A robust OCR system for stamped characters in rough industrial environments

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1 Introduction

The processing of coded information on surfaces of industrial products like paper tags today can be solved with standard reader systems with high accuracy. But there still exists the need for reading and identification capabilities in industries which can not provide flat and clean surfaces for visual markers. In the steel processing industry for example quality control of raw material for the production of pipes, steel bars, or wires is essential in order to guarantee the continuous quality of high value products where any single error due to invalid processing of the wrong material can easily cost 6 digit amounts of money.
Typically in steel plants the environmental conditions (temperatures, vibrations, huge amounts of dust, very rough material surfaces) do not lend themselves to easy solutions for visual processing of information. This work describes the design and algorithms of a code reading system which uses state-of-the-art pattern recognition. The implementation works well enough so that noisy, distorted, and partially erased characters can be identified. The codes need not be aligned with respect to the camera in terms of rotation and position within the image frame.

2 System description

2.1 System Architecture

The reading stations in the plant are built from VGA resolution cameras which image the front and backside of steel billets which are illuminated by LED ring lights. The illumination is setup so that the embossed characters create as much contrast as possible. Nevertheless their appearance can change drastically from sample to sample, so that no easy segmentation or binarization of their shape is possible. As a solution we borrowed the recognition algorithm from a totally different field of application which nevertheless exhibits very similar basic characteristics: the location and scale invariant detection of pedestrians in images with cluttered background.

2.2 Pattern Recognition

The basic algorithm for character localization and identification is built from a HOG detector which has been trained on thousands of positive character and negative background samples. The HOG features are classified using a linear Support Vector Machine. Class differentiation is achieved with a best-wins-all approach.

2.3 Code search

ID candidates are found by search of the input image with a brute force scanning at 4 pixel distance. Resulting detection candidates are collected and by applying RANSAC for the detection of lines (using the candidate detection centers) we create a hypothesis for the existence of an ID code. This procedure is continued on a 20° rotated version of the input image. After all possible rotation angles have been checked, the RANSAC line candidate with the best overall summed detection score is chosen as the ID code location. If the score is too low, we assume that the image does not contain a code and we reject the image.
After rotating the image so that the best candidate is aligned horizontally, we rescan the ROI around the line with a narrower grid of 2x2 pixel distance and choose the best detections which are spaced approximately in character width distance.
The scanning procedure for the characters relies on two properties of our feature descriptor/classifier framework, namely i) that the false positive rate is low enough that practically no false detections occur in the critical second stage dense scan (e.g. that no inter-character locations are falsely classified as characters, even in the presence of heavy background noise, and ii) that the brute force scanner can be implemented fast enough.

The performance optimization of the algorithms and the implementation is founded on

- gradient computation using SSE instructions and look up tables for angle and magnitude computation
- a very fast HOG feature implementation using SSE instructions
- integral histograms (on 8 channels) to allow fast scanning of sample windows
- a very fast linear SVM implementation using SSE instructions

3 Reading accuracy

The ID reading stations have been extensively tested and evaluated by the users of the system. All in all 6 reading cameras have ben installed in the steel plant in April 2011.

The average reading accuracy depends on the actual properties of the input material (surface type, sawing resp. cutting tools used, age of the material which influences surface corrosion, etc.). On a 9 digit code the typical accuracy is >99% which gives a per character classification accuracy of approx. 99.99%.