Using High Performance Image Processing to Ensure High Quality Printing on CDs

What: Print Quality Inspection
Who: Sony Electronics, Inc. Factory Automation Division
How: MaxTD Development System, Motif, and ImageFlow

Technical Summary: *Sony Electronics is testing an event-driven application based on Datacube hardware and software that inspects the print quality of labels silk-screened on compact discs. Initial results are favorable, showing marked improvements in inspection system speed, high levels of accuracy, and extremely low rejection and overlook rates.*

In today's compact disc industry, the music or application program distributed on a CD is not the only display of craftsmanship in the package. Savvy marketers put great effort into distinguishing their product from others with techniques including distinctive labeling on both the product packaging and on the disc itself. Careful inspection of these artistic labels is required to ensure the total quality of the product and smooth operation of the production line.

Automating the inspection of such complex artwork is no easy task. The intricacies of the printed designs and color variations require a level of intelligence never before available through any means but human observation. The Factory Automation Division of Sony Electronics met this challenge with an inspection system based on Datacube hardware and software capable of identifying a wide range of defects and subtle color inconsistencies with the accuracy of close human inspection but at greater speeds.

The Printing Process

Most compact disc production facilities use a high-speed silk-screening process to apply labels to the non-readable side of CDs. Multi-colored labels are applied in a multi-step process, onto a surface just four and a half inches across. Including both text and detailed artwork, the designs are much more difficult to work with than those commonly applied through a similar process of screen printing to t-shirts and other apparel. Because the designs are so intricate and the screens are so fine, there is an increased risk of ink clogging the screens. Screens may also break due to the high rate of production most plants maintain.

Common defects in the screening process include blotches where too much ink is passed through, and breaks or holes in the design where the flow of ink was interrupted. Because the screens used are so fine, these blotches or holes may be very small — as small as .5 mm across or less in some cases. If these small defects are allowed to pass through the production line unchecked, the company faces two problems:

- Production of an inferior product
- Uneven wear on the screens, which can cause more serious printing defects as screens clog or tear under the strain

But slowing production to a rate that permits adequate examination by human inspectors of every disc would be a significant blow to productivity and, therefore, competitiveness in this booming industry.

Automated Inspection System Design

Sony Electronics has developed an inspection system that speeds up the process, removes subjectivity and reduces human error. Currently under evaluation at Sony Music, the system uses color cameras developed by Sony and high performance imaging hardware and software from Datacube to capture and process an image of the label printed on every disc that passes through the production line.

The inspection system is contained within a MaxTD Development System from Datacube, with the image processing power of a MaxVideo 200. Using in-house expertise with ImageFlow refined on past projects with Datacube technologies, Sony engineers developed an event-driven application capable of isolating and analyzing common print quality defects found on CD labels. A graphical user interface created with Motif was added to clearly display gathered data and simplify control for system operators. Both ImageFlow and Motif come with the MaxTD Development System simplifying installation and configuration.

Images are collected by a Sony 3CCD camera at a rate of 33 frames per second. A camera controller separates the video signal into its red, green, and blue components, which are then fed sequentially into the MaxVideo 200 image processor through its analog sensor. The input images are compared to a "golden template" stored in the system's memory. Inconsistencies between the input images and the template are identified and the system rejects any discs that have inconsistencies that fall outside a pre-determined acceptable margin of error.

System Performance

The Sony/Datacube inspection system is able to process up to 110 compact discs each minute. It is able to isolate defects as small as 0.25 mm across and detect subtle color differences. False reject rates are typically no more than 1-2%, and the overlook rate is under 0.1%.

Similar automated inspection systems are succeeding in a variety of applications. Datacube now has several specialized development groups, including one dedicated to machine vision and another to web inspection. Contact Datacube at 508–777–4200 for more information.

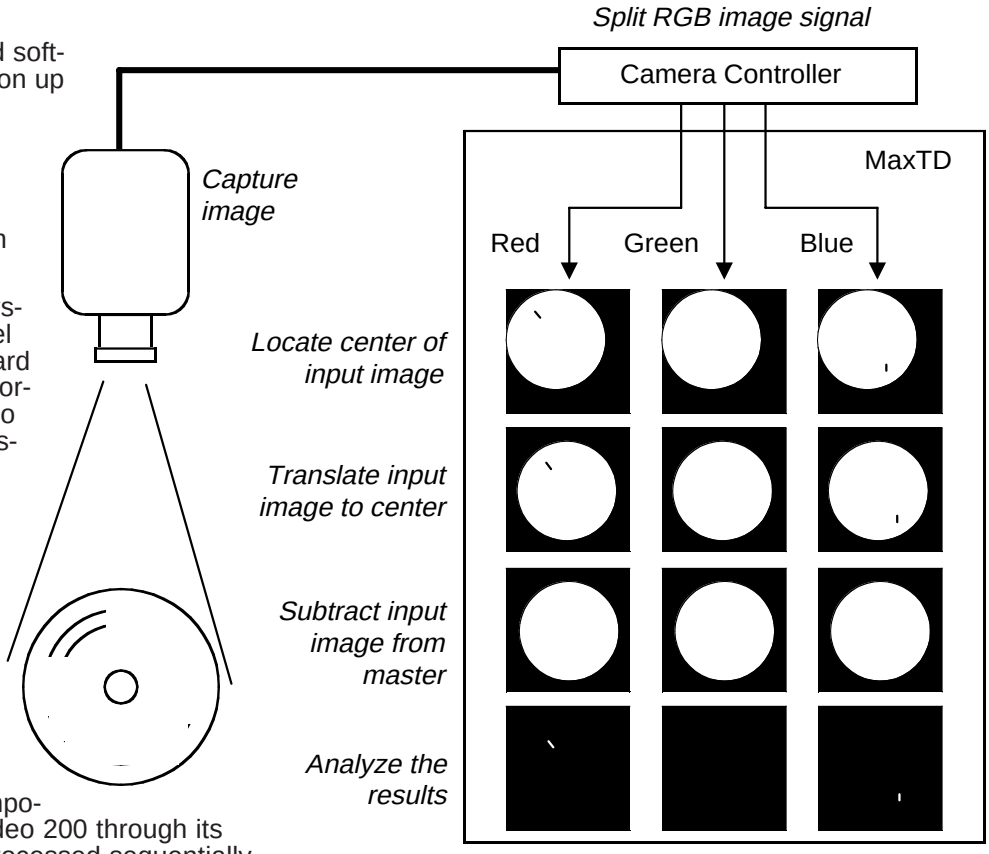
Over for technical details

System Description

Sony chose Datacube hardware and software to help them get their application up and running as quickly as possible. Relying on both in-house expertise with ImageFlow and Motif software and Datacube application development support personnel, they were able to have a prototype in operation in less than eight months.

The heart of the Sony inspection system is the MaxVideo 200 board-level image processor — a 2-slot VME card containing modules for acquiring, storing, processing, and displaying video data. Built upon the pipeline processing architecture pioneered by Datacube, the entire family of MaxVideo products provides high-speed image processing for a variety of applications.

A Sony 3CCD color camera captures images of the imprinted compact discs as they pass along the production line. The video data is passed through a controller which separates the signal into three separate components, red, green, and blue. The three component signals are fed into the MaxVideo 200 through its analog sensor (AS) interface and processed sequentially (see figure at right).



Simplified diagram of the CD label inspection system developed by

Application at Work

The first step in processing is to convert the image to a gray-scale image and orient it in memory, allowing it to be analyzed. The captured image can be oriented using one or more routines including normalized gray-scale correlation, line fitting, arc fitting, or edge detection. The system uses these routines to assess the disc's current orientation and makes the necessary adjustments to inspect it from this perspective.

The next step is to compare the input image to the stored image of a correctly imprinted CD label, referred to as the "master," or "golden template." The master is created from multiple images of acceptably imprinted labels in an effort to eliminate or reduce the significance of the subtle differences among them.

The input image is subtracted from the master, pixel by pixel, to reveal dissimilarities. If the result of the subtraction exceeds a predefined threshold, the system records the location of the pixel and categorizes the disc as a possible reject. That threshold value may be different from pixel to pixel, depending on factors like the pixel's location within the imprinted image. Areas within the image that contain a high level of detail must be treated with a greater degree of sensitivity. The inspection system uses a unique adaptive algorithm to define the variable threshold values, minimizing false rejects while at the same time reducing overlook.

The isolated differences may undergo further analysis based on screen printing expertise to determine whether or not they are great enough to be considered defects. After defects have been positively identified, the system records their exact location using a process called feature coordinate extraction. This allows the system operator to trace the problem back to its source and make the necessary adjustments to prevent continued defects.

Project Status

Now under evaluation at Sony Music, the system is outperforming both competitors' products and Sony engineers' expectations. While it's still undergoing testing and revision, the system has been adopted and will be made a permanent part of the production line.

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