Automatic Detection of Breakouts Patterns in Acoustic Image Logs Using MSRF-Net

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Abstract

The breakouts identification is an essential task to understand the borehole's stability. The interpretation process, which is usually performed manually, can be exhausting both due to the intrinsic complexity of the data and the presence of artifacts that can compromise data quality. This work presents a methodology for segmenting breakout structures automatically using a convolutional neural network called MSRF-Net, with a modification on the Shape Stream block to enhance the precision of object boundary delineation. The model achieved an average F1-Score of 75.2% and an Intersection over Union (IoU) of 59.5%.

Method

The identification and characterization of breakouts is a significant step in reservoir modeling as they can assist the stress directions determination in the wellbore. Recently, Anjos *et al*. (2023) proposed an automatic detection of breakouts using DC-Unet. Although the results were interesting, in some cases, the qualitative analysis of the detection indicated gaps or missing structures. The DC-Unet was also used for image log structures segmentation in small labeled datasets (Cunha (2023)). Dias *et al.* (2020) successfully defined a bounding box for breakouts in synthetic data using the fast-RCNN architecture. Image processing techniques were also applied in transit time logs for breakout segmentation, as described by Valentín (2018).

In this work, we followed the strategy proposed by Anjos *et al*. (2023), performing a pixel-by-pixel classification for the breakouts segmentation in the wellbore's amplitude image logs. To achieve this goal, a neural network model was trained with the MSRF-Net (Srivastava, 2021) architecture.

The MSRF-Net (Multi-Scale Residual Fusion Network) is a binary deep learning designed to solve semantic segmentation problems in medical images. The architecture's main characteristic is a dual scale dense fusion (DSDF) block, which allows better segmentation regardless of the objects' sizes in the image. In addition, the network has other important blocks, such as Shape Stream, which adds another input to the network with the initial edge of the object, and Squeeze-and-Excitation.

A modification was introduced in the Shape Stream block in the proposed work. While the original network utilized the Canny method (Canny, 1986) for extracting the object contour, in this work the Otsu's thresholding method (Otsu, 1979) was applied, followed by a Gaussian filter before extracting the edges using Canny. This enhancement allowed a more precise delineation of object boundaries, contributing to improved performance and accuracy in the segmentation process.

To train the neural network, a labeled database provided by Petrobras specialists was used, consisting of 32 distinct wells. The data distribution was approximately 60% for training, 20% for validation, and 20% for testing. A filter was applied to the ground truth mask to mitigate potential noise in the labeling process. Additionally, a dilation morphological operation was employed to expand the boundaries and enhance the accurate delimitation of breakouts areas.

Results and Conclusion

The model generation involved training for 300 epochs, employing the binary cross-entropy loss function. The model demonstrated good performance, achieving an average F1-Score of 75.2% and an IoU of 59.5%.
Figure 1 shows a comparison between the present work and the strategy proposed by Anjos et *al.* (2023). Although more false positives were detected for noisy data, the strategy using MSRF-Net detected breakouts with more quality.

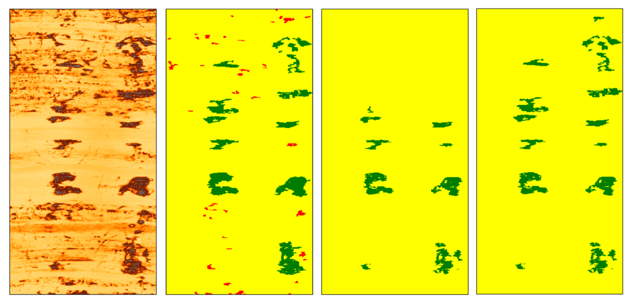

Figure 1 – Comparison between Anjos *et al.* (2023) and the present work. From left: Amplitude input; Ground truth, DC-Unet results and proposed work.

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