TECHNICAL INSIGHTS
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ALGORITHMIC PETROLEUM DETECTION

The greatest challenge facing oil and gas exploration is finding where subterranean petroleum deposits are located. Kristopher Innanen, an assistant professor of physics at the University of Houston and member of the Mission-Oriented Seismic Research Program (M-OSRP), has developed algorithms to locate petroleum targets and especially create higher-resolution pictures of the Earth's subsurface**,** improving the odds for oil and gas explorers**.** His university colleagues in this effort include Art Weglein, Cullen Distinguished Professor of Physics and Director of M-OSRP, and Tadeusz Ulrych, Professor Emeritus of the University of British Columbia's Consortium for the Development of Specialized of Specialized Seismic Techniques**.**

"We want to create methods for locating and resolving subsurface targets that require much less prior information, and that can operate regardless of how complex the subsurface is," explained Innanen. The algorithms are based on seismic data collected by geophones, that is, microphones that capture sound waves reflected back from the subsurface earth. Standard theory and practice uses measurements of how long it takes for each individual echo to come back; this requires prior knowledge of what the subsurface looks like at the outset.

Gaining Access

"At M-OSRP, we are pursuing algorithms based on a more complete theory, that involves not just how long the echoes take to come back, but how loud they are when they do, and, most importantly, how all the echoes relate to one another," explained

Innanen. "Analyzing the data in this way, it turns out, releases us from the requirements for prior information concerning how fast the sound waves travel. This will allow currently inaccessible petroleum targets to become accessible. If we can provide accurate, well-resolved subsurface images in complex regions, like under salt in the Gulf of Mexico, the risk in drilling will drop, and so will the overall number of wells required. This translates into reduced costs, reduced impact, and reduced wastage."

Innanen and M-OSRP are undertaking a portfolio of research projects using their algorithmic approach. "For some projects, the next steps are to continue to ask the most basic questions, for example, how the interrelations of the echoes can locate, resolve, and identify the make-up of the hydrocarbon targets, when there is unknown structure between them and the explorers," said the researcher. "For other projects, we understand these things well enough to focus on practical issues, and implementation issues--for instance, how to handle the imperfection and incompleteness that is part of every field data set."

One of the most important lessons Innanen learned developing the petroleum detecting algorithms was how to identify important math/geophysics problems, to solve problems of moment, and to prioritize them. "I think the most interesting, and powerful trend in the development of algorithms for geologic exploration is threefold," observed Innanen. "First, the trend in data acquisition toward more completeness, meaning more data, and of higher fidelity; second, the trend in algorithm design toward more complete physical models, with fewer assumptions; and third, the ability through both hardware and software advances to solve much larger, less apparently tractable numerical problems. Each of these trends complements and motivates each of the others, and it is very heartening to see all three growing so quickly right now. Not a bad time to be solving big, complex geophysical problems."

As for recommendations to others working in this area, Innanen responded, "I suppose would recommend that, in addition to designing algorithms specifically to

work with currently available data and computing, we develop and tout methods that ask for more in this regard, and also hold the potential to deliver more. In other words, say: here is what is possible with the right computers, and the right data."

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