Digitization of Raster Logs: A Deep Learning Application

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Summary

Raster well logs are digital representations of well logs data and have been generated over the years. Raster digital well logs represent bitmaps of the log image in a rectangular array of black and white dots called pixels. The white pixels are represented by zeros, and the black pixels are represented by ones. Well log data saved as depth-calibrated raster images provide an economic alternative to digital formats for preserving this valuable information into the future (Cisco, 1996). Although often discarded after vectorization, raster imaged well logs may be the key to a global computer-readable format for legacy hardcopy data. This legacy data is stored on multiple media and contain information for a variety of applications in addition to resource exploration and development, such as environmental protection, water management, global change studies, and basic and applied research. Experts revisit and study the raster mostly manually or with software applications that still require tremendous amount of manual input. Besides the loss of thousands of person-hours, this process is both erroneous and tedious. To digitize these raster logs and efficiently use them in conventional as well as unconventional analysis one needs to buy a costly digitizer that are not only a manual and time-consuming task but also there is a hidden technical debt since enterprises stand to lose more money in additional servicing and consulting charges. We propose a novel SOTA (state-of-the-art) AI model VeerNet, powered by our novel and cutting-edge deep learning technologies to address these challenges. We use an attention mechanism, a novel technique that mimics human-like cognitive attention. The crux is that the network devotes more focus to that small but most important part of the data in an encoder-decoder architecture. This architecture efficiently classifies the grid and the curve with an accuracy > 94% for dice loss.

Theory / Method / Workflow

To study the digitization of healthy log curves, we need ground truth in the form of both las files and images, las to be used as labels for the classification problem. We generated enough synthetic images (Log) to train the attention model in the first iteration of data generation. A synthetic curve was generated with the parameters such as mean, global standard deviation, local standard deviation, etc. This pipeline was created using pycario by introducing several defects to the image (Logs). Below mentioned are the parameters that were introduced in this version

- Curve Marker Type: solid, regular-dashed, irregular-dashed, dash-dotted, dotted
- Curve Marker Width: controllable using width_multiplier
- Curve Marker Brightness: controllable using brightness
- Grid spacing: Linear, Log, Irregular
- Gridline thickness: Global, Local
- Number of Curves
- Curve Generation Method: Random Normal, Random Standard, Parametrized Normal from Las files
- Curve Std Deviation: Global, with outliers

- Original Track Length: 32*(50,400)
- Annotations: Circle, Cross, Pointer, Text
- Scan Defects
- Curve Overflow

Loss	Mask Evaluation												CSV Evaluation			
	IoU			Precision			Recall			F1 Score			MAE		MSE	
	Mask												Curve			
	0	1	2	0	1	2	0	1	2	0	1	2	1	2	1	2
Dice	0.94	0.26	0.21	0.96	0.41	0.36	0.97	0.37	0.32	0.97	0.37	0.32	0.11	0.12	0.03	0.04
Tversky	0.94	0.22	0.22	0.97	0.41	0.34	0.98	0.30	0.36	0.97	0.34	0.34	0.12	0.13	0.03	0.04

Results, Observations, Conclusions

Figure 1: Mask and CSV evaluation based on VeerNet model.

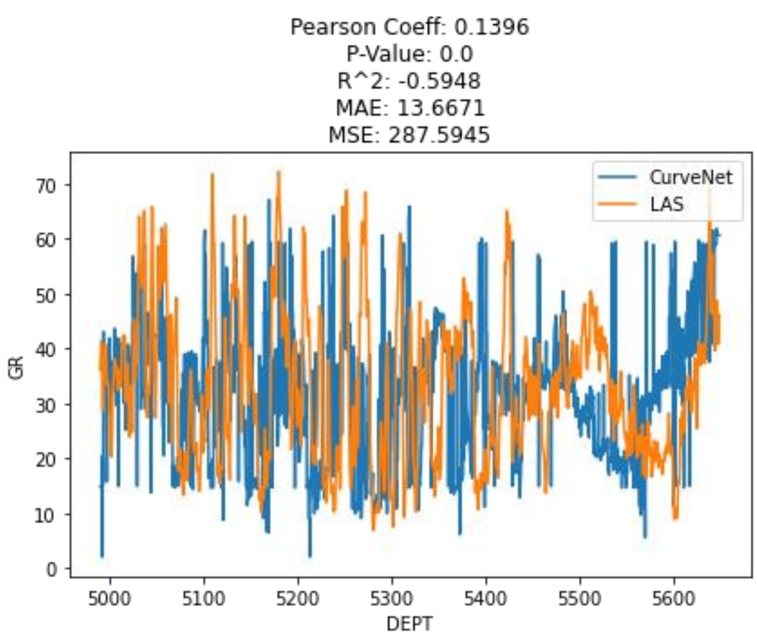

Figure 2: Comparison with real data based on VeerNet and LAS

Novel/Additive Information

The deep learning model ***VeerNet*** model takes input paper log and applies filtering to extract feature maps. The Model reduces the paper log's feature map size, then, in the middle layer, applies attention to signals present in the paper log. Using this attention information, the model expands the paper log feature map to its original shape and retains only the signals removing everything else from the image.

The VeerNet model comprises an Encoder-Decoder architecture. The encoder is composed of Residual blocks, which help in flowing information from shallower layers to deeper layers. Five residual blocks encode the image in a feature map of 1/32th size of the original image. Then the model has two transformer layers that contain an attention layer. Here the attention weights (Vaswani et. al., 2017) are computed for the input feature map and to generate an output vector with encoded information on how each pixel should attend to all other pixels in the image.5 decoder layers follow the transformer layer, each comprising an upscaling operation and a convolution operation to attain the same size of output as given in the input.

References

Cisco, S. L. (1996). Raster images offer low-cost well log preservation. *Oil and Gas Journal*, *94*(51).
Vaswani, A., Shazeer, N., Parmar, N., Uszkoreit, J., Jones, L., Gomez, A. N., ... & Polosukhin, I. (2017). Attention is all you need. *Advances in neural information processing systems*, *30*.