OEM relies on DALSA for critical inspection of bank notes

Founded in 1997 in Milan, Italy, PARVIS Systems and Services develop solutions for production, process control systems based on vision technology. The company name stands for PARallel VISion, because the company's knowledge base is founded in the application of parallel computing to visual inspection solutions. These solutions address the needs of the printing industry, mainly in the area of banknotes and security printing such as tax stamps, and lottery. These types of applications have complex printing requirements and as a result, the utmost accuracy is warranted.

Inspecting Banknotes

Traditionally, banknote quality has largely been determined by means of manual visual inspection. By definition, this check was focused on the visible aspects of the product and it was also influenced by human subjectivity and lack of consistency. Today, automatic inspection and sorting systems, such as those from PARVIS are used in many printing works to verify 100% of the final product. Banknotes identified as defective, according to specified parameters, are sorted and removed for destruction. And equally important, the visual inspection system can quickly identify process deviations, and warn the operator that intervention is required. The objective is to keep the printing press working at the best possible conditions and minimize downtimes.

Giovanni De Toni is one of the founders of PARVIS and is responsible for the company's research and development activities. The R&D department is involved in production processes analysis in order to understand the end users' needs, including details regarding the system design of hardware and software, identification of hardware components, software development, and system integration and testing. However, the department's main focus is related to system design, algorithm analysis and software development.

This is essential because banknote production is becoming increasingly more complex, and PARVIS has developed sophisticated vision systems for this type of inspection. Intricate security features have been introduced to combat counterfeiting, so the measure of banknote quality is not simply a question of aesthetical appearance, but also the capability to inspect these security features and the "machine readable features" that are built into the bank notes, themselves. These must be printed within tight specification and tolerances so that automatic equipment can efficiently process currency transactions.

The Challenge: Print Quality, Integrity and Speed

One of PARVIS' customers, a major printer of security documents based in Italy, had the goal to control the quality of its printed products during the production in order to mark defective products (to remove them in a later step of the production process) and stop the production in case of excessive defectiveness to limit the waste.

The objective was an overall quality improvement to certify its production and to reduce the risk of dispute with the end user.

To achieve the required product quality level, different print characteristics have to be controlled on both the substrate sides (front and back):

- Print integrity (missing print, dirty, spots, smears, etc.)
- Print registry (measure of distances between elements printed with different inks)
- Color
- Integrity of elements printed with fluorescent inks (visible only using UV light).

The requirements of the print integrity of the system were stated as being as small as 0.3x0.3 mm for the visible inks and a bit larger (1 x 1 mm) for the fluorescent inks. The system was also required to detect human perceivable color deviations both in homogeneous area (single color plain areas) as in non homogeneous areas printed with different colors.

The production speed is very high (300m/minute) if related to the defect detection capability required. The web size is 520 mm.

The Solution: PARVIS develops REGOLO

In the past, PARVIS developed visual inspection systems using arrays of up to 150 DSPs, their current systems are based on powerful workstations (PCs) based on multiple multi-core CPUs.

DeToni explains, "In 2002 we were looking for a 'standard platform' capable of replacing our obsolete DSP based platform. We analyzed different solutions available on the market and chose DALSA's Sapera software (the company was known back then as Coreco). Sapera met all of our application requirements; in addition, we received excellent technical support at every step by DALSA's local distributor, ImageS."

The name of the system is "REGOLO" an Italian word which means "RULER" in English. The objective of the system is the online control of the print quality on web printing machines.

The solution developed is based on two workstations (one for the front side control and one for the back side control). The two workstations

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are coordinated by a PLC. The PLC is also in charge of controlling the defective products marking device (a "Domino" ink jet printer), stopping the printing machine in case of excessive defectiveness.
Because of the "little" dimension of print integrity defects, with respect to the production speeds, PARVIS used two line scan cameras for the visible ink analysis: one high resolution (4096 pixels) black and white camera for the print integrity analysis and one RGB camera for the color analysis. (Color analysis does not require very high resolution).An additional high sensitivity black and white camera is used for the fluorescent inks analysis, resulting in a total of three cameras used for each side.
De Toni and his team developed special white LED based illumination equipment for the visible ink image acquisition (B/W and RGB) and used fluorescent tubes for the fluorescent ink images.
They decided to develop the illuminator because it is a critical element of the solution. It provides enough light intensity to permit proper high resolution image acquisition at such high speeds while at the same time providing stability in terms of intensity and color, to permit detection of very small color hue deviations.
A Heidenhain optical encoder is used to synchronize the image acquisition with the web movement.

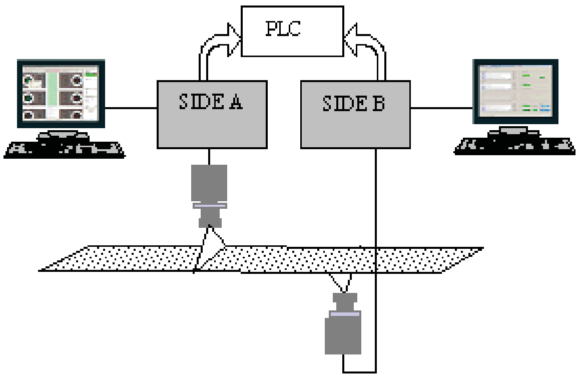

Diagram1: PARVIS's overall system structure.

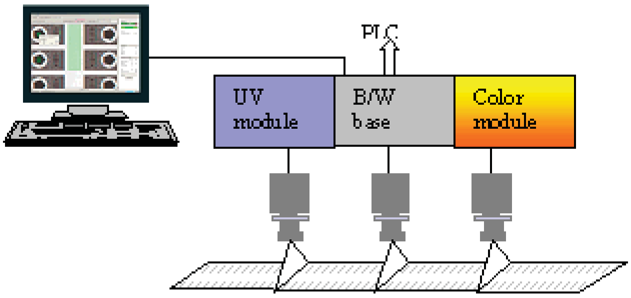

Diagram 2: PARVIS's single side structure
The entire solution is "modular" in design, enabling the configuration of a system including only the color control capability or only the high resolution B/W camera. (As a result, the company expects to tailor this solution to different users based on their specific system requirements).

DALSA's vision technology

Parvis's solution is based on the Windows operating system. Each workstation is equipped with two Xeon CPUs running at 3.6 GHz, and includes the following boards:
- Two DALSA X64 CL-iPro
- One DALSA Anaconda
- One Digital I/O board from Advantec (Tampa, Florida)

This system uses two X64 CL-iPro boards. The first one is connected to a Piranha 2 camera running at 40 MHz (four tap camera at 4096 pixels). This camera is in charge of capturing high resolution images for the visible inks integrity analysis. PARVIS' R&D team selected this camera as they required image capture at about 140 Mpixels/second and this camera is capable of up to 160 Mpixels/sec.

Piranha2 camera in action capturing high resolution images for the visible inks integrity analysis.

The second X64 CL-iPro board is connected to a Spyder 2 camera (1024 resolution). This camera is in charge of capturing the fluorescent ink images. PARVIS decided to use the Spyder as this application requires a high sensitivity, line scan camera since web speed variations and vibrations make the use of TDI cameras nearly impossible.
The Anaconda is connected to a Piranha Color PC-30 camera. In this application the major benefit from the Piranha Color is related to the short distance between the three lines. In fact, this small distance simplifies the requirements about the light homogeneity and reduces the chromatic aberration related to the lens' optical distortions.
De Toni adds, "Since we have to recognize 'human perceivable' color deviations we decided to operate in the 'Lab' color space, instead of using the camera RGB space." The RGB to Lab color space conversion is a processing power, consuming activity that can be implemented in hardware (saving CPU processing power). "For this reason we asked DALSA to provide us with a custom version of their Anaconda board on which the FPGA was programmed to perform the conversion. DALSA programmed the FPGA according to our requirements. The board provides us both the RGB image, to use for display purposes and the Lab

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image is used for color deviation detection."
For each printed element (named "page" for the sake of simplicity) the system captures up to six images (three on the front side and three on the back side). The PLC guarantees the perfect synchronization of the three images related to the same side. The three images are individually processed and a final decision is taken about the product on the basis of the three results.
"By using a custom version of the Anaconda, PARVIS has been able to completely satisfy our end users' requirements reducing the number of CPUs required for the image analysis and simplifying our development efforts," comments Giovanni De Toni, Vice President of Engineering, PARVIS. "In addition, the sensitivity of the Spyder 2 camera permits us to obtain high brightness and contrast fluorescent ink images suitable for proper detection of inking defects."

Regolo system installed

Benefits and Results

The use of a set of components also provided by DALSA and distributed by ImageS simplified the integration activity for us (one single interface) reducing the risk related with non-compatibility between components, etc. This has been possible because of the wide range of products both in term of cameras and processing boards.
The technical expertise of DALSA engineers coupled with the timely support and coordination of their Italian distributor permitted the fast integration of the special RGB to Lab function reducing the time from the start of the project to the first installation in field. The whole system has been developed and successfully installed in about nine months.
Future Goals

PARVIS is currently expanding capabilities of the REGOLO system to include OCR, bar code and matrix code detection and control. These functions will be based on the Sapera OCR and bar code libraries. PARVIS anticipates benefiting from the speed of activity and the reduction in development costs. The final system will be based on two workstation equipped with up to four Xeon dual cores.
Meet the author

About the Author

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