

Integrating Bulgarian National Identity into Sustainable Fashion Design through Digital Technologies

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Abstract - This study examines the integration of Bulgarian national identity into sustainable fashion design through the application of digital technologies. The research focuses on the use of CAD systems and digital textile design tools for the transformation and adaptation of traditional Bulgarian motifs into contemporary garment design. Emphasis is placed on preserving the cultural, symbolic, and aesthetic value of traditional elements while aligning them with the principles of sustainability. A design approach is proposed that incorporates digitalization of traditional patterns, virtual prototyping, and machine embroidery techniques to enable efficient and resource-conscious production. The study analyzes the role of digital workflows in reducing material waste, optimizing production processes, and improving design accuracy. Additionally, the use of environmentally friendly textile materials is considered as part of the sustainable design strategy. The results highlight the potential of digital technologies to support the preservation and reinterpretation of cultural heritage within modern fashion systems. The integration of national identity and sustainability principles contributes to the development of innovative, environmentally responsible, and culturally meaningful fashion products.

Keywords - Bulgarian identity; CAD systems; cultural heritage; digital textile design; eco-friendly textiles; garment design; machine embroidery; sustainable fashion.

I. INTRODUCTION

Contemporary fashion design is regarded as an interdisciplinary field in which clothing functions simultaneously as an aesthetic product and a carrier of cultural identity and social information [1]. In the context of globalization and digitalization, the fashion industry is characterized by accelerated production processes and standardization, which necessitates the preservation and

reinterpretation of local cultural characteristics through contemporary design approaches [2].

Bulgarian embroidery represents an essential component of the national cultural heritage, preserving a multilayered symbolism and aesthetic. According to [3], traditional ornaments such as the elbetitsa, kanatitsa, and the Tree of Life contain enduring symbolic meanings related to cosmological concepts, protection, and harmony. These motifs are integrated into the structure of the Bulgarian folk costume and are positioned in key areas of the garment in order to fulfill protective and communicative functions [4].

Interest in the use of folklore elements in contemporary fashion design has increased in recent years. In [5], an analysis is presented regarding the interpretation of the Bulgarian national costume in the collections of contemporary designers. It is emphasized that the adaptation of traditional elements requires an in-depth understanding of their structure and cultural context. In this regard, the integration of embroidery motifs into contemporary design should be based on a scholarly approach rather than superficial decorative use.

Sustainability is increasingly established as a key principle in the development of the fashion industry. The Bulgarian national costume embodies sustainable characteristics, including efficient use of materials, functionality, and durability [4]. In this context, the application of traditional techniques such as embroidery can be considered a means of enhancing the value and extending the lifecycle of contemporary garments.

The role of digital technologies in contemporary fashion design is significant, particularly in the transformation of traditional motifs. Study [6]

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demonstrates the possibilities for integrating folklore ornaments into modern garments through digital processing and graphic software, enabling their adaptation to various product categories. In addition, the use of CAD technologies supports the development of sustainable design solutions by optimizing construction and production processes.

In the context of sustainable fashion, the concept of a capsule collection is considered an effective model for creating a functional and versatile wardrobe. In [2], it is emphasized that a basic wardrobe developed according to the principles of sustainability allows the combination of a limited number of garments with high adaptability and long-term use.

The present study is situated at the intersection of tradition and innovation, examining the possibilities for the digital transformation of Bulgarian embroidery motifs and their application in a contemporary capsule collection. By combining cultural heritage, sustainable materials, and digital technologies, the aim is to create a fashion product that meets contemporary requirements for functionality, aesthetics, and sustainability.

II. MATERIALS AND METHODS

The present study is developed through an interdisciplinary approach that combines ethnographic analysis, digital modeling, and experimental fashion design. The methodological framework integrates qualitative analysis of traditional ornaments with their subsequent digital transformation and technological adaptation to contemporary garment production. The main objective is to establish a relationship between the structural characteristics of authentic embroidery motifs and the possibilities for their precise reproduction through digital and machine technologies.

The initial visual base includes authentic Bulgarian embroidery motifs from the album by Masha Kazandzhieva [7], presenting ornaments from women's shirts from the regions of Kyustendil, Samokov, Bansko, and Dupnitsa (Fig. 1).



Fig. 1. Authentic Bulgarian embroidery motifs [7]

The selection of motifs was carried out purposefully, prioritizing examples with clearly defined geometric structure, compositional integrity, and distinctive symbolism, which allow for subsequent digital interpretation.

The selected motifs were analyzed in terms of their morphological structure, compositional organization, and symbolic function. Morphologically, the motifs are

characterized by a high degree of geometric stylization, determined by the cross-stitch technique and the use of a regular textile grid. The main elements include rhombuses, crosses, octagonal and star-shaped forms, as well as linear and zigzag structures that form frames and connecting zones. Stylized plant and zoomorphic forms are also observed, reduced to geometric modules and governed by the principles of symmetry and repetition, which ensures their adaptability to different scales and applications.

The compositional organization of the motifs is based on a clear distinction between central and border elements. The central compositions are built around dominant ornaments with symmetrical structures, creating a visual focal point and compositional completeness. The border elements are arranged as rhythmically repeating friezes that frame the main motif and create a sense of continuity. In a number of cases, a combined compositional scheme is observed, including a central motif, side vertical bands, and lower ornamental bands, characteristic of the structure of traditional garments.

The symbolic function of the motifs encompasses protective, social, and decorative aspects. Geometric forms perform an apotropaic role associated with protection, with their placement in boundary areas of the garment reinforcing this function. Stylized elements such as the "Tree of Life" reflect cosmological concepts and the relationship between nature and humans. At the same time, the compositional complexity and color organization of the motifs can be interpreted as indicators of regional affiliation and cultural identity, while their decorative function is expressed through visual balance and color harmony.

Based on the conducted analysis, traditional embroidery techniques were identified that can be effectively adapted to machine embroidery. The main focus is placed on cross stitch and backstitch, due to their structural compatibility with a digital grid system and their capability for precise reproduction. The analysis includes an evaluation of stitch density, rhythmic organization, and the visual readability of the motifs when scaled.

The digitization of the motifs was carried out as a sequential process in two main phases.

In the first phase (Fig. 2), the ornaments were reconstructed using the Pattern Maker software, which employs a pixel-based grid corresponding to the structure of the cross stitch.



Fig. 2. Adapted Bulgarian embroidery motifs in Pattern Maker

The process includes digital tracing of the original motif, adaptation to a square coordinate system, definition of contour and fill elements, as well as reduction and optimization of the color palette in order to achieve better visual clarity and technological applicability (Fig. 3). A key parameter in this phase is the determination of stitch density (stitches per cm), which allows control over the physical dimensions of the final motif and its correspondence with the textile base (Fig. 4).

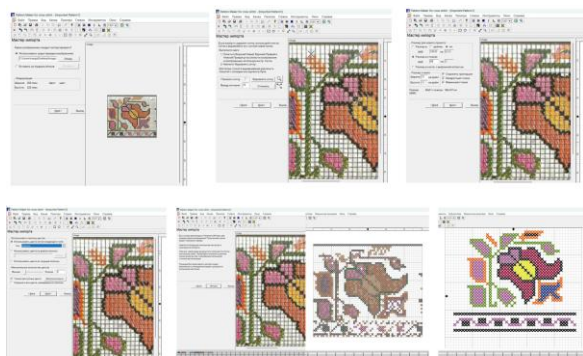


Fig. 3. Stages of motif digitization

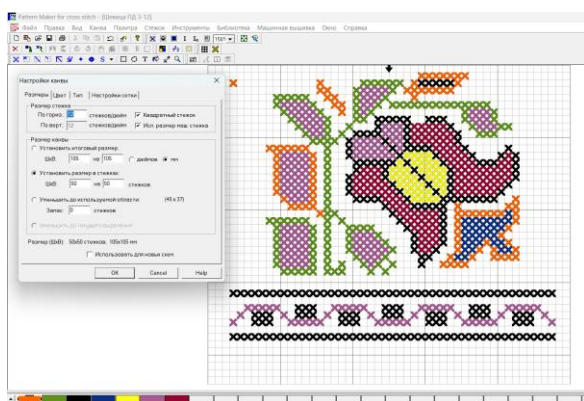


Fig. 4. Setting stitch density

In the second phase, the digitized motifs are converted into a machine-executable format using the Artistic Digitizer software. The process begins with transforming the pixel-based model into a vector-oriented embroidery structure, allowing precise control over the execution parameters. In the next stage, the main stitch characteristics are defined, including the size and density of the cross stitch, the color organization of individual elements, and the logical sequence of their stitching, in order to ensure correct layering and high visual readability of the ornament (Fig. 5).

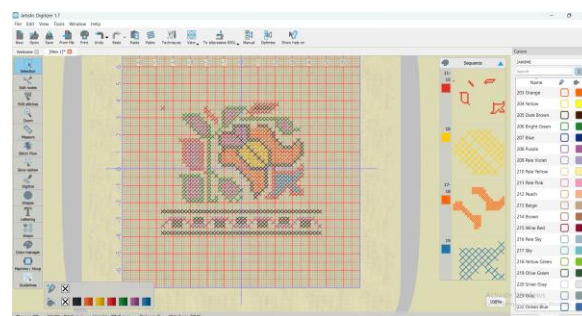


Fig. 5. Conversion in the specialized software Artistic Digitizer 1.7

In parallel with parameterization, the machine process is optimized by adjusting stitch direction, reducing unnecessary transitions, and minimizing machine jumps. Particular attention is given to optimizing the needle path (Fig. 6), which contributes to reducing production time and increasing efficiency. As a result of these sequential operations, high precision and quality are achieved in the subsequent machine embroidery on textile material, while ensuring accurate reproduction of traditional motifs through modern embroidery technologies.

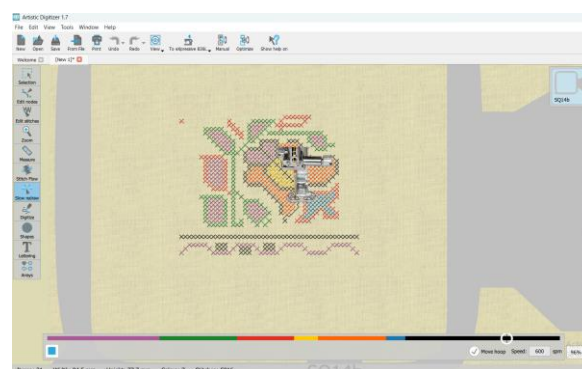


Fig. 6. Optimization of the needle path

III. RESULTS AND DISCUSSION

As a result of the activities carried out within a research project supporting PhD student No. 262PD0031-16, funded by the Internal Research Competition of the Technical University of Sofia for 2026, a capsule collection of contemporary garments with a sustainable design in a sport-elegant style, entitled "Tradition in Motion", was developed. The collection represents a synthesis between scientific research and creative interpretation, in which authentic Bulgarian ornaments and embroidery motifs are reinterpreted and adapted to a contemporary fashion context.

Fig. 7 visualizes the creative exploration process, reflecting both the sources of inspiration and the conceptual framework that led to the development of the collection.



Fig. 7. Atmosphere - map of the collection. /Moodboard/

As a primary reference framework, the map by Hristo Vakarelski [8] is used, presenting the regional diversity of Bulgarian traditional costumes and serving as a cultural-geographical basis for the interpretation of ornamental motifs. The included images of traditional women's costumes point to characteristic silhouettes, ornamentation, and color schemes specific to different ethnographic regions.

An additional source of inspiration is provided by archival and artistic visualizations of Bulgarian traditional costumes, as well as specialized studies that emphasize the role of embroidery as a carrier of symbolism and cultural identity. The inclusion of embroidery fragments and technological tools, including an embroidery machine, highlights the transition from traditional handcraft techniques to contemporary digital processes for their reproduction.

The contemporary aspect of the development is represented through the author's fashion designs, which demonstrate the transformation of traditional elements into a current, functional, and minimally structured design. The color palette, derived from the digitally developed embroidery motifs, plays a unifying role by ensuring visual balance between authenticity and modernity.

In this way, the mood board functions as a connecting link between tradition and modernity, clearly outlining the sources of inspiration and the logic of transformation that led to the creation of the sustainable capsule collection.

III.1. Design project of the capsule collection

A capsule collection design was developed (Fig. 8), presenting an original interpretation of Bulgarian traditional ornamentation integrated into sustainable fashion design through the application of digital technologies and innovative production approaches. The collection is targeted at young women aged 30–35 and is intended for everyday use, active leisure, and travel, combining functionality, comfort, and a clearly expressed cultural identity.



Fig. 8. Creative sketches of the models from the collection

The concept of the collection is based on a synthesis of traditional Bulgarian embroidery, contemporary minimalist silhouettes, and the principles of sustainable development [9]. The main idea is to create a visual dialogue between the past and the present, in which authentic motifs are not used merely as decorative elements, but as structural and compositional components of the design.

The collection includes seven main models, developed according to the capsule principle [2], allowing for versatile combinations between individual garments: short-sleeved blouses (oversized and loose silhouettes); wide-leg trousers; sport-elegant sets.

Additionally, accessories with various applications were designed (Fig. 9): a textile tote bag, a backpack, a mini phone bag, jewelry (bracelets, earrings, necklaces), and a textile belt with integrated embroidery.



Fig. 9. Accessories of the collection

This structure ensures flexibility and adaptability of the collection to different situations and stylistic preferences.

The design of the collection is characterized by clearly defined compositional principles, in which embroidery motifs function as dominant visual elements integrated into key structural areas of the garments. The ornaments are strategically positioned—on the central front part of the blouses, along the side seams of the trousers, and in the areas of cuffs and hems—in order to achieve a strong visual accent and structural clarity. In addition, a linear integration of border motifs is applied, following the construction lines of the garments, emphasizing the silhouette, creating rhythm, and visually elongating the form. In certain models, an asymmetrical arrangement of ornaments is used, adding dynamism, a contemporary character, and individuality to the design.

The ornaments included in the design (Fig. 10) were digitally developed using the algorithm applied in the creation of the main motif (Fig. 6) and subsequently implemented on a textile base—cotton knit fabric intended for the production of the garments in the collection.



Fig. 10. Machine-made embroidered ornaments

During the development process, variations of the cross stitch with different sizes (1.5, 1.8 and 2.2 mm) were examined in order to determine the optimal parameters for achieving a balance between visual readability, level of detail, and technological applicability on a knit structure (Fig. 10).

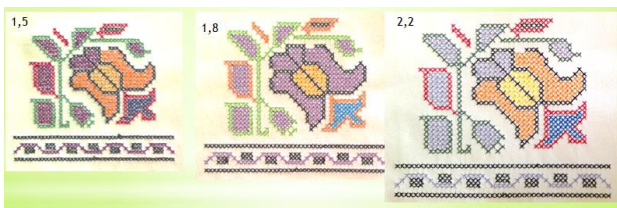


Fig. 11. Variations of the cross stitch

The collection was developed with a focus on the use of sustainable textile materials, including cotton knit fabric, linen, bamboo fibers, and Tencel™, characterized by biodegradability, low environmental impact, and a high level of wearing comfort, which corresponds to the principles of sustainable fashion and environmentally oriented textile design [10]. The application of digital technologies, including CAD design and virtual prototyping, contributes to the reduction of textile waste, optimization of pattern cutting, and improvement of production efficiency, while simultaneously creating opportunities for the preservation and contemporary reinterpretation of cultural heritage through a digital environment [11].

The color concept is designed to achieve a balance between tradition and modernity. The main color palette includes white, dark blue, and green, providing a neutral and harmonious base for the integration of the ornaments. The accent colors used in the embroidery—red, yellow, orange, purple, green, blue, and black—create contrast and emphasize the decorative elements as the primary carriers of visual identity.

From a functional and ergonomic perspective, the collection is adapted to the contemporary lifestyle, incorporating loose silhouettes, elastic construction

solutions, and functional details such as pockets, which ensure comfort and practicality. These characteristics make the garments suitable for active daily activities and travel, while maintaining a high aesthetic value.

Accessories are considered an integral part of the design concept rather than a secondary addition. Through them, visual coherence is achieved by repeating and adapting the main ornamental motifs from the garments. The inclusion of embroidered jewelry represents an innovative approach to transferring textile tradition into new product categories and expanding the application of embroidery.

Table 1 summarizes the main characteristics of the developed capsule collection.

TABLE 1 MAIN CHARACTERISTICS OF THE DEVELOPED CAPSULE COLLECTION

№	Main characteristics of the capsule collection		
	Indicator	Characteristics	Practical significance
1.	Collection type	Capsule (7 models)	Optimization of production and sustainable consumption
2.	Target group	Women aged 18–35	Focus on an active and mobile lifestyle
3.	Style	Casual, sport-elegant	Contemporary adaptation of traditional elements
4.	Main garments	Blouses, trousers	Functionality and versatility-
5.	Materials	Cotton, linen, bamboo, Tencel™	Environmental sustainability
6.	Decorative technique	Machine embroidery (cross stitch and backstitch)	Precision and digital
7.	Source of motifs	Authentic Bulgarian embroidery	Cultural identity
8.	Type of transformation	Digitization, reduction, stylization	Contemporary interpretation
9.	Compositional principles	Center, asymmetry, linearity	Balance between tradition and innovation
10.	Color palette	White, green, dark blue + accents	Harmony and visual identity
11.	Technologies	CAD, 3D visualization, machine embroidery	Waste reduction
12.	Sustainable practices	Virtual prototyping	Resource minimization
13.	Accessories	Bags and embroidered jewelry	Expansion of the product line

Through the structured presentation of key parameters—target group, style, materials, technological approaches, and sustainable practices—the relationship between the theoretical framework of the study and its practical implementation in the fashion product is illustrated. The table complements the analysis by

emphasizing the integrated approach, in which traditional elements, digital technologies, and the principles of sustainable design function as an interconnected system.

In this way, the collection presents a contemporary approach to fashion design, in which traditional cultural heritage is combined with digital technologies and sustainable practices. This approach enables the creation of comfortable, functional, and meaningful products that meet the contemporary needs of the modern Bulgarian woman. In this sense, it can be considered a relevant direction for the development of the fashion industry, oriented toward a more responsible attitude to the environment and cultural identity.

IV. CONCLUSIONS

The present study demonstrates the possibilities for successfully integrating Bulgarian national identity into contemporary fashion design through the application of digital technologies and sustainable approaches. Through a systematic analysis of authentic embroidery motifs and their subsequent digitization, a precise transformation of traditional ornamentation into a modern design context is achieved, without losing its structural and symbolic value.

The applied digitization process—using Pattern Maker and Artistic Digitizer—proves its effectiveness in adapting hand embroidery techniques to a machine-executable environment. This enables a high degree of accuracy, repeatability, and optimization of the production process, while also creating conditions for reducing resource consumption and improving technological efficiency.

The developed capsule collection “Tradition in Motion” confirms the applicability of the proposed approach in real design practice. The collection combines functionality, comfort, and aesthetic value by integrating traditional ornaments into contemporary sport-elegant silhouettes. The use of sustainable materials further enhances the ecological aspect of the development and meets current requirements for responsible production.

The findings demonstrate that digital technologies can play a key role not only in optimizing design and production processes but also in preserving and contemporarily interpreting cultural heritage. In this regard, the proposed model can be considered an effective foundation for future research and development aimed at creating sustainable, innovative, and culturally meaningful fashion products.

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