Serial Number Identification with Machine Vision

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Abstract. In this paper, DAC consulting presents a new method of acquiring accurate optical character recognition (OCR) results through the use of machine vision. The design consists of implementing a new software called Intellect 1.5, which allows us to preprocess the image by applying a layered aggregate of filters. We then apply an edge detection tool called a fiducial and finally an OCR soft-sensor. Once these layers are applied in order, the software is taught the series of characters to which it must recognize.

Key words: Image Filters, Intellect 1.5, Machine Vision, Optical Character Recognition, Programmable Logic Controllers, Serial Number Identification, Manufacturing, Automation

1 Introduction

The currently installed vision system and accompanying software at Linamars CAMTAC plant are unable to process and identify pin-stamped serial numbers on the machined cylinder heads currently in production at the plant.

Because the system cannot be trusted, the process of entering serial numbers into the database is currently done by an operator. For the system to be completely accurate, it must read and process every serial number approximately 100% of the time. The final design aimed at maximizing the reusability of current equipment; minimizing the overall cost and maximizing the reliability of the operation while ensuring that all serial numbers are correctly processed and that all information is sent to the on-site PLC without human interaction.

The optimal solution to the problem was found through the implementation of the new Intellect 1.5 software. Through the specific application of image pre-processing filters, DAC is able to produce a highly defined image upon which edge detection can be performed to locate the characters and then an OCR soft-sensor to read and learn (through training) the characters. Initially, DAC consulting defined the problem, analyzed various solutions and through analysis & optimization, DAC has developed a final solution of the Vision System. Our milestones consist of recognizing the serial number almost all of the time and of providing for a seamless PLC integration at CAMTAC.

A conceptual design will now be presented that beiefly describes the algorithm upon which a detailed design will break the solution into hardware and software implementations accordingly.

2 Conceptual Design & Methodology

There are two major components to the design of the Vision System; hardware and software. The hardware component is concerned with the camera communication with the PLC through the use of the PLC Profibus in the field and with the camera communication with the host computer running intellect in the software loading phase.

The major hardware components responsible for Intellect integration are a simple network mini-switch to interface the computer with the equipment, a SmartLink device for outputting the camera information over serial communication to the PLC Profibus as well as to a VGA monitor.

The software component is concerned with the steps required after the acquisition of an image and the steps required in order to accurately detect the serial number contained within the image provided. Figure 1 below describes the general steps for processing an image.
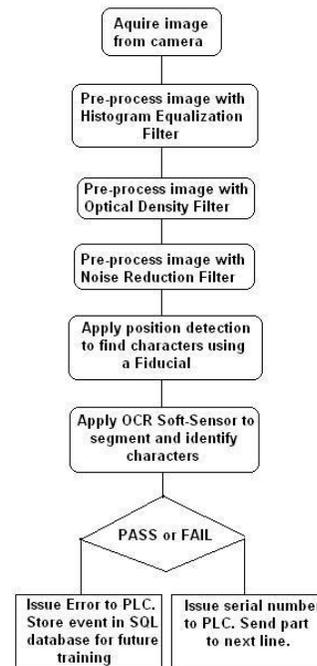

Fig. 1. This figure describes the general design algorithm proposed by DAC Consulting for processing an image

3 Detailed Design

3.1 Hardware Implementation

The Vision System consists of the Legend 530 camera powered by the Motorola power PC, a digital LED lamp to light the source and a SmartLink device, which is used to process the images sent by the camera, deliver trigger signals to the camera and the lamp to capture a frame as well as output currently captured images to a VGA monitor. All communications between the camera, SmartLink and computer are achieved through RJ-45 Ethernet and RS-232 serial communications. The PLC is the only device that requires Profibus communication. Once the computer connects to the camera through the use of the Ethernet network protocol, it receives the camera frames that are captured and is able to display them. The computer is used to make changes to the on-board image capturing component inside of the camera.

3.2 Software Implementation

The software that DAC consulting recommends is titled DVT Intellect 1.5. This software program has a few fundamental differences in functionality that the currently implemented Frameworks 2.8 does not have. A few of these include automatic exposure & gain, automatic segmentation, image pre-processing, positional tracking algorithms such as the fiducial, algorithms such as the orphan removal to remove outlier dots and flaw detection algorithms which correct known flaws in the image.

Intellect has the capability to automatically adjust the exposure and gain of the image such that most of the intensities on the sampled histogram are moved to the middle (a perfectly gray-scaled image).

In order to easily separate the foreground from the background using thresholding, Intellect 1.5 allows the application of layering and image pre-processing filters such as the histogram equalization filter. Histogram equalization of an image is a filter that evens out the frequencies of colour gradients from black to white, thus producing a more crisp image. An optical density filter also aids in the image pre-processing by inverting the white and black intensities. Finally, a noise reduction filter is then applied to the image, which efficiently reduces distortion in the image while preserving edge quality.

Tracking tools are then applied to the pre-processed image. The fiducial is one of these tools and it helps with varying serial number positioning relative to the cameras positioning. The character recognition layer will move within the fiducial (a movable box that locates groups of characters) and the fiducial layer will operate on the pre-processed image (from filtering). Finally, the OCR soft-sensor is placed on the top of the layered aggregate of filters and fiducial layers to identify the characters. Figure 2 below shows the characters identified by intellect after pre-processing.
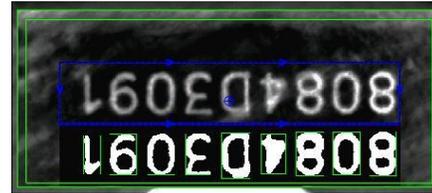

Fig. 2. This figure demonstrates the identified image of the Intellect implementation through applications of pre-processing filters, fiducial and OCR detection.

4 Discussion

As discussed in the detailed design, DAC has chosen the optimal pre-processing image filters to be a histogram equalization followed by an optical density filter and finally a noise reduction filter (through Median pass filtering). Finding the optimal filtering technique was achieved through rigorous testing on sample images gathered in the lab and on site.

On site acquisition with a frequency of 60 frames per minute provided for a real-time sensitivity analysis as it allowed for observation and gathering of images with slight variations in position (as the assembly line was being used). With a pass rate of 95% on over 600 sample images we can conclude that our design continues to maintain stability and is not very sensitive to position variations.

Also, DAC has ensured that the camera will only send a FAIL signal to the PLC when it cannot find a character that resembles the one in the image. The camera will not simply replace the unidentified character with a different (incorrect) character. This is ensured by knowledge that the fifth character is either an A or D and through application of optimal filtering. Figure 3 shows the pass/fail graph indicating a 95% pass rate.
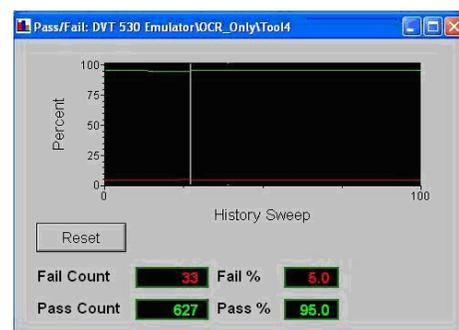

Fig. 3. Pass/Fail graph showing 95% pass rate on 660 samples

References

1. Schalkoff, Robert J., *Digital Image Processing and Computer Vision*, Canada: John Wiley & Sons Inc., 1989.