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INTEGRATION OF COMPUTER VISION ON TO WEAVERS FOR QUALITY CONTROL IN THE TEXTILE INDUSTRY

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ABSTRACT

This paper presents an automatic system for quality control of fabrics. It is based on a linear vision machine designed to be integrated on to weavers. The aim is to detect and identify, in real time, faults in the fabric in order to perform on-line diagnosis of the weavers.

A solution based on a high-resolution linear multi-sensor device is proposed in order to cope with the small size of the flaws which occur on wide fabrics. A front-processor integrated on the acquisition board performs local operations on the successive line-images as they are captured by the multi-sensor device. Flaws are discriminated using a set of local detection operators and adaptive models. These models are use to extrapolate the image of the fabric, so that any flaw can be detected by comparing the actual image to this theoretical model. The so-detected flaws are identified by means of morphological filtering and using a syntactic classification scheme which discriminates the flaws.

Reports are periodically updated, so that the main computer which supervises the whole workshop can evaluate, in real-time, the quality of the production while controlling the weavers.

1. INTRODUCTION

The hard competition in the textile industry calls for integrated automation in order to decrease production cost while increasing the quality.

Now the production goes faster and faster with less and less workers in the workshop, so that traditional inspection techniques become inadapted to ensure a good quality of the fabrics. Visual inspection of randomly selected samples gathered among the production is not reliable enough to give a good image of the quality of the whole production. When a weaver begins to product flaws, the delay before the identification of the defective weaver with traditional visual inspection is about one week during that time, the weaver has produced about 2500 meters of fabric of poor quality.

This paper presents a new automatic system for quality control of fabrics at the weaver output. It is based on a vision machine designed to be integrated on to weavers. The aim of this project is to perform on-line diagnosis of the weavers and to detect and identify, in real time, faults in the fabric.

2. WEAVING LIMITATIONS AND FLAWS

The weavers are becoming more and more sophisticated. Microprocessors are often used to supervise all mechanics thanks to sensors and actuators. Simultaneously, sensors are specially developed to control the yarn supply and the behaviour of the process. However, despite the high level of performance of contemporary weavers, it is still impossible to product materials without flaws.

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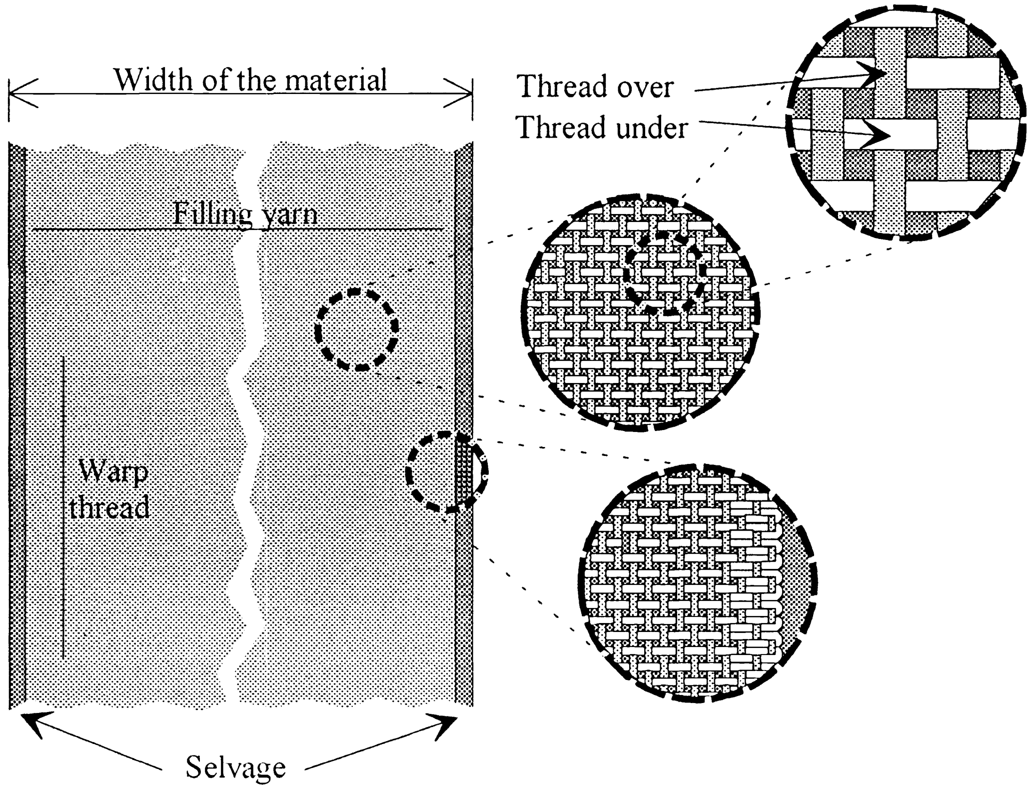
The weaving action consists in interlacing and twisting the filling yarns and the warp thread. The nature of the yarn and the interlace periods are the main characteristics of the product.



- Description of the material components -

2.1 Flaws

The weaving flaws correspond at variations of the characteristics of the interlaced yarns. The use of natural yarns, such as cotton, induce important risks of generating structural flaws. Which can be caused by:

- The bad quality of the raw material,
- A problem in the conditioning of the yarn,
- The out of order or bad working of the weaver,
- A human error.

Most flaws are caused by the lack, the excess or the distortion of either the filling yarn or the warp thread. Which produce visual variations of the contrast between the flaw and the fabric. The size of the flaw depends on the characteristics of the products. The minimum size for standard production is about a tenth of millimetre.

They are about twenty flaws that can be produced by a weaver, which can be grouped in four main classes:

- Yarn flaws

The quality of the overall transformation process is dependent on the quality of the raw material, i.e. the quality of the yarn at the output of the spinning-mills. The quality of the filling yarn is measured by sampling in the stock. The warp thread is subjected to special treatments in order to increase its strength. These flaws can occur in the filling yarn as well as in the warp thread direction.

The most common ones are :

- Soiled yarn
- Thickness yarn
- Fibre contamination

• Filling yarn flaws

Weaving with the air-flying yarn technique allows a large production with a great turn-out. But it presents a drawback in the case of natural cotton yarns, since the injection of a long yarn induces high risks of flaws.

Such flaws are named :

• Double filling	• Bar	• Filling thread break
• Beating-in mark	• Open beating-in	• Slub in fill yarn
• Tangle	• Knot	• Floss

• Warp thread flaws

Across the whole width of the weaver, they are about 6000 to 8500 warp threads. Those yarns are separated one for each other by a comb in a specific order and any permutation between only two of them yields to a flaw. Those kinds of flaws can result in a great lost in the quality of the production, because their size is unlimited.

Among the most important of these flaws, we have the three following ones :

• Double warp thread	• Wrap thread break	• Loose warp thread

• Local flaws

During the production, local flaws can appear on the material such as holes, dirt spots or oil spots. Furthermore the width of the fabric can fluctuate. Note also that after some repairs, loose warp threads or yarns can be forget on the cloth.

The following flaws are the most common local ones :

• Hole	• Loose warp thread	• Dirt spot
• Oil spots	• Width variation	

2.2 Cost of the bad quality

Flaw detection and recognition is the key problem for determining the global quality of the production[1]. But, if it becomes possible to quantify more precisely the importance, the density and the location of each flaw on a given piece of fabric, the production manager could take into account the local quality of its production to dispatch it according to the level of quality requested by each of its customers.

To achieve this goal, we propose to measure the quality of the fabric produced by each weaver of the factory. Furthermore, this inspection of the fabric will be used to control the running of each weaver.

In fact, the manager wants to reduce the number of flaws per meter of fabric while having a map of the remaining flaws. These requirements call for a system that is :

• permanent The control is permanent, all the production must be analysed in real-time.
• reliable It must detect and identify all the flaws in the workshop conditions.
• accurate It must report the exact positions of the flaws and their visual importance.
• rapid It must rapidly warn the workers or the technicians in the workshop that the quality of a specific weaver is going under a low-limit.
• informative It must periodically edit reports for the production manager.
• low cost The whole system must be economically profitable and must not disturb the production.

3. THE COMPUTER-AIDED WEAVERS QUALITY MANAGEMENT

The proposed solution is a computer-aided weaver quality management[6]. The aim of this control system is to provide a preventive diagnosis of the variations of the quality produced by the weavers. The control system helps the manager to improve the reliability of the machines thanks to an instantaneous knowledge of their running conditions[2,9,11].

This preventive diagnosis is based on the reliability and the permanence of the flaw detection system integrated on to each weaver. The inspection system provides the analysis of the material just after the production, the flaws are detected and identified, reports are generated and sent on the factory local network.

The workshop main computer centralises all the information that come from the inspection systems. Information are taken into account to evaluate, flaw by flaw the local and the global qualities of the production. The determination of the localisation and the importance of the flaw is used to detect occurrence of periodic flaws.

In case of significant variations of the global or local qualities of the material, the workshop main computer sends back short or more-detailed messages on the factory local network destined to workers, technicians and to the workshop manager. The number of the weaver, the failure characteristic, the detected flaw, it's importance and position, are listed in the message.

3.1 Computer vision for quality measurement

The purpose of this project is to design a low cost inspection system that can be installed on a large number of weavers, typically 40 per workshop. The fabrics, which are about 3 metres large, are produced at a maximum speed of 25 m/h. The number of threads per inch ranges from 34 to 60. The material is unbleached or coloured and some characteristics may change in real-time. The working conditions are very severe because of:

- Dust in suspension in atmosphere
- Fibre heap
- A 98 decibels noise
- Propagation of low frequencies
- Humidity from 90 % to 95 %
- Temperature from 20°C to 25°C.

Detection and identification of flaws by image processing on different materials such as paper, wood, glass, steel and also cloth is not a new concept[3,12]. Solutions to control the quality of real-time production has been already developed[4-5,7-8]. But there is no solution that can be used to inspect, in real-time, the production of a large process, with a high resolution at a very low cost[10].

However, most studies have shown the interest of computer vision as applied to flaws detection. In the world of the automatic inspection, linear sensors are well suited to production lines.

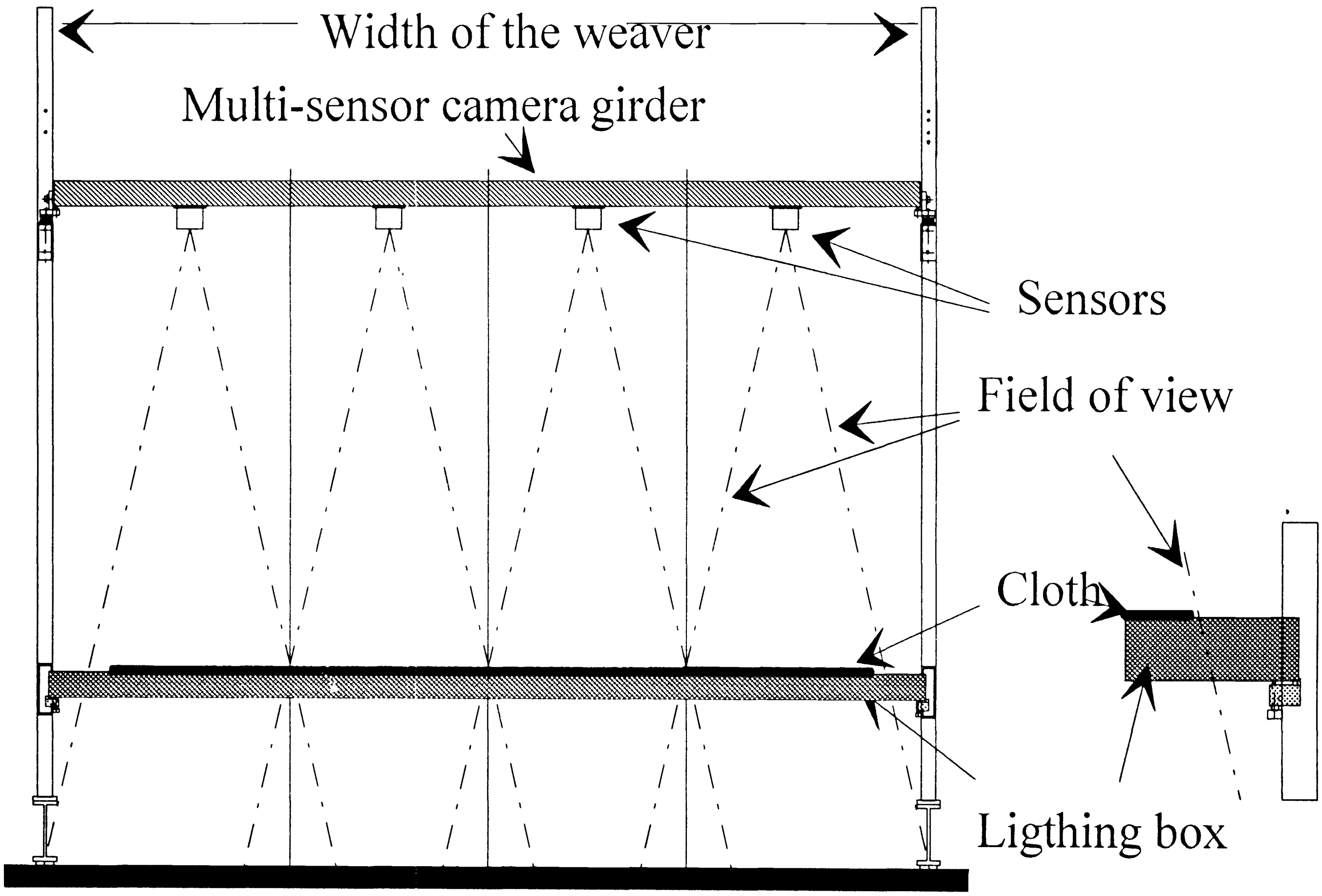
The proposed solution for the inspection is to design a dedicate automatic vision inspection system. This machine vision is based on light girder that contains an intelligent linear multi-sensor. In association with this intelligent sensor, a large lighting box as been specifically designed.

The machine vision is composed of a very high resolution linear sensor, a specific hardware computing unit, a standard C.P.U. board and a network protocol interface. Via this interface the inspection system transmits reports to the factory computer.

3.4.1 Resolution

The number of warp threads and filling yarns in standard production ranges from 34 to 60 threads per inch. That means a maximum of 2.4 threads per millimetre.

If we apply the Shannon theory, the minimum number of pixel for the acquisition of an image representing the whole width of the fabric is 14.400. Such a resolution is not possible because of the price of such a system. In fact the resolution has been limited to 7.700 pixels. This only allows the perception of the lack or of the excess of one thread, since it is the half of the desirable resolution. We propose to associate four sensors with 2048 pixels each in the girder in order to obtain the 7.700 pixels. The unused pixels are divided between the three overlapping parts of the fields of view (approximately 60 mm).



- Vision machine and lighting box architecture -

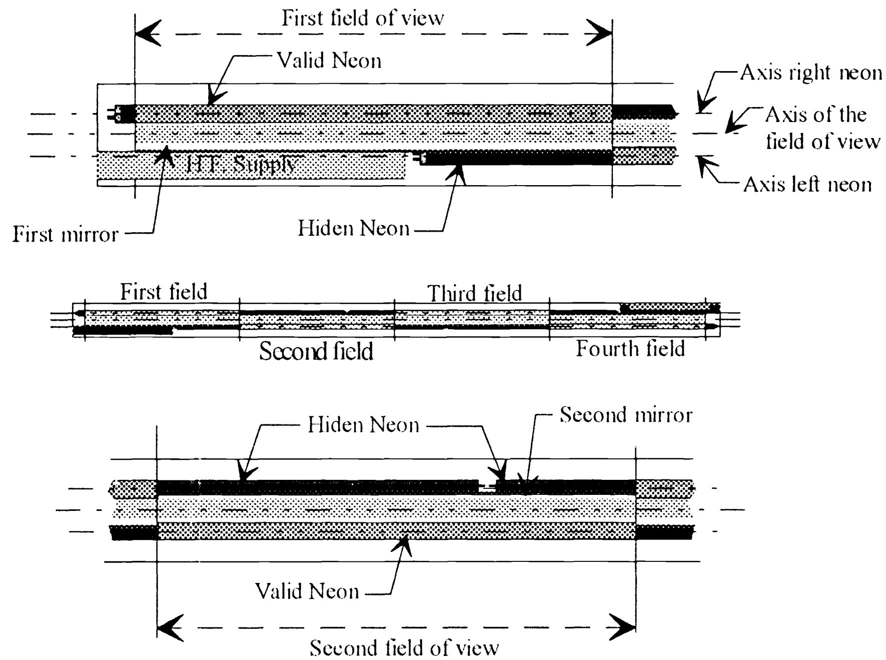
The maximum speed of the production is about 25 meters per hour (7 mm/s), with a 60 threads per inch fabric, i.e. 16.5 threads per second. With the sampling principle seen above the acquisition and processing rate is about 15 lines per second according to the speed of 25 meters per hour.

The clock frequency of the sensor is therefore set at 135 KHz. Such a low frequency allows the conception of a low cost hardware unit, to implement basic image processing procedures and the calculations required by the local filtering technique.

For the transversal and the longitudinal resolution, the principle of a multi-sensor girder seems to be a good solution, that can be applied to different kinds and sizes of weavers.

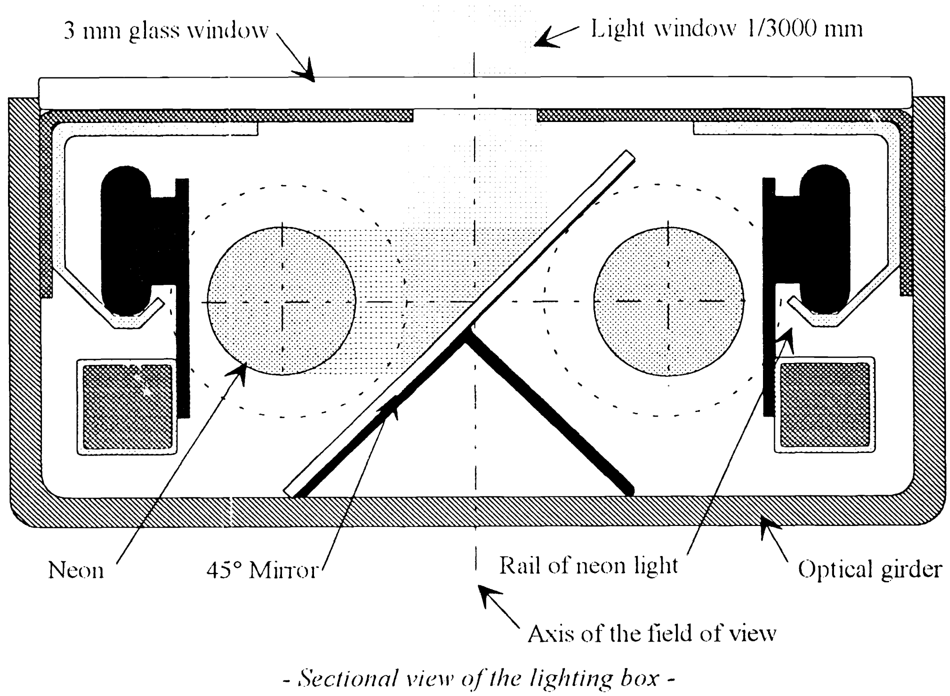
3.4.2 Lighting system

The lighting system is based on a large and uniform lighting box especially designed for an industrial dedicated vision machine integrated on weavers. One of the main difficulties when integrating the vision system into a weaver is the lighting of the fabric. To ensure a uniform intensity across the whole width of the fabric, an original mechanical and optical set-up has been designed. It is composed of several fluorescent tubes with a high frequency (25 KHz) supply.



- Description of the lighting box and the fields of view -

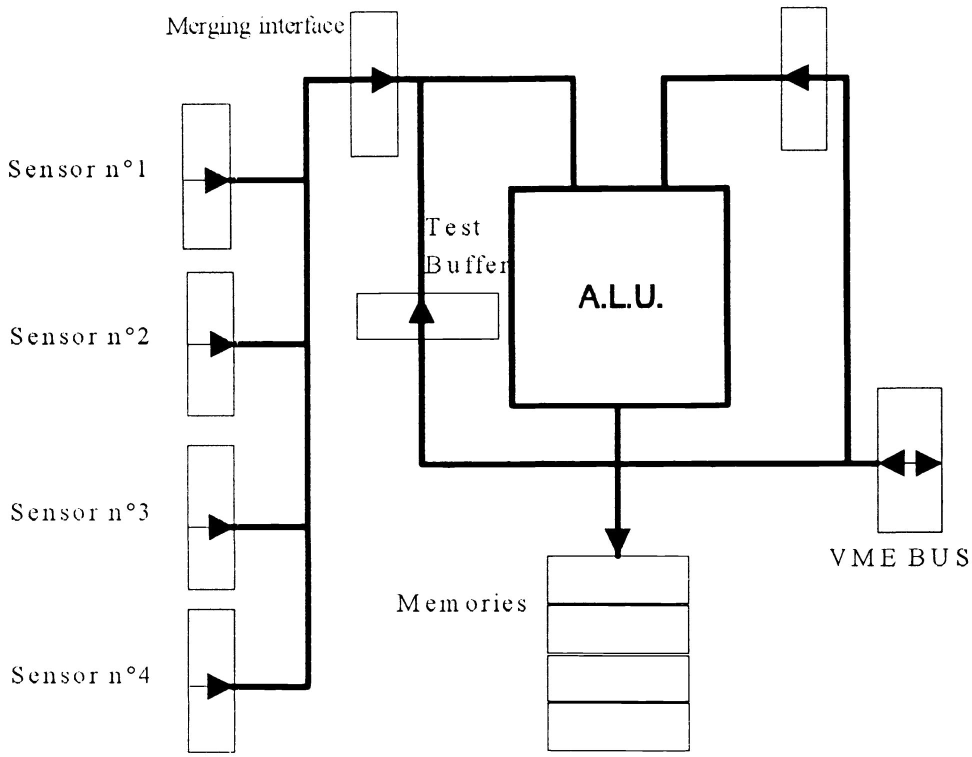
A set of mirrors reflects the light emitted by the individual tubes so as to obtain a uniform bright line in the field of view of the multi-sensor camera.



- Sectional view of the lighting box -

3.4.3 Sensor and linear image front-processor

An acquisition board has been specifically designed as a front-processor in order to merge the 4 individual images in an unique one of approximately 7700 pixels. The used of First In First Out memory and Programmable access logic simplified the merging operations.



- Functional block diagram of the hardware board -

Due to the "low" frequency of the pixels flow, a standard low cost IDT 7381 Arithmetic Logic Unit can perform local filtering in real time.

3.4.4 Real-time data flow treatment

The hardware VME board is interfaced with a standard CPU board from Motorola, based on a 68010/12.5 processor. All the image processing is implemented on this card. This configuration allows to use the hardware treatments in order to separate the flaws from the remaining parts of the linear images.

The linear images are stored in a FIFO memory in the acquisition board. They are processed one by one, in order to detect and identify the flaws as they cross the field of view of the intelligent linear multi-sensor. The two main difficulties in this step are the segmentation of flaws in linear noisy images, and the identification of the nature of the flaws. Here, we briefly present the proposed software.

For the segmentation, the software is divided into three jobs:

- The detection of filling yarn defects

  The hardware provides a lower transversal resolution by averaging a set of 1, 2, 4, 8, 16 pixels in the acquisition line. This average measure is subtracted from the last one. The software calculates automatically, in line per line, from histograms an upper and a lower threshold. When the difference image gets through these two thresholds, a flaw is supposed to be detected.

Information about the importance of the flaw is estimated from two information: the difference in grey level and the average grey level itself. Line by line, the software chains the detection. At the last detection of the defect, an identification is provided by the CPU with an historical information. The report is sent through the network to the main computer workshop.

- The detection of warp thread defects

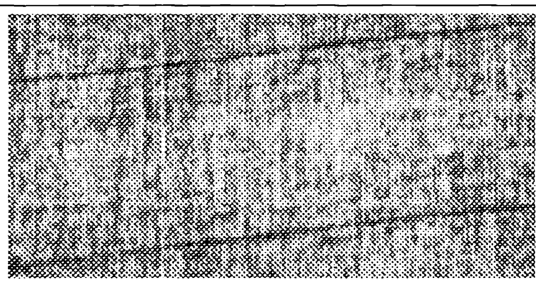
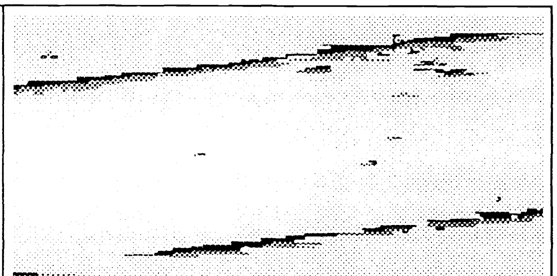
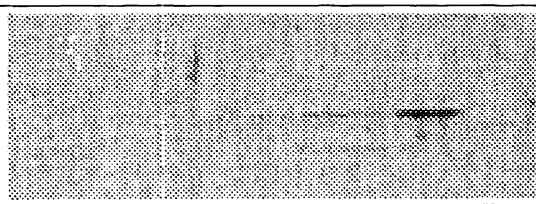
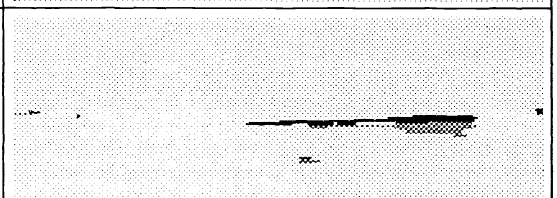
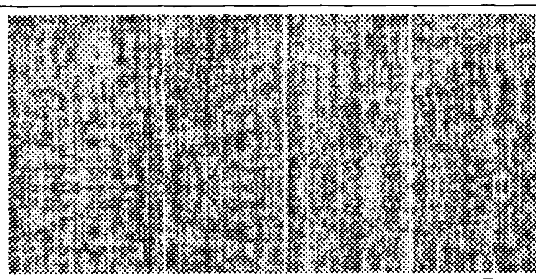
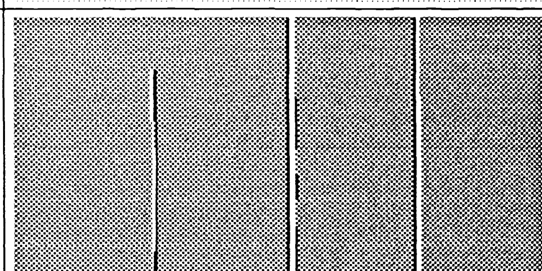
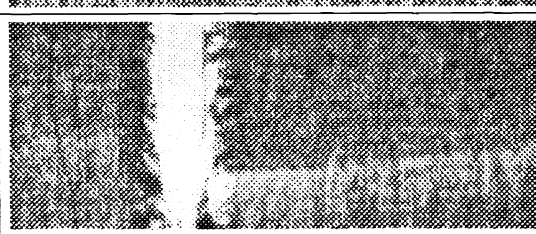
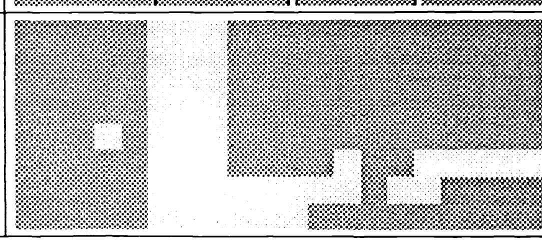
The hardware provide a lower longitudinal resolution by averaging all the 7700 pixels at each acquisition, it also provides the average difference between two adjacent pixels. The histograms and thresholds are also calculated. When a pixel stays out of the ranges, a defect is detected. After a short time a report is sent to the workshop main computer that tells a defect is beginning. This report is taken into account to provide alarm.

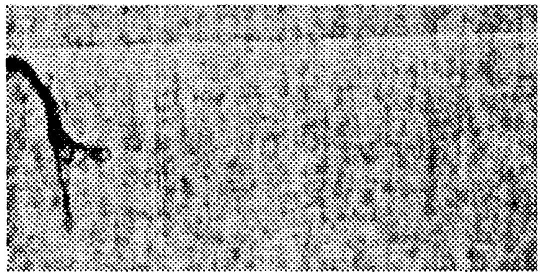
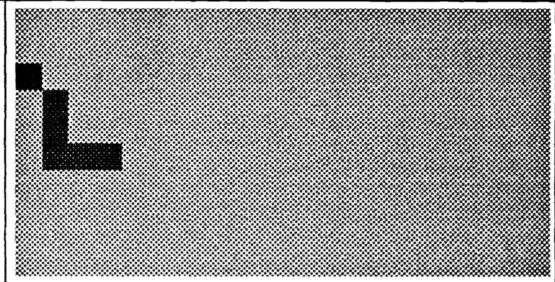
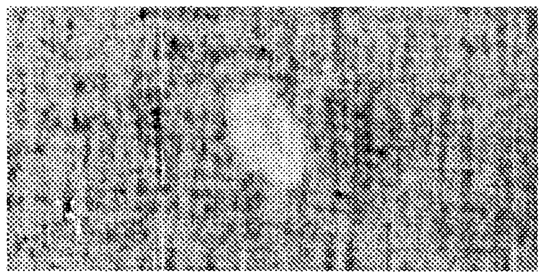
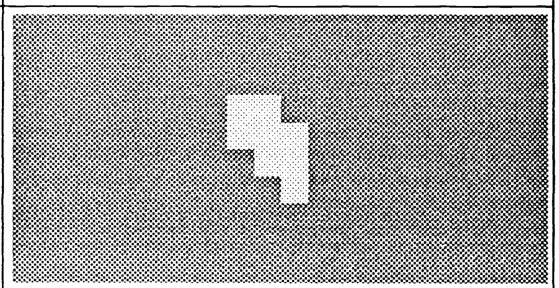
- The detection of local defects

The software provides an average measure of mosaic 16x16 pixels. The histograms and thresholds are calculated automatically, the segmentation of the mosaic gives flaws.

3.2 Some results

The system has been assessed in a weaving workshop of a textile company in the north of France. Results corresponding to a whole year of tests are reported, which demonstrate the interest of the on-line inspection of the fabric at the output of the weavers.

• *Double filling*		
• *Tangle*		
• *Double warp thread* • *Loose warp thread*		
• *Hole*		

• *Loose warp thread*		
• *Oil spots*		

4. ACKNOWLEDGEMENTS

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