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Trends in digital information search

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Introduction

Digital information search tools are ubiquitous and more than ever embedded in activities of our everyday lives. Search engines, such as Google, help us to find relevant information, solve problems, and support our decision-making.

This paper shows the important trends in a wider framework of the Fourth Industrial Revolution and web generations. On the level of digital information search tools, trends and emergent technologies are described in more detail and accompanied by recent examples of tools.

It is of critical importance to recognize possible challenges of algorithmic culture today and in the future. We describe some of related problems and underline that ethical norms and legal frameworks must be incorporated to ensure that technologies will not become even more authoritative and powerful as they are now.

1 Information seeking, information search and information agents

The concepts of information search and information seeking are often used interchangeably in information science field (Savolainen, 2016) without further difference explanation. *Information seeking* is a part of human activity focused on finding of relevant information with the help of the system or humans, to satisfy information needs. *Information search* is a subset of information seeking, "micro-level" of behavior (Wilson, 2000), which refers to the purposive actions involved in interaction with an information search tool. Information search is focused on interaction of a person with information search system or information retrieval system. The most specific concept in this hierarchy is *information retrieval*, which is a complex process by which a person with a specific information need formulates a query with a support of information retrieval system interaction aimed at finding and using relevant information.

We would like to emphasize that the concept of information search could also be seen through the prism of a new paradigm of information society introducing different categories "in between" the traditional understanding of human-tool-object relationships (in our case human-information search tool-information object). One of the important approaches is the

actor-network theory (ANT) (Latour, 2005) describing social and natural worlds in the meaning of constantly shifting networks of relationships that are simultaneously material and semiotic. ANT explores the dynamic relations between objects, ideas, processes and *actants* (expanding the concept of human actors to non-human categories of tools, technologies or objects).

ANT denies the ontological divide between the organic and the technical and recognizes the importance of non-human actors which are neither neutral nor dependent on human actors. Collective *worknet* (Latour 2007 In Alexander, Silvis 2014) is maintained by the active work of the interconnected actors which are trying to strengthen their influence by creating relations with other actors. ANT is a well-established framework that has its presence in the fields of information systems (Alexander, Silvis 2014), technology, AI, information science etc. From the ANT perspective, there are various actors present in a digital information search space. Fig. 1 shows that user, search interface, information search tool and information object are actors in interconnected network.

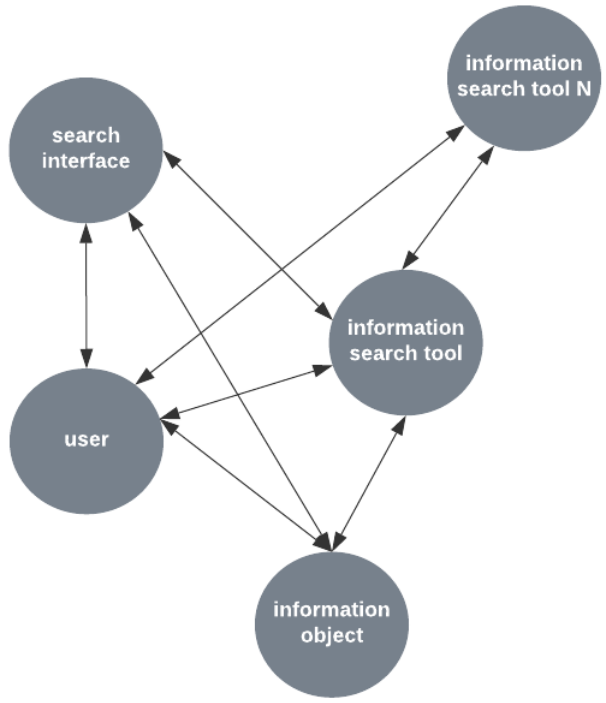

Fig. 1 *Actors in a digital information space*

2 Evolution of digital information search technology

2.1 Fourth Industrial Revolution

We live in the era of the Fourth Industrial Revolution which is characterized by integrative fusion of technologies also known as *cyber-physical systems*. This revolution has introduced a new way technology is embedded in society, culture, economy, politics, but also in

human body and mind. It redefines the boundaries between the digital, physical and biological, introduces changes affecting human existence and questions "the very idea of what it means to be human" (Kasza 2019). The speed of technological development is exponential and the changes that the Fourth Industrial Revolution brings can be described as disruptive innovations. These innovations create a new market and value network and eventually disrupt the existing market and value network, resulting in displacement of the established market (Christensen et al. 2018). Disruptive innovations have potentially radical unintended consequences that are changing our perception of the world and humanity as we know them.

2.2 From web 1.0 to web X.0

The framework which is of crucial importance from the perspective of trends in digital search, is the evolution of web generations. The historically first form of the web was *web 1.0* which was in read only, a static form with hyperlinked web sites. This era is associated with a .com bubble, when emphasis was mainly put on companies. *Web 2.0* (social web) introduced the possibilities of a dynamic read-write web, building communities by means of providing collaborative social services such as wikis, blogs, social networking etc. The subsequent *Web 3.0* generation, the one we live now, is defined as the read-write-execute web. The focus is on a definition of a machine-readable web with the help of semantic markup. The semantic web helps intelligent agents to access information and to connect them, to understand the context, to come up with meaningful knowledge and to provide services. The next step is *web 4.0*, known as the read-write-execute (concurrency) web. Web 4.0 is denoted as a ubiquitous web supported by ambient intelligence. It enables convergence of humans and machines in a symbiotic way. This new form of intelligent web has self-learning and self-organizing capacities. Web 4.0 connects devices (agents) in real and virtual world to cooperate and create knowledge networks. Another, predicted future web stage is *web 5.0*, a sensory-emotive web, defined by emotional human-machine interactions based on developments in emergent neurotechnology and nanotechnology. In the future, wearable devices will recognize emotions by tracking body responses or using real time face recognition to create deeper relations with humans (Kasza 2019).

More recently Web 3.0 has already started forming a basis for web 4.0 by building machine-readable content. The next step is for it to be also machine understandable.

3 Technological trends in information search

Google has dominated web information search on a global scale for more than a decade. According to Clement (2020) its desktop market share is 87.35% as of January 2020. It is followed by Bing with 5.53% and Yahoo (2.38%). Yandex RU had a share of 0.76% and Baidu had 0.7% at the global market.

Alexa (2020) shows that Google is ranked at the top of the global web sites' list with the highest count of daily visitors and pageviews (over the last month) combined. In average, users spend 13 minutes and 53 seconds a day on the Google site and daily unique pageviews per visitor are as high as 15.28.

Google's business model is based mainly on advertising (generating 90% of total profits), but it also provides myriad of tools, such as business suites, mobile devices, e-mail etc.

From the perspective of trends, Google has introduced three fundamental paradigm shifts in how it sees search in the future (Gomes, 2018):

- a shift from *answers to user journeys*,
- a shift from *query to query-less*,
- a shift from *text to visual information*.

Each of these is underpinned by the AI technologies based on neural networks supporting conceptual search. As Gomes (2018) stated, "*neural embeddings*, an approach developed in the field of neural networks, allow us to transform words to fuzzier representations of the underlying concepts, and then match the concepts in the query with the concepts in the document. We call this technique *neural matching*."

We will present these shifts focusing on the related technological trends in more depth further below.

3.1 User journeys

User journey captures a complex nature of information need which oftentimes consists of series of sub-processes. It is not unusual that many information searches span multiple days consisting of several longer sessions. This non-linear and explorative characteristic of information search tasks has been well documented in information science and reflected in many models, e.g. the berrypicking model (Bates, 1989). The idea of a search as a user journey is already embraced by some of the search engine features. For instance, *Google activity cards* help to retrace particular steps in a search process and resume search tasks. Useful data on past queries and visited pages related to a task are accessed from a search history. Another feature supporting user journeys is that anyone can add and organize useful content to *Collections* from a search activity according a specific topic. Collections and search activities source data to provide user content suggestions when searching for related information.

Google has also added another layer to already existing knowledge graph known as *topic layer*. Based on content analysis of topical space, this layer is developed by identifying subtopics of a specific topic and understanding how subtopics are related. In seeking a topic layer, users are provided with smart content recommendations.

3.2 Query-less search

Web search has been a query-driven search scenario for decades, often initiated by issuing keywords. By analysis of user behavior in search engine logs it was discovered by Song ang Guo (2016) that search tasks exhibit repeated patterns which are even stronger on mobile devices. This has provided possibilities to perform proactive recommendations predicting tasks without users issuing queries. These query-less search features are captured on a basis of novel deep learning framework that learns user preferences and automatically makes predictions. This type of search, also known as contextual search, uses data on user behavior, and specific dimensions of time, location, device and task are taken into account.

Some of the sample proactive recommender systems are Google services such as Discover, Assistant, YouTube etc. Google Discover (previously known as news feed) is focused mainly on interests, news and social activities and it suggests content based on user intent shown in search.

3.3 Visual information search

The computer vision technology enables search engines to recognize content and extract concepts from images. Due to these advances, conceptual models of image and video that are stored in index are developed. Imagery recognition brings many more possibilities when compared to traditional approach based on textual data assigned to an image or video (alt tags or text accompanying imagery on a page).

Imagery and videos are not only included in the results of a separate vertical search (such as Google Image/Video Search or Bing Image/Video Search etc.). They are also *infused* in the main SERP so that search is more of a visual experience.

Reverse image search has already a long tradition and it enables the use of the URL image or an uploaded image to find where it appears online. This feature is supported by such search tools as TinEye or Google Search by Image.

Google Lens, integrated in Google mobile app, provides a state of art visual search. Image recognition is used to process texts or objects which are pointed at with a phone's camera and find related images. For example, Google Lens detects a product (outfit, watch, etc.) and matches it with similar images from e-shops where it can be purchased. It also recognizes the text in an image which can be copied to a clipboard, used instead of issued query or translated to other language. Another feature of Google Lens is that by pointing at the menu in a restaurant, it will recommend the most popular dishes.

3.4 Voice search

Voice search enables users to use voice queries in a natural language on the input processed and transcribed by the system to a machine understandable form. The user is presented with a resulting voice in a form of an answer in natural language or, in case of a device extended by a display, with text results, images, maps and other related information. Voice search is based on AI technologies of natural language processing and recognition, learning algorithms (neural networks) and user data analytics and recommendation.

Voice search is becoming ubiquitous and widely popularized by the increasing usage of digital assistants, mobiles and other smart devices (mainly smart speakers). It has more intensively spread from 2008, when Google launched its "voice search" service. Today, voice search is an obvious addition to various applications and its popularity is on the rise. This is mainly due to the improvement in the quality of automatic speech recognition (Shokouhi et al. 2016) and advanced methods of learning on large-scale voice search logs based on neural networks (Guy, 2018).

Based on empirical evidence from studies analyzed by Xing, Yu and Yuan (2019), voice search is rather present in mobile scenarios, e.g. when searching for local ("near me") and less sensitive information. Typical are questions requiring tasks with concise, less complex, answers. Based on research results, it is recommended that users be provided with additional support by query reformulation in the future. In terms of perception and satisfaction of voice search, users found it more intuitive and interesting when compared to text search. On the other hand, user satisfaction was reduced when speech recognition errors occurred in the process of voice search.

Conversational content is becoming a prominent part of web pages which are being optimized for voice digital assistants (eg. Amazon's Alexa, Google Assistant, Apple's Siri, Microsoft's Cortana). Voice search has also radically impacted a traditional search, so much so that search engines are changing to question-answering engines.

3.5 Self-learning algorithms

As shown above, all of the mentioned search technology trends are one way or another supported by various advanced AI technologies. Here we will discuss the recent developments in natural language processing models based on neural networks which are an integral part of web search engine technology. More advanced algorithms of web search engines emerged because of increasing demands for unstructured content analysis and context understanding.

The most recent natural language processing algorithm is called BERT (Bidirectional Encoder Representations from Transformers). BERT is a result of Google's research into transformers (Nayak, 2019) based on processing of specific words in relation to all surrounding words in a sentence. In previous models, indexing was performed gradually, from the first word to the next, according their order in the sentence. BERT is different, it uses bidirectional language modelling.

The strength of BERT lies in the use of learning neural network technologies that were pretrained on huge data samples (whole Wikipedia in English language). After extensive testing, BERT has been deployed massively, helping to identify the context of the words and determine the user's intent when searching. As a result, BERT takes into account the specific requirements of question-answering systems with the support of conversational queries.

Since its advent, BERT algorithm was extended by Microsoft (MT-DNN), Facebook (RoBERTa) etc. Google has already presented ALBERT, an upgrade to BERT, which is even more effective in performance and redundancy elimination (Soricut, Lan, 2019).

3.6 Emerging technologies

One of the tools that provide better understanding and forecasting of trends is *Gartner hype cycle for emerging technologies* (Panetta 2020). These trends are presented in a form of a road map depicting technologies evolving through five phases, namely *innovation trigger*, *peak of inflated expectations*, *trough of disillusionment*, *slope of enlightenment* and *plateau of productivity* (see fig. 2). The most recent hype cycle introduces emerging technologies that fall into five major trends: *sensing and mobility*, *augmented human*, *postclassical compute and comms*, *digital ecosystems*, and *advanced AI and analytics*.

Some of these trends directly impact development it the area of the web information search technology. First of all, the *sensing and mobility* trend brings advantages in the autonomous agent technology and sensing technology which helps the *Internet of Things* (IoT) to evolve progressively. Intelligent sensors already collect vast amounts of data which are applicable in information search scenarios.

The next category of trends, *augmented human technology,* could improve not only physical parts of the human body, but also cognitive capacities by including technologies such as *biochips* and *emotion AI* (Panetta 2020). Enhanced "superhuman" capacities could have enormous implications on how we process information and completely change the way we use memory to retrieve and recall it. AI-brain-chips implanted in human body interface with brain and can be potentially used to restore or advance cognitive functions and alter the way we think and communicate. In line with this trend, *neural lace* is used to facilitate direct computing capacities and monitoring brain functions. Another relevant trend in this category, *personification*, enables intelligent agents to form relationships with people to better understand their needs, behavior, and act on it. Some of the practical applications could be found in the area of affective computing, emotional robotics and chatbots.

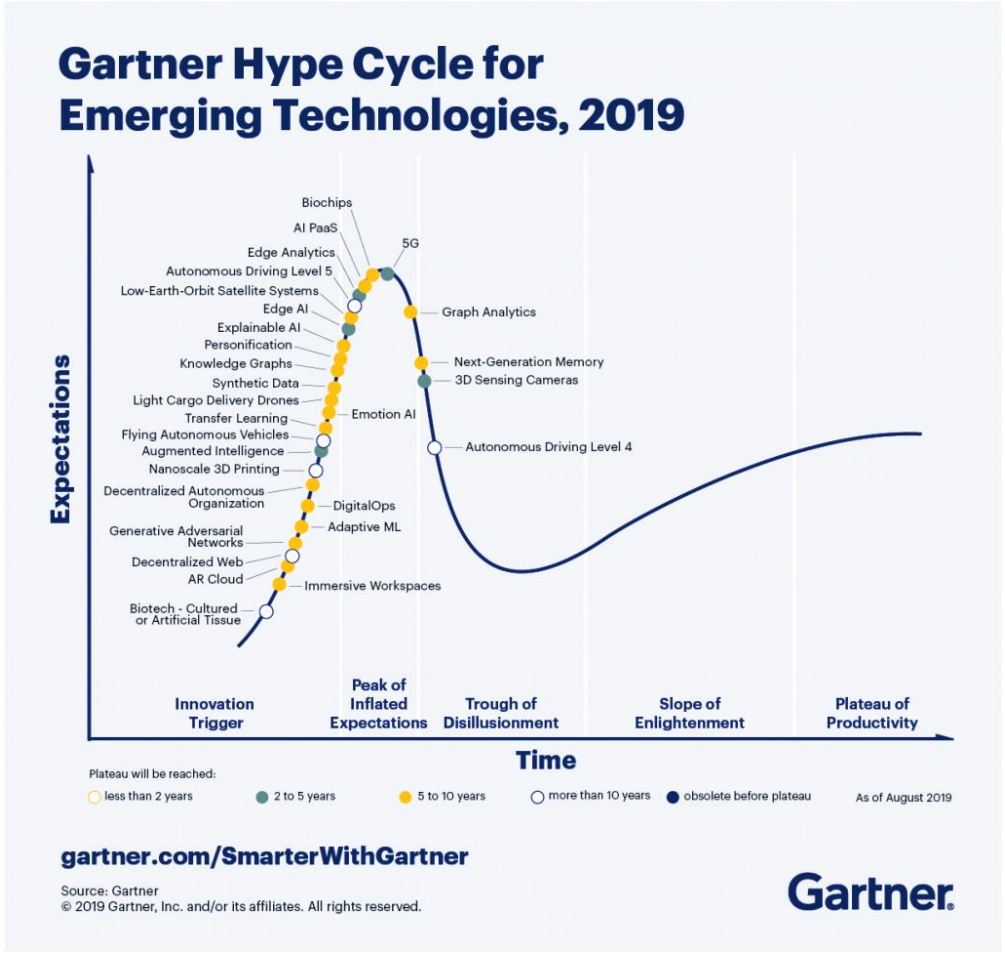

Fig. 2 *Gartner hype cycle for emerging technologies (Panetta 2020)*

The hype cycle for emerging technologies includes *digital ecosystems* as the next trend. Digital ecosystems provide infrastructure for information search technology by connecting actors, such as people, enterprises and things, sharing a digital platform (Panetta, 2020). *Knowledge graphs* based on digital ecosystems model knowledge domain by integrating data into an ontology which is further used to derive new knowledge. Knowledge graphs are used by search engines (introduced by Google in 2012) to retrieve and link semantic data from various resources and derive meaningful search results in a form of structured content.

The last category of trends in the hype cycle is presented by *advanced analytics and AI*, which we have already discussed relating to web search in more detail above. In a context of enterprise search, it is important to mention a new generation of *cognitive search* which integrates AI and uses sophisticated tools enabling deeper contextual insights, predictions and recommendations.

4 Challenges of algorithmic culture

Algorithms (including search engine algorithms) raise questions related to our perception of power and control, shifting views on the world and our complex relationships with technologies (Willson 2017). Potential problems could emerge in relation to interactions not only between humans and machines but also between machines.

It should be noted that machine algorithms collect and operate upon huge vast of user data to recognize human behaviour and its patterns. Google has publicly noted that it runs continual experiments on its users (Varian 2013, Gomes, 2018). In 2018 alone, Google carried out more than 200,000 experiments that resulted in more than 2,400 changes in search (Gomes, 2018). The main purpose behind the experiments is "to identify causality and consequence: what might drive changes in user behavior, changes in the way in which information is found and displayed, the list is endless" (Willson 2017). So anytime Google is used, we become a part of dozens of experiments (Varian 2013) without even knowing about it. Needless to say, these data are used not only to optimize search engine effectivity, but also to achieve business goals and monetize ads in SERP. As Lewandowski (2019) pointed out, Google has massive influence on displaying search results and on what results users will select. So, it is more important than ever before to call for unbiased, fair search engines.

The problem of users' limited control over their own data surfaced with one of the most public scandals of Facebook-Cambridge Analytica in 2018, which harvested users' data to optimize political advertising, without their consent. Cases like this question the role of current platforms and put pressure on search engines to be more transparent when manipulating with sensitive user data. This is also the reason why private search engines claiming that they do not collect or process personal user data were introduced to the market (eg. StartPage, Qwant, DuckDuckGo etc.).

Without a doubt, Google has become an algorithmic authority, meaning that it has a "legitimate power to direct human action and to impact which information is considered true" (Lustig and Nardi, 2015). Intelligent algorithms of search engines are changing the way we get to know our world and provide us with filtered personalized recommendations, suggestions and results based on our search history and behavioral data. Overall, there is clearly an ongoing risk of unintended adaptation to technological changes on collective, cognitive and psychological level (Kasza 2019). As Firth et al. (2019) had pointed out, information search produces a sustained impact upon cognitive processes. As it was found out by Sparrow et al. (2011), information search affects typical memory processes and people are more likely to remember where facts could be found rather than recalling facts themselves, indicating that people are quickly becoming dependent on web information search. Web information search can alter cognitive capacities so much that individuals may fail to sufficiently engage brain regions for storing information on a long-term basis. More recent studies (Fisher 2015, Hamilton, Yao 2018) have shown that information search activities can blur the lines between individual capacities and those of digital devices. Information search increases a sense of how much we know and creates an illusion of self-knowledge as we internalize external knowledge and perceive it as our own.

Reflecting on the issue of the increasing power of algorithms, the shift from algorithms being *explorative* and open to being *exploitive* needs to be considered. Algorithms are closed *black boxes* (Turkle 2005 In Hajibayova, 2019) often protected by patents.

Self-learning intelligent agents, denominated as actants, socially cooperate in an autonomous manner. Limited or no human intervention or decision-making is needed for them to act. For this reason, algorithmic procedures (such as organization, discovery, recognition,

personalization etc.) and their development must follow strictly defined rules based on ethical norms. Currently we face many possible consequences related to insufficient digital control policies and management within legal frameworks. We need to reconsider current and possible challenges and try to resolve various concerns connected with technologies and algorithms and not let them shape who we are, what we know, choices we make and our understanding of what it means to be human.

Conclusion

The purpose of this paper was to show the most recent trends in information search technology and put it in a wider context of existing evolutionary frameworks and future predictions. To mention but few, AI trends including recommender systems, machine learning, neural networks, and voice search, visual search and query-less search were analyzed in more depth. The current and emerging trends characteristics help to recognize the importance of disruptive technologies in future development.

We question the role of technology in human life and show that it already has massive impact on individual psychological and cognitive structures. Deepening relations with technologies entirely change our perception of knowledge, power and what it means to be human.

Further continual analysis must be carried out to understand progress of the web search technology and algorithms and discover possible risks that could be prevented in the future.

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List of References

ALEXA, 2020. The top 500 sites on the web. In *Alexa* [online]. Available from: https://www.alexa.com/topsites/countries/SK

ALEXANDER, P. M., SILVIS, E., 2014. Towards extending actor-network theory with a graphical syntax for information systems research. In: *Information Research, 19*(2) paper 617. Available from: http://InformationR.net/ir/19-2/paper617.html

BATES, M. J., 1989. The design of browsing and berrypicking techniques for the online search interface. In *Online Review* [online]. Vol. 13, no. 5, pp. 407-424. Available from: https://doi.org/10.1108/eb024320

BATES, M. J., 2002. Toward an integrated model of information seeking and searching. In: *New Review of Information Behaviour Research* [online]. Vol. 3, Available from: https://pages.gseis.ucla.edu/faculty/bates/articles/info_SeekSearch-i-030329.html

CLEMENT, J., 2020. Global market share of search engines 2010-2020. In: *Statista* [online]. Available from: https://www.statista.com/statistics/216573/worldwide-market-share-of-search-engines/

CHRISTENSEN, C. M. et al. Disruptive Innovation: An Intellectual History and Directions for Future Research. In: *Journal of Management Studies* [online]. Vol. 55, Issue 7. Available from: https://doi.org/10.1111/joms.12349

FIRTH, J. et al., 2019. The "online brain": how the Internet may be changing our cognition. In *World psychiatry: official journal of the World Psychiatric Association (WPA)* vol. 18, 2, p. 119-129 [online]. Available from: doi:10.1002/wps.20617

FISHER M. et al., 2015. Searching for explanations: how the Internet inflates estimates of internal knowledge. In: *Journal of Experimental Psychology*. Volume 144. p. 674-87. [online]. Available from: https://www.apa.org/pubs/journals/releases/xge-0000070.pdf

GOMES, B., 2018. Improving Search for the next 20 years. In *Google: The Keyword* [online]. https://www.blog.google/products/search/improving-search-next-20-years/

GUY, I. 2018. The Characteristics of Voice Search: Comparing Spoken with Typed-In Mobile Web Search Queries. In *ACM Transactions on Information Systems*, Vol. 36, Issue 3, [online]. Available from: https://dl.acm.org/doi/10.1145/3182163

HAMILTON, K. A, YAO M. Z., 2018. Blurring boundaries: effects of device features on metacognitive evaluations. In: Computers in Human Behavior. Volume 89 p. 213-20. [online]. Available from: https://doi.org/10.1016/j.chb.2018.07.044

KASZA, J., 2019. Forth Industrial Revolution (4 IR): Digital Disruption of Cyber – Physical Systems. In: *World Scientific News* [online]. Vol. 134, Issue 2. Available from: http://psjd.icm.edu.pl/psjd/element/bwmeta1.element.psjd-b8491667-e107-4c7e-9c49-d5e9d4f8322e/c/WSN_134_2___2019__118-147.pdf

LATOUR, B., 2005. *Reassembling the Social: An Introduction to Actor-Network-Theory*. Oxford: OUP Oxford, 2005. ISBN 9780199256044. Available from: http://search.ebscohost.com/login.aspx?direct=true&db=nlebk&AN=211608&lang=sk&site=ehost-live&scope=site

LEWANDOWSKI, D., 2019. A call for fair search engines. In Information Science Trends: Search Engines and Information Retrieval [online]. 26 April 2019. Available from: https://www.youtube.com/watch?v=Zx1o9TSYJmc&feature=youtu.be

LUSTIG, C., NARDI, B., 2015. Algorithmic authority: The case of Bitcoin. In *HICSS '15: Proceedings of the Annual Hawaii International Conference on System Sciences*. March 2015, pp. 743–752. DOI: 10.1109/HICSS.2015.95

PANETTA. K., 2019. The Gartner Hype Cycle highlights the 29 emerging technologies CIOs should experiment with over the next year. In: *Smarter With Gartner* [online]. Available from: https://www.gartner.com/smarterwithgartner/5-trends-appear-on-the-gartner-hype-cycle-for-emerging-technologies-2019/

SAVOLAINEN, R., 2016. Elaborating the conceptual space of information-seeking phenomena. In: *Information Research* [online]. Vol. 21, no. 3, paper 720. Available from: http://InformationR.net/ir/21-3/paper720.html

SHOKOUHI, M., OZERTEM, U., CRASWELL, N. 2016. Did you say u2 or youtube?: Inferring implicit transcripts from voice search logs. In *WWW '16: Proceedings of the 25th International Conference on World Wide Web*. p. 1215-1224. April 2016. [online]. Available from: https://doi.org/10.1145/2872427.2882994

SONG, Y., GUO, Q., 2016. Query-Less: Predicting Task Repetition for NextGen Proactive Search and Recommendation Engines. In: *WWW'16: Proceedings of the 25th International Conference on World Wide Web.* April 2016. p. 543–553 [online]. Available from: https://doi.org/10.1145/2872427.2883020

SORICUT, R., LAN Z., 2019. ALBERT: A Lite BERT for Self-Supervised Learning of Language Representations. In *Google AI Blog* [online]. Available from: https://ai.googleblog.com/2019/12/albert-lite-bert-for-self-supervised.html

SPARROW B. et al., 2011. Google effects on memory: cognitive consequences of having information at our fingertips. In: *Science* [online]. Available from: https://science.sciencemag.org/content/333/6043/776

TURKLE, S., 2005. The second self: computers and the human spirit. Cambridge, MA: MIT Press. In Hajibayova, L., 2019. Guardians of the knowledge: relevant, irrelevant, or algorithmic? In: *Information Research*, 24(4), paper 839. [online]. Available from: http://InformationR.net/ir/24-4/paper839.html

VARIAN, H. R., 2013. *Beyond big data*. Presented at the NABE annual meeting, San Francisco, CA. Available from: http://people.ischool.berkeley.edu/~hal/Papers/2013/BeyondBigDataPaperFINAL.pdf

WILLSON, M., 2016. Algorithms (and the) everyday. In: *Information, Communication & Society* [online]. Vol 20, Issue 1: The social power of algorithms. Available from: https://criticism.english.illinois.edu/sites/criticism.english.illinois.edu/files/Willson%20 - %20Algorithms%20and%20the%20everyday.pdf

WILSON, T.D., 2000. Human information behaviour. In: *Informing Science: Special Issue on Information Science Research* [online]. Vol. 3, no. 2. Available from: http://www.inform.nu/Articles/Vol3/v3n2p49-56.pdf

XING, Z., YU, F., YUAN, X., 2019. Research on Voice Search Behavior in the Last 10 Years. In *Proceedings of the Association for Information Science and Technology*, Vol. 56, Issue 1, p. 819-821. ISSN 2373-9231. Available from: https://asistdl.onlinelibrary.wiley.com/doi/abs/10.1002/pra2.190?af=R

Summary

TRENDS IN DIGITAL INFORMATION SEARCH

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This paper provides comprehensive analysis of the trends in digital information search. It introduces a concept of information search and underlines the difference between concepts of information search and information seeking. Then, evolutionary aspects of technology trends are presented in the wider context of the Fourth Industrial Revolution and web generations. Technological trends in digital information search are examined and details on user journeys, query-less search, visual information search, voice search, self-learning algorithms are provided. Emergent technologies based on Gartner's Hype Cycle are also characterized. The paper deals with challenges of unintended changes brought by algorithmic culture and innovations and outlines possible solutions.