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Ultra-wide Broadband Seismic Monitoring System Development

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Summary

For Alberta Oil and Gas corporations and industry consortia, who can benefit from a continuous or frequent monitoring system for subsurface dynamic changes, microseismic events, fracking development or steam chamber development. This new underground dynamic monitoring system is the first of its kind to continuously monitor subsurface events, steam/fluid path development for multiple wells, significantly reducing environmental risks with enhanced controls and reduced operating costs. Unlike 4D seismic surveys or any existing underground detection method, this new system is the first for continuous/frequent monitoring of subsurface change progress and impacts.

The overall objective of this project is to develop advanced, real time subsurface monitoring systems for the Oil and Gas industry. This underground monitoring system will consist of an advanced digital instrument array network, a remote software system with real-time geospatial data processing, machine learning, advanced mapping, and visualization techniques. The project will utilize Symroc's technology with ultra-wide broadband detection to provide the highest resolution *and* the best detection of subsurface changes and events (e.g.Smicroseismic events from fracking, etc.) The system will have a low power consumption, long range continuous wireless data transfer capability, and high flexibility with a low installation cost.

Introduction

The SAGD industry has a history of issues surrounding underground steam chamber development uncertainties. Currently, there are no efficient technologies for underground monitoring. 4D Survey projects are performed from time to time, however they come with very high costs, low resolution, and lengthy timespans for the batched surveys. The industry also requires real time detection of microseismic events, potentially affecting production and cap rock integrity.

Similarly, the fracking operations for Oil and Gas industry have been lacking in monitoring capabilities for timely identification of frack events location and progress, which can lead to missed opportunities for fracking operation controls and management, which in turn also leads to missed opportunities for ensuring accuracy, and reducing potential environmental incidents.

The detection and monitoring of subsurface changes have always been a great challenge to Oil and Gas operators. This is partially due to the very dynamic frequency response, high sensitivity required for the field instruments to detect steam, site infrastructure requirement, and the lengthy amounts of time required to get system results. Symroc's state of the art seismic instrumentation technology has a superior broadband frequency range, and flexible continuous operations capabilities that are not achievable by any other technologies. Combining with the advanced data mining, processing, mapping and visualization, the new system development has the potential to bring the following key benefits to the Oil and Gas industry:

- Much higher resolution and accuracy for the detection of subsurface dynamic changes; including fracking, microseismic events, steam chamber and reservoir changes, etc.
- Combined monitoring of ground surface elevation changes
- Frequent sampling, easy installation and/or relocation/repositioning with GPS update, continuous monitoring & wireless transmission with no external power requirement
- Fast feedback for optimization of operations
- Lower cost than all current methods, with improved results

Theory and/or Method

This system will be the first ever continuous/frequent subsurface monitoring system in the Oil and Gas industry that integrates ultra-wide broadband seismic survey, induced seismicity monitoring, and surface elevation change monitoring all together. This one integrated system eliminates the need for any combination of systems, equipment, and/or projects, while providing unprecedented capacities at the same time, such as:

1. Super broadband, first *ever* detection frequency range from 0.1– 400 Hz, a significant improvement from the current common 10-120 Hz range, enabling a new era of broadband detection for steam chamber monitoring, and induced seismicity monitoring.

2. Self powering with low power consumption sensors, easy installation and relocation, and remote switch on/off capabilities. This eliminates the need for multi-cost mobilization, demobilization of power equipment, and ground wiring requirements. The sensors can be buried underground, providing good ground clearance with low installation costs.

3. Wireless field data transmission to online server - This innovation eliminates logistical issues such as manual data collection, transfer, and multiple handover steps.

4. Integrated GPS sensor in the array, saving the entire project funds for a separate elevation monitoring system.

5. Advanced data analytics and visualization on seismic data, with fast response time and high accuracy.

6. Continuous machine learning for pattern recognition and prediction, as to continuously increase system efficiency.

7. Significantly lower costs of performing any seismic survey, with higher flexibility.

The system's design basis is based on an advanced geospatial instrument array network, with data transmission, analysis, mapping, and visualization. Field collected high volume data has hidden spatial autocorrelations and extreme noise. Processing and identifying subsurface/SAGD steam chamber changes from the large amounts of seismic data is a challenge that our system is well positioned to handle. In addition, a friendly geospatial information system with fast response data visualization will be included to assist interaction between engineers and decision makers. The proposed software will have the following characteristics:

1. High accuracy GPS imbedded in each sensor unit, enabling the first integrated system for both underground spatial data survey and ground elevation survey. The wireless sensors have self power reserves and can be easily relocated to provide higher resolution and focused surveys. The integrated GPS can provide accurate location and elevation information updates every time the sensor location is changed.

2. Geospatial data mining methods to identify key features, spatial association and autocorrelations among the data.

3. Remote sensing—sensors can be remotely turned on to monitor seismicity

4. Geospatial visualization of data: The monitoring process will be visualized through an advanced interactive map interface, with reference to current satellite surface maps, well information maps, and subsurface geological structure maps.

5. Online server provides fast responsive visualization to guide operation adjustments.

Examples

A demo unit of our ultra-wide broadband insturment can be shown at the conference to demonstrate real time acqusition of broadband data, remote transfer to online servers, and realtime visualization of the single unit vibration data.

Conclusions

With industry partners support, this project development may lead to the most advanced subsurface monitoring system in the world.

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