Image Processing Based Pattern Recognition and Computerized Embroidery Machine

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Abstract- **In the last decades, embroidery getting much attention in industries and academics. Although the technique is very old, it is still very much adopted. The current era of machine learning and smart devices makes this method even more attractive, easy to adopt and high accuracy. The proposed research work aims to highlight the implementation of new smart devices in this field, and the work is based on microcontrollers. Adopting the proposed work will be very easy and feasible to transform from the old sewing machine to a new smart method. Using smart devices, it is very easy and precise to get the embroidery fulfilling the user's demands. It gives simple raster images, which are used to convert into digital images to portray any new product. The current work is a novel idea of generating simple images rather than complicated ones, which are difficult to draw. In our method, we introduce the digitization process to input any image file used for vectorizing raster images, where vector images can easily convert into a DST embroidery file, a commonly used embroidery format originally from Tajima. It also has a Gcode file. The machine runs on a Gcode file which can be easily generated and runs on a product.**

Index Terms-- **Intelligent embroidery, image processing, pattern design, auto-digitizing, CNC machine, rasterizing, vectorization, transformation.**

I. INTRODUCTION

In Pakistan, embroidery is regarded as one of the known traditional crafts. Embroidery is a sort of art applied to fabric or various types of clothes and accessories using needles, thread, or yarn. In Pakistan, needlework is done on a big scale and is highly traditional, with most of the workers, both men, and women, coming from villages. This is how most village households generate money nowadays. Many domestic products, such as badges, flags, bed sheets, towels, uniforms, pouches, handkerchiefs, slippers, shoes, and the most popular work, Rally, are to be embroidered in Pakistan. People throughout the globe appreciate beautiful needlework work. However, the market demand cannot be met due to inadequate manufacturing efficiency. Only in refined society did elaborately embroidered garments, religious artifacts, and domestic things become popular [1].

The textile industry is Pakistan's most important, accounting for more than 67 percent of overall export revenues and 46 percent of manufacturing [2]. As the industrial revolution advanced, machine embroidery and mass production expanded. Machine embroidery may be accomplished in several techniques. Pakistan has imported more than $4 billion of textile and garment machinery in recent years. The low productivity of

textile machines is a problem for Pakistan's textile sector. We may reduce our import ratio by producing this machine, progressively improving our GDP and inflation rates. Villages are known for their gorgeous textiles, which include Ralli quilts. It's a way of repurposing cloth. Older fabrics are sewn together, and then some embroidery is done with that material to mask its flaws. Khairpur Mirs is well known for rally-making, and each item manufactured here sells for at least one to two lakes. A single bedsheet can take up to a week to make, while a double bedsheet might take up to a month.

This rally-making activity is viewed as a source of money for them and a source of cash for our country. By producing many pieces daily, this machine may speed up its job, producing revenue for the government. Rural women must demonstrate their abilities and endeavours to promote entrepreneurship and skill development among their peers. The country's unemployment rate will fall. Our inflation rate and GDP will continue both rises at the same time. Many textiles-related initiatives will be completed in the allotted period [3]. Today's fashion design students have unique design concepts and can forecast future season trends rather than squandering many hours designing and bringing to life those details. They only need to utilize the machine tools and may quickly sketch their

inventive concepts, allowing them to establish their firm or expand their sector.

The demand for automated machines has skyrocketed in recent years, thanks to the introduction of microprocessors that enable automatic machines to do numerous settings-related activities efficiently. Because of the user interface's reliability, it's much easier to learn how to use the software and develop the design. This computer contains pre-installed designs in its memory and a Wi-Fi connection for downloading additional pictures. It will accept all the user's inputs and begin creating the design automatically. There are already built-in audio and video tutorials for running this software. Modern stitching machines are adaptable to various automated stitching procedures, saving time, enhancing output, and improving efficiency. Because of its continuous technological advancement, the contemporary sewing machine is quite simple to operate.

II. BASIC WORKFLOW OF THE DESIGN AND MANUFACTURE

EmbroidAI aims to be a proficient embroidery digitizing platform based entirely on free, open-source modules, able to be used on different types of computers or with different software packages. Our goal is to be accessible for hobbyists and digitizers with the powerful auto-digitizing tool, which helps in saving time, effort, and money. To create and update a beautiful embroidery design, easily share with others, and enjoy the auto-digitizing tool. The design shown in Fig. 1 delivers gorgeous embroidery designs with ease and confidence [4]. Manage the machine and all its components to work synchronously. This software aims to create easily, update, visualize, save, and share digital embroidery files. Users can insert the file via USB, share it by Bluetooth, and upload the embroidery file through the accessible internet.

This research presents a computerized embroidery machine based on the Arduino UNO controller. An old sewing machine can be converted into an embroidery machine with some hardware components, including a 2dplotter, stepper motor, stepper driver, controller, CNC shield, and power supply. To change the platform of an embroidery machine according to the embroidery design selected by the user. A user may upload a design, such as a simple vector graphic, and have it transformed into a digitized image, which can then be used to create personalized embroidery that can be applied to a product.

This paper provides the most effective ways of tackling our research's most demanding task: auto-digitizing utilizing various AI technologies. This input file goes through several steps, including noise reduction, background removal, conversion to black and white, enhanced image resolution, edge detection, and contouring, before being rendered accurately into an SVG vector image, which can be edited, and then transformed into our machine-readable file, which converts directly to Gcode. We've discussed approaches for producing high-quality results in real time. Strong animation tools for embroidery are typical textile embellishments, and producing and drawing them automatically is useful. This study demonstrated the best conversion tool for converting any embroidery file into a machine-readable format.

Our research's main process is to turn an old sewing machine into an embroidery machine with user-interactive software that accepts various input files and converts them to a computerized embroidery file. Create and update an SVG image and transform it into a digital embroidery file compatible with the machine [5]. Upload the proper format file via USB, Bluetooth, or Wi-Fi, and place the appropriate hoop. Fabric stabilizing, placing hoops, placing and changing the ribbon, take-up lever, oiling, and bobbin winding are some of the works to be done manually [6]. Among these, the embroidery and frame movement is the most important since they finished the embroidery independently and harmoniously. The wheel pushes the needle and thread in the Z direction to move up and down, and the frame reciprocates in the X and Y directions to produce a beautiful embroidered work.

FIGURE 1: Basic Workflow Design

III. LITERATURE REVIEW

A. IMAGE PROCESSING

Image processing aims to increase the image quality so that it can be easily comprehended by people or robots [7]. Its methods

transform input images into high-quality output images. Continuous pictures and discrete images are the two types of images. Optical devices that receive analog signals, such as the human eye and analog cameras, produce continuous pictures. Continuous pictures are converted into discrete images through the digitization process. Digital cameras and scanners, for example, are equipped with digitization features that allow them to generate distinct pictures [8].

Artificial intelligence (AI) is a machine's capacity to perform activities normally performed by people and needs human intelligence and judgment, both of which Python excels at. It is perfectly suited for usage in this artificial intelligence sector, and its popularity will continue to grow [9]. The most extensively utilized AI scripting language is Python. The library is an interface, or a bundle of modules, offered by multiple sources such as PyPi, which includes an open-source code that allows users to do specific tasks or access certain functionality.

We need to determine borders and properly mark regions from the scanned input files to analyze image file embroidery designs. In this paper, we provide the most effective ways of tackling our research's most demanding task: auto-digitizing utilizing a variety of AI technologies. This input file goes through several steps, including noise reduction, background extraction, small object removal, finding shapes, conversion to a binary image, enhanced image resolution, edge detection, and contouring, before being rendered accurately into an SVG vector image, which can be edited, and then transformed into our machine-readable file, which converts directly to Gcode [10].

Canny edge detection comes to mind as the initial method for extracting edges. On the other hand, Canny edge detection looks for sudden changes in image brightness in an image. An embroidered design has well-defined boundaries and is not a large picture. The essential task is to extract areas and associated borders. The borders of an embroidered pattern are always surrounded by pixels, even if the scan appears black and white. As a result, we begin by creating a true binary image with basic. The next stage is to locate related chains of edges, which may be used to locate boundaries and regions [11].

The Hough transform is a module used for identifying forms in photographs. Lines, circles, and ellipses have all been extracted using this method. Converting an image from Cartesian to polar coordinates is a common feature extraction approach. In the Hough space, any point in the picture space is represented by a sinusoidal curve. Even though this model form is simple, it becomes extremely problematic when dealing with complex forms owing to noise and shape imperfection and the challenge of identifying vertical line slopes [12]. The CHT solves this difficulty by inserting a transformation of the shape's centroid in the parameter space's x-y plane.

Noise removal, enhanced image resolution, contouring, edge, and contrast enhancement are learned simultaneously for effective performance improvement without much training data. Applying LP decomposition on de-noised photos prevents colour distortion. Using spatially correlated information, edge information is augmented to generate high-quality output pictures. To improve de-noising performance, CNN-based noise reduction models have been added. However, these approaches must be trained on a big dataset better to understand the characteristics of pictures for noise reduction. Furthermore, the research found that while the deep CNN model learns effectively on many samples when labels are randomized, it may overfit the samples [13].

Auto tracing is a technique for converting a bit-mapped picture into a vector image. Grain, halftone dots, and other restrictions may exist in bit-mapped pictures, which are represented as dots. Converting them to vector images can address this problem. The open-source tools Map traces, Pypotrace, and auto trace display picture files to recognize paths, lines, and objects [14]. When you have a raster graphic that is too tiny for your purposes, you may use an auto-digitizing tool to convert it to a vector. It's a quick and easy procedure that yields amazing results. Improved picture resolution for resizing and detecting image file edges [15]. Since then, it has evolved due to the most advanced algorithms and high computation power (see Fig. 2). Humans can now create facial recognition software that is as accurate as humans [16].
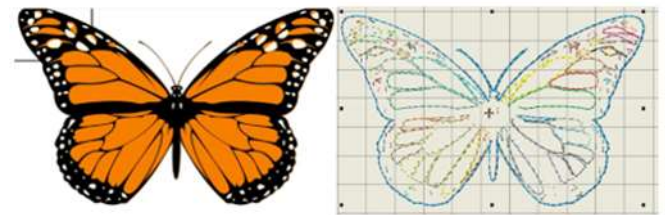

FIGURE 2: Imager processing input and output image

B. MODELING

In this research, there are four modules to be covered to create a beautiful embroidery design. We have done many processes to allow several types of files to be input, including raster, vector images, or any embroidery files.

a) DST Embroidery File:

The first module to be stitched is the Data Stitch Tajima embroidery file, a widely used commercial embroidery file developed by Tajima [17]. This is our machine-readable file, which automatically translates to Gcode. Stitch and Jump are the only commands that it understands. After finishing one colour, it switches to the next. We may use the pause command to replace the ribbon and bobbin in the interim. Finally, our lovely design will be stitched.

b) Embroidery File Converter:

In this platform, we provided the best conversion tool to insert any embroidery file type, which is the second module of our research. We've demonstrated how to convert any embroidery file into a machine-readable format using the greatest conversion tool available, which can then easily be translated to Gcode. Our machine moves in three directions, using x-y commands to move back and forth and z commands to move up and down [17].
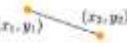
c) Raster Image:

The raster image is the fourth and last component of our research. This paper provides the most effective ways of tackling our research's most demanding task: auto-digitizing utilizing various AI technologies. This input file goes through several steps, including noise reduction, background removal, conversion to black and white, enhanced image resolution, edge detection, and contouring, before being rendered accurately into an SVG vector image, which can be edited, and then transformed into our machine-readable file, which converts directly to Gcode.

d) Vector Image:

A vector image is a computer picture used in graphic design that typically includes bright, striking colours, such as logos and printed images. It may be saved in EPS, SVG, and AI. We have mostly worked on a Scalable Vector Graphic (SVG) picture in this research. Our SVG Draw Bot provides best practices for delivering high-quality outputs in real-time and robust animation features for automatically transforming vector image files into editable forms and drawing vector images using pen and pencil tools. This input file may be turned into a machine-readable file, which can then be translated to Gcode.

Table I The SVG sketch commands included in this work, their parameters and a visualization. The beginning $(x1, y1)$ is generally specified as the previous command's terminal.

TABLE I:
SVG SKETCH COMMANDS

Command	Arguments	Description	Visualization
<SOS>	∅	'Start of SVG' token	
M (Move To)	x2, y2	Move the cursor to the endpoint (x2, y2) without drawing anything.	
L (Line To)	x2, y2	Draw a line to the point (x2, y2).	
C (Cubic Bezier)	qx1, qy1 qx2, qy2 x2, y2	Draw a cubic Bezier curve with control points (qx1, qy1), (qx2, qy2) and endpoint (x2, y2).	
z (Close Path)	∅	Close the path by moving the cursor back to the path's starting position (x0, y0).	
<EOS>	∅	'End of SVG' token.	

IV.   METHODOLOGY

A. Digitization

Before digitizing, analyze and plan the order of the pattern design forms and embroidered stitches. Automatic digitization can turn a basic form or embroidered item into a pattern design. For developing various forms or pattern design components, many tools are available. After selecting the proper tool, digitize & digital technology by designating reference points along the contour.

B. Professional Digital Technology

This application will provide you with specialized digital skills that will allow you to save time while creating special effects and machine functionality. To provide input tools including digital mosaic stitching, stars, and branches. Contouring, embroidery, and contour deepening are all methods that may be used. Use the application to digitize embroidered or sequined towels. The embroideries are removed from the pattern and exported as separate files or sent to the cutter. Large areas can also be embroidered with low-stitch cross stitches.

C. Computer-Aided Design

Linear, banded, and regional input approaches were used for the computer embroidery. In consequence, digital technology and editing modules have been merged with advanced graphics processing technology, adequately enhancing the software's efficiency to create, update, process, and manage pattern designs based on creative embroidery knowledge, an automatic needle-filling method, and a repository that can make any drawing accurate [19]. To detect and fill the appearance of a broken line and boost design, and production efficiency, use the automated single-needle linear input and single manual needle based on the side of the input, bilaterally symmetrical input, and medial input [20].

D. Drawings Sewn with Intelligence

There are plenty of methods, such as pattern preparation, to control the embroidery machine and embroidered hoop to perform multiple operations. A pattern master created this process. The phrase derives from the mechanical embroidery machine, which records stitches on punched tape. Nowadays, embroidery machines can recognize and perform their actions, using a mechanical or more modern way to record in memory for those who need to create a pattern.

Three types of tools are used in a computerized embroidery machine, embroidered plate production software, and a U disc. The basic steps for creating and modifying embroidery design using a computerized embroidery machine are as under below:

1. The initial process is the design of embroidered designs, also known as plate makers. The component of the staff's job involves plate manufacture. Designers may easily generate patterns using this tool, which can subsequently be stored on a computer's hard drive.
2. Locate and open the embroidery pattern file in the following steps. The suffix DST files are being altered.
3. The third component is to choose or upload the file into the computer embroidery machine, modify it, and save

it into memory using the control buttons on the machine's panel.

4. Now place the frame of the selected size. After sliding the embroidery frame up and down until it is in a perfect position, click the embroidery confirmation button. This will establish the embroidery's provenience.

5. Choose an embroidery colour to begin embroidering.

6. During the actual manufacturing process, several factors (such as a scarcity of needles and thread) result in the loss of part of the stitch. Use the features of broken line detection, back, and re-embroidered to finish the embroidery task (see Fig. 3).
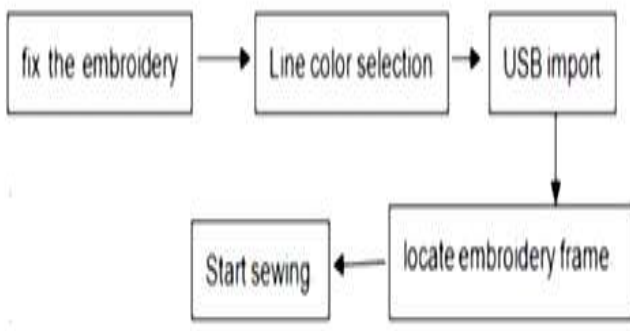

FIGURE 3: Machining Processes

V. SIMULATION RESULTS

Simulation is the process of simulating the function of a meaningful process or system through time. For simulations, designs are essential; the prototype represents a major trait or actions of the selected framework, whereas the model depicts the evolution over time. Four works are covered in this section. The first component to be stitched is the Data Stitch Tajima embroidery file (see Fig. 4) [16]. This is our machine-readable file, which automatically translates to Gcode. Stitch and Jump are the only commands that it understands. After finishing one colour, it switches to the next. We may use the pause command to replace the ribbon and bobbin in the interim. Finally, our desired design will be stitched [21]. Fabric is one of the vintage inventions of human beings [22]. In recent years, fabric pattern (texture) recognition has gained much attention and made great achievements [23].

The second element to be stitched is the Brother Embroidery file (see Fig. 5). Our machine accepts multiple formats of embroidery files and transforms them into a machine-compatible format with the powerful conversion tool. Using the greatest conversion tool, we've demonstrated how to convert any embroidery file into a machine-readable format. This input file may be turned into a machine-readable file, which can then be translated to Gcode.

Our machine moves in three directions, like a 3D printer, using x-y commands to move back and forth and z commands to move up and down [24].

FIGURE 4: DST Embroidery File

FIGURE 5: Brother Embroidery File

The third component is a Scalable Vector Graphic (SVG) image (see Fig. 6). Clean lines, flat colours, and uniform sterility are all hallmarks of vector drawings. This file is scalable and may be viewed from any location at any time. It's easy to alter and resize images to any extent beyond the drop of detail. Our SVG Draw Bot provides best practices for delivering high-quality outputs in real-time and robust animation features for automatically transforming vector image files into editable forms and drawing vector images using pen and pencil tools. This input file may be turned into a machine-readable file, which can then be translated to Gcode.

FIGURE 6: SVG Image

The PNG raster image is the fourth and last component of our research. The raster image (see Fig. 7) is a rectangular grid of pixels, which is portable and easy to share. This paper provides the most effective ways of tackling our research's most demanding task: auto-digitizing utilizing various AI technologies. This input file goes through several steps, including noise reduction, background removal, conversion to black and white, enhanced image resolution [14], edge detection, and contouring, before being rendered accurately into an SVG vector image, which can be edited, and then transformed into our machine-readable file, which converts directly to Gcode.

FIGURE 7: Raster Image

VI.   CONCLUSION

Computerized embroidery machines not only increase the efficiency and quality of embroidered production while cutting labour and production costs, but they also broaden the varieties of needlework accessible, advancing human civilization and maintaining Pakistan's traditional embroidery. We've discussed approaches for producing high-quality results in real time. Strong animation tools for embroidery is, a typical textile embellishment and being able to produce and draw it automatically is useful. This study demonstrated the best conversion tool for converting any embroidery file into a machine-readable format. This research's main purpose is to turn an old sewing machine into an embroidery machine using a user-interactive software application that accepts various input files and converts them to a computerized embroidery file.

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CONFLICT OF INTEREST

The Authors declare that they have no conflicts of interest to report regarding the present study.

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