



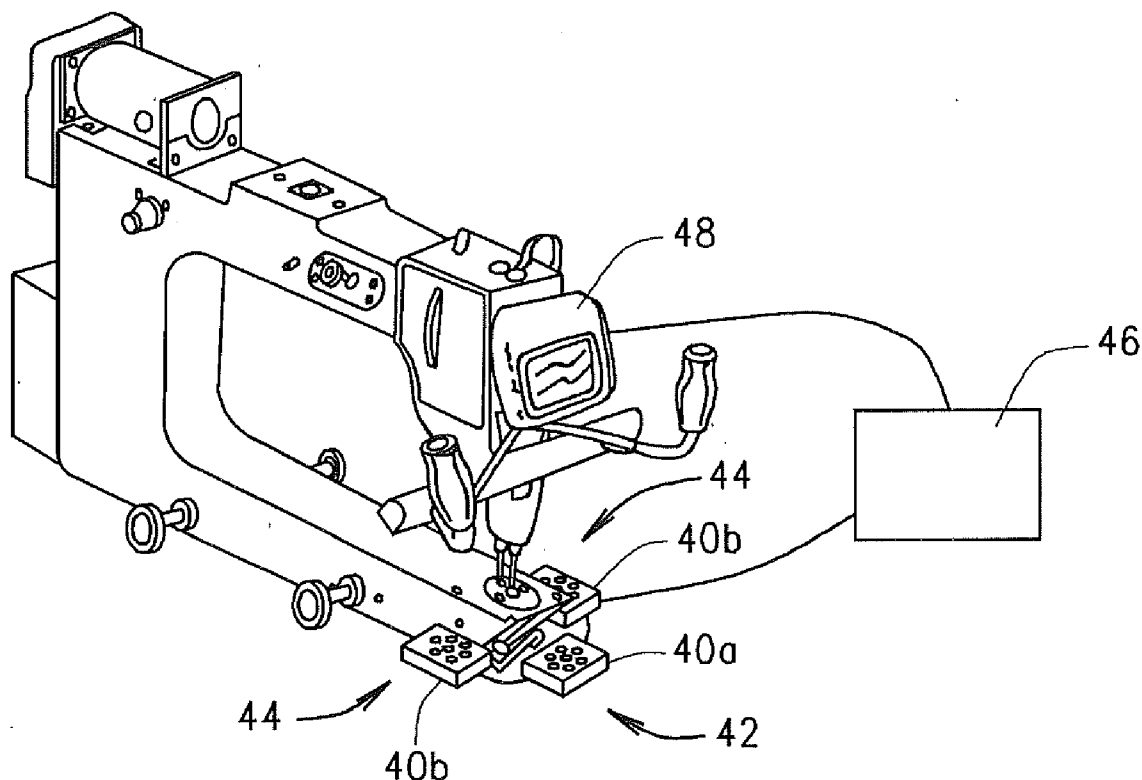
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Stokes et al.(10) **Pub. No.: US 2010/0186646 A1**(43) **Pub. Date: Jul. 29, 2010**(54) **STITCH QUALITY MONITORING SYSTEM****Related U.S. Application Data**(75) Inventors: **Theodore J. Stokes**, Lapeer, MI (US); **Matthew Paul Sherman**, Columbia, MO (US); **Kenneth Mark Eubanks**, Columbia, MO (US); **Paul Truman Statler**, Columbia, MO (US); **Joseph W. Bauman**, Cabool, MO (US)

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(52) **U.S. Cl.** **112/470.05**; 112/271; 112/475.17
(57) **ABSTRACT**Correspondence Address:
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A stitcher is provided that includes a needle configured to place stitches in a fabric that is moved therethrough. The stitcher includes a sensor positioned below the fabric to monitor stitches placed in the fabric. A microcontroller is provided configured to receive data from the sensor and, based on such data, to compare one or more attributes of the monitored stitches with one or more predetermined parameters relating at least one attribute of the fabric. The predetermined parameter may be either hardcoded in the microcontroller or input by a user of the stitcher prior to beginning operation of the machine. When the attributes of the monitored stitches fall outside of the predetermined parameters, the microcontroller initiates notification of the user.

(73) Assignee: **GAMMILL, INC.**, Columbia, MO (US)(21) Appl. No.: **12/694,667**(22) Filed: **Jan. 27, 2010**

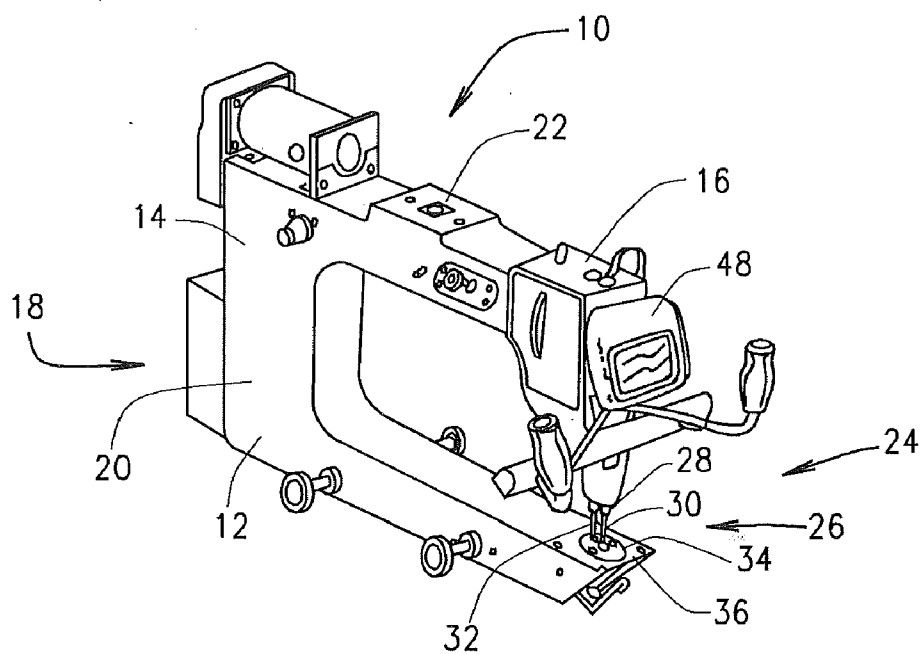


FIG. 1

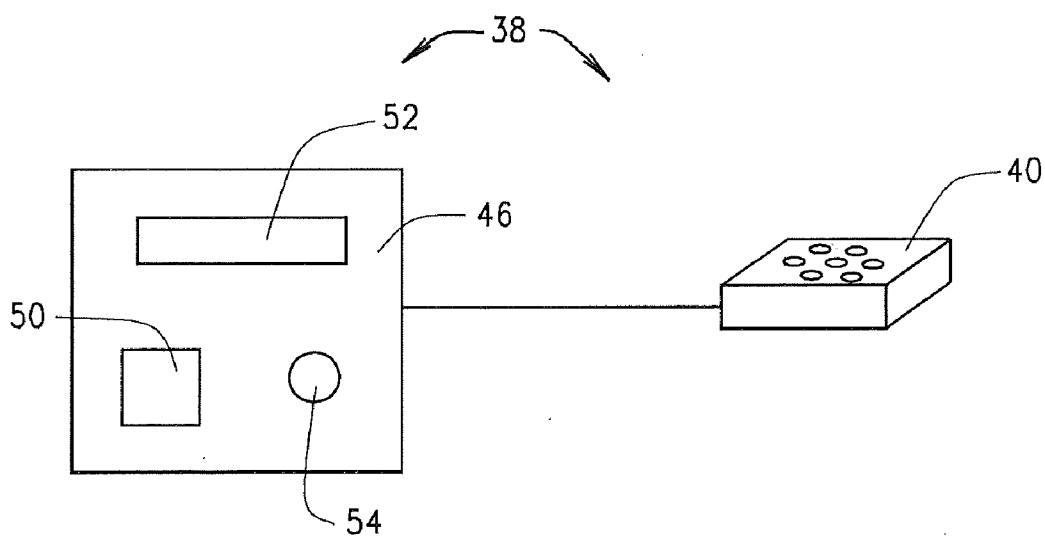


FIG. 2

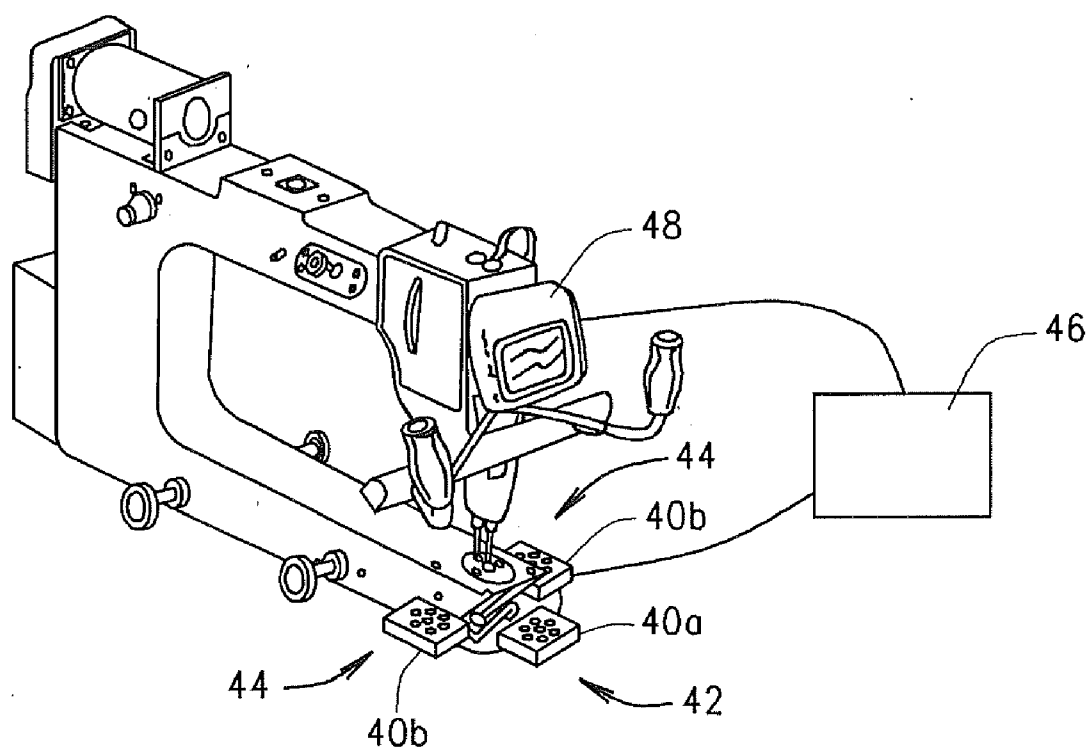


FIG. 3

GENERAL ALGORITHM FLOW

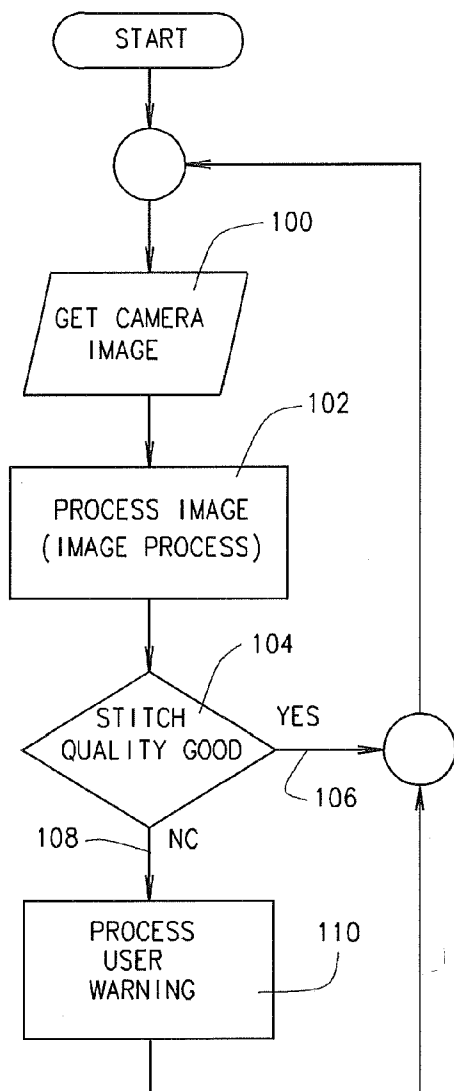


FIG. 4

IMAGE PROCESS

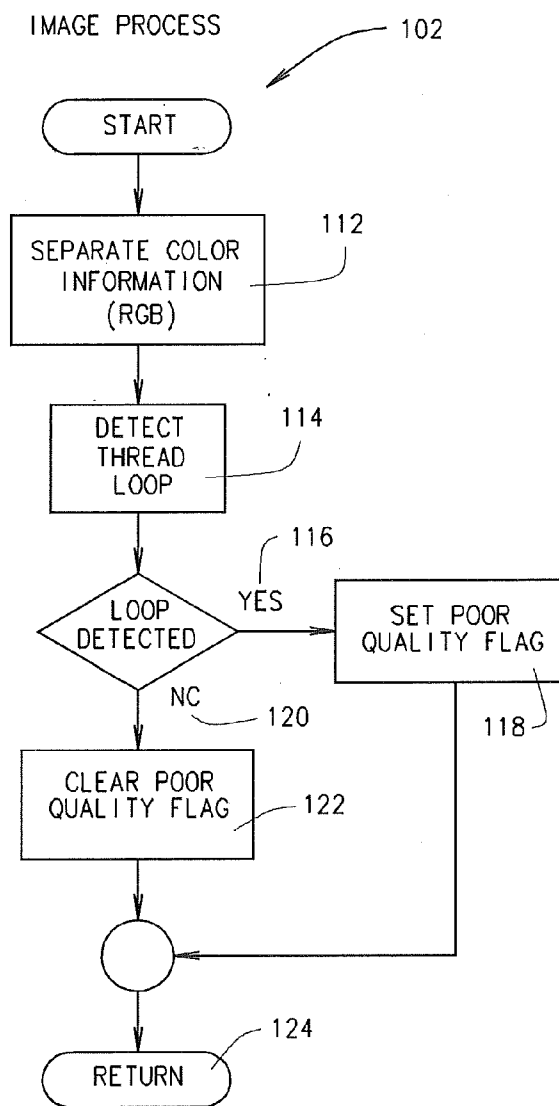


FIG. 5

STITCH QUALITY MONITORING SYSTEM

CROSS REFERENCE

[0001] This application claims the priority of provisional application Ser. No. 61/147,517, filed Jan. 27, 2009.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to long-arm stitchers and, more particularly, to a stitch quality monitoring system for long-arm stitchers.

[0004] 2. Related Art

[0005] Conventional long-arm sewing machines are generally used for quilting and/or sewing fabrics that are not easily moved through a sewing machine. In particular, quilts generally include two outer layers and a filler material that is sewn between the outer layers. Accordingly, to limit the amount of fabric movement when quilting, long-arm sewing machines are typically mounted on a pair of rails that allow the operator to move the needle of the machine while keeping the quilt stationary.

[0006] However, the fabric thickness can cause the fabric to bunch during movement of the needle and/or may cause erratic feeding of the fabric through the needle. Moreover, the filler being stitched into the quilt is often uneven, thereby adding to sewing difficulties and creating difficulty for the operator to follow a stitching pattern, especially when the pattern is not straight. As such, the stitching in the quilt may become uneven and/or may have variable stitch lengths. Additionally, the sewing thread may break and/or loop undesirably when the speed of the machine is adjusted.

[0007] Typically, stitch quality is monitored visually by the operator of the machine. For example, U.S. Pat. 6,260,495, issued to Stewart, describes a monitoring system for a sewing machine that includes a camera to provide images of the article being sewn on a monitor. The image is held for approximately two or three seconds while a worker visually inspects a quality of the hem. In the event the worker sees a hem that is defective, the worker can hit an on/off switch to stop the sewing machine. Unfortunately, such monitoring systems are subject to human error and can often allow undesirable stitching to go undetected and/or slow the sewing process.

[0008] As such, it is desirable to have a sewing machine capable of monitoring and analyzing the stitching in a quilt as the quilt is assembled.

SUMMARY OF THE INVENTION

[0009] A stitcher is provided for placing stitches in a fabric. The stitcher includes a monitoring system having at least one sensor positioned below the fabric and angled toward a needle of the stitcher to monitor the stitches placed in the fabric. A microcontroller communicates with the sensor and is programmed with software that analyzes images of the stitches acquired by the sensor. The images are compared with a predetermined set of parameters stored in a memory associated with the microcontroller. These parameters may be either hardcoded in the memory and/or input by a user of the stitcher. When the attributes of the monitored stitches fall outside of the predetermined set of parameters, the stitcher is stopped. The microcontroller then notifies the user as to which parameter has not been met by the stitches. In one embodiment, a monitor is provided to display images of the

stitches for manual stitch analysis and/or to display the parameters that have been violated by the stitches.

[0010] The stitcher may be a long-arm stitcher or a standard sewing machine that is configured for either commercial or household use. In the exemplary embodiment, the attributes of the stitches that are analyzed include any one of stitch looping, thread bunching, stitch length, and/or a distance between stitches. The system may also be configured to notify the user if no stitch is detected.

[0011] These aspects are merely illustrative of the innumerable aspects associated with the present invention and should not be deemed as limiting in any manner. These and other aspects, features and advantages of the present invention will become apparent from the following detailed description when taken in conjunction with the referenced drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Reference is now made more particularly to the drawings, which illustrate the best presently known mode of carrying out the invention and wherein similar reference characters indicate the same parts throughout the views.

[0013] FIG. 1 is a perspective view of a standard long-arm stitcher.

[0014] FIG. 2 is a schematic view of a monitoring system that may be used with the long-arm stitcher shown in FIG. 1.

[0015] FIG. 3 is a schematic view of the monitoring system shown in FIG. 2 in use with the stitcher shown in FIG. 1.

[0016] FIG. 4 is an algorithm of a monitoring process performed by the monitoring system shown in FIG. 2 to analyze a quality of stitches created by the stitcher shown in FIG. 1.

[0017] FIG. 5 is an algorithm of image processing performed by the monitoring system shown in FIG. 2 to acquire images of the stitches created by the stitcher shown in FIG. 1.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0018] In the following detailed description numerous specific details are set forth in order to provide a thorough understanding of the invention. However, it will be understood by those skilled in the art that the present invention may be practiced without these specific details. For example, the invention is not limited in scope to the particular type of industry application depicted in the figures. In other instances, well-known methods, procedures, and components have not been described in detail so as not to obscure the present invention.

[0019] FIG. 1 illustrates a standard long-arm stitcher 10 including a base 12, an arm 14, and a take up lever box 16. Although the present invention is described with respect to a long-arm stitcher, one of ordinary skill in the art would recognize that the present invention is also applicable to standard sewing machines. Moreover, the present invention is capable of operating with both commercial and household long-arm stitchers and sewing machines. The arm 14 is coupled to the base 12 at a back end 18 of the stitcher 10. A first portion 20 of the arm 14 extends upward from the base 12, and a second portion 22 of the arm 14 extends from the first portion 20 substantially parallel to the base 12. The take up lever box 16 is disposed on the arm 14 at a stitching end 24 of the stitcher 10 that is opposite the back end 18. The stitching end 24 of the stitcher 10 forms a workspace 26 where a fabric is stitched by an operator of the stitcher 10. The stitching end includes a needle bar 28 having a needle 30 inserted therein and a hop-

ping foot 32 each extending downward toward a needle plate 34 disposed on the base 12. The needle plate 34 is attached to a square throat plate 36. The throat plate 36 is configured to be removed to provide access to a rotary hook assembly (not shown) positioned within the base 12 below the throat plate 36.

[0020] During operation, the needle bar 28 moves up and down thereby moving the needle 30 to form a stitch in the fabric. The needle bar 28 can be adjusted up or down to provide a proper machine timing height. A small hole in the needle plate 34 restricts movement of the thread as the stitch is formed. The hopping foot 32 raises and lowers with the movement of the needle 30 to press and release the fabric as the stitch is formed. The hopping foot 32 is designed to be used with rulers and templates and has a height that can be adjusted for proper stitch formation. A control box 48 is provided to control the operation of the stitcher 10.

[0021] FIGS. 2 and 3 illustrate a monitoring system 38 used with the stitcher 10 shown in FIG. 1 to monitoring a stitch quality during operation of the stitcher 10. Specifically, the monitoring system 38 is configured to detect and monitor stitches placed in the fabric as it is moved through the stitcher 10. The monitoring system 38 includes a sensor or camera 40 configured to be positioned adjacent the workspace 26 of the stitcher and below the fabric. In the exemplary embodiment, the sensor 40 is a complementary metal-oxide-semiconductor (CMOS) sensor that provides images of the stitches placed in the fabric as the fabric moves through the stitcher 10. As is well known in the digital arts, CMOS sensors accomplish the task of capturing light and converting it into electrical signals. A CMOS chip is a type of active pixel sensor made using the CMOS semiconductor process. Extra circuitry next to each photo sensor converts the light energy to a voltage. Additional circuitry on the chip may be included to convert the voltage to digital data. More specifically, the CMOS sensor as utilized in an embodiment of the disclosed monitoring system accumulates a signal charge in each pixel proportional to a local illumination intensity, serving a spatial sampling function. When exposure is complete, a charge-to-voltage conversion takes place in each pixel to create an image.

[0022] In another embodiment, the sensor 40 is any sensor or camera capable of detecting and monitoring the stitches as described herein, for example a charge-coupled device (CCD) sensor. A CCD is an analog device. When light strikes the chip it is held as a small electrical charge in each photo sensor. The charges are converted to voltage one pixel at a time as they are read from the chip. Additional circuitry in the camera converts the voltage into digital information. In short, a CCD sensor transfers each pixel's charge packet sequentially to a common output structure, which converts the charge to a voltage, buffers it and sends it off-chip as an image.

[0023] In the embodiment shown in FIG. 3, three sensors 40 are positioned adjacent to the workspace 26. Specifically, a first sensor 40a is positioned in front 42 of the workspace 26, and a pair of second sensors 40b are positioned on each side 44 of the workspace 26. Each sensor 40 is angled toward the needle 30 of the stitcher 10. In an alternative embodiment, the monitoring system 38 includes only sensor 40a positioned in front 42 of the workspace 26 and angled toward the needle 30. In another embodiment, the monitoring system 38 only includes sensors 40b positioned on each side 44 of the workspace 26. In yet another embodiment, the monitoring system 38 includes only one of the pair of sensors 40b. In each

embodiment, the sensors 40 are angled toward the needle 30 of the stitcher 10. The sensor 40 is configured to acquire images of the fabric and stitches as the stitches are placed in the fabric. These images are then transmitted to a microcontroller 46 in communication with the sensor 40.

[0024] The microcontroller 46 may be disposed adjacent to the stitcher 10 and, in the exemplary embodiment, is digitally interfaced with the sensor 40 and electronically coupled to the control box 48. In alternative embodiments, the microcontroller 46 may be physically coupled to the stitcher 10 or positioned remotely from the stitcher 10 and coupled to the sensor 40 and control box 48 in a wired or wireless manner. The microcontroller 46 is configured to analyze attributes of the stitches detected by the sensor 40 to determine if the attributes fall within a set of predetermined parameters that are defined for the stitches. Specifically, the microcontroller 46 includes a processor 50 programmed with software that analyzes images of the stitches taken by the sensor 40 to compare the attributes of the detected stitches with the predetermined set of parameters. In an embodiment including more than one sensor, the images from each sensor may be combined prior to analysis or each image may be individually analyzed. In the exemplary embodiment, the processor 50 is programmed with American National Standards Institute (ANSI) C software; however, as will be appreciated by one of ordinary skill in the art, the processor may be programmed with any software capable of analyzing the image as described herein.

[0025] In the exemplary embodiment, the attributes analyzed by the microcontroller 46 include the stitch looping and stitch bunching. For example, the microcontroller 46 determines if the stitch looping includes a predetermined amount of thread and/or a predetermined tightness and if a correct amount of thread is being run through the needle. In other embodiments, the microcontroller 46 can be programmed to determine if there is no stitch present in the fabric or if the stitch length and distance between the stitches falls within predetermined parameters. The predetermined parameters are hardcoded in the processor 50 based on a desired stitch length and/or thread size. Alternatively, the predetermined parameters may be programmed by a user prior to operation of the stitcher 10. Accordingly, the monitoring system 38 allows for automatic detection of the stitches without user intervention. Further, the monitoring system 38 may be customized based on the stitch length and thread size. In the exemplary embodiment, the microcontroller 46 has the ability to save features embedded in the video in non-volatile and/or volatile memory that is used to compare the current stitch with the predetermined parameters for the purpose of "GOOD/BAD" stitch detection. Specifically the features of the stitch are seen as point to point lines of constant contrast in a video array output. This point to point line is analyzed to determine if the stitch is good or bad. For example, the criteria for "GOOD/BAD" may be the detection of the presence or absence of a loop from point to point. If the point to point line is straight, no loop is present and the stitch is flagged as "GOOD". If the point to point line is not straight and loops from point to point, the stitch is flagged as "BAD".

[0026] The algorithms shown in FIGS. 4 and 5 illustrate the steps taken by the monitoring system 38 during operation of the stitcher 10. As the fabric is run through the stitcher 10, the microcontroller 46 automatically analyzes each stitch placed in the fabric. Specifically, at step 100 an image of each stitch is taken by the sensor 40 as the fabric passes through the

workspace 26. The image is then processed at step 102 following the algorithm set forth in FIG. 5. At step 104, the microprocessor 46 determines whether the stitch quality falls within the predetermined parameters. If the stitch quality falls within the predetermined parameters 106, the microcontroller begins analyzing the next stitch. If the stitch quality falls outside of the predetermined parameters 108, a user warning is initiated 110. In one embodiment, the stitcher 10 is stopped and a notification is sent to the user via a monitor 52. The notification includes an analysis of what parameters have been violated by the stitch. The user is then able to adjust the stitcher 10 accordingly to correct the errors in stitching. When the error is corrected, the stitcher 10 is restarted and the microcontroller 46 continues to analyze each stitch. In the exemplary embodiment, the notification displays a description of each parameter violated on the monitor 52. Alternatively, the notification may be an alarm, a light, and/or any other audio/visual notification. Further, in an alternative embodiment, the user can manually inspect the stitching on the monitor 52 to determine which parameters have been violated. In one embodiment, the user manually stops the stitcher 10 using a switch 54. Although, the monitor 52 and the switch 54 are illustrated as being integral with the monitoring system 38, as will be appreciated by one of ordinary skill in the art, these features may be separate from and electronically coupled to the monitoring system 38.

[0027] FIG. 5 illustrates an algorithm of the image processing step 102. Upon initiation of the image processing step 102, color separation 112 is performed to maximize the contrast between the fabric and the thread. Next, the microprocessor 46 detects 114 loops in the stitch by analyzing the thread line. Specifically, loops in the stitch are detected 114 as curves rather than straight lines which indicate a proper stitch. If a loop is detected 116, a poor quality flag is set 118 to initiate 110 the user warning. If a loop is not detected 120, the poor quality flag is cleared 122 and the microprocessor 46 begins analyzing the next stitch 124. Although the algorithm shown in FIG. 5 is described with respect to determining loops in the stitch, as will be appreciated by one of skill in the art, the same algorithm is also used to monitor each of the predetermined parameters being analyzed by the microprocessor 46.

[0028] Accordingly, the present invention provides real-time analysis of stitches placed in a fabric by notifying a user of the stitcher 10 when a stitch quality falls outside of predetermined parameters. As such, the present invention provides a more cost efficient means of correcting stitch errors, thereby reducing costs associated with wasting or re-stitching incorrectly prepared fabrics.

[0029] As various modifications could be made to the exemplary embodiments, as described above with reference to the corresponding illustrations, without departing from the scope of the invention, it is intended that all matter contained in the foregoing description and shown in the accompanying drawings shall be interpreted as illustrative rather than limiting. Thus, the breadth and scope of the present invention should not be limited by any of the above-described exemplary embodiments, but should be defined only in accordance with the following claims appended hereto and their equivalents.

What is claimed is:

1. A monitoring system for a stitcher, said monitoring system comprising:

a sensor positioned adjacent to a workspace of the stitcher and below a fabric positioned within said workspace, said sensor configured to detect stitches placed in the fabric and create images of each detected stitch as said stitcher operates;

at least one predetermined parameter relating to at least one attribute of said detected stitches;

a microcontroller in communication with said sensor;

a memory in communication with said microcontroller, said at least one predetermined parameter being stored in said memory;

said microcontroller being configured to receive said images from said sensor, isolate said at least one attribute of each said detected stitch in said images, and to compare said at least one attribute to said at least one predetermined parameter during operation of said stitcher;

means for notification in communication with said microcontroller to notify a user of said stitcher if said at least one attribute of said detected stitch falls outside of said at least one predetermined parameter.

2. The monitoring system as set forth in claim 1, wherein said sensor is a CMOS sensor.

3. The monitoring system as set forth in claim 1, wherein said sensor is digitally interfaced with said microcontroller.

4. The monitoring system as set forth in claim 1, wherein said sensor is positioned to a side of said workspace and angled toward a needle of said stitcher to detect said stitches.

5. The monitoring system as set forth in claim 1, wherein said sensor is positioned in front of said workspace and angled toward a needle of said stitcher to detect said stitches.

6. The monitoring system as set forth in claim 1 further comprising a plurality of sensors configured to detect said stitches.

7. The monitoring system as set forth in claim 6, wherein said microcontroller is configured to analyze images received from each of said plurality of sensors and to compare said images to said at least one predetermined parameter.

8. The monitoring system as set forth in claim 1, wherein said predetermined parameters are hardcoded in said memory and said memory is integral with said microcontroller.

9. The monitoring system as set forth in claim 1, wherein said predetermined parameters are input by a user of said stitcher prior to beginning operation of said stitcher.

10. The monitoring system as set forth in claim 1, wherein said at least one said attribute of said detected stitches is selected from the group consisting of a stitch length, a size of thread used to make said stitches, stitch looping, thread bunching, stitch length, and a distance between stitches.

11. The monitoring system as set forth in claim 1, wherein said means for notification further comprises an audio/visual device.

12. The monitoring system as set forth in claim 1, wherein said microcontroller is configured to automatically stop operation of said stitcher when said at least one attribute of said detected stitch falls outside of said at least one predetermined parameter.

13. A monitoring system as set forth in claim 1, further comprising a monitor configured to display an image of each detected stitch to a user.

14. A stitcher comprising:

a needle configured to place stitches in a fabric that is moved through said stitcher;

a first sensor positioned below said fabric to monitor said stitches while said stitcher operates;

a microcontroller in communication with said first sensor and configured to receive data from said first sensor, to compare at least one attribute of said monitored stitches to at least one predetermined parameter relating to said at least one attribute based on said data received from said first sensor, and to determine if said at least one attribute of said monitored stitches satisfies said at least one predetermined parameter, wherein, when said at least one attribute of said monitored stitches falls outside of said at least one predetermined parameter, a user of said stitcher is notified while said stitcher is in operation.

15. The stitcher as set forth in claim **14**, wherein said stitcher is one of a long-arm stitcher and a standard sewing machine.

16. The stitcher as set forth in claim **14**, wherein said at least one attribute is selected from the group consisting of a stitch length, a size of thread used to make said stitches, stitch looping, thread bunching, stitch length, and a distance between stitches.

17. The stitcher as set forth in claim **14**, further comprising at least a second sensor positioned below said fabric and also in communication with said microcontroller, wherein said microcontroller is configured to receive data from said second sensor and to compare said at least one attribute of said

monitored stitches to said at least one predetermined parameter based on said data received from said second sensor.

18. A method of operating a stitcher, said method comprising:

positioning a sensor below a fabric moved through said stitcher;

monitoring, with said sensor, stitches placed in said fabric by said needle;

communicating data relating to at least one attribute of said monitored stitches from said sensor to a microcontroller in communication with said sensor;

comparing, in said microcontroller, said at least one attribute of said monitored stitches with at least one predetermined parameter relating to said at least one attribute during operation of said stitcher; and

notifying a user of said stitcher if said at least one attribute of said monitored stitches falls outside of said set of predetermined parameters.

19. The method as set forth in claim **19**, wherein the step of comparing said at least attribute of said monitored stitches with said at least one predetermined parameter further comprises comparing at least one attribute selected from the group consisting of a stitch length, a size of thread used to make said stitches, stitch looping, thread bunching, stitch length, and a distance between stitches.

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