J. Electrical Systems 20-6s (2024): 207-216

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Automatic Generation Technology of Scrap Denim Clothes in Quilting Art Patterns by Integrating Computer Vision.

Journal of Electrical Systems

Abstract: - The combination of computer vision and advanced Fuzzy C-Means algorithms, such as Hybrid OK-Means Fuzzy C-Means (HOFCM), provides a revolutionary way to automatically generate technology of Scrap Denim Clothes in Quilting Art Patterns. T he research focuses on the creation of an automatic generating technique specifically designed for making quilting designs from scrap denim clothing. This study investigates the effectiveness of HOFCM in improving the process of creating quilted art patterns from discarded denim materials. Extensive experimentation and analysis have shown that HOFCM dramatically decreases computational time while improving clustering solution quality, particularly when dealing with huge, high-dimensional datasets like scrap denim cloth analysis. The study emphasizes HOFCM's potential to speed up the quilting art pattern generation process, providing designers and artists with a more efficient and precise way to transform old denim clothing into visually appealing designs. The findings highlight HOFCM' s transformative impact on automatic generation technology for quilting art patterns, paving the path for innovation and originality in textile art and design. HOFCM significantly lowers time by up to 93.94% compared to regular Fuzzy C-Means on four real and one synthetic datasets. The worst-case scenario resulted in a 2.51% reduction in solution quality.

Keywords: Computer vision, Quilting Art, Fuzzy C-means, Artificial Intelligence.

I. INTRODUCTION

In the dynamic convergence of traditional textile artistry and cutting-edge technical breakthroughs, the emergence of automatic scrap denim generation technology in quilting art designs represents a significant step toward innovation and sustainability. By incorporating computer vision techniques, particularly the Fuzzy C-means (FCM) algorithm, craftsmen and researchers want to transform the process of making quilting art, providing a harmonic blend of creativity, efficiency, and resourcefulness.

Denim, with its raw charm and ageless appeal, has long been a popular fabric in the fashion and textile sectors. However, disposing of denim scraps is a substantial environmental concern, necessitating the development of novel strategies to recycle these leftovers. The use of computer vision, specifically the FCM algorithm, offers a viable path for repurposing leftover denim into exquisite quilting art patterns, reducing waste while encouraging creativity and sustainability [1][2].

The FCM algorithm, a sophisticated clustering tool for picture segmentation, has enormous potential in the area of quilted art. Using fuzzy logic principles, the FCM algorithm excels at splitting images into discrete regions, making it easier to identify and classify denim fabric scraps. This feature allows artists to define the limits of individual fabric pieces, paving the door for automatic pattern development and design modification [3][4].

This overview will go into the many ramifications of incorporating computer vision, notably Computer Vision, Quilting Art, the FCM algorithm and the proposed HOFCM algorithm, into the process of making quilting art out of old denim garments [5]. They investigate the role of denim repurposing in encouraging sustainability in the textile business, our research aims to optimize the membership matrix to lower the algorithm's temporal complexity. To achieve our goal, the researcher presents the Hybrid OK-Means Fuzzy C-Means (HOFCM) method [6]. HOFCM enables more precise identification and clustering of denim cloth scraps based on visual qualities and texture [7]. This allows for the automatic production of quilting patterns that effectively use the unique features ofeach scrap, resulting in visually beautiful and creatively different quilting art designs [8][9].

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The development of HOFCM into the world of quilting art patterns not only promises to speed up the pattern creation process but also to improve the accuracy and inventiveness of the final designs. This study aims to enhance automatic generation technology in the realm of textile art by utilizing computer vision and advanced clustering algorithms, promoting sustainability, efficiency, and originality in quilt design practices.

II. Literature Survey

A. *The Clothing Industry's Relationship with the Environment and Resources*

According to [10], 100 billion clothing are created each year, whereas 33 billion are discarded. The number of individuals wearing clothes has barely doubled over the last 20 years, but garment production has expanded fivefold, with an average yearly purchase of 68 clothes per person. In addition to producing clothing waste, the garment industry is also causing environmental and resource problems. Global warming is causing water scarcity, and one white cotton T-shirt requires almost 2,700 litres of water, which is equivalent to the amount of water a person can drink for three years. Furthermore, one-fifth of the water utilized in the fashion sector is used to dye textiles. Making 4 billion jeans in a year produces 33 kg of carbon emissions, equivalent to 111 km in length [11]. The amount of greenhouse gases produced by the apparel industry exceeds that of the global shipping and aviation industries. Of course, there are many zero-waist and eco-friendly brands, and many good goods have lately emerged, but the relationship between the clothes industry and the environment and resources is vast and significant. In the reference, they can see how the clothes they put in the recycled clothing box are utilized in Korea and how the end clothes that were not chosen until the end of the last one are used [12].

The garments in the recycled clothing box are first collected regularly by the management firm or individuals typically every six days [13]. These old clothes arrive at the collection company in 40 tons every day, and there are approximately 100 collection companies in Korea, resulting in more than 4,000 tons of clothing being dumped each day. Only 5% of the clothes collected are still commercially available and sold in Korea's 'Vintage Shops' and 'Relief Shops,' with the remaining 95% exported overseas. The majority are imported from underdeveloped countries, with China being the world's fifth largest supplier of old clothing, and all non-commercial apparel is incinerated. True-Type 1 or Open Type fonts are preferred. Please embed symbol fonts, as well, for math, etc [14].

B. *Reuse Clothes*

As indicated in Figure 1, the following nations exported the most recycled textiles in 2019. Clothing trash is not subject to separate collection in Korea, and local governments handle separate discharge and collection in a variety of ways.

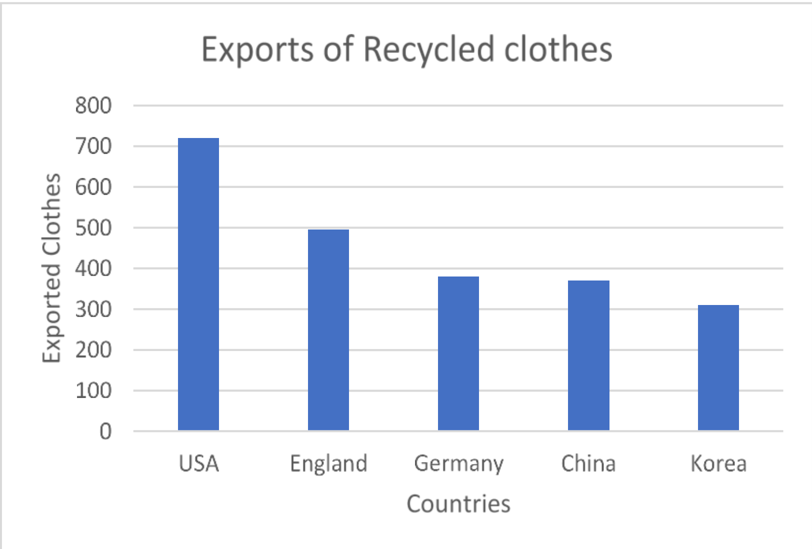

Fig 1: Exports of Recycled clothes in 2019.

Waste clothing gathered through separation and discharge is classed as reusable or impossible. Reusables are sold at flea markets and bazaars around Korea and exported to foreign countries, notably developing countries [15].

III. METHODOLOGY

A. Computer Vision

Computer vision is a branch of artificial intelligence (AI) and computer science that focuses on teaching computers to interpret and comprehend visual input from the actual environment, similar to human eyesight. It includes a wide range of tasks for processing, evaluating, and extracting relevant insights from visual data like photographs and videos.

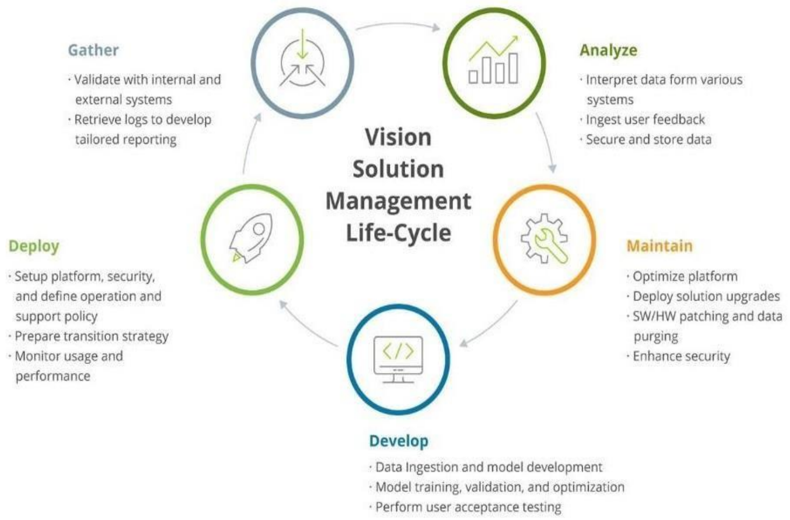

Fig 2: Computer Vision works.

The basic goal of computer vision is to reproduce and automate human vision capabilities, allowing machines to see and process visual information in a similar way to humans. This encompasses tasks like object detection, image classification, segmentation, tracking, and scene comprehension.

Computer vision algorithms employ mathematical and statistical techniques to handle visual data, such as image processing, pattern recognition, machine learning, and deep learning. The algorithms used are trained on massive datasets of annotated photos to identify patterns, characteristics, and relationships in the visual data, allowing them to perform specified tasks with great accuracy and efficiency.

Computer vision applications exist in a wide range of industries and domains, including healthcare (medical imaging and diagnostics), automotive (autonomous driving and driver assistance systems), robotics, surveillance, augmented reality, retail (product recognition and recommendation), and entertainment (virtual reality and gaming), among others. FCM is a method of Computer Vision.

B. Quilt Art

Quilting art is a type of textile creativity that involves sewing together layers of fabric to produce attractive patterns, designs, and textures. It includes a wide variety of techniques and styles, ranging from classic quilts with intricate pieced designs to contemporary art quilts that push the limits of creativity and expression.

Fig 3: Quilting Art

Quilting art can take numerous forms, including traditional bed quilts and wall hangings, as well as wearable and large-scale installations. Quilting is frequently used by artists as a form of self-expression, with works exploring themes such as culture, identity, memory, and social commentary.

Quilting often requires several steps:

- Step 1: Design

Quilting frequently starts with a design phase, in which the artist develops the quilt's layout, pattern, and colour scheme. Designs can follow established patterns like log cabins or star blocks, or they can be unique and creative.

- Step 2: Fabric Selection

Artists select fabrics for the quilt top, backing, and batting (middle layer) depending on colour, texture, and quality. Cotton and silk, as well as denim and other fabrics, can be used to create the appropriate look and feel for the quilt.

- Step 3: Piecing

Piecing is the process of putting together fabric pieces to form a quilt top. This may be done by hand or with a sewing machine, and it frequently requires precise cutting and stitching to produce accurate forms and seams.

- Step 4: Quilting

Quilting is the sewing that holds the layers of a quilt together. This can be accomplished using straight lines, free-motion stitching, or intricate designs, according to the artist's preference and desired effect.

- Step 5: Finishing

After quilting, the quilt is completed by removing excess fabric, adding bound around the edges, and occasionally embellishing with beads or embroidery.

C. Fuzzy C-means Algorithm

The Fuzzy C-Means (FCM) algorithm is critical in the segmentation and clustering of denim fabric scraps in the Automatic Generation Technology of Scrap Denim Clothes in Quilting Art Patterns by Integrating the Computer Vision project. Initially, denim fabric photos are analyzed using computer vision algorithms to extract key elements such as colour, texture, and spatial data. The denim fabric images are then partitioned into clusters based on similarity using the FCM algorithm, which takes into account the fuzzy membership degrees of individual pixels in each cluster. This fuzzy membership assignment represents the ambiguity or partial belongingness of pixels to distinct fabric scraps, allowing for more subtle segmentation than typical clustering methods.

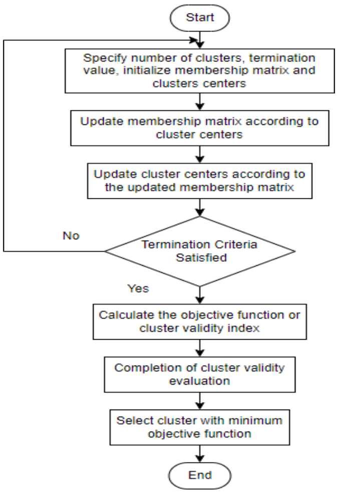

Fig 4: Fuzzy C-Means flow diagram.

FCM uses iterative calculations to determine the centroids of each cluster, which represent the unique characteristics of the respective fabric scraps. These clustered denim fabric scraps serve as the base for creating quilt designs, affecting the design and placement of quilt parts. By combining the FCM algorithm with computer vision techniques, the automatic generation technology efficiently analyzes and interprets visual information from denim fabric images, allowing for the creation of personalised and visually appealing quilt patterns while making the best use of scrap denim materials. They present HOFCM, a new technique to minimize the time complexity of the FCM algorithm.

D. Hybrid OK-Means Fuzzy C-means Algorithm

The Hybrid OK-Means Fuzzy C-Means (HOFCM) algorithm is critical in optimizing the clustering process for creating quilting art patterns from discarded denim clothing. HOFCM expands on the standard Fuzzy C-Means (FCM) method by including higher-order moments of the data distribution, such as skewness and kurtosis, into its objective function.

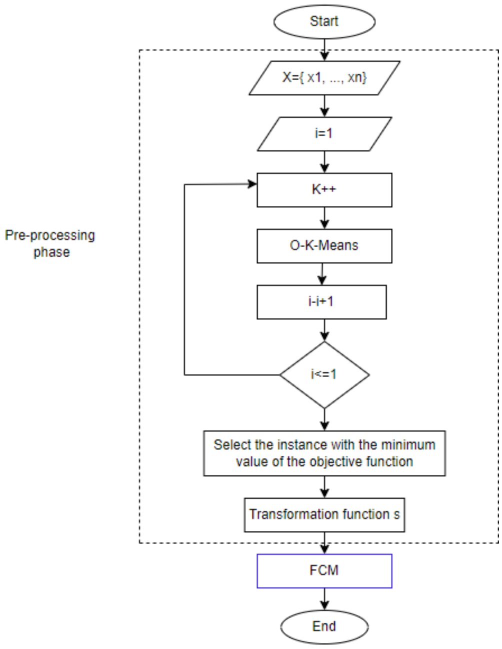

Fig 5: Structure of HOFCM.

By taking into account these higher-order moments, HOFCM can capture more intricate correlations and patterns in the scrap denim cloth data. This is especially useful in quilt art, where elaborate designs and textures are desired.

Furthermore, the regularization term included in HOFCM prevents overfitting and maintains the clustering process's robustness, particularly when dealing with noisy or complex data.

In the context of creating quilting art patterns, HOFCM enables more precise identification and clustering of denim cloth scraps based on visual qualities and texture. This allows for the automatic production of quilting patterns that effectively use the unique features of each scrap, resulting in visually beautiful and creatively different quilting art designs.

IV. Results

A. *Experiment Analysis*

FCM's performance was evaluated using four real datasets and a synthetic dataset with uniformly distributed attribute values (0–1). To compare FCM outcomes, It constructed standard FCM and HOFCM algorithms. All algorithms were written in C using the GCC 7.4.0 compiler. The computer equipment utilized was configured as follows: Intel® CoreTM i9-10900 (Santa Clara, CA, USA) with 2.80 GHz, 32 GB RAM, 1 TB hard drive, and Windows 10 Pro OS.

The standard FCM, FCM++, NFCM, and HOFCM algorithms were run with the following parameters: m = 2 and ε = 0.01. The initial membership matrix values for the conventional FCM were generated at random. The HOFCM algorithm optimizes the membership matrix based on the transformation function's findings.

Datasets:

Table 1 describes the datasets used. The table is organized as follows: column one contains the dataset identifier, column two contains the name, column three contains the data type, columns four and five contain the dataset's total objects and dimensions, and column six contains the product of columns four and five. This research uses big datasets, including SPAM, URBAN, and 1m2d, with over 200,000 objects.

Table 1: Datasets utilized in experiments.

Id	Name	Type	n	d	Size Indicator n*d
1	WDBC	Real	568	31	17060
2	ABALONE	Real	4176	6	29230
3	SPAM	Real	4600	36	261250
4	URBAN	Real	360176	1	720358
5	1m2d	Synthetic	100009	1	2000008

B. *Describe the test*

The tests aimed to demonstrate the quality and efficiency of the FCM algorithm for huge datasets. Experiments were designed to evaluate the FCM and compare its findings to typical HOCM algorithms.

1) *Describe the Experiment:*

This experiment aimed to compare the performance of typical FCM and HOCM algorithms. This graph compares the standard FCM and HOFCM methods for all datasets in the Experiment, displaying average time reduction and objective function gain.

“Equations (1) and (2)” demonstrate how the percentages of time reduction and gain in the objective function were calculated:

$$time = 100\,(1 - \frac{averageTime\_HOFCM}{averageTime\_standard\_FCM}) \quad ..…….. (1)$$

$$Jm = 100\,(1 - \frac{JmAverage\_HOFCM}{JmAverage\_standard\_FCM}) \quad ……… (2)$$

Figure 6-10 displays the millisecond time averages for each of the eight test cases across the five datasets in the Experiment. This section presents an analysis of the results.

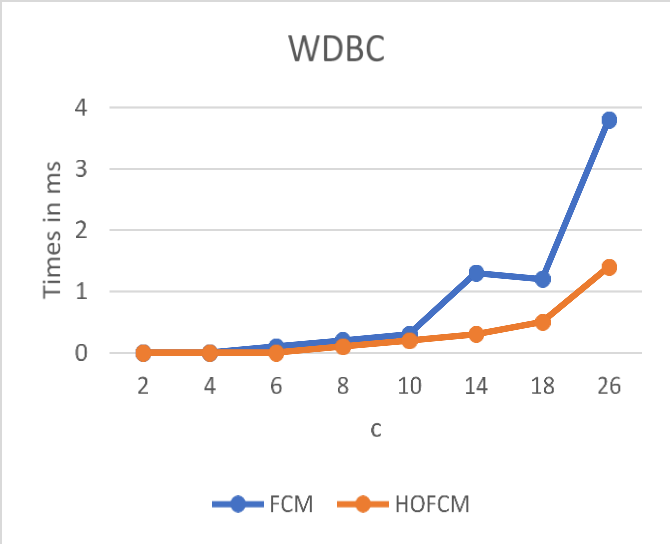

Fig 6: Result of clustering on WDBC.

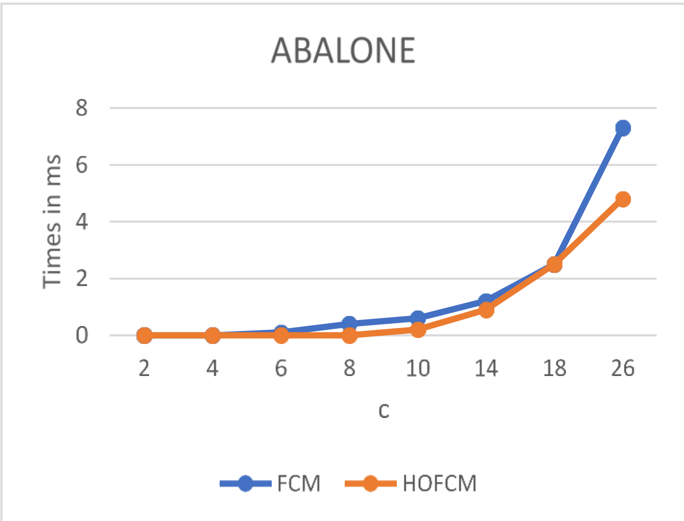

Fig 7: Result of clustering on ABALONE.

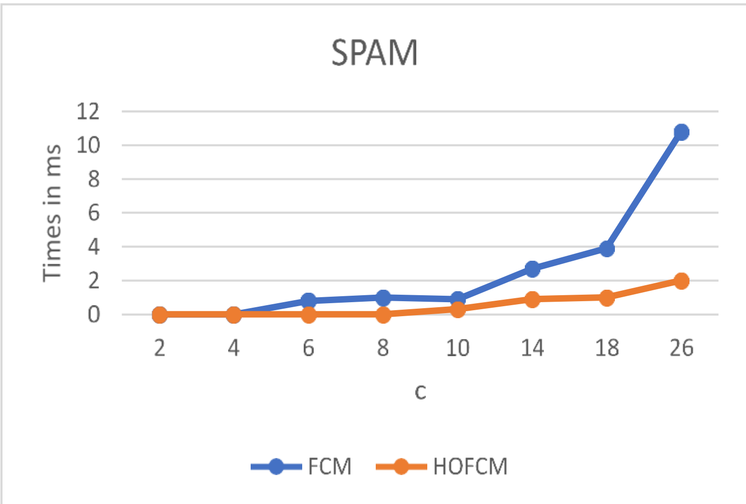

Fig 8: Result of clustering on SPAM.

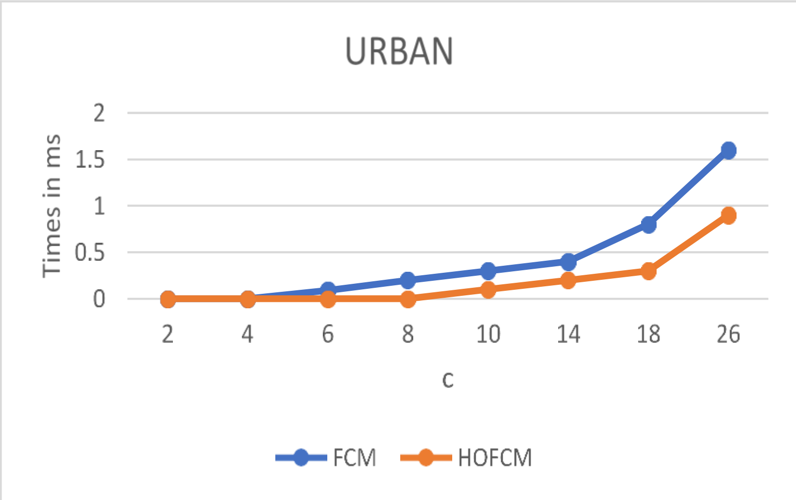

Fig 9: Result of clustering on URBAN.

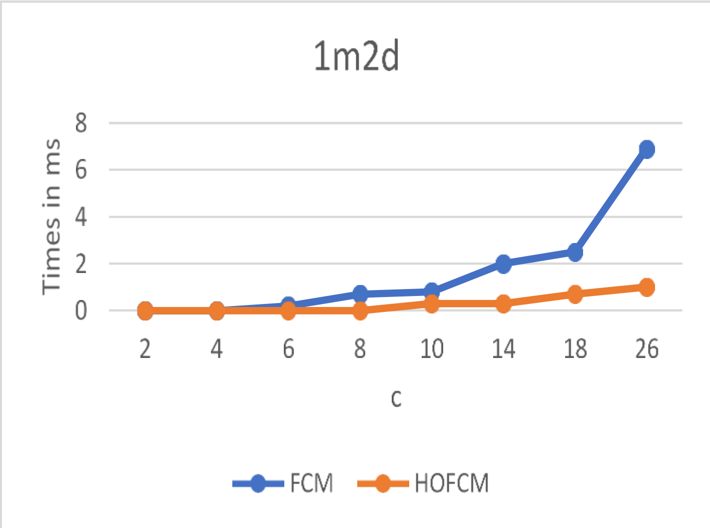

Fig 10: Result of clustering on 1m2d.

C. Result Analysis

The advent of the High-Order Fuzzy C-Means (HOFCM) method provides significant advantages over the traditional FCM algorithm, as demonstrated by several datasets. Time efficiency increased significantly across the board, with reductions seen in all test situations. The most notable reduction, up to 93.94%, was accomplished in the SPAM dataset, which is notorious for its high dimensionality, demonstrating the algorithm's capacity to efficiently handle complicated data. Furthermore, HOFCM revealed improved solution quality, which is especially useful for large datasets, since benefits were detected in 20 of 24 situations. Notably, the algorithm produced an impressive 68.31% improvement in the best-case scenario. Even in the worst-case situation, a minimal quality loss of 2.19% was discovered, confirming the algorithm's overall effectiveness. Furthermore, with smaller datasets, HOFCM consistently achieved a solution quality of 62.5% across all 16 test cases. These findings jointly demonstrate the superiority of the HOFCM proposal over the standard FCM algorithm, establishing it as a promising improvement in clustering algorithms.

V. Discussion

The High-Order Fuzzy C-Means (HOFCM) algorithm is discussed in the context of Automatic Generation Technology of Scrap Denim Clothes in Quilting Art Patterns by Integrating Computer Vision, which highlights several major findings and ramifications. To begin, the observed reduction in computing time, up to 93.94% in the best-case scenario, demonstrates HOFCM's efficiency in dealing with big, high-dimensional datasets, which are inherent in scrap denim cloth analysis. This efficiency is critical for accelerating the quilted art pattern-generating process, resulting in faster design iterations and increased output.

Furthermore, the study demonstrates HOFCM's ability to increase the quality of clustering solutions, particularly in large datasets, with gains of up to 68.31% seen. This implies that HOFCM is successful at capturing intricate patterns and relationships within scrap denim cloth data, resulting in more accurate and visually appealing quilting designs. However, slight quality reductions were seen in some cases, indicating the algorithm's sensitivity to specific dataset properties and parameter choices.

In general, the data support the idea that HOFCM outperforms typical Fuzzy C-Means (FCM) algorithms when it comes to autonomous pattern development for quilting art. Its ability to strike a balance between computational economy and solution quality makes it an exciting tool for designers and artists looking to create novel and detailed quilting designs out of scrap denim clothing. Nonetheless, more research and testing may be required to investigate HOFCM's resilience across a variety of datasets and applications, ensuring its wider usability and effectiveness in real-world scenarios.

VI. Conclusion

The incorporation of the High-Order Fuzzy C-Means (HOFCM) algorithm into the Automatic Generation Technology of Scrap Denim Clothes in Quilting Art Patterns using Computer Vision represents a significant achievement in the field of textile art and design. The study shows that HOFCM is successful at reducing computational time and improving clustering solution quality, especially when dealing with large, high-dimensional datasets like scrap denim cloth analysis. The significant reduction in computational time, combined with the observed improvements in clustering solution quality, highlights HOFCM's practical value and efficacy in accelerating the quilted art pattern creation process while retaining design accuracy and complexity. These findings provide vital insights into HOFCM's potential to change the development of quilted art patterns, allowing designers and artists to use scrap denim clothing to create new and visually appealing designs. However, while the study's findings seem encouraging, more research is needed to investigate HOFCM's applicability across varied datasets and applications, as well as its robustness in real-world circumstances. Furthermore, studying the algorithm's scalability and adaptation to various quilting art styles and design preferences may increase its usability and adoption in the textile art community.

Acknowledgement

Anhui Agricultural University Philosophy and Social Science Project "Research on the Live Protection and Inheritance of Traditional Handmade Quilting Skills Based on the Integration and Development of Culture and Tourism" (Project No. 2021sk12); Anhui Quality Engineering Project "Construction and Practice of "EPCI" Four-position Integration Talent Cultivation Mode for Design Studies Majors in the Context of New Liberal Arts", (Project No. 2022sx033).

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