Old Meets New: Integrating Artificial Intelligence in Museums' Management Practices

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Abstract
A review of artificial intelligence (AI) techniques as observed in the current literature is put in a mirror with the present practices of management in museums worldwide. The paper shows that AI initiatives are helping museums for a variety of aspects in their management, such as to design and improve knowledge management frameworks, to make operations management more efficient, to modernize visitors' experience, to enhance the educational value of these visits, and to make data-based decisions regarding visitors' journeys, resources allocation, and for financial analysis of different projects. The most common approach seems to be the chatbot, but it is not the only example, as different initiatives are centered around the usage of Big Data, machine learning, natural language processing algorithms, neural networks, etc. AI adoption for various aspects in the management of museums is considered especially by museums in the US, but several remarkable examples are to be observed in other countries too. In Romania, new technologies are mostly inserted in museums as QR or VR spots. Still, there are also some AI initiatives, which might become a base for gaining experience and for other effective and appealing initiatives.

Keywords
Artificial intelligence; museums' management; visitors' journey management; data-based decision making; knowledge management.

Introduction

Artificial intelligence is becoming a common term in our everyday lives. We propose a study of the applications that emerge by the use of artificial intelligence techniques in museums in general and we look at some cases of how they apply to Romanian museums. While museums, as cultural institutions, are not necessarily driven by the same market forces as enterprises, the context of the Covid-19 pandemic has revealed their exposure and created an incentive to extend beyond their traditional consumers and delivery methods. AI also offers long-term opportunities to diversify museums' offers, to enhance its educational and entertainment features, as well as to better manage collections or even research heritage.

We will first look into what AI represents and why there are still difficulties in the classification of various technologies into this all-encompassing technological bucket. We follow with a review of the main artificial intelligence applications as discussed in the context of museums. Examples gathered from around the world help better understand the options, the specific challenges, as well as the most appealing initiatives. The last section of the paper presents two AI initiatives of Romanian museums – IA from the Muresenilor Museum in Brasov and the Bucharest International Biennale for Contemporary Art.

Understanding Artificial Intelligence

There is an ongoing debate in both the academic and scientific community (Monett & Winkler, 2019; Nilsson, 2009; Simon et al., 2000), reflected also in the more general business area (Davenport & Bean, 2018; Scherer, 2015) and well as in politics (European Commission, 2020) about what exactly artificial intelligence represents. This is a common trend for other emerging technologies as well. For instance, Pagliari et al. (2005) discuss this in detail with a focus on eHealth but with conclusions applicable generally.

While we will not focus on identifying a single definition, we do point to the efforts of Legg and Hutter (2006) which collected 70 such definitions. However, we aim to identify a framework under which we can compare technological solutions to use it as a guide for the research path as Wang (2019) also suggests.

Classifying AI should be an easier task than defining it. One of the highest level classifications comes from the breakdown into two main categories, artificial general intelligence (AGI) and artificial narrow intelligence (ANI)(Kaplan & Haenlein, 2019). AGI refers to intelligence that is capable of influence and understanding over a broad range of situations and environments and can perform at an intellectual level comparable to at least average human performance (Bostrom, 2017, p. 23; Urban, 2015) but while there are significant potential benefits that can be brought by it (Bostrom, 2017; Kurzweil, 2013) and serious concerns about the possible risks associated to AGI (Bostrom, 2017; Vinge, 1993; Yudkowsky, 2008). There is full consensus that AGI is not yet developed (Tegmark, 2017; Yampolskiy, 2021) and some even posit that may not even be developable at all (Fjelland, 2020).

Artificial Narrow Intelligence (ANI) can only perform the functions that it was designed to do initially, which translates into a very narrow range of capabilities. For example, chess represented one of the initial paradigms in artificial intelligence and, today, computers are playing chess at a super-human level. However, this progress in a specific field did not directly translate into progress in other areas of artificial intelligence. This type of individual narrow approaches, with direct, concrete goals of solving practical problems and having real-world applications came to be known as Artificial Narrow Intelligence (ANI). The advantage of this approach was that the progress of the algorithms to beyond human abilities was very fast. The current view posits that all technologies designated as artificial intelligence fall into this category (Al-Shabandar et al., 2019; Bostrom, 2017; Kaplan & Haenlein, 2019; Pohl, 2015).

This broad classification, while technically correct, is too generic and, therefore, not sufficient for analyzing the use of artificial intelligence as a framework in a specific domain. Therefore, we acknowledge that, for this article, we will limit the use of the term artificial intelligence to refer to the narrow, real-world applications of ANI. This enables us to focus on a more granular view of the underlying technologies that are considered to make up the general field of artificial intelligence. Our choice is motivated by the fact that it seems that once a certain technology is reaching maturity and is proven to be functional it is no longer classified as artificial intelligence (John McCarthy as cited by Vardi, 2012). This future-driven view of artificial intelligence is also supported by Davenport and Bean (2018) who describe AI as that technology which "is never really here".

The adoption of Artificial Intelligence in museums

Expert systems have historically been the first type of systems to be considered as artificial intelligence (Russell & Norvig, 2010). They were based on the earlier work on knowledge systems and knowledge representation which led to the design of the first knowledge-intensive system, a system that was based on large numbers of special-purpose rules. Their main advantage, explainability (a feature that is again coming into focus today under the name of XAI – eXplainable AI) and predictability, had been offset over the years by the increase in the number of rules required as the domain of expertise expanded (Davenport, 2018).

While expert systems have been considered obsolete, newer advances in Bayesian networks, another type of artificial intelligence technique, which allows for reasoning under conditions of uncertain knowledge by using evidence to update beliefs in hypotheses has allowed for a new type of learning from experience and resulted in normative expert systems (Russell & Norvig, 2010).

Bayesian networks are simply a model for representing conditional independencies between a set of random variables (Ghahramani, 2001). A specific type of Bayesian network, the Hidden Markov Models, are a technique used today in most speech recognition software (Kurzweil, 2013, p. 13) and forms the basis of **natural language processing (NLP)** algorithms that allow the computer to understand, analyze and manipulate natural language.

Museums could also use NLP in various ways. For instance, the National Museum of Natural History in New York uses NLP to analyze visitors' feedback on Trip Advisor (Murphy & Villaespesa, 2020, pp. 4-5).

NLP forms the basis for the creation of interactive storytelling experiences in museums which, as argued by Dal Falco and Vassos (2017) are driving an increase in the value of the knowledge being passed on to visitors. NLP is a technique that has become quite usual in companies with Davenport (2018) arguing that NLP was already being used by fifty-three percent of the “cognitive aware” companies surveyed. This is generally done by the use of the now-ubiquitous chatbot.

Chatbots have been used in museums for more than a decade now, both small and large museums, benefiting from relatively low costs and resources (Gaia, Boiano, & Borda, 2019, p. 314). Varitimiadis et al. (2021) present a detailed analysis of the use of chatbots in the specific context of museums over a large sample and conclude with a proposed architecture for the implementation that takes into account the specific cases and knowledge types that museums require. Noh and Hong (2021) determined three main clusters of users: the responsive communicator with an activist learning style, the quick receiver, and the enthusiastic seeker.

One of the first chatbots used in museums was MAX, an avatar used by Heinz Nixdorf MuseumForum, the largest computer museum in the world, to engage the audience, used as a virtual guide, launched in 2004 (Kopp et al., 2005). Screening the way visitors interacted with MAX, a large variety of situations was observed – some visitors would just briefly chat with MAX, while others would have extensive “conversations”, MAX would be more talkative and formulate more complex sentences than visitors, visitors would give both positive and negative feedback to MAX, some would test the avatar, while others would even treat him abusive and course him. Nevertheless, most visitors proved to cooperate with MAX, take his “human” side seriously.

Figure 1. Max @ Heinz Nixdorf Museum Forum
(from Kopp, Gesellensetter, Krämer, & Wachsmuth, 2005)

Today, these avatars evolved at least from a design perspective – they are in most cases friendly robots welcoming people enter museums. Figure 1 shows the “old” Max, while Figure 2 shows the present robot in the same museum which welcomed visitors, and Figure 3 is a similar one in Hydropolis Museum in Wroclaw.

Figure 2. Pepper welcomes you at the Heinz
Nixdorf MuseumForum
(from museum's website/virtual tour)

Figure 3. Pepper from Hydropolis
(https://wroclaw.wyborcza.pl/wroclaw/7,35771,22761913,robot-pepper-atrakcja-hydropolis-jego-obowiazek-to-witanie.html)

Visitors can interact with chatbots in many museums around the world: Anne Frank's House in Amsterdam, Cooper-Hewitt Museum in New York, Field Museum in Chicago, Carnegie Museum in Pittsburg, Smithsonian Museums in Washington DC, Akron Art Museum in Ohio, Dali Museum in Florida, Barnes Foundation in Philadelphia, House Museums in Milan, Musée du Quai Branly in Paris, National Art Museum in Belarus; Museum of Tomorrow in Rio de Janeiro, Pinacoteca from São Paulo (Ashri, 2017; Charr, 2019, 2020; Levere, 2018; Munro, 2016; Richardson, 2019; Styx, 2021). Chatbots could be associated with museums' websites or integrated into apps or social media platforms, but also inserted in museums to enhance the visiting experience. In many cases museum chatbots direct visitors in the right direction, but they also could answer more complex questions answering in a personalized way to questions about museums' collections or topics. These chatbots could be designed to learn from the multitude of visitors' experiences and reactions to give better answers and have more appropriate reactions, as in the case of the IRIS+ chatbot of the Museum of Tomorrow in Rio de Janeiro. Some chatbot interfaces are robots, as in the case of Pepper robots of the Smithsonian Institutions, or are various types of interactive displays. Pepper displays a touch screen, but it also reacts directly, being able to dance or play games (Levere, 2018).

Figure 4. Berenson
(from https://news.artnet.com/art-world/robot-art-critic-berenson-436739)

Figure 5. IRIS+
(https://museudoamanha.org.br)

Another initiative that stands out is Berenson Art Critic (Figure 4) from the Musée du Quai Branly in Paris (Munro, 2016). The name is inspired by a famous art critic. It is developed by an engineer and an anthropologist. It is not designed actually to give expert opinions on art, but rather engage with visitors. It "reads" expressions, recognizes positive or negative reactions of visitors to various works, and "responds" similarly with smiles or frowns. Therefore, real art critics and some museum experts are not really impressed with Berenson's art knowledge and evaluations, but for sure visitors enjoyed his unusual presence. Other chatbots, even if do not have any "human" shape, like the digital Dot from Akron Art Museum, are more interactive. Dot not only answers questions but also asks visitors surprising questions trying to connect art with their interests and lives (Levere, 2018).

Gaia, Boiano, and Borda (2019) analyze how chatbots engage museum visitors, starting from the case study of four historic houses in Milano. A Facebook Messenger chatbot game invites the public to explore the historic houses, to search for clues to fight a Renaissance magician.

In the Pinacoteca from São Paulo, in 2017, an interactive audio guide has been developed. A mobile application allows visitors to ask questions related to various works of art. No pre-designed question-and-answers sets are developed, but spontaneous questions from visitors are answered in a real team using information from cloud platforms (Richardson, 2017).

The interest of the museum world in chatbots determined Victoria and Albert Museum (V&A) to host the 2016 Bot Summit (it can be viewed at http://tinysubversions.com/botsummit/2016/). The commitment of V&A is even deeper; some of the artists in residents are specialized in videogames or even artbot design. An interview with the Videogames Resident Matteo Menapace shows how collections of the museum inspire artists to design *Twitterbots* and an interactive project involving visitors both in a museum and online (Quinlan, 2018). Also, museums investigate the evolution of AI, of new technologies, and analyze their relationships with and impact on arts and society. Probably the best example is also V&A with exhibitions on videogames (https://www.vam.ac.uk/articles/about-videogames-exhibition) or emerging technologies that shape both the present and the future (https://www.vam.ac.uk/articles/about-the-future-starts-here-exhibition), and various events exploring AI through arts or generating interdisciplinary debates of this complex concept (https://www.vam.ac.uk/event/Ed6aWGg9/artificially-intelligent-display, https://www.vam.ac.uk/event/VkwjplJZ/v-a-samsung-digital-classroom-machine-learning-and-ai-16-a-24-years-old, etc.). Of course, V&A is not the only museum interested in exploring the relationship between humans and technology. Another example is the traveling exhibition *Ai: More than Human* (Murphy, 2021).

Big Data is not actually an artificial intelligence technique. However, it is both an enabler and a prerequisite for the use of machine learning algorithms. Bughin et al. (2016) argue that utilizing a data-driven approach to decision-making leads to better results when compared with the intuition/experience-driven approach. McAfee and Brynjolfsson (2012) bring up the three specific differentiators that characterize Big

Data: volume, velocity, and variety. The ability to handle all at the same time is what allowed machine algorithms to improve so fast in very short times.

An example of how museums are using Big Data is given by the National Gallery in London (Murphy & Villaespesa, 2020, pp. 6-7). As predicting future flows both to the museum's main gallery and to its various temporary exhibitions is very important to decision-making processes, the museum is investigating past experiences with this focus in mind. Museum analytics aims to design better value for visitors and to ensure financial sustainability for the organization (MuseumNext, 2017).

Bologna Museum is using an AI system to track visitors and understand how they look at artworks but also socializing patterns. This helps plan better exhibitions but also might improve the safety of museums (Charr, 2021).

Machine learning, as defined by Bringsjord and Govindarajulu (2020), is a class of AI algorithms capable of improving their performance on a task when they are provided samples of the ideal performance on the task, or, when they are allowed to repeat the task. There are three main types of machine learning algorithms: supervised learning, unsupervised learning, and reinforcement learning.

Supervised learning uses a training set of input-output pairs to find (learn) the best hypothesis out of the entire space of possible hypotheses. When the output space is finite, this becomes a classification problem while in the case of an infinite (or very large) output space it becomes a regression problem. One of the main problems in the case of supervised learning is finding relevant labeled data which can be used to train the algorithms.

Unsupervised learning alleviates this problem and it doesn't require any training data or feedback to map from the input to the output space. Unsupervised learning is generally used to solve clustering problems. The expected output of the unsupervised learning algorithms is to identify discernible patterns (clusters) in the presented data.

Reinforcement learning algorithms enable the system to observe the environment and decide based on its inputs while being presented with reinforcement as a result of its decision (be it positive or negative reinforcement, reward, or punishment).

Chris Michaels, digital director of the National Gallery in London, considers that "the major applications of AI will come under the hood of museum operations. (…) Machine learning models trained on historic data can pick up all sorts of minute details not obvious to the human eye and quickly make granular and accurate predictions that would take months of manual analysis to achieve. Having this sort of insight easily available, and democratized for museums of all sizes, and museum professionals of many disciplines, means their decisions are more likely to be insight-informed as opposed to guesswork." (Styx, 2021).

Some museums use AI to analyze visitors' reactions in all environments where they interact with museums to better understand their audience, analyze the journeys in museums to better plan their visits, to better design exhibitions and various offers.

Examples of such approaches are offered by The New Museum in New York through NEW INC – the museum's incubator -, the MoMA in New York, or the Art Institute in Chicago (Levere, 2018).

An initiative worth mentioning is the one of the Dali Museum in St. Petersburg, Florida, which allows visitors to actually interact with Dali. Even if a real actor was the main support for Dali's reincarnation, an AI algorithm was used to "learn" how Dali talked and how were his face's movements by exploring hundreds of interviews, films, by exploring quotes (see Figure 6).

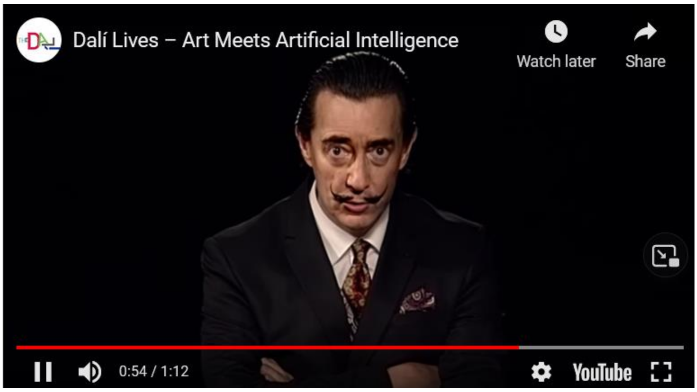

Figure 6. Dali Lives @ Dali Museum Florida
(https://youtu.be/0kq9zabY8rI)

Another good example of machine learning based on arts and heritage is Google Arts and Culture. It has developed an Art Selfie app that finds your match in the art collections worldwide (Styx, 2021). It also has developed Art Filter and Art Transfer (the latter in cooperation with Getty Museum in Los Angeles) (Luo, 2020; Selvin, 2020). Art Filter is based on famous museum artifacts, while Art Transfer changes a photo using classical artworks. Maybe these are not very complex and unique AI applications, but they are a fun engagement of the public with arts and also have educational added value by presenting actual information on artworks, artists, and/or art styles while using these apps. Figure 7 presents some examples.

Figure 7. Google Arts & Culture's Art Filter & Art Transfer in action

Neural networks are based on a loose model of the human brain where the artificial neurons are connected to each other via connections with randomly assigned initial weights. Going through a learning process allows the neural net to adjust those weights and establish pattern recognizers at each layer. Neural networks have progressed very fast in recent years and have proven very effective at image recognition, voice recognition, at learning from unreliable data while still maintaining a high degree of accuracy (Kurzweil, 2013, p. 133). Bringsjord and Govindarajulu (2020) see the emergence of deep learning as a consequence of deep networks, though the definition that they propose is slightly different: "a general form of learning in which one learns from the raw sensory data without much hand-based feature engineering".

Tate Museum is a museum committed to exploring the new technologies' potential in connection to heritage. Annually, it offers the IK Prize "for an idea that uses digital technology to innovate the way we discover, explore and enjoy British art in the Tate collection" (https://www.tate.org.uk/about-us/projects/ik-prize). For instance, the winner in 2016 was *Recognition*, an AI program that compares contemporary photojournalism with museum's art collections, looking for similarities (http://recognition.tate.org.uk/, see also Styx, 2021; Figure 7).

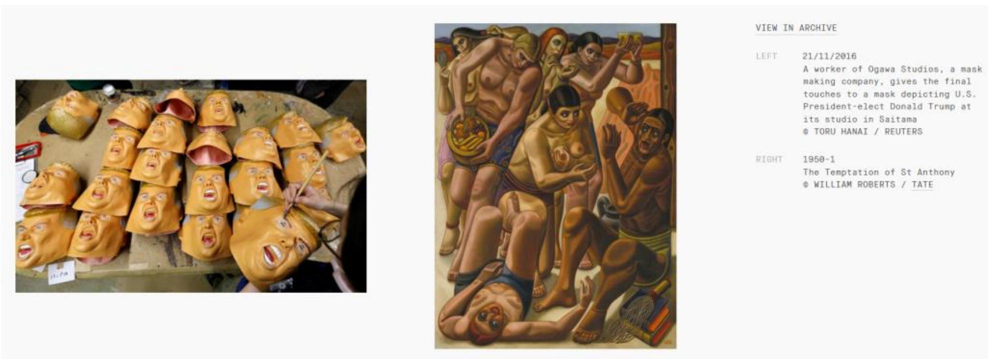

Figure 7. Recognition
(http://recognition.tate.org.uk/#highlights10)

Metropolitan Museum of Art in New York uses AI/ Machine vision to increase the accessibility to its huge and varied collections (Murphy & Villaespesa, 2020, pp. 8-9). Another museum committed to exploring AI is the Cooper Hewitt Smithsonian Design Museum in New York, which has an Interaction Lab. It is meant to be an R&D center aiming to shape new museum visitor experiences for the 21st Century. The Interaction Lab states: "Working in an open and participatory process, we will develop, iterate, and test prototypes with audiences inside our galleries, and optimize successful products for a wider rollout. We will host gatherings of thinkers and practitioners across creative, technology, and cultural disciplines; offer public programs that engage audiences as collaborators; launch design challenges and commissions; develop digital and physical products and services; and generate thought leadership on evolving visitor experience in the museum sector—all of which will be shared widely and openly with the public" (https://chsdmstaging.wpengine.com/interaction-lab/).

Art Galleries have also experimented with AI, both to contribute to a better visitor experience, and to enhance the added value of the visit. For instance, the 2019 exhibition “To Be Real,” at Philadelphia Photo Arts Cente, featured a chatbot named Being created by the artist Rashaad Newsome. Being interacted with visitors as a guide, not only presenting the creative processes associated with the artwork but also asking visitors about their thoughts, leading to reflections on identity (Liberty, 2019).

Other discussions that contextualize AI in the field of museums explore the future use in terms of curating exhibitions. Chen and Lampert (2020) discuss if some future exhibitions will be designed entirely by optimized algorithms. Nevertheless, implementing AI instruments on a large scale in the museum sector is not a simple task considering the interdisciplinary approach needed, the complex challenges, as well as the various resources needed. Advances will be for sure made to simplify the design and implementation of such projects. Already in 2020 a Toolkit entitled AI: A Museum Planning Toolkit was developed by Museums + AI Network to permit non-specialist museums professionals to understand better AI technologies and stimulate their adoption (Murphy & Villaespesa, 2020).

Also, additional applications of AI are relevant for educational design (Pisoni et al., 2021). AI helps to create open-ended learning experiences and autonomous development. AI has also proved to be very useful in the research of museum collections. The most recent example is the one of a hidden artwork of Picasso, discovered under another work of the same artist (Ioniță, 2021). In general, AI can facilitate access to heritage, both for professionals, researchers, and visitors in many ways, involving participatory design, interaction design, and/or pedagogical design (Pisoni et al., 2021).

Artificial intelligence in Romanian museums

Considering the various challenges and specific context, Romanian museums integrate with difficulty the new technologies into their operations, or in their exhibitions. The most frequently considered interventions are QR codes and VR insertions. Some museums managed to have more consistent projects using VR, such as the History and Art Museum in Zalău (http://muzeuzalau.ro/clio-high-tech/), or use it consistently in a creative way, such as in the case of *Dicționar pe sărite* from the National Romanian Peasant Museum in Bucharest (https://www.facebook.com/DictionarPeSarite). In terms of using AI, use present two mini-case-studies.

IA @ Casa Mureșenilor Museum in Brașov

IA is a museum virtual assistant developed in 2019, the first one in Romania. The coordinator of this project was Ms. Cristina Seitz, to whom we are very grateful for all information, images, and explanations. IA is a female avatar, present at the entrance in the museum on a digital display, who can answer questions on the museum, its exhibition, and the city of Brașov. Besides talking, IA also has some non-verbal answers.

IA has been developed based on qualitative analysis meant to identify interests and curiosities that visitors might have. The second step was the design of three main scenarios. After that, the AI program was created and tested. The audience, a young one, chose a contemporary version over a 19-century character. The team involved was multidisciplinary: historians, museologists, sociologists, IT experts. They had to overcome many different challenges (Duguleană et al., 2020). Part of the financing came from the Administration of National Cultural Fund which annually supports many cultural projects, being probably the most important funding body for culture in Romania.

A demo of the result can be seen on YouTube: https://fb.watch/8IujkvIZfc/. Figure 8 presents various use contexts.

Figure 8. Testing IA – the virtual assistent of Casa Mureșenilor
(Source: Casa Mureșenilor Museum in Brașov)

Satisfaction studies show that both visitors and museum staff display good acceptance (Duguleană et al., 2020). Especially for young visitors, AI proved to be a valid knowledge transfer channel.

Bucharest International Biennale for Contemporary Art

This is not a museum initiative; still, it is relevant for the topic we discuss. The organizer is Biennale Foundation, which sets: "The Bucharest Biennale likes to operate in a way that demonstrates sensitivity and competence in dealing with the –'others' as the 'alter' from different cultural backgrounds. The Biennial aims to encourage the creativity of artists, public access to culture, the dissemination of art and culture, inter-cultural dialogue, and knowledge of the history and cultural heritage of the European and extra-European people. The general purpose is to engender a shared cultural area by bringing people together while preserving their national and regional multiplicity and diversity." (https://www.biennialfoundation.org/biennials/bucharest-biennale/)

The Curator of this event is Jarvis (da Silva, 2020). He will harvest information online from universities, museums, galleries, and art centers to plan for the event, to select artists. The name of the curator was inspired by a fictional AI from Iron Man. It is an acronym from Just A Rather Very Intelligent System). The 2022 biennial will be a virtual one, taking place in the Spinnwerk VR gallery. VR booths will also be available in Bucharest and Vienna

As the organizers specify, the 2022 Bucharest Biennale will be the first biennial in the world curated by AI in VR.

Conclusions

From a "nice to have" option, Artificial Intelligence becomes more and more a "must-have" solution for many organizations in search of efficiency and solutions to attract new customers and to increase return rates of users. This is the case for many markets and activities, including the one of museums, where one can find many examples of lessons to be learned and that could be translated to other sectors as well. From far, the most used AI instrument in museums is currently the one of chatbots, in a variety of forms, as it is considered a viable option for the interaction with visitors and is highly appreciated as such. However, chatbots are not the only option and other examples as the ones presented in this paper can be used beyond the marketing imperative. For instance, museums can (and in some cases, do) use Big Data and machine learning for complex analytics that are translated into more efficient operations management, more elaborate and appealing visitors' journeys, or detailed financial analysis for new exhibitions. The implementation of such instruments is still an emergent one, but it tends to accelerate. Thus, it is hard to say if the adoption of AI in museums is already a strategical choice of museums' managers or it remains, for the time being, a distinct solution for concrete and well-defined practical issues.

Adopting AI can be an opportunity for complex and productive frameworks of organizational knowledge management strategies (Zbuchea et al., 2019) if operations are integrated and related to such an approach. Evidence shows that technology is already available, but we know from academic literature on the adoption of AI in diverse organizations that translating Artificial Intelligence solutions into managerial strategies for an optimized use is possible only if mindsets are transformed as well (Solberg et al., 2020), ethical aspects are addressed (Vidu et al., 2020), financial resources are allocated and the cost-benefit ratio is appropriate for the organization (Ivanov & Webster, 2017), and processes are redesigned (Davenport & Ronanki, 2018). These pre-requisites are valid in the case of museums as well and thus, further investigations of the topic are necessary for an exhaustive exploration and understanding of the evolution of AI adoption, from operational individual choices to strategic management of museums.

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