AI and Ethics (2023) 3:49–52
https://doi.org/10.1007/s43681-022-00181-5

OPINION PAPER

Needs-aware artificial intelligence: AI that 'serves [human] needs'

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Received: 18 January 2022 / Accepted: 26 May 2022 / Published online: 27 June 2022

Abstract
By defining the current limits (and thereby the frontiers), many boundaries are shaping, and will continue to shape, the future of Artificial Intelligence (AI). We push on these boundaries to make further progress into what were yesterday's frontiers. They are both pliable and resilient—always creating new boundaries of what AI can (or should) achieve. Among these are technical boundaries (such as processing capacity), psychological boundaries (such as human trust in AI systems), ethical boundaries (such as with AI weapons), and conceptual boundaries (such as the AI people can imagine). It is within these boundaries that we find the construct of *needs* and the limitations that our current concept of *need* places on the future AI.

Keywords Needs · Needs-aware · Sociotechnical · Interdisciplinary

1 Serve [human] Needs

Multiple AI advocates (including Kai-Fu Lee [1] and Ben Shneiderman [2, 3]), among many others, have posited that a primary goal of AI (and Human-centric AI[1]) is to serve human *needs*. A laudable goal for sure, but there is a great deal of history, controversy, and complexity packed into both the word *need* and the overarching construct of *needs* [4]. Thus, if serving *needs* is to remain an ambition of our AI systems, further attention (i.e., dialogue, research, guidelines, policies) and collaboration across multiple disciplines is required to develop the construct of *needs* into a pragmatic tool that be applied to shape the very goals of what future AI can and should achieve.

Need is a commonplace word (such as,"I *need* coffee"), making it easy to overlook that the term has specific meaning, definition, connotation, and power. Its power, for example, stems from the connotation that the object of the statement (such as, coffee in the example above) seems to be absolutely necessary and without alternative. In other words, coffee is required to satisfy the implied *need*. Coffee may not be sufficient, but tea or water alone definitely won't do.[2]

Most of us routinely leverage this power (as do politicians and advertisers) when we use the word *need* to effectively eliminate other options (such as, "Cryptocurrency companies *need* national regulations", when, e.g., international regulations, market-based instruments, co-regulation, self-regulation, education [5], and end-user empowerment [6] might be other viable options to be considered)[3]. We do this because *need* statements typically induce the desired associated behaviors (such as, choosing national regulations rather than other alternatives); though typically creating ethical difficulties both for those defining the *need*, and those tasked with satisfying the *need*. Defining *needs*, after all, is not just about an academic concept; rather it can determine whose *needs* are prioritized, who gets resources and who does not, and how inequalities are considered in meeting the basics of the human condition. In these cases, *need* is

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[2] A useful exercise can be to go a day, or week, without using the word "need" at all; quickly allowing each of us to recognize just how often we use the power of the term in our daily activities.

[3] Here, we suspend our judgment regarding the national regulations of cryptocurrency companies since this is out of the scope of this article; the point here is that by using "need" we imply necessity [without evidence] and infer that any action *must* include national regulations when other options should also be considered.

a very powerful construct—and yet it remains one that we have little understanding of or agreement on. Those who define *needs* (whether they be individuals for themselves or for others, institutions such as companies or governments, or in the future AI systems) have both implicit and explicit power—and yet we rarely recognize that power since it is routinely lost in the common usage of the term. If an AI system, for example, were permitted to determine [and prioritize] a patient's *needs* [and the satisfiers of that needs], the power of the tool is substantially greater than if it only offers options for medical care.

It is worth emphasizing that being *in need* (and accordingly serving *needs*) is not limited to individual humans. *Needs* can be associated with different types of systems (e.g. life forms, organizations, societies). Therefore, *needs*-aware AI systems [7] should ideally consider different systems' needs (plural) on different levels and different contexts *sustainably*.

2 What are Needs?

Distinguishing between what is necessary (i.e., *needs*) and what is desired (i.e., transitory wants, cravings, motivators) has multiple ethical implications for AI and AI developers. This distinction is easily lost, for example, when put into the context of determining what potential clients or customers will purchase (where people might elect to spend their own money on what they desire over what is necessary). While ascertaining peoples' desires is not always an easy task, it is relatively much easier than identifying and prioritizing their *needs* (i.e., the goal of a needs assessment [8]). Different scholars, such as the philosopher Stephen McLeod, have even questioned if people are capable of knowing their *needs* at all [9].

For AI developers, for instance, the challenges of this distinction (i.e., *needs* from wants)[4] leads to an ethical difficulty that spans the continuum stretching from creating systems that merely meet consumers stated desires at the moment, to systems that assist in resolving [human] *needs* even when people may be unaware of the benefits at the time. Moving from basic perspectives of *needs* (e.g., *needs* are what people say they *need*, or *needs* are only what motivates an individual to take action [10]) to a more robust and multidimensional definition and understanding of *needs* (e.g., *needs* are gaps between desired accomplishments and current achievements at multiple interdependent levels [8]) brings many benefits, but also introduces complexity for AI developers creating (or co-creating) Sustainable Human-centric, Accountable, Lawful, and Ethical AI (Sustainable HALE AI [11]) systems (for instance, balancing individual, organizational, and societal *needs* that are routinely in conflict).

What are *needs*? What are not *needs*? How do we prioritize among *needs*? How do my *needs* relate to your *needs*, and how do our *needs* relate to the *needs* of others? How do we measure *needs*? How can we utilize needs? What will satisfy a *need*, and how will we know if the *need* has been satisfied? How can AI serve *needs* and still be economically viable? How can/will different sociopolitical, socio-economic, socio-technical and socio-cognitive aspects influence the co-creation of *needs-aware AI* systems, and how can/will such aspects be appropriately considered in a *Sustainable HALE* co-creation of such systems? These, and many other, questions have been and are still debated within and across multiple disciplines (e.g., philosophy, ethics, law, social work, education, business, economics, political science, sociology, management, cognitive science, psychology, and engineering). These debates have not, however, reached a resolution; and we suggest that this does, and will continue to, create pragmatic boundaries on what AI can and should achieve. Likewise, without answers to these questions (or at least many/most of them) it might be ethically challenging to ask (or expect) AI developers (or AI systems) to assess the *needs* of others, and then to use the results of those assessments to create AI systems that meet ethical standards.

3 Roles for *Needs*

AI developers are often placed in a so-called *social dilemmas*—with societal good on one side and commercial pressures on the other [12]. Part of the solution to these dilemmas (beyond ethical, legal, and regulatory frameworks) could be the introduction of well-defined and measurable *needs*[5]. For example, by identifying and measuring *needs* (i.e., societal, organizational, and individual *needs*) we can contribute to building the foundations for finding an appropriate equilibrium that serves *needs* in meaningful and balanced ways; while providing tools capable of guiding AI ethics. As an integrated component of *H*uman-centric, *A*ccountable, *L*awful, and *E*thical AI (or HALE AI) [11], the construct of *needs* can, we suggest, add value and push

[4] Though we recognize that colleagues in multiple disciplines have also proposed typologies for "needs", we will not address those in this article. Typologies are one of many topics we hope will be taken up in future interdisciplinary dialogues/debates.

[5] Calling for well-define and measurable *needs* (or needs satisfaction) does not mean that we are advocating absolutist perspectives on *needs*. With that in mind, we propose that, among others, considering *disagreements*[13] should be an important aspect of *needs-aware* AI systems (see [7] for a more detailed discussion on *measuring*, *explicitizing*, *utilizing*, or *enactizing* needs).

the boundaries of AI development from chasing wants, to serving *needs*[6].

Needs can thereby contribute in multiple roles in the development of AI. HCAI developers, for example, can utilize *needs* to identify and prioritize both what the systems can and should achieve; meeting peoples' desires and also serving their *needs*. AI systems, for instance, can use measurable *needs* to evaluate their own performance in resolving *needs*, while at the same time assisting people in making decisions where the complex relationships among *needs* must be weighed. Meanwhile, policymakers can utilize well-defined societal *needs* to craft effective policy, regulatory, and ethical frameworks. As such, precise, comprehensive, and transparent constructs of *needs* can play many vital roles in the future development of AI (and our digital societies).

4 What next?

If AI is going to serve our *needs*, then we have to answer some of these questions, and discover new questions that are waiting below the surface. From our perspective this is an urgent matter since these questions will not be answered quickly and without debate, and AI researchers and developers must be part of the professional dialogues in order for useful guidance to be achieved. No single discipline or field can come to resolution on these matters, and thereby *needs* are illustrative of the types of broad interdisciplinary challenges (bringing together STEM, social science, and humanities scholars and practitioners) that will be the hallmark of future decades of AI research and development. At the same time, the development of new AI systems will not necessarily wait for academic debates—as history shows.

Needs, both as a construct and professional term, can (and should) be a fundamental element of ethical (and sociotechnical) frameworks and the tools that are derived from those frameworks. We must use the word with the same precision and with the same care as we accord to terms such as "values" or "rights". We must also work to create a shared understanding of what *needs* are, defining them in manners that can transcend disciplinary boundaries and allow us to align individual, organizational, and societal *needs* [14].

If we give up, however, and choose not to become precise in our construct of *need* (our language when discussing *needs*), and the operational definitions required for future *Needs-aware AI* systems, then we will be left with AI that merely helps us meet our transitory wants, desires, cravings, motivations, or passions[7]. All of which may be profitable and favorable at times, but none of which are sufficient (nor necessary) for meeting our ideal of future AI that has the capacity to serve [human] *needs*.

The path to *needs-aware* AI will take time. Truly interdisciplinary dialogue and collaboration requires time.[8] From philosophy to computer science, and cognitive science to social science, many disciplines have contributions to offer, and yet there is much to learn about those potential contributions as we prepare for the future. For instance, many scholars who study the psychology of need do not also follow current development in computer science and AI; and the reverse is true as well. We therefore suggest that the process of interdisciplinary collaboration on *needs-aware AI* must begin soon, to ensure that the distinction of *needs* isn't lost (or assumed) as technologies develop over the next decade(s). This can begin here, with responses to this initial editorial; and then grow through cross-disciplinary dialogue. Whether it is maintaining *needs* as a distinct concept in [re] presentations, high-lighting the unique role of *needs* as systemic or algorithm features, or applying *needs* in design and co-creation processes, the role of *needs* in the future of AI depends on recognizing the power and value of this frequently misunderstood construct.

Funding No funding was received to assist with the preparation of this manuscript.

Declarations

Conflict of ineterst The authors have no relevant financial or non-financial interests to disclose.

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[6] Considering that meeting different systems' interrelated (and sometimes conflicting) needs in a sustainable manner is crucially important for our societies, re-thinking needs (and needs satisfaction) into AI can not only contribute toward the development of HALE AI but *Sustainable* HALE AI [11].

[7] and maybe only as a by-product some of our "needs", though we would have a hard time knowing it.

[8] while developers might not wait for it.

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Emerging Artificial Intelligence Tools Useful for Researchers, Scientists and Librarians

Article · October 2023

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Emerging Artificial Intelligence Tools Useful for Researchers, Scientists and Librarians

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Abstract

Artificial Intelligence (AI) is rapidly transforming the way we live and work. AI has significant impact on academic and scientific research. The world of academic research is constantly evolving, and AI is playing a significant role in transforming the research landscape. From finding sources to analyzing data, AI-powered tools are making the research process more efficient and accurate. By harnessing the power of AI, research scholars and scientists can streamline their research processes, enhance data analysis, and accelerate discoveries. In this context, this paper attempts to review some of the emerging AI technologies and tools, helpfulness of those tools for researchers and scientists with advantages of AI. Again, it describes how AI tools are revolutionizing academic researchand useful for researchers, librarians, and scientists.

Keywords: Artificial Intelligence Tools, Academic Research, Machine Learning, Natural Language Processing, Computer Vision.

1. Introduction

The term artificial intelligence (AI) was coined in 1956. Earlier, AI research in the 1950s explored topics like problem solving and symbolic methods. During 1960s, the US Department of Defence took interest in this type of work and began training computers to mimic basic human reasoning. For example, the Defence Advanced Research Projects Agency (DARPA) completed street mapping projects in the 1970s and produced intelligent personal assistants in 2003, long before Siri, Alexa or Cortana were household names. The above early works paved the way for the automation and formal reasoning that we see in computers today, including decision support systems, expert systems and smart search systems that can be designed to complement and augment human abilities.Though the foundation for AI was laid in the early 1950s, it has become more popular today due to increased data volumes, advanced algorithms, and improvements in computing power and storage. During 1950s –1970s, neural networks emerged. The neural networks stirred excitement for 'thinking machines. During 1980s–2010s, machine learning became popular. At present, deep learning breakthrough drive AI book. No doubt, artificial intelligence has evolved to provide many specific benefits in every industry starting from health care to retail. Artificial intelligence is rapidly changing the education and research environment and use of AI tools will significantly improve the workflow of the

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researchers, scholars and librarians starting from generating lesson plans to looking for journals to cite.

2. Emerging Artificial Intelligence Technologies

The following are some of the important AI tools described briefly.

2.1. Machine Learning

Machine learning is a branch of artificial intelligence based on the idea that systems can learn from data, identify patterns and make decisions with minimal human intervention. While artificial intelligence (AI) is the broad science of mimicking human abilities, machine learning is a specific subset of AI that trains a machine how to learn. It is nothing but a method of data analysis that automates analytical model building.

2.2. Deep Learning

Deep learning is a type of machine learning that trains a computer to perform human-like tasks, such as recognizing speech, identifying images or making predictions. Instead of organizing data to run through predefined equations, deep learning sets up basic parameters about the data and trains the computer to learn on its own by recognizing patterns using many layers of processing.

2.3. Natural Language Processing

Natural language processing (NLP) is a branch of artificial intelligence that helps computers understand, interpret and manipulate human language. It helps computers communicate with humans in their own language, making it possible for computers to read text, hear speech, interpret it, measure sentiment and determine which parts are important.

2.4. Computer Vision

Computer vision is a field of artificial intelligence that trains computers to interpret and understand the visual world. Using digital images from cameras and videos and deep learning models, machines can accurately identify and classify objects. From recognizing faces to processing the live action of a game, computer vision rivals and surpasses human visual abilities in many areas.

3. Advantages of Artificial Intelligence

Artificial Intelligence (AI) makes it possible for machines to learn from experience, adjust to new inputs and perform human-like tasks. Most AI examples rely heavily on deep learning and natural language processing. Using these technologies, computers can be trained to accomplish specific tasks by processing large amounts of data and recognizing patterns in the data. The following are some of the important advantages of artificial intelligence.

- AI automates repetitive learning and discovery through data;
- AI adds intelligence to existing products;
- AI adapts through progressive learning algorithms to let the data do the programming;
- AI analyzes more and deeper data using neural networks that have many hidden layers;
- AI achieves incredible accuracy through deep neural networks; and
- AI gets the most out of data, when algorithms are self-learning, the data itself is an asset.

4. Artificial Intelligence Tools and Research

Gone are the days where scholars and students devoted countless hours in the libraries to search literature to support their academic research and writing. In those days, the availability of research literature was scanty and mostly in print. Due to the advancements in ICT, there is a tremendous information explosion and abundant availability of information becomes a problem. Scholars and researchers require assistance to sort and organize sources due to the abundance of information available today. Moreover, they must write informative, engaging and quality articles and reports due to the ongoing pressure to publish.

AI has revolutionized numerous industries, and scientific research is no exception. By harnessing the power of AI, research scholars, and scientists can streamline their research processes, enhance data analysis, and accelerate discoveries. AI tools are being used to automate tasks, analyze data, and generate insights in ways that were not possible before. This is helping researchers to make faster progress, achieve breakthroughs, and improve the quality of their work. AI tools that have proven to be invaluable assets for researchers. Whether you're conducting experiments in the lab, writing scientific articles, publishing in journals, or working on your thesis or dissertation, these tools can greatly enhance your efficiency and productivity.

5. How AI tools help research scholars and scientists?

AI tools can be a valuable resource for research scholars and scientists at all stages of their research. They may be helpful to:

- conduct comprehensive literature reviews, generating summaries, and organising references, facilitating the writing process;
- automate tasks, such as data collection and analysis. This may free up researchers to focus on more creative and strategic work and ensure effective use of their precious time;
- brainstorm, write and edit their work. They may also be used to generate citations, create bibliographies, and check for plagiarism;
- find relevant high-impact factor journals, submit their work, and track their progress through the publication process;
- design experiments, optimizing parameters and automating data collection, saving time and reducing human error; and.
- provide sophisticated algorithms for data analysis, enabling researchers to uncover patterns, identify trends, and derive meaningful insights from complex datasets.

6. AI Tools helpful for the research scholars and scientists

When we talk about AI tools, many of us think about ChatGPT, a large language model-based chatbot developed by OpenAI which was launched during 2022, an AI tool which enables users to refine and steer a conversation towards a desired length, format, level of detail, style and language used. But, apart from ChatGPT, there are a variety of AI tools available for researchers and librarians.

The following are some of the important AI tools helpful for the scholars, researchers, and librarians.

6.1. **Any Summary**

Any Summary is an AI-powered tool that quickly summarizes long interview audio, video files, long texts, research papers, etc. It offers a customizable summary format such as bullet points, quotes, or a full abstract, and can create summaries from files or URLs. It supports various file types including images, audio, video, text and CSV files. Any Summary also provides helpful FAQs, examples, and customer feedback. No doubt Any Summary is a valuable tool for librarians and researchers who need to sift through extensive textual or video data. It enables them to extract key insights efficiently, aiding in research analysis and content curation.

6.2. Bing Create

The Microsoft Bing Image Creator is a tool that uses AI to generate images based on words and text. It is currently available in some regions, and the team is working to bring it to more regions. It is powered by an advanced version of DALLE-2.Librarians and researchers can use Bing Create to quickly produce visual representations of concepts or research findings, enhancing the visual appeal of their materials and presentations.

6.3. Books AI

BooksAI takes a novel approach by utilizing Vision AI and GPT-4 to create book summaries from images of book covers. This innovative tool enables users to generate concise book summaries swiftly and effortlessly, merely by capturing a photo of the book in question. For librarians and researchers, BooksAI offers a time-saving solution for producing succinct overviews of books, an essential resource for those seeking quick insights into the content of various publications.

6.4. ChatGPT for Search Engines

ChatGPT for search engines is an AI-powered chatbot extension that can be added to search engines that allows users to ask questions and receive human-like responses. It includes syntax highlighting for code, trigger settings, a dark theme, and a right-click option to send selected text as a prompt. It is compatible with most devices and can be triggered manually, with a question mark, or always. There are no ads, analytics, trackers, or cookies, and no user data is collected.This tool enhances the efficiency of researchers and librarians by providing a quick and reliable way to find information, clarify doubts, and gather research insights, all while maintaining user privacy and security.

6.5. Consensus

Consensus is an AI search engine that helps researchers to find relevant research papers. It uses machine learning to identify papers that are likely to be relevant to a given

research question, even if they do not use the same keywords. Consensus also provides summaries of each paper, making it easy to assess their relevance.

6.6. Elicit

Elicit stands as a valuable research assistant tool, leveraging language models to automate various research tasks, with a particular focus on literature reviews. For librarians and researchers, Elicit can efficiently locate pertinent research papers, summarize essential findings, and extract vital information. Additionally, it extends its capabilities to tasks like brainstorming, summarization, and text classification, providing a multifaceted solution to research challenges. Researchers and librarians can benefit significantly from Elicit's ability to streamline literature review processes and facilitate information retrieval.

6.7. Explain Paper

Explain Paper simplifies the daunting task of understanding complex academic papers. Users can upload academic papers, highlight perplexing passages, and receive explanations. This tool is a game-changer for researchers and librarians who often grapple with intricate research articles. Explain Paper offers a more accessible path to comprehending academic materials, enabling users to grasp the content's nuances and significance.Each of these tools provides unique benefits for librarians and researchers, whether through efficient literature reviews, simplified data management, creative engagement with academic and literary content, or accelerated research processes.

6.8. Formulizer

Formulizer emerges as an indispensable AI assistant tailored for users of Excel, Google Sheets, Notion, and other spreadsheet applications. Its primary goal is to expedite tasks by swiftly transforming ideas into functional formulas. This AI marvel generates and clarifies formulas, tasks, regex patterns, and script code based on user inputs. Furthermore, it prides itself on data privacy and security, boasting rapid response times, impeccable accuracy, and a user-friendly interface. Librarians and researchers can harness the power of Formulizer to automate data-related operations, reducing errors and saving valuable time in data management and analysis.

6.9. Gamma App

Gamma is a user-friendly tool that simplifies the creation of visually engaging and interactive content from raw notes. It utilizes AI-powered design tools to generate attractive slides and presentations with one-click templates and no-code editing required. Users can easily embed various elements like GIFs, videos, charts, and websites. Additionally, it offers built-in analytics and collaboration features. For librarians, Gamma can enhance content creation for library presentations and workshops. Researchers can use it to create visually appealing reports and presentations to communicate their findings effectively.

6.10. GPT for Sheets

The GPT Sheets Add-on provides an easy way to access OpenAI GPT-3's powerful capabilities from within Google Sheets. It exposes two simple custom functions: =GPT and =GPT_LIST that can be used for tasks such as generating blog post ideas, writing paragraphs or procedures, cleaning up lists, classifying reviews, summarizing, writing responses to comments, and experimenting with hyperparameters. The add-on is free to use, with the only cost being OpenAI's API cost.This tool can assist researchers and librarians in various tasks related to data analysis, content creation, and organization within Google Sheets, improving productivity and facilitating data-driven decision-making

6.11. Grammar GPT

The GPTGrammar Fixer with ChatGPT Technology is an ultimate writing companion that provides users with an AI-powered tool to help them improve grammar in their writing. The tool uses OpenAI technology to detect and suggest corrections for grammar mistakes, allowing users to edit their writing quickly and efficiently for accuracy and clarity.Grammar GPT assists researchers and librarians in ensuring the correctness and clarity of their written materials, including research papers and reports, enhancing the overall quality of their work.

6.12. Inciteful

Inciteful is a comprehensive AI tool that empowers researchers to find relevant literature, understand new topics, and explore connections between ideas. Within the Inciteful suite of tools, Paper Discovery stands out as a powerful feature. Leveraging citation networks, Paper Discovery creates a robust web of interconnected papers, providing valuable insights into similar works, important contributions, and prolific authors and institutions. This unique approach allows researchers to navigate the literature landscape more effectively, gaining a holistic understanding of a particular field. Inciteful is accessible to researchers worldwide, and it is available free of charge, making it an invaluable resource for the academic community.

6.13. Konjer

Konjer offers a unique and engaging experience for both librarians and researchers. It allows users to interact with historical figures, fictional characters, or dive deep into specific topics of interest. This tool fosters creative exploration and discussion of texts, making it a valuable resource for librarians and researchers seeking fresh perspectives or innovative ways to understand and engage with literary and historical content.

6.14. Litmaps

Litmaps is a user-friendly platform that simplifies the exploration of academic papers relevant to your research interests. By leveraging advanced AI algorithms, Litmaps enhances the literature review process, providing researchers with powerful features to streamline their workflow. Through automated citation searching, interactive visualisations, and seamless collaboration with other researchers, Litmaps empowers you to delve deep into scholarly works effortlessly.

6.15. MiniGPT-4

MiniGPT-4 enhances vision-language understanding by combining a frozen visual encoder with a large language model. It excels in generating detailed image descriptions, creating

websites from hand-written drafts, composing stories and poems inspired by images, solving problems depicted in images, and providing cooking instructions based on food photos. This tool is computationally efficient, requiring minimal training, and aligning visual features with text using image-text pairs. For librarians, MiniGPT-4 can assist in creating visually engaging content for library events and promotions. Researchers can utilize it to enhance data visualization and communication of research findings through visuals.

6.16. OpenRead

OpenRead is an innovative AI-powered interactive paper platform designed to revolutionize the way librarians and researchers access and interact with research papers. It introduces a range of powerful features, including the Paper Q&A tool, which facilitates rapid answers to questions about research papers. Additionally, the Paper Espresso feature expedites the generation of literature reviews. OpenRead accelerates the reading process with AI assistance, offers a user-friendly low-code paper editor, and provides a robust notes system complete with backlinks and outgoing links for increased efficiency. To further enhance collaboration, OpenRead hosts a research community and university alliance. Librarians and researchers will find OpenRead indispensable for efficient paper interaction, note-taking, and collaborative research efforts.

6.17. Paper Brain

Paper Brain is a powerful tool designed to streamline the research workflow, particularly for librarians and researchers engaged in literature reviews. It utilizes advanced algorithms to identify and organize relevant papers, extracting key points and crucial information. This tool is an indispensable assistant in research endeavours, simplifying tasks such as summarization, information extraction, and even brainstorming. Librarians and researchers can rely on Paper Brain to enhance their productivity and efficiency when dealing with vast amounts of research materials.

6.18. PDF GPT IO

PDFGPT is a tool where you can upload PDF files and chat with it,i.e., ask questions in the content of the pdf and get specific answers. It also provides a demo video and Discord link to join for more information. Researchers and librarians can use PDFGPT to engage in discussions related to their research materials and extract information from PDF documents, facilitating knowledge sharing and content extraction. There are free version as well as paid version available.

6.19. PDFgear

PDFgear is a free AI academic tool which is quite powerful PDF reader for users engaged in academic research work. It efficiently sorts through and organise source pages using its built-in AI summarizer, which accurately extracts key information and locates paragraphs and sentences with archive quotes. The best feature of PDFgear is its support for editing research files according to users' needs. Whether it is text replacement, annotating, rewriting, or proofreading of academic research files, PDFgear makes it incredibly easy and it will be highly useful for the research scholars and scientists.

6.20. Recast

Recast is an AI-powered tool that converts articles into audio summaries. It allows users to listen to summarized versions of articles instead of reading them. The tool aims to make content consumption more convenient, whether users are on the go, working out, or looking for a more efficient way to stay informed. Recast provides an app and a browser extension, enabling users to add their own articles and easily access and listen to the audio summaries.Researchers and librarians can use Recast to consume research articles more efficiently, especially when multitasking or engaging in activities where reading is not practical, such as during commutes or workouts.

6.21. Research Rabbit

Research Rabbit is a powerful AI research assistant. It finds and organizes research papers. If we enter a keyword or phrase, Research Rabbit will return a lit of relevant papers through semantic scholar or PubMed search. After signing up, it will prompt to search for a topic and add papers to a collection. Once articles are added, we can rename the collection and send it to our co-researchers or collaborators through email. It streamlines the research process so that we can do away with manually listing our sources.

6.22. Scholarcy

Scholarcy is an AI-powered tool designed to assist researchers in summarising their research papers. By employing advanced algorithms,it can generate concise summaries, saving researchers valuable time while ensuring the essential aspects of their works that are effectively communicated. This tool simplifies the research process, enabling researchers to share key findings efficiently.

6.23. SciSpace

SciSpace or Typeset.io is an AI-powered platform that helps researchers to publish their work. It provides a one-stop shop for everything from manuscript submission to peer review to publication. SciSpace can help researchers to save time and get their work published faster.

6.24. Scite Assistant

Scite Assistant is an AI-powered research tool that helps researchers to find, read, and understand scientific literature. It can automatically extract key information from papers, such as the research question, methods, results, and conclusions. Scite Assistant can also help researchers to identify relevant papers, track their progress, and collaborate with others.

6.25. Semantic Scholar

Semantic Scholar is a free, AI-powered research tool that revolutionizes the way researcher’s access scientific literature. With a vast repository of over 200 million papers covering all fields of science, Semantic Scholar provides an extensive knowledge base for researchers worldwide. By leveraging advanced AI algorithms, Semantic Scholar enables users to discover, access, and explore scholarly articles with remarkable efficiency.

6.26. Talk to Books

Talk to Books is a revolutionary AI-powered search engine designed to assist librarians and researchers in their quest for knowledge. Users can engage in natural language conversations with this tool, asking questions about books and receiving human-like responses. What sets

Talk to Books apart is its utilization of advanced machine learning algorithms, which scour millions of books to generate responses, providing users with an immersive and conversational search experience. This tool is a game-changer for librarians and researchers as it offers an engaging and efficient way to explore and discover new books, aiding in the discovery of valuable resources and enabling deeper exploration of various topics.

6.27. Teach Anything

The Teach Anything tool is a teaching tool that allows users to quickly get answers to their questions by selecting a language, a difficulty level, and writing a question. Researchers and librarians can use this tool to promptly access answers to specific questions related to their research or information needs, expediting their research process and knowledge acquisition.

6.28. Tome AI

Tome is a collaborative AI partner that helps you create interactive presentations, surveys, games, etc. It features drag-and-drop creation, responsive pages, one-click themes, embeds from the web, native video recording, easy sharing, and an iOS app. It is designed to help you create customer education, sales decks and pitches, and to help you share complex ideas.Researchers and librarians can use Tome AI to simplify the process of creating engaging content for presentations, reports, and educational materials, making their work more impactful and visually appealing.

6.29. Trinka

Trinka is an online sentence structure checker and language proof reader. It is made for specialized and scholastic composition. It catches errors that other grammar checkers miss, like issues with subject-verb agreement, syntax, word choices, the use of pronouns and articles, and technical spelling. Further, it incorporates a professional tone, the use of technical worlds, conciseness that goes beyond grammar and spelling, and style guides.

6.30. Zeroscope Text-to-Video

Zeroscope Text-to-Video is a powerful tool that transforms written text into compelling videos. Users can input descriptive text, narratives, or scripts, and the tool automatically generates corresponding video content. This feature is particularly beneficial for content creators, marketers, and individuals who need to produce video content quickly without extensive video editing skills or resources. For librarians, Zeroscope can simplify the creation of engaging video tutorials or promotional materials for library services and resources. Researchers can leverage it to visually present their research findings and engage a wider audience.These tools offer a range of capabilities, from simplifying content creation and enhancing data visualization to providing innovative solutions for generating video content. They can assist both librarians and researchers in effectively communicating information and engaging with their target audience.

7. Conclusion

The future of academia is likely to be transformed by artificial intelligence language models such as ChatGPT. Academia and AI are becoming increasingly intertwined and as AI continues to advance, it is likely that academics and librarians will continue to either embrace

its potential or voice concerns about its risks. AI tools are a powerful new tool for scientific research. They can help researchers to save time, improve their work, and make faster progress.There is no doubt that the AI tools will redefine the future of academic research but many academics don't know how to use the AI tools intelligently. So, the Librarians shall play a key role to sensitize their users viz., students, research scholars, faculty and scientists about the effective and efficient use of the AI tools to support their academic and research activities.

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Artificial Intelligence in News Media: Current Perceptions and Future Outlook

Article *in* Journalism and Media · December 2021

DOI: 10.3390/journalmedia3010002

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Artificial Intelligence in News Media: Current Perceptions and Future Outlook

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Abstract: In recent years, news media has been greatly disrupted by the potential of technologically driven approaches in the creation, production, and distribution of news products and services. Artificial intelligence (AI) has emerged from the realm of science fiction and has become a very real tool that can aid society in addressing many issues, including the challenges faced by the news industry. The ubiquity of computing has become apparent and has demonstrated the different approaches that can be achieved using AI. We analyzed the news industry's AI adoption based on the seven subfields of AI: (i) machine learning; (ii) computer vision (CV); (iii) speech recognition; (iv) natural language processing (NLP); (v) planning, scheduling, and optimization; (vi) expert systems; and (vii) robotics. Our findings suggest that three subfields are being developed more in the news media: machine learning, computer vision, and planning, scheduling, and optimization. Other areas have not been fully deployed in the journalistic field. Most AI news projects rely on funds from tech companies such as Google. This limits AI's potential to a small number of players in the news industry. We made conclusions by providing examples of how these subfields are being developed in journalism and presented an agenda for future research.

Keywords: journalism; artificial intelligence; computer science; machine learning; computer vision; NLP

Citation: de-Lima-Santos, Mathias-Felipe, and Wilson Ceron. 2022. Artificial Intelligence in News Media: Current Perceptions and Future Outlook. *Journalism and Media* 3: 13–26. https://doi.org/10.3390/journalmedia3010002

Academic Editor: Andreu Casero-Ripolles

Received: 30 September 2021
Accepted: 23 December 2021
Published: 30 December 2021

1. Introduction

We are now living in a world where technology and data guide a large array of decisions in our lives. This means that every industry must adapt and embrace these technologies to become sustainable in the future. This is no different for the news industry since "the future of journalism and its business models seem to be bound by the penetration of technological deployment" (de-Lima-Santos and Mesquita 2021a, pp. 1416–17).

In recent years, news media has been greatly disrupted by the potential of technologically driven approaches in the creation, production, and distribution of news products and services (Hernandez Serrano et al. 2015; Örnebring 2010). This can be seen in novel news products and practices such as data journalism (Coddington 2015; Hermida and Young 2019), immersive and drone journalism (Harvard 2020; Kang et al. 2019), analytics (Nelson and Tandoc 2018; Ferrer-Conill and Tandoc 2018), and automation (Linden 2017b; Lewis et al. 2019).

Over the last several years, scholars have expanded their knowledge and experiences by confirming that artificial intelligence (AI) capabilities are evolving every year, which have made it cost less and offer more affordable computing power. The concept of AI refers more narrowly "to a branch of computer science focused on simulating human intelligence" (Broussard et al. 2019, p. 673).

AI in news media can certainly make journalism easier for overburdened resources without replacing journalists' unique skills. Furthermore, AI can enhance new forms of participation and leverage new products that could increase news media consumption

(Diakopoulos 2020; Jamil 2020). However, several challenges tend to delay technological innovations in newsrooms, such as the resistance to change, the institutional landscape, historical competition, insufficient funding, a lack of skill, and complementary ambitions (Boczkowski 2004; de-Lima-Santos and Mesquita 2021b; Krumsvik et al. 2019; Paulussen 2016).

Despite the practical deployment of AI in news media, the academic literature on this subject is still at a nascent stage. In this context, this study aims to expand the existing literature by examining case studies collected by JournalismAI, a project from the London School of Economics and Political Science (LSE). The list includes 102 cases that were collected by the institution and examples that were submitted by other researchers and practitioners in the AI field. Although this list is not exhaustive, it highlights the level of the development of AI in news and related areas.

To make a theoretical contribution to this field, this study draws upon literature on artificial intelligence to sketch an outline of the field and understand where the journalism industry is positioning itself. Thus, this article poses the following questions:

RQ1. How is news media positioning itself in the subfields of artificial intelligence?
RQ2. To what extent is AI being deployed in the news industry?
RQ3. What are the future avenues for AI in news media?

The contribution of this paper is twofold. First, it describes the types of AI that are being developed in the news media industry by facilitating research on the topic and helping practitioners to understand the possibilities, implications, and responsibilities that come along with AI adoption and use. Second, it provides a comprehensive analysis of the related subfields to encourage scholars and professionals to consider further steps for utilizing AI in the news industry.

2. Theoretical Framework

2.1. Artificial Intelligence in Its Current Manifestation

Although the term "artificial intelligence" has gained popularity in recent years, AI is not new. It dates back to 1955 when Stanford University's Professor John McCarthy used the term to describe the science and engineering of making intelligent machines. (McCarthy 1998). The pervasive nature of information and communications technology (ICT) and the datafication of society have expanded their applicability in a variety of fields, such as journalism (Gelgel 2020).

As technology evolves, new opportunities become available to consumers and businesses and help to address some of the challenges of our time (Paulussen 2016). As a result, the field of artificial intelligence has seen significant progress in recent years and has been led by numerous technological developments that have made it more affordable. Although Hollywood and science fiction movies often depict AI as sentient machines such as robots that can mimic human reasoning and behavior (Broussard 2018), the field is concerned with understanding and building intelligent entities that can compute "how to act effectively and safely in a wide variety of novel situations" (Russell and Norvig 2021, p. 19). Therefore, intelligence involves performing human tasks such as recognizing images or performing repetitive tasks (Broussard et al. 2019). In this sense, some authors understand intelligence in AI as rationality, which can be loosely understood as making correct decisions (Russell and Norvig 2021). However, scholars and experts have developed different definitions over the years. In simple terms, AI can be defined as the process of "creating computing machines and systems that perform operations analogous to human learning and decision-making" (Castro and New 2016, p. 2). Therefore, AI represents a step-by-step procedure for solving problems.

The academic scholarship of AI has been part of computer science for decades, but the automation of cognitive tasks became possible only after the developments relating to data, sensors, and advances in technology (Chan-Olmsted 2019). The ubiquity of computing has become apparent and has demonstrated the different approaches that can be achieved using AI. Based on opinions about the most promising methods and theories, experts have effectively deployed AI in some fields and have discovered that utilizing it in other fields is still unattainable (Aronson 2018; Castro and New 2016; Ortiz Freuler and Iglesias 2018).

Despite AI being a disputed concept, seven subfields emanate from this major field and share significant connections and commonalities: (i) machine learning; (ii) computer vision (CV); (iii) speech recognition; (iv) natural language processing (NLP); (v) planning, scheduling, and optimization; (vi) expert systems; and (vii) robotics.

The most popular of these subfields is machine learning, which is a "subfield of AI that studies the ability to improve performance based on previous experience" (Russell and Norvig 2021, p. 19). In other words, machine learning is a branch of AI that is dedicated to designing algorithms that build models from data without pre-existing solutions to a problem (Castro and New 2016). This has reduced operational costs and the cost of manpower substantially in the news industry.

The development of machine learning highly relates to deep learning and predictive analytics. In deep learning, statistical techniques are used to solve problems with little human intervention. To solve problems, models rely on large and complex datasets to replicate the human brain's learning capabilities (Chan-Olmsted 2019; Hassaballah and Awad 2020). The designs of some of these models were inspired by the structure and function of neural networks that were used to enable a computer to learn to recognize abstract patterns to simulate large, multilayered webs of virtual neurons (Castro and New 2016). Predictive analytics is a branch of machine learning that is dedicated to making predictions about future outcomes using historical data (Russell and Norvig 2021).

Another subfield of AI is computer vision. Through the use of mathematical algorithms, CV allows computers to derive meaningful information from digital images (Szeliski 2011). This does not mean that a CV model can actually see the content of an image like a human can, but it is capable of detecting or deducing an object (Marr 2010). CV algorithms can be divided into two strands: image recognition and machine vision. Image recognition involves a set of methods for detecting and analyzing images that can be used for the automation of specific tasks. Machine vision encompasses a computer's capabilities to perceive an environment (Szeliski 2011; Marr 2010).

Speech recognition focuses on automatically and accurately transcribing human speech and converting voice data into text data; it is commonly found in applications that follow voice commands or answer spoken questions (Deloitte 2014). Natural language processing goes beyond that and refers to the automatic computational processing of human language (Castro and New 2016). In other words, NLP is a computer program's ability to manipulate text and spoken words like humans do by understanding and responding to text or voice data, extracting meaning from sentences, or generating readable texts (Deloitte 2014). This broader subfield includes other areas such as translation, classification, and clustering, as well as information extraction. Other terms that relate to NLP are natural language generation (NLG) and natural language understanding (NLU), as illustrated in Figure 1. While the former is responsible for converting structured data into meaningful sentences in the form of natural language, the latter represents the process that turns unstructured data into understandable structured data (Future Today Institute 2018; Locker et al. 2019).

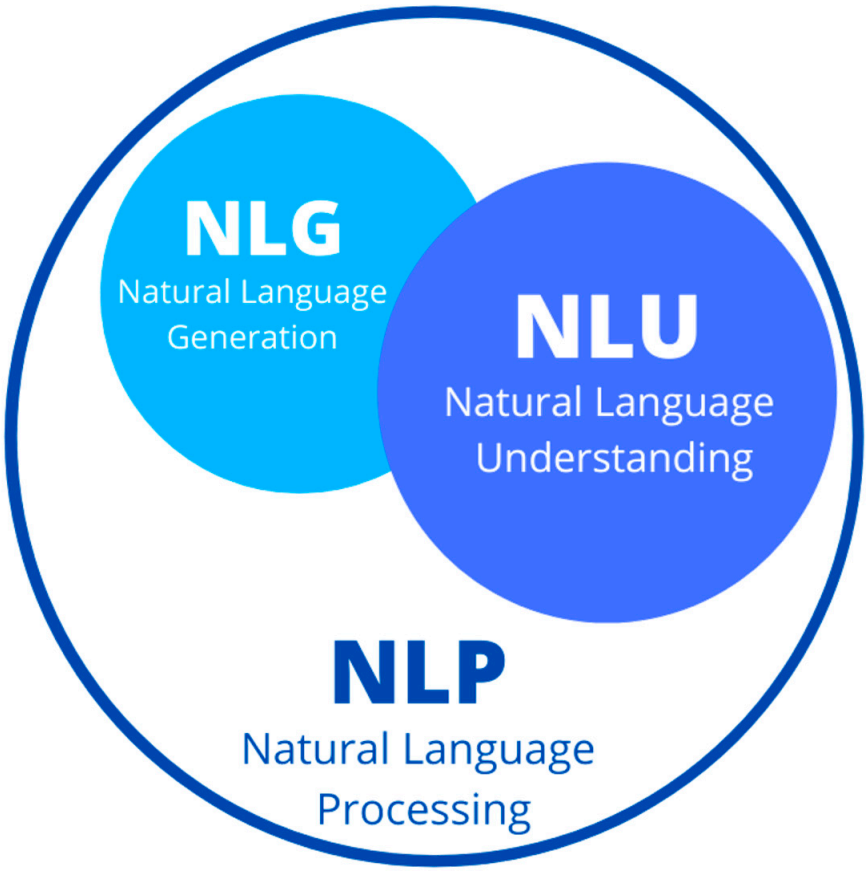

Figure 1. NLP models can be divided into two subsections: NLG and NLU (Source: Authors).

Other mature cognitive technologies include systems that use AI to determine steps to take (planning) and understand when to carry out a certain step (scheduling) to achieve a goal. Additionally, such a system can find the most optimal way to make all the necessary adjustments in the most efficient manner (optimization). This step is important in some cases due to trade-offs concerning limited resources and complex decisions required of the model. This subfield is known as planning, scheduling, and optimization (Deloitte 2014; Russell and Norvig 2021).

Rules-based systems simulate the behavior and judgment of humans who have expert knowledge and experience in a particular field to automate the process of making inferences about information. Known as expert systems, these models use databases of knowledge and rules to solve complex problems (Russell and Norvig 2021). Robotics is a subfield of AI that integrates different cognitive technologies to enable computers and systems to perform different tasks in conjunction with people in unpredictable environments. Some examples of robotics are robotic vacuums and unmanned aerial vehicles (Russell and Norvig 2021).

Although these subfields describe different applications of AI, they are interwoven and often mutually reinforcing. For this reason, some authors view AI according to its five functions: monitoring, discovering, predicting, interpreting, and interacting with physical environments, humans, or machines (Castro and New 2016).

However, artificial intelligence has not yet been fully deployed in all industries. It is particularly difficult to develop technologies in areas that are suffering from liabilities, such as news media. The following section presents the nascent literature on artificial intelligence in journalism and discusses the potential that AI brings to the news industry.

2.2. Artificial Intelligence in the News Industry

Artificial intelligence has demonstrated potential in numerous experimental studies, particularly in scientific and technological fields. Although it is hard to estimate the cost of creating and implementing an artificial intelligence application without delving into one's project's details, many experts understand that the development of AI systems has reduced costs in recent years. However, AI still requires specialized expertise, which makes it difficult to compete with Silicon Valley companies. Big tech companies leverage their control over AI by actively acquiring startup companies that are deploying AI solutions in an attempt to concentrate power and thwart any competitors (Linden 2017a).

A recent report revealed that a major bottleneck for the development of AI in news media is the talent competition. This competition not only involves attracting talent but also retaining professionals in newsrooms, which offer lower salaries in comparison to the tech industry (Cook et al. 2021). This newsroom brain drain works against the adoption of technologies in the news industry (Broussard et al. 2019; Lokot and Diakopoulos 2016).

Even under those conditions, news outlets around the world are embracing AI solutions in their newsrooms. In recent years, newsrooms began to increasingly automate news stories (Linden 2017b). Although machine learning algorithms are used to a certain extent for some of these projects, many projects still rely on simple automation that fills in the blanks of template stories and does not produce stories built on prior data (Biswal and Gouda 2020).

Although many of these journalistic bots do not use machine learning or NLP models, they rely on a series of steps to take (planning) and understand when to carry out a certain step (scheduling) in order to publish messages. Some researchers have identified four different categories of news bots: "the inputs and sources of input data; the outputs produced by the news bots; the algorithms that guide how a news bot turns inputs into outputs; and the function or intent of the news bot" (Lokot and Diakopoulos 2016, p. 696). In Brazil, newsrooms mainly rely on Twitter bots that use AI models, particularly NLP, machine learning, and planning, scheduling, and optimization to process large volumes of data and interact on digital media platforms (DalBen and Jurno 2021). However, bots have also been used with malicious intent in several recent events, such as the 2016 US elections and the Brexit campaign (Bastos and Mercea 2018).

Many people expect AI techniques to reduce the costs of investigative journalism (Broussard 2015). However, AI models are generally built for a particular story, which means that these algorithms must be created and trained again for novel projects. As a result, high initial investments cannot be amortized over multiple products (Stray 2019). Similarly, investigative news projects that rely on computer vision require significant investments to build technological infrastructure and hire highly qualified personnel to develop such codes (de-Lima-Santos and Salaverría 2021). Furthermore, AI models are usually trained using old and biased datasets, which can generate many ethical complications (Guzman and Lewis 2020).

Traditional news outlets have successfully deployed AI projects in their newsrooms, such as *The New York Times* (NYT), *The Washington Post,* and *Associated Press* (Chan-Olmsted 2019). However, AI is expensive, even for them (Broussard et al. 2019). Furthermore, elite news organizations have to make a great deal of progress to realize what is possible with AI in their newsrooms. For example, the release of GPT-3 in 2020 evolved machine learning models for text to the next level. This "autoregressive language model with 175 billion parameters, 10× more than any previous non-sparse language model" (Brown et al. 2020, p. 1), can perform many different tasks such as article generation, translation, summarization, and prediction and uses less computing power (Gage 2020). However, this applicability also brings risks such as the creation of distorted content, which can be used to deceive the public.

These advances in AI-related technologies have the potential to significantly disrupt the nature of human–machine interactions. AI technologies have proven to be in short-, medium-, and long-term part of a broader reconfiguration of the news industry, which started with digitalization and the creation of the internet (Broussard et al. 2019; Erdal 2011). AI is not a silver bullet for journalism, but it is a new tool that requires members of the news industry to possess more understanding to further support and bolster AI capabilities in newsrooms. AI-enforcement mechanisms are important for ensuring that AI systems adhere to legal and ethical guidelines without explicitly considering the power structures between various stakeholders (Broussard et al. 2019). For this reason, understanding the different subfields of AI is important.

3. Methods

To understand the evolution of AI in the news industry, one can turn to the list of case studies from JournalismAI. This is a global initiative led by the LSE journalism's think-tank, Polis, which aims to expand the knowledge about AI-powered technologies in newsrooms through collaborative projects. The institute offers a network for best practices and innovation sharing and also produces research reports and training materials for the news industry. On one of the fronts, JournalismAI built a database of cases that are at the intersection of AI and journalism. For this dataset, the team collected the best case studies that they could find and created a form for organizations and practitioners to submit examples of AI applications being used in the news industry. According to JournalismAI's portal, the database aims to "ensure that everyone in our global network can learn from and be inspired by these creative applications of AI in journalism" (JournalismAI n.d.).

The list comprises 102 items. We excluded nine entries that could not be accessed through the available URLs or that we could not find information about on the internet. Although we recognize that this database does not represent an extensive list, it should provide some idea of how AI is being developed in the news industry. To analyze the list, we built on the previous literature and classified these cases according to the types of AI applications that they use. As illustrated in Figure 2, the available artificial intelligence literature suggests that there are seven major areas of AI: (i) machine learning; (ii) natural language processing (NLP); (iii) speech recognition; (iv) expert systems; (v) planning, scheduling, and optimization; (vi) robotics; and (vii) computer vision. Based on these subfields, we formulated our categories of analysis and, from them, developed a theoretical discussion of our findings, highlighting examples that illuminate the application of AI in the news media industry.

Although we recognize that some subareas are present within each of these areas (for example, deep learning and predictive analytics are part of machine learning), our objective is to provide a macro approach to demonstrate how those topics work together in the journalistic field. We also acknowledge that certain projects rely on more than one subfield of AI. In this case, we classified only the two major subfields of AI found in these projects. Each author qualitatively analyzed each item from the database and coded it separately. During the process, we made annotations about each project to facilitate the discussion of discrepancies. After this process, we reunited and discussed the differences in classification. In total, 12 news products were initially classified differently.

Additionally, we analyzed where these projects were developed to obtain a better understanding of the distribution of AI-powered technologies in newsrooms worldwide. Our findings brought into perspective newsrooms' use of AI, especially regarding its use beyond the traditional forms of machine learning applications and natural language processing algorithms by detailing the most relevant aspects of these cases. In the following section, we present our findings based on our explorative research.

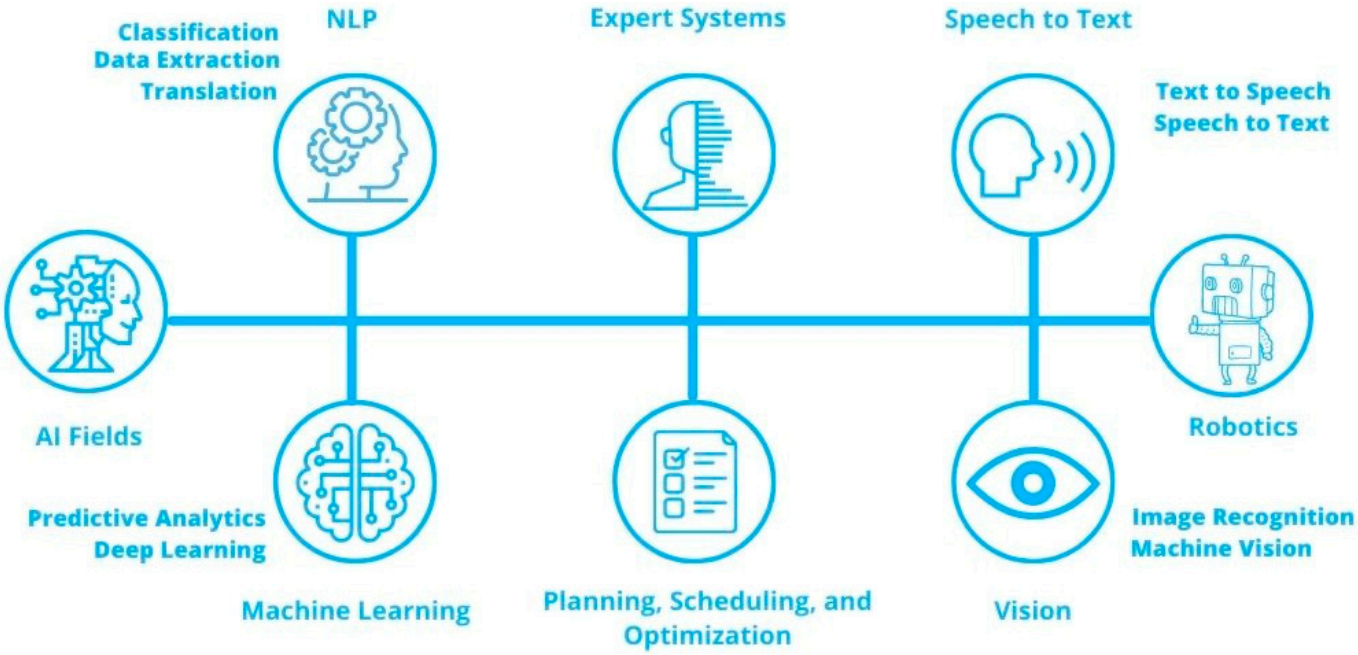

Figure 2. The seven fields of AI (Source: Authors).

4. Findings

4.1. An Overview of the AI in News Media

Overall, our findings reveal that most AI applications in the news industry are being developed in two regions: the Americas (43.01%, $N = 40$) and Europe (39.78%, $N = 37$). Our findings resemble those of prior studies on other technological developments in the news media ecosystem. For example, data journalism was first developed in the United States and European nations such as the United Kingdom and the Nordic countries (Appelgren and Nygren 2014; Borges-Rey 2016; Parasie and Dagiral 2013; Young and Hermida 2015). More recently scholars have identified developments in non-Western countries (Mutsvairo 2019). This is important because, as happened with data journalism, many have assumed the ubiquity and growing universal acceptance of AI in the news industry when this is not the reality. Artificial intelligence has been unequally developed since it is far too expensive for the majority of media companies. This limits most newsrooms' abilities to adopt cutting-edge technologies in the Global South (Linden 2017a). In our list, only 5.38% ($N = 5$) of the cases were from Asia, and 2.15% ($N = 2$) were from Oceania. The application of AI in African newsrooms appears to be very limited, as shown in prior studies (Kothari and Cruikshank 2021; Munoriyarwa et al. 2021).

Looking more specifically at the Americas, which also includes Latin America and Canada, only 4.3% ($N = 4$) of all the cases belong to this region. Although prior studies have highlighted some examples of Latin American organizations (de-Lima-Santos and Mesquita 2021b). The rest (38.71%, $N = 6$) belong to the US. Only 9.68% of these cases encompass global projects—that is, projects that reach wider audiences and different continents. Figure 3 depicts these subfields of AI in relation to each continent.

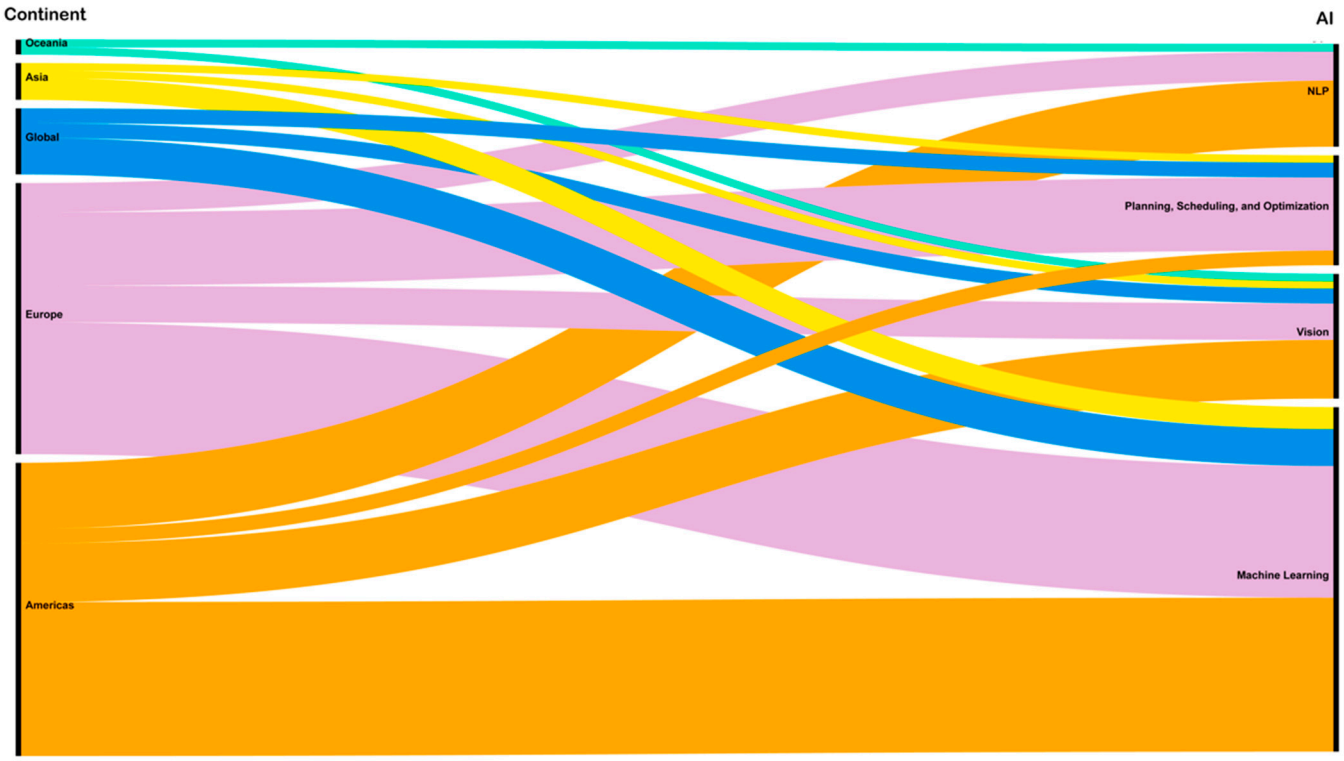

Figure 3. Fields of AI in relation to the continents (Source: Authors).

Regarding AI subfields, some researchers have noticed that the most common subfield is machine learning (66.67%, $N = 62$). This is followed by applications that rely on computer vision (18.28%, $N = 17$) and planning, scheduling, and optimization (16.13%, $N = 15$). NLP models learn a non-trivial amount of linguistic knowledge, which makes it harder for them to replicate it in different languages, such as Portuguese (Rodrigues et al. 2014). Although it can be found in computer science literature on fine-tuning models for the English language, NLP requires higher layers of specific knowledge for other languages, which impedes its consistent implementation in the news industry. For this reason, NLP models represent 15.05% ($N = 14$) of our sample.

However, the subfields of speech recognition, expert systems, and robotics are not present in our sample. Within such a fluid environment, increasing complexity is needed to deploy projects in these subfields of artificial intelligence in the news ecosystem since they require more specialized skills and since some of them require an innovative approach to develop novel products that were not previously available in the industry. This is happening at a moment when media companies are trying to survive uncertain times (Chan-Olmsted 2019). Such integration would require significant alignment within an organization and resource investments that news outlets do not foresee becoming obtainable in the near future (Locker et al. 2019).

However, we could note that most of these projects rely on external funds for deployment. Most funding comes from Google's Digital News Innovation (DNI) grants. Currently, news media is working with technology companies in a relationship that could be colloquially described as "frenemies" (Rashidian et al. 2018). On one hand, tech companies broke news media's business models; on the other hand, big tech platforms have become a major source of funding and a disruptor of innovation in the news industry (Rashidian 2020). Additionally, news organizations rely on third-party platforms such as Google's incubator Jigsaw to help them develop AI solutions for their business, echoing findings from previous studies (Cook et al. 2021). In the following subsections, we describe how the three main subfields of AI are being developed in the news industry.

4.2. Machine Learning and Its Applications in the Journalistic Field

Although many of these organizations rely on external funding to develop some projects, members of the news media are looking for ways to improve their strategies and boost their revenue streams. In our cases, two major trends appeared. First, the use of machine learning models was commonly found in projects that aimed to learn about readers' interests to boost engagement using a content recommendation engine. For example, *The New York Times*, *New Zealand Media and Entertainment* (NZME), and *Toutiao* (China) launched AI-powered news applications with this intent. In the same vein, *The Times* (UK) halved digital subscriber churn using tailored emails for its subscribers.

Second, a growing number of news outlets have built paywalls that bend to the individual reader or predict subscription cancellation. The Wall Street Journal is an example of this: the newspaper deployed a machine learning model that would allow non-subscribers to sample some stories. Using this machine learning algorithm, The Wall Street Journal could build a more flexible paywall that would inform news managers of the kinds of stories users are interested in. Similarly, third-party organizations began to build these solutions and offer them to newsrooms, such as Piano in the US and Deep BI in the UK; this echoes findings from previous studies about the emergence of new players in this field (Cook et al. 2021).

Although machine learning is the most popular subfield of AI since it helps computers improve their performance based on previous experiences (Russell and Norvig 2021), it is also the most common model because it can be applied to other AI subfields. One could easily identify some projects that have combined machine learning algorithms with NLP, computer vision, and planning, scheduling, and optimization. These subfields can be merged because these different components are entangled in the AI space (Castro and New 2016). Thus, the field of planning, scheduling, and optimization is one of the subfields of AI that is commonly applied in conjunction with machine learning.

4.3. Computer Vision to Investigative Reporting

Until recently, AI only worked at a limited capacity since technologists had to program a wide array of functions into a system to mimic human intelligence, which required massive computing power with low throughput. This has changed due to better hardware, more data, and better algorithms (Aronson 2018; Castro and New 2016; Hassaballah and Awad 2020; Whittaker 2019). Nonetheless, computer vision is still a subfield of AI that requires powerful tools to simulate human vision and enable a machine to learn to recognize abstract patterns in images (Castro and New 2016; Szeliski 2011).

Our sample included some small news outlets that have developed news stories using CV. The small news outlet Texty from Ukraine has relied on CV models to detect land that turned into lunar-looking landscapes due to illegal amber mining in the country. We also identified a major number of traditional news organizations that have adopted different approaches to the use of computer vision in their newsrooms. For example, *The New York Times* and Reuters have used CV algorithms in their news stories. NYT used computer vision algorithms to estimate 3D poses of sports athletes at live events, and Reuters used CV and satellite images to track urban expansion in the South China Sea. Reuter has also used this subfield of AI to enhance the search feature that is part of its video archive. The Chinese Xinhua News Agency has used CV in combination with other AI subfields to rebuild its newsroom by emphasizing human–machine collaboration to produce real-time stories.

In a similar vein, news organizations are using CV to detect fake images. In an event promoted by Google, Asian practitioners developed an app called Source, which is powered by Storyful. This app uses Google's AI technology to provide access to an image's public history, which can allow users to understand an image's provenance and any sort of manipulation that has been done to it.