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Application of Artificial Intelligence in Textile Industry

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Abstract

Textile manufacturing industry is labour-intensive, which is characterized by high-fixed capital investment; a wide range of product designs and, hence, input materials; variable production volumes; high competitiveness; and often high demand on product quality. To cater these demands, the labour-intensive processes should be converted into automated processes accomplished by the use of computers, models, digital components, and artificial intelligence (AI). AI is the field of study that deals with the synthesis and analysis of computational agents that act intelligently. In this proposition various applications of AI in textile manufacturing industry have been described. And also includes different types of AI such as expert systems, neural network, fuzzy logic, genetic algorithm, and other approaches used in textile and garment manufacturing.

Keywords Artificial intelligence Defect identification: Pattern inspection: Colour matching:

1. Introduction

Textile manufacturing is a major industry. It is largely based on the conversion of fibre into yarn, yarn into fabric. These are then dyed or printed, fabricated into clothes which are then converted into useful goods such as clothing, household items, upholstery and various industrial products.

Different types of fibres are used to produce yarn. Cotton remains the most important natural fibre, so is treated in depth. There are many variable processes available at the spinning and fabric-forming stages coupled with the complexities of the finishing and colouration processes to the production of a wide range of products.

Artificial intelligence is becoming an important tool for the processors to enhance quality, increase production, lower operating costs and exercise inhouse control over production amounting to shorter lead times.

Textile industry in developed countries has started exploiting artificial intelligent (AI) techniques to their advantage. It is time that we should use these techniques. AI systems are one of the hopeful benefits available to textile industry to integrate the elements such as production, quality, cost, information, statistical process control, and just-in-time manufacturing. The textile industry must constantly seek to improve quality, increase production and lower operating cost. A decade ago, the main emphasis was only on production but not anymore. Now along with the production, quality, cost, information, statistical process control, Justin-time manufacturing and computer integrated manufacturing all play an equally important role.

AI techniques transform large amounts of quantitative data into intelligible classification, by spotting trends and patterns. Until recently the primary means of spotting trends was through the statistical methods such as statistical clustering and regression. Now, AI techniques are in many cases outperforming traditional statistical techniques. Textile industry and research institutions have started realising the potential of these techniques, especially in the areas such as fabric inspection and planning in garment manufacturing, where even very marginal improvements in performance translate into large financial gains.

AI can be used in various processes of textile production such as fibre grading, prediction of yarn properties, fabric fault analysis, and dye recipe prediction. Similarly, AI can be applied in all the stages (preproduction, production, and postproduction) of textile manufacturing.

2. Industry 4.0 Revolution in Textile Industry

In manufacturing, Industry 4.0 is the name given to this era of manufacturing, where computers and software have become essential parts of the production process. To understand the foundations of Industry 4.0, you have to look back to the history that preceded it.

Production companies are facing the fourth iteration in a series of major industry shifts. Each evolution has brought on improvements by way of new technologies, systems and advancements in manufacturing. From the beginning stages of mass production to the modern era and beyond, every method has been enhanced in some way. The four periods in manufacturing history thus far are:

i. The Industrial Revolution 1.0: Manufacturers used water and steam power to create the first methods of mechanized production.
ii. Industry 2.0: Companies advanced to using electric machinery and assembly lines for mass production that was more efficient
iii. Industry 3.0: The third iteration began with the inclusion of computers and information technology, including micro-processing, programming and telecommunications.
iv. Industry 4.0: Currently, the manufacturing industry relies on the same information technology, but with many more improvements. It focuses on creating digital connectivity and full integration of production processes with hardware and software. Industry 4.0 enhances the foundation of 3.0 with autonomous systems fuelled by data and machine learning, lessening the need for intensive human involvement and creating smart factories.

While Industry 4.0 is the current period in the evolution of manufacturing, it will always continue to grow and change. It's important to keep up with the shifting trends and make sure your company can adapt to the new modes of production. If you resist the changes, you'll miss out on the many benefits that come with each new development.

Industry is the part of an economy that produces highly mechanized and automatized products. The term 'Industry 4.0' is originated from a project, promoting the computerization of manufacturing in the high-tech strategy of the German government dated back to 2011. Industry 4.0 is a new level of value chain organization and management that integrates complex physical machinery and devices with interconnected sensors and software which predicts, controls and plans for better business and societal outcomes. The objectives of Industry 4.0 are to achieve a higher level of operational efficiency and productivity, with a higher level of automatization. In an 'Industry 4.0' context, factory, besides monitoring and fault diagnosis (done in traditional industries), components and systems are able to gain self-awareness and self-predictiveness, providing management with more insight on the status of the factory.

Industry 4.0 is the future of manufacturing technologies and is increasingly important trend in automation and data exchange. This enhanced technology, digital systems and automated processes will make it optimum for manufacturing of quality products.

Five key features of Industry 4.0 are digitization, optimization, and customization of production; automation and adaptation; human machine interaction (HMI); value-added services and businesses, and automatic data exchange and communication. This fourth industrial revolution encapsulates future industry development trends to achieve more intelligent manufacturing processes.

Smart textile products hold large growth potential. According to market forecasts, the global market for smart textiles will grow to about USD 3 billion by 2026. For the mass production of smart textile products, the hybrid and typically highly fragmented value chains are required to become increasingly interconnected, which is achievable by Industry 4.0 developments.

3. Application of AI in textile industry

AI can be used in various processes of textile production such as fibre grading, prediction of yarn properties, detection of fabric faults, and dye recipe prediction. Similarly, AI can be applied in all the stages of garment production such as preproduction, production, and postproduction operations

Defects in fabric reduce the value of textile products. To counter this problem, Artificial Intelligence techniques such as Artificial Neural Network (ANN) are applied for defect identification in fabric inspection of textile industry. The images to be analysed are obtained from image acquisition system and saved in relevant standard format (JPEG, PNG etc.). Features are extracted from the acquired image and feature selection method is used to reduce the dimensionality of feature set by creating new feature set of smaller size that are a combination of old features. Multi-Layer Back Propagation algorithm is used to train and test the ANN.

3.1. AI on fibre properties

High performance computerised system of artificial intelligence conceived for the analysis of fibres properties and structure. Equipment suitable to perform in a fast and easy way the fineness analysis of single fibres; identify the different fibres contained in a blend and analyse the composition percentage; check the purchased material and identify the type of fibre; analyse the yarn structure and detect possible defects; measure the count of circular section yarns and filaments in Dtex or den; check and measure the quality and shape of Lycra or synthetic multifilament single threads; analyse the compactness of non-woven fabrics; analysis of yarn and fibre sections; measure section surfaces and perimeters; analyse mechanical parts (i.e. needle points, spinnerets, etc); process, store and print the produced measurements and the minimum, medium and maximum values, CV% and distribution graphs.

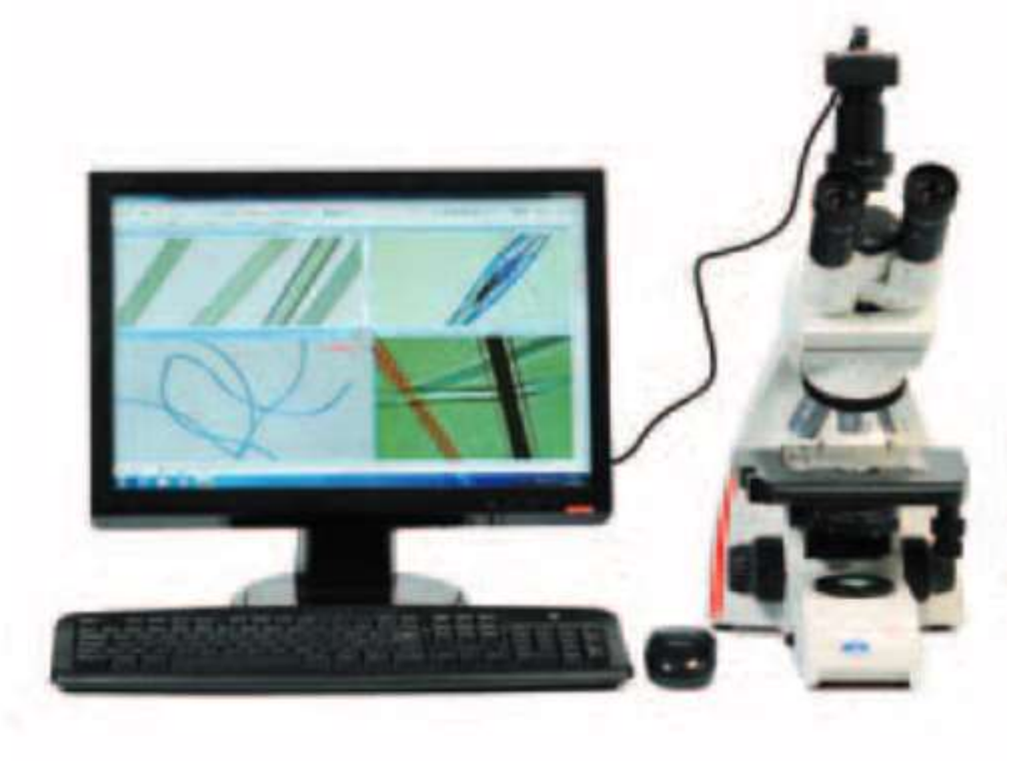

Fig.1. fibre morphological identification

3.2.AI on Yarn spinning

In the textile industry, the “yarn” means the general term “yarn” and “thread”. Arrange many short fibres or filaments in an approximate parallel state and twisted along the axis to form a slender object with a certain strength and linear density, which is the “yarn”; the “thread” is strands of two or more single yarns. There are different properties that are affect yarn quality. A major factor affecting yarn evenness is the evenness of the slivers from which they are produced. The sliver evenness is generally controlled by the auto-levellers mounted on the majority of the modern carding and draw frames. The distance between the scanning rollers pair and the point of draft is called the Levelling Action Point (LAP). The value of the LAP is one of the most important parameters determining the performance of auto-levellers. The accurate adjustment of this point should lead to an exact correction of the defective material monitored by the auto-levelling system. This parameter is affected by a large number of material and production parameters. The selection of the suitable value of LAP is therefore very complicated and requires the consideration of all or at least the most relevant influencing parameters.

Sliver evenness is a very important parameter affecting the quality of the yarn produced. Therefore, controlling the sliver evenness is of major importance. Auto-levellers mounted on modern Carding and Drawing Frames should be accurately adjusted to help to achieve this task. The Levelling Action Point (LAP) is one of the important auto-leveling parameters which highly influence the evenness of the slivers produced. Its adjustment is therefore of a crucial importance. There for Artificial Neural Networks are applied to predict the optimum value of the Levelling Action Point under different productions and material conditions.

On auto-leveller draw frame Tongue and Grove rollers, pneumatic transducers and other devices are used for online monitoring of sliver weight. Infect, auto-leveller at high-speed drawing frame helped a lot in producing regularities in sliver by detecting the variations at feeding point and by synchronization in quick control of weight per yard of the material. Efficiency of the control varies with auto-leveller model and technology. The auto-leveller at drawframe act on open control loop principle. According to this principle, the thickness of the arriving sliver is measured with a groove and tonge roller. The measured values are stored until the measured sliver reaches the drafting point in the main drafting area. At this moment the amount of draft size is changed by highly dynamic servo derive motor. This can even balance the smallest deviations.

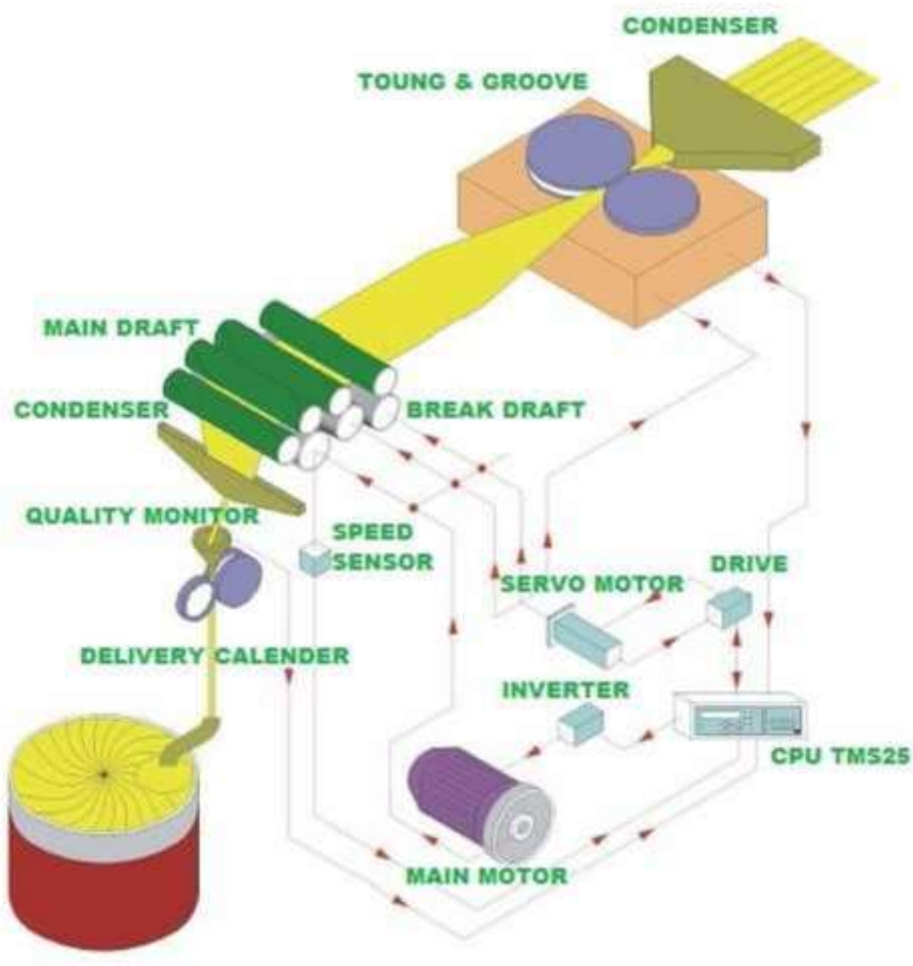

Fig.2. yarn evenness controlling in draw frame

One of the main tasks of the draw frame is to improve evenness over short, medium and long terms. Card sliver fed to the draw frame have a degree of unevenness that can not be tolerated in practice and slivers from the comber contain the infamous piecing these must be obscured. It should be noted however that short wave sliver evenness is not as sometimes assumed, the sole criterion for evaluating the performance of draw frame. It is true that unevenness over short length can be noticeably reduced by narrow settings of the drafting arrangement. But this is often associated with deterioration in others quality parameters of yarn. Drafting is an indispensable stage in yarn formation and plays a critical role in yarn quality. Each drafting process from carding to spinning introduces its irregularities to the product and these irregularities degrade the final textile product.

3.3. AI on Yarn quality and defect detection

The yarn has a stable quality only when it formed by the fibre of close length and relatively uniform. In order to get such fibres, the fibres from different production areas and batches must be mixed together. Use cotton opener, cotton mixer and cotton cleaning machine to open, remove and mix all kinds of fibres. In this process, most dust and impurities are removed by gravity and centrifugal force.

Compared with the yarn produced by the intermittent system, the yarn produced on the automatic unit is more uniform and stronger. In addition, the continuous production speed of the automatic unit is higher, the manpower is saved, and the factory is cleaner. No matter what processing system is used, the final quality of yarn mainly depends on the selection of raw materials and the thoroughness of cotton opening, removing impurity removal and cotton blending.

Standard production parameters from blow room lap to finished yarn production were maintained during the whole spinning process of 40Ne, 50Ne and 60Ne ring spun yarn of 35% cotton and 65% polyester blended yarn produced from same quality cotton and polyester fibre and sliver blending process was continued in draw frame stage of spinning. 40Ne, 50Ne and 60Ne ring spun yarn of 35% cotton and 65% polyester blended yarn were tested with Uster Machine to find the variation of three types of yarn considering the major parameters of yarn qualities like irregularity or unevenness (U%), coefficient of variation of mass (CVm%) and hairiness of spun yarn. Relative humidity (RH%) and temperature was given the result by the machine.

Fig.3. yarn quality tester

3.4. AI Weaving process

Although weaving machine manufacturers have made progress toward producing digital machines that are Industry 4.0-ready, more still needs to be done. Weavers are looking for machines with automatic warp break repair; a fully automated start mark prevention mechanism that does not need operator intervention; fully automated style changes; automatic formation of flexible integrated circuits for smart e-textiles; multiphase weaving machines for dobby and jacquard weaving; and variable width/warp density jacquard weaving to overcome the current speed limit of single-phase weaving machines.

The road to Industry 4.0 also requires systems to collect and store large amounts of digital data, use of IoT to allow machine manufacturers to access and process big data using AI and analytics to diagnose and predict disruptive issues, development of robotics to complete automation, etc. It should be pointed out that the upstream yarn manufacturing and downstream — fabric finishing, conversion to products, and marketing — should be integrated with weaving since all data are correlated starting from fibre and ending with the market. One major issue manufacturer is concerned about is the compromise of data and intellectual property (IP), which is an impediment to the road to Industry 4.0. The textile industry is global and diversified and there is a need for global laws to protect manufacturers' data and IP from hackers.

Electronics have always been a key factor in the development of science and technology. In the last decade, textile industry has entered a new era of electronics, microprocessors, information technology and their application to the production of woven fabrics. The contribution of microelectronics has be-come more remarkable in case of air jet weaving and jacquard designing. The manufacturers of various types of shuttle less looms have made the best use of the great potential offered by the use of electronics and microprocessors for the automation of following functions on the loom:

- machine speed efficiency,
- weft entry angle,
- cause of stoppage,
- machine running and down time,

- total number of stoppages and their nature, display of trouble shooting messages on the screen and suggestion for action,
- machine variables adjustment,
- starting, stopping and reverse position,
- electronic weft insertion control,
- automatic pick finder,
- automatic weft breakage repair,
- automatic faulty pick removal, in case of air jet loom: (i) auto setting and opening of valves, and (ii) measurement of weft insertion velocity and control of main nozzle,
- Transfer of messages and storage and production of vital data,
- machine settings for weave, colour and colour pattern,
- automatic package switches over,
- electronic let-off and take-up,
- automatic speed control inverters,
- automatic stop mark preventer,
- automatic cloth doffing, and
- automatic package supply system.

AJI the machine functions mentioned above are monitored and controlled and some of them can be optimized by the multifunction microprocessor and also by using suitable software with PC-link. The microprocessor also allows bidirectional communication, enabling the dialogue between the weaving machine and production management system. The adaptation of electronics to various functions has simplified numerous manual interventions, leading to improvement in the general management of the weaving process.

Fig.4. Electronic Rapier Jacquard Loom

3.5. AI on Fabric quality and defect detection

Fabric texture refers to the feel of the fabric. It is rough, velvety, smooth, soft, silky, lustrous etc. The different textures of the fabric depend upon the types of weaves used. Textures are given to all types of fabrics, cotton, silk, wool, leather, and also to linen. Textile Fabric materials are used to prepare different categories and types of Fabric products in the textile industry. Natural fabric and synthetic fabric are the two different classifications of textile fabric. Synthetic fabrics are fairly new and have evolved with the continuous growth in textile industry.

In a fabric, defects can occur due to Machine faults, Hole, Colour bleeding, Yarn problems, Scratch and Poor finishing.

There are different applications of computer vision and digital image processing in various applied domains and automated production process. In textile industry, fabric defect detection is considered as a challenging task as the quality and the price of any textile product are dependent on the efficiency and effectiveness of the automatic defect detection. Previously, manual human efforts are applied in textile industry to detect the defects in the fabric production process. Lack of concentration, human fatigue, and time consumption are the main drawbacks associated with the manual fabric defect detection process. Applications based on computer vision and digital image processing can address the abovementioned limitations and drawbacks. Since the last two decades, various computer vision-based applications are proposed in various research articles to address these limitations. In this review article, we aim to present a detailed study about various computer vision-based approaches with application in textile industry to detect fabric defects. The proposed study presents a detailed overview of histogram-based approaches, colour-based approaches, image segmentation-based approaches, frequency domain operations, texture-based defect detection, sparse feature-based operation, image morphology operations, and recent trends of deep learning. The performance evaluation criteria for automatic fabric defect detection is also presented and discussed. The drawbacks and limitations associated with the existing published research are discussed in detail, and possible future research directions are also mentioned. This research study provides comprehensive details about computer vision and digital image processing applications to detect different types of fabric defects.

The automation of visual inspection process is a multifaceted problem and requires complex interaction among various system components. If you have shown that the investment in the automated fabric inspection system is economically attractive when reduction in personnel cost and associated benefits are considered. The architecture of a typical automated textile web inspection system is shown in **Fig**. The system consists of a bank of cameras arranged in parallel across the web to be scanned, a computer console hosting (single or an array of) processors, the frame grabber, a lighting system and the supporting electrical and mechanical interfaces for the inspection machine. The inspection system employs massive parallelism in image acquisition with a front-end algorithm that reduces the data flow to the region of interest only. The key components of this system are briefly reviewed below:

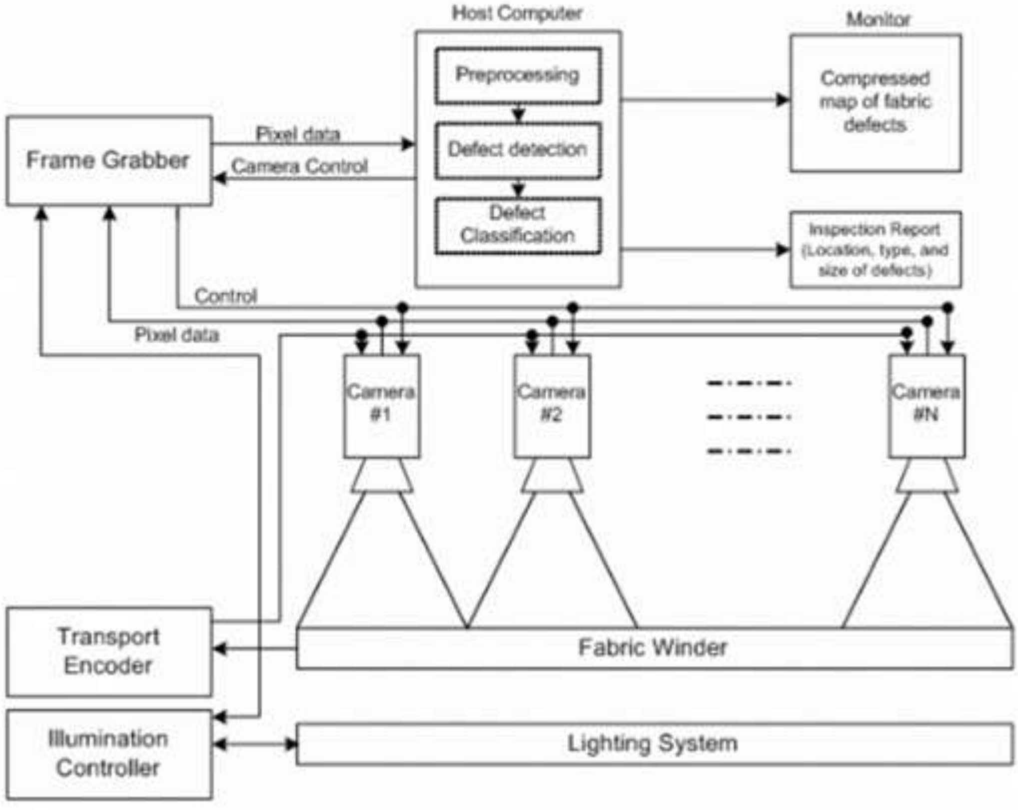

Fig.5. architecture of a typical automated visual inspection system for textile web

Lighting system: The quality of acquired images plays a vital role in simplifying an inspection problem. The image quality is drastically affected by the type and level of illumination. Bachelor has performed a comprehensive study of various lighting schemes for automated visual inspection. There are four common types of lighting schemes used for visual inspection i.e. front, back, fiber-optic, and structured. The backlighting eliminates the shadow and glare effects, and is used for fabric inspection. It is also possible to employ fibre optic illumination for the fabric inspection, as it provides uniform illumination of products without any shadow or glare problem. However, fibre-optic illumination is most expensive to realize and is not economical for 6-8 feet wide textile webs. A fuzzy logic control scheme using a feedback photo-resistor is sometimes used by the illumination controller to maintain a constant (within 1%) level of illumination.

Camera: A large variety of cameras with tremendous difference in sensor types, resolution, read out speed, accuracy and other features find their applications in the machine vision . The resolution of a camera is limited by the number of pixels in the camera photosensor and the object Field of View (FOV). The FOV is dependent on the characteristics of the background and the nature of defects to be detected.

There are two common types of scanning techniques employed for the fabric inspection cameras: line scanning and area scanning. The line scanning techniques utilize a system of linear array photosensors, and the resolution in the vertical direction is a function of the velocity of object (web) movement and the scan rate (line rate) at which the camera is operating. The modern line scan cameras usually provide very high resolution and can inspect a large portion of textile web in the single line scan. A transport encoder is always required for all line scan cameras to ensure synchronization of the camera scan rate with the transport velocity . The disadvantage with the line scan cameras is that they do not generate complete image at once and requires external hardware to build up images from multiple line scans. For area scan cameras, the usage of transport encoders is optional and the inspection resolution in both directions is independent of object (web) speed. At present, the cost of a line scan camera is very high and therefore an array of area scan cameras is commonly used to provide economical solutions for the web inspection problem. The state-of-the-art for the line scan and area scan cameras is available with CCD or CMOS photosensors. The photosensors with CMOS active pixel architecture provide higher level of on-chip functionality at lower cost and low power usage than those from the CCD ones. However, the CMOS sensors are generally less sensitive than their CCD counterparts, mainly due to higher uniformity and smaller fill factor. The inspection of fabric defects using CMOS area scan cameras, time-delay-and-integration (TDI) line scan cameras, have been attempted by researchers.

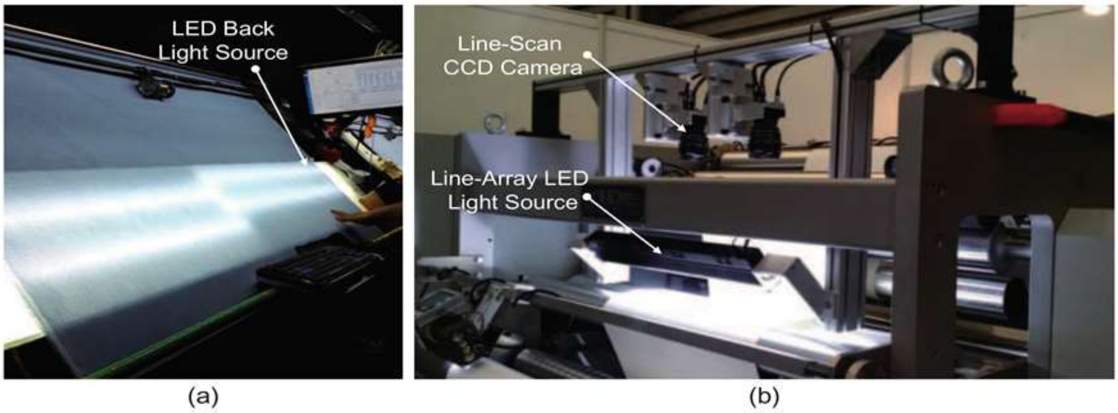

Fig.6. AI fabric defect inspection

Transport encoder: The transport encoder is used to provide master timing pulses for the camera. The wheel of the transport encoder is in direct contact with fabric winder. In case of line scan cameras, the resolution of the transport encoder (i.e. number of pulses per revolution) determines the pixel resolution. The line scan cameras can acquire crisp images at any speed by slaving camera scan rate to transport velocity . The velocity information from the transport encoder is also used to control any undesirable variation in the speed of shaft rollers.

Frame grabbers: The pixel data coming from each of the camera is converted into a digitized image by the frame grabber. All web inspection systems, such as the one used for fabric, have to cope with the multiple camera inputs. Some systems do this by using some kind of video multiplexer unit between the camera and the frame grabber. A rather expensive way to cope with multiple cameras is to use one frame grabber unit per camera . This permits parallel processing of image pixel data if the system is equipped with the multiple processors. The output from the frame grabber is transported to the host computer in any of the popular PC formats (ISA, VESA, PCI, etc.) or industrial bus formats (VME, PICMG, PC100, etc.).

Host computer: The functions of the host computer can be classified into three main categories.

i. Defect detection and classification: The image data from the frame grabbers is downloaded into the host computer. The host computer is responsible for processing this image data for defect detection using sophisticated algorithms. The defects detected from the acquired image data are classified into several categories depending on their origin or size.

ii. Camera illumination and control: The host computer is responsible for the external loading of control setting parameters of the camera. These parameters are usually loaded at the power-up or operated manually through Graphical User Interface (GUI). The host computer is also responsible for the settings of the illumination controller, which controls the illumination level of web.

iii. System control: The host computer also performs several input and output system control functions. The functions in this category include Interrupt Service Routine (ISR), Graphical User Interface (GUI) and printing/storage of the compressed defect map etc.

A single general purpose host computer is insufficient to process high volume of image data acquired to inspect the textile web moving at the speed of 15-20 meters per minute. Therefore, most systems use a single separate processor to detect all defects present in images from an individual camera . Each of these processors usually requires additional DSP processors (such as TMS320C40 , AT&T 32C , etc.) for real time implementation of sophisticated defect detection algorithm. Each of the detected defects is classified into one of the several desired categories. Fabric defects are characterized by three types of uncertainty : Vagueness, Incompleteness and Ambiguity. Furthermore, large number of defect classes, inter-class similarity and intra-class diversity of fabric defects form major obstacles in their classification.

3.6. AI on colour matching

Colour is very important aspect of products for customers. The appearance of a product is perceived to be related to its quality. Like other industries this is also important in Textile industry. The colour of a product may be judged generally to be "acceptable" or "unsatisfactory", or it may be judged in more detail to be "too light", "too red" or "too blue". Such judgements can be made visually or instrumentally based on a perceived difference between an ideal product standard and a sample. When this difference is quantified, tolerances can be established.

While traditional colour tolerancing was done based on numeric descriptions of colour through" instrumental tolerancing systems", that method generally had a lot of false positives compared with visual inspections, causing delays in the approval process because of the need for careful human intervention. To counter this problem, an AI enabled platform, similar to Defect Identification, can be developed that has Pass/Fail (P/F) feature to help improve the accuracy and efficiency of instrumental tolerance.

This platform can take into account historical data of visual inspection results from human operators while creating the tolerances. The system can then be tested for new batches to automatically set AI tolerances, training the system to determine which samples pass and fail.

Fig.7. AI in textile colour matching

3.7. AI on garment manufacturing

Garment manufacturing" means sewing, cutting, making, processing, repairing, finishing, assembling, or otherwise preparing any garment or any article of wearing apparel or accessories designed or intended to be worn by any individual, including, but not limited to, clothing, hats, gloves, handbags, hosiery, ties.

Garment is known as a piece of clothing. Garment design and manufacturing is the combination of art and technology. Garment manufacturing has seen several advancements in design development, computer-aided manufacturing (CAD), and automation. However, the older version of garment manufacturing process is still the main theme today—that is, the cutting and joining of at least two pieces of fabric. The sewing machine has the function of joining woven or cut-knitted fabrics. Garments are mostly produced by sewing the pieces of fabric using a sewing machine. These machines are still based on the primary format used. Today the important topics in the current garment manufacturing industry range over product development, production planning, and material selection. The selection of garment design, including computer-aided design, spreading, cutting, and sewing; joining techniques; and seamless garment construction are beneficial in meeting the consumer needs. The development in finishing, quality control, and care-labelling of garment are meeting the point-of-sale requirements.

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Textile industry in developed countries has started exploiting artificial intelligent (AI) techniques to their advantage. It is time that we should use these techniques. AI systems are one of the hopeful benefits available to textile industry to integrate the elements such as production, quality, cost, information, statistical process control, and just-in-time manufacturing. The textile industry must constantly seek to improve quality, increase production and lower operating cost. A decade ago, the main emphasis was only on production but not anymore. Now along with the production, quality, cost, information, statistical process control, Justin-time manufacturing and computer integrated manufacturing all play an equally important role.

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Additive manufacturing is interesting for garment technology as it allows to work more easily on fashion designs and to create amazing things for the fashion industry such as garments, ornaments, and meshes. This technology is really giving a lot of freedom to the designers in terms of geometry.

The advancing technical possibilities in 3D printing and 3D scanning make developments possible that will revolutionize production and trade in the fashion and textile industry. Clothing and shoes will soon be coming out of the 3D printer in an individualized way, new possibilities will open up for functional textiles, and 4D printing will take the 3D process to a new level with fascinating applications.

Not only 3D printing, 3D technology itself is changing the entire value chain in the apparel industry from design and prototyping to the finished product and its delivery.

Up to now, the designer has designed a product with two-dimensional materials and then created one or more cost-intensive prototypes and sample collections before the product could go into mass production. These cost drivers can now be replaced by a virtual 3D simulation. The software is now mature enough to test cuts on virtual size avatars as well as colors and patterns. The folds and movement of the avatars are also realistically simulated

The 3D simulation makes the creation of the collection faster, more accurate and more cost-effective. If the prototype production is shortened, idle times and waiting times are eliminated and variants are possible at any time. This gives the company more flexibility and enables it to react much faster to new trends.

The data from the 3D scan serve as the basis for all other 3D applications. As soon as the data has been captured digitally - and thus three-dimensionally - the step to 3D printing is not far away and ultimately a logical consequence. The clothing purchase could then take place individually in the near future and look as follows:

- 3D scan of the own body

- Creating an avatar
- online testing
- Online 3D catwalk with your own avatar, possibly also with VR reality glasses
- Online type advice and clothing suggestions
- Online shopping of the 3D model
- 3D printing of the model

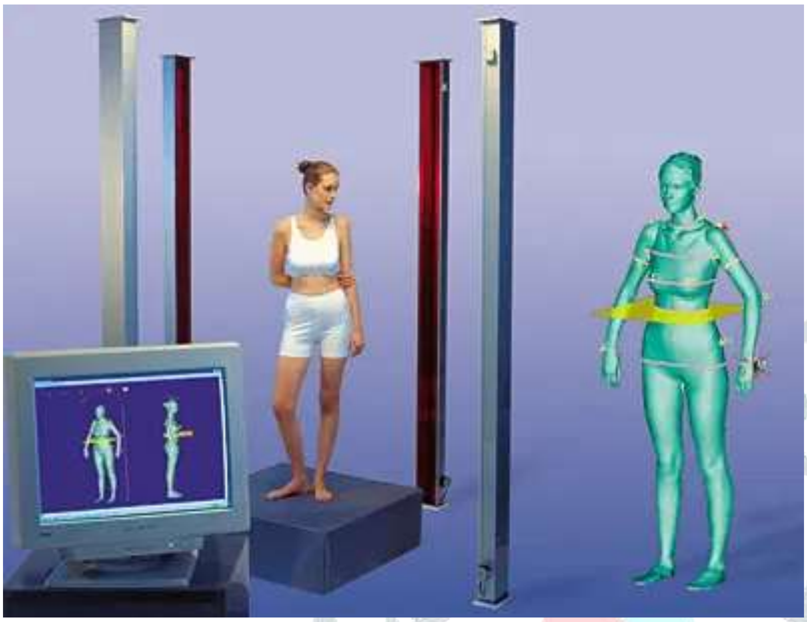

Fig.8. 3D garment scanning

4. Conclusion

The application of AI in textile technology is not still widespread, even in developed countries. potential AI technologies have great scopes to benefit textile industries in developing countries where production and quality control problems persist. The application of AI technologies in the textile industry is becoming visible as solving complex problems quickly and accurately is becoming key to competitiveness. The textile industry is a labour-intensive industry where many operations, including production and quality control, are predominantly handled by human hands. With AI innovation, attempts are made to develop technologies to improve efficiency and effectiveness in such operations. The concept of AI technology is based on basic actions like detection, identification, inspection, grading, machine vision, prediction, etc. All these actions are primarily done by humans, often considered tedious and often with ambiguous outcomes. AI can augment these basic actions' efficiency and accuracy with technologies and solve the problems and labour-intensive works.

References

1. King, H The clothing industry2000OxfordHeinemann Library48–48
2. Jacobs-Blecha, C, Ammons, J, Schutte, A, Smith, TCut order planning for apparel manufacturing
3. Guo, ZX, Wong, WK, Leung, SYS, Fan, JT, Chan, SF Mathematical model and genetic optimization for the job shop scheduling problem in a mixed- and multi product assembly environment: a case study based on the apparel industry Comput Ind Eng
4. Guo, ZX, Wong, WK, Leung, SYS, Fan, JT, Chan, SFA genetic-algorithm-based optimization model for solving the flexible assembly line balancing problem with work sharing and workstation revisiting
5. Automation in Garment Manufacturing by byRajkishore Nayak and Rajiv Padhye
6. https://clothingindustry.blogspot.com/2018/03/artificial-intelligence-apparel industry.html
7. https://textilelearner.blogspot.com/2020/07/application-of-artificial intelligence.html
8. http://stitchdiary.com/artificial-intelligence-apparel-industry/
9. http://www.cazerbud.pl/forum/b7nay.php?ff57e8=how-big-is-the-textile-industry
10. https://www.longdom.org/peer-reviewed journals/artificialintelligenceresearcharticles-56177.html
11. https://valiancesolutions.com/applications-artificial-intelligence-ai-textile-industry/
12. https://www.investopedia.com/terms/a/artificial-intelligence-ai.asp
13. Au, K, Choi, T, Yu, Fashion retail forecasting by evolutionary neural network sInt
14. Thomasson, S, Happiette, M, Castelain, JA short and mean-term automatic forecasting system - application to textile logistics J Oper
15. Koehl, L, Zeng, X, Camargo, M, Fonteix, C, Delmotte, FAnalysis and identification of fashion oriented industrial products using fuzzy logic techniquesProceedings of the 3rd International Conference on Intelligent Systems and Knowledge Engineering2008Xiamen, China,
16. Jaouadi, M, Msahli, S, Babay, A, Zitouni, BAnalysis of the modeling methodologies for predicting the sewing thread consumptionInt J Cloth Sci Tech20061
17. Ding, Y, Xu, YIntelligent optimal selection of garment sizes by using Immune Algorithm and AHP methodJ
18. Jones, RM The apparel industry2002Malden, MABlackwell Science, Inc.