

The Beauty of Flaws: Embracing Machine Errors in Textile Design

Natnicha Kajkumjohnde¹, Eakachat Joneurairatana², Veerawat Sirivesmas³,

Sone Simatrang⁴ and Minjade Paklapas⁵

^{1,2,3,4}Faculty of Decorative Arts, Silpakorn University, Thailand

⁵College of Design, Rangsit University, Thailand

Corresponding Author, E-mail: ¹n.kajkum@gmail.com

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Abstract

In this paper, a transformative approach to textile design is explored by redefining machine-induced imperfections as intended and innovative design elements. Combining the use of emerging technologies such as artificial intelligence (Paklapas et al., 2024) together with the Wabi-Sabi philosophical underpinning, the aesthetics of these flaws—formerly considered imperfections are engaged in a new way to be creative, sustainable and towards waste reduction. The focus of the study is on how aesthetic irregularities, like seam puckering, misalignment, and distortion may accommodate the industry push towards awareness and emphasis on environmental responsibility.

A mixed-methods approach is applied, including literature analysis, experimental prototyping, and stakeholder feedback to explore the potential of machine-induced flaws. Findings show that these irregularities, when embraced intentionally, open new opportunities for sustainable design strategies and creative innovation. The results recommend a shift in paradigm where imperfection is embraced as being an enabler for innovation, authenticity, and sustainability in future textile design.

Keywords: Flaw-Inspired Aesthetics; Textile Innovation; Sustainable Design; Imperfection Aesthetics; Wabi-Sabi Textiles

Introduction

Machine-induced imperfections such as seam puckering, misalignment, and distortion have traditionally been regarded as defects, often leading to waste and excessive resource use

(Nualdaisri, 2022; Hati & Das, 2011; Pan et al., 2016; Nguyen et al., 2023). However, emerging design philosophies like Wabi-Sabi embrace imperfection as beauty (Matcha Design, 2025). With the rise of artificial intelligence (Paklapas et al., 2024) and IoT, these irregularities can be transformed into intentional aesthetic elements (Nguyen et al., 2023; DHL, 2024; Marwala, 2025). This paper explores how such flaws can be integrated into textile design to promote innovation, authenticity, and sustainability.

Research Objective

The goal of this work is to reassert machine-induced irregularities as designed rather than as faults in the textile tabular product. The research aims to find how imperfections can stimulate creativity, foster environmental responsibility, and change the perception of industry by using emerging technologies and sustainable practices. It delivers actionable strategies to embed these elements into design processes to foster innovation, reduce waste, and respond to market growth for eco-conscious, unique textile products.

Methodology

In this study, the author employs a mixed-methods approach, mixing research that encompasses both qualitative and experimental research. The qualitative part of the paper involves deep reading of existing literature on understanding errors produced by machines in textile production, for example, seam puckering, misalignment, and distortions. The errors are analysed as potential repurposing as design aesthetic elements. The experiment focuses on testing and converting these imperfections into functional and aesthetically pleasing factors in the designs.

Additionally, experimental prototyping explores how these imperfections can be transformed into intentional features, supported by stakeholder feedback from designers, manufacturers, and academic peers. This integration ensures both creative experimentation and practical industry applicability.

Data Collection

1. Literature Review: Analyse previous research and case studies on seam puckering, misalignment, and distortions to identify patterns and creative possibilities.

2. Observational Analysis: Collect samples of garments and textiles exhibiting machine-induced errors for detailed examination.

The experimental process tests the potential that flawed textiles have, taking to explore materials with puckering seams, misaligned edges, and distortions. These errors are tested to improve and then turn into unique design features. These imperfections are demonstrated in prototypes to show how they can be integrated into sustainable textile design. It centres the development of designs like those that minimise waste, capitalize on resource use, and can provide new aesthetic possibilities.

This study focuses on sustainability. Through the design process, we assess the impact of using flawed materials on reducing waste, introducing eco-friendly practices, and ultimately on time, money, and product development. To achieve both industry needs and sustainability goals, the outcomes are informed by feedback from stakeholders, including designers, artists, and manufacturers.

The data analysis consists of a qualitative thematic analysis of literature, feedback from stakeholders, and visual assessment of prototypes. Building upon our previous research on AI-driven defect analysis and pattern generation (Paklapas et al., 2024), this study extends beyond classification to focus on creative transformation. The resulting prototypes are evaluated for beauty, functionality, and market potential in order not only to create aesthetically pleasing designs that are also sustainable but also to generate a potential market for the products. Finally, the findings are validated via industry professionals and academic peers presentations to refine the findings and increase their applicability. Based on this methodology, machine-induced errors are reimagined as valuable contributors to sustainable textile design. The study combines creative experimentation with a sustainability assessment to provide practical and original solutions of how to recode imperfections in the textile industry.

Research Conceptual Framework

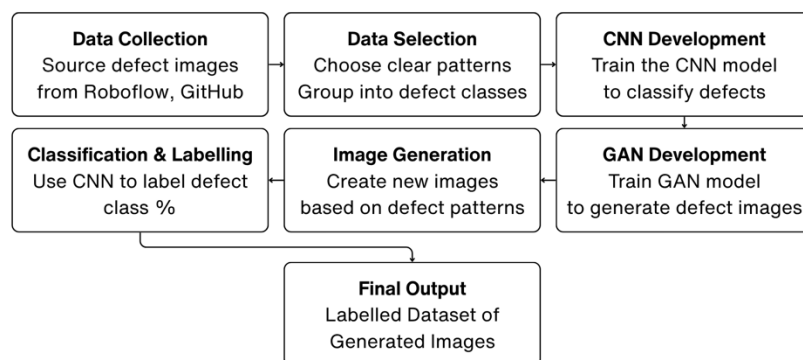


Fig 1 Research Conceptual Framework

Research Result

The reinterpretation of seam puckering, misalignment, and distortions transforms what was traditionally seen as flaws into celebrated aesthetic features (Paklapas et al., 2024). Through prototypes and experimental testing, this study demonstrates how embracing imperfections leads to new design opportunities and directly supports the research objectives by connecting sustainability, creativity, and industry needs.

1. Seam-Puckering Seam puckering occurs when the fabric wrinkles or gathers because of uneven tension between the seam and the surrounding fabric, or when there is a mismatch in certain fabric properties. This defect remains one of the most common issues in textile production and is often attributed to poor workmanship or improper machine settings. Researchers have extensively analysed the causes of seam puckering to better understand and control it. Fabric thickness, stiffness, elasticity, and critical sewing parameters—such as thread tension and machine feed settings—have been identified as key factors by Hati and Das (2011). Even minor inconsistencies in these variables can directly lead to puckering, with the severity often proportionate to the fabric properties. Supporting the view that puckering can arise from interactions between fabric layers, Pan et al. (2016) demonstrated that puckering frequently occurs when one layer stretches more than the other during sewing. Maintaining precise fabric alignment and carefully adjusting thread tension are therefore essential to prevent these distortions, particularly when the goal is for sewn products such as bags to retain their

form. For instance, Tan et al. (2022) applied advanced AI and IoT systems to identify puckering levels with greater precision, enabling improved analysis of correlations between puckering patterns and specific material or process variations.

1.1 Random Seam Puckering Random seam puckering describes unpredictable wrinkling patterns along the seam. They are the result of the puckers developing to accommodate uneven thread tension, inconsistencies in the way the fabric feed, or material elasticity problems. These patterns are not uniform puckering, as the intensity and distribution of puckering vary along the fabric. Random seam puckering challenges researchers to quantify its occurrence and provides opportunities to study the unpredictable behaviour of textiles under tension.

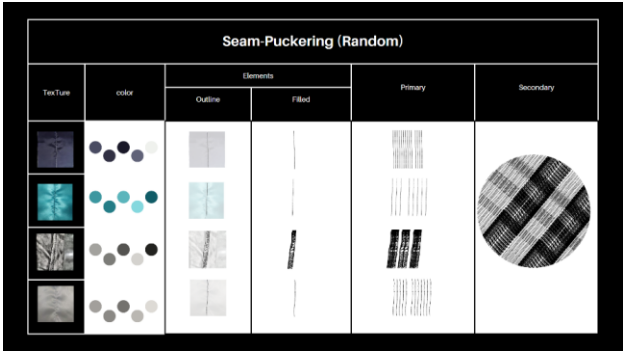


Fig 2 Random Seam Puckering

1.2 Abstract Loose Thread Puckering Loose or poorly affixed threads protrude from the seam to reach the puckered fabric, causing the abstract loose thread puckering. The visual displacement from loose thread and the puckering texture reinforce each other in this form. This type is frequently created by thread slippage or mechanical inconsistencies, resulting in a layered and irregular pattern that both visually and structurally complicates the fabric. The results clearly demonstrate how seam stress develops dynamically and highlight the potential for improving thread behaviour and tension calibration.

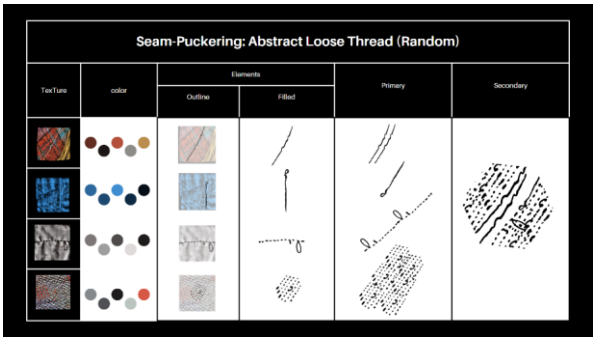


Fig 3 Abstract Loose Thread Puckering

The reinterpretation of seam puckering transforms what was traditionally seen as a flaw into a celebrated aesthetic feature. These irregularities, caused by variations in fabric tension or thread mismatches, are reimagined as organic, flowing patterns resembling ripples or veins. Using tools like Python for simulation and Illustrator for refinement, seam puckering becomes a key visual element that adds depth and texture to the design. Colours such as earthy greens and browns enhance its natural appeal, while rough and uneven textures align with Wabi-Sabi principles, celebrating imperfection and natural flow. The use of seam puckering in designs demonstrates how subtle flaws can create tactile and visually rich narratives that shift the perception of imperfection as undesirable.

2. Misalignment Fabric layers are out of alignment when not properly stitched or when shifted during sewing, creating skewed seams or unpainted patterns. Rather than treating this solely as a defect, designers increasingly view misalignment as a source of movement, depth, and visual interest in textiles (Nualdaisri, 2022). This approach aligns with sustainable design practices, particularly upcycling, where irregular seams or off-centre details become intentional features rather than waste (Tan et al., 2022). Asymmetry in fashion, long valued for its ability to break monotony and energise garments, illustrates how misaligned elements such as uneven hems or displaced seams can create dynamic compositions. Similarly, the Japanese aesthetic of wabi-sabi celebrates imperfection as authenticity, encouraging designers to embrace flaws as part of a piece's unique character (Matcha Design, 2024). Today, misalignment is being reframed as a deliberate design strategy, transforming what might be considered an error into a contemporary, sustainable, and aesthetically engaging feature.

2.1 Abstract Seam Slippage Abstract seam slippage occurs when one fabric layer shifts slightly relative to the other during sewing. This creates unexpected gaps, distorted edges, or a wave-like flow along the seam. Rather than being a defect, this slippage can lend textiles to a playful or experimental quality. Designers can highlight these shifts by contrasting colours or textures, amplifying the organic movement created by the slippage. This approach allows for the creation of asymmetrical designs that feel modern and bold.

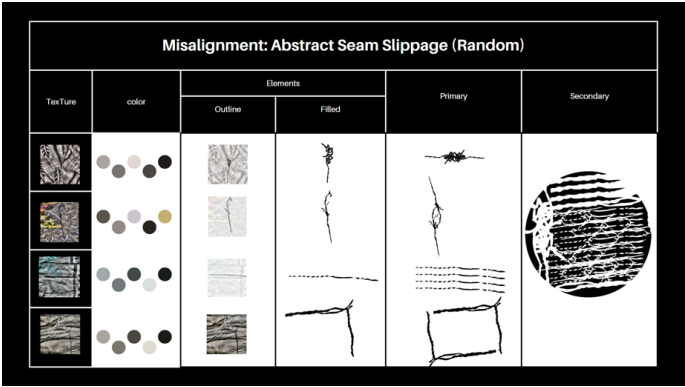


Fig 4 Abstract Seam Slippage (Random)

2.2 Machine Error Misalignment Machine error misalignment arises from stitching deviations caused by mechanical irregularities, such as improper feed timing or thread tension. These deviations produce uneven or fragmented patterns that disrupt the uniformity of the fabric. However, when embraced creatively, these disruptions can introduce unique visual rhythm and texture to a design. For instance, broken or staggered stitch lines can create a layered or fragmented aesthetic, resembling glitch art or deconstructed fashion. By showcasing these "errors," designers can celebrate the unexpected beauty of imperfection.

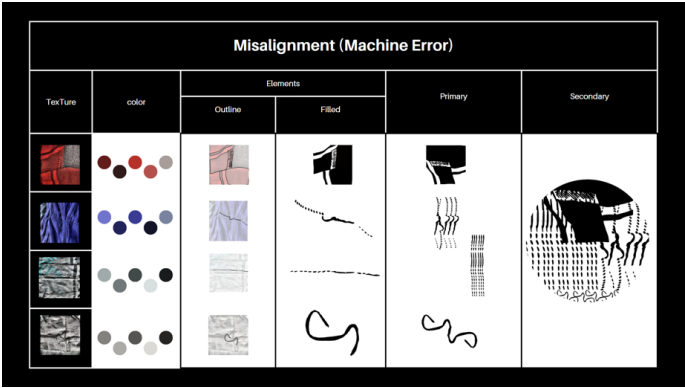


Fig 5 Machine Error Misalignment

2.3 Skipped Stitches (Random) The "Skipped Stitches (Random)" type of misalignment is defined by irregularities in stitching where certain stitches are incomplete, unevenly spaced, or entirely skipped. This error is typically caused by mechanical inconsistencies, improper thread tension, or misaligned fabric layers during sewing. These disruptions create unique, organic patterns that enhance the visual and tactile complexity of the textile.

This misalignment leverages a greyscale colour palette, emphasising subtle contrasts between disrupted and smooth sections of the fabric. Key design elements include disjointed outlines

formed by the skipped stitches and filled areas that develop layered textures. These irregularities are further abstracted into circular or wavy patterns, adding rhythm and movement to the design. By reimagining these skipped stitches, designers embrace imperfection, aligning with Wabi-Sabi aesthetics that celebrate flaws as intrinsic beauty.

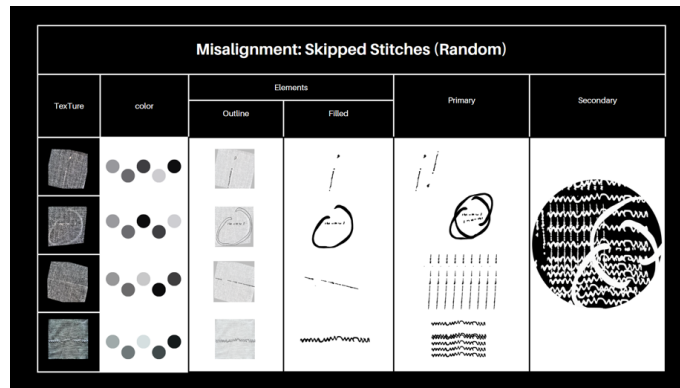


Fig 6 Skipped Stitches (Random)

Misalignment, characterised by uneven seams and fabric layer shifts, is intentionally leveraged to add asymmetry and visual complexity. Techniques involving Python algorithms and Illustrator layering reimagine these irregularities into dynamic and asymmetrical patterns. Bold, contrasting colours like reds and blacks emphasise the misalignment, creating a sense of movement and unpredictability. These choices reflect the avant-garde philosophy of embracing imperfection as a unique characteristic rather than a defect. Misalignment's integration into textile design embodies the glitch aesthetic, transforming unpredictability into a compelling narrative that challenges traditional notions of symmetry and precision while contributing to the emotional authenticity of the final product.

3. Distortion Distortion encompasses various irregularities, including knots, slubs, stains, and waving defects, often resulting from material stress or manufacturing inconsistencies (Nualdaisri, 2022). While traditionally viewed as flaws, these features can introduce unexpected textures and shapes, inspiring unique and fluid designs (Matcha Design, 2024). For instance, abstract knots create tactile elements, slubs add linear accents that break smooth surfaces, and stains or waving defects mimic organic patterns such as water ripples or natural landscapes (Tan et al., 2022). These irregularities offer designers a chance to break away from conventional perfection, crafting textiles with character and individuality. The distinctive nature of these distortions allows them to serve as bold and intentional design elements. By incorporating such imperfections, designers create textiles with a raw, unpolished aesthetic that appeals to consumers seeking authenticity (Nguyen et al., 2023). Furthermore, utilising

distorted materials supports sustainable practices by reducing waste and transforming flaws into high-value design assets (DHL, 2024).

3.1 Abstract Knot (Random) Abstract knot distortions occur when fabric irregularities or mechanical inconsistencies form small, concentrated knots. These disruptions forge organic outlines with a wide variation in the size and texture of the slabs. The distorted filled elements of these distortions often assume amorphous blob shapes, not the structural patterns typical of textiles. However, the principal design consists of these irregularities as scattered and organic motifs and secondary features compose them in dense, abstract compositions. The greyscale palette works on bringing out the texture and evoking raw and tactile as a whole. This kind of distortion could be used in textile art and fashion and more, to create layers of complexity and to celebrate the fact that imperfection as a deliberate artistic choice.

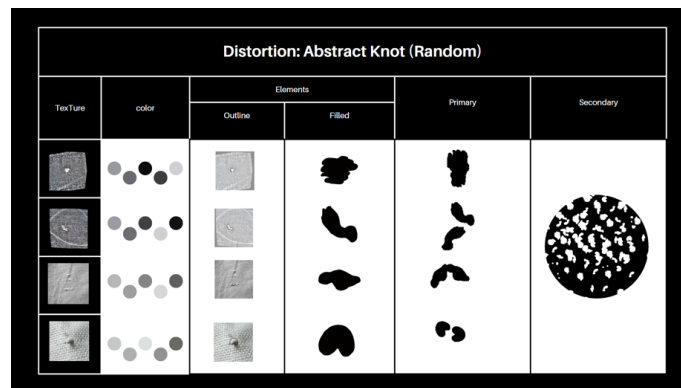


Fig 7 Abstract Knot (Random)

3.2 Abstract Slub (Random) Abstract Slub distortions are characterized by uneven thread thickness or irregular weaving patterns, forming lines or crosshatch elements on fabric surfaces. The outlines represent the organic fluidity of the slubs, while the filled elements represent the representation of the slubs in the form of sharp or linear or fragmented patterns. In the first place, the main design focuses on the irregular threads as individual motifs, while the second works to interrelate or overlap to provide depth. Textile designs with a minimalist, yet textural air come together in a greyscale and neutral palette with these distortions. This kind of distortion is really commonly being used in avant-garde fashion and interior textiles, which are harmonizing with the ambitious aesthetics of contemporary age.

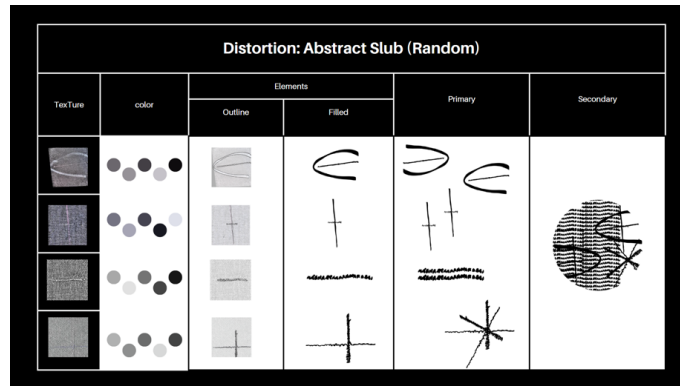


Fig 8 Abstract Slub (Random)

3.3 Abstract Hole (Random) Abstract hole distortions emerge from fabric defects where material is punctured or removed. These are distorted, marked out irregularly and with hollow, voidlike shapes that are somewhat abstracted into dynamic primary and secondary designs. These holes tend to complete filled elements into the intricate, interconnected forms which create an appearance of fragmentation. The use of muted tones such as greens, greys, and blues creates a natural and even ethereal colour palette. Abstract hole distortions can be used in textile design to explore themes of decay, impermanence, and reconstruction, offering unique possibilities for experimental art installations or conceptual fashion.

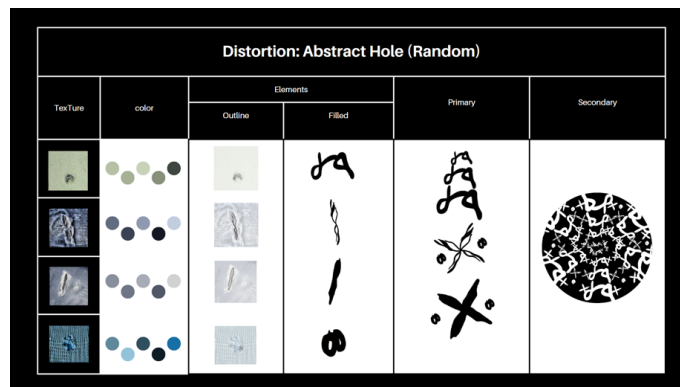


Fig 9 Abstract Hole (Random)

3.4 Abstract Snag (Random) When threads are pulled on Snag distortions occur in which protrusions or loops will form on the fabric surface. They are presented as small, organic shapes, which become amorphous or scattered patterns when filled. Isolated snags are the primary features, and, as secondary elements, clusters of these distractions create a denser visual texture. The warm colour palette of greys to purples and pinks gives the design vibrancy. Specifically, abstract snags offer

particularly elegant solutions to representing deconstruction and tactility and are fundamental in modern fashion collections incorporating texture and imperfection as aesthetic hallmarks.

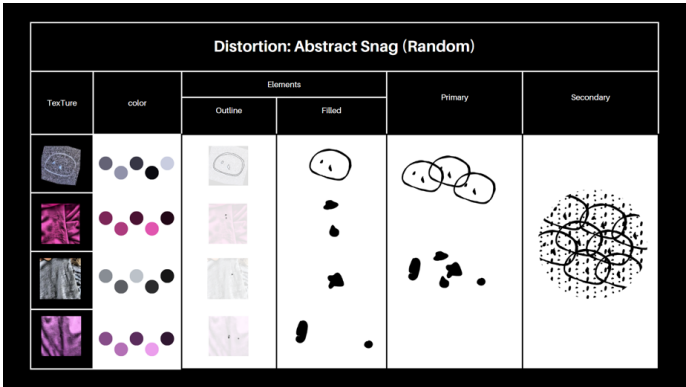


Fig 10 Abstract Snag (Random)

3.5 Abstract Stain (Random) Abstract stain distortions manifest as irregular discolouruations or surface marks on textiles. The front outlines transform into splashes of various organic influences or fluid substances, while the back fills towards, creating elaborate compositions. Isolated stains serve as the primary focus, while combined stains form rhythmic patterns on the secondary fabric. A colour palette predominantly featuring grey tones, complemented by touches of gold or earthy hues, adds a touch of richness to the overall visual impact. Stain distortions are ideal for exploring themes of transformation and decay, as these images are raw and unfiltered, aligning perfectly with contemporary design philosophies. These distortions are commonly employed in the fashion and home textiles industries to create expressive and dramatic visual narratives.

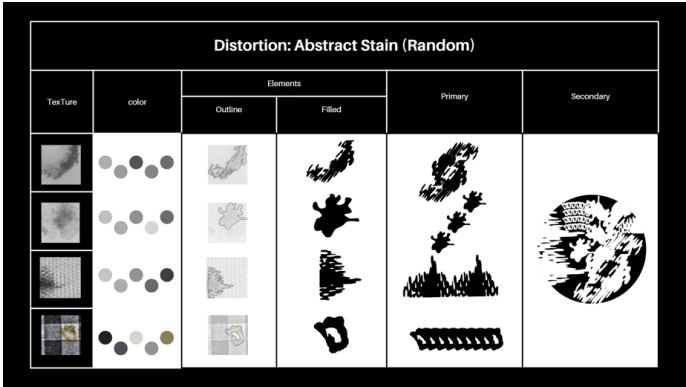


Fig 11 Abstract Stain (Random)

3.6 Waving Defect (Random) Weaving defects are caused by fabric undulations or distortions during the weaving process, resulting in flowing, wave-like patterns. These defects are represented as linear outlines and filled elements that mimic the natural movement of waves. The

primary designs feature undulating lines, while secondary features stack these waves in concentric or intersecting compositions. These patterns evoke a lusciously calming and organic play of colours using neutral and earth tones in their palette. Waving defects are frequently employed in high-end textiles and fashion to convey a sense of fluidity and dynamic motion, transforming imperfections into intentional and elegant design elements.

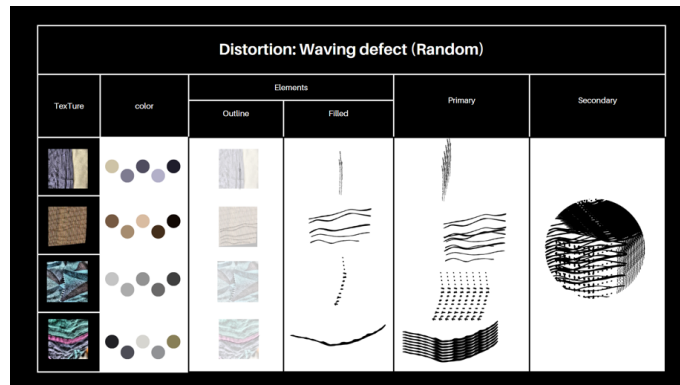


Fig 12 Waving Defect (Random)

Discussion: Creative Practices in Textile Design

In textile design, creative practices are reshaping the industry by blending artistic expression, technical innovation, and sustainability. Designers now embrace imperfections and emerging technologies (Paklapas et al., 2024) to turn entrenched methods into dynamic, future-ready solutions. Techniques such as pleating, laser cutting, and thermal bonding elevate both the aesthetic and functional qualities of fabrics, creating sculptural materials that challenge conventional standards (Kiron, 2024; Kiron, 2025; Aiman, 2024; Hulatt, 2024).

Artists like Liz Collins demonstrate how creative practice can transform textiles. Her “knit grafting” reconstructs garments by intertwining diverse materials, producing bold, multi-sensory pieces that also speak to labour and sustainability issues. Projects such as Knitting Nation illustrate how textile art merges cultural narrative with environmental engagement (Collins, n.d.).

Participatory design approaches further enhance sustainability by involving stakeholders throughout the process. Modular systems and adaptable designs extend product lifecycles and counter the undervaluation of traditional crafts. These collaborations bridge creativity with industrial function, fostering less waste and greater resource efficiency.

As highlighted by Kiron (2024), integrating zero-waste pattern-making principles within such collaborative frameworks allows designers to refine production methods in real time, ensuring that material usage, functional requirements, and aesthetic goals align more closely with sustainable outcomes.

Discussion: Sustainability in Textile Design

Sustainability has become central to textile design, guiding material choices, production methods, and consumer engagement. Designers increasingly favour organic cotton, hemp, and regenerated fibres like Tencel to reduce resource use, alongside bio-materials such as mycelium leather and algae-based textiles (Marwala, 2025). Post-consumer recycling, such as converting PET bottles into polyester, strengthens the circular economy (Kiron, 2024).

Production innovations—like zero-waste pattern making—minimise environmental impact (Kiron, 2024). Upcycling discarded textiles into high-value products and promoting slow fashion further reflect sustainable thinking. Consumers are engaged through ecolabels and verified eco-standards. Brands such as Patagonia, which promotes repair and reuse, and Stella McCartney, which integrates circularity strategies, show how sustainable design can be both scalable and market-ready (Patagonia Worn Wear®, n.d.; Stella McCartney, n.d.; Adidas, n.d.).

These findings support the ongoing shift towards imperfection-inspired design. For example, Hati & Das (2011) explained seam puckering as a technical defect caused by thread tension, but this study highlights how these same distortions can enrich texture and narrative. Similarly, Nguyen et al. (2023) focused on AI flaw detection, while here, AI tools were used to simulate and enhance imperfections creatively. This contribution aligns with Wabi-Sabi aesthetics (Matcha Design, 2025) by demonstrating how consumers value authenticity and uniqueness.

New Knowledge Contribution

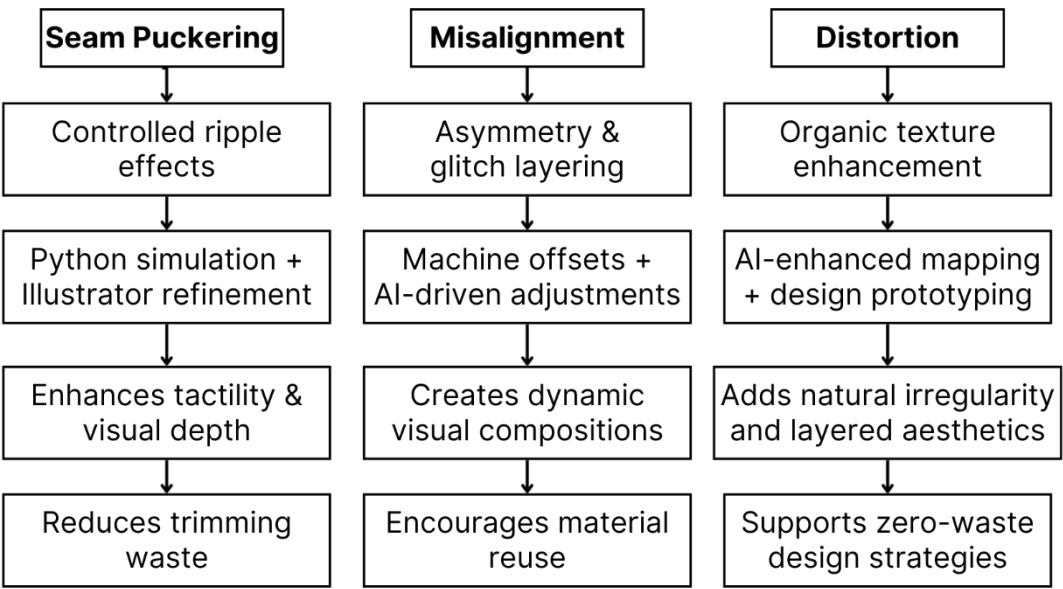


Fig 13 Flaw-to-Design Knowledge Model

Extending from our prior research on AI-driven defect analysis and GAN-based pattern generation (Paklapas et al., 2024), this study introduces the Flaw-to-Design Knowledge Model to integrate aesthetic transformation, sustainability, and creative innovation.

Table 1 Structured Knowledge Table

Flaw Type	Design Strategy	Tools Applied	Aesthetic Impact	Sustainability Impact
Seam Puckering	Controlled ripple effects	Python + Illustrator	Enhances tactility & depth	Reduces trimming waste
Misalignment	Asymmetry & glitch layering	Machine offsets + AI	Creates dynamic visuals	Encourages material reuse
Distortion	Knots, slubs, stains, snags	AI-enhanced mapping	Adds natural irregularity	Promotes zero-waste design

This table supports a scalable approach for designers, manufacturers, and researchers to integrate flaws intentionally while promoting sustainability.

Conclusion

This study presents a panorama of sustainable and innovative practices that redefine the textile industry's perception of machine-generated errors as design opportunities. By drawing inspiration from Wabi-Sabi philosophy (Matcha Design, 2025) and aided by AI and IoT (Nguyen et al., 2023), these perceived flaws are transformed into sources of creativity, individuality, and sustainability campaigns (Marwala, 2025). Embracing imperfections reframes them as authentic and human-centric design elements, responding to consumer demand for originality and environmental awareness (DHL, 2024). By recognising flaws as aesthetic assets, the textile industry evolves towards a more inclusive, innovative, and sustainable future.

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