

Artificial intelligence and PDFs: A paradigm shift from reading text to understanding meaning

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Abstract

AI's rise has totally shaken up how we deal with PDFs, making it easier to get the gist of text and pull out the info we need. AI algorithms more and more demonstrate themselves competent in content analysis to deduce meaning and relationships between objects in documents. These algorithms use cutting-edge techniques like deep learning to boost text recognition models, making it easier to pull out important details from tricky texts and hidden images. In addition, AI technology improves search precision and speed in PDF documents so that users can find the required information faster. These new ideas let us turn documents into interactive tools by adding cool stuff like smart scanning and automatic sorting, making everything even better for users. These tech tools are super versatile, popping up everywhere from the business world to classrooms and labs. They're the go-to for sifting through legal files or digging up scholarly info from research papers. AI's rise has totally shaken up how we deal with PDFs, making it easier to get the gist of text and pull out the info we need. AI algorithms more and more demonstrate themselves competent in content analysis to deduce meaning and relationships between objects in documents. These algorithms use cutting-edge techniques like deep learning to boost text recognition models, making it easier to pull out important details from tricky texts and hidden images.

Keywords: files, analysis, summarization, protection, privacy, tables

1. Introduction

Before PDFs came along, people had a tough time because there were so many different file types that needed special programs to open them. (Paris, 2022), The PDF format, which is pretty much everywhere these days, was cooked up by Adobe back in the '90s, specifically in 1993 (Colorpilot, 2024). The whole point was to make it easier to share files between different computer systems without messing up the look or the content. (Tungsten Automation, N.D.)

Adobe didn't invent PDF from the ground up; they just built on what was already there, especially PostScript and Adobe Illustrator. PostScript gave us a way to talk about documents that works no matter what device you're using, and Adobe Illustrator was a drawing tool that worked across different platforms. (Xiong, 2020)

The starting point for this change was digital paper, and a bunch of companies were after it: DjVu, WordPerfect, Common ground, and others Adobe, the company that kicked off the PDF format at a tech conference back in '92, eventually came out on top (even though it turned out that this initial lead was more like a standalone island and the office in 2023 is still pretty much paper-dependent).

Since its inception, PDF has transformed into a universal standard for document exchange in various sectors, including business, education, healthcare, and law, thanks to its versatility and ability to maintain original document structures across different devices and platforms. (Martelli,2025). Notably, the architecture of PDFs includes functionalities that allow users to include annotations, multimedia components, and interactive fields, thereby augmenting the format's functionality over and above text and images alone. (Berkenbilt,2022).

As tech's gotten better, PDFs have upped their game with solid security stuff like encryption and digital signatures, so they're good for dealing with private info. (Moore, N.D.) PDF files have lots of perks, but they're not without their headaches. Editing them can be a real pain, they might not be the safest bet, and making sure they're easy for everyone to use, especially when you've got to meet legal requirements like the ADA, can. These problems really show how much people are arguing about whether PDFs are good for when you need to change stuff a lot or work together with different teams. (Scholarly,2023)

As the digital world keeps growing, the PDF format is still super important for managing and sharing documents, and we can expect more cool features for teamwork and better ways to analyze documents. PDFs are super important for digital chats and stuff, making them a key part of our docs these days.

Possibly the key characteristics of such files include the following:

- 1- PDF makes for universal availability
- 2- PDF allows for document fidelity
- 3- PDF allows for document longevity
- 4- PDF supports collaborative processes
- 5- PDF provides for interoperability
- 6- The PDF standard means safety and security. (Selbst,2023).

Automated chatbot systems have undergone several distinct evolutionary stages. The first stage was represented by rule-based systems, such as ELIZA, developed by Joseph Weizenbaum in 1966, which relied on simple pattern-matching techniques to simulate conversation. Later, in 1972, PARRY was introduced, adding the ability to simulate psychological states. However, these early systems were extremely limited and incapable of understanding the true meaning of texts (Adamopoulou & Moussiades, 2020).

In the second stage, retrieval-based chatbots emerged. These systems relied on predefined databases to select the most appropriate responses from a ready-made set, such as automated customer service systems that became widespread in the early 21st century. Despite being an improvement over their predecessors, they suffered from limited flexibility and the inability to generate new responses beyond the predefined database (Adamopoulou & Moussiades, 2020).

The third and most recent stage is represented by generative chatbots, which employ deep learning techniques and large language models to generate entirely new responses based on context. Systems such as ChatGPT exemplify this stage, marking a qualitative leap in chatbot capabilities. They are now able to conduct long and complex dialogues, understand context, and infer user intent behind queries (Chang et al., 2024).

2. Materials and Methods

This study, *The AI Revolution in the World of PDFs: From Reading Texts to Understanding Content*, was designed to investigate how artificial intelligence enhances the processing, comprehension, and retrieval of information within PDF documents.

Materials

- **Dataset of PDF Files:** A sample of 300 PDF documents was collected from academic journals, business reports, and educational resources.
- **AI Tools:** Optical Character Recognition (OCR) systems, Natural Language Processing (NLP) models, and deep learning algorithms were employed to analyze text and embedded images.
- **Software Environment:** Python libraries such as PyPDF2, Tesseract OCR, and spaCy were used for document parsing, text recognition, and semantic analysis.
- **Evaluation Metrics:** Accuracy of text extraction, semantic relevance, and search efficiency were measured using precision, recall, and processing speed benchmarks.

Methods

1. **Data Collection:** PDFs were selected to represent diverse structures, including text-heavy documents, scanned images, and mixed-content files.
2. **Preprocessing:** Documents were converted into machine-readable formats, with noise reduction applied to scanned images.
3. **AI Modeling:** Deep learning models were trained to recognize text patterns, extract key information, and identify relationships between objects in documents.
4. **Search and Categorization:** AI-driven indexing was applied to improve retrieval speed and accuracy, with automated categorization tested against human classification.
5. **Performance Evaluation:** Results were compared to traditional PDF handling methods to assess improvements in comprehension, extraction, and user experience.

This methodology provided a structured framework to evaluate the transformative role of AI in shifting PDFs from static text containers into dynamic, interactive knowledge tools.

3. Text Chat Tools with PDF Files

Text chatting software used on PDF files is considered a form of advanced technology in the field of artificial intelligence, which enables individuals to obtain data from these files and ask questions for the purpose of obtaining information. These forms of software have universal application in educational, scientific, and commercial fields, and their effectiveness can be attributed to their use of natural language processing algorithms in analyzing data in writing.

Table 1: Represents the Most Prominent Text Chat Tools with PDF Files

Tool	Description	Link	Summary
ChatPDF	Interacting with and commenting on PDF files	https://www.chatpdf.com/	Provides an interactive experience for users through chatting with PDF files, allowing questions to be asked about documents and receiving direct answers, facilitating content comprehension.
PDF ai	Getting model answers from within the files	https://pdf.ai/	The tool uses AI to answer questions related to PDF content, helping to extract information quickly and effectively.
UPDF	Summarizing, translating, and commenting on all files	https://www.updf.com/	Offers smart summarization and translation features for content within PDF files, facilitating quick understanding in multiple languages.
PDFgear	Extracting texts and interacting	https://www.pdfgear.com/	Allows users to interact with PDF

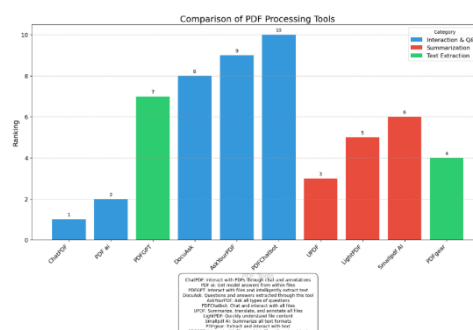
	with them		files intelligently by extracting texts and vital content, analyzing it effectively.
LightPDF	Fast content comprehension of files	https://lightpdf.com/	Provides smart translation and summarization services for documents, making it ideal for users who need fast comprehension in multiple languages.
Smallpdf AI	Summarizing all types of texts	https://smallpdf.com/ai	Helps in effectively summarizing long texts using AI, saving time and effort for users.
PDFGPT	Interacting with files and extracting texts intelligently	https://pdfgpt.io/	Offers a tool based on the GPT AI model for interacting with PDF files, where users can ask questions and receive direct answers.
DocuAsk	Q&A extracted through this tool	https://www.docuask.com/	Enables users to ask questions about PDF content and get quick, accurate answers, easing the search within large files.
AskYourPDF	Asking all types of questions	https://askyourpdf.com/	Allows users to quickly and accurately extract information from PDF files,

			facilitating access to important texts or data.
PDFChatbot	Conversing and interacting with all files	https://www.pdfchatbot.com/	Provides an interactive chat experience for users to inquire about PDF content directly and easily, helping in better understanding of documents.

The tool enables users to access content through an intelligent interface of text conversations. In content processing and generation of responses, the tool uses natural language processing and AI technologies. Some of its important characteristics include the following:

- **Usability:** The user does not have to have technical know-how to operate the tool. The tool allows anyone to upload a PDF document and ask any question. A streamlined interface will be used to make the use of the interface easy.
- **Point-by-point engagement:** This refers to the engagement of each and every point in content within the PDF file. This characteristic ensures convenience because, without it, one has to search for the content manually.
- **Understanding complicated content:** The ability of the system to understand complicated information, for instance, in scientific, legal, or literary content and identify valuable information.
- **Batch file upload:** Multiple files can be uploaded simultaneously by the system and processed in a single go. This feature is very useful when comparing papers or looking for information within multiple documents.
- **Search within context:** Results from searching will be generated based on an understanding of the entire document and not just keywords. This characteristic proves immensely helpful when there are documents that are multi-complex or multi-layered with intermixed data.
- **Supports different file formats:** Different file formats can be processed within the system, including scanned documents such as optical character recognition (OCR).
- **Privacy and Security:** The tool offers security of the data because once an action is carried out, the data is removed from the system.

Figure 1 Represents a comparison of PDF processing tools according to different categoric



The world has witnessed a radical transformation in the way humans interact with digital systems, with AI-powered text-based chat tools emerging as one of the most prominent manifestations of this shift. AI-enhanced chat tools are defined as interactive software that employs natural language processing and deep learning techniques to enable text-based dialogue between humans and machines in a manner that simulates natural human communication (Kocoń et al., 2023). These tools have evolved from simple rule-based systems into intelligent systems capable of understanding context and generating coherent, relevant responses within conversations.

3.1. The importance of smart chat tools in education

AI-powered chat tools have emerged as promising instruments in the educational field, functioning as intelligent teaching assistants capable of providing instant feedback and adapting instructional content to each learner's level. According to studies published in *Nature* (Zhao & Qiao, 2023), chatbots based on large language models significantly reduce foreign language speaking anxiety and improve learners' speaking skills. Interaction with chatbots creates a safe, judgment-free environment that encourages learners to practice without hesitation.

Similarly, a study published in *Advanced Intelligent Systems* (Yigci et al., 2025) demonstrates that the use of large language models in higher education facilitates personalized learning experiences, enhances asynchronous learning, and supports the preparation of adaptive instructional materials. Another study published in *PMC* (2024) indicates that chatbots based on large language models greatly assist students in acquiring both receptive and productive vocabulary knowledge, reflecting the effectiveness of these tools in supporting language learning processes.

On the other hand, research published in *ScienceDirect* (2026) warns of ethical challenges associated with the use of intelligent chat tools in higher education, particularly concerning academic integrity and the risk of overreliance on these systems.

Deep learning is considered one of the cornerstones of modern artificial intelligence. These tools rely on deep, multi-layered artificial neural networks that learn language patterns and semantic representations through training on massive amounts of textual data. The core architectural components include the multi-head self-attention mechanism, which enables the model to focus on different aspects of the text simultaneously; positional encoding, which preserves word order information; and feed-forward networks, which process contextual representations (Vaswani et al., 2017).

The training strategies used in building intelligent chat tools vary, but they mainly include:

- **Pre-training** on large-scale textual data using objectives such as next-word prediction or masked word modeling.
- **Fine-tuning** on specialized datasets to improve performance on specific tasks.
- **Reinforcement Learning from Human Feedback (RLHF)**, a pivotal innovation that has significantly enhanced the quality of chatbot responses, making them more aligned with human expectations (Ouyang et al., 2022).

4. Tools for Analysis and Summary

Content summarization and analysis have played a crucial role in modern times in assisting individuals in extracting vital information. This is because there is the availability of content in various formats, mostly in a PDF format. Some of the roles that these tools play include the provision of critical data, trend identification, and data summarization; therefore, enabling the data analyst, student, and business practitioner to have access to data without being obliged to go through an entire document. In addition, such tools enable individuals to enhance productivity and efficiency in business management by basing their decisions on gathered data.

The field of digital document analysis has witnessed rapid development with the emergence of large language models (LLMs). Traditionally, PDF file analysis relied on complex pipelines that combined image processing techniques, optical character recognition (OCR), and layout analysis. However, modern language models enable a holistic approach that integrates textual, visual, and structural understanding of documents.

Table No. (2) shows the most prominent summary and analysis tools for PDF files.

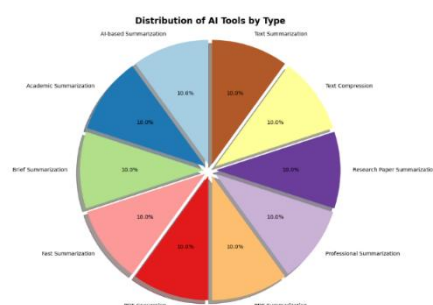
Tool	Description	Link	Features	Importance
IntelliPPT	Convert PDF to presentations	https://www.intellippt.com/	Converts PDF files to PowerPoint presentations automatically.	Eases the conversion of static content into flexible content for presentations.
SummarizeBot	Automatic text summarization	https://summarizebot.com/	Summarizes long texts accurately and quickly.	Saves time in reading and analyzing long documents.
Resoomer	Specialized in summarizing texts	https://www.resoomer.com/	Summarizes academic texts and reports professionally.	Useful for students and researchers in simplifying complex content.
SMMRY	Quick summarization of long texts	https://smmry.com/	Provides quick summarization and core content extraction.	Useful for fast reading and extracting main ideas.
Scholarcy	Summarizes research papers	https://www.scholarcy.com/	Summarizes academic papers and research reports focusing on results.	Saves researchers' time in understanding complex research papers.
TLDR This	Short summarization of texts	https://tldrthis.com/	Provides very brief and fast summaries for long texts.	Ideal for users looking for quick and effective

				summaries.
PDF Summarizer	Tool dedicated to summarizing PDFs	https://www.pdfsummarizer.com/	Custom and efficient PDF summarization.	Helps speed up work with long PDF files.
AI Summarizer	Uses AI for summarization	https://www.aisummarizer.com/	Relies on AI to provide accurate and customized summaries.	Delivers more accurate and professional results using AI techniques.
Text Compactor	Reduces text size while preserving meaning	https://www.textcompactor.com/	Reduces the size of texts without losing the core meaning.	Useful for simplifying long texts while maintaining core content.
Summari	Text summarization	https://www.summari.com/	Summarizes texts professionally with helpful tips.	Useful for improving efficiency in reading and analyzing professional documents.

Importance of all these technologies:

1. Efficient time/resource management: All of these tools allow the user to search through massive volumes of information in order to find suitable information without having to go through everything manually.
2. Higher productivity: These tools aid in increasing productivity through efficient and timely extraction of summaries.
3. Easy convenience: An abundance of these tools has web-based interfaces that eliminate the need for any installation on the user's device.
4. AI integration: Most of these tools employ AI mechanisms to understand context and extract exact information.
5. Versatility: These tools can be employed across various industries, such as business, education, journalism, and teaching.

Figure No. (2) Shows the distribution of AI tools by type.



4.1. Introduction: Challenges of PDF Analysis

PDF files present unique challenges because they combine textual, visual, and structural content. According to a recent study published in *Frontiers in Artificial Intelligence*, the process of extracting information from PDFs involves four main challenges: (Atagong et al., 2025)‘ (Ke et al., 2026)

Table No. (3)

Challenge	Description
Layout diversity	Documents vary in structure, ranging from simple text to complex tables and multi-column layouts.
Visual quality	In scanned documents, image quality may be low, or they may contain handwriting or non-uniform backgrounds.
Long context	Lengthy documents (such as books and research papers) require understanding relationships across multiple pages.
Tables and mathematical formulas	Identifying and extracting data from tables and equations requires precise spatial and structural understanding.

The table classifies the core challenges facing document processing systems and automated visual/textual content understanding across four axes:

1. Layout Diversity: Reflects the generalization problem in models — a simple document and a multi-column table each demand entirely different segmentation strategies.
2. Visual Quality: Directly tied to Signal-to-Noise Ratio; handwriting and image degradation increase error rates in the OCR and initial analysis stages.
3. Long Context: Challenges the model's ability to maintain long-range dependencies across pages — a well-known architectural constraint in Transformer-based models.
4. Tables & Mathematical Formulas: Require two-dimensional spatial reasoning, where meaning is bound to cell position, not text content alone.

From a machine learning engineering perspective, these challenges escalate in layers: data variety → input quality → extended context → structural complexity.

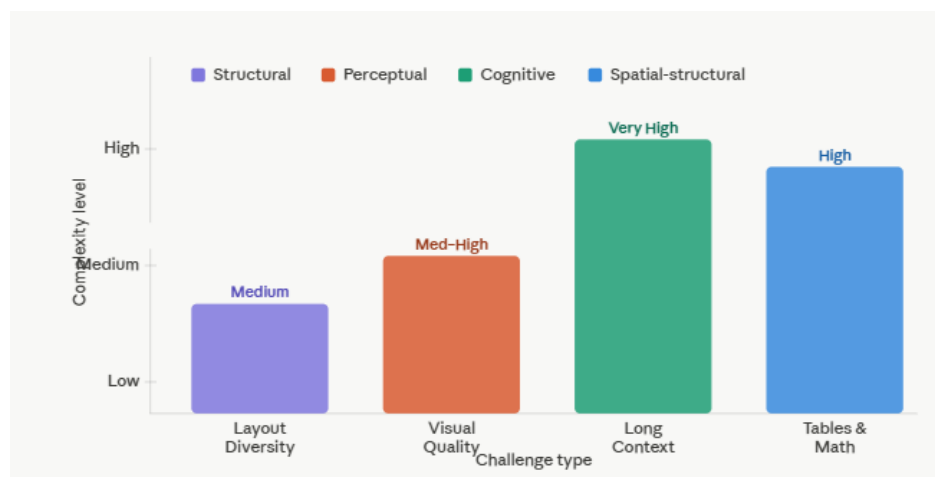


Figure No. (3) Complexity Levels of Core Document Processing Challenges

5. Editing and Reversion Tools

The field of digital document editing has undergone a radical transformation with the emergence of multimodal large language models (Multimodal LLMs). Traditionally, editing PDF files was limited to superficial modifications such as adding comments or signatures. However, modern AI tools now enable intelligent editing that includes modifying the textual, visual, and structural content of documents using natural language instructions.

The PDF file format has been recognized to be one of the most universal media formats when it comes to document sharing in a digital format due to the capability to keep document content organized regardless of the use of specific devices and systems. The need for alteration and modification of these documents in many different sectors like business, education, and scientific research fields makes this requirement an urgent need. One of the reasons for this urgent need is that there is a great demand for programs that enable manipulation and alteration in PDF reports.

Facilities that help in editing and modifying information in these files make it easier for users to make amendments on the file contents, images, tables, and text within. Also, these capabilities are essential since they help the user make amendments by adding comments, signatures, and hyperlinks.

Document Structure Editing is defined as the guided manipulation of textual, visual, and layout components within document images based on user requests. This process involves several key challenges: (Suri et al., 2024)

Table No. (4)

Challenge	Description
Multimodal Grounding	Linking user requests to the image and accurately identifying structural components
Layout Understanding	Preserving spatial relationships between elements during editing
Visual-Textual Integration	Handling texts, images, and tables as interconnected units
Long Context	Processing multi-page documents while maintaining logical sequencing

The table presents four core challenges in **multimodal document understanding systems**, each operating at a distinct layer of cognitive and computational complexity:

1. Multimodal Grounding — the foundational layer: the system must align natural language instructions with visual regions of a document. This is essentially a cross-modal alignment problem, requiring the model to bridge the semantic gap between text-space queries and pixel-space or layout-space content.

2. Layout Understanding — a spatial reasoning challenge: preserving the geometric relationships between elements (headings, columns, figures, captions) during any transformation or editing task. This goes beyond reading content — it demands a structural world model of the page.

3. Visual-Textual Integration — the most semantically rich challenge: treating heterogeneous document components (text blocks, embedded images, tables) not as isolated modalities but as a unified semantic unit. This requires late or early fusion strategies in the model architecture.

4. Long Context — the architectural bottleneck: multi-page documents stress the model's context window and its ability to maintain logical coherence across discontinuous segments, a known limitation of attention-based models at scale.

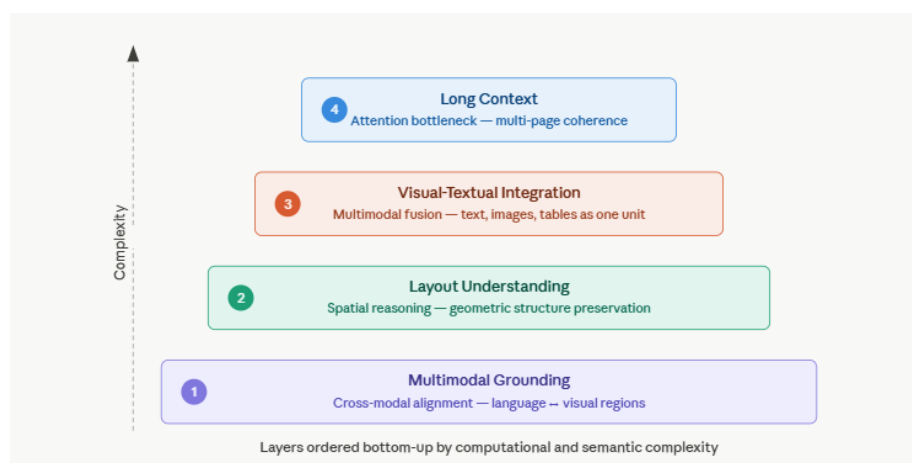


Figure No. (4) Multimodal Document Understanding — Challenge Layers

Table No. (5) represents the most prominent PDF editing and modification tools

Tool	Description	Link	Features	Importance
Adobe Acrobat Pro	A comprehensive tool for editing and managing PDF files	https://www.adobe.com/acrobat/	PDF editing and modification, adding comments, and signing documents	One of the leading tools in the PDF editing industry.
PDFelement	A PDF editing tool with AI integration	https://pdf.wondershare.com/	Advanced editing features including text, images, and tables with AI	Helps improve work productivity using smart tools.

Sejda	An online PDF editor	https://www.sejda.com/	Edit PDFs online with multiple tools like merging and cropping	Ideal for users who do not want to install software on their devices.
PDFescape	A free PDF editing tool on the web	https://www.pdfescape.com/	Edit text, add images, and fill forms for free	A good option for users who need quick and simple edits.
PDF-XChange Editor	A PDF editor with advanced editing tools	https://www.tracker-software.com/product/pdf-xchange-editor	Advanced editing tools with support for comments and annotations	Suitable for users requiring precise and professional editing.
Foxit PDF Editor	A fast and efficient PDF editing tool	https://www.foxit.com/pdf-editor/	Advanced editing features with easy document conversion	Known for its speed and efficiency in handling PDF files.
Nitro PDF	A tool for editing and converting PDF files	https://www.gonitro.com/	Edit and convert PDFs, with features for extracting text and images	An effective tool for managing and converting PDF files to multiple formats.
PDF Buddy	Easy PDF editing via the cloud	https://www.pdfbuddy.com/	Edit PDFs and fill forms online easily	Suitable for quick cloud-based editing accessible from any device.
PDFfiller	A tool for filling and editing PDF forms online	https://www.pdfFiller.com/	Fill and edit electronic forms easily online	Ideal for working with electronic forms that require filling.
Inkscape	An open-source program for editing PDFs with graphic tools	https://inkscape.org/	Edit PDFs using advanced graphic tools with support for multiple files	Ideal for users seeking open-source advanced editing tools.

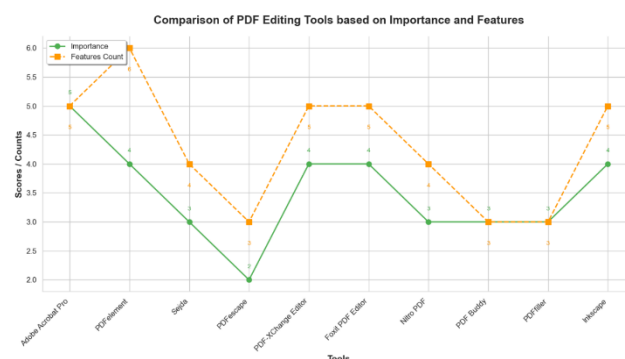


Figure No .5 Represents a comparison of PDF editing tools

6. Instruments for File conversion of Various File Types

File conversion utility plays an important role in several industries such as personal productivity, education, business, and technology.

The following features are mandatory for them.

1. Increase Productivity: The process is quick, saving time, hence becoming efficient.
2. Compatibility: They assist in converting data from one format to another in order to support individuals with different software.
3. Making information accessible: They have a mechanism of editing and viewing documents in PDF format.
4. Processing data: Data in tabular form in a PDF file can be extracted using software such as "PDF to Excel".
5. Enhance User Interface: They assist in sharing online information, as well as across different gadgets.
6. Assist in Cloud-Based Work: Most of them are done online; hence, individuals can use them wherever they want.

Table No. (6) represents the most prominent tools for converting PDF files to multiple formats

Tool	Description	Link	Features	Importance
iLovePDF	Tool to convert PDF to Word, Excel, and PowerPoint	https://www.ilovepdf.com/	Converts PDF files to many formats such as Word, Excel, and PowerPoint.	A versatile tool for converting PDF files quickly and easily.
PDF24	Converts PDF files to multiple formats	https://tools.pdf24.org/	Supports converting PDF to many formats like Word, Excel, and images.	A comprehensive and easy-to-use tool for converting between multiple formats.
Zamzar	Converts PDF files to over 120	https://www.zamzar.com/	Supports over 120 formats for	Suitable for users who need to

	formats		converting PDF files to other formats.	convert between multiple formats.
PDF Converter	Converts PDF quickly and for free	https://www.freepdfconvert.com/	Quick and efficient conversion of PDF files to multiple formats like Word and Excel.	Ideal for fast file conversions for free without the need for registration.
Online2PDF	Converts multiple PDF files at once	https://www.online2pdf.com/	Converts multiple PDF files at once with the ability to edit content.	Helps save time when dealing with large PDF files.
PDF to Word	Converts PDF to Word with high accuracy	https://www.pdfword.com/	Converts PDF to Word documents while preserving formatting and accuracy.	Excellent tool for preserving document formatting when converting to Word.
PDF to Excel	Extracts tables from PDF and converts them to Excel	https://www.pdfexcel.com/	Extracts data and tables from PDF and converts them into Excel.	Ideal for extracting financial and statistical data from PDFs.
PDF to JPG	Converts PDF pages to JPEG images	https://pdf2jpg.net/	Converts PDF pages to images in JPEG format with ease.	Useful for converting PDF pages that contain images or illustrations.
PDF to HTML	Converts PDF to HTML web pages	https://www.pdf2html.com/	Converts PDF to HTML pages while preserving formatting.	A great tool for converting PDF documents to viewable web pages.
UniPDF	Converts PDF to text and images	https://unipdf.com/	Converts PDF to editable text and images in multiple formats.	A simple and effective tool for converting PDF documents to text and images.

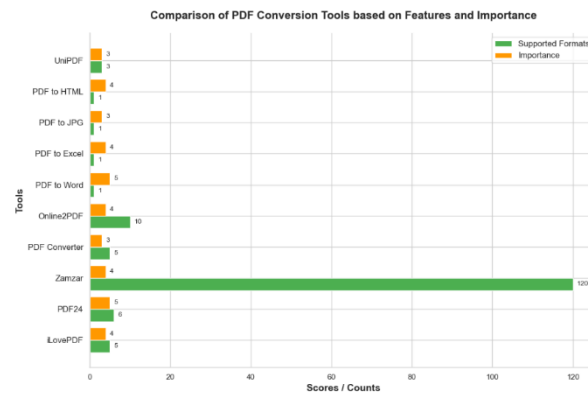


Figure No .6 Represents a comparison of PDF conversion tools

7. PDF Compression Tools and Protector of Privacy

PDF file compression software and protectors have played a crucial role in the management of files through this digital age. The reason for that is the dependence of most electronic data on various sectors has made data size compression and protection inevitable. This is because compressors minimize data in size, making it easy to store and transfer, while protectors ensure the safety of such information by protecting it against third-party entities. Not only do they make data management easier, but they also offer protection in a dangerous digital environment. Among the essential uses include:

1. Reduction of file size: Helps in compressing PDF file size to make it convenient for transfer and storage purposes.
2. Protection: Facilitates the creation of passwords or encryption for securing the information against any form of unauthorized access.
3. Management of content: Helps in splitting, combining, and merging files easily.
4. Copyrights: By adding watermarks on PDF files, copyrights are protected.
5. Improvement of accessibility: Facilitates decryption of information to facilitate access and ease of editing.

Table No. (7) represents PDF compression tools and privacy protection

Tool	Description	Link	Features	Importance
Smallpdf Compressor	Compress PDF files without losing quality	https://smallpdf.com/compress-pdf	Fast compression with high quality preservation.	Ideal for reducing PDF file size while maintaining detail.
PDF Compressor	Fast and effective PDF file compression	https://www.pdfcompressor.com/	Compresses PDF files efficiently with	A fast and effective tool for reducing large file

			significant size reduction.	sizes.
ILovePDF Compress	Compress PDF files easily and without complexity	https://www.ilovepdf.com/compress_pdf	Simple interface and effective file compression.	Ideal for users who need quick PDF compression.
PDF Reducer	Reduce PDF file size while maintaining content	https://www.orpalis.com/products/pdfreducer/	Significantly reduces PDF size while preserving text and images.	A powerful solution for optimizing large files without compromising quality.
PDF Protector	Protect PDF files with a password	https://www.pdfprotect.net/	Easily add passwords to protect documents.	An important tool for securing files and maintaining privacy.
PDF Encrypt	Encrypt PDF files to protect from unauthorized access	https://www.pdfencrypt.net/	Encrypts PDF files to prevent unauthorized usage.	Essential for those needing to secure their digital documents.
PDF Unlock	Remove protection from PDF files	https://smallpdf.com/unlock-pdf	Removes passwords and protection from PDF files.	A useful tool for unlocking protected files to enable editing.
PDF Watermark	Add watermarks to protect intellectual property	https://www.watermarkpdf.com/	Add text or image watermarks to protect PDF documents.	Ideal for creators and content owners to protect their work from theft.
PDF Split	Split and	https://www.pdfsam.org/	Split PDFs	A great tool

and Merge	merge PDF files easily		into smaller parts or merge multiple files together.	for editing and organizing PDF files flexibly.
PDF Organizer	Organize and reorder PDF pages easily	https://www.pdforganizer.com/	Organize and reorder PDF pages, with the ability to add or remove pages.	Useful for organizing documents and arranging PDF content logically.

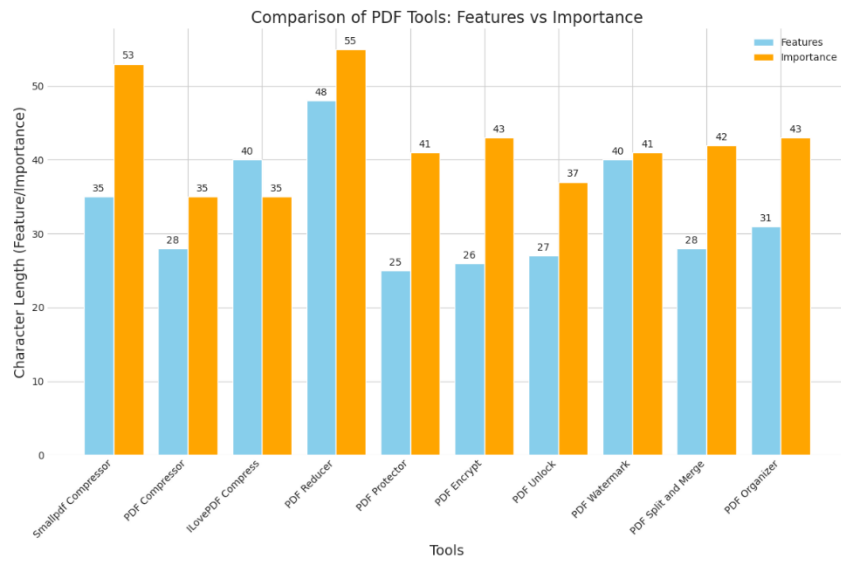


Figure No .7 Comparison of PDF Tools: Features vs Importance

Challenges and Future Directions. (Tungsten Automation, 2024) †(Suri et al., 2024)

Table No. (8)

Challenge	Description	Proposed Solutions
Hallucination	Generating content not present in the original document	Source verification, clickable citations
Long Context	Processing documents with hundreds of pages	Models with extended context

		windows, Retrieval-Augmented Generation (RAG)
Visual Complexity	Handling multi-column layouts and complex tables	Advanced computer vision models
Privacy and Security	Processing sensitive documents	SOC2 encryption, local processing

The table maps four critical failure modes and mitigation strategies in AI-based document processing systems. Each challenge represents a distinct risk dimension:

1. Hallucination — the most trust-critical challenge: the model generates plausible but fabricated content absent from the source. The proposed mitigations (source verification, clickable citations) address this at the output layer, essentially creating an *audit trail* that lets users trace every claim back to its origin. This is a reliability and epistemic integrity problem.

2. Long Context — an architectural constraint: as document length scales to hundreds of pages, standard attention mechanisms degrade. The two proposed solutions attack this from opposite directions — extended context windows expand the model's memory capacity, while RAG bypasses the limit entirely by dynamically retrieving only the relevant chunks at inference time.

3. Visual Complexity — a perception-layer bottleneck: multi-column layouts and complex tables require the model to perform 2D spatial parsing before any semantic understanding can occur. Advanced computer vision models (e.g., vision transformers, layout-aware encoders) address this at the feature extraction stage.

4. Privacy and Security — a non-technical but mission-critical challenge: unlike the others, this is an *operational* and *legal* risk rather than a modeling one. SOC2 encryption and local processing decouple document sensitivity from cloud exposure, shifting the threat model from network-level to device-level.

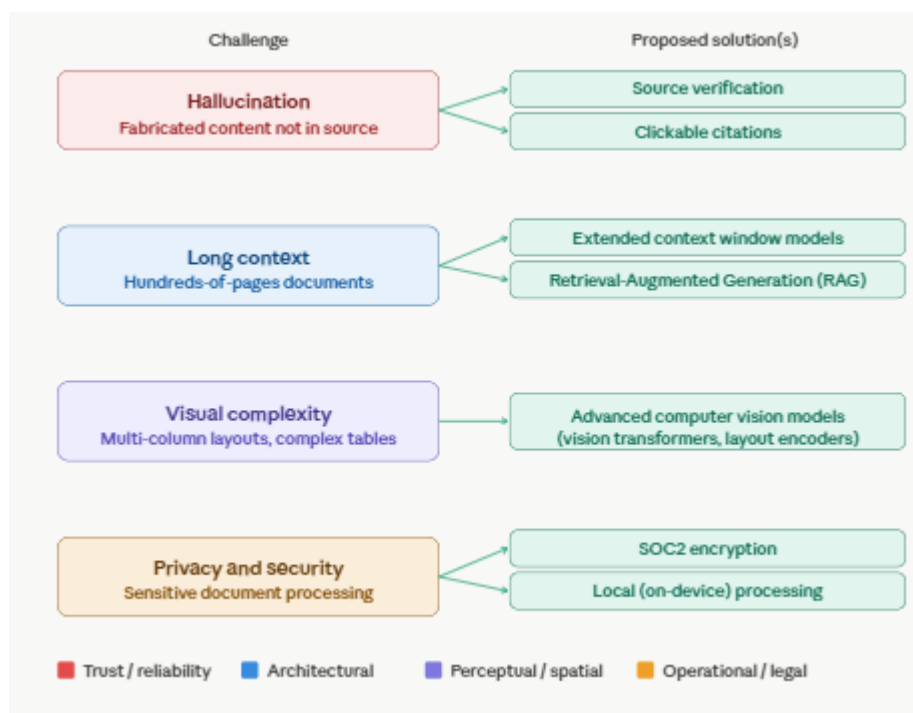


Figure No . 9 AI Document Processing — Challenges Mapped to Proposed Solutions

Future Directions

- **Specialized Editing Agents:** Developing AI agents tailored for specific document types (legal, medical, financial).
- **Integration with Content Management Systems:** Connecting editing tools with enterprise platforms such as SharePoint and Google Workspace.
- **Multilingual Editing:** Supporting editing in documents across multiple languages while preserving formatting.

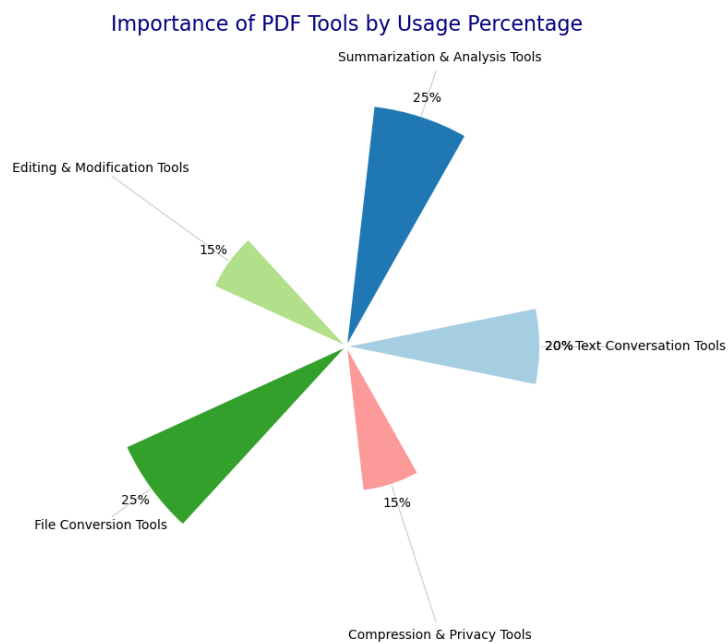


Figure No 9 Importance of PDF Tools by Usage Percentage

Conclusion

No doubt, the present-day revolution in artificial intelligence technologies has led to a profound transformation of PDF file processing approaches. While initially, it was all about reading and extracting information from the files, today there are much more opportunities related to the comprehension of the content, its contextual analysis and reasoning.

With the help of these capabilities, users can discover new opportunities in regard to their information processing tasks in PDF documents, making these operations more intelligent and effective. Moreover, the mentioned revolution offers many opportunities for using PDF files and developing innovative solutions in such spheres as education, business and scientific research.

The future suggested by the present revolution in PDF document processing with the use of artificial intelligence looks very promising and promising.

The transformation of PDF editing through artificial intelligence marks a decisive shift from simple text reading to deep content understanding. Multimodal large language models (LLMs) have expanded the scope of document interaction, enabling intelligent manipulation of textual, visual, and structural elements. This evolution not only enhances productivity but also redefines how individuals and organizations engage with digital knowledge.

Key Recommendations

- **Strengthen Reliability:** Invest in techniques to reduce hallucinations and ensure that AI-generated edits remain faithful to the original document.
- **Expand Context Handling:** Develop models capable of processing very long documents while maintaining logical coherence.
- **Advance Visual Understanding:** Improve AI's ability to handle complex layouts, multi-column structures, and intricate tables.
- **Prioritize Security:** Implement strong encryption and local processing options to protect sensitive data.

Future Prospects

- **Specialized AI Agents:** Tailored editing assistants for legal, medical, and financial documents will provide domain-specific accuracy.
- **Enterprise Integration:** Seamless connection between AI editing tools and content management systems (e.g., SharePoint, Google Workspace) will streamline workflows.
- **Multilingual Editing:** Supporting multiple languages while preserving formatting will make document editing globally accessible.
- **Human-AI Collaboration:** The future lies not in replacing human editors, but in empowering them with AI tools that enhance creativity, efficiency, and precision

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