issue in data collection from textile industry was cross-referencing and standardization (Niinimäki et al. 2024). Thus, the proposed methodology focuses on cross-validated data: the structure fabric's properties from around one hundred raw knitted fabrics. Tables 1 and 2 detail the structure and quality features collected, including composition, machine parameters and dimensional stability.

Features	Type
Dimensionnal stability course	Numeric
Dimensionnal stability wale	Numeric

Table 2. Quality tests

As a first approach, the selected raw knitwear references are those made from a single yarn reference such as rib, jersey or interlock.

This study was carried out using Orange Data Mining software. The methods worked with thereafter, hierarchical clustering and decision trees effectively structure and classify complex datasets, maintaining strong predictive ability and robustness to data variations (Ghattas et al. 2017).

Data cleaning

A clean-up of outliers, based on the results of the Local Outliner Factor method and expert judgement, results in a more homogeneous dataset of 110 knitted fabric. These outliers concern references with unusual stability probably due to production issues or singleton like flax-based reference.

Prediction of dimensional stability according to knitwear features

To demonstrate the benefits of clustering, an investigative step was implemented, based on the direct prediction of dimensional stabilities from knitting features (Figure 2). All predictive models used are based on regressive or classification trees due to their ease of use and accuracy on relatively small datasets.

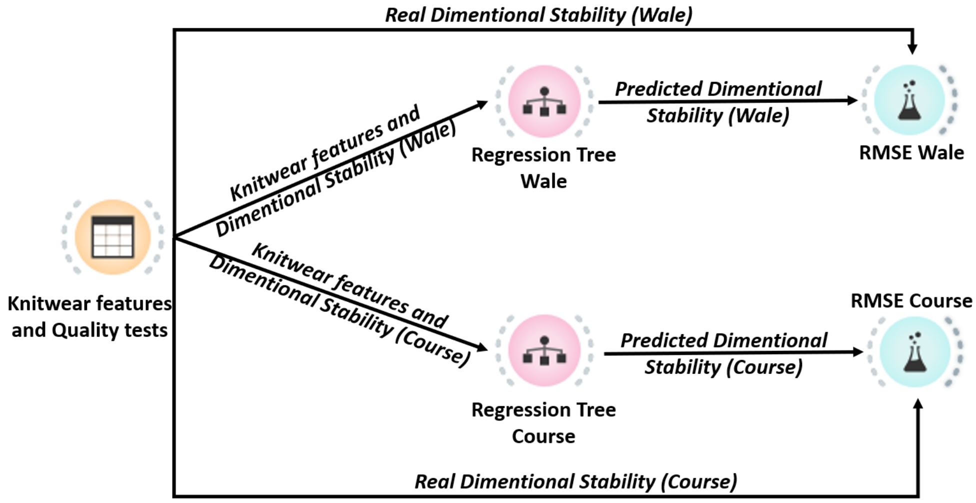

Figure 2. Prediction of dimensional stability based on regression tree

Cluster based prediction and analysis of feature influences

The proposed approach is a two-step method (Figure 3):

1- A hierarchical clustering defines clusters of fabrics with similar dimensional stability behavior.

2- A classification tree assigns a cluster to a fabric according to its knitwear features. The cluster average is considered as the dimensional stability of the fabric assigned to this cluster.

Finally, the obtained tree is analyzed to highlight the knitwear features with the highest influence on their dimensional behavior with the permutation feature importance technique.

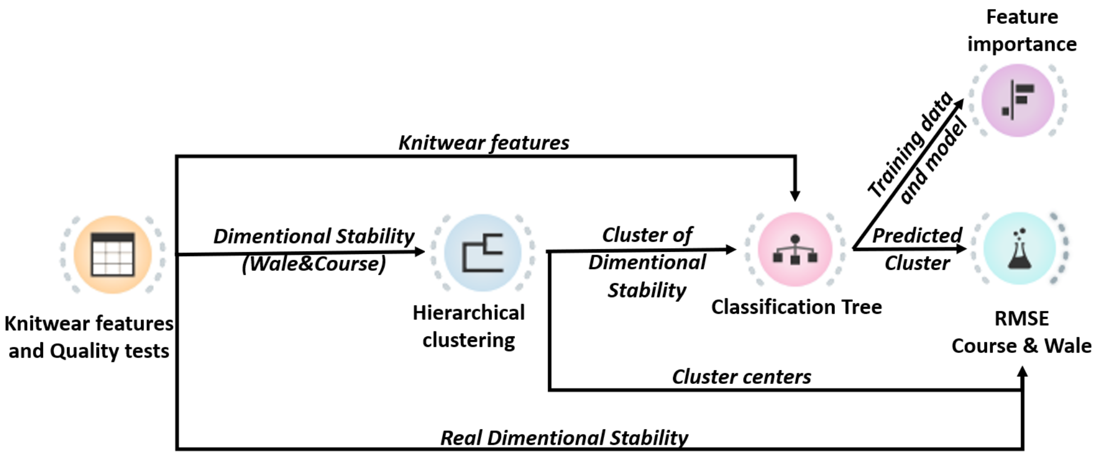

Figure 3. Cluster of dimensional stability and prediction of knitting features based on classification tree

Results

Cluster quality results beforehand confirmed as the most accurate by calculating the root-mean-square deviation (RMSE) between the actual dimensional stabilities and the course and wale dimensional stabilities. RMSE values are reported in Table 3.

RMSE	*Prediction according to features*	*Cluster based prediction*
Course	0,535	0,316
Wale	0,552	0,470

Table 3. RMSE values

The dendrogram of the hierarchical clustering (Figure 4) is used to select 8 clusters considering the balance between separation and compactness. The point distribution (Figure 5) shows distinct groups, validating the segmentation despite the limited data.

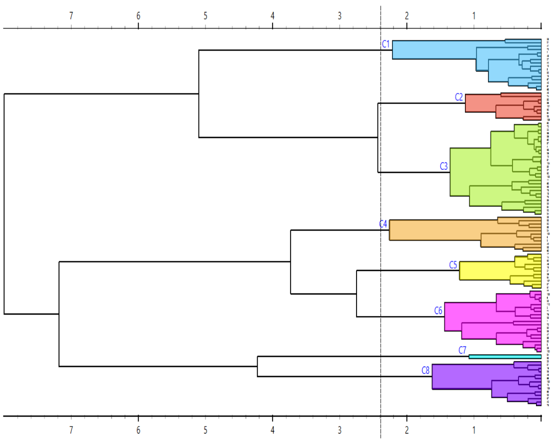

Figure 4. Hierarchical clustering of raw knitwear reference according to dimensional stability

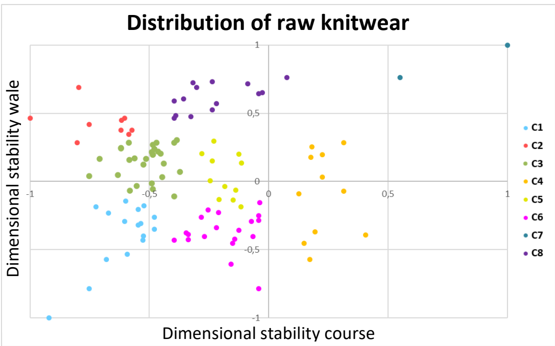

Figure 5. Distribution of raw knitwear according to dimensional stability in course and wale (data normalized and bounded)

The analysis of the attribute importance of the prediction model highlights that fabric width, knit type and fabric weight are the 3 most influential features on knitwear dimensional stability (Figure 6).

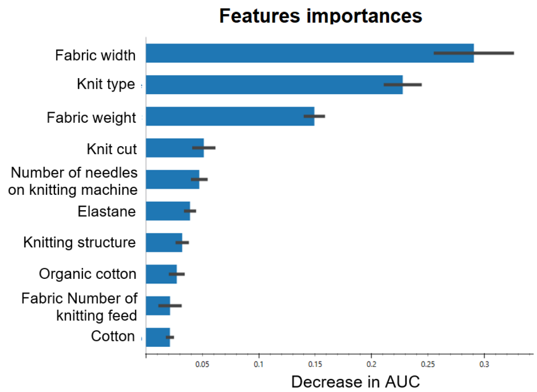

Figure 6. Features importances

At the studied knitwear manufacturer, fabric width has a strong influence, mainly because it is processed either open-width or tubular, causing data variations up to threefold. It is essential to assess the gap between theoretical and actual values to determine its true impact.

Conclusion

This study demonstrates that clustering of fabrics improves the prediction accuracy of quality test results. Furthermore, the proposed methodology highlights the most important features for eco-design. However, a deeper analysis of the results is required to identify the relationship between prediction accuracy and clusters. This further analysis should identify if a fabric requires a test to be performed or if the prediction is enough accurate to qualify its quality.

A limitation of this study is that the influence of finishing was not considered in the fabric features, though it could impact on the dimensional stability. This will be the subject of future works.

Acknowledgments

This article is based on research carried out at Petit Bateau and GEMTEX, with financial support from ANRT and Petit Bateau.

References

AFNOR. 2025. "NF G30-113 - Articles Textiles d'habillement et Linge de Maison - Évaluation de La Durabilité."

Degenstein, Lauren M., Rachel H. McQueen, Lisa S. McNeill, Robert P. Hamlin, Sarah J. Wakes, and Linda A. Dunn. 2020. "Impact of Physical Condition on Disposal and End-of-life Extension of Clothing." *International Journal of Consumer Studies* 44(6):586–96. doi: 10.1111/ijcs.12590.

European Commission. 2021. "Product Environmental Footprint Category Rules: Apparel and Footwear."

Fletcher, Kate. 2012. "Durability, Fashion, Sustainability: The Processes and Practices of Use." *Fashion Practice* 4(2):221–38. doi: 10.2752/175693812X13403765252389.

Ghattas, Badih, Pierre Michel, and Laurent Boyer. 2017. "Clustering Nominal Data Using Unsupervised Binary Decision Trees: Comparisons with the State of the Art Methods." *Pattern Recognition* 67:177–85. doi: 10.1016/j.patcog.2017.01.031.

Laitala, Kirsi, and Ingun Grimstad Klepp. 2020. "What Affects Garment Lifespans? International Clothing Practices Based on a Wardrobe Survey in China, Germany, Japan, the UK, and the USA." *Sustainability* 12(21):9151. doi: 10.3390/su12219151.

McNeill, Lisa S., Robert P. Hamlin, Rachel H. McQueen, Lauren Degenstein, Sarah Wakes, Tony C. Garrett, and Linda Dunn. 2020. "Waste Not Want Not: Behavioural Intentions toward Garment Life Extension Practices, the Role of Damage, Brand and Cost on Textile Disposal." *Journal of Cleaner Production* 260:121026. doi: 10.1016/j.jclepro.2020.121026.

Niinimäki, Kirsi, Anubhuti Bhatnagar, Hella Hernberg, and Malahat Ghoreishi. 2024. *Identifying Data Gaps in the Textile Industry and Assessing Current Initiatives to Address Them. Technical report*. LU: Publications Office.

Pichon, Noémie, Romain Benkirane, and Sébastien Thomassey. 2022. "Obsolescence des vêtements : un effet de mode ?" *Techniques de l'Ingénieur*. doi: https://doi-org.ressources-electroniques.univ-lille.fr/10.51257/a-v1-g7004.

Pires, Paulo Botelho, Cláudia Morais, Catarina J. M. Delgado, and José Duarte Santos. 2024. "Sustainable Fashion: Conceptualization, Purchase Determinants, and Willingness to Pay More." *Administrative Sciences* 14(7):143. doi: 10.3390/admsci14070143.

United Nations Environment Programme. 2023. *Full Report - UNEP Sustainability and Circularity in the Textile Value Chain A Global Roadmap*.

Wakes, Sarah, Linda Dunn, Dahna Penty, Kayla Kitson, and Tim Jowett. 2020. "Is Price an Indicator of Garment Durability and Longevity?" *Sustainability* 12(21):8906. doi: 10.3390/su12218906.