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12 Projects in Machine Learning and Natural Language Processing in Libraries: An Introductory Overview

Introduction

Recent advancements in Natural Language Processing (NLP) and Machine Learning (ML) present amazing new avenues of discovery and innovation in the quickly transforming environment of information technology possibilities for libraries. Within an evolving framework, artificial intelligence (AI) emerges as a fundamental new driver, heralding unprecedented opportunities to foster enriched library patron experiences, novel operational efficiencies, and new possibilities for library automation. The following chapters in this section of the book review some of the developments over the past two-year period, setting the stage for the ever-evolving role of AI, large language models (LLMs) and autonomous agents for the global library sector.

In delving into these types of AI library projects, the chapters in this section explore a range of nascent and compelling library-related AI projects ranging from chatbots tailored specifically for libraries to developments offering readers a glimpse into new AI inspired recommender systems for building intelligent library patron assistants. In the realm of library systems integration, open-source solutions also promise remarkable potential in augmenting library management systems and these beginnings are highlighted. The new possibilities facilitate richer interaction with bibliographic records leveraging machine learning for more refined and focused book recommendations and these are also discussed.

Libraries are embarking on an intricate process of document analysis through ML. Some have taken on the ambitious task of automated linked data subject systems creation through AI enabled approaches to automatic indexing.Two of these types of projects are highlighted in chapters in this section: chapter 13 by Martin Malmsten and his colleagues describes work at the National Library of Sweden while chapter 14 by Anna Kasprzik presents the experiences of the *Deutsche Zentralbibliothek für Wirtschaftswissenschaften (ZBW)/German National Library for Economics*. The subject classification trajectory includes a deep dive into AI enabled topic modeling, highlighting efforts to bring more nuanced understanding for large-scale historical text-based archives with Sümeyye Akça's exploration of a project digitizing

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the Ottoman court registers, the Khadi registers, in chapter 15. The developments set the stage for a collaborative future where the integration of automated subject indexing promises to reshape the library search, retrieval, and research landscape. Caroline Saccucci and Abigail Potter's description of a project at the United States Library of Congress in chapter 16 and Thomas Zaragoza, Yann Nicolas and Aline Le Provost's outline of work undertaken on the union catalogue of French academic and research libraries in chapter 17 demonstrate the possibilities. In opening discussions towards these areas and the chapters to follow, it is worth briefly reflecting not only on a few tentative earlier starting points but also the blistering pace of the present and what is to come. Hopefully, these brief few pages can set wider contexts and references for present day trajectories that are recreating our world of communication, technology and information as this book goes to publication.

Historical Antecedents and Present-Day Library Possibilities

The journey towards creating virtual library assistants began with an early system, , conceived by Joseph Weizenbaum in the mid-1960s (Weizenbaum 1966). Acting as a simulated Rogerian psychotherapist, ELIZA facilitated first attempts at a sense-making, open-ended, human computer interactive questioning process. ELIZA parsed and processed simple natural language keywords through what are now regarded as primitive and basic algorithms. Remarkably, more than 50 years ago, ELIZA was able to simulate empathetic and understanding conversation. Eliza also utilized reflective thinking using a psychodynamic reference model, synthesizing algorithmic possibility with technological infrastructures. This monumental stride marked the first early incursions into an AI domain. Machines could potentially mirror or, at least, mimic human-like interactions offering a glimpse of future possibilities. Chat + computer processing could offer assistance and guidance.

The early work on ELIZA provided a historical legacy that still finds resonance in today's library AI reference infrastructure beginnings. It is important to remember that virtual reference and question and answer through computers began with humanistic psychodynamic principles of self-reflection to focus user/patient/patron questions. Virtual reference leaned heavily on the foundational human-centered, principle of focusing attention on keywords. This principle instituted by ELIZA and later Boolean keyword searching was carried forward by AI large language models in a paper on transformer models (Vaswani et al. 2023). The abstract idea of reflection was originally famously formulated by René Descartes in the expression "*Cogito ergo sum*/I think therefore I am" contained in his *Discours de la méthode/*

Discourse on the Method in 1637 with the mind reflecting on itself. The abstract idea of reflection was expressed in early AI thinking with feedback loops. Servers watched and reflected on each other to improve, adjust, and correct performance. The approach continues with current thinking involving the next level of large language model AI development and autonomous agents (Wang et al. 2023).

Large Language Models

As libraries and others have navigated the new millennium, they have found the AI tipping point. Transformative changes mark the moment underscored by the advent of large language models nurtured through deep learning and neural network technologies. A critical inflection point was vividly epitomized in OpenAI's public announcement of GPT-3.5 in November 2022 and GPT-4 in early 2023 (OpenAI 2024). This monumental sea change in the AI and technology landscape of today's global village denoted not just a staircase evolutionary step but a phase change or, as Kuhn would call it, a paradigm shift. The turnaround occurred through the combined synthesis and expansive power of neural network possibility, logarithmically increasing processing power and the unexpected revelations and emergent properties of what very large, connected data sets with associated repositories and training can accomplish.

Autonomous Agents

The various but intricately connected burgeoning developments introduce a new generation of virtual assistants, products, and infrastructures. They will together fundamentally reshape our global landscape. Library and information science and all libraries are inevitably included in the huge sea change occurring. Virtual assistants and AI inspired developments have changed all aspects of information creation, discovery, access, and use. All research, learning, and reference systems are evolving into sophisticated multi-level forms with AIs and autonomous agents (Wang et al. 2023). The new approaches are proficient in guiding users and provide unprecedented access to knowledge and information. Precision and personalization of knowledge and information are available on a multiplicity of levels and can be used to conduct increasingly complicated tasks. The developments are leading to what some are calling AGI or Artificial General Intelligence (Bubeck 2023). The empowerment and augmentation of human intelligence is courtesy of deep learning neural net mechanisms. These neural net layer outputs leverage vast trillion parameter data content archives to connect nodes. Connections open ever more

nuanced responses to complex questions. The neural net multi-trillion parameter distillations are able to provide insight into arcane problems and challenges. Just a few years ago, these levels of discovery and insight were thought impossible for technology to fathom.

This new 21st century birth comes from stochastic and statistically based probabilistic paradigmatic AI technology models. The models represent the evolution of linguistic-based human cognitive capabilities. They evoke whispers of the hopes and anxieties of AGI. The emerging large language models become incredibly powerful as a group working together, reflecting evolving, learning, adapting, and improving at an iterative pace impossible for humans to fathom in their layers of complex connection. New philosophical, pragmatic 21st century toys of AI's large language models have offered the world a deceptively simple search box user conversational interface that is also quickly shifting to smart phone voice recognition. This type of AI human/language model question/answer model will now respond instantly from a phone on any topic possible. This new interface and question/answer conversation represents a paradigm shift. The previous 25-year dominance of the keyword search and retrieval screen is now displaced to sidelines. The new interface is deceptively intuitive and simple but also richly layered. It is also incredibly powerful, facilitating in-depth possibilities and new insights and discoveries. Questions now arising are: How soon will AI developments give rise to radically different future library models? How soon will present online vendor database infrastructures and applications all change? Information retrieval has shifted from a keyword task to a conversation and an interactive conversation and experience with an artificial intelligence.

Prompt Engineering and Multimodal Artificial Intelligence

The search and retrieval process requires what is termed prompt engineering. The prompting quickly becomes an immersive experience requiring a new set of specialized skills. AI is rapidly synthesizing the intricate web of human text-based knowledge contained in ever larger datasets with the language models processing power through AI's deep learning brain-like neural nets. Language models are quickly evolving to more human-like polyphonic cognitive modalities. They are moving to incorporate and process all other media including images, video, and data along with other lesser thought about modalities of human communication and interaction with the world using tactile, phatic, and robotic means to ingest, process, analyze and create responses. These novel approaches utilize human-associated semiotic linguistic structures in various modalities for their systems of organization and response. Global activity and dynamic responses are

quickly deepened, enriched, detailed, and personalized for what is now termed the AI orchestration of multi-modal human perspectives. New lines of research and systems promise a future trajectory where libraries and indeed the globe transform into vibrant imaginative learning hubs. The new knowledge and information systems will nurture and kindle human curiosity in areas yet unexplored. They will foster a deeper, richer understanding of the world and the people within it through new AI-powered lenses. The exciting new possibilities whisper through the early reflective aspirations kindled by human computer interaction trailblazers, like Weizenbaum's humanly self-reflective ELIZA algorithm.

Libraries and the New Artificial Intelligence Paradigms

In navigating the intricate topography of the present shifts, there are fascinating synergies developing among new open-source AI toolkits and library automation systems. The open-source relationship is deeply steeped in historical technological cooperation and global library communal software development. The open-source software community has long been a stalwart ally to libraries, offering vital tools and systems. DSpace, Koha, Harvard's Dataverse and other open-source library related systems have fortified libraries' operational efficiencies and capabilities over the years. Today, the collaborative spirit is flourishing anew with the integration of AI and AI toolkits. Hugging Face (2023), Gemini, LangChain, Voyager, Llama2 and other new products or services emerge daily and are crystallized through new browser plugins, open APIs and an ever-evolving digital ecosystem infrastructure. The kaleidoscope of new possibilities and developments like Gutenberg3 open fertile ground for new library exploration with interdisciplinary possibilities for using bibliographic records and content, paving the way for AI enhanced query and retrieval functionalities where deep, rich contextual insights are readily accessible.

The expansive embrace of AI technologies is not just transformative but necessary for the competitive survival of today's dominant library vendors. Library IT vendors across the spectrum are scrambling to rapidly come up to speed with AI enhanced product roadmaps. If they wade into new AI waters, they can hopefully make a speedy transition with new strategies to encapsulate the boundless opportunities presented by large language models and other AI utilities. The shifts to new ways of working and providing service herald a new era for libraries, especially those already embracing robust digital resource directions. Libraries and their information stores will be more dynamically connected not just as passive repositories but as interactive conversing entities. They will evolve to maximize the use

of new technological AI possibilities and adapt to the changing informational and AI technological landscape. The new landscape promises a spectrum of enriched library and archival experiences along with research and learning possibilities. New AI services will be tailored to multimedia and multimodal needs of postmodern or fourth industrial revolution patron expectations.

Library Recommender Systems

Going forward, the emphasis in new developments is gravitating towards breaking deeper ground for new possibilities for AI recommender systems and patron query research responses in libraries. Sophisticated AI setups, fostered by large language model deep learning algorithms, are steering away from the conventional pathways of previous 20th century subject access compartmentalization of disciplinary areas. New offerings will usher in more fluid domains and subject constellations replete with a richer and more connected interdisciplinary tapestry of information categories customized for users and user needs. New AI systems bear the potential to revolutionize patron research and browsing experiences. They will provide platforms where focused user interests are not just met but are enriched, expanded, and rethought on the fly through a web of interrelated interdisciplinary content and focused contextual suggestions. The new possibilities wield the capacity to turn a curious mind towards unexpected yet aligned avenues of exploration, entertainment, and research, fostering a nurturing more personalized environment for learning, research, insight, and discovery.

Artificial Intelligence Topic Modeling and New Metadata Possibilities

This section focuses on and explores the less trodden realm of topic modeling and subject clustering. Topic modeling utilizes applied mathematical modeling methodology to unlock unprecedented depths in content analysis. The methods facilitate the unearthing of unrealized connections, ushering in fresh perspectives through the identification and clustering of keywords into discernible subjects. Topic modeling provides a more nuanced and dynamic lens through which to view and engage with content. The approach unveils a network of subject connections, offering users a pathway to delve deeper and find strong subject associations that would remain obscured in a traditional cataloging environment. The area stands as a promising frontier in the ongoing pursuit of accessing and synthesizing knowledge and providing insights into large archives previously more difficult to access.

Present possibilities of topic modeling allow better access and division into intuitive, fluid, and interconnected frameworks. They nurture a space where learning is not linear but richly layered and a multidimensional subject access journey. It is through these innovative techniques that libraries can begin to participate in the continually evolving AI landscape. It is also a landscape which adapts to the diverse needs of its patrons and offers not just resources but also vibrant new ecosystem possibilities for exploration and discovery.

Audiovisual Media, Libraries and Artificial Intelligence

Chapters in this text herald the next burgeoning frontier for AI in media, unfolding within libraries a vibrant locus for not only image and video analysis but also for delving into potentialities engendered by generative AI technologies such as Adobe Firefly, Midjourney, DALL-E and Stable Diffusion. The sophisticated new tools available stand as testimony to the advanced cognitive abilities of current AI systems. They are equipped to both classify and generate visual and multimedia content with an unprecedented depth and nuance. They also open questions about which new methodologies should be selected for appropriate archiving, creating, and retrieving multimedia resources in libraries, and how they might best be used.

The advances in AI are poised to catalyze a seismic shift in the way business is done in library special collections and archives, especially multimedia collections. The advancements promise a renaissance where historical video footage, photographs, and complex art works can be analyzed, annotated, and remixed. Libraries are nurturing grounds for digital literacy and knowledge dissemination. They play auspicious roles in fostering new competencies in new digital literacies, equipping patrons with the skills and tools to not only navigate but actively engage, create, and recreate within a dynamically evolving media and multimodal landscape of resources available.

Conclusion

As libraries and librarians begin to find a path through an era of groundbreaking change and augmentation for the library sphere, this section heralds glimpses of a future brimming with potential but also raises questions about the present and the past. The chapters paint a portrait of an emerging epoch where library possibilities are overflowing traditional bounds and metamorphizing beyond prescribed definitions to enable creative production in innovative digital and algorithmic ways. Libraries, their knowledge stores, access gateways and warehouses are evolving into

intelligent ecosystems pulsating with life, capable of fostering environments where user information and knowledge seeking experiences are dynamically personalized and tailored, intuitive, and richly responsive and immersive to the unique individual posing the questions. Through the advanced lens of AI, libraries are becoming crucibles and incubators for new genres of artifacts. These developments all speak to the necessity of digital and algorithmic literacy for librarians and patrons. There are new domains where patrons will need to be empowered to engage with content in a more immersive, interactive, and creative way than they do currently. Hopefully, the developments will nurture larger global learning and professional communities to harness the transformative power of AI in understanding and generating new media and learning narratives for knowledge on both local and global levels. The current era marks the dawn of a new AI horizon. Libraries stand in their historical role but are also now positioned towards the necessities of innovative engagement, offering new enriched, personalized journeys through a digital landscape. It is up to all to use the new tools wisely, adopt a fresh philosophic stance, and optimize AI's potential to create, research and understand the world and the people within it.

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