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Savić, Dobrica
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ARE WE READY FOR THE FUTURE? IMPACT OF ARTIFICIAL INTELLIGENCE ON GREY LITERATURE MANAGEMENT

Dr. Dobrica Savić

linkedin.com/in/dobricasavic

Vienna, Austria

DISCLAIMER: Any views or opinions expressed here are those of the author and do not necessarily reflect those of his employer.

Abstract

Information management is one of many areas being affected by artificial intelligence (AI). From science fiction to Google's search algorithms, self-driven cars, chatbots, and factory robots, AI has become part of our daily reality. Many books, articles, and blogs have been written, elaborated, and debated in numerous fields and industries about the use of AI. Scientists like Stephen Hawking and many others, businessmen like Jeff Bezos and Elon Musk, politicians and managers have talked about AI from different perspectives and with different aims. Information technology developments impact the way we work, learn, communicate and go about our lives. This paper examines the potential impact of AI on grey literature (GL) management and is based on analysis of pertinent GL facets such as value, volume, variety, velocity, and veracity. The impact of AI on processing, sustainability and usability of GL management are given special attention. Examples of AI systems already implemented in similar fields or activities are offered. In conclusion, the paper presents possible solutions to challenges that GL managers could face in the near future.

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Keywords
Grey literature, artificial intelligence, information technology, information management

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Introduction
During the last few years, the term artificial intelligence (AI), has become omnipresent. It is being discussed in books, scientific articles, newspaper stories, government reports, parliament debates, court decisions, and ordinary conversations. From science fiction to Google's search algorithms, self-driven cars, chatbots, and factory robots, AI has become part of our daily reality. Scientists like Stephen Hawking and many others, businessmen like Jeff Bezos and Elon Musk, politicians and managers alike have made their own contributions. Information technology (IT) developments impact the way we work, learn, communicate and go about our lives. Information management is one of many areas being affected by various disruptive information technologies such as AI (Savic, 2017a).

This paper examines the potential impact of AI on information management (IM), specifically on grey literature (GL), starting from the analysis of pertinent GL facets such as volume, variety, velocity, veracity, and value. It continues with a review of the potential impact of AI on GL processing, sustainability, and usability challenges. It also offers parallel examples of AI systems already being implemented in similar fields or activities.

In conclusion, the paper will present possible solutions to challenges that grey literature managers will most likely face while trying to accommodate and benefit from new AI technologies. By increasing our knowledge about AI and other potentially disruptive technologies, we improve our chances to increase their relevance and potential benefits to our work.

Definitions
Two basic concepts considered in this paper which need clarification and explanation are *grey literature* and *artificial intelligence*.

Grey literature has been defined differently by a number of researchers, justifying Schöpfel's (2011) theory that GL is much easier to describe than to define. The most widely accepted and used definition is from the 12th International Conference on Grey Literature (GL12), held in Prague in 2010.

> *"Grey literature stands for manifold document types produced on all levels of government, academics, business and industry in print and electronic formats that are protected by intellectual property rights, of sufficient quality to be collected and preserved by library holdings or institutional repositories, but not controlled by commercial publishers, i.e., where publishing is not the primary activity of the producing body".* (Farace and Schöpfel, 2010).

Although this definition focuses on important aspects of GL, it might need to be expanded to take into consideration new challenges brought about by new disruptive technologies, such as AI. In 2017, I proposed a new definition, which might help meet some of these challenges. According to this revised definition,

> *GL represents any recorded, referable and sustainable data or information resource of current or future value, made publicly available without a traditional peer-review process.* (Savic, 2017b).

Artificial intelligence (AI) and related machine learning (ML) applications[1] are systems that can think and act rationally, almost like humans. They are usually very costly and complex to develop maintain and deploy. Their power comes from a combination of many technologies and techniques, such as powerful parallel computer processing, deep learning, neural networks, and natural language processing (NLP). Initially, they appeared as rule-based or expert systems, but today's algorithms can understand, learn, predict, adapt and potentially operate autonomously. They are often built into physical devices (e. g., robots, cars, consumer electronics, and security systems); and into apps and services (e.g. virtual personal assistants, smart advisors, voice recognition, computer vision, translation, and finance). Applied in the area of information and knowledge management they become a powerful help in processing, organizing and disseminating data and information. Incorporated in some web apps, AI enhances the user experience by offering new smart and adaptive user interfaces.

One of the earliest yet still popular definitions of AI is that offered by Marvin Minsky[2] back in 1968. He defined artificial intelligence as “the science of making machines do things that would require intelligence if done by men”. Another definition that AI researchers believe will be valid for many years states that “artificial intelligence is the study of how to make computers do things at which, at the moment, people are better.” (Rich, 2010).

On the practical side, AI started with simple test applications, such as the famous Turing test, continued with games, like checkers, and later with expert systems which represented knowledge through rules. A good example of this was Deep Blue, an IBM developed system for playing chess that defeated world champion Garry Kasparov in 1997.

Machine learning, as part of AI, came into focus in the 80s. It allowed computers to learn how to recognize patterns and make predictions. This was a revolutionary move from the traditional hard-coding software programs to performing specific instructions to complete a task. Systems became dynamic and the need for programmers to make certain changes was eliminated.

The latest stage of AI is ‘deep learning’. It typically requires a lot of processing power and a large set of “training data”, through which the use of neural networks allows ‘intelligent behavior’. The three most popular forms of training are: unsupervised, supervised, and

[1] AI is the broader concept of machines being able to carry out tasks in a way that we would consider “smart”. Machine Learning is a current application of AI based around the idea that we should really just be able to give machines access to data and let them learn for themselves. (Marr, 2016)

[2] Marvin Lee Minsky (August 9, 1927 - January 24, 2016) was an American scientist in the field of artificial intelligence (AI), co-founder of MIT's AI laboratory, author of several texts on AI and philosophy, and winner of the 1969 Turing Award.

reinforcement training. Good examples of deep learning applications are those used for face and speech recognition, robotics, chatbots, self-driving cars, computer games, etc.

Regarding the level of AI complexity three types are generally acknowledged (Dickson, 2017):

- Artificial narrow intelligence
  (a system developed and trained for a particular single task within a limited domain)
- Artificial general intelligence
  (a system that can understand and reason about its environment as a human would)
- Artificial super intelligence
  (a system much smarter than the best human brains in practically every field).

All of the AI systems currently in use, or currently being developed, are at the initial, narrow level of AI. More powerful programs and computers, potentially quantum ones, would be needed to achieve the second, general level of intelligence. Some researchers believe that once that level is achieved, it will not be much longer until the level of super intelligence is reached.

The general impact of artificial intelligence

Artificial intelligence is here to stay and its impact is irreversible. The benefits and the magnitude of its potential power have been experienced by many people. The history of its progress is exemplified by a collection of remarkable achievements. In 1956, Arthur Samuels Checker program, developed for play on IBM's 701, was introduced and in 1962 beat the checkers master. In 1966, ELIZA, one of the first chatbots, carried out conversations with people in natural language. In 1976, an expert system called MYCIN made a successful diagnosis of infectious diseases, while dealing with uncertainty. In 1986, an artificial neural network system NETtalk[3] read written English texts aloud. In 1977, IBM's super computer Deep Blue defeated world chess champion, Gary Kasparov. 2009 brought the first Google self-driven car to the California freeway. In 2011, IBM's Watson system beat two human experts at the Jeopardy TV game show. Just four years later Daimler-Benz demonstrated its first autonomous big rig truck on Germany's autobahn, while Google self-driving cars drove over one million miles. In 2016, Google's DeepMind AlphaGo computer program beat the world's best Go player. (Ertel, 2017). These are just some of AI researchers many successes. Various countries, universities and research centers have placed their current priorities on AI projects. It is, therefore, reasonable to expect exponential future developments in this interesting area of research.

Even today, although at the initial or somewhat basic level of complexity, a number of operational AI applications in classic office environments strongly indicate the trends of their future impacts. Big companies such as Microsoft, Google, Facebook, Instagram, Twitter, and Disney are heavily involved with AI applications. Here are some examples of lesser known applications which demonstrate variety, depth, and the force of change to come[4].

[3] **https://www.nytimes.com/1988/08/16/science/learning-then-talking.html**

[4] Examples adapted from Dom Nicastro, 8 Examples of Artificial Intelligence (AI) in the Workplace', Dec 7 2017. CMSWire. https://goo.gl/s6bWGH and Bernard Marr, 27 Incredible Examples Of AI And Machine Learning In Practice. April 30 2018. Forbes. https://goo.gl/YX52TK

SAP CoPilot: Digital Assistant for the enterprise – using their phones, users can ask business related questions and the system offers an answer.

Deloitte: Automated document review with natural language processing - quickly reads thousands of complex documents, extracting and structuring textual information for better analysis.

AISense: Call, Meeting Transcriptions – records voice conversations and makes them searchable and easily accessible using automatic speech recognition, speaker identification, speech-and-text synchronization, and natural language processing.

WalkMe: AI for Software Training - enables business software to learn about the user's individual roles, habits, and actions.

ServiceChannel: Restaurant Facilities Management Aid - helps automate the repair and maintenance process, cut repair and maintenance costs, maintain compliance, and minimize risk. It manages contractors, work orders, preventative maintenance, assets, proposals, and invoices.

Niles: Learning Slack Conversations - listens and records conversations that happen within the Slack collaboration platform. Every time someone sends a message, it learns, so users can ask questions such as, "What products do we sell? What sizes? How much do we charge? Who's in charge of this department?" If it fails at an answer, users can keep the system up-to-date by providing the right answer.

Acculation, Inc.: AI Meets Social Media - uses data-driven processes to make decisions about content for social media. It can actually create the content.

BBC Talking with Machines - an audio drama that allows listeners to join in and have a two-way conversation via their smart speaker. They are prompted to answer questions and insert their own lines into the story.

UK Press Association RADAR (Reporters and Data and Robots) - robots write 30,000 local news stories each month fed with a variety of data from government, public services, and local authorities. The machine uses natural language generation technology to write local news stories that are not covered by humans.

American Express - relies heavily on data analytics and machine learning algorithms to help detect fraud in near real time, therefore saving millions in losses.

Impact of artificial intelligence on grey literature creation

There are various ways to look at the impact artificial intelligence will have on the creation of grey literature. This review takes an analytical approach by looking at each of the main facets of grey literature, taken from wider studies in the field of information and data management. As Figure 1 shows, five Vs are taken into consideration. They are variety, volume, veracity, velocity, and value.

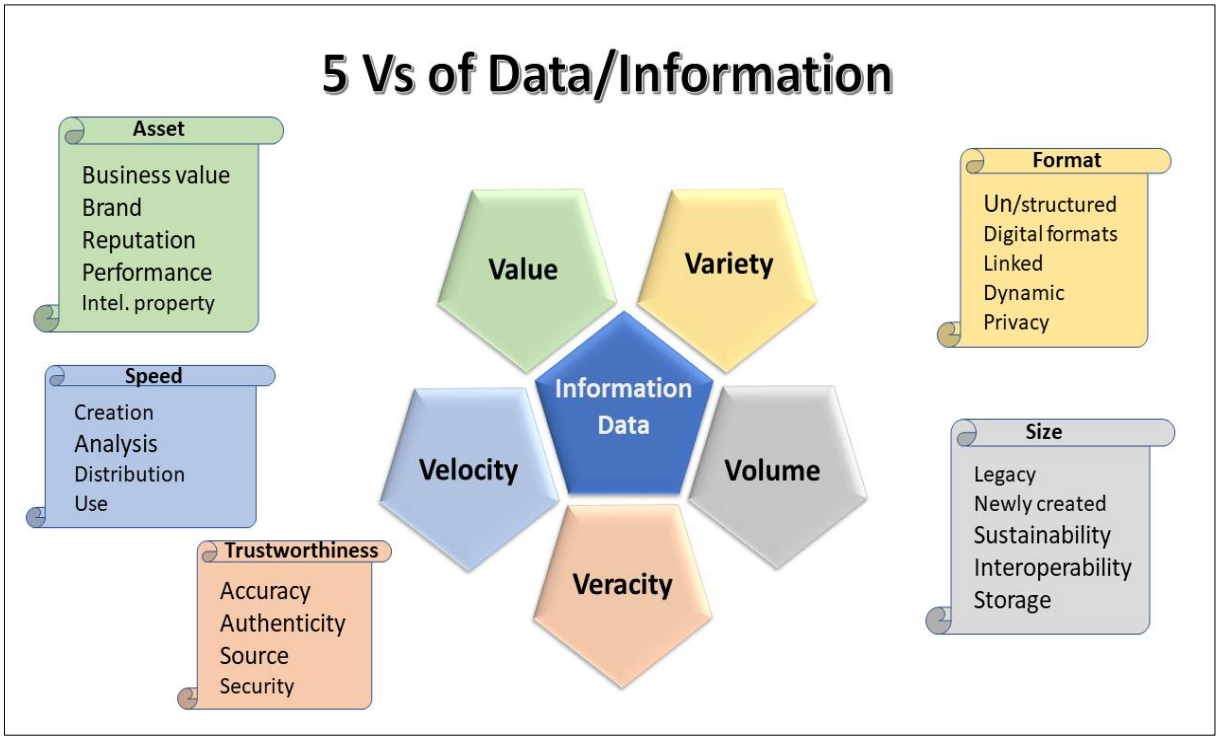

Figure 1: 5Vs of data/information

The variety of grey literature formats could experience a considerable impact from AI use, although as Figure 2 indicates, there are already a large number of identified formats. A more complete list is available at the GreyNet International website[5]. It lists over 150 document types specific to GL.

Bibliographies	Rejected manuscripts	Publications from NGOs and consulting firms
Discussion papers	Un-submitted manuscripts	Videos
Newsletters	Conference abstracts	Wiki articles
PowerPoint presentations	Book chapters	Emails
Program evaluation reports	Personal correspondence	Blogs and social media
Technical notes	Newsletters	Data sets
Publications from governmental agencies	Informal communications	Committee reports
Reports to funding agencies	Census data	Working papers
Unpublished reports	Pre-prints	Company reports
Dissertations	Standards	Catalogues
Policy documents	Patents	Speeches
	Webinars	Reports on websites

Figure 2: Types of grey literature

If we examine only one GL type, namely 'data set' (marked above in red), this type alone typically includes a tremendous amount of data and information coming from the Internet of Things (IoT), Machine to Machine communication (M2M), self-driven cars, robots, sensors, security systems, surveillance cameras, and many other systems using AI. Estimates for the number of connected devices creating specific data trace vary by billions.[6] Such a huge number of devices, generating tons of data, in multiple formats, mostly unstructured and application specific, will represent a considerable challenge for GL researchers, practitioners,

[5] http://www.greynet.org/greysourceindex/documenttypes.html

[6] Gartner says that there will be some 20 billion connected devices communicating to each other by 2020. Allied Business Intelligence says more than 30 billion, Nelson Research says 100 billion, Intel says 200 billion, and International Data Co. says 212 billion.

and managers. Such highly contextual and software dependent data and information would be hard to collect and process, and even harder to make sense of and preserve for future use.

Closely related to single data sets is the question of connected multiple data sets, often referred to as linked data. Linked data represents the main ingredient of Semantic Web that's understandable not only to humans but also to computers. A good example of a large linked data set is DBpedia, which, in fact, makes the content of Wikipedia available in the Resource Description Framework (RDF), while including links to other datasets on the Web, such as GeoNames. By providing those extra links, the application offers much better access to knowledge and a more satisfying user experience. However, identifying and finding a role for classical GL management becomes a challenge.

The volume of grey literature is the next area already undergoing a visible change which will be further impacted by the use of AI. According to available statistics, 2.5 exabytes of data are produced every day, which is equivalent to 250,000 Libraries of Congress. In comparison, the human brain has an estimated storage capacity of 1000 terabytes or one petabyte. 90% of all the data in the world has been generated over the last two years. There are 130 million published books around the world, with over 800,000 new titles added annually. At the same time, the digital world is moving towards increased use of mobile phones creating even more data. Currently, over half the world uses a smartphone. According to Cisco's (2017) prediction, the number of devices connected to IP networks will be three times as high as the global population in 2021. At the moment, the number of worldwide users of the four most popular messaging apps[7] have reached 4 billion.

If we mention just dissertations as one of more important GL types, Google Scholar hosts almost 4.3 million dissertations from all around the world, while ProQuest adds annually more than 130,000 new dissertations and theses to its largest dissertation database, ProQuest Dissertations & Theses (PQDT) Global[8].

Figure 3 gives an interesting statistical overview of some of the parameters regarding the volume of Internet traffic.

[7] WhatsApp, Facebook Messanger, WeChat, QQ Mobile. Source: **https://goo.gl/UYArhS**
[8] **https://www.proquest.com/products-services/dissertations/ProQuest-Dissertations-FAQ.html**

	Amount per minute
Forecast requests received by The Weather Channel	18,055,555
Text messages sent	12,986,111
Videos watched by YouTube users	4,333,560
Google searches conducted	3,788,140
GB of internet traffic generated by Americans	3,138,420
Snaps shared by Snapchat users	2,083,333
GIFs served by GIPH	1,388,889
Songs streamed on Spotify	750,000
Tweets sent by Twitter users	473,400
Calls made by Skype users	176,220
Hours of video streamed on Netflix	97,222
Posts published by Tumblr users	79,740
Dollars processed via Venmo P2P transactions	68,493

Figure 3: Media usage in an internet minute as of June 2018 (statista.com)

From the aspect of GL management, even more alarming than the above statistics is the fact that 56% of all internet traffic is from automated sources such as hacking tools, scrapers and spammers, impersonators, and bots. There are 269 billion emails sent and received each day, out of which 60% is spam. Still, the world is hungry for information which is nicely supported by the figure issued by Google that it processes daily over 6.6 billion queries, out of which 15% have never been searched for on Google before.[9]

If we combine the variety of GL formats with the volume, as partially described above, and the increased emergence of AI, the challenge that GL professionals are facing, and will continue to face in the future, is enormous. The questions of storage, sustainability, processing, usability, and many others are overwhelming. With current operational capacity, general interest, and available resources, the fear that most of GL will disappear or become unusable over time is well founded.

The increased volume of GL also merits the question of ways to measure its impact and popularity of the scientists and researchers. A common way was „counting the number of articles citing other articles, resulting in journal impact factors, normalized citation rates, and the h-index. Even those rare studies including conference papers are limited to published

[9] 100+ Internet Stats and Facts for 2018. Available from: https://goo.gl/iUcnxc

proceedings. Grey literature remains out of scope“ Schöpfel (2017). Major effort and additional resources are needed to demonstrate the value and extent of the GL impact.

The veracity of grey literature looks at its validity and trustworthiness. It is defined as “conformity to facts; accuracy; habitual truthfulness”[10]. In particular, it deals with GL accuracy, authenticity, information source, and security. Spam email, fake news, computer bots, botnets, web spiders, crawlers, viruses, plain misinformation and disinformation, they all represent multiple dangers that web users, including GL users, face today. Uncovering deception and estimating the veracity of information and data is difficult, in particular when prior background knowledge about content, context, or source is weak or not available.

The main assumption about establishing the veracity of some information is its originating source. If it is a well-known source with a long tradition of trustworthiness, information is usually regarded as reliable, although there are many cases of inadvertently created false information placed on the web or included in some documentation. Such cases lead us to conclude that, as users, we always need to be on the lookout for possible errors or false information. Multiple checkpoints, such as source, independent confirmation, a best practice used in preparing the information, and even intention, all need to be taken into consideration when establishing information veracity.

The use of artificial intelligence in almost any sphere will increase problems with defining the actual information veracity. We can look at two facets of the information created while relying on AI in the process of its creation. The first is the question of documented procedures, steps followed, inference paths, and decision justifications. Quite often, the whole process becomes a ‘black box’ where all we have is the input and the output, without any trace of the logic or reasoning used. Such machine-learning models are already having an impact on people’s lives. A system called COMPAS offers to predict an offender’s likelihood of reoffending and is used by some judges to determine whether an inmate is granted parole. Some suspect bias against minorities (Knight, 2017). Such AI machines do not offer any documented justifications and could display a strong potential bias, especially when there is a probability that the training data used was biased.

The velocity of grey literature refers to the speed of information creation, processing, analysis, distribution, and use. Figure 3 shows the amount of data and information created, but in addition to the amount, we also need to look at the speed at which this humongous amount of data is being created.

It is estimated that more data has been created in the past two years than in the entire history of the human race. The speed of creation results in zettabytes of stored information which, unfortunately, is barely being processed. Technical, physical, financial, and other challenges limit the possibilities for analyzing such a huge amount of data. Research shows that 99.5% of

[10] Oxford Dictionary. Available from: **https://goo.gl/AkG95E**

all data is not currently being analyzed and used (Bansal, 2014). This represents a big financial, business, and information loss for everyone involved.

This huge amount of information and data enables artificial intelligence and machine learning to turn data analysis from retrospective practice into a proactive approach to strategic decision making. AI can greatly increase the frequency, flexibility, and immediacy of data analysis across a range of industries and applications.The International Data Corporation (IDC) estimates that the amount of global data subject to data analysis will grow by a factor of 50 to 5.2 ZB in 2025; the amount of analyzed data that is "touched" by AI systems will grow by a factor of 100 to 1.4 ZB in 2025. (Reinsel et al., 2017).

As information grows in variety, volume, veracity, and velocity, business needs would focus on the information that has the most important value. Not all data is equally important to businesses or consumers, providing an opportunity for GL and other information managers to offer tools, expertise, and visible results to identify that specific value of information from the ocean of available data. The organizations that succeed during this transformation will be those that can successfully identify and take advantage of the critical subset of data that will have a meaningful, positive impact on user experience, solving complex problems, and creating new economies of scale (Ibid).

The value of grey literature, and the value of information in general, rarely finds its place on a balance sheet. Almost everyone agrees that information is an asset that costs millions[11], but hardly anyone can tell where the asset sits, its quantity, or even where it came from. It is difficult to measure, although many claim to own the asset while trying to avoid any accountability for it.

The glossary of the Queensland Government Chief Information Office offers a valuable and widely applicable definition of an 'information asset'. It defines it as „An identifiable collection of data stored in any manner and recognized as having value for the purpose of enabling an agency to perform its business functions thereby satisfying a recognized agency requirement. Data or information that is referenced by an agency, but which is not intended to become a source of reference for multiple business functions is not considered to be an information asset of the agency. This is merely information." (Information Asset, 2017).

Many organizations and industries recognize information as a strategic business asset and Gartner predicts that by 2020 10% of organizations will have a highly profitable business unit specifically for making and commercializing their information assets (Pettey, 2017). They also claim that information assets have great potential, beyond the utility for which they were originally produced. Unlike most of your enterprise's other assets, information isn't depleted after it's consumed. In order to utilize its value, they propose (see Figure 4) to review

[11] An asset is a resource with economic value that an individual, corporation or country owns or controls with the expectation that it will provide a future benefit. Assets are reported on a company's balance sheet and are bought or created to increase a firm's value or benefit the firm's operations. Investopedia **https://www.investopedia.com/terms/a/asset.asp#ixzz5QKbl1CnA**

performance and vision gaps that exist between the three levels of information value – realized, probable, and potential.

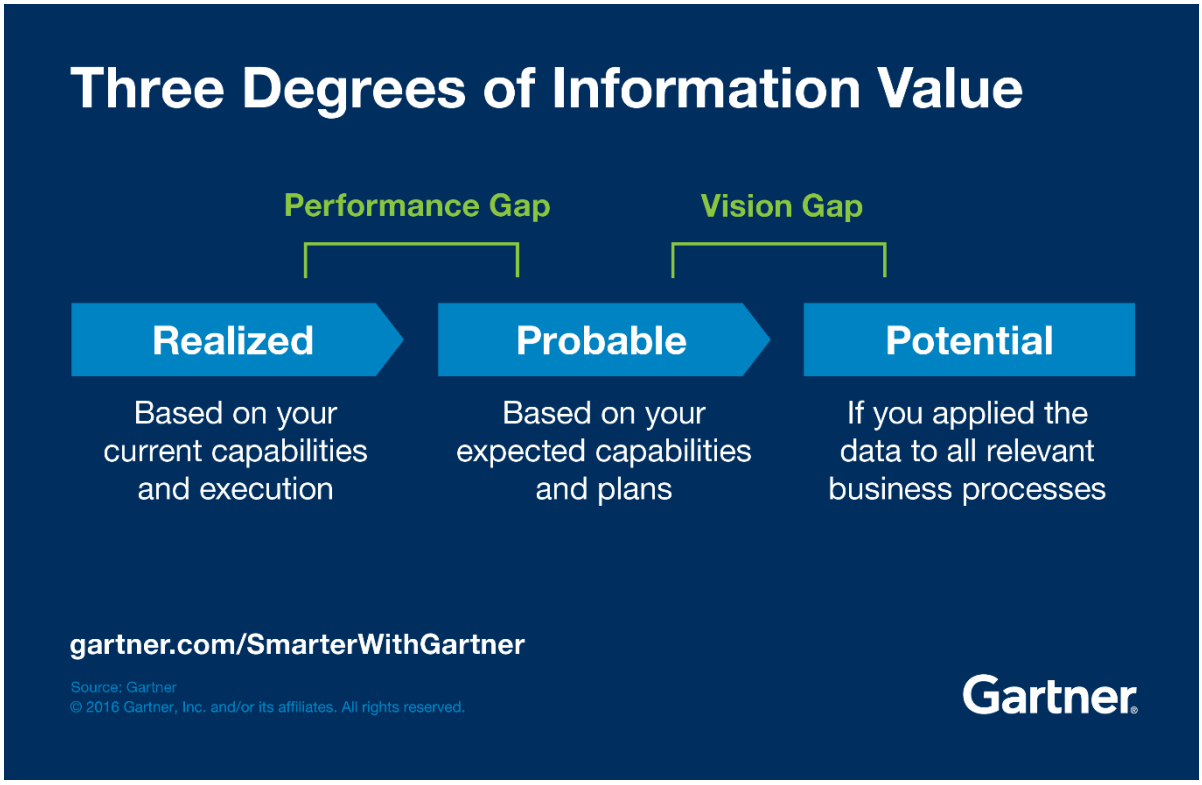

Figure 4: Three degrees of information value

The performance gap is the difference between the realized value of an information asset and its probable value, while the information vision gap represents the difference between probable and potential information value (Levy, 2016).

Impact of artificial intelligence on grey literature management

In the era of intensive artificial intelligence use and machine learning, three main areas of grey literature management will be directly impacted. They include GL processing, sustainability, and usability.

GL processing and the related management tools used are directly impacted by the increased volume, variety, velocity, veracity, and value of the grey literature created. A single document and ad-hoc approach to management will be neither appropriate nor sufficient. What is required is the transparent inclusion of GL-type processing[12] during document creation, rather than post-processing. An additional requirement is to have a GL management system in place all the time, eliminating the need for any ad-hoc solutions or deviations from an already set-up plan.

[12] E.g. meta-data creation, retention scheduling, distribution channels, copyright, confidentiality, etc.

GL sustainability, the next challenge regarding the impact of artificial intelligence on grey literature management, includes three broad challenges – environmental and technical; economic and financial; and social or organizational. Preservation of documents, technical knowledge transfer over long periods, information continuity, technical operability, and usability are just some of the important aspects related to environmental sustainability. Economic and financial sustainability focuses attention on the availability of long-term adequate funding, public vs. commercial interests, and the future value of collected GL as it relates to the value of information. Social and organizational considerations emphasize the existence of multiple stakeholders, information ownership and governance, international cooperation, and also safety and security.

GL usability of large amounts of information generated by the use of AI creates an additional category of problems, such as the existence of adequate IT tools, the availability of qualified human resources, and the protection of intellectual property (IP) and privacy. Let's look at some of the challenges here. IT technology and tools are constantly changing, contributing to new software functionality, concepts, and expectations in quantum leaps, and making previous technology obsolete in almost no time. Related to this issue is the creation of dynamic vs. static information and documents, and their visualization (e.g. 2D, 3D, VR, AR). Many predictions about the impact of AI relate to job loss,[13] which translates to staffing requirements, but there is also the issue of the required technical skills, education, and training[14]. Intellectual property involves issues such as over-protectionism; open access and open science; and the role of current IP in helping world development, health, and innovation. Related to this are issues of privacy, including the protection of commercial information, and the protection of the sensitive public and personal information.

The above mentioned three areas of the expected impact of AI on grey literature management mainly deal with challenges. However, there are also some great opportunities that the use of AI on GL can offer to its management process. The first and probably most important opportunity is the reliable automation of repetitive tasks, with great accuracy, and without fatigue[15]. AI can improve current services by adding intelligence, semantic understanding, and powerful analytics to existing GL management processes. A great amount of the created and easily available data can be used to further improve learning algorithms, increasing AI accuracy, and it can create new knowledge and extract new value from existing GL resources. This coupling of big data and AI can bring a new type of AI often referred to as 'data intelligence'.[16]

Conclusion

In the last few decades, developments in information technology have had an immense impact on the way we manage information in general, and on the way we create, disseminate and use

[13] A two-year study from McKinsey Global Institute suggests that by 2030, intelligent agents and robots could eliminate as much as 30 percent of the world's human labor. (McKinsey, 2017). Available from: **https://goo.gl/RHr53a**

[14] By one popular estimate, 65% of children entering primary school today will ultimately end up working in completely new job types that don't yet exist. (World Economic Forum, 2016). Available from: **https://goo.gl/JKwsbn**

[15] SAS Insights: Artificial Intelligence: What it is and why it matters. Available from: **https://goo.gl/zgpJHz**

[16] The UNESCO Courier, 2018-3. Available from: **https://goo.gl/jeRxkk**

grey literature. This paper examined the potential impact of AI on grey literature management and elaborated on its main facets, such as value, volume, variety, velocity, and veracity. Based on the growing volume of data, information, and knowledge generated and further increased by the use of AI, we can conclude that GL will not disappear in the future, that its volume will probably experience exponential growth, and that the number of GL types, its velocity, and value will increase.

The impact of AI on GL management will be especially felt in the way GL is processed, kept sustainable, and used in the long run. GL-type processing needs to be included in the f document creation process, rather than post-processing; and the GL management system should be in place all the time, eliminating the need for any ad-hoc interventions. Environmental and technical; economic and financial; as well as social or organizational constraints need to be taken into consideration if long-term GL sustainability is to be provided. Usability of GL depends on the existence of adequate IT tools, the availability of qualified human resources, the protection of intellectual property (IP) and the protection of personal privacy.

Artificial intelligence will impact every aspect of our work environment therfore, in order to secure the future and maintain the value of grey literature, intensive training, wide cooperation, and rigorous preparation need to be organized by all stakeholders and key-players.

Studies show that only a very small percent of businesses extract full value from the information they hold [17]. Use of artificial intelligence in GL management might enable organizations to focus on what matters most – business results, efficiency gains, quality of products and services.

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