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# Introduction

In recent years, the field of natural language processing (NLP) has witnessed remarkable advancements, with significant contributions from state-of-the-art language models like ChatGPT, developed by OpenAI. These powerful models have demonstrated unparalleled capabilities in understanding, generating, and processing human-like language. As the demand for sophisticated AI-driven text generation systems continues to grow, researchers and developers are turning their attention to the concept of "prompt engineering."

Prompt engineering refers to the strategic design and formulation of input text, or prompts, provided to language models to influence their outputs effectively. By carefully crafting prompts, we can guide models like ChatGPT to produce more accurate, contextually appropriate, and coherent responses. This emerging technique holds great potential in revolutionizing various applications, such as automated content creation, chatbots, language translation, and creative writing, among others.

In this thesis, we delve into the exciting realm of prompt engineering and explore its profound impact on the performance and capabilities of ChatGPT. We aim to investigate how tweaking prompts can enhance text generation quality, foster adaptability to various domains, and mitigate biases inherent in language models. Through extensive experiments and analyses, we seek to uncover the underlying mechanisms that drive prompt-based improvements in ChatGPT's performance.

The structure of this thesis is as follows: Chapter 1 provides an in-depth review of the existing literature on language models, NLP, and prompt engineering techniques. Chapter 2 presents the methodology and experimental setup adopted for our study. We elucidate the datasets used, the fine-tuning process, and the evaluation metrics applied.

In Chapter 3, we present the empirical results of our experiments, demonstrating how prompt engineering positively influences ChatGPT's language generation. Additionally, we address potential challenges and limitations that arise during the process.

Chapter 4 discusses the implications of our findings in practical applications and explores potential ethical considerations. As prompt engineering opens doors to more context-aware, user-responsive AI systems, we examine the implications of its integration into real-world scenarios.

Finally, in Chapter 5, we summarize our research findings, draw overarching conclusions, and propose recommendations for future work in this exciting area of study.

By investigating the potential of prompt engineering in the context of ChatGPT, we aspire to contribute to the broader understanding of language models and their evolution into more sophisticated, empathetic, and versatile AI language assistants.

# Theory

## Language model Background

Due to significant advancements in deep learning models, natural language processing (NLP) has emerged as a vital area of research. Its primary objective is to enable machines to comprehensively comprehend human language. NLP has a crucial role in various applications, including interpreting textual context, machine translation, correcting grammatical errors, recognizing speech, retrieving information, generating summaries, answering questions, and analysing sentiment.

## Introduction to ChatGPT

ChatGPT is a large language model created by OpenAI that predicts the next word in a sequence of words. By iterating the process, it can generate lengthy text. ChatGPT is trained on a very large body of natural language text taken from news, books, journal articles and much of the publicly accessible internet, alongside voluminous opensource computer code. It is then further fine-tuned to produce output that aligns with human preferences. As a chatbot, it remembers previous context in a chat session. Importantly, it produces novel and intrinsically unpredictable responses, even when asked the same question again.

Most generative models, including ChatGPT, rely on using Reinforcement Learning with Human Feedback combined with variations of a new powerful neural network architecture known as a Transformer. ChatGPT is in essence a very large (175 billion parameter) model trained on a very large volume of text. It is reported that it cost c. $12 million dollars in computational resources to just train the model.

It should be emphasised that ChatGPT is a language model, not a knowledge model, database, calculator, or search engine. As such won’t always produce factually correct text, only plausible looking text. While its output is sometimes factually correct and sometimes wrong, it is always presented in a confident and convincing tone.

ChatGPT is only the latest iteration of the GPT family of large language models and will likely be joined by an array of models developed by various technology firms and research groups. While we will focus on ChatGPT, our discussion and policy recommendation apply equally to other large language models.

### Difference between chatGpt and other language models

One of the defining features of [ChatGPT](https://www.wepc.com/tips/is-chat-gpt-free/)is the sheer size of the corpus of data it was trained on. With over 45 terabytes of text, [ChatGPT](https://www.wepc.com/tips/what-countries-is-chat-gpt-unavailable/)is one of the largest language models in existence. In contrast, its competitors are trained on significantly smaller datasets, ranging from several gigabytes to a few terabytes of text. This difference in training data size has a significant impact on the performance and [accuracy of the model.](https://www.wepc.com/tips/how-accurate-is-chat-gpt-generating-responses/) The larger the training data, the more diverse and comprehensive the language model can be.

Another difference between ChatGPT and other language models is the way in which the models are fine-tuned. OpenAI has fine-tuned ChatGPT for specific NLP tasks such as question answering and text generation by further training it on smaller, specialized datasets.

This fine-tuning capability allows ChatGPT to generate text that is highly relevant to specific domains and industries. While other language models can also be fine-tuned for specific use cases, they may require additional training data and computational resources to achieve the same level of accuracy.

The model size of ChatGPT is another factor that sets it apart from its competitors. With over 175 billion parameters, it is one of the largest language models in existence.

In comparison, BERT, RoBERTa, and XLNet, some of its main competitors, have significantly fewer parameters, ranging from 110 million to 340 million. The large model size of ChatGPT allows it to generate more accurate and coherent text, but also comes with some drawbacks such as increased latency and consumption of more energy as compared other language models.

Pre-training is another aspect in which ChatGPT excels. By being pre-trained on a massive amount of text data, ChatGPT has the ability to understand and respond to a wide variety of topics and conversations. This pre-training provides ChatGPT with a solid foundation that can be further fine-tuned for specific use cases.

ChatGPT’s large model size and optimized algorithms allow it to generate text much faster than other models. With the use of parallel processing, ChatGPT can produce high-quality text in real-time, making it an ideal tool for NLP applications that require quick response times.

### The Advantages of ChatGPT

ChatGPT is incredibly easy to sign up and use, and it’s open to everyone — for free. Even though it was a consumer app initially, it is much more than that now. It has become increasingly popular among professionals and companies across a wide range of industries.

Thousands of professionals, including marketers, programmers, educators, [students](https://www.calendar.com/blog/productivity-hacks-for-students/), researchers, copywriters, doctors, scientists, journalists, and others, use the tool to enhance their work.

In light of that, here are some of ChatGPT’s advantages.

Conversations that mimic human interaction.

With ChatGPT, users can place queries or commands to initiate human-like conversations. As with Siri from Apple and Alexa from Amazon, it is generally similar to [virtual assistant](https://www.calendar.com/blog/what-a-virtual-assistant-means-for-your-productivity/)technology.

However, because of its advanced supervised and reinforcement learning capabilities, it mimics real-life conversations because it uses large language models to learn.

Modeled after the advanced GPT.

With GPT-3, OpenAI predicts language and language use using autoregressive relationships. One of the most important AI systems ever designed, it’s the biggest non-sparse language model ever.

ChatGPT Plus uses GPT-4, which is a more advanced version of GPT-3. Because of this, it’s hard to tell if the text generated by this software is human-written.

ChatGPT is versatile.

You can get the same results from ChatGPT as you would with a commercial AI copywriter. Even experiments have shown it can compose music and create fiction, such as short stories. Content creators or technical writers can use this tool to create an outline.

Besides summarizing, digesting, and explaining long texts, the chatbot can also summarize and digest short texts. As another interesting use for ChatGPT, you can write and debug computer programs with it.

But that’s just the tip of the iceberg. Here are some other potential uses of ChatGPT.

Using ChatGPT to automate repetitive tasks.

Using ChatGPT, companies can manage repetitive tasks with artificial intelligence. With language models, you may be able to respond to customers’ natural language input in an accurate and human-like way. [Increasing customer satisfaction and engagement](https://www.calendar.com/blog/the-appointment-economy-customer-engagement/) is possible by automating these tedious tasks.

Additionally, ChatGPT’s search function helps users find information related to their query fast, saving them time and money. By leveraging this technology, businesses can reduce operating costs. A wide range of advantages makes ChatGPT a great choice for creating and managing large-scale applications.

With ChatGPT, you can improve customer satisfaction and engagement.

In a world where customer service is increasingly moving to digital interactions, many companies are turning to ChatGPT to help them. By providing accurate responses to even rudimentary questions, this artificial intelligence tool enhances customer experiences. When ChatGPT interacts with customers, it learns and adjusts over time based on [machine learning](https://www.calendar.com/blog/12-ai-and-machine-learning-tools-for-entrepreneurs/) capabilities.

The use of this powerful technology can increase customer engagement and satisfaction while reducing operational costs for companies. Businesses looking for seamless customer service without human intervention should consider ChatGPT due to its ability to answer follow-up questions accurately. It is possible for businesses to save billions of dollars by automating repetitive tasks while simultaneously reducing the number of frustrated customers.

Ultimately, ChatGPT can offer businesses a wide range of benefits that make it the go-to tool for enhancing customer service.

Optimizing a website for search engines (SEO).

A business that wants to increase its online visibility and web traffic needs to invest in [Search Engine Optimization (SEO)](https://www.calendar.com/blog/trends-in-seo-that-will-affect-every-industry/). A company can attract visitors to its website by using SEO techniques such as keyword research and content optimization. Aside from optimizing page speed and mobile compatibility, SEO strategies can also help create more user-friendly experiences.

Further, SEO helps businesses create content tailored to their target audience’s needs. Creating informative and useful content for potential customers requires understanding what users are looking for when they discuss a particular topic. For such reasons, SEO is a crucial part of a business’s digital strategy.

ChatGPT improves the user experience.

Businesses can optimize customer engagement, satisfaction, and user experience with ChatGPT, a powerful text-based Artificial Intelligence (AI) tool. Without the need for human intervention, ChatGPT can respond accurately to customer inquiries using language models. Customer service agents are freed up to handle more complex conversations due to the elimination of repetitive tasks like answering rudimentary questions.

Besides customer service, ChatGPT also optimizes search queries and creates content. With ChatGPT, businesses can rank higher in SERPs and generate billions of dollars in revenue by understanding customer queries and providing accurate answers. Moreover, ChatGPT’s human-like text responses can greatly reduce frustrated customers and improve their experience with a company.

Time management can be improved.

[You can use Chat GPT to locate dental appointments or team meetings on your calendar](https://www.calendar.com/blog/the-future-of-calendars-predictions-and-trends/). Write a prompt telling the system what your schedule is and ask for a reorganization to fix this problem.

With ChatGPT, meetings can be scheduled, deadlines tracked, and deliverables can be tracked. A calendar view of event schedules is available through ChatGPT’s natural language processing feature.

Extensions and plugins are available.

Plugins are available to extend ChatGPT’s functionality. It’s easy to integrate chatbots with third-party apps and services. It’s possible to access up-to-date information with some plugins. This lets you use ChatGPT like Bing Chat. The chatbot can also access and control third-party services.

Continually improving.

Besides fine-tuning responses, ChatGPT can be customized too. In active training, supervised learning and reinforcement learning can improve existing large language models.

You can also give feedback on a response besides upvotes or downvotes. In the future, GPT will be able to do more as its capabilities improve.

### Limitations of ChatGPT

Despite its advanced capabilities, ChatGPT is not without limitations. As with any AI technology, ChatGPT has certain weaknesses and challenges that can impact its performance and accuracy. By understanding the limitations of ChatGPT, we can gain a better understanding of the potential drawbacks and challenges of using AI language models in various contexts.

Lack of common sense: While ChatGPT can generate human-like responses and has access to a large amount of information, it does not possess human-level common sense — and the model also lacks the background knowledge we have. This means that ChatGPT may sometimes provide nonsensical or inaccurate responses to certain questions or situations.

Lack of emotional intelligence: While ChatGPT can generate responses that seem empathetic, it does not possess true emotional intelligence. It cannot detect subtle emotional cues or respond appropriately to complex emotional situations.

Limitations in understanding context: ChatGPT has difficulty understanding context, especially sarcasm and humor. While ChatGPT is proficient in language processing, it can struggle to grasp the subtle nuances of human communication. For example, if a user were to use sarcasm or humor in their message, ChatGPT may fail to pick up on the intended meaning and instead provide a response that is inappropriate or irrelevant.

Trouble generating long-form, structured content: At this time, ChatGPT has some trouble generating long-form structured content. While the model is capable of creating coherent and grammatically correct sentences, it may struggle to produce lengthy pieces of content that follow a particular structure, format, or narrative. As a result, ChatGPT is currently best suited for generating shorter pieces of content like summaries, bullet points, or brief explanations.

Limitations in handling multiple tasks at the same time: The model performs best when it’s given a single task or objective to focus on. If you ask ChatGPT to perform multiple tasks at once, it will struggle to prioritize them, which will lead to a decrease in effectiveness and accuracy.

Limited knowledge: Although ChatGPT has access to a large amount of information, it is not able to access all of the knowledge that humans have. It may not be able to answer questions about very specific or niche topics, and it may not be aware of recent developments or changes in certain fields.

Accuracy problems or grammatical issues: ChatGPT's sensitivity to typos, grammatical errors, and misspellings is limited at the moment. The model may also produce responses that are technically correct but may not be entirely accurate in terms of context or relevance. This limitation can be particularly challenging when processing complex or specialized information, where accuracy and precision are crucial. You should always take steps to verify the information ChatGPT generates.

Faces issues with complex mathematical problems: No matter how cool ChatGPT is with helping you solve mathematical problems, it faces glaring issues. A ChatGPT limit that not many know of is that this AI cannot accurately compute complex mathematical problems. The chatbot will easily be able to do your simple maths but provide it with multiple maths operations, which will be its end. It will either take too long to deliver an answer or give you the wrong answer.

Need for fine-tuning: If you need to use ChatGPT for very specific use cases, you may need to fine-tune the model to get what you need. Fine-tuning involves training the model on a specific set of data to optimize its performance for a particular task or objective, and can be time-consuming and resource-intensive.

Computational costs and power: ChatGPT is a highly complex and sophisticated AI language model that requires substantial computational resources to operate efficiently — which means running the model can be expensive and may require access to specialized hardware and software systems. Additionally, running ChatGPT on low-end hardware or systems with limited computational power can result in slower processing times, reduced accuracy, and other performance issues. Organizations should carefully consider their computational resources and capabilities before using ChatGPT.

Ethical implications: There’s also a risk of misuse with AI-generated language models. As a result of the way they use internet information, they might respond in a biased or discriminatory way, which could upset others. As such, all content needs to be carefully reviewed. Many schools have banned it too. Because it relies on human-generated text, researchers and creatives are worried about copyright infringement. Additionally, replacing it with human services like customer service or counseling raises ethical questions.

legal issues: ChatGPT is trained on a variety of sources, many of which are protected by copyright. As a result, ChatGPT may reproduce copyrighted content in its outputs. This is not only an ethical issue but also a potential legal issue.

## Prompt Engineering

Prompt Engineering centers around the science and art of formulating effective prompts to generate more precise outputs from AI models. Prompt engineering has become a powerful method for optimizing language models in [natural language processing (NLP)](https://cointelegraph.com/news/5-natural-language-processing-libraries-to-use). It entails creating efficient prompts, often referred to as instructions or questions, to direct the behavior and output of AI models. Due it’s capacity to enhance the functionality and management of language models, it has attracted a lot of attention.

Prompt engineering involves creating precise and informative questions or instructions that allow users to acquire desired outputs from AI models. These prompts serve as precise inputs that direct language modeling behavior and text generation. Users can modify and control the output of AI models by carefully structuring prompts, which increases their usefulness and dependability.

Prompt engineering was less common before the development of transformer-based models like [OpenAI’s  generative pre-trained transformer (GPT)](https://cointelegraph.com/news/open-ai-prepares-release-open-source-model). The introduction of transformers [revolutionized](https://arxiv.org/abs/1706.03762) the field of NLP. Transformers made it possible to pre-train language models on a broad scale and teach them how to represent words and sentences in context. A major turning point for rapid engineering occurred with the introduction of OpenAI’s GPT models. GPT models demonstrated the [effectiveness of pre-training](https://cointelegraph.com/learn/training-vs-testing-data-in-machine-learning) and fine-tuning on particular downstream tasks. For a variety of purposes, researchers and practitioners have started using quick engineering techniques to direct the behavior and output of GPT models. As the understanding of prompt engineering grew, researchers began experimenting with different approaches and strategies. This included designing context-rich prompts, using rule-based templates, incorporating system or user instructions, and exploring techniques like prefix tuning. The goal was to enhance control, mitigate biases and improve the overall performance of language models.

Prompt engineering continues to be an active area of research and development. Researchers are exploring ways to make prompt engineering more effective, interpretable and user-friendly.

Pros of prompt engineering:

Improved control: Users can direct the language model to generate desired responses by giving clear instructions through prompts. This degree of oversight can aid in ensuring that AI models provide results that comply with predetermined standards or requirements.

Reducing bias in AI systems: Prompt engineering can be used as a tool to [reduce bias in AI systems](https://cointelegraph.com/explained/ethical-considerations-in-ai-development-and-deployment). Biases in generated text can be found and reduced by carefully designing the prompts, leading to more just and equal results.

Modifying model behavior: Language models can be modified to display desired behaviors using prompt engineering. As a result, AI systems can become experts in particular tasks or domains, which enhances their accuracy and dependability in particular use cases.

cons of prompt engineering

Time-consuming: Prompt engineering can be a time-consuming process, requiring significant effort and expertise to develop effective prompts.

Limited flexibility: Language models trained using prompt engineering may be less flexible in their responses than models trained without prompts.

Dependence on high-quality data: Prompt engineering requires high-quality training data, which may not always be available.

Risk of bias: Poorly designed prompts can introduce bias into the language model's res

### Prompt Engineering Techniques

Prompt engineering is a growing field, with research on this topic rapidly increasing from 2022 onwards. Some of the state-of-the-art prompting techniques commonly used include n-shot prompting, chain-of-thought (CoT) prompting, and generated knowledge prompting.

1. N-shot prompting (Zero-shot prompting, Few-shot prompting)

The term “N-shot prompting” is used to represent a spectrum of approaches where N symbolizes the count of examples or cues given to the language model to assist in generating predictions. This spectrum includes, notably, zero-shot prompting and few-shot prompting.

Zero-shot prompting refers to a situation where the language model generates predictions without any explicit, additional examples. It’s particularly effective for tasks the model has been extensively trained on, including but not limited to, classification tasks like sentiment analysis or spam detection, text transformation tasks like translation or summarization, and simple text generation.

On the other hand, few-shot prompting employs a limited set of examples, usually ranging from two to five, to guide the model’s output. These instances are designed to direct the model towards improved performance in addressing more context-specific problems. By offering a snapshot of the desired output, few-shot prompts enable the model to tailor its responses more effectively, thus increasing the accuracy of its predictions.

2. Chain-of-Thought (CoT) prompting

[Chain-of-Thought prompting](https://ai.googleblog.com/2022/05/language-models-perform-reasoning-via.html) was introduced by Google researchers in 2022. In the Chain-of-Thought prompting, the model is prompted to produce intermediate reasoning steps before giving the final answer to a multi-step problem. The idea is that a model-generated chain of thought would mimic an intuitive thought process when working through a multi-step reasoning problem.

This method enables models to decompose multi-step problems into intermediate steps, enabling them to solve complex reasoning problems that are not solvable with standard prompting methods.

Some further variations of Chain-of Thought prompting include:

[Self-consistency prompting](https://arxiv.org/pdf/2203.11171.pdf): This variation involves creating multiple diverse paths of reasoning and selecting answers that show the highest level of consistency. This method ensures increased precision and dependability in answers by implementing a consensus-based system.

[Least-to-Most prompting (LtM)](https://arxiv.org/abs/2205.10625): Here, the chain-of-thought technique begins by fragmenting a problem into a series of less complex sub-problems. The model then solves them in an ordered sequence. Each subsequent sub-problem is solved using the solutions to previously addressed sub-problems. This methodology is motivated by real-world teaching strategies used in educating children.

[Active Prompting](https://arxiv.org/abs/2302.12246): This technique scales the CoT approach by identifying the most crucial and beneficial questions for human annotation. Initially, the model computes the uncertainty present in the LLM’s predictions, then it selects the questions that contain the highest uncertainty. These questions are sent for human annotation, after which they are integrated into a CoT prompt.

3. Generated knowledge prompting

Generated knowledge prompting operates on the principle of leveraging a large language model’s ability to produce potentially beneficial information related to a given prompt. The concept is to let the language model offer additional knowledge which can then be used to shape a more informed, contextual, and precise final response.

For example, say you want to write an article about cybersecurity, particularly cookie theft. Before asking the LLM to write the article, you can ask it to generate some danger and protection against cookie theft. This will help the LLM write a more informative blog post.

# Materials and Methods

## ChatGPT Model

The OpenAI API is powered by a diverse set of models with different capabilities and price points. Some of the models include GPT-4, GPT-3.5, [DALL·E](https://platform.openai.com/docs/models/dall-e), Whisper, Embedding and so on. For this thesis we took GPT-3.5-turbo model.

GPT-3.5-turbo is most capable GPT-3.5 model. It has remarkable language processing capabilities and offers numerous benefits, from writing assistance to content generation. Here are some reasons for choosing gpt-3.5-turbo for text generating and prompt engineering:

Improved performance: GPT-3.5-turbo is a highly advanced language model with 4 billion parameters, making it more powerful and capable of generating high-quality text outputs compared to smaller models. This can lead to better text generation results for a wide range of applications.

Versatility: The GPT-3.5-turbo model can handle various text generation tasks, including content creation, translation, summarization, question-answering, and more. Its flexibility allows you to use it for diverse applications within your project.

Prompt engineering capabilities: GPT-3.5-turbo is designed to respond effectively to instructions and prompts, making it well-suited for prompt engineering tasks. By crafting appropriate prompts and instructions, you can guide the model to generate specific types of text content as per your project's requirements.

Large context window: The model can process long sequences of text, up to 4096 tokens, enabling it to understand and incorporate more context in the text generation process. This can be beneficial for tasks that require a deeper understanding of context and context-based responses.

Reduced cost: GPT-3.5-turbo is more cost-effective compared to the larger models like GPT-3. While it may have slightly fewer parameters, it still provides strong performance and cost savings, making it a practical choice for many projects.

API accessibility: GPT-3.5-turbo is available through OpenAI's API, which allows you to integrate the model into your project seamlessly. This API-based access makes it convenient to implement and scale the usage as per your project's needs.

Continual updates and improvements: As part of the GPT-3 family, GPT-3.5-turbo is likely to receive ongoing updates and improvements, ensuring that you can benefit from the latest advancements in language modeling.

If an even larger model is required with more parameters and have the resources to accommodate it, gpt-3.5-turbo-16k might also be a viable option. It has the Same capabilities as the standard gpt-3.5-turbo model but with 4 times the context. But overall, GPT-3.5-turbo offers a compelling balance of performance, cost, and versatility, making it an excellent choice for many text generation and prompt engineering projects.

## Requirements for desired outcome

## Prompt Engineering Techniques

In the preceding chapter, we delved into a variety of prompt engineering techniques, exploring their unique attributes and benefits. For the purpose of this thesis, we focused on the N-shot prompting technique, skillfully applying both zero-shot prompting and one-shot prompting approaches. Subsequently, we compared and analyzed the obtained results.

## Software requirements

This section of this thesis outlines the key components and functionalities of the developed application, designed primarily for easy and efficient testing of different prompts.

Backend application:

For this thesis java spring boot was used to develop the backend. Java Spring Boot is an open-source tool that makes it easier to use Java-based frameworks to create microservices and web apps. For any definition of Spring Boot, the conversation has to start with Java—one of the most popular and widely used development languages and computing platforms for app development.

This backend application is designed to continuously interact with the ChatGPT chatbot through API requests, facilitating smooth and efficient text generation. Developed with robustness and scalability in mind, this application serves as the intermediary between the user and the ChatGPT service.

Key features:

1. API Integration: The heart of the backend application lies in its API integration capabilities. It skilfully communicates with the ChatGPT service, allowing users to effortlessly submit their prompts for text generation.
2. Prompt Submission: Users can easily submit prompts to the backend application through a well-defined API endpoint. The application ensures prompt data is accurately processed and transmitted to the ChatGPT API.
3. Response Handling: Upon receiving the prompt from the user, the backend application promptly sends the API request to the ChatGPT service. Once the generated text response is received, the application meticulously handles and processes the response, preparing it for further display.

## Design and Implementation Details

# Results and Discussion

## 4.1. Comparison with related work

## 4.2. Limitations

# Conclusion

# Summary

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