Acoustic Maps Processing with Image Enhancement Techniques in Grinding Wheel Dressing for Industry 4.0

ECSA-11 2024 Conference

Matheus Luis Despirito, Marcio Rafael Buzoli, Fabio Romano Lofrano Dotto, Pedro de Oliveira Conceição Junior, Paulo Roberto de Aguiar.

São Carlos School of Engineering (EESC) - University of São Paulo (USP) - São Carlos/SP - Brazil

Introduction

Grinding is the final stage of machining, utilizing an abrasive wheel for finishing. Over time, the surface of the wheel wears down, and its pores become clogged with chips. To restore its functionality, a process called dressing is performed, which renews the surface of the wheel. Studies, such as the work In-Dressing Acoustic Map by Low-Cost Piezoelectric Transducer [1], implement systems to analyze the quality of dressing, focusing on the acoustic mapping of the wheel's surface. However, acoustic maps often exhibit noise and tonal variations that complicate processing with simple filtering methods. Thus, this study proposes the application of edge detection algorithms to enhance the interpretation of acoustic maps by reducing noise, highlighting defects and marks, and integrating cloud processing for better efficiency in data handling.

Objective

To study the application of edge detection algorithms to enhance the analysis of acoustic maps, utilizing cloud-based digital image processing to increase efficiency in analyzing this type of image.

Methodology

Figure 1 shows an acoustic map generated during the dressing process, using a grinding wheel with a known topology engraved with the symbols "+" and "T". These maps are grayscale images in which details are highlighted by abrupt intensity variations, revealing the edges.

a)
b)

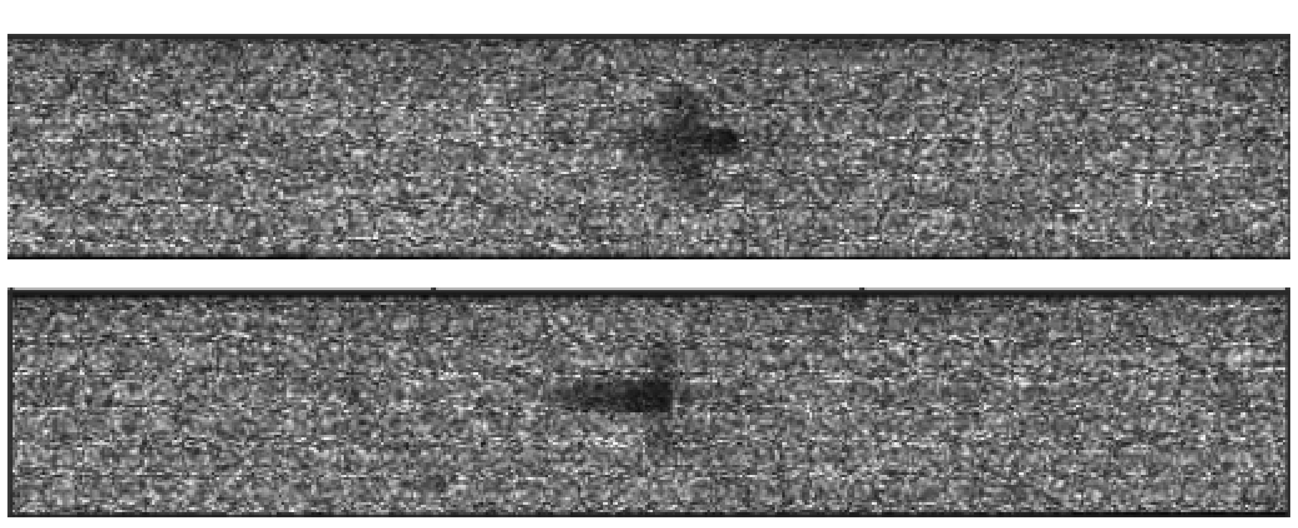

Figure 1: Original acoustic map of the marks inserted on the grinding wheel: (a) "+" mark; (b) "T" mark.[1]

Edge detection is based on image convolution with masks (kernels) and magnitude calculation, highlighting important features of the acoustic map. The main algorithms analyzed include Roberts, Sobel, Prewitt, and Canny. The Canny algorithm, in addition to applying masks, uses non-maximum suppression and edge tracking by hysteresis, providing more precise and continuous edge detection. [2]

Results and Discussion

The following figures display the results of each filter and analyze the overlay of the results, leveraging the distinct characteristics of each one.

a)
b)

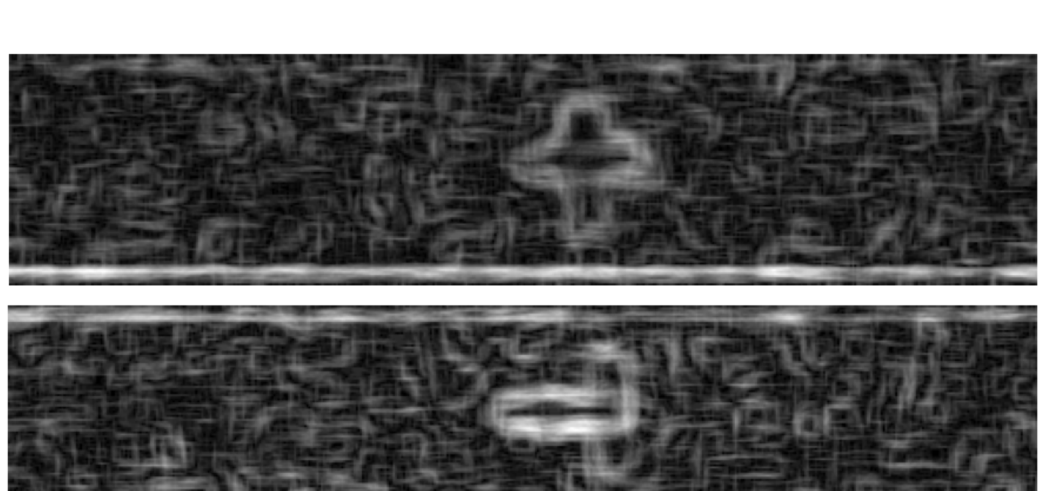

Figure 2: Image with Sobel detector: (a) “+” mark; (b) “T” mark.

a)
b)

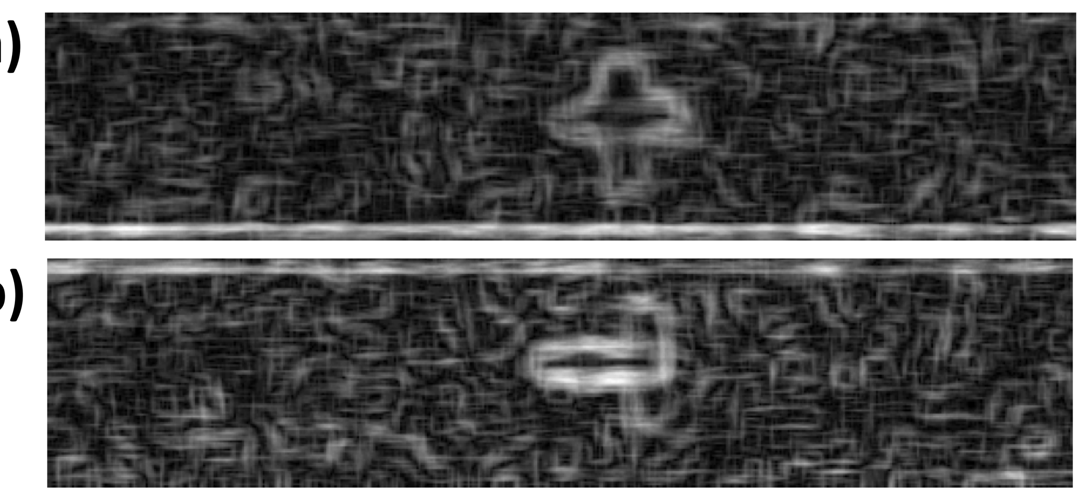

Figura 3: Image with Prewitt detector: (a) “+” mark; (b) “T” mark.

a)
b)

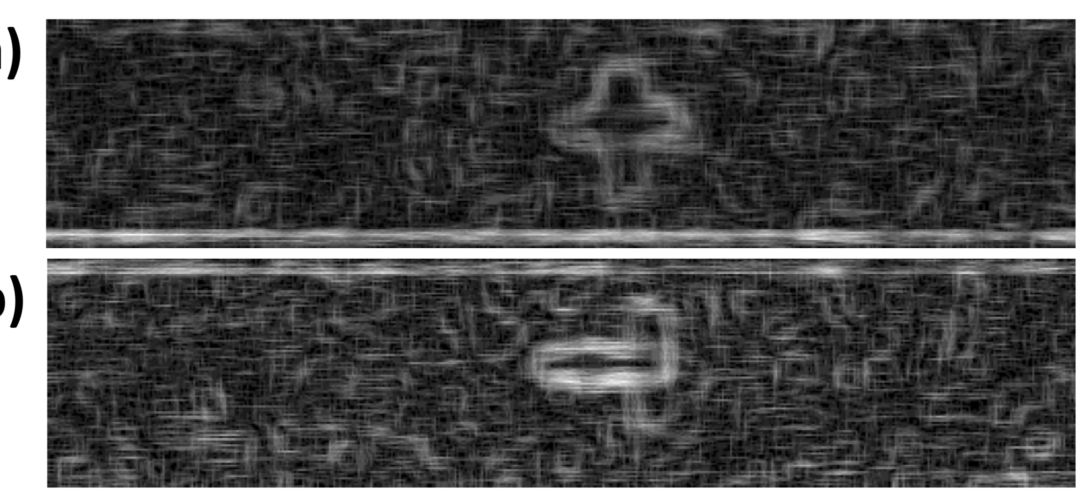

Figura 4: Image with Roberts detector: (a) “+” mark; (b) “T” mark.

a)
b)

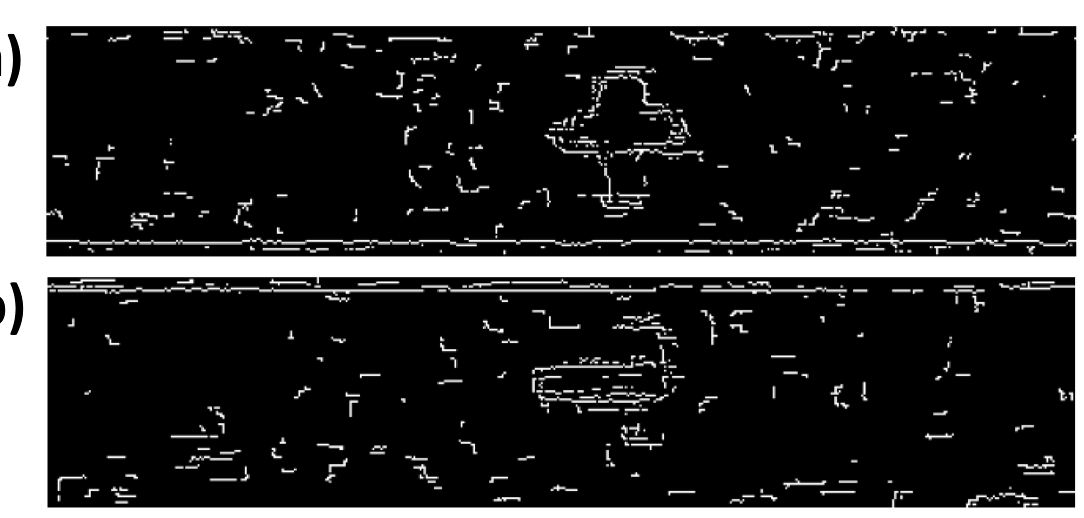

Figura 5: Image with Canny detector: (a) “+” mark; (b) “T” mark.

a)
b)

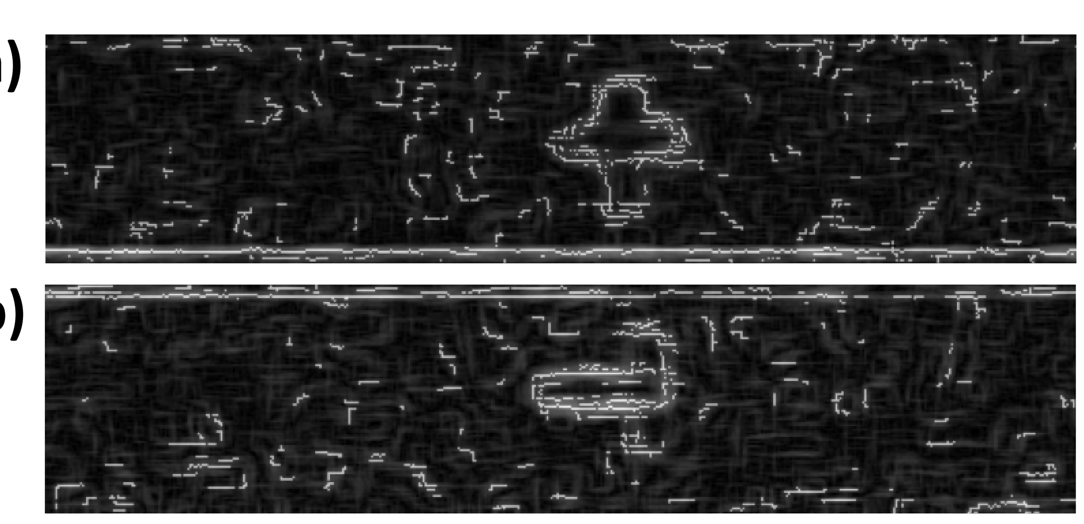

Figura 6: Canny image with 50% Sobel Overlay: (a) “+” mark; (b) “T” mark.

Conclusion

The study demonstrated that applying edge detection to acoustic maps is an effective approach to enhancing the interpretation of this information. The use of cloud processing tools proved advantageous, providing a robust infrastructure for executing complex algorithms and eliminating the need for local computational resources. Overlaying images from different algorithms enables more detailed analysis, as each has unique detection characteristics. The results suggest that these tools can not only improve the quality of acoustic maps but also facilitate the integration of image processing methods into tool condition monitoring (TCM) systems in the dressing process. Additionally, the discussed approaches can be applied to other machining processes, such as turning and milling, contributing to the advancement of sensor-based monitoring technologies and the development of Industry 4.0, where technological solutions are essential for smart manufacturing.

References

[1] Dotto, F. R. L.; Aguiar, P. R.; Alexandre, F. A.; Lopes, W. N.; Bianchi, E. C. In-Dressing Acoustic Map by Low-Cost Piezoelectric 16 Transducer. IEEE Transactions on Industrial Electronics, 2020, Volume. 67, 6927–6936.

[2] Gonzales, R. C., and Woods, R. E. Digital Image Processing, 4th ed.; Pearson Education Limited: Upper Saddle River, NJ, USA, 18 2017; pp. 154–162.