

**Ray Uzwyshyn, Ph.D. MBA MLIS**

## **Section III Introduction : Projects in Machine Learning and Natural Language Processing in Libraries**

### **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 IT possibilities for libraries. Within this evolving framework, artificial intelligence (AI) now 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 articles and chapters review some of these developments over the past two-year period, setting the stage for the ever-evolving role of AI, large language models and autonomous agents for the global library sector.

In delving into these types of AI/library projects, the articles which follow explore a wide range of nascent and compelling library-related AI projects ranging from chatbots tailored for libraries to 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. These beginnings are highlighted. These new possibilities also facilitate richer interactions with bibliographic records leveraging machine learning for refined and focused book recommendations and these are also discussed.

Libraries are now embarking on the intricate process of document analysis through machine learning and projects. Some have taken on the ambitious task of automated linked data subject systems creation through AI enabled approaches to automatic indexing. This classification trajectory also includes a dive into AI enabled topic modeling, highlighting efforts in bringing nuanced understanding for largescale historical text-based archives and setting the stage for a collaborative future where the integration of automated subject indexing promises to reshape the library search, retrieval, and research landscape. In opening discussions towards these areas and articles to follow, it is worthwhile to briefly reflect 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 context and a few further 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 AI Possibilities

The journey for library virtual assistant begins with an early system, ELIZA, conceived by Joseph Weizenbaum in the mid-1960s (Weizenbaum 1966). Acting as a simulated Rogerian psychotherapist, ELIZA facilitated first attempts at sense-making - an 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 understandable conversation. Through reflective thinking, Eliza used a psychodynamic reference model, synthesizing algorithmic possibility with technological infrastructures. This monumental stride marked the first early incursion into an AI domain where machines could potentially mirror or at least mimic human-like interactions offering a glimpse of this possibility. Chat plus computer processing could offer assistance and guidance, a historical legacy that still finds resonance in today's library AI reference infrastructures beginnings. It is important to also remember that virtual reference and question and answer through computers began with humanistic psychodynamic principles of 'self-reflection' to focus user/patient/patron questions and leaned heavily on the foundational human-centered, principle of 'focusing attention' on keywords, a principle instituted by ELIZA and later Boolean Keyword searching and later carried forward by AI large language models through a paper on transformer models (Vaswani et al. 2023). The abstract idea of cognition as 'reflection' was most famously formulated by Rene Descartes in his discourse on Method (1637), *Cogito ergo sum*, (I think, therefore I am), the mind here reflecting on itself. This abstract idea of reflection continued in early AI thinking with the idea of feedback and servers watching and reflecting on each other to improve, adjust and correct performance. Currently, this continues with the next level of large language model AI development and autonomous agents (Wang et al., 2023)

As we navigate into our new millennium, we find our AI tipping point and transformative phase change moment underscored by the advent of large language models. These are nurtured through deep learning and neural network technologies, a critical inflection point reified and epitomized through OpenAI's GPT-4 announced in November of 2022. This monumental paradigm shift in the AI and technology landscape of our global village denoted not just a staircase evolution but a phase change or, as Thomas Kuhn termed it, a paradigm shift. This shift occurred here through the synthesis of the expansive power of neural network possibility, logarithmically increasing processing power and the unexpected revelations of what very large connected data sets with associated repositories and training open.

These burgeoning developments now introduce a new generation of virtual assistants, products, and infrastructures. They are fundamentally reshaping our global landscape. As part of this general sea change, library and information science and all libraries are included. Virtual AI inspired information and research, learning, and all reference systems are now evolving into sophisticated multi-level AI's and autonomous agents (Wang et al. 2023). They now guide users with unprecedented access to knowledge and information. Precision and personalization of knowledge and information is also available on a multiplicity of levels including, increasingly complicated tasks. This is also leading to what some are calling AGI or Augmented General Intelligence or Artificial General Intelligence (Bubeck 2023). This empowerment and augmentation of human intelligence is courtesy of deep learning mechanisms that leverage vast trillion parameter data archives to provide nuanced responses and neural net distillations

of the most arcane questions. Questions are answered on levels that just a few years ago were thought impossible for technology to fathom. This new 21<sup>st</sup> century birth, comes from stochastic and statistically based probabilistic paradigmatic AI technology models. These models represent the evolution of linguistic based human cognitive capabilities. They evoke whispers of the hopes and anxieties of Artificial General Intelligence. These large language models also become incredibly powerful as a group working together. They reflect, evolve, learn, adapt and improve at a superhuman iterative pace impossible for humans. Currently, this new philosophical and pragmatic toy (Michelson 1984) is offered to the world through deceptively simple user conversation interfaces. This new interface and question/answer conversation also represents a paradigm shift of the previous 25-year dominance of the now displaced keyword search and retrieval screen. The new interface is intuitive, simple but also richly layered and incredibly powerful. Questions here become, how soon will this give rise to future research library models and how soon will present online vendor database infrastructures and applications change. Information retrieval has now shifted from a keyword task to a conversation. This is also an interactive conversation and experience with an 'artificial intelligence'. This process requires what is now termed 'prompt engineering' to elicit better answers from the model and this is also quickly becoming 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 and the language models processing power through AI's deep learning brain-like neural nets. Language models are also quickly evolving to more human-like polyphonic cognitive modalities. They are quickly moving to process and incorporate other media (images, video) and modalities of human communication and interaction with the world (tactile, phatic, robotic) into their 'responses'. They are utilizing our human associated semiotic 'linguistic' structures in various 'modalities for their systems of organization and response. This global activity and dynamic panorama are also quickly becoming more enriched, detailed, and personalized - what is termed now 'multi-modal' human perspectives (Yang 2023). These new lines of research and systems promise a future trajectory where libraries and indeed the globe transforms into a vibrant yet still unrealized learning hub. These systems will nurture and kindle human curiosity in areas yet unexplored. They will foster a deeper, richer understanding of the world and ourselves through new AI-powered lenses. These also whisper through the early reflective aspirations kindled by human computer interaction trailblazers, like Weizenbaum's humanly self-reflective ELIZA algorithm.

In navigating the intricate topography of these present shifts, there are also fascinating synergies developing among new open-source AI toolkits and library automation systems. This is an open-source relationship 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, this collaborative spirit is flourishing anew with the integration of AI and AI toolkits. Hugging Face (2023), Gemini, LangChain, Voyager, Llama2 and other new names emerge daily. They are available through new browser plugins, open API's and an ever-evolving digital ecosystem infrastructure. This kaleidoscope of new possibilities and Gutenberg3 like efflorescence opens fertile ground for new library exploration with interdisciplinary possibilities for bibliographic records and content. It also paves the way for AI enhanced query and retrieval functionalities where deep, rich contextual insights become readily accessible.

The expansive embrace of AI technologies is not just transformative but necessary for competitive survival. Dominant library vendors Library IT vendors across the spectrum are currently scrambling to rapidly come up to speed with AI enhanced product roadmaps. If they have been wading into these waters, they can hopefully make a quick transition to these new strategies to encapsulate the boundless opportunities presented by large language models and other AI utilities. These shifts will herald a new era for libraries, especially those already embracing robust digital resource directions. Libraries and their information stores will be able to be more dynamically connected. They will no longer be passive repositories but interactive ‘conversing’ entities, beginning to evolve with these new technological AI possibilities and adapting to the changing informational and AI technological landscape. This new landscape promises a spectrum of enriched library and archival experiences. Research and learning possibilities and new AI services will be tailored to the multimedia and now ‘multimodal’ needs of our postmodern or fourth industrial revolution patron expectations.

As we proceed, the emphasis gravitates towards breaking deeper ground for new possibilities for AI recommender systems and patron query research response in libraries. These sophisticated AI setups, fostered by large language model’s deep learning algorithms, are steering away from the conventional pathways of previous 20<sup>th</sup> century subject access compartmentalization of disciplinary areas. They are now ushering in new more fluid domain and subject constellations. These constellations too are replete with a rich and more connected interdisciplinary tapestry of information categories. They can be customized for users and user needs. These 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. This will be through a rich web of interrelated interdisciplinary content and more focused contextual suggestions. The new possibilities wield the capacity to turn a curious mind towards unexpected yet aligned avenues of exploration, entertainment and research. These possibilities will foster a nurturing more personalized environment for learning, research, insight, and discovery.

Further into these sections’ exploration, we also traverse the less trodden realm of topic modeling and subject clustering. Topic modelling utilizes applied mathematical modelling methodology to unlock unprecedented depths in content analysis. The methods facilitate the unearthing of previously unrealized connections. They usher in fresh perspectives through the identification and clustering of keywords into discernible subjects. Topic Modelling also provides a more nuanced and dynamic lens through which to view and engage with content. This 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 synthesizing knowledge and providing insights into previously harder to access large archives. Present possibilities of Topic modelling allow better access and division into intuitive, fluid and interconnected frameworks. This nurtures a space where learning is not linear but a more richly layered and a multidimensional subject access journey. It is through these innovative techniques that libraries can begin to participate in this continually evolving AI landscape. This is also a landscape which adapts to the diverse needs of its patrons, offering not just resources but vibrant new ecosystem possibilities for exploration and discovery.

Articles in this section cast a spotlight on the burgeoning frontier of AI in media, unfolding within libraries as a vibrant locus. This is not only image and video analysis but also for delving into potentialities engendered by generative AI technologies such as Adobe Firefly, Midjourney, and Stable

Diffusion. These sophisticated new tools stand as testimony to the advanced cognitive abilities of AI systems today. They are equipped to both classify and generate new visual and multimedia content with an unprecedented depth and nuance. These AI's also open questions for these new methodologies towards archiving, creating and retrieving multimedia resources in libraries.

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

As we begin to steer through this era of groundbreaking alteration and new augmentation for the library sphere, this section of this book exhibits sparks of a future brimming with potential but also raising questions about our present and past. The articles paint a portrait of an emerging epoch where library possibilities are overflowing traditional bounds. Traditional storehouse roles are metamorphosing beyond prescribed definition to enabling creative production in ever more innovative digital and algorithmic ways. Libraries, their knowledge stores and warehouses are evolving into intelligent ecosystems pulsating with life, fostering new environments where user experiences are not static but dynamically tailored, intuitive, and richly immersive. Through the advanced lens of artificial intelligence, libraries will become crucibles and incubators spurring new genres of artifacts but also speaking to the future necessities of digital and algorithmic literacy. These are also new domains where patrons are empowered to engage with content in a more immersive, interactive, and creative way. Hopefully all of these developments will nurture larger global communities to harness the transformative power of AI in understanding and generating new media narratives and knowledge on both local and levels. Our era marks the dawn of a new AI horizon. Libraries stand in their historical role but also now positioned towards the necessities of innovative engagement. They will offer new enriched, personalized journeys through a digital landscape of AI's potentialities to further help us create, research, learn and understand.

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