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Optimization algorithm for positioning of spark points on samples used for OES analysis

Abstract

In this study, we assessed the performance of the new SparkPoint module in determining the location of spark points on samples used for optical emission spectroscopy. Both in a simulation environment and robot automation, the module was challenged by a varying number and size of defects on the sample surface. We evaluated the software's efficiency in avoiding these sample defects and locating the spark points within the preferential target area. In all 150 tested samples we found a sufficient spark point location being consistent with a successful OES analysis.

Key words

• **Spark point** • **Optical Emission Spectroscopy** • **SCADA** • **PrepMaster** •

Introduction

Herzog has recently launched a new software module for automatic determination of spark point (SP) locations on a sample surface. The so-called "SparkPoint module" is part of the PrepMaster Core and Entry SCADA software controlling the SteelLab and MetalLab used for analysis of ferrous and non-ferrous samples. The SparkPoint module has numerous options for setting basic parameters including sample shape and size, diameter of SP's and number of analyses per sample. Furthermore, constraint for computation of SP locations can be defined like, e.g., minimum distance between SP's, distance from the sample edge or proximity to the sample pin.

The optimization algorithm of the SparkPoint module takes into account these basic parameters and constraints as well as the position of defects on the sample surface as revealed by a vision system. It calculates the best possible distribution of the SP's on the sample surface avoiding the sample defects. The coordinates are transmitted to the robot placing the sample on the stand of the optical emission spectrometry (OES). Usually, computation is so fast that the transfer of coordinates has been accomplished before the robot arm reaches the OES instrument.

In this application note, we present the results of a study assessing the efficiency of the algorithm in determining the accurate SP locations.

Methods

For this study, we used round lollipop samples (diameter 35.0 mm) with a pin length between 0.4 and 0.8 mm. In the configuration menu of the SparkPoint module, we set the inner diameter of the SP to 5.0 mm, the outer diameter (corresponding to the condensate from the sparking process) to 8.5 mm. The number of SP's per sample was 3. In all trials the selected preferential areas for SP location were identical (Figure 1).

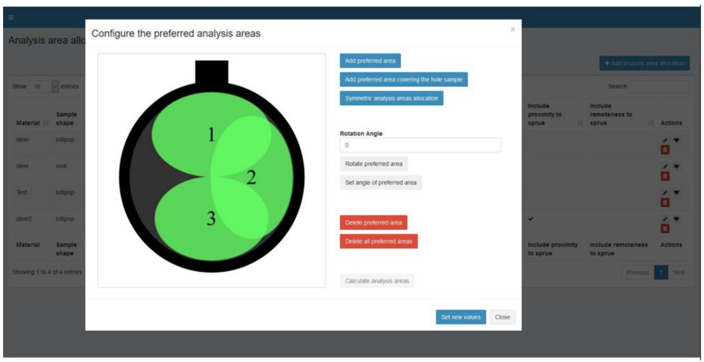

Figure 1: *Setting of the preferential areas numbered from 1 to 3 within the configuration menu of the Sparc Point module.*

In the first part of the study , we run a simulation with the following parameters altered randomly within given value ranges: Sample rotation, position of the sample defects on the sample surface, extension of defects in x- and y-direction, size of defects, and number of defects on the sample surface (Table 1).

Parameter	Value range
Sample position (x-axis/ y-axis)	315-325/ 325-345
Sample angle	0- 360°
Number of defects/ sample	0-8
Position of defects (x-axis/y-axis)	100–400/ 50-550
Extension of defects (x-axis/y-axis)	1-100/ 1-100
Area size of defects	1- 10000

Table 1: *Parameters and corresponding value ranges used for the simulation study. The parameters were randomly altered within the given limits.*

In the total of 100 simulation trials, the probability of occurrence of 5, 6, 7 or 8 defects was set to 2.5 %. The probability for no defect was 10 %. For 1, 2, 3, or 4 defects, it was 20 %.

After completion of the simulation, each trial was evaluated manually to verify that the SP's were positioned in the preferred areas and did not overlap with the sample defects.

In the second part, we inserted 50 round lollipop steel samples into a robot automation equipped with a vision system and an OES analyzer (model SPECTROMAXx, Spectro Ametek, Germany). We artificially added defects on the surface of each sample. The total area of the defects varied between 5 to 33% of the whole sample surface. After computation of the SP location by the SparkPoint module, the coordinates were transferred to the robot which positioned the sample on the spark stand of the OES instrument. Following completion of all trials, we evaluated whether all SP's were located within the preferential area and did not overlap with sample defects.

Results

<u>Simulation study</u>

In the simulation, all computed SP's were located within the chosen preferential areas. Furthermore, we did not notice any overlap of the SP's with the simulated defects (Figure 2). This was true for all samples being simulated in this study.

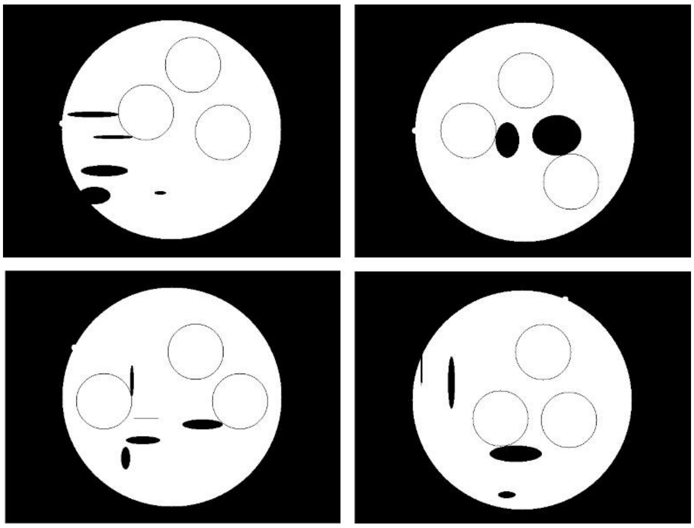

Figure 2: *Typical examples for the distribution of spark point locations in the simulation study. In each trial, the defects (black areas) were randomly spread across the sample surface. The number and size of defects were also randomized according to the pre-defined probability of occurrence.*

Robot automation study

In the robot automation study, all computed SP positions were located within the preferential areas without any overlap with sample defects. After completion of the OES analysis, the position of the actual SP`s were compared to the SP's computed by the SparkPoint module. We did not find any indication for significant differences. The number and area size of the defects did not affect the ability of the SparcPoint module to find appropriate SP locations (Figure 3).

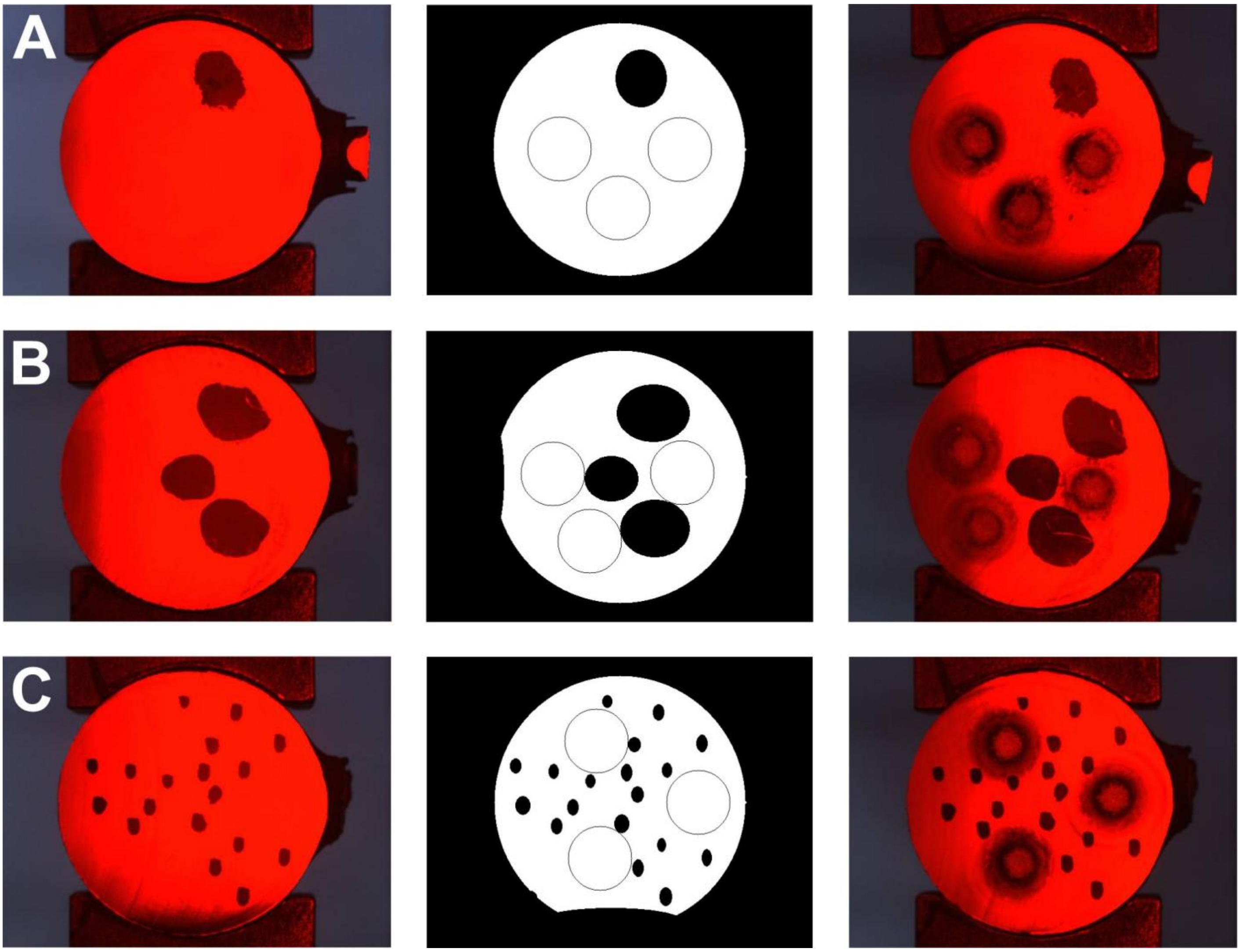

Figure 3: *Examples of samples with artificially added defects on the sample surface: (A) Sample surface with one larger defect, (B): Sample with three larger defects, (C): Sample with multiple smaller lesions. The left pictures show the image of the vision system for defect detection, the middle pictures depict the computed spark point areas, the right pictures shows the location of the actual spark points after OES analysis.*

Discussion

The outcome of the study shows that the new SparkPoint module of the PrepMaster software is a powerful tool for determination of SP locations. Both the simulation and the robot automation study demonstrate that the module is capable of dealing with difficult challenges like large defects or an unfavorable distribution pattern of defects on the sample surface. In every case, the module will reliably place the SP's within the targeted zone.

The new module gives the operator multiple options to adapt the configuration of SP's to the specific demands of each QC laboratory. Accordingly, it is selectable whether the module considers only large cavity defects or also small lesions due to slag inclusions. Furthermore, certain areas of the sample can be eliminated from OES analysis like, e.g., the surface edge. Eventually, it is guaranteed that the analysis takes place only in the target zones of the sample. This is of particular importance because there might be significant discrepancies of the elemental concentration within a sample. These discrepancies are due to the segregation processes taking place during sampling. A further improvement of the analytical bias can be achieved if the sample is preferentially analyzed in an area which has been proven to produce reproducible results.

While not observed in this study it might happen that the software is unable to find a workable solution. In this case, the operator is either notified of the unsuccessful attempt or the sample is automatically re-prepared. Alternatively, it is also possible to soften the constraints for SP determination by, e.g., automatically reducing the distance between SP's. The operator is free to decide which will be the best approach according to the specific requirements and processes of the laboratory.

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