

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**

© 2024

This work is licensed under a [Creative Commons](#)  
“Attribution-NonCommercial-ShareAlike 4.0 International” license.



---

**Author** Gabriel Gomes Ziegler

---

**Title** Automating Information Extraction from Non-Standard Financial Reports  
Using Large Language Models — Enhancing Efficiency through Format-Aware  
Extraction with Large Language Models

---

**Degree programme** Data Science

---

**Major** ICT Innovation

---

**Supervisor** Prof. Bo Zhao

---

**Advisor** MS Liliya Shakhpazyan (MSc)

---

**Collaborative partner** Datia

---

**Date** 21 September 2023      **Number of pages** 17+1      **Language** English

---

**Abstract**

The abstract is a short description of the essential contents of the thesis, usually in one paragraph: what was studied and how and what were the main findings.

For a Finnish thesis, the abstract should be written in both Finnish and English; for a Swedish thesis, in Swedish and English. The abstracts for English theses written by Finnish or Swedish speakers should be written in English and either in Finnish or in Swedish, depending on the student's language of basic education. Students educated in languages other than Finnish or Swedish write the abstract only in English. Students may include a second or third abstract in their native language, if they wish.

The abstract text of this thesis is written on the readable abstract page as well as into the pdf file's metadata via the `\thesisabstract` macro (see comment in this  $\text{\TeX}$  file above). Write here the text that goes onto the readable abstract page. You can have special characters, linebreaks, and paragraphs here. Otherwise, this abstract text must be identical to the metadata abstract text.

If your abstract does not contain special characters and it does not require paragraphs, you may take advantage of the `\abstracttext` macro (see the comment in this  $\text{\TeX}$  file below).

---

**Keywords** For keywords choose, concepts that are, central to your, thesis

---

---

**Tekijä** Gabriel Gomes Ziegler

---

**Työn nimi** Opinnäytteen otsikko — Opinnäytteen mahdollinen alaotsikko

---

**Koulutusohjelma** Elektroniikka ja sähkötekniikka

---

**Pääaine** Sopiva pääaine

---

**Työn valvoja** Prof. Pirjo Professori

---

**Työn ohjaajat** TkT Alan Advisor, DI Elsa Expert

---

**Yhteistyötaho** Yhtiön tai laitoksen nimi (tarvittaessa)

---

**Päivämäärä** 21.9.2023

**Sivumäärä** 17+1

**Kieli** englanti

---

### **Tiivistelmä**

Tiivistelmä on lyhyt kuvaus työn keskeisestä sisällöstä usein yhtenä kappaleena: mitä tutkittiin ja miten sekä mitkä olivat tärkeimmät tulokset. Suomenkielisen opinnäytteen tiivistelmä kirjoitetaan suomeksi ja englanniksi ja ruotsinkielisen vastaavasti ruotsiksi ja englanniksi. Suomen- tai ruotsinkielisten opiskelijoiden, joiden opinnäytteen kieli on englanti, tulee kirjoittaa tiivistelmänsä englanniksi ja koulusivistyskielellään. Muiden kuin koulusivistyskieleltään suomen- tai ruotsinkielisten tulee kirjoittaa tiivistelmänsä vain englanniksi. Opiskelija voi halutessaan lisätä opinnäytteeseensä toisen tai kolmannen tiivistelmän omalla äidinkielellään. Tämän opinnäytteen tiivistelmäteksi kirjoitetaan opinnäytteen luettavan osan lomakkeen lisäksi myös pdf-tiedoston metadataan. Kirjoita tähän metadataan kirjoitettavaa teksti. Metadatatekstissa ei saa olla erikoismerkkejä, rivinvaiho- tai kappaleenjako-merkkiä, joten näitä merkkejä ei saa käyttää tässä. Jos tiivistelmäsi ei sisällä erikoismerkkejä eikä kaipaa kappaleenjako-  
voit hyödyntää makroa abstracttext luodessasi lomakkeen tiivistelmää (katso kommentti tässä TeX-tiedostossa alla). Metadatatiivistelmäteksin on muuten oltava sama kuin lomakkeessa oleva teksti.

---

**Avainsanat** Vastus, resistanssi, lämpötila

---

---

**Författare** Gabriel Gomes Ziegler

---

**Titel** Arbetets titel — Opinnäytteen mahdollinen alaotsikko

---

**Utbildningsprogram** Elektronik och electroteknik

---

**Huvudämne** Sopiva pääaine

---

**Övervakare** Prof. Pirjo Professori

---

**Handledare** TkD Alan Advisor, DI Elsa Expert

---

**Samarbetspartner** Company or institute name in Swedish (if relevant)

---

**Datum** 21.9.2023

**Sidantal** 17+1

**Språk** engelska

---

### **Sammandrag**

Sammandraget är en kort beskrivning av arbetets centrala innehåll: vad undersöktes, hur undersöktes det och vilka var de viktigaste resultaten?

I lärdomsprov som skrivs på svenska skrivs sammandraget på svenska och engelska, på motsvarande sätt skrivs sammandraget på finska och engelska i lärdomsprov på finska. Finsk- eller svenskspråkiga studerande som skriver sitt lärdomsprov på engelska ska skriva sammandraget på engelska och på sitt skolutbildningsspråk. Studerande vars skolutbildningsspråk inte är svenska eller finska skriver sammandraget endast på engelska. Den studerande kan om hen så önskar lägga till ett andra eller tredje sammandrag på sitt eget modersmål. Sammandraget fungerar då ofta som mognadsprov och bör i så fall vara minst 300 ord långt. Information om mognadsprov på svenska finns på MyCourses:

<https://mycourses.aalto.fi/course/view.php?id=26872>.

---

**Nyckelord** Nyckelord på svenska, temperatur

---

## **Preface**

Thanks notes

Otaniemi, 31 August 2024

Eddie E. Engineer

# Contents

<b>Abstract</b>	<b>3</b>
<b>Abstract (in Finnish)</b>	<b>4</b>
<b>Abstract (in Swedish)</b>	<b>5</b>
<b>Preface</b>	<b>6</b>
<b>Contents</b>	<b>7</b>
<b>1 Introduction</b>	<b>8</b>
1.1 Structure of the thesis . . . . .	8
1.2 Background of the Field of Study . . . . .	9
1.3 General Objective . . . . .	9
1.4 Research Question and Sub-Problems . . . . .	9
<b>2 Concepts and State of the Art</b>	<b>11</b>
2.1 Large Language Models (LLMs) . . . . .	11
2.2 Generative Pre-trained Transformer (GPT) . . . . .	11
2.3 GPT-4 . . . . .	11
2.4 GPT-4V . . . . .	12
2.5 LLMs for Document AI . . . . .	12
2.6 Question answering with Retrieval Augmented Generation (RAG) . . . . .	12
<b>3 Financial Reports Dataset</b>	<b>14</b>
<b>4 Extracting information from financial reports</b>	<b>14</b>
4.1 Metrics and Evaluation Criteria . . . . .	14
4.2 System Specifications . . . . .	14
4.3 Large Language Model (LLM) to make sense of text . . . . .	14
4.4 Multimodal LLMs to extract information from images . . . . .	14
4.5 Multimodal LLMs to extract information from images and text . . . . .	14
<b>5 Results</b>	<b>15</b>
5.1 Limitations of the data extraction systems . . . . .	15
<b>6 Summary/Conclusions</b>	<b>16</b>
<b>References</b>	<b>17</b>
<b>A Contents of an appendix</b>	<b>18</b>

<b>NLP</b> Natural Language Processing . . . . .	9
<b>PDFs</b> Portable Document Formats . . . . .	11
<b>OCR</b> Optical Character Recognition . . . . .	11
<b>LLMs</b> Large Language Models . . . . .	7
<b>LLM</b> Large Language Model . . . . .	7
<b>GPT</b> Generative Pre-trained Transformer . . . . .	7
<b>BERT</b> Bidirectional Encoder Representations from Transformers . . . . .	9
<b>KPI</b> Key Performance Indicator . . . . .	11
<b>RAG</b> Retrieval Augmented Generation . . . . .	7

# 1 Introduction

## 1.1 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 (Context, Problem Definition, Objectives)
2. Literature review (Concepts, State of the Art)
3. Methodology (Detail how experiments were conducted)
4. Results (Present the results of the experiments)
5. Conclusion (Interpretation of results, implications, limitations)
6. References



## 1.2 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.

## 1.3 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: elaborating 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.

## 1.4 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 arisen 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 [?].

### **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.

Be critical of the significance of your results. You may critically scrutinise the results and your interpretation of the results here, or you may do so later in the chapter with the discussion of your work or in the conclusions part.

This part should discuss how reliable the data used in the study are. You may discuss the reliability of the conclusions drawn from the study either in this chapter or later in the discussions part. You may have the discussion in a chapter of its own, separate from the summary or conclusions.

### **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.

As the author of the thesis, you alone are responsible for ensuring that the layout, form and structure of your thesis adheres to the guidelines outlined by your school. This template aims to help you meet these requirements.



## References

## **A Contents of an appendix**