EMERGING DIGITAL TECHNOLOGIES

Module 3: emerging technologies and their impact on libraries from the perspective of librarians and users

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- Wearable computing
- Artificial intelligence and augmented intelligence

Virtual reality (VR)

There are many approaches and definitions to define virtual reality - it is a technology described both by computer science and from the point of view of other sciences, including social science and humanities.
See for instance definitons by: Gandhi, R. D., & Patel, D. S. (2018). Virtual reality–opportunities and challenges. *Virtual Reality*, *5*(01), 2714-2724; Greengard, S. (2019). *Virtual reality*. Mit Press; Wohlgenannt, I., Simons, A., & Stieglitz, S. (2020). Virtual reality. Business & Information Systems Engineering, 62, 455-461.
The way it is defined depends not only on the adopted perspective of scientific disciplines but also evolves over time through the relationship of VR to other technologies.

In a most general sense, virtual reality is defined as a digitally generated environment that may, but does not have to, resemble the world of physical objects, and with which the user can interact. The key features of virtual environments are: immersion in an artificially generated environment obtained by limiting or cutting off external stimuli, multisensory nature of experiences and interactive, simulation-based environment.

To receive VR, computer equipment is needed, for example in the form of special VR goggles, but not only that, it may be less (e.g. Google Cardboards) or more complicated (special suits, controllers, etc.) depending on the situation and users needs.

Virtual reality

Areas of practical application:

- entertainment (e.g. games based on Oculus Rift and other similar devices)
- education (e.g. virtual training, serious games, use in school learning)
- promotion (presentation of products, models, services, etc.)
- art (experimental, immersive forms; virtual exhibitions)
- medicine (supporting therapy, e.g. in patients suffering from severe pain - see e.g. Indovina, Paola, et al. "Virtual Reality as a Distraction Intervention to Relieve Pain and Distress During Medical Procedures." The Clinical journal of pain 34.9 (2018): 858-877.), psychology (e.g. treatment of phobias), and even... sharing live reports from surgeries in VR, which was supposed to enable new training experience for young doctors (not only the opportunity to observe the operation (e.g. in the form of a recording) but the opportunity to immerse yourself in the situation)
- architecture (e.g. creating visualizations)
- military activities (so-called virtual training grounds, simulators)
- and much more… ☺

Virtual reality

Interesting research:

Indovina, Paola, et al. "Virtual Reality as a Distraction Intervention to Relieve Pain and Distress During Medical Procedures." The Clinical journal of pain 34.9 (2018): 858-877 - an article summarizing (by analyzing and criticizing the literature) the state of empirical research on the possibility of using VR in the treatment of patients' pain.

Conclusions: "VR has proven to be effective in reducing procedural pain, as almost invariably observed even in patients subjected to extremely painful procedures, such as patients with burn injuries undergoing wound care, and physical therapy”.

The authors emphasize that the topic is not exhausted yet and the usefulness of VR varies depending on the situation, but there is potential.

Virtual reality

Main areas of application in libraries:

- education - broadly understood, for various groups of users, including people with special educational needs, both library training and subject courses conducted in the VR environment
- exhibitions - presenting cultural heritage in VR, emerging area of research and practice
- library services, especially information services
- entertainment – games

Virtual reality

What is worth thinking about in the context of practical implementations in the library:

What could be the problem?

- VR environment is cognitively rich and multisensory, which can enrich the process of obtaining information (Kaufmann, 2003; Ibanez et al., 2011; Pasaréti et al. 2011), but can also be a guide to a state of disorientation, "information overload" (Wu, 2013).

What skills are needed?

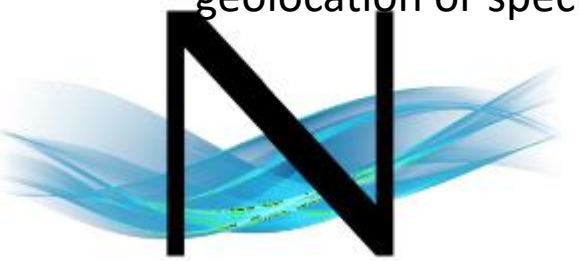
- basic technical skills of computer equipment
- information/media literacy competences

Augmented reality (AR)

Augmented reality, like virtual reality, is defined in different ways depending on the perspective adopted. See for example the definitions: Carmigniani, J., & Furht, B. (2011). Augmented reality: an overview. Handbook of augmented reality, 3-46; Wu, H. K., Lee, S. W. Y., Chang, H. Y., & Liang, J. C. (2013). Current status, opportunities and challenges of augmented reality in education. Computers & education, 62, 41-49 or Edwards-Stewart, A., Hoyt, T., & Reger, G. (2016). Classifying different types of augmented reality technology. Annual review of cybertherapy and telemedicine, 14, 199-2.

In practice, augmented reality is most often defined as an additional information layer applied in real time to physically existing objects. Therefore, it is characteristic that it combines the real world and electronic content, provides users with interactions in real time and allows them for the freedom of movement in three dimensions.

To receive AR, a mobile device, most often a smartphone or tablet, is needed, which allows you to see the world of physical objects with an additional information layer. The basis for adding an information layer may be geolocation or special beacons associated with physical locations.



Augmented reality

Areas of practical application:

- navigation (in cars, planes),
- military activities (targeting objects, planning operations),
- hydro- and geological research (three-dimensional maps, terrain analysis),
- architecture (reconstruction of the appearance of destroyed buildings, design simulation),
- engineering (real-time interactive tutorials, construction simulations)
- medicine (didactics, medical imaging, simulations of procedures and treatments),
- education, culture and entertainment (interactive exhibitions, conferences)
- tourism (city guides, personalized sightseeing paths)
- and others ☺

Augmented reality

Interesting research:

Javornik, A. (2016). ‘It’s an illusion, but it looks real!’ Consumer affective, cognitive and behavioural responses to augmented reality applications. Journal of Marketing Management, 32/9-10, p. 987-1011 and Javornik, A., et al. (2016b). Revealing the Shopper Experience of Using a ‘Magic Mirror’Augmented Reality Make-Up Application. In: Proceedings of the 2016 ACM Conference on Designing Interactive Systems. Brisbane: ACM, p. 871-882.

Conclusions: The use of augmented reality in some market sectors makes consumers more willing to make decisions about purchasing a product (e.g. fashion, make-up, home furnishings) having the opportunity to "try on" products through AR applications, but, of course, much depends on the context, individual characteristics of the respondents and the technical quality of the application.

Augmented reality

Application areas in libraries:

- location of objects, e.g. specific collections - applications that impose signposts on the image of the library
- records of collections by librarians - AR applications showing books displayed on the shelf
- entertainment - library games, e.g. searching for virtual objects or characters in the library space, just like in the popular Pokemon Go game
- various types of information services, e.g. contextual suggestions and recommendations for users based on where the library is located

Implementation examples: the Los Angeles Public Library in cooperation with USC Annenberg, the University of Oulu (Finland) or the library of North Carolina State University.

Virtuality continuum and mixed reality

Nowadays, the spheres of virtuality and reality (understood as the world of physical objects) interpenetrate each other.

This is not a new observation, the beginnings of reflection on this subject are attributed to Milgram and Kishino, who developed the concept of virtuality continuum in the 1990s, showing that between virtuality and the world of physical objects there is a spectrum of various mixed solutions.

Much reflection is devoted to the social reception of new technologies. Various authors emphasize that creating an opposition between the virtual world and the real world is not justified because virtual world is a non-real world only in the sense that there is no physical space, but when people meet, collaborate and communicate, there is a built-in existence (Grassian & Trueman, 2007) and therefore, it is more justified to talk about the virtual and physical world, rather than the virtual and real world.

Grassian, Esther, and Rhonda B. Trueman. "Stumbling, bumbling, teleporting and flying… librarian avatars in Second Life."

Reference Services Review 35.1 (2007): 84-89.

Internet of things (IoT)

IoT technology is based on the idea that everyday objects equipped with appropriate sensors can communicate with each other and perform specific tasks.

The goal is to network objects in homes, institutions and, more broadly, cities, in such a way that some of the routine processes performed by humans are subject to far-reaching automation, which will save time and money.

On the other hand, there are questions about the degree of autonomy of IoT-based solutions, responsibility for actions taken by IoT and threats related to data privacy.

Internet of things

Main areas of application:

- logistics and organization of processes in companies
- trade
- promotion and marketing
- transport
- architecture (smart buildings, cities)
- public safety and comfort - optimization of urban infrastructure operation, e.g. traffic lights, parking spaces, city lighting, energy networks, waste management, monitoring the wear and tear of infrastructure elements (roads, bridges, etc.), intelligent medical monitoring networks, control of logistics and production processes and many others
- smart buildings and smast cities

Internet of things

IoT technology is very often used to create the so-called intelligent buildings, and in a broader perspective also the so-called smart cities.

There is no single definition o smart building and this term is controversial among practitioners (e.g. architects), often being used too loosely. It can be generally assumed that smart buildings are architectural structures that use new technologies to automate and optimize their functions, and thus provide higher quality of life and/or work for residents. An intelligent building responds to internal and external factors through a system of sensors and detectors and adapts to the individual needs of its residents. The building can, for example, assess weather conditions and, accordingly, protect itself against the effects of rain or strong wind, and can also adjust the temperature and lighting to the preferences of individual users. The building can also simulate the presence of household members to prevent burglary attempts, be equipped with a monitoring system, a fire protection system and other solutions aimed at increasing security. Smart buildings are also often identified with ergonomic and ecological buildings - they are designed in such a way as to optimize the use of resources, e.g. electricity and emissions of pollutants.

Internet of things

In a broader context, IoT is also used to create the so-called smart cities. This is a concept that assumes the use of new information and communication technologies in urban infrastructure in order to increase the efficiency of processes and services provided to residents.

The concept of a smart city assumes not only the creative use of new tools, but also human capital (e.g. civic initiatives, entrepreneurship, proactivity).

Implementation examples: Stockholm – big data, open data, optimization of electricity consumption and carbon dioxide emissions. Boston – Better Traffic Management and Street Bump, i.e. better traffic management and road safety.

Internet of things

Application areas in libraries:

- information services, especially contextual hints
- locating objects
- ongoing checking of space and equipment availability
- personalization of services

An interesting application example: Orlando Public Library - sensors built into the floor and elements of the library's equipment "track" the user and provide him with contextual suggestions regarding his further actions via a mobile application. From this perspective, IoT can become a tool supporting user navigation in the library, as well as an important element in the provision of personalized information services adapted to the current situation.

Internet of things

Smart library concept:

Smart library can be defined as an idea for a highly autometed library in which new technologies are used to provide relevant, integrated services for users. Smart library should:

– rely on personalized response services for users' needs,

– be entirely designed intelligently as a system,

– use the activity and potential of its users.

(Cao et al. 2018).

Cao, Gaohui; Liang, Mengli; Li, Xuguang (2018). How to make the library smart? The conceptualization of the smart library. Electronic Library, vol. 36(5), pp. 811-825.

3d printing

3D printing allows to easily create three-dimensional objects of various sizes and from various materials based on projects created in specialized computer programs.

Creating a 3D object is done by superimposing many layers of material, which after hardening retains the desired shape. Designs for 3D printing are constructed in 3D modeling programs such as AutoCAD or Blender, or they can be downloaded for free or purchased from databases of ready-made 3D models.

3d printing

Areas of application:

- in business (creating product prototypes),
- in science (creating 3D models, visualization),
- in teaching (easy creation of teaching aids, especially in exact and natural sciences),
- in art (new forms of art based on 3D printing, e.g. sculptures, jewelry, even clothes),
- in medicine (implants, prostheses)
- in everyday life (printing small items, toys)

3d printing

Interesting research:

Erin Buehler, Niara Comrie, Megan Hofmann, Samantha McDonald, and Amy Hurst. 2016. Investigating the implications of 3D printing in special education. ACM Trans. Access. Comput. 8, 3, Article 11 (March 2016), 28 pages. DOI: http://dx.doi.org/10.1145/2870640.

Research regarding use in education, especially for children and people with special educational needs.

Method: Observation research + interviews with teachers.

Conclusions: haptic reinforcements related to 3D printing may have a positive impact on the educational processes of people with special educational needs in the STEM education sector (Science, Technology, Engineering, and Math).

3d printing

Application in cultural institutions, including libraries:

- making copies of exhibits for the purpose of popularizing them in educational and promotional istitutions or for research and documentation purposes
- in the form of the so-called maker space - a creative workspace in which users can express themselves creatively, which is in line with the interesting social trend of DIY culture or maker culture - the social need to independently produce items for personal or commercial use, creating unique, original items that counterbalance mass production, a return to handicraft
- in education, easy printing of models, diagrams, 3D aids (needed e.g. in medical studies, engineering studies, etc.), in education of children and people with special educational needs.

Brain-computer interface (BCI)

Brain Computer Interface (BCI) - technologies that use various signals created by the brain to control devices and use other technologies, most often based on reading EEG signals.

A futuristic, but already implemented technology, currently used mainly in the medical sector. With great prospects for increasing the inclusiveness of information services.

It can be implemented in an invasive form (preferably for medical purposes) in the form of implants implanted in patients, or more often in a non-invasive form through special caps that sew brain waves.

Brain-computer interface (BCI)

Areas of use:

- primarily medicine and patient care by enabling the most seriously ill patients to communicate with the world, which not only significantly improves their quality of life but also enables better monitoring of their health condition
- in designing inclusive information services for various user groups, especially people with limited mobility
- in entertainment and education - as an innovative tool that builds user engagement through a new, non-standard form of interface

Brain-computer interface

Areas of application in libraries:

- designing information systems, including library systems, adapted to the needs of seriously ill users, e.g. people with full body paralysis and the so-called locked-in syndrome, important for creating inclusive information services
- designing inclusive information services

For more detailes, see reading list: Wójcik, M. (2022). Brain–computer interface in the context of information retrieval systems in a library. Library Hi Tech, Vol. 40 No. 6, pp. 1766-1781. https://doi.org/10.1108/LHT-09-2020-0239

Robotics

Robotics – a discipline combining elements of mechanics, automation, electronics and computer science

Robot – broadly speaking, a technical device designed to perform certain manipulation and locomotion functions of humans.

There are different generations of robots, from less advanced robots that perform simple tasks, through robots with adaptive control, to intelligent robots. They offer various functions and applications - industrial robots, scientific research robots, medical robots, nanorobots ect. The scale of their mobility also varies - there are stationary and mobile robots with different construction methods.

Robotics

Areas of use:

- industry – industrial robots (production, processing, logistics, transport, etc.) and agricultural
- households - simple robots that facilitate routine activities, e.g. cleaning
- services, e.g. information, catering, delivery and others
- medicine, e.g. Johns Hopkins University Applied Physics Laboratory (APL) research on robotic prostheses or robotic arms used in surgeries
- education - e.g. robots used to learn foreign languages
- entertainment - robotic presenters and performers
- and more …

Robotics

Some interesting examples:

- HyQReal Robot - A four-legged robot that can tow a plane
- RoboRaise system - an assistant robot that helps, for example, in lifting heavy objects, and is controlled by human muscles, specifically through sensors connected to the human body
- Salto robot - a small robot capable of performing various types of acrobatics, e.g. jumps, rolls, jumping on moving objects, overcoming an obstacle course, etc.
- LEeCH robot - a robot that can climb walls

Robotics

Interesting research:

Belpaeme, Tony, et al. "Social robots for education: A review." Science Robotics 3.21 (2018), p. 1-9.

Topic: use of robots in education

Hypothesis: “Social robots can be used in education as tutors or peer learners. They have been shown to be effective at increasing cognitive and affective outcomes and have achieved outcomes similar to those of human tutoring on restricted tasks”

Method: analysis and criticism of the literature (1992 - the earliest work on this topic identified by the authors up to and including 2017), a total of over 300 works selected for the sample

Conclusions: "Although an increasing number of studies confirm the promise of social robots for education and tutoring, this Review also lays bare number of challenges for the field"

Problems: scope of autonomy, communication, logistics, ethics

Robotics

Areas of use in libraries:

- in library warehouses, for moving collections
- in back-end activities, to automate selected processes, e.g. selection or ordering of files
- in services - for direct service to users
- in education - as a tool to increase the attractiveness of the teaching process
- in the promotion of libraries

For more detailes, see reading list: Tella, A. & Ajani, Y.A. (2022). Robots and public libraries. Library Hi Tech News, Vol. 39 No. 7, pp. 15-18, https://doi.org/10.1108/LHTN-05-2022-0072

Haptic technology

Haptic technologies are based on the sense of touch. Within this general definition there are various approaches - see definition examples below.

P. Fernandez: “Haptic technology is a term that encompasses a set of rapidly evolving technologies centring on recreating the sense of touch, with a wide range of applications (…)” (2017, p. 12).

„Haptic technology, in the most general sense, can therefore be defined as communication via the sense of touch. The idea assumes that the user can perceive the properties of materials (porosity, texture, etc.) and the vibrations produced in contact with these materials, and on this basis be informed about something” (Visell et al, 2011).

A. Tiwari, “Haptic technology is built into a device to create tactile feedback (…)” (2016, p. 83).

American Library Association “(…) technology that incorporates tactile experience or feedback as part of its user interface, creating a sense of touch through vibrations, motion, or other forces” (ALA…, 2018).

Haptic technology

Areas of use:

- road traffic control (porous surfaces for cars and pedestrians, especially important for blind people)
- educating e.g. medical students, but also educating people with disabilities (haptic reinforcements)
- art, e.g. based on 3D forms, haptic art perceived through touch
- entertainment, e.g. games, especially those based on VR, toys
- interfaces, e.g. vibrations when touching selected elements

Haptic technology

Interesting research:

Mangen, A., Walgermo, B. R, and Brønnick, K. (2013), "Reading linear texts on paper versus computer screen: Effects on reading comprehension", International journal of educational research, Vol. 58, pp. 61-68.

Mangen, A., et al. (2015), "Handwriting versus keyboard writing: effect on word recall", Journal of writing research, Vol. 7, Issue 2, pp. 227-247.

Thesis: book as a precursor of haptic technologies, tactile qualities are inherent in print, as well as in handwriting and that this tactile elements can facilitate learning processes possibly better than purely electronic sources.

Method: a series of studies using the experimental method.

Conclusions: children who used printed sources remembered the material better than those who learned only from electronic sources.

Haptic technology

Application areas in libraries:

- signage of library spaces and electronic information systems, e.g. interactive boards
- education, especially for people with visual disabilities and people with special educational needs
- services - especially for users requiring additional, multi-sensory support in absorbing information

Artificial intelligence (AI)

What is artificial intelligence?
A broad, interdisciplinary field of knowledge combining elements of: logic, neuroscience, psychology, philosophy, cognitive science, computer science and robotics.
Problems in defining what intelligence is in general translates into problems in defining the concept of artificial intelligence.
Beginning of research - 1950s, first laboratories - Carnegie Mellon University http://www.cmu.edu/ and Massachusetts Institute of Technology http://web.mit.edu/. First attempts to difine AI were done in 1950s by John McCarthy, since then there have been many attempts to define this concept, most often either by comparison to human activities and processes or by comparing it to simple computer programs and showing the greater capabilities of AI.
General goal: construction of machines/software capable of imitating selected functions of the human mind and solving problems that do not lend themselves to simple algorithmization.

Artificial intelligence

Areas of application:

- recognition – of faces, images, writing, landform elements
- forecasting – even based on incomplete data
- translation – but only of specialized texts, not colloquial ones
- expertise – help in making good decisions
- games – artificial opponents
- art - art generated by AI (controversial issue - is it still art?)
- expert and diagnostic systems - systems using knowledge bases and inference mechanisms
- control and repair systems – detect errors and suggest solutions
- education - as a teaching tool, but also a controversial topic - how can students use AI in an ethical way to suport their education?

Important note: Currently, a lot of attention is directed to the so-called generative artificial intelligence influenced by the development of GPT chat, but it must be remembered that this is only one branch of AI development.

Artificial intelligence

Interesting research:

DeWan, Peter Abdul, et al. "Artificial intelligence methods to predict chemotherapy-induced neutropenia in breast cancer patients." Journal of Clinical Oncology, vol. 36, no. 15 (2018), p. 6555-6555.

Objective: to investigate the possibility of using AI to predict patients' reactions to chemotherapy (neutropenia).

Analysis of clinical trials of over 10,000 patients undergoing oncological treatment.

Conclusions: thanks to the use of AI, the accuracy of predictions regarding the probability of neutropenia increased by 45%.

Of course, this is a study on a specific sample and there are a number of methodological reservations, but the results are promising.

Artificial intelligence

Interesting research in the context of the controversy around AI - is it a threat to humans?

Grace, Katja, et al. "When will AI exceed human performance? Evidence from AI experts." Journal of Artificial Intelligence Research 62 (2018): 729-754.

Question: Will artificial intelligence surpass humans and when?

Method: interviews with experts (352 people)

Results: 50% predict that HLMI (High-level machine intelligence) will be developed within 45 years, 10% that within 9 years, full automation of workplaces - 50% within 122 years, 10% - within 20 years

General conclusions: "1. Researchers believe the field of machine learning has accelerated in recent years 2. Explosive progress in AI after HLMI is seen as possible but improbable 3. HLMI is seen as likely to have positive outcomes but catastrophic risks are possible 4. Society should prioritize research aimed at minimizing the potential risks of AI”

Augmented intelligence

A relatively new phenomenon (although the first glimpses of this concept already in the 1990s, earlier attempts to describe the phenomenon in the 1950s and 1960s but under different names), rarely described in the literature, more often presented at conferences (and conference materials) and on industry portals

The next stage in the development of artificial intelligence, touching on the controversial idea of transhumanism assuming that artificial intelligence is intended to increase human potential, and not to act alongside/instead of it

Is it the answer to concerns about the development of AI?

Application in medicine, economics, management and (potentially) in many other scientific disciplines and areas of practical activity.

Artificial intelligence and augmented intelligence

Areas of use in the library:

- information services, including advisory, decision-making and expert databases in various fields of knowledge
- chatbots serving users
- automation of library processes, e.g. cataloguing
- education - as a new teaching tool
- promotion - due to the high attractiveness of AI for users, especially younger ones

For more detailes, see reading list: Wójcik, M. (2021). Augmented intelligence technology. The ethical and practical problems of its implementation in libraries. Library Hi Tech, Vol. 39 No. 2, pp. 435-447, https://doi.org/10.1108/LHT-02-2020-0043

Thank you!