Artificial Intelligence in Service Delivery Systems: a Systematic Literature Review

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Abstract. Artificial intelligence (AI) is transforming the 21st century service industries. With increased availability of virtual channels, new approaches to resource management are required for effective service delivery. A notable example is Amazon, which is reshaping itself with AI-based technologies, relying on robot service delivery systems, either through faster inventory checks or product delivery that reached unprecedented speed. This study provides an overview of the existing theory concerning the next generation of AI technologies that are revolutionizing the service delivery systems (SDS). To this end, we have systematically reviewed the literature to identify and synthesize the existing body of knowledge and update academics and practitioners regarding the latest AI developments on the SDS´s. This article argues that AI technologies are driving the service industry and have had promising results in reducing the service lead time while is being more cost-effective and error-free. Future studies should contribute to strengthen the theoretical production, while AI is being continuously reinforced with new empirical evidence.

Keywords: Artificial intelligence, Service delivery systems, Systematic literature review.

1 Introduction

The field of AI has shown an upward trend of growth in the 21st century [1], and have been increasingly reshaping the service industry by performing several tasks and constituting a major source of innovation [2, 3].

The AI-based technologies can be put in use in human services to help companies alleviating considerable administrative burden and free up time for more critical responsibilities by improving decision-making, and creating cheaper and faster delivery services [4, 5]. In that extent, Amazon has developed a retail store in Seattle that enables shoppers to take products from shelved and walk directly without checking out to pay, the store is called *Amazon Go*, and relies on computer vision to track shoppers during the buying process [6].

In the service domain, robots are also encompassing a wider range of advanced technologies that has the potential to overcome the traditional capabilities of industrial robots [7]. The aforementioned argument is reinforced by Wirtz *et al*. [8, p. 907], which states that "modern robotics, in combination with rapidly improving technologies, like AI, are bringing opportunities to a wide range of innovations, that have the potential to dramatically change service industries". A few examples are presented by McKinsey Global Institute, that is now arguing that autonomous drones that uses AI technologies as *deep learning* are completing last-mile deliveries and/or AI-enhanced robots are tracking inventory in warehouses and recognizing empty shelves in zero-error perspective [9].

This article is organized as follows. Section 2 presents the preliminary concepts. Section 3, it is explained the methodological process. Section 4, we discuss the most relevant results from the systematic review. We conclude this article by presenting the contributions to theory and practice, and guidelines for future research.

2 Terminology

AI has been labelled in a context of digital transformation that enabled major business improvements to augment customer experience, streamline operations or create new business models [10, 11]. AI technologies are able to develop cognitive abilities, or enhance human capabilities [12]. Consequently, AI developments in service delivery may potentially increase the added value to customers. In line with the above, we review in this section the AI technologies that are revolutionizing the service delivery systems. In short, artificial intelligence is being coined in the literature as human behaviours, which can be performed by machines, systems or networks [13]. According to Diebolt *et al*. [14, p. 1] AI combines two properties: "self-learning by the successive and repetitive processing of data, as well as the capacity to adapt, that is to say the possibility for a scripted program to deal with multiple situations likely to vary over time". Following, we provide an overview of six AI-related technologies used in SDS (Figure 1).

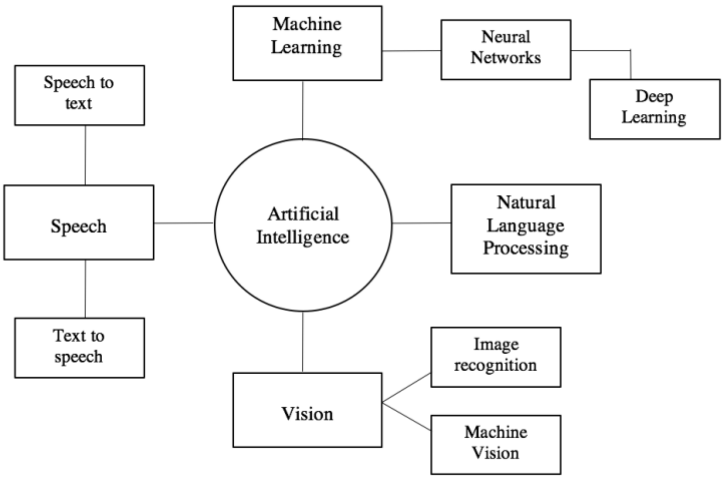

Fig. 1. Artificial intelligence in service delivery systems

The first AI technology we have identified is the *Machine Learning* (ML) that is a subset of artificial intelligence, which often uses statistical techniques to allow computers to learn with data, even if they have not been programmed to do so [15]. Probably, one of the best-known examples of ML is in healthcare – IBM´s Watson Health [16]. Bini [16] argues that Watson Health has been fed everything that has ever been written in any language and at any time related to the diagnosis and treatment of cancer. The program has the ability to match all the information that has been incorporated to it and cross-checks with all the patient-specific information. As a result, the program recommends a treatment, which basically supports the doctor´s decision-making process. Under the umbrella of ML, we have identified the *artificial neural networks* (NNs) that is the process through which machines learn from observational data, i.e. the activation of sensors that perceive the environment, and figuring out its own solutions [17, 18]. Several NNs applications are being used in the service industry, such as healthcare e.g., by predicting sociodemographic variables of depression among geriatric population [19], or in business e.g., to evaluate customer loyalty and improve satisfaction [20]. The advent of *deep learning* (DL) represents a major development in the field of neural networks and achieved tremendous success in real-world application [21], including the SDS. DL is considered as part of the broader family of machine learning [22] and is considered as the ability to exploit hierarchical feature representation learned solely from the available data, instead of features designed by hand according to domain-specific knowledge [23]. According to Sui *et al.* [23] deep models have made significant advances, outperforming regular classification models in multiple domains such as medical diagnoses. The aforementioned argument is corroborated by Cao *et al.* [24] which argues that "developed from artificial neural networks, deep-learning-based algorithms show great promise in extracting features and learning patterns from complex data", examples includes medical image classification, genomic sequence analysis, as well as protein structure classification and prediction. A number of deep learning architectures have been applied to other fields, such as computer vision, automatic speech recognition, and audio and music signal recognition and these have been shown to produce cutting-edge results in various tasks [25].

Speech recognition enables devices to recognize, adapt and translate voice information in understandable forms, including e.g. voice user interfaces such as voice dialling [26]. Speech recognition software was initially designed for individuals with physical disabilities, which had been adopting assisting technologies with writing difficulties [27]. Those technologies are also used in the healthcare services that include voice recognition systems used by radiologist to record and convert the voice into text. This process is called speech recognition–voice-to-text (VTT) even though there are no consensus about its advantages, while there are many benefits and pitfalls [28, 29]. Speech recognition–text-to-speech (TTS) technologies automatically speaks textual information although it produces mostly reasonable-sounding speech, however, it does not yet sound quite human [30].

Computer vision is a technology that aims to reproduce the effect of human vision by electronically perceiving and understanding an image [31]. Computer vision has several different applications, for instance, it provides an effective alternative for automated, non-destructive and cost-effective technique to inspection and grading fruits and vegetables to accomplish quality requirements [32]. Therefore, great advances were made in computer vision in improving visual perception, increasing the capabilities of intelligent agents and robots in performing complex tasks, combined with visual patter recognition, which also paved the way to self-driving cars [25]. Although computer vision is often identified as *machine vision* [33], our understanding is that *machine vision* is being increasingly addressed to industrial processes where the outcome is based on the image analysis done by a vision system [34].

Natural language processing (NLP) is the study of mathematical and computational modelling of various aspects of language, which includes spoken language systems that integrate speech and natural language [35]. In practical terms, NLP facilitates the rise of virtual assistants by making dialogue more intuitive [36], example of this use are the translating languages of Google translate [16] or virtual assistant technologies like Apple´s Siri, Amazon´s Alexa, and so on. Improvements in NLP, when combined with other AI technologies i.e. machine learning – based voice recognition systems, achieved a few years ago 95% accuracy [37]. In turn, speech recognition systems have the ability to recognize human speech, related applications include voice search, call routing, voice dialling and speech-to-text [26], as was mentioned before.

3 Methodology

We have conducted a systematic literature review, which is considered by Fink [38, p. 3] a "systematic, explicit, and reproducible method for identifying, evaluating, and synthesizing the existing body of completed and recorded work produced by researchers, scholars and practitioners". Dilevko [39, p. 451] also argues that conducting research literature reviews promotes the "scientification of the literature review" while, according to Petticrew and Roberts [40, p. 9], it "adheres closely to a set of scientific methods that explicitly aim to limit systematic error (bias), mainly by attempting to identify, appraise and synthesize all relevant studies". We therefore argue in favour of the suitability of the method for this specific research, since the objective is to narrow the field of study, and synthetizing the existing literature in order to evaluate the artificial intelligence phenomenon in service delivery systems.

To keep transparency and easy reproduction of results [41] we have used a single databased – Scopus, which is one of the largest abstract and citation databased of peer-reviewed literature. The search query was conducted with the following words: "Artificial Intelligence" AND "Service Delivery" limited to document title, abstract and keywords. The database search was conducted on January 31st, 2019, and yielded 131 manuscripts. The selected documents spanned from 1992-2018 due the raising expectations regarding the impact of AI technologies on the everyday practice of medicine [42]. More recent publication peaks are related to new AI technologies, such as speech recognition, natural language generation, machine learning and so on (Figure 2).

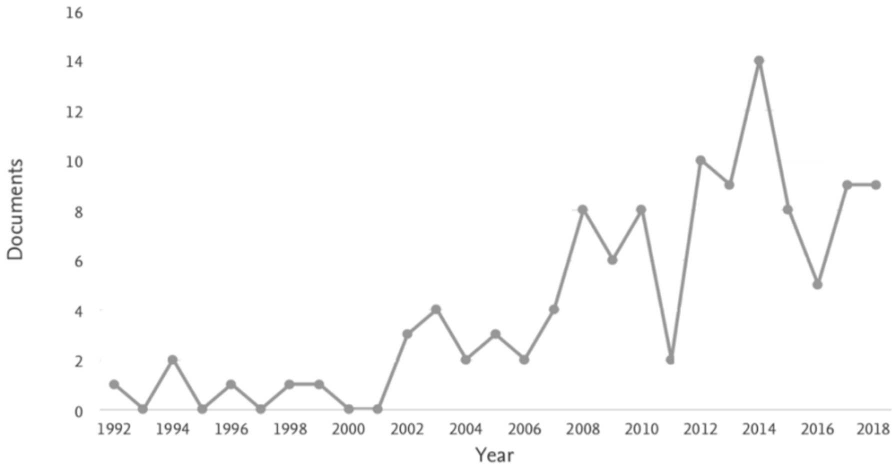

Fig. 2. Documents by year – range 1992 to 2018

We have also included peer-reviewed articles and conference papers available in full-text format. To avoid wrong interpretations, we have selected literature in English and to narrow the field of study we have selected manuscripts from the following subject areas: industrial engineering and management, decision sciences, healthcare and, computer and social sciences. The introduction AI technologies in service encounter was ultimately enhanced by the digitalization of health records in the United States [43]. More recently, new developments in the healthcare industry continued and are mainly due to artificial intelligence robots [44]. Followed by the US we have found India, which focused AI studies on computer science i.e. cloud computing [45, 46] and also on healthcare e.g. e-Medicare services [47]. Figure 3 shows the reviewed documents by country.

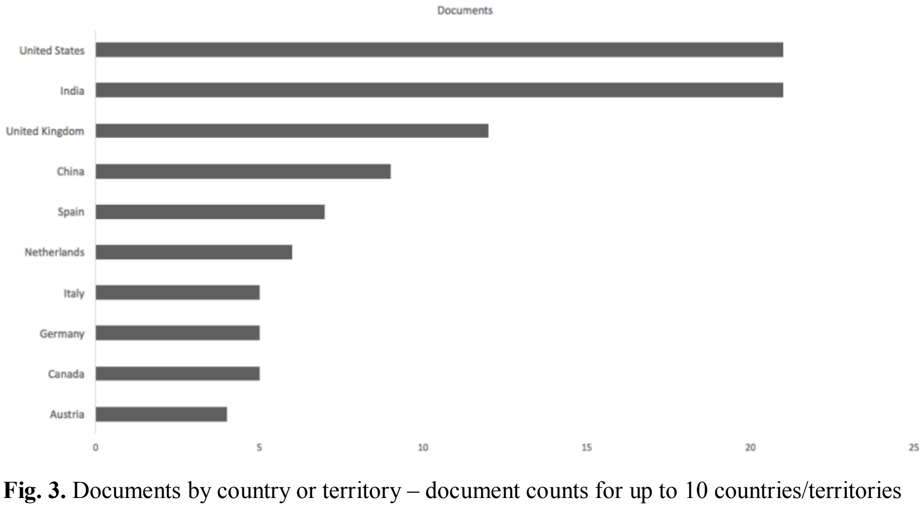

Fig. 3. Documents by country or territory – document counts for up to 10 countries/territories

The remaining 112 references included 28 journal articles and 84 conference papers. Data as then analysed according to the technique of content analysis [48], with the help of dedicated software for qualitative analysis (NVivo), which allowed to build and hierarchize categories and subcategories so as to identify emerging patterns and ideas [49]. The methodological section also presents some limitations, namely: the literature review is restricted to the selected words, therefore, we acknowledge the possibility of having some articles missing. Due to space limitations it was also not possible to list all the selected references, which may be provided on request by contacting the first author.

4 Findings

4.1 Next generation of AI in SDS – technological synergies

As previously explained, AI is composed of several associated technologies (fig. 1). In a broader context, the literature labels several autonomous agents that are independent in their actions to adapt their service based activities as situation changes [50]. In a nutshell, we found some additional technological advancements that are of particular interest, as some articles raises the indication that leading companies are actually combining AI-based technologies to complementary technologies, such as robotics, with the intent of potentiating or even modernising their SDS´s. Therefore, in the private sector, technological advances such as AI, biometrics and robotics are set to become the norm and challenge conventional thinking, which is revolutionising service industries [51]. At a boarder domain, this view is shared by Mikhaylov *et al.* [52], arguing that AI also has significant potential in the public sector, that is undergoing in a transformation with robotics and automation, changing the way how services are provided. Therefore, building on AI-based technology, several companies (e.g. Amazon) are testing autonomous vehicles and taking advantages of current advances in technology for robotics and drones [53]. In light with the above, well-defined strategies are currently advanced by practitioners [54, 55, 56] that will certainly attract further academic attention. Some examples are followed illustrated to enlighten readers:

Autonomous ground vehicles (AGVs), these are driverless vehicles that need little or no human intervention to deliver services or products, these SDS requires customers to open parcel lockers using a personal code, but are unlikely to be widely available until the 2020s [55]. Autonomous ground vehicles solutions are being coined to several markets. For instance, fully autonomous ground vehicles (FAGV) that operates in a real worlds environment were firstly developed for use in factories and other industrial/business sites based on behaviour-based artificial intelligence control [57]. Examples of AI usage are: artificial neural networks, capable of performing the reactive aspects of autonomous driving, such as staying on the road and avoiding obstacles [58]. In recent years, the rapid development of several technologies such as AI, cognitive science, automatic control, ground mapping, sensor technology and other fields are continually revolutionizing the field of unmanned driving [59].

Service robots, which are machines capable of conducting autonomous decision making based on data they gather from sensors in order to adapt to specific situations and learn from previous episodes [8]. They are used in logistics (e.g. to move goods around warehouses), medicine (e.g. exoskeletons or surgical robots) or sales (e.g. to give customers information) [60]. Service robots soon encompassed a wide spectrum of advanced technologies and hold the potential for surpassing industrial robots in both scope and diversity [7]. A notable contemporaneous example is the use of service robots in smart homes, as an efficient solution for domestic healthcare. As population is growing older, seniors are subjected to isolation and health issues are risen, this created an opportunity to domestic healthcare [61]. Ramoly *et al*. [61] argues that in response, scientists currently observed the emergence of both service robotics and smart environment to "monitor the activity of users, understand situations from different sources of data, intervene through actuators or robots, interact with a person, maintain a company to the user, and/or alert the medical staff if necessary" (p. 414). An example to outdoor conditions and rough-terrain is provided by Raibert *et al.* [62], which argues that Boston Dynamics is developing new breed of rough-terrain robots that capture mobility, autonomy and speed of living creatures. These robots use AI-enable technologies, such as computer vision, to autonomously conduct operations without human intervention.

Service drones, are autonomous aircrafts that carry packages to the destination along the most direct route and with relatively high average speed [54]. Joerss *et al.* [54] also states that, like droids and AGVs, they also need to be supervised due to AI absence. In that regard, Levy [63] argues Amazons´ Prime Air drone-delivery service, which is still in the prototype phase, has to build its AI separately, since its autonomous drones cannot count on cloud connectivity. Apart from the term drone, *Unmanned Aerial System* (UAS) is a term that refers to flying platform and the ground station that controls platforms [64]. While most people think of UAS as sophisticated military technology, business across industries realize that drones have multiple commercial applications (i.e. drone-delivery services) for retail stores [65]. The future of service drones is promising, not just in the service industries, but also in research. Recently, a team Japanese researcher´s has given the next step towards robotic pollination. They have equipped a radio wave-controlled drone to pollinize flowers due to bee declines. Gross [66] argue that there is little doubt that with current technologies it would be relatively straightforward to make pollinating drones independent of the radio controller, by using AI technologies to navigate between plants (e.g. computer vision assisted obstacle avoidance) and decide where to pick up pollen and where to deposit it.

Although the mentioned articles from practitioners (i.e. McKinsey) have not been identified in the systematic review. In the absence of existing AI-related cases, we were required to illustrate reality with practitioners' knowledge. In our opinion, scholars need to strengthen the existing theory with new evidence, while practitioners develop new technologies associated with AI.

4.2 Cost-effective and error-free? Reality or myth?

It is more or less acceptable to say that digital ecosystem business models possibly enable better sales and earnings growth driven to cost-effective environments [51]. Governments around the world are attempting to grow benefits of digital ecosystems to transform traditional public administration into a modern and citizen-centred to ensure cost-efficient delivery of public services [67].

Despite the investment made with digital technologies, in the specific sphere of AI we found contradictory results. On Pezzullo´s *et al.* [28] article, the authors admit that cost savings in voice recognition dictation may not be observed. The authors have surveyed radiologists that expressed dissatisfaction with voice recognition with feelings of frustration and increased fatigue, result from more error ridden radiology reports and increased costs when compared with traditional transcription services. Chang *et al.* [29] somewhat found the same results, as they refer that voice recognition presents many benefits, but there are also many pitfalls. The pitfalls they refer are due to error rates and strike a balance between quality and speed of reports generated by the machine. On the other hand, Gartner *et al.* [68] discusses the introduction of diagnosis-related groups (DRGs), which in prospective payment systems has put some pressure on hospitals to use efficiently their resources. Hospitals where DRG systems are being used, patients are classified into groups with related characteristics, as they are expected to use the same amount of resources. These classifications versus used resources, in turn, will influence the hospital revenue. It was in that extent that Gartner *et al.* [68] gave their contribution, as the authors shown that accurate DRG classification using AI methods and programming-based resources increased the hospital´s contribution margin, along with the number of patients and the utilization of resources, such as operating rooms and beds. Huang *et al.* [69] studied inpatient length of stay (LOS) perdition using AI-based technologies to improve the health services delivery, as well as to assess reasonable representation of resource consumption.

Overall, it is our understanding that AI may be *de facto* cost-efficient to most of the reviewed cases; however, in some presented cases, the respective authors expressed dissatisfaction with AI-enables technologies due to errors rates, which, in turn, increased costs when compared to the traditional services. Which makes us believe that there may be some AI-enabled technologies that need to be suitable for each type of SDS. Despite the advances in AI, particularly in the field of computer science, it is expected that advances in the coming decades will indeed make the AI error-free and cost-effective in SDS.

5 Concluding Remarks

Despite the latest AI progresses, few organizations have incorporated AI-related technologies into their service delivery systems. In fact, McKinsey Global Institute refers a survey to 3,073 respondents, where only 20 percent said they had adopted one or more AI-related technology at scale or in a core part of their business [36]. The aforementioned arguments can be revealing of the importance of theoretical research in this area of knowledge, thereby shedding light on possible best practices and successful implementation of AI in the SDS of the world´s leading companies.

This article also provides some theoretical contributions, as we have proposed an exploratory theoretical model for the use AI technologies in SDS. We also discussed the possibilities of using distinct existing technologies that, if associated with AI, may eventually strengthen the SDS. Some clarification is also needed regarding the efficiency of AI technologies, in particular with regard to costs and reduction of failures in certain SDS. To practitioners, this article provides an overview of current developments from worldwide leading companies, such as Amazon, which is testing artificial intelligence technologies in SDS (e.g. Amazon Go), but also because it continues to develop new prototypes to improve each time plus the service delivery (e.g. Prime Air drone-delivery service).

Future research may provide insightful contributions to strengthen the theoretical production, while AI is being continuously reinforced with new empirical evidence. The theoretical production should therefore deepen the empirical knowledge established by practitioners in the area of AI synergies with other technologies (e.g. robotics) to improve the SDS. Finally, further research may focus on perceiving the areas where AI can be most successful in reducing costs in SDS. This line of research aims to provide avenues for scholars and academics and stimulate scientific research in less exploited areas, where AI has lower financial revenues and has greater error prospect in SDS.

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