Virtual Instrumentation – an Easy Solution for Industrial Video Inspection

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Abstract

The textile industry is one of the most dynamic and competitive sectors in Romanian industry and it also present international interest through its products on the world market and especially on the EU market. For the commercial societies, the assurance of the products quality represents the capacity of satisfying consumers' needs. To accomplish that, a commercial society needs to bring up-to-date its management and to introduce new elements in the labor's organization. For example, to obtain a better quality for the textile materials they are inspected using modern methods of visual inspection that implies the special use of two programs: Vision Builder for Automated Inspection and NI Vision Development Module. Using these two programs in the image acquisition the automated inspection will be easier and the products quality will be the expected one.

1. The difference between Traditional Inspection and Automated Video Inspection

The inspection of the textile materials may be realized by using two methods: traditional inspection (with human operator) and automated video inspection. The traditional equipments for inspection use the capacity of the human operator in perceiving, analyzing and interpreting the flaws' presence in the textile materials. The disadvantage of these traditional methods consists in the fact that the human operator can detect only a part of the existing flaws in the textile material. Another disadvantage is operator's fatigue which may lead to a bad quality of the textiles.

The automation of the inspection procedure may be realized by replacing the human operator with an automated system for video inspection. The processor interface is composed of the video system, the illumination system, the motive system and the electrostatic filter. The software inspection procedure is an assembly of routines developed through complex techniques of virtual and neuro-fuzzy instrumentation with a role in realizing the appearance of a material flaw, in classifying the recorded flaws and adapting the automatic decisions according to previous interventions of human operator. This procedure is an adaptive type one, which memorizes and processes correction interventions, of the human operator, on the decisions elaborated by the software inspection procedure of the system and accomplishes the transfer of solving some complex disturbing problems, generating false flaws, from the hardware domain to the software one.

Using automated systems instead of traditional ones the productivity will grow with 3-5%, the production cost will decrease and this will improve the technological projects and will reduce the production errors.

2. The acquisition software and the image processing

In the election of the image acquisition software we have to consider a few factors: the type of the camera, the interface

hardware, the flexibility and the levity of programming, the algorithms' precision, the integration with other devices and programs, the price and the partners. The camera is chosen after the application is carefully analyzed and are established the necessary resolution, the scanning rate, the transfer speed, the interface type etc.

There are five algorithm types for image processing.

Image improvement – the algorithm uses different filters to eliminate the noise, to sharpen edges and to obtain frequency informations. It uses image calibration tools to eliminate the linear and perspective errors caused by distortions due to the camera's lentils or its position.

Presence detection - this is the simplest algorithm used in the video inspection. It uses histograms, pattern match, color match and the detection result is represented as a Boolean (yes/no, accepted/rejected).

Components identification – this consists in OCR, bar code reading and objects classification. The results are represented as strings that define the object or the identified component.

Localization – it's used to align the objects or to exactly place an object in a specified area. A few functions used in this algorithm are: edge detection, gray level or color match, shape match, dimension match etc. The functions return the object's position or some parts of the object's position in Cartesian coordinates and the rotation angle with precision to 1/10 pixels.

Measurement – it uses functions for edge detection, particle analyzing and geometrical functions to measure the distance, the diameter, the angle and the surface. The result is always a number.

2.1. Vision Builder for Automated Inspection

It has an interface easy to be used, it recognize the hardware that the user works with and with the help of a wizard it finds applications that already exist that might be integrated in the user's applications when he needs them.

With this programs pack we can develop a video inspection application using the algorithm from figure 1.
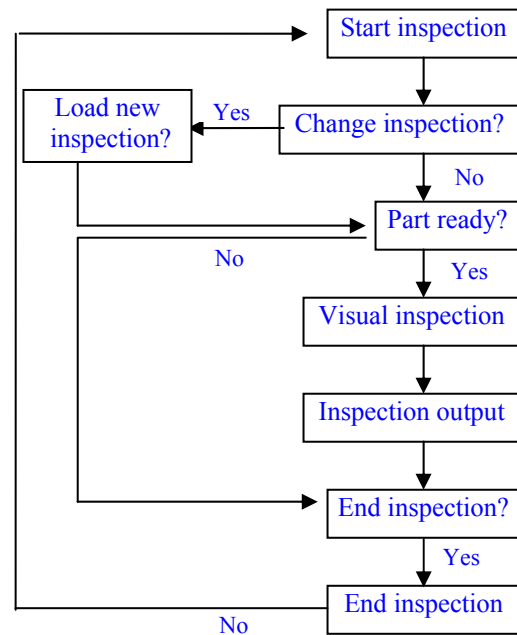

Figure 1. The Algorithm for the Automated Inspection

Vision Builder for Automated Inspection may be integrated in programs as LabView, Test Stand and Visual Basic by appealing the Active X components. It includes the ability of processing images from .bmp, .jpeg, .png, .tiff files. Using this program you can take decisions at the end of each step of the video inspection process. It acquires saves and displays images from hundreds of types of cameras, including IEEE 1394 and GigE Vision. This software includes the option for decisional control, type "admitted/rejected" for I/O digital control devices and it also has the communication option for serial devices, as the PLCs.

Some of the functions offered by this program are presented in figure 2.

- Pattern, shape and dimensions match;
- Characters recognition (OCR);
- Particles analysis;
- Color inspection-it quantizes what color and how much of that color exists in the image;
- Edge detection;
- Objects' classification;
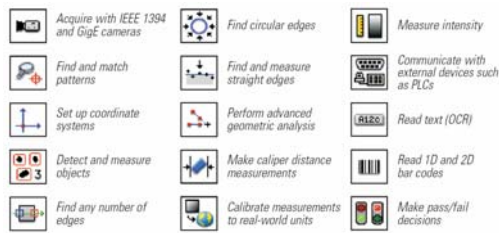
Figure 2. Examples of the Many
Functions Available in Vision Builder AI

- Dimensions measurement;
- Bar code reading;
- Spatial   calibration-corrects   the
  distortion errors;
- Arithmetic or logical operations with
  images;
- Frequency filtering and analysis;
- Image segmentation;

Vision Builder AI may call any virtual
instrument realized in LabView.

2.2. NI Vision Development Module

The NI Vision Development Module is
for developing machine vision and scientific
imaging application. The module includes NI
Vision Assistant, an interactive environment
for developers who need to quickly prototype
vision applications without programming,
and IMAQ Vision, a library of powerful
functions for image processing. NI Vision
Assistant and IMAQ Vision work together to
simplify vision software development.

NI Vision Acquisition - it acquires, saves and
displays images from different types of
cameras, such as IEEE 1394 and GigE
Vision.

IMAQ Vision is a high-level
programming   library   that   includes   an
extensive set of functions for machine vision
and   scientific   imaging.   Using   IMAQ
hardware you can acquire images at full
frame rate. Using the image browser you can
review, load and display multiple images at
once. IMAQ Vision is able to load and save
binary, grayscale or color images in different
format types (.bmp, .tiff, .jpeg, .png).

IMAQ Vision software from National
Instruments adds high-level machine vision
and   scientific   imaging   to   LabView,
LabWindows/CVI, C and Visual Basic. It

includes an extensive set of functions for
grayscale, color and binary image display;
image processing; pattern matching; shape
matching;   blob   analysis;   gauging;
measurement.

You can use pattern matching function
for alignment, measurement and inspection
applications. Train on an object and then
search for the object. Specify search
parameters and constraints to limit the search.
The search function uses a smart search
strategy to quickly find objects even then
when the objects are out of focus, at various
angles, in shadows or partially hidden.

Use particle and morphology functions
to process and analyze binary particles in an
image, to count, label and measure cells and
objects or to calculate the area, perimeter,
orientation, location and 80 other parameters.

Color can often simplify a monochrome
problem by improving contrast or separation
of the object from the background. Use color
pattern matching to locate reference patterns
in color images that are fully described by the
color and spatial information in the pattern.
With these functions you create a model or
template of an object. The search tool first
scans the image to match the color of the
model and then scores match for shape. The
score relates how closely the match resembles
the template or the model.

NI Vision Assistant – using the inspection
software   tool   integrated   in   NI   Vision
Assistant we may quickly realize and develop
an inspection strategy by specifying the
search parameters to limit and to accelerate in
the same time the searching (for example, the
flaws detection in the textile materials).

NI Vision Assistant contains more than
200 functions and it is compatible with
IMAQ Vision. NI Vision Assistant can
automatically generate a LabView block
diagram. You can use the diagram generated
by itself or integrate it into your automation
or production test application, which may
include instrument control, data acquisition
or motion control.

NI Vision Assistant is for developing
gauging, alignment, inspection and particle
analysis applications. It accelerates vision

application development. It is easy to learn image processing and investigate vision software strategies because it requires no programming.

In figure 3 is shown an example which uses the LabView functions to create an instrument for event tracking, without using the Vision Assistant functions.
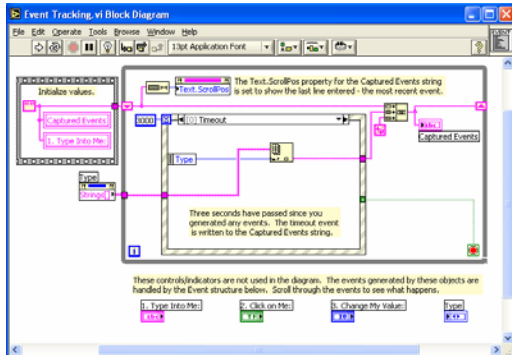

Figure 3. Event tracking block diagram

This instrument tracks which events are happening with the Event structure. The Captured Events string displays which events have occurred:

Timeout: this event occurs every three seconds that the VI runs idle. If another event occurs within the three seconds, that event is handled and the timeout timer starts over.

Menu Selection - this event occurs each time you make a selection from the LabView menus.

Panel Closing - this event occurs when you try to close the front panel by either clicking the close box in the window or by selecting File»Close. When the Ignore Exit and Close Events Boolean is TRUE, only the event is returned and the front panel does not close. When this Boolean is FALSE, the window closes as requested.

Application Exiting - this event occurs when you try to exit LabView by selecting File»Exit. When the Ignore Exit and Close Events Boolean is TRUE, only the event is returned and the application does not exit. When this Boolean is FALSE, LabView exits as requested.

"stop": Value Changed - this event occurs when you click the stop button

NI Vision Assistant generates a LabView block diagram that is the complete

LabView VI source code for your interactive session.

"Wood inspection" is an example which uses the Vision Assistant functions. This example checks the surface of wood planks for structural defects using a lookup table, an automatic threshold, binary image processing, advanced morphology and particle analysis as it is shown in figure 4.
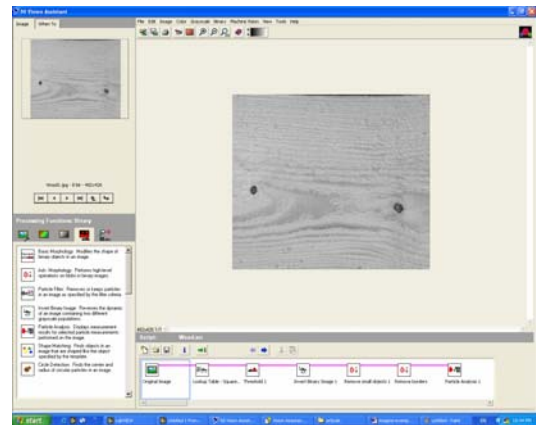

Figure 4. Wood inspection diagram

Lookup Table: Square Root-Enhances the appearance of the pixels in the image with low grayscale values. Structural defects on the wood surface appear as slightly darker regions in the image. A lookup table that applies a square root function to the image helps to enhance the difference between the defects and the surface of the wood.

Threshold: Auto – Threshold – Entropy-Separates the areas in the image that may be defects from the rest of the wood surface. An automatic thresholding technique is applied to create a binary image. An automatic threshold has the advantage of being independent of the imaging conditions. Because the defects are darker than the surface of the wood, they appear as background regions in the resulting binary image.

Binary: Invert Binary Image **-**Reverses the dynamic of the image.

Adv. Morphology: Remove Small Particles **-** Removes small noise particles from the binary image. Particles that are removed by an iteration of erosion are assumed to be noise particles.

Adv. Morphology: Remove Border Objects - Removes particles that touch the border of the image. Complete information about particles that touch the border of the image is not available, so the particles are removed from further analysis.

Particle Analysis – determines characteristics of each particle (defect) in the image.

3. The choose of the video camera

Depending on the signal type desired at the exit, the camera may be analogical or digital. The analogical cameras are cheaper but the noise immunity is lower. They have a good flexibility in choosing the number of frames/sec and resolutions. In case that there are no strict conditions for precision, speed or operating in noisy environments, the analogical cameras can be satisfying.

Digital cameras offer much more possibilities to choose the signal type. The typical transfer signals are: TTL, RS-422, Low – Voltage - Differential Signal (LVDS or RS-644). TTL signals are very sensitives at the attenuation and noise and may be used for short distances. RS-422 and LVDS transport differential signals for bigger distances.

The digital signals advantages comparing to the analogical ones consists in high spatial resolution (big dimensions images), high speed, characteristics flexibility, noise immunity.

The digital signals deployment in time is much simpler than the analogical one because the signal is already digitized.

An image is represented as a bidimensional matrix, and at the camera's output is a single data string. Displaying an image on the screen needs an acquisition board which acquires the data, digitizes (if it's necessary) and transmits them to the computer's memory through PCI bus. From here they will be taken over, displayed or processed.

Video scanning – to obtain an image on the screen it is necessary to explore the screen line by line. The cameras that provide at the output interpolated images are known as *area scan cameras.* For a high scan speed used in

applications with objects which are moving very quickly you can use *progressive scan cameras. Line scan cameras* represent another type of cameras that generate one single line at the time. The acquisition board collects the lines and builds an image with a predeteminate height in its own memory. This scanning mode it is called VHA (Variable Height Acquisition). It is used in visualized objects with variable or unknown length applications.

The main element of the image acquisition device is the CCD sensor. A linear CCD sensor consists in a line of sensors. To acquire an image by using a linear sensor, this sensor has to move with a constant speed along the image. The camera's CCD structure determines the size of each pixel.*Linear or area scanning* – area scanning cameras need a bidimensional matrix of sensors to acquire an image. The sensors' outputs are explored and transferred to the data acquisition board.

The line scan cameras have just one line of sensors which collects just one horizontal line at the time. They are usually used to produce flat images, cylindrical objects projections or big dimensions objects with a good resolution.

4. Image acquisition modes

"Snap" mode (acquisition without buffer) – this is the most simple acquisition mode. The board acquires one single image in a memory buffer. The image may be processed as soon as it is acquired. This mode is used when the informations obtained from one single image are sufficient for the image processing.

"Grab" mode (acquisition with simple buffer) - the acquisition board transfers each image in an acquisition buffer in the computer's memory. The board writes the same buffer at each image acquisition and that's why, for a further utilization, the images are transferred from the acquisition buffer to a processing buffer. The data sampling and processing from the acquisition

buffer must be realized with a bigger rate than the acquisition rate.

"Ring" mode (acquisition with circular buffer) – the data acquisition is made by deposing them in multiple acquisition buffers without being necessary to transfer them in processing buffers. The dates are continuously deposed in successive buffers and then are processed. This mode is used in high speed applications, in which the data processing must be realized in real time.

"Sequence" mode - similarly to the "ring" mode, this mode uses multiple buffers, but these are written just once and the processing takes place after the acquisition is complete.

Conclusions

The direct consequences of using virtual instrumentation in industrial video inspection are productivity growth with 3-5%, immediate and rapid improvement of technological projects and production errors reduction.

Virtual instrumentation helps you to elaborate special applications, easy to test and refit, perfectly adapted to the requirements of the data acquisition systems. The LabView functions are diversified and strong, centered on fields that are very useful in developing the process monitoring systems, as industrial video inspection.

Selective biography

1. Grönlund U (1995) Quality improvements in forest products industry. Dissertation, Luleå University of Technology, Sweden.
2. Boukouvalas C, De Natale F, De Toni G, Kittler J, Marik R, Mirmehdi M, Petrou M, Le Roy P, Salgari R & Vernazza G (1998) ASSIST: Automatic system for surface inspection and sorting of tiles. Journal of Materials Processing Technology 82(1-3): 179-188.
3. Friedman JH, Bentley JL & Finkel RA (1977) An algorithm for finding best matches in logarithmic expected time. ACM Transactions on Mathematical Software 3(3): 209-226.
4. Duda RO, Hart PE & Stork DG (2001) Pattern Classification (2nd Edition). John Wiley & sons, New York.

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