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Understanding Artificial Intelligence in Research Libraries: An Extensive Literature Review

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Abstract

Artificial intelligence (AI) now forms a part of various activities in the academic world. AI will also affect how research libraries perform and carry out their services and how the various kinds of data they hold in their repositories will be used in the future. For the moment, the landscape is complex and unclear, and library personnel and leaders are uncertain about where they should lay the path ahead. This extensive literature review provides an overview of how research libraries understand, react to, and work with AI. This paper examines the roles conceived for libraries and librarians, their users, and AI. Finally, design thinking is presented as an approach to solving emerging issues with AI and opening up opportunities for this technology at a more strategic level.

Keywords: artificial intelligence; machine learning; research libraries; literature review

1. Introduction

New technological innovations, such as artificial intelligence (AI), machine learning (ML), natural language processing (NLP), big data, and other

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concepts related to the data science landscape, are surging through the academic world. While private actors, including publishers (UNISILO, 2019) and various start-ups, are eagerly exploring AI to improve their production processes and services, public service providers may seem less proactive.

Research libraries that serve academia and other scholarly communities are at the center of this flux. They browse library technology reports to pick the most appropriate products to support their operations and services, join national or international projects to gain the benefits of collaborative technology development, and follow the progress of academic publishers and other close partners with mixed feelings. In the wake of these new innovations, debates have arisen about their impact on the research ecosystem.

In this paper, we examine the advancement of these new algorithm-powered and artificially intelligent technologies (hereafter "AI") in the context of research libraries (hereafter "libraries"). Amid surging discussions, diverging interests, and an abundance of new technology buzzwords, it seems obvious that libraries need a better understanding of this phenomenon as well as guiding principles to help them deal with the current questions concerning these new technologies and to make sense of their future existence with AI. In particular, libraries need to be able to define their own roles in a changing world and understand the consequences these changes pose for their customers. Interactions with various stakeholders need to be orchestrated, and one viable way is to find and deploy an empathic standpoint.

The complexity of this phenomenon calls for approaches that acknowledge and build on a multitude of viewpoints, aims, values, and trajectories. Both in theory and in practice, design methods propose viable approaches for embracing multiplicity and complexity. Design thinking, understood as the process of deploying designerly methods to achieve organisational goals (Brown, 2008, 2009), and service design, which emphasises the intangible and social characteristics of service production and consumption (Miettinen & Koivisto, 2009), are also gaining approval in the context of public services (Kimbell, 2009; Kimbell & Vesnić-Alujević, 2020). The major benefits of designerly approaches are seen in their ability to address user viewpoints in product development and innovation (e.g., Keinonen, 2010; Whicher, 2017), to foster discourse and frame contradictions toward constructive and situated solutions (Dorst, 2015; Nelson & Stolterman, 2012; Paton & Dorst, 2011), and to inform problem-solving processes with empathy (Gasparini 2015; Koskinen et al., 2003).

The flavour of divergent and convergent thinking at the core of design activities enables us to address complex problems and unforeseen societal issues that emerge from, for example, rapid changes in information and communication technology (Kimbell, 2009). Design methods, such as prototyping and co-designing, may serve organisations as "learning devices to develop strategic responses to changes in their environment" (Kimbell & Bailey, 2017). There is evidence of successful design interventions, including in the library context, when new information systems or organisational collaborations have been introduced and developed (Priestner, 2020, 2021; Young et al., 2020). Thus, the aspect of designerly approaches (hereafter "design") seems worth exploring when discussions on AI in libraries are examined.

AI is a technology that is taking over intellectual capacities previously associated solely with humans. The recent development of, for example, NLP and ML methods and applications indicates that algorithms can overcome human intelligence in some respects, such as the speed and precision of data processing (Stahl, 2021).

There are arguments that stress the importance of a critical view of the social shaping of technology (Dutton, 2013). The well-established conceptual frameworks provided by, for example, Human-Computer Interaction (HCI) studies or Actor-Network Theory (ANT) aim to explain the impact of digital technologies on humans. With regard to AI, these frameworks may seem too narrow. Posthumanistic theories present a worldview that extends from the anthropocentric toward an interrelation of different forms of human and non-human agents (Smart & Smart, 2017).

The prevailing understanding of technology as merely instrumental (the "man versus machine" dichotomy) can prove inadequate for analysing the complex and multiple aspects of interacting with AI. Instead, addressing technology with subjectivity, an agent or actor that is "intimately interwoven in our social fabric" (Braidotti, 2019, p. 32) may better enable an understanding of the full extent of the technological impact on our daily lives (see also the critical accounts of human-non-human cultures by Collomb and Goyet, 2020, and Thompson, 2019, p. 145–153). Moreover, the interdependence of humans and the technology that we have designed for ourselves (Latour, 2013), or the fact that these tools shape our existence in an ontological manner (Escobar, 2018), suggest that it is imperative to look at these new technologies and their role in the process of interaction.

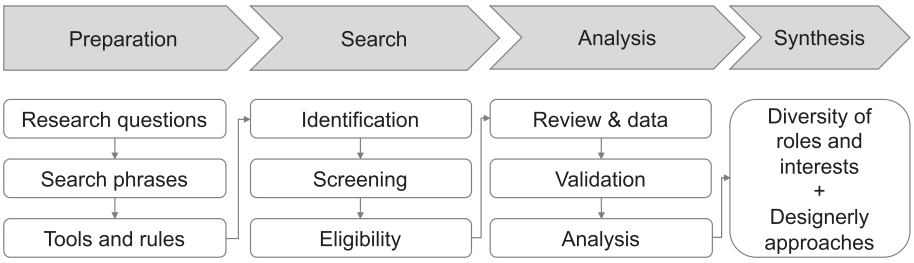
The goal of this study was to find paths that aid libraries in the age of AI. To achieve this, we conducted an extensive literature review of various publication repositories and indexes with the aim of discovering literature on AI technologies in libraries. Converging toward the notions of design and posthumanistic thinking, we specifically explored the roles dedicated to the different actors in the literature. We paid attention to the center of focus when engaging with AI and sought to detect case examples of feasible designerly approaches.

2. Review methodology and procedures

The aim of the study was to form an understanding of the current status of the research and the diversity of discussions on the field. We applied explorative and extensive, yet systematic, review methodologies. Figure 1 depicts the process of the study from preparation through the literature search and inductive content analysis to the final synthesis.

The research question(s) (RQ) that cover the researchers' areas of interest drive the study process and reveal the relevant elements for further analysis (Foster & Jewell, 2017; Hart, 1998). As libraries and their users are the most obvious stakeholders in the adoption of new technologies, we decided to examine the literature from their perspectives. Inspired by the theories of posthumanism, we also wanted to seek indications of AI itself as a non-human agent. Finally, instructed by the literature on design, we sought examples of designerly approaches in libraries' AI deliberations.

Fig. 1: Phases of the study.



The following research questions scan the problem area from these perspectives:

> RQ 1: How is the role of libraries and/or librarians described in relation to library users and AI?
>
> RQ 2: How is the role of the user of research libraries (students, researchers, and citizens) described in relation to AI and libraries?
>
> RQ 3: How is the role of AI (i.e., the non-human entity) described in relation to libraries and their users?
>
> RQ 4: What is the role of design (if any)?

The following search phrases, utilising Boolean operators, provided an adequate body of publications for our review:

- Artificial intelligence AND ("academic librar*" OR "university librar*" OR "research librar*")
- Machine learning AND ("academic librar*" OR "university librar*" OR "research librar*").

We considered the free but robust online tools provided by Google and Zotero most efficient for cross-organisational collaboration. Our most important tool was an online sheet (called "the matrix"), which we used to take down detailed notes about each paper and each research question. In the analysis phase, we used the online visualisation tool Padlet to compose affinity diagrams and to elaborate on the conclusions.

We refined the screening rules and eligibility criteria while the search proceeded. Since our aim was to capture academic and professional discussions in this field, we accepted all types of papers, including scientific articles, white papers, and even event reports.

We extended the search to several available platforms. Our review included material from various discovery services and databases: ACM, Emerald Insight, Jstor, Scopus, Science Direct, Web of Science, and LISSA. We identified almost half of the articles that fitted the eligibility criteria from the first resource, but our persistent search resulted in several more articles from other resources. We conducted the first round of searches in July 2020 and

selected 152 papers for closer review. In October 2020, a complementary search resulted in seven papers that were published after the first round.

At the beginning of the analysis phase, we both read an equal share of the papers, made notes about each paper, extracted key concepts and phrases, and transcribed some citations on the notes sheet. This phase revealed that some texts could not answer any of the research questions, and they were excluded as irrelevant. The final body of literature accepted for further analysis consisted of 126 texts.

To verify the accuracy of the content analysis, and thereby the reliability of the review findings, we chose an analogical approach. In total, we selected 25 papers for a comparison, which corresponded to approximately 20 per cent of all the papers in our review. When we compared the notes that each of us had produced for this sample of papers, we found them to be highly conformant. Therefore, we considered the rest of the analysis acceptable.

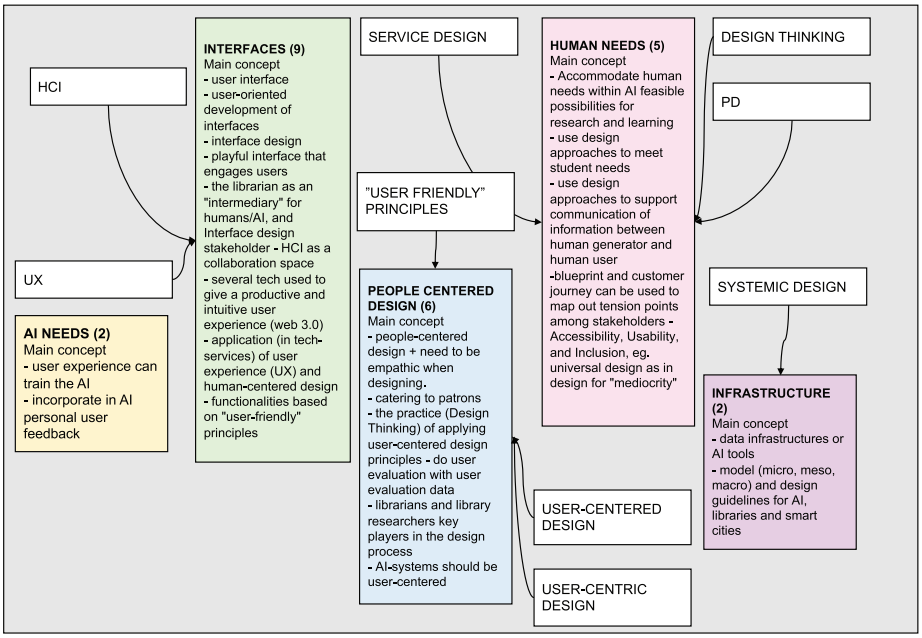
The abstraction and interpretation of field data are key challenges for the trustworthiness of qualitative research (Elo et al., 2014; Holtzblatt & Beyer, 2017). In this study, this required several rereadings, concept creations, and affinity iterations before we had the final list of codes, that is, the concepts explaining the corresponding and relevant themes for each research question. First, we identified and named emerging themes or patterns from the notes for each research question. Then, to better arrange the themes in categories, encapsulate the essence of the themes into codes, and eliminate avoidable overlapping of the codes, we utilised the visualisation capacity of Padlet and composed affinity diagrams for all four research questions (see the example in Figure 2 and the definition of affinity diagrams in Holtzblatt & Beyer, 2017, p. 127–146). The final list of codes in Appendix A serves as a "categorisation matrix" (see Elo et al., 2014) that represents the identified and relevant themes from the content.

3. Findings

3.1. Overview of the literature

More than one-quarter of the literature comprises position papers (33/126), a fraction of which are targeted at library professionals (14/126), while the

Fig. 2: Affinity diagram of the roles of design (RQ4).



majority contribute to academic discussion (79/126). A total of 41 articles (out of 126) fulfilled the criteria for a conceptual or theoretical research paper. Of the papers, 32 build their arguments on empirical findings from a case study or real-world project. The publications extend over six decades. The first article in the review was from 1975 and the last was from October 2020. Almost half of the papers were published after 2018, signifying a growing interest in the topic.

3.2. Role of the library and librarians

The first research question focuses on the roles proposed for libraries and library staff in relation to the new technology emerging in the research ecosystem. Even though the literature was accepted for review due to its connection with the research library business, 30 per cent of the papers (38/126) do not explicitly address any role for a library or its staff. The remaining 88 papers express a variety of roles for libraries.

Our review detected seven distinct, implicit roles for people working in libraries. The following codes indicate the distinction between the activeness or passiveness of the proposed role and a library's relation to other active agents:

- Professional using AI tools and services (L-1)
- Professional developing AI tools and services (L-2)
- Guardian of values (L-3)
- Investigator of change (L-4)
- Professional replaced by AI (L-5)
- Partner/participant in change (L-6)
- Agent of desirable change (L-7).

The most prominent roles depicted for librarians are related to the development of new tools and services based on AI technologies. Most of the texts emphasise that librarians need to develop their skills as users of new AI technology (code L-1, 43/126 papers) and abandon their old paradigms, practices, and workflows, for example, by producing metadata (Yelton, 2019). These skills are needed at different levels of library operations, from customer services and collection management to strategic management and leadership (e.g., Rubin et al., 2010; Siguenza-Guzman et al., 2015). The librarian's role as a knowledge professional would remain, but the new technology would require a scaling up of professional competencies (e.g., Adams Becker et al., 2017; Nolin, 2013; Walker & Jiang, 2019).

A few papers extend future library expertise even further to the development of AI-based tools and services (code L-2, 8/126 papers). These authors are willing to assign new technology-intensive tasks to librarians, including the preparation of ML training data (Griffey, 2019b; Maringanti et al., 2019), the definition of data capture criteria (Hähner & Seeger, 2009), or the evaluation of AI outputs (Griffey, 2019b). Some authors propose that librarians could be assigned to the development and procurement of automated systems (Walch, 1993) or the design of new services (Cox et al., 2019b; Gasparini et al., 2018; Hepworth, 2007).

Librarians' institutionalised experiences in trustworthy knowledge management and delivery are viewed as virtues to be nurtured or inconveniences to be eliminated. Of the papers, seven highlight librarians' central role in safeguarding societal values (code L-3, 7/126 papers); libraries are seen as

guardians of free and unbiased knowledge (Johnson, 2018, 2019), algorithmic literacy (Ridley, 2019), ethical provision of access (Schneider et al., 2019), and democracy (Ylipulli & Luusua, 2019) or as havens of old-school information technology (including books) and people (Steele, 2011).

In the review, six authors express an investigation-oriented role for libraries (code L-4, 6/126 papers), highlighting the need to survey libraries' opinions on change (Ali et al., 2020), monitor the change (Cox et al., 2019a; Frederick, 2017; Lorang et al., 2020), or conduct library and information science research (Gorichanaz et al., 2020; Kushkowski et al., 2020). In contrast to these views, three authors forecast that AI will eventually replace librarians (code L-5, 3/126 papers). When librarians' professional expertise and behaviour are transferred to automated operations, there may be no need for librarians in the scholarly ecosystem (Asemi et al., 2020; Bethard et al., 2009; Ewing & Hauptman, 1995).

There are eight papers that emphasise that libraries can be seen as valued partners and collaborators in the change (code L-6, 8/126 papers). Libraries can harness existing structures of collaboration with schools and other educational institutions by providing tutorials or other learning materials that aid in understanding AI technology and its implications (EDUCASE, 2020; Massis, 2018; Watkins, 2019). Learning algorithms should be taught with relevant materials, and the outcomes should be validated against human-quality criteria. This is considered to be a new area in which librarians and archivists can become distinguished partners (Johnston & Weckert, 1990).

Libraries can also reach out to new fields of expertise and play an active role in the development of new services or research infrastructures. Kennedy (2019) and Muehlberger et al. (2019) encourage librarians to engage in interdisciplinary collaboration with computer scientists, developers, humanities scholars, and other researchers because the enterprise requires expertise from different fields. Through active participation in the change, libraries will become (or maintain their role as) crucial research infrastructures, serving as "amplifiers" for research (Burton et al., 2018; Finnemann, 2014).

The review included 12 articles that suggest an even more active role for libraries: they should not just participate in the development of AI but should drive desirable change as proactive agents (code L-7, 12/126 papers). The authors argue that by positioning themselves at the forefront of

transformation, libraries can safeguard their interests and ensure that their values are respected.

The traditional role of libraries as trusted partners in research communities provides libraries with an opportunity and responsibility to educate their patrons on AI-related topics (Head et al., 2020; Lund et al., 2020; Wheatley & Hervieux, 2019). As the new technology entails issues of bias, social justice, and privacy, education in information literacy should be extended to new areas of digital ethics (Griffey, 2019a; Head et al., 2020). A proactive role can also be achieved through experiments with AI. Libraries could host AI laboratories in which their patrons and personnel learn how to deal with new technology (Griffey, 2019a; Jakeway, 2020; Kim, 2019a). Librarians could even take the lead in designing and integrating practical uses for AI technology in library systems and services (Exlibris, 2019; Lund et al., 2020).

In the service of better science, libraries could also be considered responsible for thinking critically about the relation between humans and technology. The future will require the integration of the expertise of human librarians with the intelligence of machines (Cordell, 2020). By asking the right questions, librarians may be able to "tame the demon" and help judge whether a task should be assigned to a machine or accomplished by a human (Bourg, 2017). In strategic planning processes, librarians could compensate for a lack of humanistic spirit in the often technology-focused conversation (Cao et al., 2018). Some consider it imperative for libraries to take a leadership role in the broader societal discussion about responsible technology (Cordell, 2020).

3.3. Role of the user

The second research question is an exploration of the different roles that library users (students, researchers, and citizens) can play when they relate to upcoming AI-based services. From this viewpoint, 79 papers were considered relevant, while 47 did not indicate any identifiable role for users. The affinity work denoted users as follows:

- Information seeker (U-1)
- Being exploited by AI (U-2)
- Victim of bias (U-3)
- Community member (U-4)

- Learner of AI technology (U-5)
- Consumer of AI services (U-6)
- Beneficiary of AI help in knowledge creation (U-7)
- Part of a trade-off with AI (U-8)
- Co-designer (U-9)
- Bypassing librarians (U-10).

In total, nine papers (code U-1, 9/126 papers) define users as information seekers, with their quest, insecurity, and willingness to use a research library. Seeking information is the first user-wise approach to AI in the context of a research library (Golub et al., 2020; Wang, 2011). As information seekers, users of libraries should be able to find resources quickly and accurately (Wen & Li, 2019) and become informed patrons (Miller, 2020). Today's systems are often difficult to use, and resources are often in different locations (Wen & Li, 2019). A first step could be to enrich library metadata with correct tags (Voorbij, 2012) and the interests and needs of a "great variety of users" (Niininen et al., 2017). In libraries, users, their needs, and their data, such as library usage and website visits, have always been kept secret (Johnson, 2018), but this is undergoing a change.

The review showed examples of exploitation in 11 papers (code U-2, 11/126 papers), whereby the data provided by patrons are used to analyse users' satisfaction (Ochilbek, 2019; Yue & Jia, 2008) or to make predictions concerning future requests (Litsey & Mauldin, 2018). Facebook posts from patrons can also be used to predict responses to different types of library posts (Gruss et al., 2020). Library patrons could thus be victims of AI transformation when a system adjusts itself to the user data received without a user's explicit interaction (Asemi et al., 2020; Johnson, 2018). Moreover, if robots are introduced into libraries, they may exploit sensitive data by misusing students' observed or shared private matters (Kim, 2019b).

A few papers (code U-3, 6/126 papers) pinpoint problems with bias in the metadata inserted into library systems over many decades and now used in algorithms (Brygfjeld et al., 2017). Nowadays, the tuning of algorithms and AI-based tools causes these biases to emerge, and in the worst case, they become reinforced (Schoeb et al., 2020). These effects may have unprecedented results on already vulnerable groups of citizens (Padilla, 2019). In an academic context, blindly trusting systems that have "implicit bias programmed into them" will lead to dubious research results (Benedetti et al., 2020; Henry, 2019).

The context of which a community member is part, or entering, is considered by two papers (code U-4, 2/126 papers). Guerra and Da Silva (2008) propose a system that reacts to information that users share with a handheld device when moving around a library, while Ylipulli and Luusua (2019) address the role of a library as part of a city.

A total of 12 papers regard competence as crucial (code U-5, 12/126 papers), with a proactive and non-passive approach to AI from patrons being necessary. In an already established AI lab, one of the goals is to support "self-directed learning and peer-to-peer learning among students" (Kim, 2019a). However, libraries have a crucial role to play in identifying and presenting this new digital evolution to "help increase user adoption and staff acceptance" (Wheatley & Hervieux, 2019), and librarians should be involved in teaching patrons about the implications of data-driven decision systems (Head et al., 2020; Massis, 2018; Morriello, 2019). Users need AI literacy to explore new ways of understanding their own fields (Adams Becker et al., 2017). AI literacy may also avoid misunderstandings, as users might otherwise believe that AI gives normative outputs "rather than descriptive fact" (Yelton, 2019, p. 14). Moreover, patrons need this competence to react to "systems of surveillance and algorithmic injustice" (Cordell, 2020) and avoid a new digital divide: "a class of people who can use algorithms and a class used by algorithms" (Ridley, 2019, p. 36).

In our review, 12 papers indicate the user as a consumer of AI services (code U-6, 12/126 papers). A motivation for researchers to search for help from AI is the need to be able to tackle new and varied media and the growing production of knowledge (Finnemann, 2014), access them more easily (Garzone & Mercer, 2000; Steele, 2011), and gain better search strategies (Dent, 2007).

The analysis of the papers revealed a variety of services of additional epistemic value to patrons when in use (code U-7, 8/126 papers). A paper by Hofman-Apitius et al. (2009) presents an ML-enhanced tool to extract biological information from text. There are papers that argue for the role of patrons in sustaining lifelong cooperation with AI (Lee, 2011; Wang & Cao, 2014), with different and novel types of services (Koehler, 2004; Porcel et al., 2017). Finally, library staff and patrons need to understand all aspects of how this new technology wave will shape research (Jakeway, 2020; Kennedy, 2019).

A group of papers (code U-8, 9/126 papers) takes a different approach, arguing for a trade-off between AI and its users. In some cases, users give

away their personal data to achieve better service (Alam et al., 2020; Iqbal et al., 2020) and personalised recommendations (Hahn & McDonald, 2018; Hepworth, 2007; Zhu & Wang, 2007) through personalised search engines (Montaner et al., 2003; Porcel et al., 2009). Research has also found methods to use algorithms to develop users' recommendations for relevant books using small amounts of data (Neumann & Geyer-Schulz, 2008). Libraries also do this work using circulation data (Lund, 2020).

Patrons can also play a more prominent role when AI services are conceived according to six papers (code U-9, 6/126 papers). Co-designing AI-based services with patrons would allow smart libraries for and by humans to become more truthful (Cao et al., 2018; Gasparini et al., 2018). After all, user-centered development of education services (EDUCASE, 2020) and library systems for information retrieval (Keshavarz, 2008) and user cultivation are crucial and also require context awareness in the design process (Cox et al., 2019b). As explained by Cabrerizo et al. (2015), library systems must consider a "multitude" of users.

The last topic (code U-10, 4/126 papers) emphasises how users can bypass librarians and make them obsolete (Ewing & Hauptman, 1995), as patrons have access to better and faster services elsewhere.

3.4. Role of AI (non-human)

In addition to looking at the roles of librarians and library users, our review aimed to find indications of the roles given to intelligent technology (i.e., a non-human entity). The authors' expressions were examined, grouped by their affinities, and coded. While the differences between the roles can be small and ambiguous, it seemed important to interpret the slightest indication from the authors of a non-human counterpart's autonomy and status in the relationship between human and non-human in the context of libraries and their services. In total, one-third of the papers (41/126) did not indicate any identifiable role for the technological counterpart.

Our review revealed seven distinctive roles for AI (non-human), as defined by the following codes:

- Tool/system (AI-1)
- Extension of human skills (AI-2)

- Replacement of human skills (AI-3)
- Black box (AI-4)
- Mediator (AI-5)
- Agent/actor (AI-6).

Many of the authors address new technology as a useful tool or system (code AI-1, 51/126) or beneficial extension of human skills (code AI-2, 8/126). This viewpoint is most obvious in research and case reports that describe the concept or features of new applications for a variety of library services and operations, including acquisition and circulation (e.g., Iqbal et al., 2020; Ochilbek, 2019; Walker & Jiang, 2019), classification and subject indexing (e.g., Bethard et al., 2009; Golub et al., 2020; Suominen, 2019), resource retrieval and recommendations (e.g., Färber & Sampath, 2020; Hahn, 2019; Hahn & McDonald, 2018; Smith, 1976), or overall performance analysis (Ennis et al., 2013). These tools are described as automating some laborious or error-prone library operations, enabling faster processes in larger volumes and assisting with librarians' tasks.

Our review also included papers describing new instruments for use by researchers and students. These intelligent research assistants can help with tasks such as literature searches and reviews (see Schoeb et al., 2020), knowledge discovery/extraction (see Hofman-Apitius et al., 2009), and library customer services (e.g., Allison, 2012; Rubin et al., 2010).

The review included three position papers that warn about the unpredictable, opaque, and potentially biased nature of algorithms—black-box systems (code AI-4, 3/126, e.g., Cox et al., 2019b). For three authors, intelligent technology represents a threat that can replace human skills in libraries (code AI-3, 3/126, e.g., Steele, 2011).

In six papers, the role of intelligent technology was considered to be less of an instrument for librarians or library customers and more of a mediator (code AI-5, 6/126) in the process of change. Some authors argue that the transformative power of AI and ML does not emerge from the technological innovations themselves but from the changes they impose on research library practices (Finnemann, 2014; Lorang et al., 2020). By incorporating new technologies into their services, librarians will be able to learn new skills and build new tasks and professional roles for themselves (Benedetti et al., 2020; Nolin, 2013).

Finally, 14 papers indicate an active role for AI as an agent or actor with more or less human capabilities (code AI-6, 14/126). When referring to intelligent technology, the authors use human-like expressions, such as "stakeholder," "intermediary expert," "intelligent agent," "assistant," "companion," and "research buddy," and indicate more independent than instrumental activities for these technologies (e.g., Dent, 2007; Gasparini et al., 2018; Iantovics et al., 2016; Kim, 2019b; Koehler, 2004; Riddick, 1990). Computer programs and algorithms may be considered autonomous managers and producers of information and even autonomous problem solvers (Bourg, 2017; Gorichanaz et al., 2020; Wang, 2011). By freeing librarians' time for other tasks, machines can independently tailor content to meet users' needs, locate connections in a large set of data, and facilitate users' interactions with library services (Kim, 2019a; Adams Becker et al., 2017). Some authors argue that systems using algorithms should or can already be considered new users of library materials and services (Bourg, 2017; Miller, 2020) or even new types of scholars (Johnson, 2019).

Some papers in the review also examine the autonomous role of a non-human entity from a wider perspective and consider the consequences for society overall. Algorithm-based technologies are considered to gain authority that requires assessment with the same rigor relevant to all aspects of the academic mission (Ridley, 2019). These technologies will also enter libraries from the surrounding environment and via public authorities (Ylipulli & Luusua, 2019) or partners, such as publishers (Riddick, 1990).

3.5. Design

Only 24 papers (24/126) approach design in various ways to underpin the use of AI in the context of libraries. Affinities on the goal or focus of design were detected and grouped accordingly. The following five main themes emerged:

- Interfaces (D-1)
- People-centered design (D-2)
- Human needs (D-3)
- Infrastructure (D-4)
- AI needs (D-5).

In total, nine papers (code D-1, 9/126 papers) address an obvious need when using AI-based services in the context of libraries: the design of interfaces or, more specifically, HCI. The interaction should be playful to ensure engagement (Allison, 2012), use interface design to accomplish a good experience (Cao et al., 2018), and apply user-friendly principles (Bao et al., 2017). However, this user-oriented development of interfaces is complex. For instance, Myhill et al. (2009) argue for the focalisation of several technologies (e.g., semantic web, microformats, natural language search, data mining, ML, and recommendation agents) to offer a productive and intuitive user experience. Enis et al., 2018 call for the application of user experience and human-centered design in technology-related fields. This perspective is also supported by Cordell (2020), who aims to use HCI as a collaboration space for relevant stakeholders, such as researchers, librarians, and designers.

The second theme, "People-centered design" (code D-2, 6/126 papers), addresses a holistic view of patrons (Hepworth, 2007). This empathic reaching out to users includes all the perspectives necessary to offer them the correct learning context and content that suits them. Library staff and their skills also play an important role in the development of services. Federer et al. (2020) address the new Open Science activity in libraries to explain why library staff need various skills, including design thinking, to be able to include ML-based solutions. Librarians are considered highly relevant stakeholders in the design process (Dent, 2007). However, as Guerra et al. (2008) point out, usability testing and user data must be gathered before or during the development of systems. In the intersection between AI and libraries' efforts to include all users, the Adams Becker et al. (2017) mentions a project that aims to design for the visually impaired. Future systems used in libraries must be user-centered (Benedetti et al., 2020) and focus on accessibility, universal design, and data concerning patron needs.

A total of five papers (code D-3, 5/126 papers) propose a designerly approach to human needs when encountering AI-based services. Even though user-centered design emphasises a focus on patrons, Uzwyshyn (2018) argues for a holistic approach, using Design Thinking, to understand and accommodate users. Two other articles also argue for inclusion and universal access for all (Gasparini et al., 2018; Koehler, 2004), and there is a call for design to be inclusive and to take all kinds of users into consideration. One relevant source of insight into libraries is information science, as this supports the

communication of information between the "human generator and human user" (Keshavarz, 2008, p. 354).

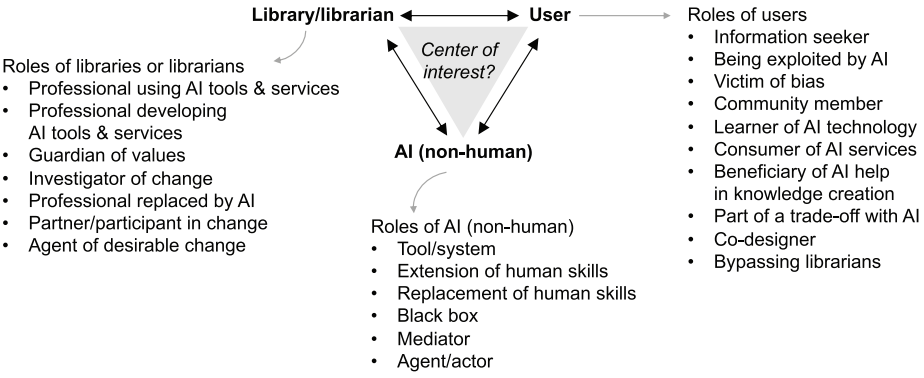
The term infrastructure is used in two papers in the context of designing AI for libraries (code D-4, 2/126 papers). Finally, the analysis revealed the theme of "AI needs" (code D-5, 2/126). From this perspective, AI is an entity with its own need for large quantities of correct data (Brygfjeld et al., 2017; Hahn & McDonald, 2018).

4. Discussion

4.1. Diversity of roles and interests

In this study, we examined the roles of libraries or librarians (RQ 1), the roles of library users (RQ 2), and the roles of AI (the non-human entity) (RQ 3) in the context of library operations and services. The analysis of the findings was informed by posthumanistic theories that contest the taken-for-granted authority of humans (Braidotti, 2019) and call for an examination of the power balance between the entities, including during everyday interactions with technology (Collomb & Goyet, 2020). Figure 3 displays the diversity of roles detected in the literature, which indicates the shifting center of interest.

Fig. 3: Diversity of roles indicates the shifting center of interest.



The roles conceived for libraries or librarians in the adoption of AI technology vary from a neutral investigator or a dutiful professional learning to use new tools to a responsible agent or even a champion of desirable change. Nevertheless, the underlying message seems to be a desire for continuity. "We must continue to find ways to make the machines work for us" (Arlitsch & Newell, 2017). The varying roles given to the non-human entity seem to indicate the authors' trust or mistrust in the survival of the librarian profession. A strong tension between continuity and extinction characterises the contemporary technology-related worldview and discourses in this review and in wider discourses on AI (e.g., Gill, 2017).

The roles conceived for library customers as users of AI-enhanced tools or services reflect the ethical justification dimensions of protection and appreciation characteristics in the discipline of user-centric design (Keinonen, 2010; cf. Kimbell, 2019). In the context of libraries, as shown by our literature review, users can be appreciated as active information seekers, learners, knowledge creators, co-designers, or even cunning traders in AI, or they need to be protected from the bias of or exploitation by AI. For example, libraries are encouraged to warn their patrons to be careful about what they reveal of their identity to AI-based systems when they seek access to the required information. In contrast to these ethical viewpoints, our review revealed a more ambivalent approach: data from and about users can also be seen as an asset that libraries can exploit to improve their services. Libraries should understand the power they hold over their customers and critically reflect on their use of data analysis technologies.

4.2. Designerly approaches to AI in research libraries

The analysis of the literature revealed an abundance of roles and tensions that are built up from the central point of interest. In addition to traditional library-centric approaches to new technology, the results show that libraries are committed to adopting user-centric viewpoints and methods that involve their patrons. Ultimately, a few papers present AI-centric notes on the new phenomenon. The literature indicates that the new technology entails considerable uncertainty about how libraries can approach this phenomenon.

Posthuman theories promise to provide conceptual mechanisms to span the divides between viewpoints and have the potential to ease tensions, for

example, by suggesting decentering or reconfiguring relationships between counterparts (Collomb & Goyet, 2020). However, these theories do not provide practical methods for tackling everyday challenges or for developing the strategies that libraries desire as they face their future with AI. Closer to organisational life, design studies have offered clusters of ideas and practices that help tackle product and service innovation (Brown, 2008, 2009), as well as institutional policies and strategies (Kimbell, 2009; Kimbell & Vesnić-Alujević, 2020). Designerly approaches that involve stakeholders with empathy and appreciation have also become more visible in the development of new library services (Gasparini, 2020; Kautonen & Nieminen, 2018).

The findings from the literature review show that the full potential of different designerly approaches and methods has not yet been used for AI strategies (RQ 4). The perspective from which design has been viewed is rather narrow and limited to solving problems of user interface design (human-AI interaction). There have been some experiments using design methods, such as blueprints and customer journeys, to map out tension points among stakeholders, but none of these experiments seems to extend this mapping to the special characteristics or needs of AI. Yet, the qualities of intelligent technology (for example, the ability to provide information on its own activity) may be essential for revealing potential biases or balancing power relations between non-human technology and human library users. To avoid the anthropocentric perspective of technology as mere tools or as entities with mythical potency, machines should be granted an agency on their own terms (Collomb & Goyet, 2020). Designerly approaches could provide applicable means and instruments for this.

4.3. Limitations

The outcomes of this study are dictated by the research questions that focus on the diversity of roles and, specifically, on indications of designerly approaches. The literature affords findings from many other viewpoints, and would therefore be a rich resource for questions about library operations influenced by AI. As the increasing number of publications in the area of AI indicates, libraries (and archives and museums) are eagerly experimenting with AI technologies and investigating this new phenomenon. However, there seem to be few suggestions for strategic or managerial approaches for libraries. The application of rapid (and even AI-enhanced) literature review

methods in this review may have enabled the inclusion of the latest publications and thereby new arguments on appropriate strategies. Since we relied on traditional review methods, we were able to build a profound insight into the discussion. Despite these limitations, this study reveals the diversity of approaches that libraries take to AI.

5. Conclusions

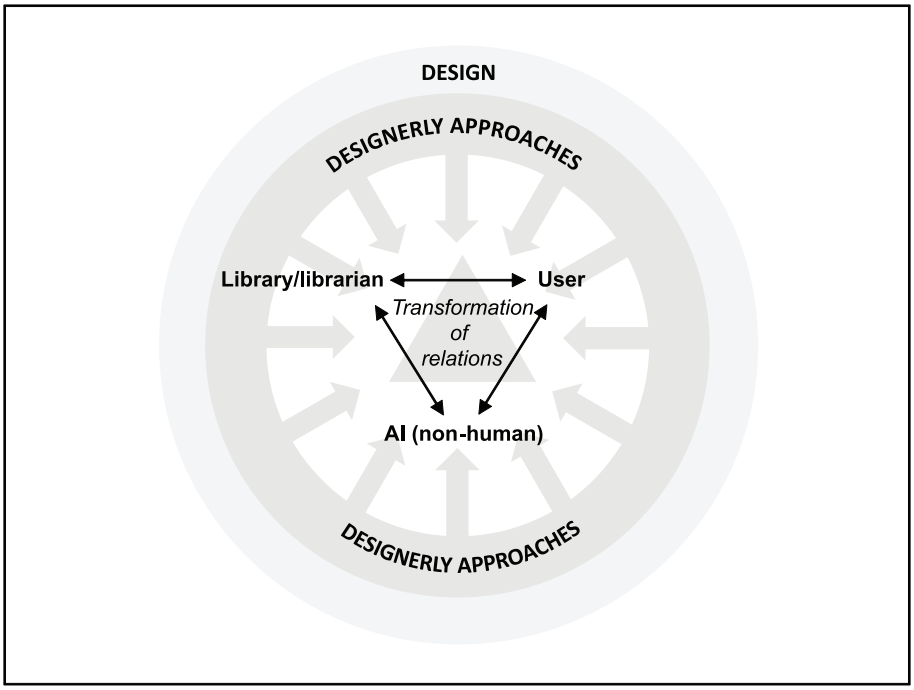
This study presents an extensive literature review on the topic of artificial intelligence (AI) technologies in the context of research libraries. The analysis of the findings from 126 papers reveals an abundance of roles conceived for libraries or librarians, their users, and AI (the non-human entity), as well as the tensions that build from the central point of interest. Libraries' motivation to engage with new technology appears to vary from techno-optimism to the fear of machines surpassing librarians and eradicating human values. This study broadens the discussion of the strategic approaches that libraries can take in their endeavours for their future with AI.

In this study, our proposition is to use designerly approaches to ensure, first and foremost, an appropriate understanding of library users' perspectives (see Figure 4). There are a multitude of viable methodologies that entail elaborative forces, including innovation, empathy for the user, and the inclusion of organisational issues. Designerly approaches seem justified and well suited to frame the transforming relations between libraries, their users, and AI.

The literature included in our review highlights encouraging examples of libraries approaching this complex phenomenon with design methods. This gives reason to assume that the elaborative forces of design could be employed to solve emerging issues and to open up opportunities for AI on a more strategic level. Questions concerning ethical transparency, adequate competence development in libraries, or appreciation of AI as an independent agency, among others, deserve more theoretical and practical elaboration. Attention should also be paid to the intersection of libraries and their stakeholder communities.

As a conclusion to this study, we foresee a more profound transformation in the relationships that libraries have with their customers, the new technology,

Fig. 4: Designerly approaches framing the transformation of relations between libraries, their users, and AI.



and its developers. Future research could investigate the transforming role and work practices of libraries and their staff that result from the increasing use of AI in research. Closely related to this, the new forms of information literacy deserve a closer look from research libraries, whose core task is to empower their patrons in the AI-enhanced information environment. Finally, we would like to see more experiments that study the role of design as a broker for competence and as a supporter of the changing interactions between the new technology, libraries, and their patrons.

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Appendix A: Table of codes

Code ID	Code name	Occurrences	References (max. 10 examples)
RQ 1 Role of Library/staff			
L-1	Professional using AI tools & services	43	(e.g., Adams Becker et al., 2017; Arms, 2012; Boman, 2019; Clough et al., 2011; Hjørland, 2012; Ibekwe-SanJuan, 2006; Madhusudhan & Nagabhushanam, 2012; Ramanayaka et al., 2016; Siguenza-Guzman et al., 2015; Walker & Jiang, 2019)
L-2	Professional developing AI tools & services	8	(e.g., Cox et al., 2019b; Gasparini et al., 2018; Golub et al., 2020; Griffey, 2019b; Hepworth, 2007)
L-3	Guardian of values	7	(e.g., Henry, 2019; Johnson, 2019; Ridley, 2019; Steele, 2011; Ylipulli & Luusua, 2019)
L-4	Investigator of change	6	(Ali et al., 2020; Cox et al., 2019a; Frederick, 2017; Gorichanaz et al., 2020; Kushkowski et al., 2020; Lorang et al., 2020)
L-5	Professional replaced by AI	3	(Asemi et al., 2020; Bethard et al., 2009; Ewing & Hauptman, 1995)
L-6	Partner/participant in change	9	(e.g., Burton et al., 2018; Finnemann, 2014; Kennedy, 2019; Massis, 2018; Padilla, 2019)
L-7	Agent of desirable change	12	(e.g., Griffey, 2019a; Head et al., 2020; Jakeway, 2020; Kim, 2019a,b; Wheatley & Hervieux, 2019)
	No role	38	(e.g., Golub, 2006; Guo et al., 2015)
RQ 2 Role of users			
U-1	Information seeker	9	(e.g., Du, 2020; ExLibris, 2019; Golub et al., 2020; Miller, 2020; Niininen et al., 2017; Stribling et al., 2005; Voorbij, 2012; White et al., 2014)
U-2	Being exploited by the AI	11	(e.g., Asemi et al., 2020; Johnson, 2018, 2019; Kim, 2019a,b; Ochilbek, 2019)
U-3	Victim of bias	6	(Benedetti et al., 2020; Fox, 2010; Henry, 2019; Padilla, 2019; Schoeb et al., 2020; Zhu et al., 2018)
U-4	Community member	2	(Guerra & Da Silva, 2008; Ylipulli & Luusua, 2019)
U-5	Learner of AI technology	12	(e.g., Adams Becker et al., 2017; Cordell, 2020; Head et al., 2020; Ridley, 2019; Wheatley & Hervieux, 2019)
U-6	Consumer of AI services	12	(e.g., Färber & Sampath, 2020; Finnemann, 2014; Hauptmann et al., 1997; Rubin et al., 2010; Steele, 2011; Suominen, 2019)
U-7	Beneficiary of AI help in knowledge creation	8	(e.g., Hofman-Apitius et al., 2009; Jakeway, 2020; Kennedy, 2019; Lee, 2011; Riddick, 1990)
U-8	Part in a trade-off with AI	9	(e.g., Hahn & McDonald, 2018; Hepworth, 2007; Iqbal et al., 2020; Neumann & Geyer-Schulz, 2008; Porcel et al., 2009)

Appendix 1; continued

Code ID	Code name	Occurrences	References (max. 10 examples)
U-9	Co-designer	6	(Cao et al., 2018; Cox et al., 2019b; EDUCASE, 2020; Gasparini et al., 2018; Javier Cabrerizo et al., 2015; Keshavarz, 2008)
U-10	Bypassing librarians	4	(Arlitsch & Newell, 2017; Ewing & Hauptman, 1995; Gorichanaz et al., 2020; Nolin, 2013)
	No role	47	(e.g., Stehno & Retti, 2003; Wetzler et al., 2009)
RQ 3 Role of non-humans			
AI-1	Tool/system	51	(e.g., Alexander et al., 2019; Baba et al., 2016; Iqbal et al., 2020; Jadhav & Shenoy, 2020; Kanarkard et al., 2017; Rubin et al., 2010; Schoeb et al., 2020; Tsuji et al., 2014; Von Seggern et al., 2010; Walker & Jiang, 2019)
AI-2	Extension of human skills	8	(e.g., American Library Association, 2019; Cordell, 2020; Mitchell, 2006; Rah et al., 2010; Schneider et al., 2019; Walker & Jiang, 2019; Yelton, 2019)
AI-3	Replacement of human skills	3	(Asemi et al., 2020; Ewing & Hauptman, 1995; Steele, 2011)
AI-4	Black box	3	(Cox et al., 2019b; Griffey, 2019a; Henry, 2019)
AI-5	Mediator	6	(Benedetti et al., 2020; Finnemann, 2014; Lorang et al., 2020; Muehlberger et al., 2019; Nolin, 2013; Sidorko, 2009)
AI-6	Agent/actor	14	(e.g., Adams Becker et al., 2017; Gasparini et al., 2018; Johnson, 2019; Riddick, 1990; Ridley, 2019; Ylipulli & Luusua, 2019)
	No role	41	(e.g., Joorabchi & Mahdi, 2013; Zhou, 2005)
RQ 4 Role of design			
D-1	Interfaces	9	(e.g., Allison, 2012; Cao et al., 2018; Cordell, 2020; Finnemann, 2014; Myhill et al., 2009; Yelton, 2019)
D-2	People-centered design	6	(Adams Becker et al., 2017; Benedetti et al., 2020; Dent, 2007; Federer et al., 2020; Guerra & Da Silva, 2008; Hepworth, 2007)
D-3	Human needs	5	(EDUCASE, 2020; Gasparini et al., 2018; Keshavarz, 2008; Koehler, 2004; Uzwyshyn, 2018)
D-4	Infrastructure	2	(Cox et al., 2019b; Ylipulli & Luusua, 2019)
D-5	AI-needs	2	(Brygfjeld et al., 2017; Hahn & McDonald, 2018)
	No role	102	(e.g., Powell et al., 2012; Xia & Liu, 2019)