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A Typology for Applications of Public Sector AI

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Abstract: The use of Artificial Intelligence (AI) in the public sector is on the rise. Yet, there is no clear definition of AI. While AI is considered to be useful for process optimizing and efficiency, there are also concerns for its impact on citizens, for example regarding transparency and discrimination. For this reason it is important to understand how and for which purpose AI is being used within government. Few explorative studies have provided fragmented insight into how AI is used in the public sector, but a clear overview of typical applications is still lacking. To support insight into public sector use of AI, this paper develops a typology for applications of public sector AI. This typology is based on a literature review. Based on the literature, we find eight types of applications of public sector AI. In further research, we will validate this typology with evidence from practice.

Keywords: AI, Public Sector AI, Artificial Intelligence, Typology, AI challenges

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1. Introduction

The use of AI in the public sector has increased in the past years. The European Commission defines AI as: "Artificial intelligence (AI) refers to systems that display intelligent behavior by analyzing their environment and taking actions – with some degree of autonomy – to achieve specific goals." (European Commission, 2018, p. 1). As such, AI may improve public sector performance, by making processes more efficient, thereby reducing costs, and by improving the quality of services (Chui et al, 2018; De Sousa et al, 2019; Misuraca, van Noordt & Boukli, 2020). However the use of AI also raises some concerns; depending on how it is used, it can help or damage people (Feijoo & Kwon, 2020). For example, AI systems can be used for profiling, which if used in the wrong way could lead to discrimination (Thierer, O'Sullivan & Russell, 2017; Wirtz, Weyerer & Geyer, 2019; Feijoo & Kwon, 2020).

To improve our understanding on the opportunities and challenges of public sector AI, it is important to first understand how and for which purposes AI systems are used within government. A few studies have provided explorative and fragmented insight into how AI is used in the public sector (Misuraca, Van Noordt & Boukli, 2020; Van Veenstra, Grommé & Djafari, 2020). However, a structured overview of how and for which purposes AI is used in the public sector is still lacking (Kankanhalli, Charalabidis & Mellouli, 2019; Misuraca, Van Noordt & Boukli, 2020). To gain such an overview, it is useful to have a typology that focuses on typical applications of public sector AI. Individual case studies have provided us with fragmented evidence of specific types of use of public sector AI (Androutsopoulou et al, 2019; Sun & Medaglia, 2019). Furthermore, many typologies of public sector AI often have a technological focus (e.g. Wirtz, Weyerer & Geyer, 2019; Misuraca, Van Noordt & Boukli, 2020). Therefore, the objective of this study is to develop a typology for public sector AI applications based on literature, that will support the understanding of how and for which purposes is AI technology applied.

To develop such a typology, the following method is applied: a study of the literature is conducted and then a typology based on literature is introduced. The paper is structured as follows. First the state of the literature on AI in the public sector is discussed. Subsequently an overview of current typologies on AI in the public sector is used to develop a typology based on literature. The paper concludes with a discussion of the findings.

2. Public Sector AI

While AI is not a new phenomenon, it has, as a result of a large increase in computing power gained much attention over the last years (Kankanhalli, Charalabidis & Mellouli, 2019; Misuraca, Van Noordt & Boukli, 2020). However, there is no generally accepted definition of AI (yet). Based on four often used definitions from the European Commission (2018), OECD (2019), the High-Level Expert Group on AI (AI HLEG) (2019) and the Dutch Strategic Action Plan for AI (SAPAI) (2019) we discerned four common elements. The first element is that AI systems are either software or hardware systems that are designed by humans (European Commission, 2018; High-Level Expert Group on Artificial Intelligence, 2019). The second element is that data is processed for specific and complex purposes. The third element is that AI systems can operate with varying levels of autonomy (OECD, 2019; Dutch Ministry of Economic Affairs and Climate, 2019). And the fourth element is that AI either uses symbolic rules or numeric models for prediction, recommendations or automated decisions (High-Level Expert Group on Artificial Intelligence, 2019). From a technological perspective, AI is considered an umbrella term that includes many different types of technologies such as predictive analytics, natural language processing (NLP), speech analytics, robotics and image recognition techniques (Fong, 2018; Berryhill et al., 2019).

Misuraca, Van Noordt & Boukli (2020) found that within the public sector the use of AI applications is emerging, based on a landscape analysis of the use of AI in European countries. They found 85 different examples of AI applications in government across fifteen European member states. Van Veenstra, Grommé & Djafari (2020) performed a mapping exercise of public sector data analytics in the Netherlands, including examples of AI. While they identified 74 examples of public sector data analytics, they were not able to determine how many of them make use of AI. However,

beyond these exploratory mapping exercises not much is known yet about how and for which purposes AI is used to improve public services and government operations (Misuraca, Van Noordt & Boukli, 2020). There are however a couple of case studies that aimed to give an insight into the use of specific AI technologies in the public sector. For example, with the use of NLP, machine learning and data mining technologies, Androutsopoulou et al. (2019) developed a chatbot that can foster communication between citizens and government.

There is a lot of research on challenges regarding the application of AI in the public sector. Technical and data challenges are insufficient size of available data, a lack of standards for data collection, the data and system quality and data security (Androutsopoulou et al., 2019; Sun & Medaglia, 2019; Wirtz, Weyerer & Geyer, 2019; Campion et al., 2020). Organizational challenges are a lack of skills and expertise in public organizations, financial feasibility, a lack of collaborative culture and a resistance to sharing data between parties (Wirtz, Weyerer & Geyer, 2019; Campion et al., 2020). However, these challenges are not new. Similar challenges have also been identified in the context of the use of public sector data analytics (Van Veenstra, Grommé & Djafari, 2020). Ethical and societal challenges that are often attributed more specifically to AI-based algorithms are transparency and explainability, since the autonomous nature of many AI algorithms means that these algorithms may function as a 'black-box', which means that the outcomes of these algorithms may be difficult to explain (Janssen & Kuk, 2016; Craglia et al., 2018). AI can also create bias, which may result in discrimination; the use of AI therefore risks hampering human rights and public values like human dignity, equal treatment and privacy (Craglia et al., 2018). Since there is no generally accepted definition of AI and we are still trying to understand for which purposes public sector AI is used, we do not know when and in which phase specific challenges can arise. For this reason, there is a need for a typology that takes into account both the purpose of an application and the type of AI technology that is used.

3. A Typology for Public Sector AI Based on Literature

To develop a typology for public sector AI, a literature search was undertaken. First, a Scopus search using the search terms "AI" AND "Government", "AI" AND "Public sector", was conducted. Subsequently, the snowball method was used, in which the key documents found through the Scopus search were used as a starting point for finding other literature. In addition, two expert researchers were asked to give suggestions on known typologies. Many of the challenges regarding the use of public sector AI are identical to the challenges encountered with the use of public sector data analytics. Therefore typologies based on data analytics are included within the scope of this study.

The literature search identified nine papers presenting typologies. These were subsequently reviewed and compared. We included both typologies with a focus on the use of big data analytics in the public sector (Mehr, 2017; Poel, Meyer & Schroeder, 2018; Santiso & Roseth, 2018; Van Ooijen, Ubaldi & Welby, 2019; Van Veenstra, Grommé & Djafari, 2020) and typologies with a focus on the use of AI in the public sector (Chui et al, 2018; De Sousa et al, 2019; Wirtz, Weyerer & Geyer, 2019; Misuraca, Van Noordt & Boukli, 2020). Among the nine papers with typologies, a distinction can be made between those that focus on the technical applications of data analytics and AI, and those

applications that address a type of governmental process. Furthermore, some of the typologies are developed based on literature only, while others are also validated by empirical research.

Four of the examined typologies focus on the technical applications of data analytics and AI (Mehr, 2017; Chui et al, 2018; Wirtz, Weyerer & Geyer, 2019; Misuraca, Van Noordt & Boukli, 2020). For example Wirtz, Weyerer & Geyer (2019) provided a list of ten technical applications of AI in the public sector, varying from virtual agents to cognitive robotics & autonomous systems. For each of these technical applications they provide examples of public sector use cases found in the literature. For example, predictive analytics can be used for prediction of water levels or crime prediction and virtual agents can be used for the application of chatbots. Mehr (2017) on the other hand, identified six problems where AI techniques can provide a solution for, including resource allocation, shortage of experts, working in large data sets, procedural and repetitive tasks, scenario prediction and diverse data. Whereas Chui et al. (2018) identified three categories where AI can help to improve performance: predictive maintenance, logistics optimization and personalization. All these typologies look at how AI techniques can help governments, but they do not take into account the specific role that a governmental organization may have (Van Veenstra, Grommé & Djafari, 2020).

Five studies have identified types of applications that are aimed at improving governmental processes and policymaking (Poel, Meyer & Schroeder, 2018; Santiso & Roseth, 2018; Van Ooijen, Ubaldi & Welby, 2019; De Sousa et al., 2019; Van Veenstra, Grommé & Djafari, 2020). Santiso & Roseth (2018) and Van Ooijen, Ubaldi & Welby (2019) distinguish four different stages of data analytics: descriptive analytics, diagnostic analytics, predictive analytics and prescriptive analytics. Based on other studies in the literature, De Sousa et al. (2019) developed an overview of 22 AI solutions for the public sector, ranging from knowledge management and data processing automation, detecting fraud, measurement and optimization of public transport to crime prediction and assessment.

Five studies that were found have been based on literature research, or have mentioned individual examples of applications of public sector AI (Mehr, 2017; Santiso & Roseth, 2018; Van Ooijen, Ubaldi & Welby, 2019; De Sousa et al., 2019; Wirtz, Weyerer & Geyer, 2019). Some papers have gone a step further and also based their typologies on an empirical mapping of examples of usage in practice (Chui et al., 2018; Poel, Meyer & Schroeder, 2018; Misuraca, Van Noordt & Boukli, 2020; Van Veenstra, Grommé & Djafari, 2020). Poel, Meyer & Schroeder (2018), Van Veenstra, Grommé & Djafari (2020) and Misuraca, Van Noordt & Boukli (2020) developed their typologies by undertaking such mapping studies. After conducting a policy analysis and interviews with stakeholders, Poel, Meyer & Schroeder (2018) identified different phases in the policy making process like foresight and agenda setting, monitoring and interim evaluation, problem analysis, identification and design of policy options, policy implementation and ex-post evaluation and impact assessment, of which most of the examples were in the foresight and agenda setting phase. Misuraca, Van Noordt & Boukli (2020) conducted a preliminary mapping exercise across the EU where they aimed to gain a better understanding of current AI implementations in the public sector. Their typology focuses on the type of AI techniques that are applied in practice, including image recognition, natural language processing, pattern recognition, robotic process automation and robotics.

Based on a mapping study on the usage of data analytics in the Dutch public sector, Van Veenstra, Grommé & Djafari (2020) formulated a typology for the use and purpose of public sector data analytics, including AI. Six types of purposes have been identified, including personalization, resource allocation, maintenance, inspection and enforcement, crime investigation and forecasting. Based on the typologies discussed above we have further developed Van Veenstra, Grommé & Djafari (2020)'s typology on the use of public sector data analytics in the Netherlands and specifically tailored it to the use of AI in the public sector. Because this typology combines technical aspects of data analytics with government roles and has been developed based on an empirical study of 74 applications, we use this typology as a starting point. Subsequently, we attune this typology based on literature on the other typologies specifically to AI.

Table 1 presents the results of this exercise. To attune the typology of Van Veenstra, Grommé & Djafari (2020) to public sector AI, we investigated the typologies found in the literature in relation to the categories of the framework. Based on the literature, we found that two categories were missing. Therefore, to give a more complete overview of the type of use of AI in the public sector, based on the study of Poel, Meyer & Schroeder (2018) on the use of big data for policy analysis and the study of De Sousa et al. (2019) and Wirtz, Weyerer & Geyer (2019) on AI applications for knowledge management, we added the categories 'knowledge management' and 'policy analysis'.

Table 1: Types of applications found in the literature linked to the typology of Van Veenstra, Grommé & Djafari (2020).

Type of application	**Description**	**Source**
Tailored solutions (personalization)	Personalization of public service to individual needs of citizens, e.g. with the use of chatbots or virtual agents	Mehr, 2017; Chui et al, 2018; Wirtz, Weyerer & Geyer, 2019; Van Veenstra, Grommé & Djafari, 2020; Misuraca, Van Noordt & Boukli, 2020
Process optimization (resource allocation)	Improving the process by making it more efficient and effective, e.g. with the use of predictive analytics	Mehr, 2017; Chui et al, 2018; De Sousa et al, 2019; Wirtz, Weyerer & Geyer, 2019; Van Veenstra, Grommé & Djafari, 2020
Maintenance	Identifying when something needs to be repaired, e.g. with the use of predictive analytics	Chui et al, 2018; De Sousa et al, 2019; Wirtz, Weyerer & Geyer, 2019; Van Veenstra, Grommé & Djafari, 2020
Inspection and enforcement	Fraud identification, inspection of the physical environment, e.g. with the use of predictive analytics	De Sousa et al, 2019; Wirtz, Weyerer & Geyer, 2019; Van Veenstra, Grommé & Djafari, 2020
(Crime) investigation	Investigation of crime, e.g. with the use of predictive analytics, pattern recognition and identity analytics	De Sousa et al, 2019; Wirtz, Weyerer & Geyer, 2019; Van Veenstra, Grommé & Djafari, 2020 Misuraca, Van Noordt & Boukli, 2020

Forecasting	Prediction of trends and scenario's, e.g. with the use of predictive analytics	Mehr, 2017; De Sousa et al, 2019; Wirtz, Weyerer & Geyer, 2019; Van Veenstra, Grommé & Djafari, 2020
Knowledge management	The use of AI for archiving of information, e.g. with the use of knowledge management software	De Sousa et al, 2019; Wirtz, Weyerer & Geyer, 2019
Policy analysis	Use of data for decision making and policy evaluation, e.g. with the use of predictive analytics	Poel, Meyer & Schroeder, 2018; Wirtz, Weyerer & Geyer, 2019

4. Findings and Discussion

The objective of this study was to develop a typology for public sector AI based on literature, that supports the understanding of how and for which purposes is AI technology applied. Based on the literature we find that a typology based on eight categories is useful to map the use of public sector AI. These eight categories of public sector AI illustrate for which purpose AI can be used within government: 'tailored solutions', 'process optimization', 'maintenance', 'inspection and enforcement', 'crime investigation', 'knowledge management', 'forecasting' and 'policy analysis'.

This typology of eight categories addresses three main challenges with public sector AI. The first challenge is that there currently is no clear definition of AI. AI is considered an umbrella term for different technologies that can be used for different purposes. The second challenge is that there are no definite mapping studies available. There are few exploratory mapping studies available, such as Van Veenstra, Grommé & Djafari (2020) and Misuraca, Van Noordt & Boukli (2020). However, these studies do not give a complete overview of how public sector AI is used in practice. In addition, a third challenge is that we do not know which type of AI can be linked to certain challenges, as it is unclear which challenges are associated with which phases.

Currently, there is a lot of effort to understand, define and map public sector AI. This typology may support this research, and may help to categorize challenges. In addition, a more complete overview can be given of when and for which purposes a certain AI technology can be used. For example, in this study we found that chatbots and virtual agents are often used for tailored solutions aimed at personalizing public service to individual needs of citizens, whereas forecasting and the prediction of trends and scenario's use predictive analytics. This typology has not yet been validated with evidence from practice. We aim to validate this typology with evidence from practice in the next phase of our research.

5. Conclusion

This study developed a typology for applications of public sector AI based on literature. Such a typology can be used not only to gain a structured overview of public sector AI, but also to gain insight into which type of applications are associated with certain challenges. Based on a literature

study of nine typologies of public sector data analytics and AI we identified eight categories of public sector AI: 'tailored solutions', 'process optimization', 'maintenance', 'inspection and enforcement', 'crime investigation', 'knowledge management', 'forecasting' and 'policy analysis'. A limitation of this study is that it is solely based on other typologies mentioned in the literature. Therefore, we do not know if this typology is representative in practice. For this reason, we aim to validate this typology in practice in further research.

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