U.S. DEPARTMENT OF **ENERGY** | Energy Efficiency & Renewable Energy

Machine Learning for Geothermal Energy and the Geosciences

DATE: May 7, 2018
SUBJECT: Request for Information (RFI)

Description

The Geothermal Technologies Office (GTO), within the U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE), invites input from the public regarding opportunities associated with applying machine learning techniques toward challenges in the geosciences that are relevant to geothermal energy. With the overall goals of establishing the practice of machine learning (ML) in the geothermal industry and maximizing the value of the rich datasets utilized in the geosciences, GTO is seeking input in three areas: Identifying the most promising applications of machine learning in subsurface R&D; building open community datasets capable of supporting the most advanced ML techniques; and leveraging crowd-sourced R&D through alternative funding mechanisms. As ML is already well-established in some industries, GTO is also very interested in feedback from outside of the geothermal community. The information requested is intended to advance GTO goals in geothermal development, though there are likely crosscutting applications with other industries operating in the subsurface. Opportunities for partnerships with other industries are also of interest.

Background

The term "machine learning" encompasses a wide range of tools and techniques that are applied to a wide range of problem types – from data mining and exploratory data analysis to predictive analytics. It is not known at this time which of these approaches are most relevant to the technical challenges faced in the geothermal industry. This RFI seeks information that would help GTO focus its efforts on the most promising applications of ML technology to geothermal energy, during all phases of a geothermal development. Of particular interest to GTO:

- Technologies that characterize the subsurface: While advanced methods for imaging and inferring subsurface properties prior to commencement of drilling operations are available, it is likely that traditional approaches could be augmented with novel ML

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approaches. The identification of signatures that accurately predict subsurface characteristics can have an enormous impact on the geothermal industry.

- Detection of critical transitions in reservoirs: In this area, it is hoped that ML approaches could identify signatures capable of predicting impending changes in subsurface stress. This information is valuable in many applications, whether the stress changes are due to natural movement (non- anthropogenic), stimulation, or disposal operations (anthropogenic).
- Automation and control technologies for field operations including drilling: As an example in this area, ML could improve efficiency and reduce costs by automating certain operations on a drilling rig, and reduce risk through improved well control and early warning of trouble.

Purpose

The purpose of this RFI is to solicit feedback from industry, academia, research laboratories, government agencies, and other stakeholders on issues related to potential applications of machine learning in subsurface R&D. This is solely a request for information and not a Funding Opportunity Announcement (FOA). EERE is not accepting applications.

Disclaimer and Important Notes

This RFI is not a Funding Opportunity Announcement (FOA); therefore, EERE is not accepting applications at this time. EERE may issue a FOA in the future based on or related to the content and responses to this RFI; however, EERE may also elect not to issue a FOA. There is no guarantee that a FOA will be issued as a result of this RFI. Responding to this RFI does not provide any advantage or disadvantage to potential applicants if EERE chooses to issue a FOA regarding the subject matter. Final details, including the anticipated award size, quantity, and timing of EERE funded awards, will be subject to Congressional appropriations and direction.

Any information obtained as a result of this RFI is intended to be used by the Government on a non-attribution basis for planning and strategy development; this RFI does not constitute a formal solicitation for proposals or abstracts. Your response to this notice will be treated as information only. EERE will review and consider all responses in its formulation of program strategies for the identified materials of interest that are the subject of this request. EERE will not provide reimbursement for costs incurred in responding to this RFI. Respondents are advised that EERE is under no obligation to acknowledge receipt of the information received or provide feedback to respondents with respect to any information submitted under this RFI. Responses to this RFI do not bind EERE to any further actions related to this topic.

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Proprietary Information

Because information received in response to this RFI may be used to structure future programs and FOAs and/or otherwise be made available to the public, **respondents are strongly advised to NOT include any information in their responses that might be considered business sensitive, proprietary, or otherwise confidential.** If, however, a respondent chooses to submit business sensitive, proprietary, or otherwise confidential information, it must be clearly and conspicuously marked as such in the response.

Responses containing confidential, proprietary, or privileged information must be conspicuously marked as described below. Failure to comply with these marking requirements may result in the disclosure of the unmarked information under the Freedom of Information Act or otherwise. The U.S. Federal Government is not liable for the disclosure or use of unmarked information, and may use or disclose such information for any purpose.

If your response contains confidential, proprietary, or privileged information, you must include a cover sheet marked as follows identifying the specific pages containing confidential, proprietary, or privileged information:

> **Notice of Restriction on Disclosure and Use of Data:**
> Pages [List Applicable Pages] of this response may contain confidential, proprietary, or privileged information that is exempt from public disclosure. Such information shall be used or disclosed only for the purposes described in this RFI [Enter RFI Number]. The Government may use or disclose any information that is not appropriately marked or otherwise restricted, regardless of source.

In addition, (1) the header and footer of every page that contains confidential, proprietary, or privileged information must be marked as follows: "Contains Confidential, Proprietary, or Privileged Information Exempt from Public Disclosure" and (2) every line and paragraph containing proprietary, privileged, or trade secret information must be clearly marked with double brackets or highlighting.

Evaluation and Administration by Federal and Non-Federal Personnel

Federal employees are subject to the non-disclosure requirements of a criminal statute, the Trade Secrets Act, 18 USC 1905. The Government may seek the advice of qualified non-Federal personnel. The Government may also use non-Federal personnel to conduct routine, nondiscretionary administrative activities. The respondents, by submitting their response, consent to EERE providing their response to non-Federal parties. Non-Federal parties given access to responses must be subject to an appropriate obligation of confidentiality prior to

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being given the access. Submissions may be reviewed by support contractors and private consultants.

Request for Information Categories and Questions

Category 1: Applications of Machine Learning in Geothermal Energy

GTO seeks feedback to identify the specific challenges in geothermal development where ML could add great value, and to develop a community of practice.

1. What are the most promising potential applications of ML technology to geothermal development? Responses do not have to be limited to the areas described in the background section above. Approaches that could be transferred from the oil and gas sector are also of interest.
2. Please comment on the level of effort that would be required (project cost and duration) to test the applicability of recently developed ML tools for geothermal applications. In addition, please comment on how expertise from the ML community may best be integrated into project teams working on subsurface R&D.

Category 2: Building Community Datasets to advance machine learning in Geothermal

Many important advances in ML have resulted from the coupling of advanced deep learning techniques with suitably large datasets for training models[1]. Availability of data is key to implementation of all ML techniques, and GTO has taken steps in this area through its development of the DOE Geothermal Data Repository (GDR).[2] Data infrastructure is now in place to develop a geothermal ML community. However, there is a notable paucity of large public datasets for ML work in the geosciences, due to the high acquisition cost and competitive value of geological, geophysical, and geochemical data. This constitutes a significant barrier to the adoption of the most powerful ML techniques by the geothermal industry.

1. Please comment on the economic and technical feasibility of developing open seismic, electromagnetic, geochemical, remote sensing, borehole, and other relevant datasets at the scale required to support ML (possibly including deep learning applications). Please also comment on the level of effort required (project cost and duration) to develop open datasets as described above.
2. What metrics can be used to assess the suitability of datasets for use in deep learning R&D?
3. In terms of availability of data and quality of geothermal resource, which specific geothermal provinces in the U.S. are most suited as a focus for this type of effort?

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[1] ImageNet
www.image-net.org
[2] Weers and Anderson, 2016, "The DOE Geothermal Data Repository and the Future of Geothermal Data"
https://pangea.stanford.edu/ERE/db/GeoConf/papers/SGW/2016/Weers.pdf
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4. Are there opportunities for developing partnerships where multiple parties could share acquisition or licensing costs in order to build community datasets?

Category 3: Crowd-Sourced R&D
1. The use of contests, prizes, and other challenge formats is an established practice in the ML community, and there have been several successes in the minerals exploration industry using this format[3]. What opportunities exist to leverage these types of mechanisms in geothermal R&D?
2. Are suitable datasets available to support crowd-sourced R&D for geothermal at this time, or would this have to be preceded by work in Category 2 above?

Request for Information Response Guidelines

Responses to this RFI must be submitted electronically to machinelearninggeo@ee.doe.gov no later than 5:00pm (ET) on June 6, 2018. Responses must be provided as attachments to an email. It is recommended that attachments with file sizes exceeding 25MB be compressed (i.e., zipped) to ensure message delivery. Responses must be provided as a Microsoft Word (.docx) attachment to the email, and no more than 3 pages in length, 12 point font, 1 inch margins. Only electronic responses will be accepted.

Please identify your answers by responding to a specific question or topic if applicable. Respondents may answer as many or as few questions as they wish.

EERE will not respond to individual submissions or publish publicly a compendium of responses. A response to this RFI will not be viewed as a binding commitment to develop or pursue the project or ideas discussed.

Respondents are requested to provide the following information at the start of their response to this RFI:
- Company / institution name;
- Company / institution contact;
- Contact's address, phone number, and e-mail address.

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[3] Integra Gold Rush Challenge
https://www.herox.com/IntegraGoldRush/community

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