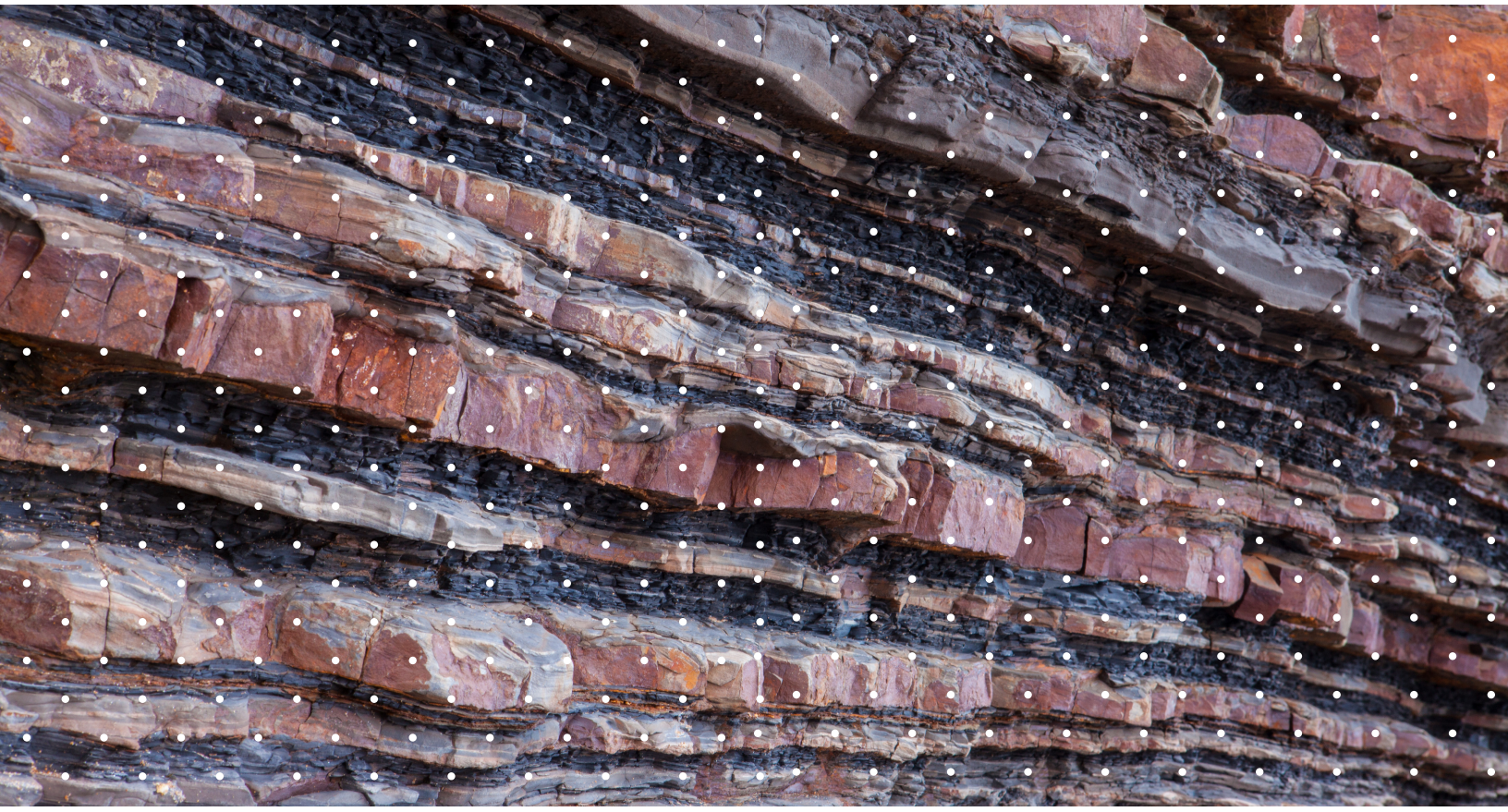
EarthScan

O&G AI Practice

AI in Geology: Transforming Noisy Curves into Instant Insights

The ongoing digital revolution, often referred to as the "fourth industrial revolution," is marked by the integration of advanced technologies such as AI, robotics, and autonomous vehicles. Deep learning, a subset of AI, has the potential to significantly enhance traditional reservoir engineering practices and address a diverse range of challenges in this field.

by Tannistha Maiti, Tarry Singh



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Digital transformation, driven by the extensive application of Artificial Intelligence (AI), has the potential to disrupt various industries, with a projected compound annual growth rate of 38.1% from 2022 to 2030. This presents opportunities for companies to leverage new technologies across their entire value chain, including areas such as research and development, supply chain, finance, and human resources. However, companies in the upstream industries of oil and gas and mining are facing challenges in shifting their business models to capitalize on this potential, such as a lack of resources and expertise in AI, as well as a slow pace of technology adoption.

The concept of the "great crew change" within the oil and gas industry is a well-known phenomenon. It refers to the significant age gap present in the workforce, with most engineers and geoscientists being either over 55 or under 35.

This talent shortage is further exacerbated by a lack of technological innovation within the industry and a shift towards online technologies driven by the internet, leaving the oil and gas sector behind. Historically, the industry has relied on basic, paper-based technology and has not prioritized the need for innovation as companies focused on resource development and profit generation.

However, as the industry faces the challenges of the great crew change, it has become increasingly important to explore innovative solutions to address the talent shortage and stay competitive in a rapidly changing technological landscape.

Automation is vital for the future of business

One such solution is the integration of advanced technologies such as AI and Machine Learning. For example, the use of large language AI models like ChatGPT can assist in automating repetitive tasks and knowledge transfer, allowing for more efficient use of resources and reducing the reliance on a single expert. This can help bridge the knowledge gap and ease the transition during the great crew change, allowing companies to continue to operate at optimal levels.

Regardless of the specific automation solution implemented, there are several common benefits that can be achieved.

- Improved operational efficiency: Automation solutions can streamline processes and reduce the need for manual labor, resulting in increased efficiency and productivity.
- **Cost and time savings:** Automation can help to reduce costs associated with labor and errors, while also reducing the time required to complete repetitive tasks.
- **Improved quality and consistency:** Automating processes can ensure that tasks are performed in a consistent and accurate manner, leading to higher quality results.
- **Increased employee satisfaction:** Automation can free employees from performing tedious, manual tasks, allowing them to focus on more engaging and fulfilling activities.
- **Increased customer satisfaction:** Automation can support faster processing times and improved customer service, leading to higher levels of satisfaction among customers.

The Challenge: Slow Adoption of Technology

The oil and gas industry has faced a unique challenge in terms of adopting new technologies. Ironically, the industry's success in terms of high market prices and a steady influx of capital has led to a lack of investment in more efficient practices. With a focus on growth and reserve exploration, companies have been able to overlook inefficiencies in their operations. This has led to a mentality among some industry leaders that if the company is performing well in the market, there is no need for change. This mentality is often referred to as the "old-guard" and it is one that does not fully comprehend the potential for technologies to drive significant business value.

The Immense Potential of Digital Transformation with AI

As reported by a recent market analysis, the AI market is projected to surpass US$ 1,597 billion by 2030. Across various industries, organizations are recognizing the importance of embracing digital transformation in order to remain competitive in the current market. The oil and gas industry, however, has been slow to adopt new technologies such as robotics and Artificial Intelligence. While the industry has begun to implement these technologies in recent years, such as the use of the Iron Roughneck system developed by National Oilwell Varco Inc. to automate dangerous and repetitive tasks on oil rigs, there is still room for significant growth in the adoption of AI in most oil and gas companies.

"Although AI's entrance into the oil and gas industry announces "*the end of petroleum engineering*", we expect to see an opposite effect. In the AI-era, next to data scientists O&G companies will invest in petroleum engineers with a strong sense of data science and the ability to identify and design tasks to be solved by AI."

AI Automation is already happening, but will it expand to all players?

Schlumberger customers will now have access to a cutting-edge machine learning platform with market-leading AI capabilities. Through its partnership with Dataiku, a world leader in "Everyday AI," Schlumberger is empowering its customers to design, deploy, govern, and manage AI and analytics applications on a single, centralized platform.

This move follows Schlumberger's successful launch of two AI centers in the Americas, one in Rio, Brazil, and a recently opened center in Houston, Texas, as well as the company's existing network of experts in Abu Dhabi, Beijing and Kuala Lumpur.

The DELFI cognitive E&P environment, with its powerful artificial intelligence (AI) and industry-leading analytics, is the first step in providing customers with a wide range of cognitive capabilities.
And this is just the beginning, as Schlumberger plans to continue to innovate and push beyond AI in the future.
Some examples of the impact of this technology include:

- Seismic processing timelines reduced from 13 months to 2.5 months
- 80% decrease in fault interpretation time
- 50% increase in well planning efficiency, and
- The ability to run 14 extra field development scenarios in 1/3 of the time.

Halliburton, a leading provider of products and services to the energy industry, recently launched DS365.ai - a cutting-edge solution that delivers curated subsurface, drilling, and production AI/ML models as cloud services to enable predictive operations for the real-time enterprise.

With over 70 projects and more than 60 AI/ML models deployed at scale, DS365.ai has already demonstrated a rapid return on investment for our clients. For example, a national oil company used our technology to predict artificial lift failure, resulting in a savings of $4 million across 60 wells. Another client, an international oil company in Latin America, deployed an ML seismic conversion methodology, which reduced uncertainty and led to a 70 percent reduction in modeling cycle time.

What's happening at Shell is pretty amazing. They have a very deliberate strategy of using AI, right across their operation... from the drilling operations to safety in... Shell Retail stations.
Satya Nadella, Microsoft CEO

Shell is a leader in digital technology, with over 100 AI applications in various stages of development and deployment across their businesses, a large data lake, and use of machine learning to monitor thousands of pieces of equipment in upstream, downstream manufacturing and integrated gas.

Transformers Take Over AI

The Transformer model, first introduced in 2017 through the paper "Attention Is All You Need," revolutionized the way in which neural networks approach language processing. Unlike traditional approaches, the Transformer model utilizes self-attention, allowing every element in the input data to connect and pay attention to every other element. This allows for the model to see traces of the entire dataset as soon as training begins.

The Transformer's success in language processing was quickly followed by breakthroughs in image recognition. The model achieved over 90% accuracy in image classification, surpassing expectations and quickly becoming a leading contender in the ImageNet classification challenge, a prestigious contest in the field of image recognition.

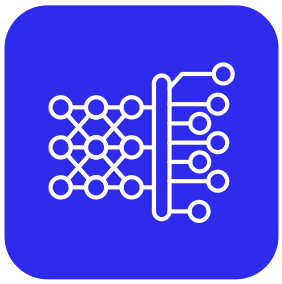
The Transformer model's ability to process language and vision with such efficiency has sparked a wave of innovation in the field of AI, and researchers are now exploring its potential applications in a wide range of industries and tasks.

One of the most notable is the invention of ChatGPT, a large language model developed by OpenAI. ChatGPT is based on the transformer architecture and has been trained on a massive dataset of internet text, allowing it to generate human-like text with high coherence and consistency.

Another breakthrough coming out of the transformer architecture is BERT, which stands for "Bidirectional Encoder Representations from Transformers" and it is a transformer-based model trained to understand natural language. These breakthroughs in transformer-based models such as ChatGPT and BERT have pushed the boundaries of what was thought possible with AI, and have opened up new possibilities for natural language processing and understanding.

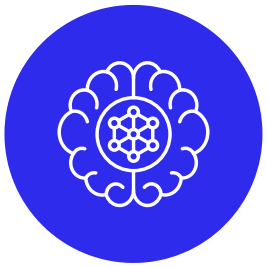
CNNs, its predecessor, have powered the image recognition technology by providing a way to automatically learn the most important features of the image that are useful for the task at hand. This enables the network to achieve high accuracy in recognizing objects, faces, scenes and even images. They have been used in various applications such as medical imaging, facial recognition, self-driving cars, and more.

While powerful but they have some inherent weaknesses when compared to transformer-based models. CNNs are based on the assumption of spatial invariance, which is not always suitable for complex computer vision tasks where features in different parts of the image may vary greatly. Furthermore, CNNs are not well-suited for tasks that require understanding the relationships between different parts of the image. For example, in object detection tasks, a CNN would need to be trained separately for the task of object classification and the task of object localization, while transformer-based models can learn to perform both tasks simultaneously, which makes them more suitable for more complex computer vision tasks.



A CNN uses a series of mathematical computations, known as filters, to analyze small portions of an image and gradually build up a more complete and detailed understanding of the image's features. This process is repeated multiple times, allowing the CNN to extract increasingly complex information from the image.

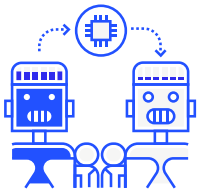
On the other hand, transformer-based models such as Vision Transformer (ViT) are better suited for more complex computer vision tasks. This is because they are based on the transformer architecture, which is able to capture long-range dependencies and relationships between different parts of the image.



A transformer architecture utilizes self-attention mechanisms to connect every element of the input to every other element in the first layer, creating a global representation of the input, even if it may not be complete. This approach allows the transformer to efficiently process sequences of variable length and leverage contextual information throughout the input.

Moreover, transformer-based models such as ViT can process entire images as a sequence of tokens rather than breaking them into patches. This enables the model to capture the global context of the image, which is crucial for understanding the relationships between different parts of the image. Additionally, transformer-based models are able to process images of any resolution, whereas CNNs are constrained by the fixed size of their convolutional kernels.

Flexibility and Reduced Volume

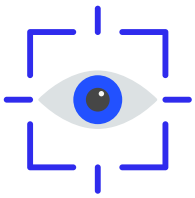


- Transformers can use pre-trained models as a starting point, which **reduces the amount of data and compute resources** needed to train the model from scratch This can **save teams significant amounts of time and money on training costs.**
- Transformers can process entire images as a sequence of tokens, which enables them to capture the global context of the image. This allows teams to **perform multiple tasks** (e.g object detection and classification) simultaneously which reduces the need for multiple models, thus saving on compute costs.
- Transformers can **process images of any resolution**, which eliminates the need to downsample the images before feeding them into the model, and it also allows teams to process higher resolution images, which can provide more accurate results. This can help teams to **deliver business value quicker by providing more accurate insights from the images**.

Cloud, On-Prem & Edge Compute Benefits

- Transformers can be easily deployed on cloud infrastructures, such as AWS, Azure, and GCP. This allows enterprises to take advantage of the **scalability and cost-effectiveness** of cloud computing while also leveraging the power of transformer-based models.
- **Transformers can be run on edge devices** such as smartphones or cameras, which allows enterprises to perform on-device AI, reducing the need for expensive cloud infrastructure and internet connectivity.
- Transformers can be fine-tuned on specific tasks, which allows enterprises to use pre-trained models and reduce the amount of data and compute resources needed to train the model from scratch. This can **help enterprises to manage their infrastructure costs while also delivering business value.**

View through Same Lens, Develop Shared Understanding



- **Transformers can help business functions** outside of domain experts, such as low-level reservoir engineers and business leaders, to understand and interpret findings in their specific areas of expertise, **regardless of their prior knowledge of the domain**.
- Transformers can **generate advanced reports** that are easy to understand and interpret, which can help non-experts to make informed decisions based on the data provided.
- Transformers based tools such as ChatGPT can **help teams to collaborate effectively across different business functions**, as they can provide a common language and understanding of the data, which helps teams to work more efficiently and effectively.

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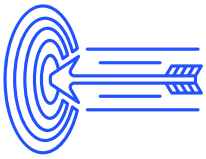
Improvement in Accuracy



- Transformer based models can **analyze entire well logs in one go**, and thus can detect fractures and faults in the subsurface with high accuracy, as it allows the model to capture long-range dependencies and relationships between different parts of the data.
- Transformer-based models can **leverage self-attention mechanisms** which allows them to weigh the importance of different parts of the data, which **improves the accuracy of the predictions**.
- Transformers can be fine-tuned on specific tasks, **such as fracture and fault detection**, which allows them to achieve high accuracy by learning to focus on the most relevant features of the data.

Do More with Less

- Transformers can leverage pre-trained models, which allows operators to **save on training costs and achieve better results** within a smaller budget.
- Transformers can **perform multiple tasks simultaneously**, which allows operators to get more insights from the data without having to invest in multiple models.
- Transformers can be fine-tuned on specific tasks, which allows operators to **focus their budget on the most important tasks** and achieve better results.

Speedier Deployment, Continuous Monitoring

- Transformer based models can be integrated with MLOps (Machine Learning Operations) frameworks, which allows for **faster deployment and scaling of models**.
- Transformers can be **trained on continuous and updated data**, which allows for faster delivery of insights and predictions.
- Transformers combined with a continuous AI ready data estate allows teams to **continuously improve and optimize their models**, which results in faster delivery of business value.

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Digitization: Transformer based models provide new value in raster log interpretation

Well-logging is a popular process of taking measurements of various rock properties along the length of the well by drilling tools. The Well logging parameters are used to derive lithofacies groups and facies-by-facies descriptions of rock properties. Accurate readings of well properties provide information on drilling locations. Well log data saved as depth-calibrated raster images offer an economical alternative to digital formats for preserving this valuable information into the future (Cisco, 1996).

A novel transformer-based deep learning model named VeerNet, which employs self-attention mechanisms for identifying individual curves from a single track, has been developed. The model can provide fast, stable, and auto scalability to otherwise careful and painstaking reading of raster logs. The model has been trained over 20000 images where the raster log images had several defects, including scanning defects, random grid line thickness, random markers, random texts, etc.

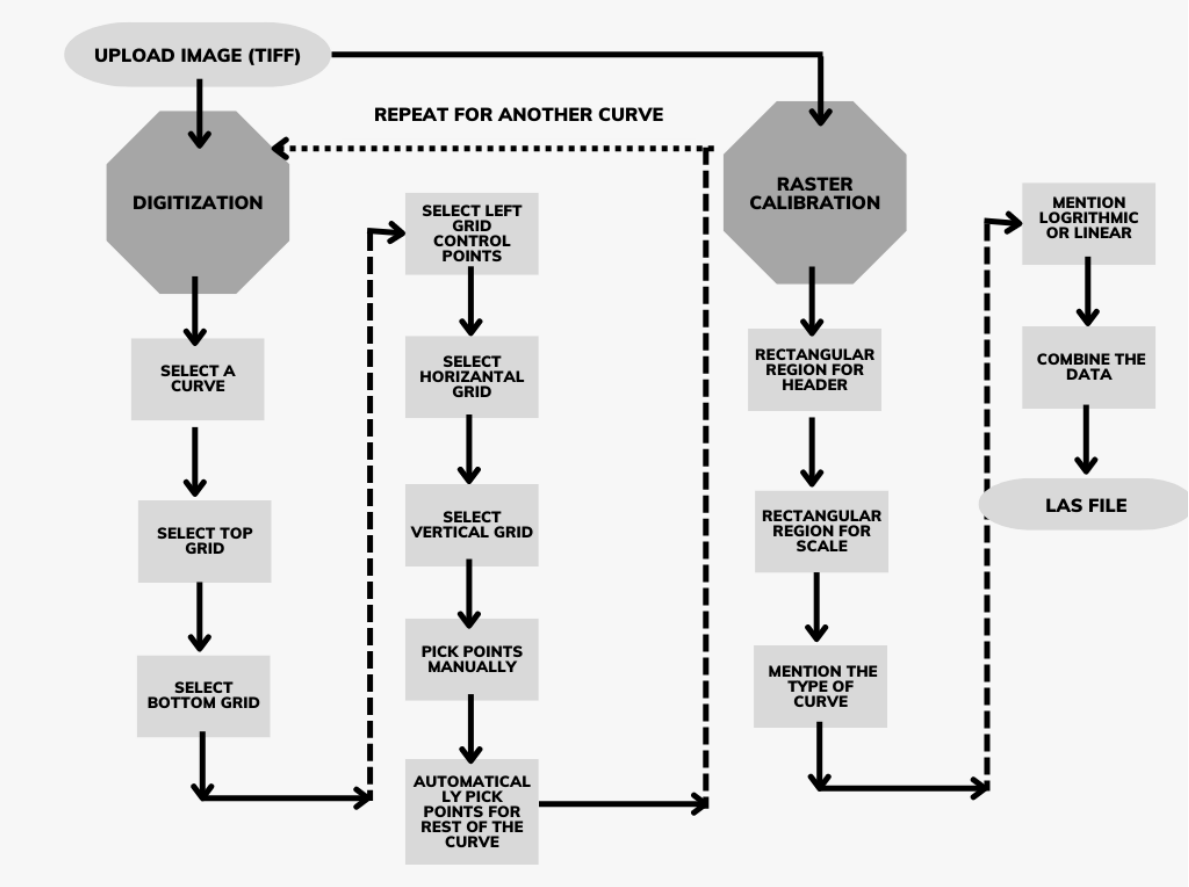
The algorithm can efficiently differentiate between grids and curves. The user only needs to provide a cropped section of raster or paper log.

Painstaking interpretation of Raster Logs

- Painstaking interpretation of Raster Logs
- Geologists/reservoir engineers revisit and study these raster logs manually or with software applications requiring a tremendous amount of manual input.
- Thousands of person-hours are lost to read raster logs using erroneous and tedious commercial software.
- More often enterprises needs to buy expensive digitizer. There is also a hidden technical debt since enterprises stand to lose more money in additional servicing and to consult charges.
- In existing software the user provide a rectangular region that captures the header and scale. They also provide a set of points to capture the log tracking depth and determine the left and right axis values and the type of scale, whether logarithmic or linear.

Exhibit 1

Hill of pain: Current process is sequential, error-prone and expensive



Digitization: Add new value to old logs
In this new improved solution, the user only needs to provide a cropped section of raster or paper log and verify the name and scale of curves digitized by the model. Dashboards: uses raster logs in tif or png format and provides solutions within seconds, requires no expertise to use & delivers completeness in the real-time calculation.

Robust and Scalable Model
Low latency system has the ability to infer in seconds. They are fast stable and auto scalable. Works with any tech stack and the model can be served in any cloud (i.e AWS, GCP, Azure) or on-premise solution. Depending on utilization customers can choose any container (AKS, GKE, EKS)

SOTA (state-of-the-art) AI Algorithm
A novel transformer-based deep learning model named VeerNet employs self-attention mechanisms to identify individual curves from a single track.The present model can effectively digitize well log curves based on single track and can read the track headers. The model can be extended to work on multiple tracks too.

Straightforward User Interface

Our dashboard is interactive and easy to understand by the user and operates with minimal manual intervention. The user needs to follow only four steps.
First, the user is required to upload a raster log and, using the interactive dashboard tool select the section of interest. Then, with the resulting cropped section, the user provides the scale ranges for all the logs present in the track and scale depth. Next, a comparison is provided so that the csv generated at the end of the steps are mapped correctly. This third step offers the option of QC so the user can check how well the sections are digitized and whether to proceed to generate a csv file. In the present digitizer version, digitization of curves is provided for one track at a time. Unlike traditional software, users don't have to give any points on the track's curve. The transformer-based AI model can seamlessly differentiate grid lines from curves with 99% accuracy. For a three curve single track the model performed with a precision of 94% on gamma ray.

Exhibit 2
Faster, Streamlined and Reproducible Process

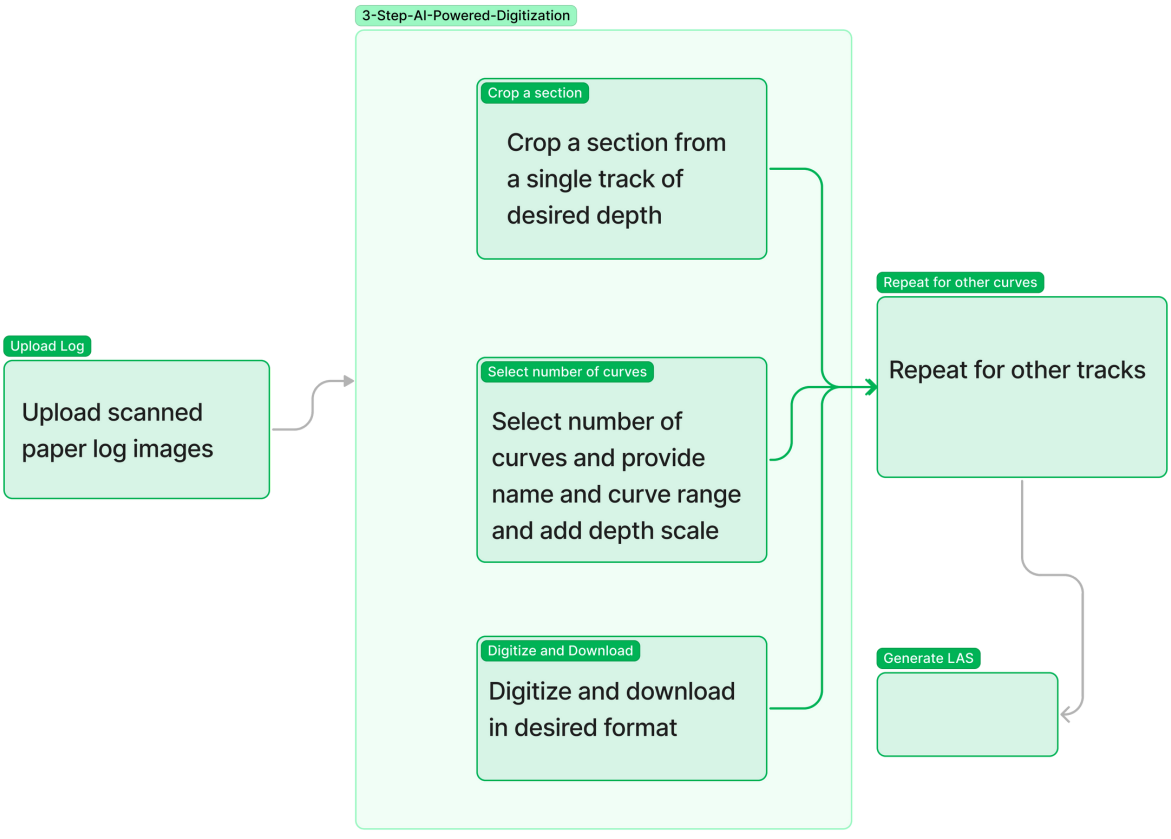


Exhibit 2

An efficient operating model enables business/technology cooperation on tech-debt paydown.

CONVENTIONAL METHOD

- A lot of calibration and manual intervention are required which introduces errors.
- Systematic errors (also called bias errors) are consistent, repeatable errors. This error can arise during the calibration of scale and grid-scale for a particular track. Everything that is measured based on this calibration will cause – a systematic error.
- Random errors (also called precision errors) are caused by a lack of repeatability in the output of the measuring system. With the interference of the background grid noise, such errors are frequently introduced.
- The major disadvantage of conventional techniques is high time complexity, loses line width information, and is prone to deformation and wrong branches in the *intersection area*.

CONTINUOUS AI MODEL

- Minimum calibration is required hence systematic and random error is minimized.
- The model is trained with a large number of dataset that contains masks of individual curves. The model can seamlessly differentiate between signal.
- The object detection accuracy to identify grid from signal is around ~90%.
- Continues AI model **VeerNet** is a transformer based which is also trained on a range of different curves such as resistivity, gamma ray, caliper etc.
- Time Complexity is reduced drastically. Once the model is loaded in the first call the consequent calls are ~5s.
- Custom models can be trained by using specific data for specific reservoir.

Learn more about our VeerNet AI Model in our New Paper Here: https://arxiv.org/abs/2210.05597

"Reduce uncertainty, predict and define outcomes, automate complex processes, and optimize your experts' time."

Way forward

In order to embark on AI transformation program, companies need to do the following : establish a dedicated Digital Transformation Hub to drive the implementation of AI across the organization, Harness data using Continuous AI and MLOps to ensure that the organization can extract maximum value from its data, and invest in people by providing them with the necessary training and development opportunities to acquire the skills required to participate in the AI transformation. By doing this, companies will be better equipped to navigate the rapidly changing landscape of AI and gain a competitive advantage in the marketplace.

Setup / Revamp Your Digital Transformation Hub for AI

To fully leverage the power of AI, companies must establish a dedicated Digital Transformation Hub. This central hub will coordinate the implementation of AI across the organization, identifying and prioritizing use cases, developing and deploying custom solutions, and ensuring data governance and quality. The hub must be staffed with experts in AI, data science, and business domain knowledge, working closely with other departments to meet their specific needs. An AI strategy that aligns with overall business objectives, including key performance indicators and a roadmap for implementation, must also be developed and implemented. The Digital Transformation Hub serves as the foundation for the organization's AI journey, providing structure and guidance for successful implementation.

Harnessing Data with Continuous AI, while keeping an eye on emerging AI Technical Debt

To harness the full potential of AI, companies in the oil and gas industry must focus on running smooth and lean operations with MLOps while keeping the cost of AI technical debt to a minimum. By utilizing Continuous AI and MLOps, they can ensure that their AI systems are constantly fed with high-quality data of the appropriate volume. This will help them to train their AI systems effectively, and to ensure that they work efficiently in operational mode. However, it's important to keep in mind that even the most advanced algorithms cannot compensate for bad data.

Therefore, it's crucial that companies make sure to use only high-quality data in their AI systems to avoid incurring unnecessary technical debt and to ensure that they are getting accurate and reliable results.

Managing emerging AI technical debt is critical for companies in the oil and gas industry as it can significantly impact the efficiency and effectiveness of their operations. One way to manage this technical debt is to measure its size and cost by getting as granular as possible to identify where it originates and quantify its impact. For example, an oil and gas company may discover that technical debt in their drilling operations amounts to 15 to 60 percent of every dollar spent on IT, which had not been accounted for in their budget. To address this, the company should price the technical debt into all their IT work, factoring in the cost of corresponding technical debt for any IT development. This way, the cost of IT services will dynamically change over time based on the decisions the company makes around growing or paying down technical debt. This approach ensures that the company is aware of the impact of technical debt on their operations and can make informed decisions to minimize its impact.

Unlock the full potential of AI with a skilled workforce

The ability to leverage AI technology is becoming increasingly important for companies across all industries, including the oil and gas sector. To stay competitive and drive innovation, it is essential for companies to invest in the development of new skills for their employees. This includes reskilling and upskilling in areas such as data science, machine learning, and AI. Without a team of experts in these fields, companies will be unable to fully utilize the potential of AI in their operations and processes. As the use of AI continues to grow, it is crucial for employees in all functions to develop these new skills in order to stay relevant and drive success for the organization.

"The battle for the last drop will not be fought in the reservoir fields but inside sophisticated AI labs"

UNDERSTANDING PLANETARY SCIENCES WITH AI

Unlocking hidden insights of planetary surface and sub-surfaces with artificial intelligence

EarthScan