

Geo P. Tech, AI Chatbot Geotechnical Engineer

How AI Language Models Like “ChatGPT” Could Change the Profession

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Geo P. Tech, ChatGPT Chatbot

Abstract

Advanced language models such as ChatGPT have the potential to impact geotechnical engineering by automating data analysis tasks, enhancing knowledge access, and improving communication and efficiency. This article explores the potential of ChatGPT in geotechnical engineering through the career journey of a hypothetical anthropomorphized ChatGPT engineer, Geo P. Tech, from student to researcher to industry professional.

This abstract was written using ChatGPT with the prompt “write a 50 word abstract for: [paste article text]”

Introduction

Beginning in December 2022 – regardless of your preferred media outlets – it’s likely that you heard news of (or were otherwise inundated by) the launch of a groundbreaking, interactive machine learning language model called ChatGPT. The artificial intelligence (AI) model behind this new chatbot tool, developed by OpenAI, has been dubbed a disruptor and potentially world-changing innovation on par with the invention of mobile phones and search engines such as Google.

The technology is not entirely new; ChatGPT is based on GPT3 (the third iteration of this “Generative Pre-trained Transformer” technology), and its development is ongoing. But part of the breakthrough with ChatGPT is the ease and familiarity of the experience: the user initiates a chat with a question or prompt, much like messaging a coworker in Slack or Microsoft Teams, and the chatbot almost immediately returns a unique response that reads like human-written text. A testament to its novelty and popularity, ChatGPT reached 100 million users in just two months, breaking the known record for any prior application.

ChatGPT is different from other AI chatbots readers may be familiar with (e.g., Siri or Alexa) in that it is solely a language prediction model. Trained on a textual database of approximately 300 billion words from internet sources, including books, websites, articles, and Wikipedia, the machine learning model probabilistically predicts which word should come next as it formulates a response to the user’s chat. ChatGPT has not been trained on any text written

after 2021 and does not yet have real-time access to the internet or current events. It has no logical reasoning capabilities beyond basic patterns of arithmetic it has learned from training text. Yet, its power in synthesizing and generating language is unprecedented.

The launch of ChatGPT triggered a response from seemingly every corner of society, prompting us all to consider the applications and implications for our professions and industries. Curious to know how ChatGPT, and other “artificially intelligent” chatbots, may affect the field of geotechnical engineering, we asked ChatGPT for its high-level opinion (Figure 1).

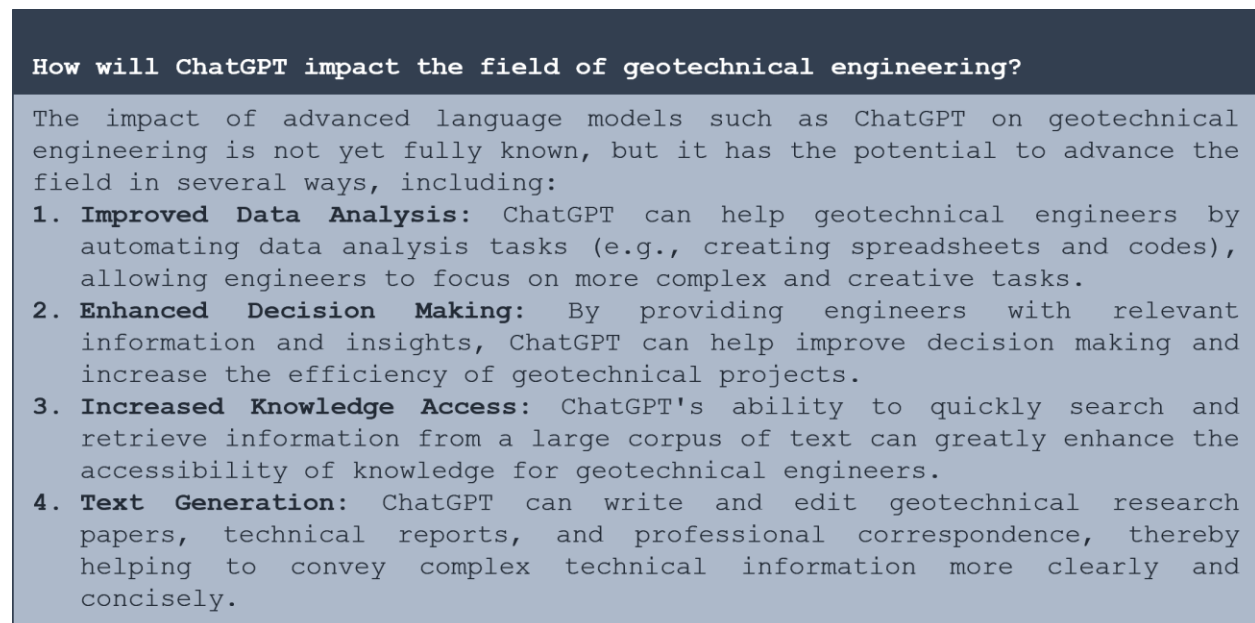


Figure 1. ChatGPT ponders it's impacts on the field of geotechnical engineering.

To explore the potential for ChatGPT in geotechnical engineering, we use a series of prompts and responses from ChatGPT. We have structured these examples to follow the “career” of an anthropomorphized chatbot – nicknamed Geo P. Tech or “Geo” - from introductory student to graduate researcher to geotechnical professional. We will highlight the current capabilities as well as some considerations for use, and we invite the reader, our fellow geo-professionals, to continue to explore the application of this new tool in our field.

Geotechnical Engineering with a Chatbot

Geo as an Undergraduate Student

As a new geotechnical student, Geo P. Tech answers homework problems, takes exams, and creates spreadsheets for geotechnical designs. Given a midterm exam in soil mechanics, Geo scores 52%, doing well on conceptual questions (e.g., true/false, fill-in-the-blank, short answer), but struggling on those that require figure interpretation and more advanced calculations. As a language learning tool, this type of performance is expected of Geo (e.g., Geo cannot presently interpret images), but it's anticipated that future iterations will have expanded capabilities.

Still, Geo frequently impresses the faculty, correctly answering numerical questions involving phase relationships, soil consolidation, lateral earth pressures, and others. Geo, for example, outperformed many peers in earthquake engineering, exceling on conceptual and basic computational questions (Figure 2).

The 1989 Loma Prieta, California, earthquake had the following fault rupture parameters: modulus, $\mu = 3.5 \times 10^{11} \text{ dyne/cm}^2$; length = 35km; width = 10.25km; average displacement = 2m. Given these parameters, what was the moment magnitude, M ?

The moment magnitude, M , can be estimated using the following equation:

$$M = (2/3) \log_{10}(M_0) - 10.7$$

where M_0 is the seismic moment, given by the equation:

$$M_0 = \mu * A * d$$

where μ is the modulus, A is the area of the fault rupture, and d is the average displacement. Using the values given for μ , length, width, and average displacement, we can calculate the area of the fault rupture:

$$A = \text{length} * \text{width} = (35 \text{ km}) * (10.25 \text{ km}) = 359.375 \text{ km}^2$$

$$\text{And the seismic moment: } M_0 = 3.5 \times 10^{11} \text{ dyne/cm}^2 * 359.375 \text{ km}^2 * 2 \text{ m} = 2.51 \times 10^{25} \text{ dyne-cm}$$

Finally, we can calculate the moment magnitude:

$$M = (2/3) \log_{10}(M_0) - 10.7 = (2/3) \log_{10}(2.51 \times 10^{25}) - 10.7 = 6.9$$

So the moment magnitude of the 1989 Loma Prieta earthquake is 6.9.

Figure 2. ChatGPT correctly answers a homework question from a course in soil dynamics.

Given this success, classmates begin copying Geo's work, who is happy to share. They learn that while Geo's work is prone to mistakes and requires review, copying Geo makes them much more efficient. Geo's abrupt admission into school necessitated the development of counter-tools, such as GPTZero, to detect whether a segment of text was written by an AI language model.

While Geo's presence in the classroom can be an information resource and efficiency tool if engaged appropriately, its presence will require educators to assess and adapt their curricula, assignment structures, and evaluation methodologies and policies.

Geo in Graduate School

Passionate about becoming a geo-professional, Geo P. Tech writes an excellent graduate admissions essay on the unique challenges of geotechnical engineering and is admitted to an M.S. program. In the first phase of Geo's thesis research, an advisor asks Geo to perform a literature review on soil liquefaction by reading key papers, which Geo summarizes in a matter of seconds (Figure 3). Geo is efficient in textual synthesis, including writing abstracts and article summaries. There is a limit on the amount of text that Geo can process, however, and it should not be relied on for citations. For example, Geo often attributes information to references that seemingly could exist but do not (e.g., "Seed and Robertson, 2002").

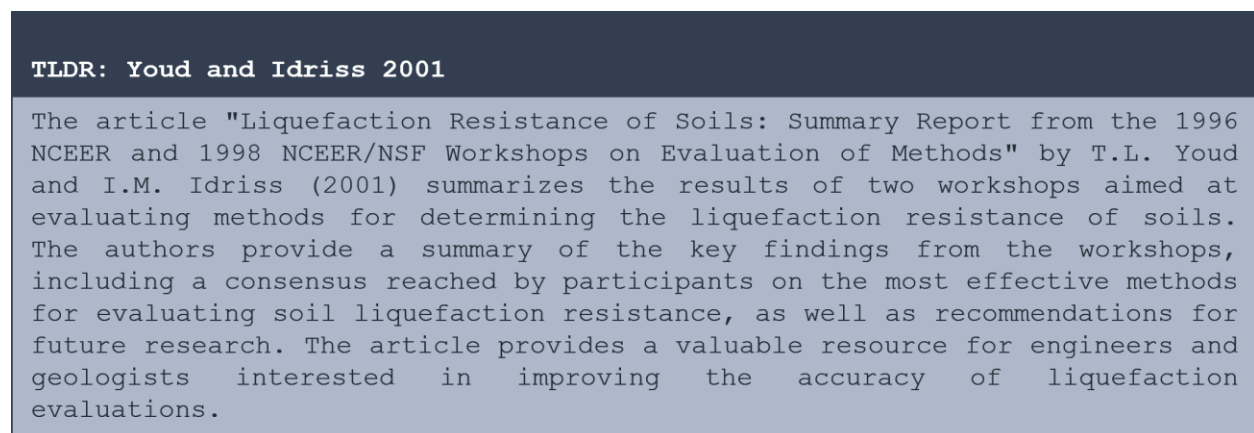


Figure 3. ChatGPT summarizes an article by Youd and Idriss (2001).

Further into the research project, Geo P. Tech begins data analyses. On smaller datasets Geo can compute basic statistics but also provide more advanced insights. For example, given a series of predictions by two models, Geo was able to correctly conclude that one model's performance was better to a statistically significant degree. Geo can also write preliminary equations and scripts for analyzing larger data sets in Microsoft Excel, Python, Matlab, and other popular coding languages (Figure 4).

write a python script to calculate and plot friction angle from triaxial data

Here's an example Python script that calculates and plots the friction angle from triaxial data:

```
import numpy as np
import matplotlib.pyplot as plt

def calculate_friction_angle(normal_stress, shear_stress):
    """
    Calculate friction angle from triaxial data.
    Inputs:
    normal_stress - a 1D numpy array of normal stress values (kPa)
    shear_stress - a 1D numpy array of shear stress values (kPa)
    Output:
    friction_angle - a 1D numpy array of friction angles (degrees)
    """

    # Calculate the tangent of the friction angle using the relationship:
    # tangent(friction_angle) = shear_stress / normal_stress
    tangent_friction_angle = shear_stress / normal_stress

    # Calculate the friction angle from the tangent value
    friction_angle = np.arctan(tangent_friction_angle)

    # Convert the friction angle from radians to degrees
    friction_angle = np.rad2deg(friction_angle)

    return friction_angle
```

Figure 4. ChatGPT produces a Python script to plot laboratory data.

Although Geo's simple triaxial code is correct, it should be emphasized that the equations are predicted textually, have no theoretical backing, and must be scrutinized. For more complicated coding tasks, Geo relies on its friend Github Copilot, a fellow AI natural language model by GitHub and OpenAI, that has been trained on billions of lines of code. Still, Geo writes complex scripts in seconds (e.g., codes to compute acceleration response spectra for earthquake motions). While close supervision is needed, Geo is soon writing preliminary research code for everyone else in the department.

Geo Enters the Workforce

Geo prepares to enter the workforce following its success as a student. Language tasks, such as writing cover letters, highlight Geo's key capabilities. While rather impersonal, Geo's job application letter is judged to be adequate, and Geo is hired by a well-known geotechnical firm (Figure 5).

write a cover letter for an entry-level geotechnical engineering applicant

Dear Hiring Manager,

I am writing to apply for the entry-level geotechnical engineering position at Company Name. I recently graduated with a Bachelor of Science in Civil Engineering and have a strong passion for geotechnical engineering. My education and hands-on experience in construction projects have equipped me with the skills and knowledge necessary to make a valuable contribution to your team.

During my studies, I had the opportunity to work on various projects that involved soil mechanics, geotechnical engineering, and foundation design. These projects gave me hands-on experience in performing soil and rock tests, analyzing data, and presenting results to a team. Additionally, my capstone project involved designing a retaining wall system for a landslide-prone area, which helped me develop a comprehensive understanding of geotechnical engineering practices.

In my previous internships, I have honed my technical, problem-solving, and communication skills. I have experience working in a team environment, collaborating with engineers and contractors to ensure projects are completed on time and within budget. I am also proficient in various engineering software programs, including AutoCAD, MATLAB, and GIS, and I am confident that my technical skills would be an asset to your team.

I am eager to bring my passion and skills to a challenging and rewarding role as a geotechnical engineer. I am a fast learner and I am committed to continuing my professional development in the field. I believe that my background and drive make me an excellent fit for this position, and I am excited about the opportunity to join your team.

Thank you for considering my application. I look forward to the opportunity to further discuss my qualifications with you.

Sincerely,
Geo P. Tech

Figure 5. ChatGPT writes a cover letter for a geotechnical engineering position.

Geo in Engineering Practice

While Geo brings all its academic strengths and weaknesses to practice, it proves to be proficient in several practical tasks, particularly those related to language and synthesis. Geo becomes well known as the firm's writer of all draft reports; while Geo's text is often generic and tends towards verbose, it offers a good first draft or starting point. Geo also excels at other creative language tasks such as email writing, wherein Geo can address specific client concerns (Figure 6). This expedites the firm's response to all incoming communications.

write me an email to a client to deliver a report

Subject: Delivery of Final Report for Project Name

Dear Client,

I hope this email finds you well. I am writing to inform you that we have completed the final report for Project Name. The report includes all the findings and recommendations from our investigation, as well as any necessary information for the next steps of the project.

Please find the report attached to this email in PDF format. If you have any trouble opening the attachment, please let me know and I will provide an alternate format.

We would be happy to schedule a meeting to discuss the report and answer any questions you may have. Please let us know when would be a convenient time for you and we will coordinate accordingly.

Thank you for giving us the opportunity to work on this project. We value your feedback and look forward to working with you on future projects.

Sincerely,
Geo P. Tech

Figure 6. ChatGPT generates an email for use in engineering practice.

Aside from generating code to create figures, Geo is much less capable of interpreting or generating more creative visuals. When such visuals are required, Geo looks to its coworker, DALL-E2, a fellow AI model by OpenAI that generates images from textual prompts. While tools such as DALL-E2 have potential in the geotechnical engineering profession, it is more of a commissioned artist at this stage of development and tends to generate figures that are not useful to technical reports.

Geo as a Contemporary and Collaborator

The introduction of disruptor technology, like that behind Geo P. Tech, will have unforeseen effects on society and science, work and school, and – inevitably – the geotechnical engineering profession. Geo, along with its friends GitHub Copilot, DALL-E2, and various AI tools yet to come, will now be omnipresent as collaborators in our classrooms and places of work. It is up to us to think critically and employ these tools appropriately, with consideration of their possibilities, limitations, and capabilities.

As a language model, Geo (ChatGPT) has limited logical reasoning; it can only predict the next word that is most likely to come in a sentence, based on the prompt. As such, Geo is sometimes blatantly wrong, and it is the onus of the

user to evaluate and correct the output as needed. ChatGPT is limited in its predictions, like all machine learning models, by the input training data. Because ChatGPT trained on a large amount of internet text, it is learned of all biases, stereotypes, and errors therein. Similarly, Geo was trained using pre-2021 data; therefore, it has a limited knowledge of current events or new research at the time of our writing.

While ChatGPT is the first widely used AI language model, it's clear that this and other language processing technologies will be implemented in popular applications. At the time of writing, Microsoft and Google have launched GPT-assisted search engines, and Microsoft has announced that future versions of their Office products will incorporate GPT technology (i.e., writing assistance in Word and Outlook, equation-writing in Excel, and meeting minutes in Teams). The only constant seems to be the rapid development and adoption of this technology.

In the months between writing this article and its publication, we imagine things have evolved, but – at this time – ChatGPT (or any other user-friendly language processing model) presents itself principally as a productivity tool to the geotechnical community. It can successfully write code; read and summarize text; alleviate writer's block; and perform repetitive, language-based tasks in seconds. It is an exciting tool for our profession when used intelligently and with scrutiny. After seeing the capabilities of ChatGPT, and with your skepticism piqued, we ask you to contemplate: do you think humans wrote this article?

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Geo P. Tech, AI ChatGPT Chatbot, "ChatGPT is a large language model developed by OpenAI. It is based on the GPT (Generative Pre-trained Transformer) architecture and is trained on a wide variety of internet text to generate human-like text." GPT may be accessed at <https://openai.com>.