Machine Vision System

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Abstract. In this paper we present a design for a machine vision system. The design of an existing machine vision system was modified to increase its performance. The current state of the system at the manufacturing plant uses three softsensors and a lens with a wide field of view. Also included is a light source that surrounds the camera. The idea for the suggested solution includes narrowing the field of view by changing the lens or decreasing the distance between the camera and the head. The solution also involves keeping the same number of softsensors and making changes to the settings in the software. Also, the position of the light source has been changed so it is on an angle to the side of the camera.

Key words: machine vision system, optical character recognition, soft sensors, exposure value

1 Introduction

A manufacturing company wants to successfully track engine parts which go through a manufacturing process at an engineering plant with the use of a machine vision system. These parts have serial numbers on the castings that are read through a camera and stored in a central database. The optical character recognition of the machine vision system used is currently functionning at a low success rate. It has been improved to a success rate of 98%, allowing for the firm to eliminate the need for manual entry. The low success rate is being caused by a lack of software settings optimization, non-optimal lighting conditions and exposure settings, and use of an incorrect lens. As such, these components have each been addressed to greatly improve the accuracy and robustness of the system.

2 Conceptual Design/Methodology

2.1 Overall design

The system consists of three major phases. The first phase of the manufacturing process involving the machine vision system consists of the entry of the engine head within the field of vision of the camera. The engine head is positioned such that the camera is able to take a picture of the printed serial number. The second phase involves the optical character recognition (OCR). The picture is analysed through a set of soft sensors, which are created to recognized the characters using the software algorithm. These soft sensors are implemented with respect to the lighting conditions of the manufacturing plant, as well as the possible alterations of exposure of the camera. The last phase of the machine vision process involves the communication of the results to the programmable logic computer (PLC), which disperses the information towards a database.

2.2 Major components

The machine vision system can be divided into major components. The DVT OCR camera is used to capture the image of the engine header as it passes through. In order to eliminate areas that are not of interest, such as reflections and shadows, the lens attached to the camera allows to change the exposure value. In order to store the image captured by the camera onto memory, the smartlink connectivity module is used within the system. The smartlink module connects the camera with the live feed and the profibus. The DVT framework software settings such as soft sensors can be applied onto the digital output of the image of the camera stored within the smartlink module's memory space.

3 Detailed Design

3.1 Lighting

The aperture, the shutter speed, and the sensitivity of the camera are combined to produce the exposure. The exposure of the camera determines the amount of light that is absorbed by the sensor of the camera. One of the reasons that the optical character recognition did not function properly is due to the exposure value. This is because the process of extracting the optical characters rely heavily on the image quality. The exposure value (EV) that generated the solution for the problem is 14 EV. This is was obtained with an aperture size of f/64, as well as a shutter speed of 1/5s. Since the manufacturing plant has conditions where the product is moving and is subject to low light conditions. Having the lens aperture at a small opening allows the use of a high shutter speed in order to keep a sufficiently average exposure. The low aperture specifically eliminates the lighting condition problem by relying on the sensitivity values of the system rather than the ambient lighting. The high shutter speed specifically eliminated the movement problem. Having a low aperture and a high shutter speed required that the infrared flash did not directly reflect into the camera as to not obstruct the view of the engine header. Therefore, the infrared flash was positioned further on the side so that the majority of the light would not reflect into the aperture.

3.2 Software

The software used to perform analysis on the images taken from the camera is the DVT framework version 2.8. This program was supplied with the camera and is currently installed at the plant. Framework is equipped to read strings of any sort of characters using OCR (optical character recognition) soft sensors. These sensors use a variety of methods and algorithms to extract what they believe to be characters in the string, and then to compare each extracted character to one that is already known. Framework provides tools to adjust many settings related to how the characters are extracted and compared, and these settings have been optimized in our solution to improve on those of the current system.

Table 1. Framework Solutions Settings

Menu Item	Sub-Item	Cur. Settings	Sol. Settings
Threshold		OCR: Auto.	OCR: Auto.
Merge Char.	Horizontal	1 pixel	2 pixels
if Less Than	Vertical	1 pixel	2 pixels
Other	Min. Area	30 pixels	400 pixels
	Max. Width	N/A	45 pixels
Advanced	Min. Edge Width	N/A	2 pixels
	Max. # Chars.	N/A	4 - 1 - 4
Matching Threshold		60%	60%

3.3 Hardware

The Smartlink Connectivity Module (SCM) was first set up to ensure optimal communication with the camera and proper display on the monitor. The smartlink provides a common memory space that the PLC and camera use to communicate therefore it is important that the SCM set up properly and is similar to the setting in the manufacturing plant. This enabled proper flashing of the camera using the manufacturer settings and various suggested settings from the group for testing. These included adjusting the threshold, retraining the camera at different lighting conditions, and adjusting the gain values.

A monitor is conencted to the smartlink conenctivity module. This will display the output of the camera and will show the results of the softsensor readings on the head. The DVT camera cannot be directly connected to the smartlink without a crossover cable. The crossover cable reverses the bit order on both pieces of hardware to avoid connecting two send bits to each other and two recieve bits to each other. The ethernet switch replaces a crossover cable in performing this task. The Legend 530 Camera was used in junction with the lens to get the clearest and most legible image possible. Zooming in with the lens while using the aperture settings described in the lighting section above yielded the best results. A closer image results in a bigger and wider area. This means that there are more available pixels from each character for the softsensors to read, and this resulted in improved accuracy of the soft sensors.

4 Results & Discussion

Our solution greatly improved the accuracy and robustness of the system, but was still not able to reach 100% successfull recognition of characters in some cases. The below table sumarizes the results of the current system at CAMTAC as compared to the results of our system.

Table 2. Results of system at CAMTAC vs. Solution

	Head A		Head B	
	Range	Average	Range	Average
Current System	1 to 1	1	0 to 0	0
Our Solution	9 to 9	9	3 to 5	4

As can be seen, our solution was able to attain 100% successful character recognition with engine head A but not head B since it recognized 9 characters out of 9. The painted background surrounding head B was stained and smudged with a black residue making character recognition more difficult. If engine heads can be kept at a level of quality and cleanliness surrounding the serial number as seen in head A then our solution will be able to perform at 100% success.

For future work it is recomended to invistage the use of scripting within the framework software. Scripting would allow the combination of results from multiple images into one final result, and thus reduce the number of system failures.

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