PK-LM: A Large Language Model-based System for Optimizing Competitive Pokémon Teams

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Abstract.

The Pokémon Battle is a complex strategy game that serves as a good test case to evaluate the abilities of intelligent agents in managing elaborate situations. In this project, we propose PK-LLM , an innovative method that exploits the GPT-2 [15] [18] language model by fine-tuning [9] [17] with data extracted via Selenium [14] [1] from the Smogon platform. Our goal is to generate Pokémon teams optimized for competitive battles by integrating users' strategic preferences and competition rules. It provide simple access and the ability to generate teams that can be directly exported to Pokémon Showdown [12]. Using modules such as Hugging Face Transformers [16] [11][6], we are improving the model's ability to provide consistent and effective team building. The results show a significant improvement in team suggestions compared to traditional methods, underscoring the effectiveness of our approach in competitive Pokémon fights.

KEYWORDS

Large-language models, GPT-2, Hugging Face, Transformers, fine-tuning, Selenium

1 Introduction

In the rapidly expanding field of artificial intelligence, large language models (LLMs) [4][8] such as GPT-2 [15] [18] have demonstrated remarkable capabilities for understanding and text generation. However, fine-tuning [9] [17] is essential to adapt these models to specific applications. This step allows to specialize a pre-trained model by readjusting it on a targeted set of data, thus optimizing its performance for particular tasks.

In specific domains such as competitive Pokémon battles, optimization through language models remains underexplored. Currently, players must rely on their personal expertise or external resources, such as static databases (e.g., Smogon [13]),which are used to build teams and collect informations. This process heavily relies on human experience and can be time-consuming, especially for new players or those looking to personalize their approach. It exists tools but they often lack of flexibility to integrate user preferences, such as Pokémon choices or specific strategies.

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This project focuses on the exploitation of GPT-2 to generate strategic and optimized Pokémon teams for competitive battles. To do this, we used Selenium[14] [1], a powerful web browser automation tool, to extract relevant data from the Smogon. This data is the basis for fine-tuning the model, providing detailed information on Pokémon characteristics, skills and strategies used in competitions.

The integration of libraries such as Hugging Face Transformers[16] [11][6] has facilitated the fine-tuning process, allowing for efficient handling of the GPT-2 model and precise adaptation to the specific requirements of the Pokémon team generation. This approach aims to offer an innovative and high-performance solution, capable of meeting the needs of players of all levels by optimizing their team compositions for increased performance during competitive battles.

2 Related work

Pokémon battles are a complex strategic area, ideal for evaluating the abilities of intelligent agents to manage elaborate situations such as managing hidden information and long-term planning. Several approaches based on the large language models (LLMs) were explored to optimize agent performance in this context. For example, Pok eLLMon Trainer [10] offers a model distillation method to improve the selection of valid movements and agent performance against human opponents. Similarly, Pok'eChamp [7] introduces a game theory-aware agent, powered by an LLM, that uses in-depth minimax research to sample actions, model opponents and evaluate game states, Significantly surpassing existing bots in battles against human players. In addition, another study develops a Pokémon combat agent by combining supervised fine-tuning, Knowledge-Augmented Generation (KAG) and self-coherence [11] to improve contextual understanding and generate effective battle commands, Showing a significant improvement in win rates and strategic performance on the Pokémon Showdown platform.

Mewtagen is a tool specifically designed to facilitate team creation by leveraging advanced algorithms to optimize grouping based on predefined criteria such as skills, roles, or preferences. Unlike a large language model (LLM), which excels at generating and understanding complex and context-rich textual data, Mewtagen [2] is purpose-built for structured tasks like team formation. While LLMs offer flexibility and adaptability in processing unstructured information or simulating dynamic interactions, Mewtagen focuses on delivering precise, rule-based solutions tailored to the specific needs of

team creation. This specialization makes Mewtagen a powerful and efficient tool for organizing and managing collaborative groups.

Alongside the specific Pokémon-fighting applications, LLMs have also been used in other interactive areas, such as digital humanities. For example, an innovative method uses LLM-created embeddings to represent Twitch users, allowing in-depth analysis of the behaviour of the [5] chatters. This versatility of LLMs in complex behavior analysis and modeling highlights their potential to be adapted for various strategic applications. By integrating advanced data collection techniques via Selenium and leveraging the capabilities of Hugging Face Transformers, our PK-LLM approach stands out by offering flexible and customized optimization of competitive Pokémon teams, Thus filling a significant gap in existing methods and demonstrating the superior efficiency of LLMs in dynamic and complex environments.

3 PK-LM

In this project, we used the Selenium web scraping method to extract information about Pokémon and their personalities. Although there are several scraping methods, such as Beautiful Soup, adapted to static pages or used in addition to the library requests for a quick scraping, Selenium has proven to be the most appropriate solution, because the Smogon site is a dynamic web page requiring interactions.

The dataset used in this study, although derived from Smogon's [13] comprehensive repository, suffers from several notable limitations that impact the quality of the generated teams. First, the data is incomplete, with certain Pokémon particularly those less popular in competitive play or belonging to niche tiers lacking detailed builds or strategies. This results in an uneven representation of the Pokémon pool, favoring meta-relevant species while neglecting others. Additionally, much of the scraped information is outdated, reflecting older metagame trends rather than current strategies influenced by recent updates to Pokémon Showdown [12] or competitive formats. This discrepancy means that some generated teams may fail to align with the latest standards of competitive viability, such as counters to modern threats or adherence to newly established tier lists. These limitations underscore the need for a more comprehensive and up-to-date dataset to ensure higher accuracy and consistency in the generated outputs.

We collected data on strategic Pokémon sets, including detailed information about their optimal moves and stats. Then we collected data of complete teams on Coup Critique [3], tailored to different strategies, which are provided in an easily exportable format compatible with Pokémon Showdown. In addition to full teams, we also gathered lists of Pokémon names, which can be presented in a team format for quick assembly.

After extracting data from the Smogon site using Selenium, these, representing the characteristics of the Pokémon personalities, were used to train the GPT-2 model[15] [18]. This choice was ideal for the PK-LLM project, as GPT-2 requires fewer resources due to its reduced number of parameters, compared to heavier models like Llama 3. This allowed us to effectively adapt the model to a specific area while optimizing costs and performance.

Once the model was fine-tuned[9] [17] , we tested its capabilities by creating a web interface. This interface allows you to enter a prompt, such as "Recommend 6 Pokémon for me", and the fine-tuned model generates a text describing the personalities of the Pokémon. This text is then imported into the Pokémon Showdown[12] platform, which generates a team of Pokémon as shown in (Figure 1). You can view our project source code via this GitHub link: https://github.com/PK-LM

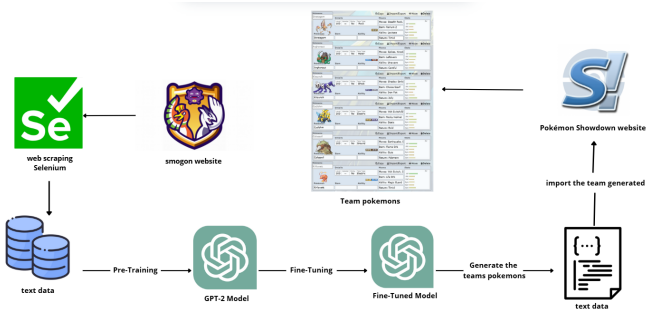

Figure 1. PK-LM Architecture: From data mining to team generation in Pokémon Showdown.

The use of a language model (LLM) for generating Pokémon teams for Pokémon Showdown [12] allows users to easily request a team tailored to specific needs. Users can ask the model to generate a complete team, and the model will provide it along with a format that can be directly copied and pasted into Pokémon Showdown. Additionally, the model allows users to specify certain Pokémon they want to be included in the team. It will then adjust the rest of the team to ensure synergies and optimal strategies. This makes it easy and fast for players to create a team based on their preferences, offering a quick and efficient way to build teams according to their desired playstyle or strategy.

4 Evaluation

We observed that when using the initial dataset, which only included strategic Pokémon sets, the results were suboptimal. The model frequently generated teams consisting of fictional Pokémon or Pokémon with impossible sets. This issue arose because the model primarily retrieved the most commonly used moves, rather than moves that were actually viable for the Pokémon in question. As a result, many of the generated sets included attacks that were either not accessible to the selected Pokémon or were strategically inefficient, leading to unrealistic and ineffective teams. This highlighted the need for more refined data and improved algorithms to ensure that the generated teams not only aligned with common strategies but also adhered to the actual mechanics and constraints of the game.

To resolve these issues, we implemented a pre-training process using Pokémon names in team format. This allowed the model to first generate realistic teams based on existing Pokémon rather than relying solely on abstract sets. Once the team structure was established, we then incorporated strategic sets for each Pokémon, ensuring that the generated teams were both viable and accurate within the game mechanics. This approach enabled us to retrieve strategic sets that were not only appropriate for the selected Pokémon but also ensured the team was realistic, exportable, and playable on Pokémon Showdown. As a result, this methodology significantly improved the quality of the generated teams, leading to more effective and practical outcomes for users.

This (Figure 2) shows the reduction in loss when training our fine-tuned GPT-2 model. There is a rapid convergence at the beginning, then stabilization after several iterations, indicating that the model

adapts effectively to data extracted from Smogon. This ensures good optimization while limiting errors on the text data of Pokémon personalities.

Figure 2. Training Progress (Loss).

5 Conclusions

In this project, we introduced PK-LM, an innovative system based on the GPT-2 language model, designed to optimize the composition of Pokémon teams in competitive battles. By exploiting data extracted from the Smogon platform via Selenium and using the Hugging Face Transformers libraries, We have managed to refine the model in order to generate teams that are adapted to users' strategic preferences and conform to competition rules.

Our results demonstrate a significant improvement of team suggestions compared to traditional methods, highlighting the effectiveness of the PK-LM approach in creating competitive and sustainable compositions. The integration of a pre-training process on team formats has helped overcome the initial limitations related to the generation of fictitious Pokémon or invalid sets, ensuring the relevance and playability of teams generated on the Pokémon Showdown platform.

However, our study reveals certain constraints, including incompleteness and obsolescence of extracted data, which may affect the quality of the proposed teams. To address these limitations, future efforts could focus on enriching and continuously updating the database used for model training. In addition, the exploration of newer and more powerful language models could further improve PK-LM's performance.

One promising extension for future work lies in the customization of Pokémon sets rather than relying solely on pre-existing ones. By allowing users to fine-tune the moves, stats, and abilities of individual Pokémon, we could offer even greater flexibility in team-building, catering to a wider range of strategies and playstyles. This customization would enable the model to generate more personalized and unique teams, reflecting the specific preferences and tactics of the player. Furthermore, incorporating advanced features like the ability to adjust the synergy between Pokémon in real-time or optimize teams for particular battle formats could further enhance the user experience, making the tool even more powerful and adaptable for competitive players.

In conclusion, PK-LM represents a promising step forward in the use of language models for competitive strategy in video games. This work paves the way for similar applications in other areas requiring strategic optimization, while highlighting the importance of high quality data and appropriate training methods to maximize the potential of language models in specialized contexts.

Link of the video demo : PK-LM video

Link of the github : https://github.com/ASRI7198/PK-LM

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