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9 Building Library Artificial Intelligence Capacity: Research Data Repositories and Scholarly Ecosystems

Abstract: Artificial intelligence (AI) possibilities for deep learning, machine learning and natural language processing present fascinating new library service areas. These areas are being integrated into traditional academic library activities, digital literacy, and university research environments. Most university faculty, graduate students and library staff work outside of computer science disciplines and require help in discovering, accessing and using data. This chapter overviews methodologies, infrastructure, and skills needed for building AI capacity and new AI services within academic libraries suggesting steps that may be taken by way of training to establish a sound foundation for future implementation. The role of AI in the digital scholarly ecosystem is discussed. Library AI scholarly pathways are clarified and focused steps are suggested to move library staff, researchers, and students towards new AI possibilities.

Keywords: Artificial intelligence – Training; Deep learning, Data storage and retrieval systems; Academic libraries; Research libraries

Introduction

Deep learning, machine learning and natural language processing are fascinating new areas of artificial intelligence (AI). This chapter overviews pragmatic steps which can be taken to establish sound foundations for optimizing AI possibilities. Topics outlined include research data repository foundations, digital scholarly research ecosystems and relevant tools and services to set the groundwork for new emerging AI possibilities. The ideas presented draw on the pragmatic work of the author in two universities and over nine years of AI related projects, 2014–2024. Developing AI-related library scholarly services for research faculty, graduate students and library staff begins with education and training. This chapter provides a list of learning resources in the Appendix, along with background material references.

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Educational Steps and Scaffolding

To build any successful library AI program, educational steps and scaffolding are needed (Figure 9.1). The learning curve for AI is steep and staff education and training must be seriously considered by library managers and administrators. AI implementation combines areas of computer and information science, programming, and information technology project management. The objective of any AI educational program is to develop a more sophisticated vocabulary towards AI programmatic literacy enabling larger conversations. The university's learning community must become familiar with the language of AI to facilitate subsequent conversations on project possibilities and work effectively with AI engineers and experts for successful implementation of projects.

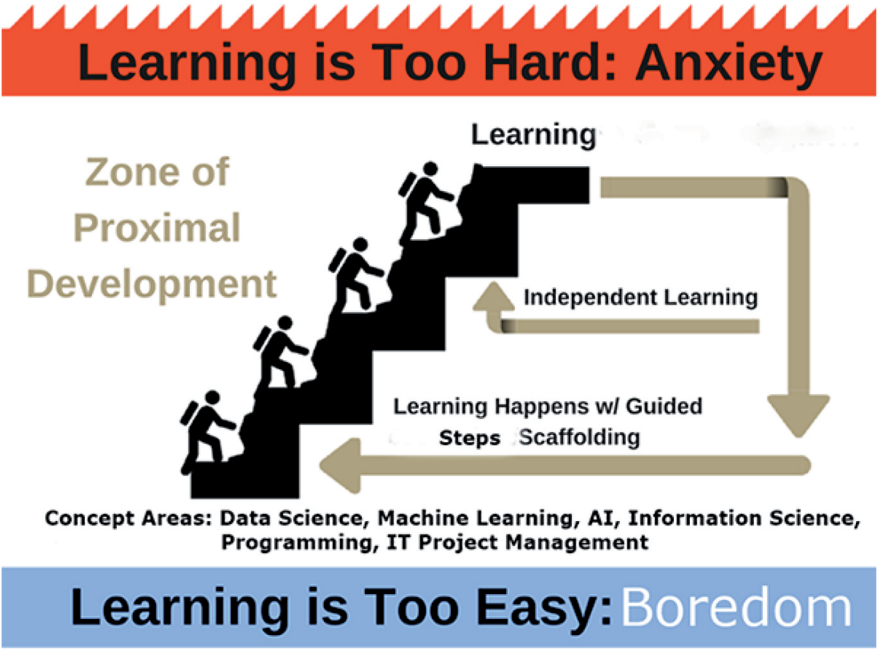

Figure 9.1: Educational Scaffolding and Steps Towards Learning (Warren 2021)

Artificial Intelligence Paradigms and Origins

AI has many origins, each with unique algorithmic paradigms (Table 9.1). Some paradigms are better suited than others for particular problem areas and it is best for any algorithmic literacy program to begin generally. There are many good introductory texts, documentaries, online courses, and *YouTube* videos to inspire learners before engaging with more complex aspects like deep learning's back propagation, matrix math and calculus cribs needed to understand processes. Learning materials are listed in Appendix 1 of this chapter, with two parts A and B. Part A lists introductory materials and Part B provides a list of learning materials in specific aspects of AI. Carnegie Mellon's Tom Mitchell and independent scientist from Vienna University of Technology Károly Zsolnai-Fehér through his *Two Minute Papers YouTube* videos (Appendix 1A Mitchell 2022; Zsolnai-Fehér 2022) provide inspiring overviews of recent AI development and progress. Pedro Domingos' book *The Master Algorithm,* provides an excellent categorization of the different AI schools, origins, algorithms and best solutions for various problem areas or tasks (Domingos 2015). Video interviews with Domingos provide additional useful information (Appendix 1A Domingos 2016, 2020, 2022).

The goal of building awareness of AI in the larger university community and library staff is to inspire and create the desire for further knowledge to build new skill sets. Present AI attention is largely focused on deep learning, machine learning (Hart and Recht 2022) and neural nets or networks (Carnes 2019; Appendix 1A ColdFusion 2020, LeCun 2022, Mitchell 2022; Appendix 1B Fridman 2022). While there are other important areas, beginning with deep learning and moving on to machine learning present useful approaches for an initial focus on AI which can be used as the basis for extending to a wider program.

Table 9.1: AI Paradigms, Origins and Algorithms (Based on Domingos 2015)

AI Paradigm	Origin	Algorithm	Problem	Solution
Deep Learning Machine Learning	Neuroscience (Neural Nets)	Back Propagation Neural Nets	Complex Tasks, Hidden Patterns	Back propagation
Symbolic AI	Logic, Philosophy	Inverse Deduction	Knowledge Composition	Inverse Deduction
Bayesian Inference	Statistics, Probability Theory	Probabilistic Inference	Uncertainty	Probabilistic Inference
Evolutionary Computation	Evolutionary Biology (Complexity Theory)	Genetic Algorithms	Structure Discovery	Genetic Programming
Reasoning by Analogy	Psychology	Kernel Machines (Support Vector Machines)	Similarity	Kernel Machines

The last ten years of developments in deep learning or neural net algorithms have shown incredible progress. There have been significant results in natural language processing, conversational chatbots, cybersecurity and strategic reasoning with sophisticated AI programs like AlphaGo that plays the board game Go, computer vision and object recognition (Appendix 1A Mitchell 2022). In initially exploring AI, it is best to overview the field briefly and set scalable limits. Progress can be made incrementally with both algorithmic paradigms and pragmatic applications for library staff, research faculty and graduate students so that projects may be achieved, and core research and data analysis enabled. Once a level of awareness of the subject area has been attained, along with inspiration about potential uses, learners can gain skills which lead to mastery (Figure 9.3). Deeper knowledge and skills enable library projects and ensure that faculty and graduate student research moves to new levels.

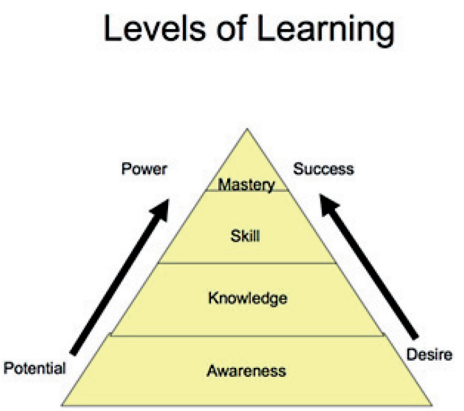

Figure 9.2: Levels of Learning

Online Research Data Repositories

There is a clear trajectory in academic libraries from data and data collection to data science, analytics, visualization, and AI. Everything begins with the data and its organization. A good online research data repository will allow a university library to consolidate and share online faculty and graduate student research. A data repository organizes university research data and provides important online data archiving and publishing strategies. Constructing and using a data repository provide library staff, faculty, researchers, and students foundational skills surrounding important tasks of data organization, cleaning and creating structured data, data citation and building metadata schemas. The skills acquired will be important building blocks for forging AI's larger pathways.

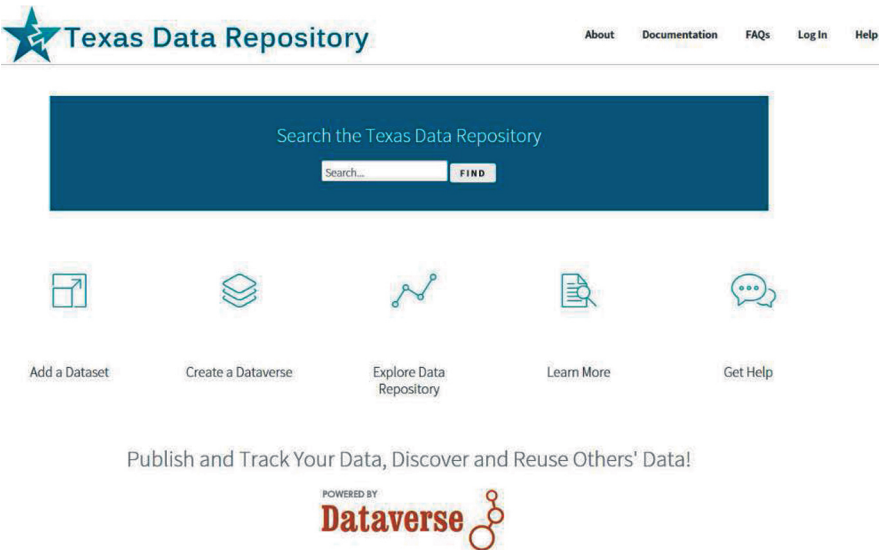

Figure 9.3: Original Homepage for Texas Data Repository (Uzwyshyn 2016, 2022b)

The Texas Data Repository (Figure 9.3) is an example of a research data repository which reconfigures the open source Harvard Dataverse as a consortial, environmental, aggregating data from various Texas universities. Establishing such an open-source software application on an individual, institutional or consortial configuration builds staff human resource infrastructure skills contributing to understanding and implementing AI. Building a data repository for an institution encourages scholars and library staff to use and understand basic data cleaning tools such as OpenRefine which is a powerful tool for working with messy data and transforming it to a suitable state for use by an AI algorithm for later training and processing.

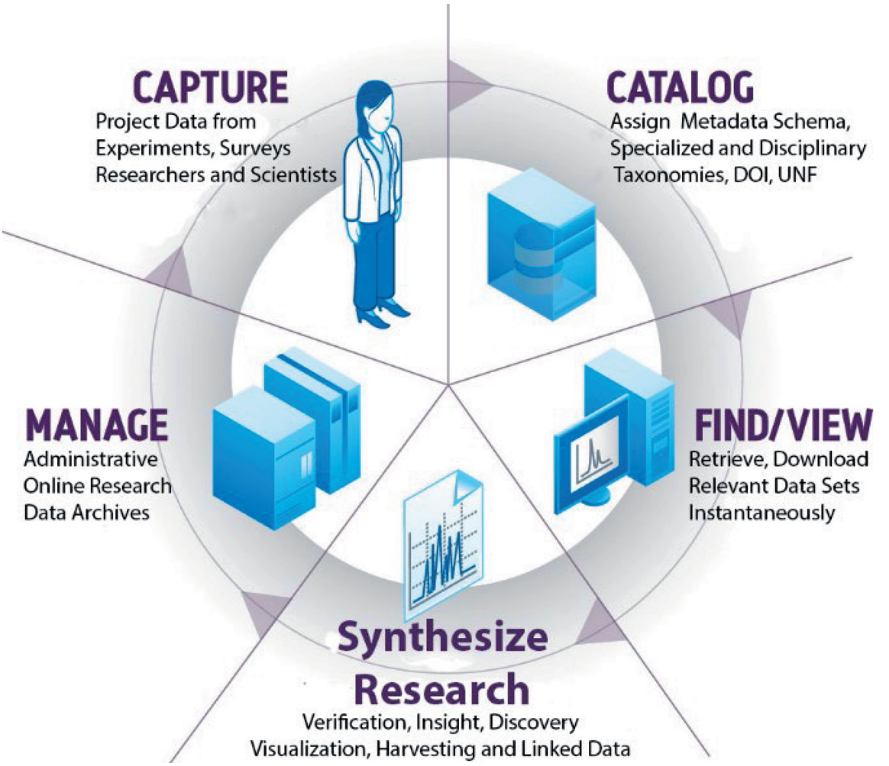

Figure 9.4: The Online Research Data Repository Lifecycle (Uzwyshyn 2022b)

Gaining fundamental data literacy through experience with the online research data repository lifecycle (Figure 9.4) will serve the university community and library staff well for building AI projects.

Digital Scholarship Ecosystems

A digital scholarship ecosystem (Figure 9.5) should be pursued following the development of an online research data repository. While a data repository will always be central, an online institutional collections repository should also not be overlooked, especially for the ability to store and house metadata, core data and textual files. The well-known open-source software, dSPACE, can be used for the university's digital collections repository. There are four tertiary communication components to the Texas repository: an online electronic theses and dissertation management system (ETD) using VIREO software; an identity management system

using ORCID; an open academic journal system using OJS3; and user interface content management software based on OMEKA. The combination of the content and communication components make up the digital scholarly ecosystem which can be used as the foundation to enable future larger AI pathways.

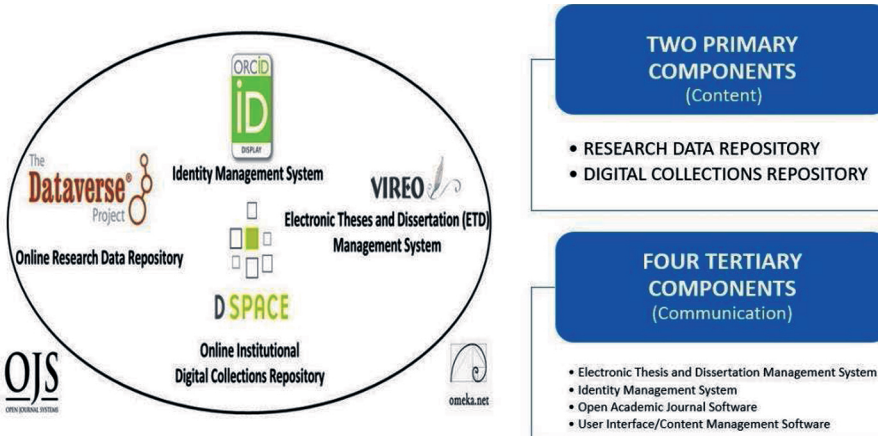

Figure 9.5: Digital Scholarship Research Ecosystem, (Uzwyshyn 2022a).

Capitalizing on Digital Scholarship Ecosystems through Artificial Intelligence

Innovative open science and AI possibilities can be used to extend the use and value of a DSE. The following exemplifies what can be achieved. Harvard's Dataverse allows for the uploading of datasets from other universities to a specific research data repository for later sharing or use by anyone globally. The HAM10000 image dataset is a large collection of multi-source dermatoscopic images of cancerous skin lesions uploaded to Dataverse by Viennese dermatologist, Dr. Philipp Tschandl (Tschandl 2018). The data was subsequently used by Islam, Khan, and Chowdhury (2021) at BRAC University in Bangladesh for an undergraduate thesis. The students downloaded and used the image data to train a deep learning neural net algorithm to recognize cancer growths with efficiency greater than, or equal to, board certified dermatologists. BRAC University library provides an institutional repository to house theses and dissertations and the student work has been further opened globally by this means. The example demonstrates the power of open science combined with AI operating on global levels through the enabling power of digital scholar-

ship ecosystems and data repositories. Content and data that would otherwise be unavailable can be brought together with new machine learning algorithmic techniques (Esteva et al. 2017). New research is enabled; students can produce quality theses; and geographically dispersed content and knowledge from different continents can be aggregated to advance the pursuit of knowledge and science.

Artificial Intelligence and Human Resources

In creating an appropriate AI staffing infrastructure, hiring a whole new department is not feasible for most libraries. Most research and academic libraries have in place operational digital collections and/or data repositories and some have DSEs. Previous experience with such systems will shorten the AI learning curve and facilitate the training process. A staff member already in place working on repositories can initially take up a data-centered function with a new AI-focused research data repository. Other skills related to cataloguing digital metadata creation can be transferred. Use of existing staff skills will serve upcoming AI functions well, especially with regards to machine learning.

One particular skill required for AI implementation relates to data labeling which is a key step in neural net training and machine learning (Kudan 2023). Various other data cleaning and metadata skills are also useful. As a tiered gateway towards AI, hiring a data visualization specialist is useful for expanding skills and knowledge for more complex AI initiatives. A data visualization specialist can initially provide support through the creation of dashboards (Figure 9.6), visual representations for analytical projects and data-driven decision making. Visual techniques can be applied to faculty and graduate student research data. Library staff working with researchers can introduce the potential of expanded data repositories and create bridges toward upcoming AI pathways.

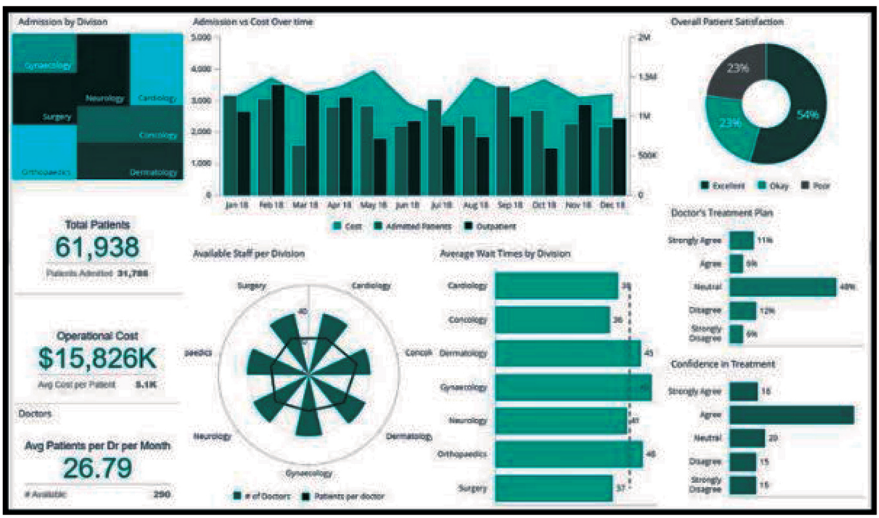

Figure 9.6: Library Data Driven Dashboards as Operational Gateways Towards AI

Artificial Intelligence Learning Paths from Data to Carpentries

As the algorithmic literacy needs of both library staff and the surrounding university research community are recognized and understood, researchers and library staff alike will require more pragmatically oriented foundational coding and data science skills to optimize research data through higher level insights. Education and training for librarians, researchers and faculty should include development of strategies to clean and normalize data along with the use of programming languages like Python.

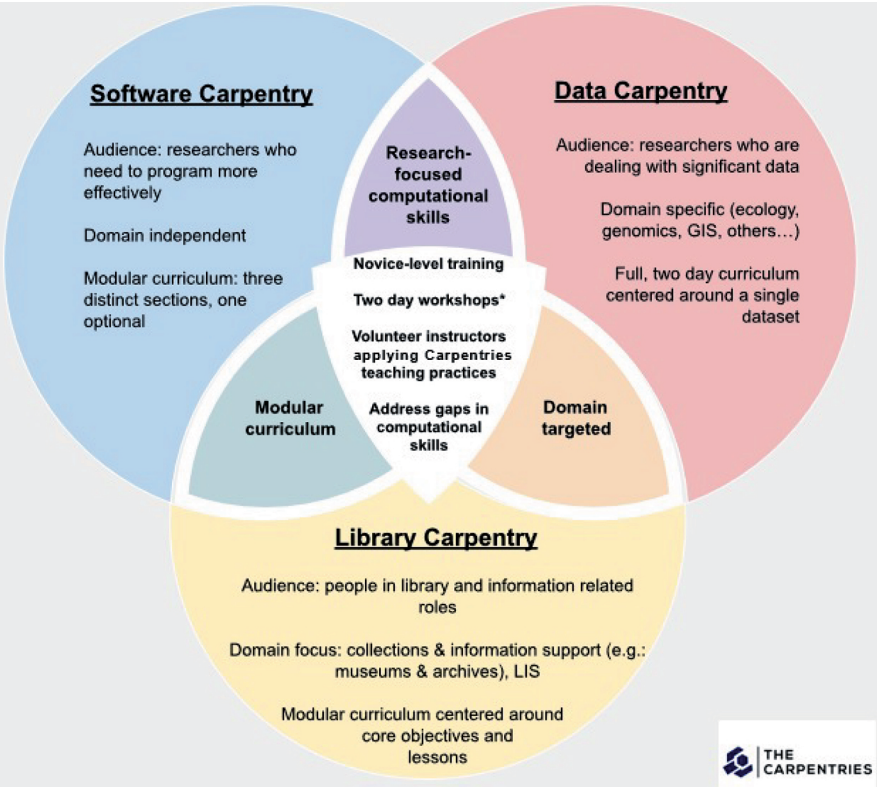

Figure 9.7: Data, Software and Library Carpentries. (Appendix 1A Carpentries n.d.)

The Carpentries is a global community project based in California, US, which provides foundational computational and data science educational programs. The Carpentries' workshops (Appendix 1A The Carpentries n.d.) combine pragmatic programmatic knowledge needed by university researchers and graduate students with algorithmic literacy needs of library staff (Figure 9.7). Collaborative work may begin between research faculty working on learning how to empower their research through effective data organization and programming and library staff who are taking up new methodologies towards enhanced library algorithmic literacy AI infrastructures and programs.

Conferences on Artificial Intelligence

It is important to keep staff both motivated and inspired through understanding benchmarks and milestones being achieved in society in areas like medicine, natural language processing, and games. New library AI conferences are emerging along with specialized sessions at general library conferences and serve the purposes of informing and inspiring. Early conferences included Carnegie Mellon on Artificial Intelligence for Data Discovery) 2019, 2020 (Carnegie Mellon University 2023). The annual Fantastic Futures International Conference on AI for Libraries, Archives, and Museums has been held in various locations ranging from Norway with the 2018 Conference to Canberra, Australia in 2024. AI presentations are now regularly held at library technology conferences such as Computers in Libraries scheduled for March 2024, and events sponsored by the US based Coalition for Networked Information. The activities of the International Federation of Library Associations and Institutions (IFLA) Artificial Intelligence Special Interest Group have sponsored conferences on topics like New Horizons for AI in Libraries in 2022.

Library Artificial Intelligence Prototypes

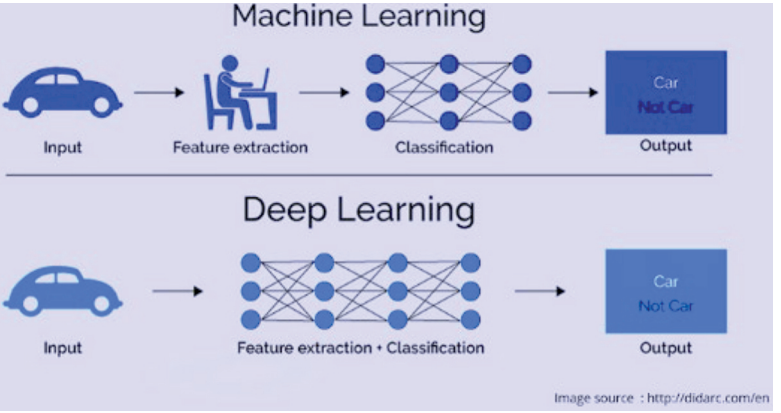

Figure 9.8: Convolutional Neural Net (Uzwyshyn 2022a)

Figure 9.9: Image Extraction Classification (Uzwyshyn 2022a)

Encouraging library staff to pursue AI beta projects allows them to gain initial understandings of the various models for use in machine learning and deep learning (Figure 9.8) and to become familiar with various pieces of the puzzle needed for working on machine learning projects. Involvement in visual AI projects will require knowledge of new tools like NVIDIA graphic cards and skills in image extraction (Figure 9.9). What is important in conducting AI experiments is encouraging staff to think about new possibilities. Understanding processes and possibilities is more important than achieving results at the early stages. Experimenting with protypes provides opportunities for library staff to learn and gain expertise in the various applications of AI to research and development.

Other Artificial Intelligence Training Programs and Experiences

AI library specific institutes and workshops are being offered by organizations like the Institute of Museum and Library Services (IMLS). The IDEA (Innovation Disruption Enquiry Access) Institute on Artificial Intelligence (Table 9.2) is a one-week professional development program for library and information professionals. Initially funded by the IMLS Laura Bush 21st Century Librarian Program (2020–23),

it now operates under the banner of the Association for Information Science and Technology. It has provided a wide range of content related to AI, with the 2020 program held at the University of Tennessee and the 2021 program at the University of Texas at Austin. Some information and library schools are extending their offerings into AI-related areas and offering doctoral programs in specialized areas including AI, which will bring new skillsets into libraries. Organizations like the Council for Library and Information Resources (CLIR) promote and provide programs on both US and global levels (CLIR n.d.).

It is important for library leaders to encourage attendance by library staff at such programs, to write recommendation letters and to ensure motivated employees apply for and attend training programs available. Workshops and institutes motivate staff, provide curriculum content, facilitate sharing of ideas and create new networks for attendees.

Table 9.2: IDEA Institute on Artificial Intelligence

	
• Weeklong Fellows Program at University of Texas, Austin (20 Fellows)	■ AI challenges and opportunities ■ Ethical considerations and guidelines ■ UX-Human/AI Interaction Lifecycle ■ Existing library, archive, and museum projects ■ AI project planning o Project Design o Data collection, classification, and transformation o Roles and implementation ■ Python Basics, Python for Machine Learning ■ APIs and bibliometrics ■ AI in search and discovery ■ Machine learning and coding ■ Harvesting, evaluating, and training data sets for use in AI ■ Conversational AI – Theoretical Foundations ■ Conversational AI – applications ■ Linked Open Data Machine Learning for text with topic modeling and clustering
• Onboarding, • AI Institute • Library Centered AI • Programming Workshops • Final Project • AI Specialist Support	
• Networking with National Library AI Experts • Other Fellows	

Library staff attendance at such programs is essential. Attendees can be offered leadership opportunities through sharing curricula content with others and planning infrastructure development at the local level to meet emerging needs.

Library Collaboration

As libraries retool for the paradigm shift caused by the emergence of AI, so too must parent institutions and associated information technology infrastructures. Adopting new processes and implementing new hardware and software provide unexpected opportunities for collaboration, participation, and partnerships. Many universities are adopting new AI ChatGPT-like (Open AI 2024) infrastructures for students and faculty campus-wide. The use of chatbots presents opportunities for libraries and librarians to utilize old skills in different ways and to develop new skills for improved services to users.

Subject librarians may retrain to gain new skills for AI projects, Previous research skills can be retooled towards new AI research software possibilities or deeper understanding of AI natural language processing models ranging from Open AI's GPT4 to Google DeepMind and other upcoming models. The previous research and instruction librarian can be newly minted in the role of Chatbot Administrator or Prompt Engineer (Cohere 2023; Go 2023; Woodie 2023).

Libraries as Complex Adaptive Systems

Universities are complex adaptive systems (Bryant, Dortmund, and Lavoie 2020) and libraries are dynamic systems within them (Figure 9.10). Patterns emerge from complex interdependencies (Human Dynamics Systems Institute 2024). As patterns emerge from relationships between faculty, librarians, and others, it is helpful to formalize activity through some kind of mechanism such as an AI Working Group. Ideally, the membership of such a group will begin through informal partnerships and collaborations of interested library staff and others within the university or organization. As work ramps up on specific projects, the group should be formalized to continue conversations. Membership of the group can be extended to include university faculty, researchers, and graduate students. Formal structuring of activity will help guide future directions and lead to the development of strategic paths adding innovation and vision to new activities and optimizing the potential use of AI within the university.

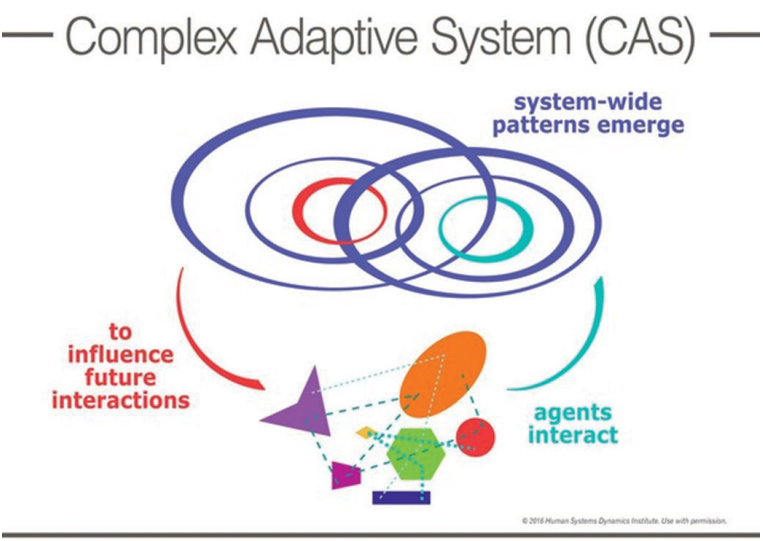

Figure 9.10: Libraries as Complex Adaptive Systems (Human Dynamics Systems Institute 2024)

Conclusion

The new road to library success in AI is largely open (Cordell 2020) and there are further trailblazing opportunities. AI adds value through deriving insight from the vast arrays of data which make up the 21st century academic research library research content areas (Hervieux and Wheatley 2022; Kleinveldt 2022; Nogales, García, and Medina 2022). The prospects of using AI for advances towards the next levels of human knowledge seeking and discovery are huge. The potential for exploration of new connections between ideas from disparate disciplinary sets and making new discoveries with fresh insights is incredible. It is vitally important that libraries and librarians develop knowledge and expertise in AI and its applications. Libraries should be currently taking planned steps along the AI path to begin exploring possibilities and implementing projects which will allow them to deliver new leading edge information services to the communities they serve.

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Appendix 1: Educational Resources on Artificial Intelligence

A. General Video Overviews and Introductions

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B. Machine Learning, Data Science and Python Online Courses

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