Optimal statistical detection of rolled sheet's surface defects

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Keywords: Optimization, statistical inference, probability, histogram, density function, sheet.

1 Introduction

The aim of this work is to develop an artificial vision system for detecting surface defects on cold rolled sheets. [1]

These sheets are obtained from hot-rolled sheet and pass into the cold rolling mill by four main steps: The pickling, rolling, annealing and skin-passing [2]. After the pickling step the sheet may have defects such as folds, rips and marks of cylinders, or metallurgical defects such as creeks and straws. Appearance defects can also be formed such as claws, cut away, spots of residual calamine, spots of rinsing…etc. These surface defects have different levels of severity, according to their influence on the rolling mill, the production and the functions to which they are intended. If these faults are not detected in time, they will evolve during rolling and the other process steps. The combination of thermal, metallurgical and mechanical factors will amplify the default by its lengthening, increasing its depth, its transformation into a more harmful default, its propagation… etc. The evolution of these defects can cause the deterioration of mill rolls, the break of the steel strip and many other problems [3]. These incidents involve stopping production for a period ranging from several hours to several days. The engendered damage and decreased productivity directly drive to financial losses.

We opted for a detection method based on a statistical approach using essentially the Bayesian philosophy seconded by specific criteria of detection and carefully selected attributes.

Our work is divided into three parts: The classification, the detection of the presence of a defect and the recognition of this type of defect.

We chose two defects (cracks and straw) to simulate our study [4]. First, we proceeded to a preliminary study to obtain the density functions and the priori probabilities of the sheet and defects, and then we integrated them in the Bayes formula [5]. Such as the histograms of sheet flawless and two chosen defects have an allure close to the Gaussian distribution, we made a statistical inference from a significant number of samples of these histograms and we estimate the parameters (expectation μ and standard deviation σ) of Gaussian distribution representatives of these density functions with method of the maximum-likelihood. [6]

Seen that these histograms overlap on a common interval, only the calculation of the probabilities of belonging of each pixel to sheet metal and to the defects are not sufficient and detecting the presence of a defect will be always with a probability of error. It was then necessary to add a criterion of differentiation to minimize this error and ensure the reliability of the detection of presence of the defect.

Finally, to optimize the operation of defect detection, we introduced geometrical attributes of each defect (elongation criteria dimensional criteria, criteria specific to the shape and area ratios).

This method will subsequently be implemented in a program using image processing software adapted to a matrix camera. [7]

We plan to extend this study to all major surfaces defects that occur on a rolling line. For this we will develop a list of all defects with their characteristics and we will classify them in an album file, which will be used as reference for the calculation and the development of the specific criteria for detection.

In conclusion, this work will increase the quantity and the quality of the product, prevent the evolution of defects (and therefore the stops of the chain), simplify working conditions of the operator and it allow the optimization of the sheet rolling process thanks to early detection of surface defects.

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