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Master's Programme in Data Science

Automating Information Extraction from Non-Standard Financial Reports Using Large Language Models

Enhancing Efficiency through Format-Aware Extraction with Large Language Models

Gabriel Gomes Ziegler

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Abstract

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Nyckelord Nyckelord på svenska, temperatur

Preface

Thanks notes

Otaniemi, 31 August 2024

Eddie E. Engineer

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NLP Natural Language Processing 9

PDFs Portable Document Formats 10

OCR Optical Character Recognition 10

LLMs Large Language Models 7

LLM Large Language Model 7

GPT Generative Pre-trained Transformer 7

BERT Bidirectional Encoder Representations from Transformers 8

KPI Key Performance Indicator 10

RAG Retrieval Augmented Generation 7

1 Introduction

1.1 Background of the Field of Study

The field of data extraction from financial reports has evolved significantly with advancements in text processing and machine learning technologies. Historically, this task involved manual data entry or rule-based systems that were labor-intensive and prone to errors. The emergence of LLMs, such as GPT and Bidirectional Encoder Representations from Transformers (BERT), has revolutionized this domain. These models have the ability to understand and extract complex financial information from unstructured data, thereby increasing accuracy and efficiency. Recent studies have demonstrated the potential of LLMs in automating financial data extraction, highlighting improvements in processing time and data accuracy over traditional methods.

1.2 General Objective

This study aims to extend the current capabilities of data extraction systems by incorporating advanced LLMs and exploring novel methodologies in the field. The primary goals include: ellaborating a comprehensive comparison of methods for extracting information from financial reports, with a focus on non-standard reports,

enhancing the precision and efficiency of data extraction from financial reports, developing a scalable system capable of processing large volumes of data, and comparing the effectiveness of various LLMs and extraction techniques. By achieving these goals, the study seeks to contribute to the broader understanding of automated data extraction and its application in financial analysis.

1.3 Research Question and Sub-Problems

The primary research question of this study focuses on: “LLMs be optimized for more accurate and efficient extraction of financial data from unstructured reports?" Sub-problems in this line of inquiry include: identifying the most effective LLM architectures for financial data recognition, developing methodologies for context-aware data extraction, enhancing the system's ability to handle diverse report formats, and evaluating the impact of training data quality and volume on model performance. These sub-problems are essential for understanding the intricacies of applying LLMs to financial data extraction and for developing a comprehensive solution.

Scope and Constraints

The scope of this study is limited to the extraction of financial data from English-language reports, focusing on publicly available annual and quarterly financial statements. Key constraints include the variability in report formats, the complexity of financial terminology, and the inherent limitations of current LLM technologies in understanding domain-specific contexts. The study primarily revolves around the use of GPT and BERT models, considering their widespread adoption and state-of-the-art performance in text processing tasks. Main concepts involved include Natural Language Processing (NLP), machine learning, data extraction, and financial analysis, with a particular emphasis on the adaptation and optimization of LLMs for specialized data extraction tasks.

2 Concepts and State of the Art

Ever since Portable Document Formats (PDFs) were created by Adobe in 1993, they have been used to store and share information. These document standard quickly became a way of companies reporting their financial information for the public as well as Key Performance Indicator (KPI)s and other important information internally. This has led to a large amount of information being stored in PDFs, which has led to a need to extract information from these files. A series of professions have arised from this need, such as data entry, data extraction, and data analysis. The extraction of information from PDFs has been a manual process for most of the tasks until recent years, when Optical Character Recognition (OCR) and NLP technologies have been developed to automate processes involving processing PDFs.

Extracting information from a document, recently referred to "Document AI" is a complex problem that often involves cross-modal interactions where information is represented in both text and visual form. This is particularly true for financial reports, where information is often presented in tables, charts, and text. The problem is further complicated by the fact that financial reports are often not standardized, and the information is presented in diverse range of formats.

2.1 LLMs

Large Language Models (LLMs) are a class of artificial intelligence models that have been designed to understand, generate, and interact with human language at a large scale. These models are trained on vast amounts of text data, allowing them to learn language patterns, grammar, context, and even domain-specific knowledge. As a result, LLMs can perform a wide range of language-related tasks, such as translation, summarization, question answering, and more, with remarkable proficiency. The development and evolution of LLMs have been instrumental in advancing the field of natural language processing (NLP), enabling more natural and effective human-computer interactions. The capabilities of LLMs have found applications in various sectors, including but not limited to customer service, content creation, and, notably, in extracting and analyzing information from documents in the field known as Document AI [**?**].

2.2 GPT

2.3 GPT-4

GPT-4 — the fourth GPT release by OpenAI, brought a significant leap in the capabilities of LLMs when compared to its predecessor GPT-3. This model builds upon the architecture and training methodologies of its predecessors, incorporating lessons learned and innovations to achieve unprecedented performance across a broad spectrum of language tasks. GPT-4 is characterized by its deep learning architecture, which allows it to generate human-like text, comprehend complex instructions, and provide accurate information and analysis based on the context provided to it. Its training involved feeding the model with diverse and extensive datasets, enabling it to grasp nuances across different languages, cultures, and domains. GPT-4's versatility and adaptability have made it a valuable tool in numerous applications, from creative writing assistance to sophisticated data analysis and interpretation in academic research [?].

2.4 GPT-4V

GPT-4 Vision represents an extension of the capabilities of traditional LLMs into the realm of visual understanding and analysis. By integrating vision-based artificial intelligence technologies with the language processing prowess of GPT-4, this model can interpret and analyze images, diagrams, and visual data in conjunction with textual information. This multimodal approach enables GPT-4 Vision to perform tasks that require an understanding of both visual and textual content, such as extracting data from charts and graphs in financial reports, identifying key information in documents with complex layouts, and answering questions that depend on visual cues. The development of GPT-4 Vision is a testament to the ongoing advancements in AI, highlighting the move towards more integrated and comprehensive models that can navigate the complexities of human communication and information processing [?].

2.5 LLMs for Document AI

LLMs have become a popular strategy in the field of Document AI, transforming how information is extracted, processed, and analyzed from documents. In the context of Document AI, LLMs are utilized to understand the content within documents, ranging from simple text to complex structures like tables and charts, and the relationships between different pieces of information. These models leverage their extensive training on diverse datasets to adapt to the specific challenges posed by document analysis, such as varying formats, layouts, and the integration of multimodal data. Through techniques such as transfer learning and fine-tuning, LLMs can be specialized to perform tasks including but not limited to information extraction, document summarization, and semantic search within documents. Their ability to process and analyze documents at scale significantly reduces the time and effort required for data entry, extraction, and analysis, enabling more efficient and accurate handling of document-based information [?].

2.6 Question answering with RAG

RAG represents a novel approach in leveraging LLMs for the task of question answering. RAG combines the generative capabilities of models like GPT with retrieval-based methods, which search a large corpus of documents to find relevant information that can aid in generating accurate and informative answers. This technique involves two main components: a retriever, which identifies relevant documents or passages given a query, and a generator, which synthesizes the retrieved information into a coherent response. By integrating these two processes, RAG is able to produce answers that are not only contextually relevant but also enriched with details and insights drawn from a wide range of sources. This method has shown significant promise in improving the accuracy and depth of responses provided by AI systems in question answering applications, particularly in domains where detailed and specific knowledge is required, such as academic research and technical support [**?**].

2.7 Structure of the thesis

The thesis is composed by a comprehensive comparison of methods for extracting information from financial reports, with a focus on non-standard reports. The thesis is structured as follows:

1. Introduction
2. Literature review
3. Research material and methods
4. Results / Findings
5. Discussion
6. Summary / Conclusions
7. References

3 Financial Reports Dataset

Dataset used to benchmark different methods.

4 Extracting information from financial reports

In this section, we define the metrics, methods and processes used to extract information from financial reports

4.1 Metrics and Evaluation Criteria

4.2 System Specifications

Define the system specifications and requirements used to run the experiments

4.3 LLM to make sense of text

LLM model using only text to identify key indicators reported in PDF files.

4.4 Multimodal LLMs to extract information from images

4.5 Multimodal LLMs to extract information from images and text

5 Results

Present the results of your study here and answer the research questions, asked earlier in the thesis (in the introduction, perhaps), this study strives to answer. The scientific value of your work is measured by the results you obtain along with the arguments you give to back the answers to your research questions.

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5.1 Limitations of the data extraction systems

Explain what are the observed limitations

6 Summary/Conclusions

This is where you tie up any loose ends. Tell your reader briefly and clearly what you have done, what you have discovered, and the value of your discovery in the context of similar work done earlier. Draw clear conclusions regarding the research problem, sub-problems or hypotheses. You also discuss future lines of study and new questions your study might have posed.

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References

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