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AI Transforms the Fashion Industry for Circularity

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Introduction

The fashion industry grapples with considerable environmental predicaments, attributed to unchecked overproduction, stockpiling, consumption, reuse, and disposal. Recognizing the industry's importance and its innovative pulse, the European Union has singled it out for a pioneering initiative in advancing circular economy principles. These principles stress product quality, longevity, repairability, and reuse. The plan is to engage designers, producers, retailers, advertisers, and consumers in remolding EU fashion (European Commission, 2022, a.).

Our proposition targets the fashion industry's environmental dilemmas by leveraging three game-changing technologies: Digital Twin, Blockchain, and Artificial Intelligence (AI). These technologies, compliant with the Digital Product Passport (DPP), are designed to steer businesses towards a Circular Economy. The integration of these technologies is critical to adhering to a DPP-driven circular economy across the entire value chain – from the cotton fields to the retailers, and from customer interactions to the final utilizations of garments. Our approach includes AI systems to heighten customer engagement and education, alongside decision-making and classification tools to streamline the upscaling and downscaling processes. Our solution, directed towards large-scale, fast-fashion brands, advocates for garment re-use and re-sale, thereby optimizing sustainability. Our plan focuses on reducing emissions and preventing fashion waste, therefore mitigating environmental impact.

Policy and Regulation in the EU

The European Commission (2021) believes stringent sustainability reporting standards are vital to achieving the ambitious European Green Deal within the critical timeframe. The Commission, in March 2022, introduced a package of measures under the Deal, with the Circular Economy Action Plan as a cornerstone (European Commission, 2022, a.).

The package also included a proposal for a Regulation on Eco-design for Sustainable Products, a fresh approach to enhance the durability, reparability, reusability, and recyclability of textiles. The aim is to confront fast fashion and textile waste, halt the destruction of unsold textiles, and ensure socially-respectful production (European Commission, 2022, b.).

The strategy includes implementing a DPP for all regulated products to enhance circularity, traceability, and accountability, incentivizing sustainability (European Commission, 2022, c.). To support the DPP in fashion, the Commission proposed the EU Strategy for Sustainable and Circular Textiles (European Commission, 2022, d.), encompassing:

- New design requirements for textiles.
- Clearer information on textiles.
- Tight controls on greenwashing.
- Action to address the unintentional release of microplastics from textiles.
- Harmonized EU rules on extended producer responsibility for textiles and economic incentives.
- Support to research, innovation, and investments.

- Halting the export of textile waste.
- The co-creation of a Transition Pathway for the Textiles Ecosystem to achieve the 2030 goals set by the strategy.

Problem Description

Textile consumption in Europe ranks fourth in terms of environmental and climate impact. It's the third-highest water and land user and the fifth-highest in raw material use and greenhouse emissions (European Commission, 2022, d.). With product design dictating nearly 80% of a product's environmental impact, the European Commission aims to ensure energy efficiency, circularity, and overall footprint reduction (European Commission, 2022, a.).

However, the fashion industry remains largely linear, with billions of garments ending up in landfills or incinerators. The industry grapples with the collection, sorting, cost, and output quality of sustainable innovation (McKinsey, 2022). The fashion life cycle's climate impact is distributed across material production (35%), yarn/fabric preparation (30%), garment manufacturing (5%), retail consumption (25%), and end-of-use (5%) (McKinsey, 2022). Hence, focusing on overproduction, overstocking, and overconsumption can mitigate waste and climate impact (Legl, 2023).

Increasing regulation and corporate sustainability interest coincide with consumer consciousness about the environmental and social impacts of their purchases. Surveys show that sustainability drives 25% of UK respondents' purchase decisions, with 80% of US consumers and 95% of Indian consumers acknowledging its importance. However, brand authenticity and verification remain crucial, as 88% of US respondents distrust brand claims (McKinsey, 2022).

The DPP serves as a customer engagement tool and an EU directive, potentially fostering trust. The Regulation on Eco-design for Sustainable Products mandates durability, efficiency, and waste reduction, with the European Commission establishing these requirements.

The obligation for a DPP presents both an opportunity and a challenge in innovation management, business transformation, and implementation. Efficient brand-customer communication, garment authentication, inventory management, skilled workforce recruitment, and revenue generation are some challenges in achieving circularity and recommerce (SAP Recommerce, 2023).

Status Quo

SAP Recommerce facilitates brands' and retailers' transition from linear to circular businesses. It enables customers to return items, which, after inspection, may re-enter the supply chain as second-hand merchandise, promoting circularity through reuse and creating new revenue streams for brands, as shown in Figure 1.

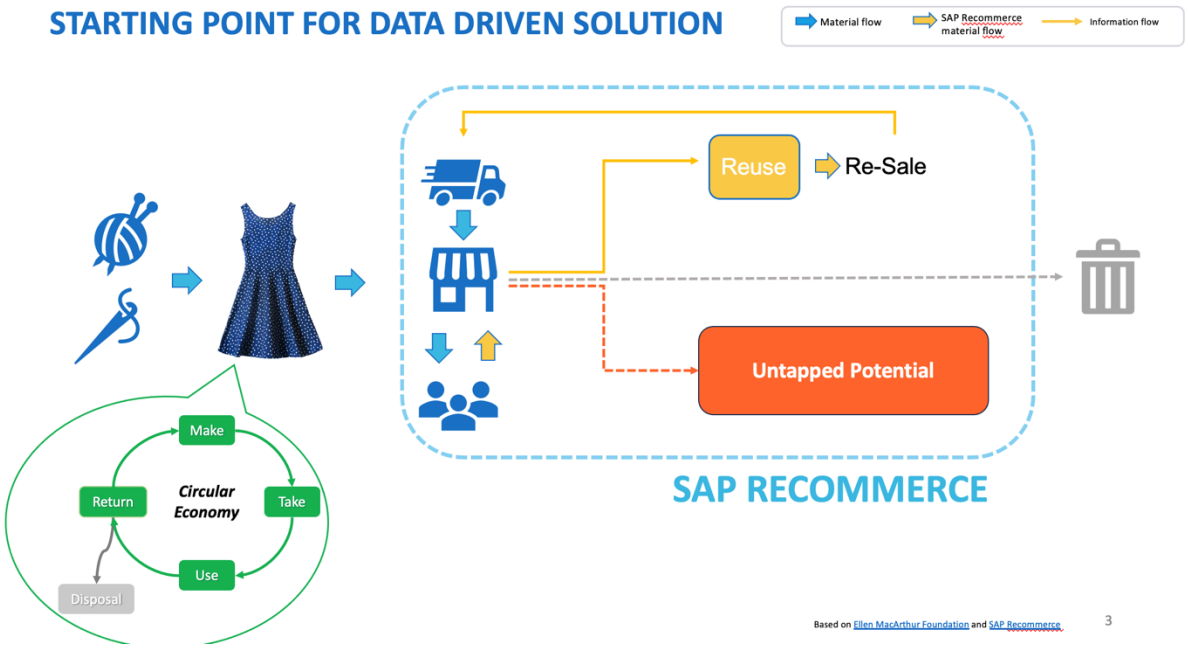

Figure 1: Starting Point for Data Driven Solution based on SAP Recommerce

Customers are incentivized, often with store credit, to return items. Brands using SAP Recommerce can track the resale records of their products, simplifying and streamlining business processes. Proper communication of this circular process can bolster customer trust and loyalty, attracting new customers (SAP Recommerce, 2023). Although this marks a significant move toward a circular economy, our proposal seeks to broaden the scope of what can be offered to brands and retailers, aiming for a more efficient process to address overproduction, overstocking, and overconsumption in the value chain.

Proposed Solution

SAP Recommerce already encourages circularity through item reuse, but the integration of multiple technologies can unlock further potential. In response to SAP's challenge to aid fashion brands in becoming circular, combined with the DPP directive, we propose to amplify their solution by incorporating Digital Twin, Blockchain, and AI. This aims to streamline key processes across the entire value chain, from raw materials to manufacturing, retail, customer purchase, and ultimately, the collection, classification, and reuse of clothes.

Our proposed solution, in Figure 2, is modeled after the butterfly diagram advocated by the Ellen MacArthur Foundation (2023), illustrating circular loops in a circular economy. The proposed solution, applicable to large-scale fast-fashion brands, high-fashion brands, and even small to medium-sized businesses, fosters a broader circular economy environment.

We suggest integrating AI systems at two points in the reverse fashion supply chain. First, towards customers, AI can act as an information and educational tool. The user interface would display product details from the DPP, provide garment care advice, suggest washing methods, offer incentives, and gamify certain features.

In the event of an item return, the customer would be guided on where to return it and how to regain credit from specific retailers or brands. The system would not only give information on end-of-use items, but the DPP would also allow customers to understand the lifecycle of their purchases, including the origin of the fabric, the production processes, the environmental impact, any previous ownership, and the potential positive environmental contribution made by purchasing the item.

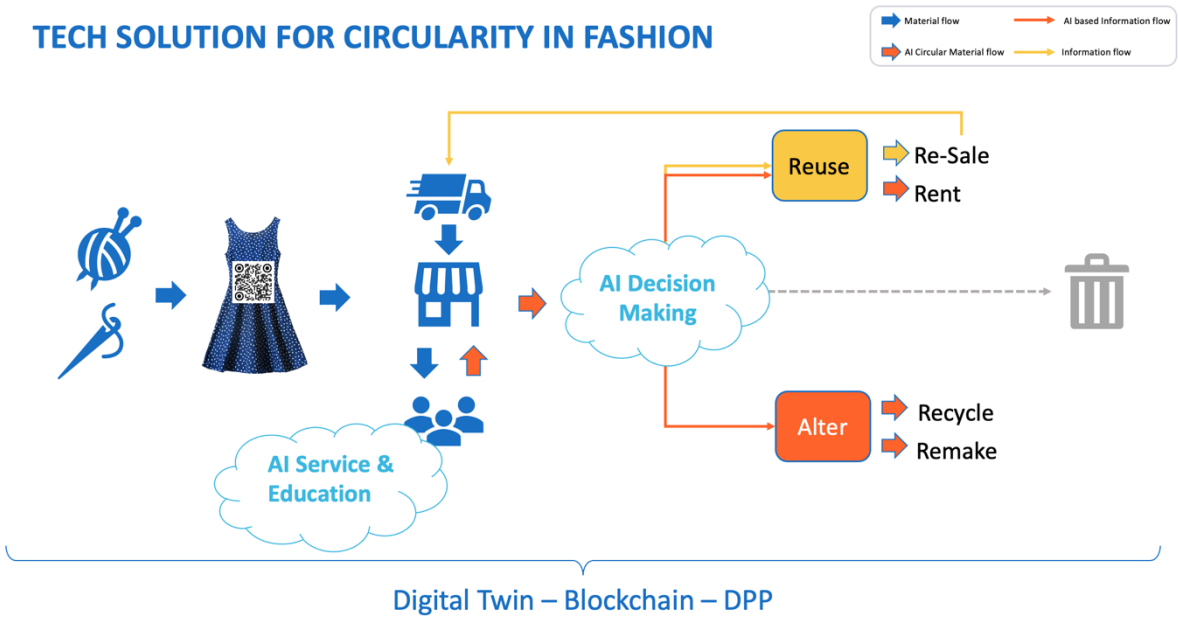

Figure 2: Our Solution for Circularity in Fashion based on Ellen MacArthur Foundation

Secondly, we propose integrating an AI system at the retailer end, acting as a decision-making and sorting tool. Upon return of an item, various possibilities for its second life arise. The system streamlines the decision-making process, assessing the condition of the returned item, and determining if it can be reused directly or needs some form of alteration. If reusable, it can be immediately resold or utilized in a rental business model, contingent upon the brand's chosen business strategy for the garment's next best use. If the item is beyond reuse, the system decides whether to remake it, supplement it with other resources, reduce it to fibers, or recycle it.

Whichever path is chosen, the item receives a new lease of life, promoting a circular fashion economy. The modification and reuse process can continue until the fabric is finally exhausted. The goal of our proposed solution is to push back the point of disposal as far as possible, minimizing environmental and climate impact.

Technological Aspects

Digital Twin technology provides a virtual representation of both an object and a process by integrating the smallest and most relevant elements of physical reality (Trauer, & Schweigert-Recksiek, et al., 2020). For a fashion item, digital twin information begins at the raw material

source, like a cotton field, noting not just the product's characteristics, but also the components used in its creation, such as fertilizers, water, and dyes. This information continues to evolve until the finished garment is complete. The digital twin can also replicate processes or entire facilities, providing capabilities to:

- Perform simulations to enhance product durability or suggest alterations for a new garment.
- Calculate the environmental impact of processes, facilities, and products, thereby enabling brands to strategize for better sustainability outcomes.
- Supply data for the DPP, improve customer app experiences, contribute to the item authentication process, and serve as a preliminary fraud deterrent.
- Update the transformation or alteration of the original product, recording any additional elements and implications for the item's lifespan.

Blockchain technology serves as an unalterable, shared ledger that records transactions or information securely through cryptography (Crosby, & Nachiappan, et al., 2023). Its key benefits for the fashion industry include:

- Reliable traceability of a product's creation process, down to the details of the harvested batch.
- Consistency and completeness of information at every stage of the supply chain.
- Accessibility of information for all authorized parties, ensuring compliance with privacy and personal data laws.
- Automated contract execution, alerts, and permissions, crucial for regulatory compliance, partner agreements, product recalls, and circular economy operations.

AI, specifically **Neural Networks**, trains computers to process data similarly to the human brain. This technology excels at inference and generalization and is commonly used for image classification, process, and quality control (D'Addona, 2014). It can also improve its classification through external inputs, such as manual product classification (D'Addona, 2014). For this case:

- AI screens the condition of returned garments.
- The data collected, in conjunction with energy consumption, waste, pollution, supply, and demand data, can optimize the circular economy process.

Large Language Models (LLMs) form another branch of AI that predicts the next word in a sentence based on the provided information. It's trained on billions of different documents and can respond well to everyday scenarios (Riedl, 2023). In this case, it nudges customers towards circular decisions, offers advice, and enables gamification within the app.

Integration of these technologies simplifies the process, as shown in Figure 3:

1. A Digital Twin is created and continuously updated throughout the value chain, providing the first input for the DPP.

2. Digital Twin information, along with data about processes, actors, contracts, and permits, is added to the Blockchain.
3. The product is ready for sale. A customer buys it and adds it to their virtual closet, enhancing the shopping experience.
4. Customers can either keep the garment, return it after use, or lose it. Incentives are given to update the item's status, especially for returns.
5. Upon deciding to return the item, customers are required to upload a two-sided photo and optionally rate its usage frequency.
6. Upon return, customers earn points immediately, with the transaction recorded on the blockchain and DPP.
7. Concurrently, a review request is sent to another customer to rate the returned item based on the digital twin, providing additional information for the AI tool.
8. The returned garment is inspected and photographed, with the images fed into the Neural Network. After considering all available information, the AI suggests whether to reuse, resell, rent, remake, or recycle the item.
9. Finally, the returned product, complete with its history, is available in the store through the DPP.

AI AS THE DECISION MAKER AND SUPPORTER

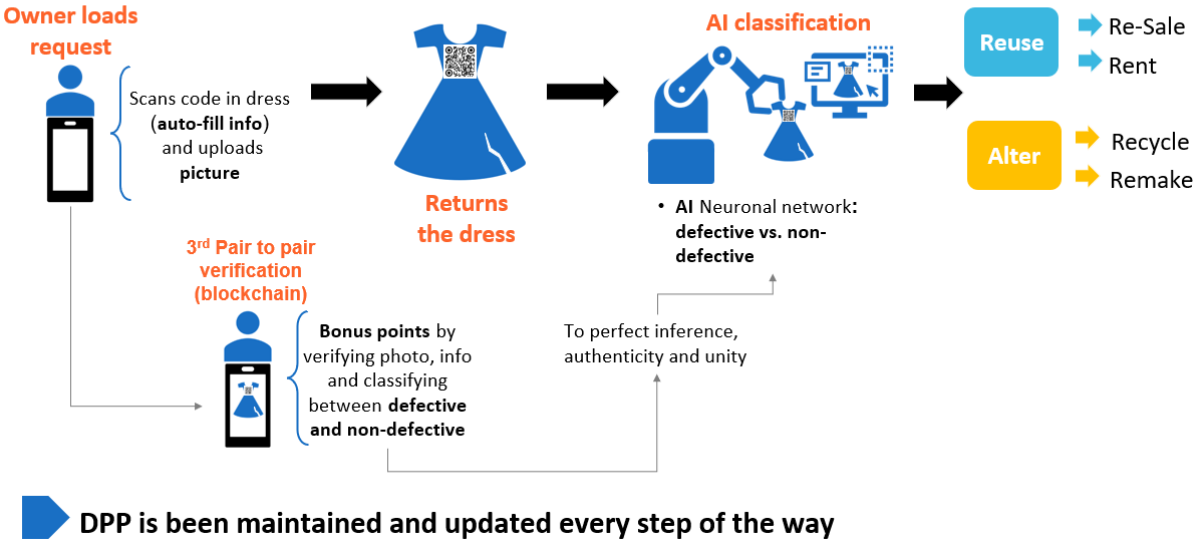

Figure 3: AI as the Decision Maker and Supporter

Our Comprehensive Benefits and Recommended Future Steps

This integrated solution offers comprehensive benefits, not merely focusing on traceability, transparency, logistics, compliance, or authenticity, but effectively incorporating all of these aspects into a single platform:

1. Unified, Adaptable, and Modular Solution: The integration of internal control, DPP, ESG, and regulatory audits into one platform reduces duplication and ensures rigorous verification, leading to improved efficiency and reliability.
2. Multifaceted Engagement: The application and technological solution involves customers, suppliers, partners, and businesses at various levels, fostering a sense of shared responsibility and community.
3. Truly Circular, Transparent, and Scalable: The tool embodies the principles of circularity, openness, and scalability, supporting long-term, sustainable growth and adaptation.
4. Technological Application for Maximum Impact: The strategic use of technology maximizes positive environmental and social impact, while mitigating potential negative externalities during the training and information handling phase.

Given these advantages, there are recommended next steps to realize this ambitious project:

1. Partnership and Pilot Development: It's essential to seek partners for co-developing a pilot project and designing the detailed solution architecture. Collaborating with those who share a similar vision can help refine the idea, identify potential hurdles, and work towards a successful implementation.
2. Strategic Collaborations: Partnering with companies already invested in DPP compliance and the circular economy, especially those using blockchain and Digital Twin technology, can provide valuable insights, synergies, and resources.
3. AI Development and Training: Developing the AI solution and collecting data for its training phase will be critical. It can enhance the tool's ability to make circular decisions, authenticate products, and educate customers, adding further value to the platform.

By following these steps, this solution can help transform the fashion industry, making it more sustainable, transparent, and consumer-friendly. The integration of these advanced technologies will lead to a more robust circular economy, benefitting not only the fashion brands but also our environment and society as a whole.

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