Realizing the Accountability of Algorithms in the Public Sector: a Reference Method for Managing Algorithm Registers

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Abstract. The government of The Netherlands has mandated public organizations to disclose an algorithm register in the future. This aligns with the upcoming AI Act of the European Union, as a directive that aims to enhance transparency in algorithmic decision-making and use. This research highlights that the practices are rarely mature and not fully understood, which is characterized by their variability. The novelty of the practices in the industry and the limited research to date, currently make this a chaotic domain. In this research, we explore this domain through a method engineering approach. We conduct six case studies to elicit the process that each organization applies or envisions to manage their algorithm register. We model their processes using Process-Deliverable Diagrams, a meta-modeling technique that integrates dynamic and static perspectives. By applying a systematic method comparison approach, we compare and combine the processes into a single reference method for algorithm register management (RM4AR). This paper documents the process and outcomes of developing such a reference method, demonstrating how method engineering techniques aid in bringing structure into an emerging field.

Keywords: Algorithm register · Reference method · Method engineering · AI accountability · Public sector.

1 Introduction

As part of the ongoing digital transformation, organizations worldwide are adopting disruptive technologies in order to benefit from unprecedented technological possibilities [15]. Artificial intelligence (AI) is currently being considered as the main driving force behind the ongoing digital transformation of organizations

[22]. The wish to adopt new disruptive technologies to achieve their benefits has not been limited to the private sector, with governments worldwide already having committed major investments towards the research and development of AI-related technologies [55]. However, inherent challenges of AI as a technology complicate the implementation and adoption of the technology in practice, as a vast majority of AI and data science projects fail to be effectively deployed to achieve a significant positive impact [51]. Even with these challenges, it is expected that AI-driven innovation will have a continued profound impact on public sector employees, citizens, and societies [34]. Inadequately dealing with these challenges in combination with the inherent susceptibility of the technology to lead to privacy and ethical issues, has citizens increasingly expressing their concerns [30]. These increasing concerns have resulted in a push for more regulations and ethics in AI [2].

The AI act that is in development within the European Union among others calls for transparency obligations towards the use of AI systems [48]. More specifically, one of the answers to the calls for regulation from the government of The Netherlands has been the proposal to instate policies for the realization of an algorithm register. An algorithm register is defined as *a governance mechanism that allows organizations to be transparent and to provide accountability to society by providing an overview of (1) the documentation about algorithms, (2) the organization or organizational department responsible for their use, and (3) the goals pursued with their use* [47]. An algorithm register is a new societal phenomenon and a critical concept in the rapidly emerging field of accountability of AI. The mandatory nature of the topic inclined a multitude of government organizations in the Netherlands to figure out how to realize an algorithm register. The National Algorithm Register of The Netherlands currently contains information on 340 algorithms that are used in a total of 116 government organizations [12]. The current iteration of the national register and its available entries can be viewed here. The information available in this national register is divided into three categories:

- **General information:** Provides information such as: the name and short description of the algorithm, the organization using the algorithm, whether it is self-learning or not, the domain that it is deployed in, the launching date, contact information, and links towards external information.
- **Responsible use:** Descriptions about the goal and impact of the algorithm, functional considerations, whether human intervention plays a role, risk management aspects, legal basis, and what impact assessment was applied.
- **Technical references:** Elaborations on the data that are processed by the algorithm, and textual descriptions of its technical design.

This research applies method engineering practices towards the creation of an algorithm register. Based on conducted case studies, a reference method for the management of an algorithm register was created. Method engineering was used to achieve a reference method by analyzing the processes and activities from each individual case study. This paper intends to contribute to the method engineering literature by proposing a detailed process to construct a reference method.

Moreover, it shows how method engineering, and its established practices, can be applied to a unique and chaotic research topic in an emerging field.

In Section 2, we provide an overview of the relevant existing literature on the domains of method engineering and algorithm registers and discuss the relevance to the current challenges surrounding the adoption of AI in organizations. In Section 3, we present our objectives and discuss our research method and the theory building approach based on the conducted case studies. Section 4 shows the constructed Reference Method for Algorithm Registers (RM4AR). Lastly, in Section 5, we discuss the importance of managing the traceability of the research results towards the sources, what the implications of our findings are, their limitations, and the possibilities for future research.

2 Related work

2.1 Implementation and adoption of AI in organizations

Alluring benefits such as improvement in predictions and decision making, reduction in required production time and costs, increased performance and customer satisfaction are important drivers for the adoption of AI in organizations [10]. In the chase to achieve these benefits, AI has emerged as the most critical technological factor influencing organizations structures worldwide [7]. As a result, advanced algorithms are currently transforming the workforce and altering the way that firms operate [20]. Challenges surrounding the implementation and adoption of AI come from many areas. Dwivedi et al. (2021) mention challenges of organizational and managerial kind, issues related to data, legal constraints, ethical concerns, technological nature, social concerns and economical impact [14]. The current lack of realized impact of AI projects illustrate the effects of the many challenges in these seven areas, and that they pose a significant barrier for impactful implementation and adoption of AI [53]. The existing challenges allow for instances to occur where unwanted consequences from the use of AI systems, either intentionally or unintentionally become reality. Therefore, especially in the context of AI, organizations need adequate systems to ensure that their use of AI technologies aligns with the strategies, objectives and values of the organization in the long term [35]. Benbya et al. (2020) state that mechanisms for the management and governance for the adoption of AI in organizations are one of the main directions organizations should focus on, to remove or diminish the barriers that block AI being used to its fullest potential [5].

The awareness within the scientific community that AI is already having a large impact on society and the daily life of people has already been identified [19]. Toreini et al. (2020) state that the area of trustworthy AI reflects the recognition that maintaining trust in AI may be critical for ensuring acceptance and successful adoption of AI driven services and products [45]. In response to the rise of AI, many people have proposed guidelines for the responsible use of AI [23]. Fjeld et al. (2020) discuss eight themes within the field of trustworthy AI such as privacy, accountability, safety and security, transparency and explainability, fairness and non-discrimination, human control of technology, professional responsibility, promotion of human values and international human rights [18]. These themes and their underlying principles however are often considered too high-level and provide few specific recommendations in practice. Hagendorf (2020) and Mittelstadt (2019) mention that AI development lacks proven methods to translate responsible AI principles into practice [25] [37].

2.2 The necessity of algorithm registers

Examples of malpractice of the application of (AI) algorithms are not hard to find. A well-known recent example of inadequate deployment of algorithms in the public sector is that of the Dutch Tax Authorities. The so-called childcare-benefits scandal caused by a discriminating algorithm resulted in more than 20,000 parents being accused of fraudulent conduct, ultimately resulting in the wrongful separation of at least 1,100 children from their families [27].

Currently, citizens and users are not well aware of the hidden complex information that is used to influence their daily lives[42][36]. Transparency is key in ensuring that the government and its public organizations abide by the law. This includes transparency about the generation, collection, and processing of data which contains information that is used for (AI) algorithms [13]. The algorithm register is proposed as a possible solution for providing sufficient insights into the algorithm usage of public organizations [31].

This upcoming law will require public organizations in The Netherlands to publish information about the characteristics and the use of algorithms. The goal of the upcoming legislation is to raise organizational awareness on critical aspects of the development and use of algorithms within their organizations. By adhering to the guidelines, they want to stimulate organizations to realize unprecedented levels of proactive transparency and accountability and to make them more aware of the development and operational use of algorithms and potential inherent risks. The law requiring public organizations to have an algorithm register is not in effect yet but will be in the coming years [46]. As the algorithm register is a new concept in an emerging field, more research is required to evolve into a complete mechanism that is able to fulfill its intended goals [47].

Various scholarly works assess their perspectives on the effectiveness and limitations of algorithm registers [19][9][29]. Floridi (2020) commends the initiative and explains the content of the Helsinki and Amsterdam algorithm registers [19]. Others have a much more critical view of algorithm registers. They critique the registers for lacking contextualization and highlight potential issues in addressing algorithmic aspects adequately [9]. Houtzager, Verbeek, and Terlouw (2022) seem to support this and suggest ethical guidelines but fail to provide any concrete guidelines [29]. Murad (2021) focuses on best practices for Algorithmic Decision-Making systems registers', yet overlooks the organizational perspective [38]. Additional literature briefly touches on algorithm registers' transparency, including a self-reported report with limited scope [8][39][24]. Overall, these works offer insights into algorithm registers' benefits and shortcomings, advocating for better contextualization and ethical guidelines but providing limited actionable suggestions.

2.3 Reference method construction

Several approaches exist for constructing reference methods. For example, in Business Process Management (BPM) literature, configurable process models were proposed as building blocks for reference modeling [1], and business process reference models were used to capture best practices [33,17]. Research in this domain has a large emphasis on the process side of models and methods, and less so on the data or deliverable side.

Another research area in which reference methods have been constructed is method engineering, for example for game production [50] and partner selection in software ecosystems [4]. Method engineering has been defined as *the engineering discipline to design, construct, and adapt methods, techniques, and tools for the development of information systems* [6]. To properly perform these engineering activities special purpose specification techniques, called meta-modeling techniques, are required. One form of a method meta-modeling technique is process-deliverable diagrams (PDD) [49]. In comparison to BPM approaches, method engineering emphasizes process and data perspectives equally. New methods can be constructed by selecting fragments containing activities as well as deliverables from different methods. Therefore, method fragments are the basic building blocks, which allow us to construct methods in a modular way [41]. Method engineering even allows for a situational adaptation of methods to fit, for example, a specific project [26]. This is especially helpful in the context of algorithm registers for public organizations, as research has shown that the transparency level of these organizations varies considerably [3]. For our research this was relevant to organize the chaotic nature of the emerging field. Furthermore, it allowed us to structure and combine the strong parts of the approaches between the different cases, to make a concrete step towards the development of an effective and efficient method for the management of an algorithm register.

3 Research approach

This research adopts a design science methodology involving three principal phases: problem investigation, treatment design, and treatment validation [54]. In our research, we specifically focus on theory-building [11]. We conduct a literature review to explore the problem and case studies to investigate and document so-called "theories-in-use" [11][6]. Finally, these theories-in-use are translated into the reference method for managing an algorithm register.

3.1 Problem investigation: literature study and observations

Our problem investigation focused on two questions: (1) What is known about public registers in general, and algorithm registers more specifically and (2) how are algorithm registers currently used? To answer these questions, we conducted a multivocal literature study encompassing both academic and non-academic resources [21]. The reason for including non-academic literature was the limited availability of academic literature on algorithm registers. We incorporated diverse sources, such as academic papers, blogs, news articles, government reports, and white papers to gather broad knowledge. Additionally, existing algorithm registers were examined as part of the literature study to prepare the case studies.

During the problem investigation, we developed a conceptualization of an algorithm register exploring its potential functionalities and applications. Additionally, we explored the role of algorithms in organizations and identified disparities and similarities between existing management practices and envisioned possibilities.

3.2 Treatment design: theory-building case studies and reference method design

Building upon insights garnered from the problem investigation, a treatment strategy was devised. As prescribed in theory-building, case studies were integral during this phase to understand how organizations approach managing an algorithm register [11]. Emphasizing diversity, our comparative case study encompassed seven participants from six different organizations (referred to with the identifiers `O1` to `O6`). The organizations varied in size, tasks, reputation, level of transparency, and the state of their algorithm registers to ensure a robust theoretical foundation. Moreover, the seven participants had varying backgrounds, functions, IT knowledge and experience, and involvement with algorithm registers.

Observations. Observations were first done at the Netherlands Police, where many inquiries regarding the creation and execution of an algorithm register became apparent. Subsequently, two workshops organized by The Netherlands Ministry of Internal Affairs were attended. Here, representatives from other attending governmental organizations of The Netherlands echoed similar inquiries about the algorithm register.

Survey. Before conducting the interviews, all seven participants were asked to fill in a survey. The goal of this survey was threefold: (1) to get an overview of the perceptions of the participants and their organizations on responsible AI and its principles; (2) to get an indication of their beliefs in the algorithm register's capability to help with enforcing these principles; and (3) to prepare participants on the interviews and give them enough time to think about their answers. We structured the first part of our survey questions according to eight common themes describing responsible AI: privacy, accountability, safety and security, transparency and explainability, fairness and non-discrimination, human control of technology, professional responsibility, and promotion of human values [18].

Interviews. Two members of the author team conducted 2-hour interviews with all seven participants in May and July, 2023. All interviews were audio recorded. Our interview guide was divided into three main phases: (1) background information of the participant and the organization; (2) discussion on the survey results in order to find out more about the theory-to-practice gap that is currently present regarding responsible AI principles and to find out how the algorithm register can contribute to this; (3) the discussion of the organizational process of the algorithm register. During the last phase, participants were asked to draw the process, existing or envisioned, of their organization regarding the algorithm register. Participants were asked to draw the process without any input from the researchers, which made the interviewees focus mainly on the activities that have to be performed to realize an algorithm register. Only afterward, we asked questions about their drawings. These questions were especially focused on why certain things were included or excluded from the process and what the reasoning was for this.

Data analysis. After all interviews were conducted, we analyzed the observation notes, survey results, interview notes, and drawings of the participants. We followed the formal method engineering approach of Hong, Van den Goor, and Brinkkemper (1993) to compare the participants' different algorithm register processes [28]. We coded our notes and drawings with the structural themes of *activities*, *roles,* and *concepts*, as well as for five content themes *inventory*, *risk assessment*, *internal registration*, *publication*, and *maintenance.*

Our method comparison approach was supported by a meta-modeling technique [49]. We used Process-Deliverable Diagrams (PDDs) to transform the drawings provided by the participants into formal meta-models. The PDD technique was specifically designed for method engineering and consists of two integrated diagrams. The left side of the PDD showcases the process view of a method (comparable to a UML activity diagram). The right side of the PDD showcases the deliverables of a method (comparable to a UML class diagram).

Finally, the method fragments that resulted from the six different case studies were compared with each other. These method fragments were then combined into a reference method for the management of an algorithm register.

3.3 Treatment validation: expert interviews

The goal of the treatment validation was to confirm that the participants' perspectives were accurately captured and to refine and adapt the reference method based on their feedback. We conducted three expert interviews with three research participants. The three participants were selected based on their own experience, their organization's experience with an algorithm register and their availability. All validation interviews were recorded and transcribed.

3.4 Mitigating threats to validity

We took several measures to mitigate threats to validity in the different phases of our research project [44]. First, we ensured *construct validity* by gathering data from multiple sources and by triangulating [56]. Multiple case studies were conducted, each at a different public organization.

External validity was improved by selecting case study participants with diversity in mind. Additionally, a cross-case analysis was performed with six organizations where four case studies would already be a good basis for analytical generalization [16].

Reliability was ensured by applying proper research methods. We used a literature research protocol, case study protocol, and interview protocol to perform research in a logical and systematic manner to ensure the reliability of this study. Each step of this study was documented carefully to ensure reliability [56].

4 Reference method

The research method resulted in method fragments containing activities from the case studies. Each individual activity from each case was discussed and classified as to whether they were relevant to be included in the reference method. The exclusion criteria (EC) that we considered during the construction of the reference method are shown in Table 1. Fig. 2 shows `A4. Safeguard re-use of data` as an example of an activity that was excluded from the reference method based on criteria `EC2`. The activity is part of the work practices of organization `O4`. Details about what specific activities were excluded from the reference method can be found in the technical report [43].

Table 1: Exclusion criteria table.

EC	**Definition**
EC1	Activity was indicative of what was considered a too premature stage to be included in the reference method. Activity was potentially a one-time occurrence and was only relevant during the construction of the initial iteration of the algorithm register.
EC2	Activity was directly related to the development process of an algorithm or a (AI) system. This kind of activity was considered to be out of scope, as it refers to something that predates the process described in the reference method.
EC3	Too case specific. Activity was only deemed relevant for that particular case/organization.

The activities were included in the reference model based on the following inclusion criteria: they were explicitly and directly stated as necessary by a participating organization, they were in line with our impression of what is relevant for the algorithm register process, or they were identified recurringly by different organizations. During the construction of the reference process, activities from a more mature organization were given greater consideration for inclusion compared to those who were less mature. Nonetheless, the essence of concepts and process steps that came from less mature organizations were still considered during the construction of the reference method.

4.1 A reference method for managing an algorithm register

The reference method (RM4AR) synthesizes the findings and provides a structured approach for the management of an algorithm register. The resulting PDD is shown in Fig. 1.

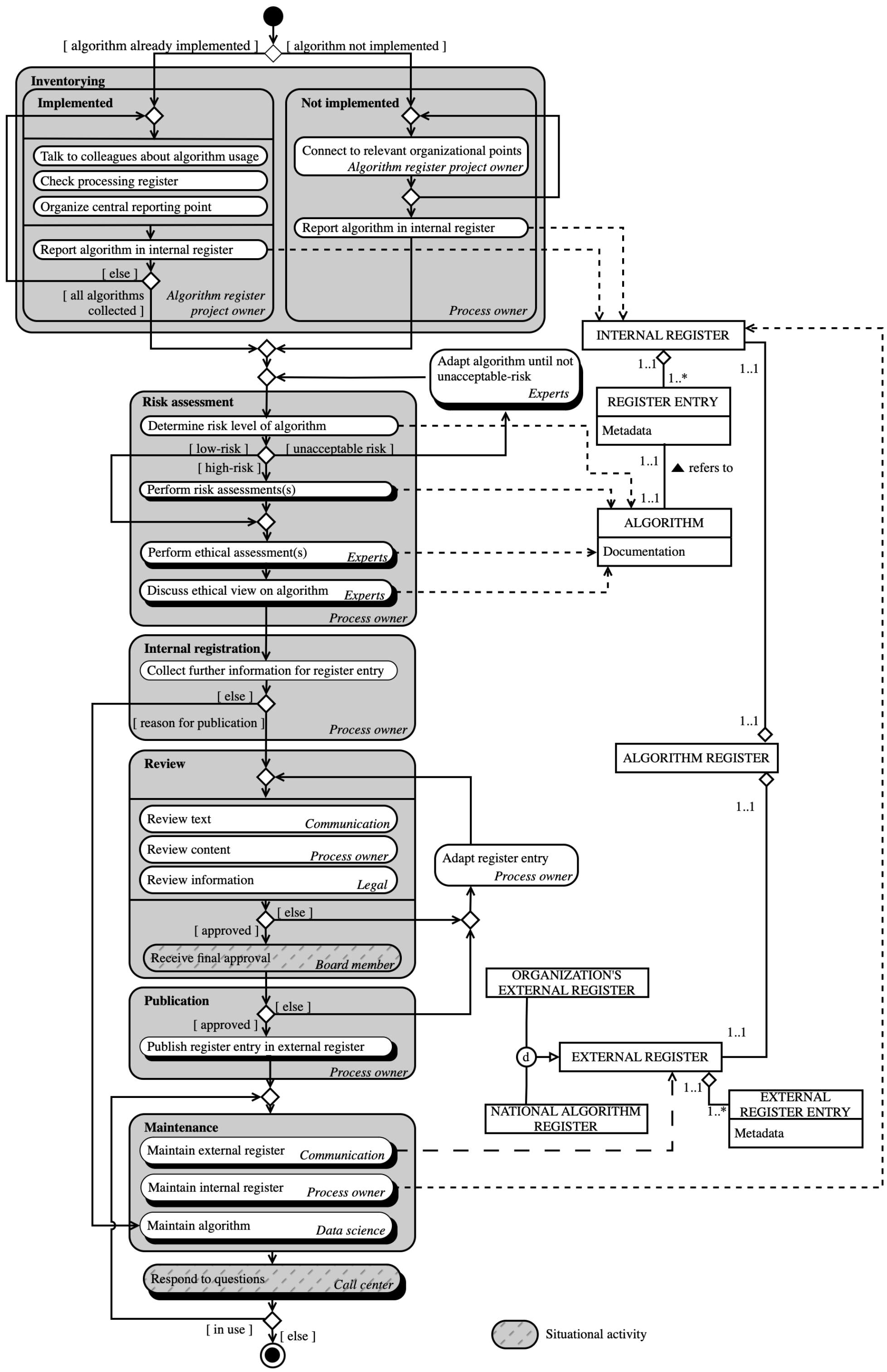

Fig. 1: Model of the RM4AR reference method for managing algorithm registers.

4.2 A method comparison

Table 2 shows how the organizations' methods are compared to the reference method. The following notation is used to describe the relationship between the PDDs [50]:

- Blank fields in the comparison table indicate that the particular activity was not present in the PDD of the organization.
- A 'V' indicates that the activity came up during the validation session.
- The '<' symbol denotes that the activity in the reference method constitutes more than the activity found in the PDD of the organization.
- The '>' symbol denotes that the activity in the reference method constitutes less than the activity found in the PDD of the organization.
- The '><' symbol indicates that the activity in the reference method partly overlaps with the activity of the organization's PDD.

Table 2: Activity comparison table

Activity	**O1**	**O2**	**O3**	**O4**	**O5**	**O6**
Inventorying						
Connect to relevant organizational points			V			
Report algorithm in internal register	= A10		= A2			= A8
Talk to colleagues about algorithm usage					>A2, A3, A4	
Check processing register			><A1			
Organize central reporting point			><A1			
Risk assessment						
Determine risk level of algorithm		= A4				<A2
Adapt algorithm until not unacceptable-risk		V				
Perform risk assessment(s)			>A3, A4			<A2
Perform ethical assessment(s)			= A5			<A2
Discuss ethical view on algorithm	= A6					
Internal registration						
Collect further information for register entry	= A8		= A6	= A3	= A6	
Review						
Review text		>A9, A10, A11, A16, A17, A18, A19, A20			<A12, A13	
Review content		>A9, A10, A11, A16			<A12, A13	
Review information		V				
Adapt register entry		= A12, A21	><A10		= A11	
Receive final approval		= A23	= A8		= A14	
Publication						
Publish register entry in external register		= A28	= A9	= A5	>A15, A16, A17	= A9
Maintenance						

Maintain external register		= A30	= A12			<A11
Maintain internal register			= A11			<A11
Maintain algorithm	= A11	><A31		= A2		= A10
Respond to questions		>A33, A34, A35, A36, A37, A38, A39, A40, A41				

4.3 Validation

During the validation interviews, the reference method presented in Fig. 1 was shown to participants. They were asked specific questions, but also given the opportunity to provide questions and remarks of their own. The participants were generally positive about the reference method and acknowledged its applicability. It was recognized that it is especially valuable for organizations that are in the first stages of managing an algorithm register. Even though organizations with a more mature process recognize many elements, it is "not less directive" for them, as stated by one of the participants.

The validation interviews resulted in adding a sub-activity for enhanced inventorying coordination, introducing a new activity to address unacceptable risk, shifting the responsibility for ethical assessments to experts, streamlining documentation by removing a sub-activity, adding legal review to ensure compliance, and incorporating a situational activity to address citizen inquiries.

The National Police of The Netherlands is implementing their Algorithm Register based on the RM4AR method. This gives us additional confidence that our contribution is valuable.

5 Discussion and conclusion

Organizations require mechanism to govern their AI efforts, to ensure that they stay aligned with their strategies, objectives, and values in the long term [35]. Furthermore, practices are needed that allow responsible AI principles to be applied in practice [25][37]. In this paper, we have proposed a reference method to manage algorithm registers. Six organizations were analyzed that find themselves in different stages of implementing an algorithm register and have different tasks in the public domain. By performing case studies, we were able to create method fragments of all organizations that were subsequently used to configure a reference method. The reference method contains parts of the different participating organizations and integrates the perspectives that were encountered during the case studies.

5.1 Traceability

We have kept the data traceable throughout the research project. This allows now to trace each activity of the reference method to the organizations that

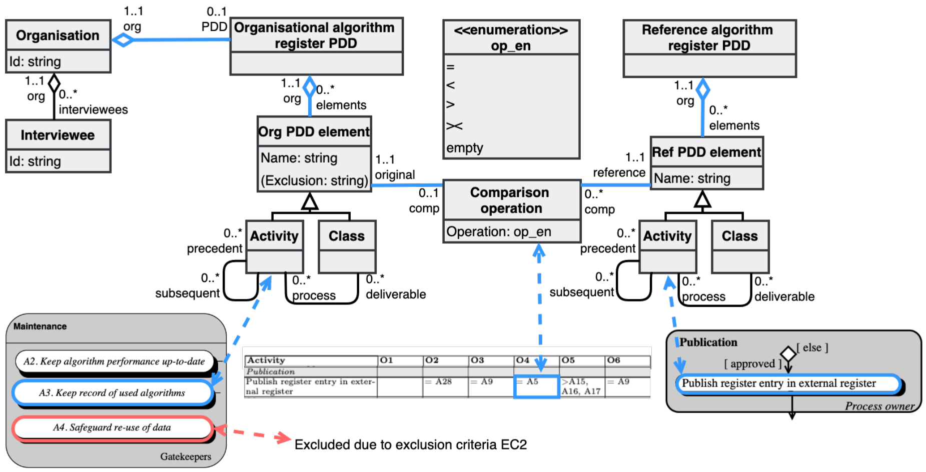

Fig. 2: Simplified information model of the research results and their traceability.

have expressed an equivalent practice. A simplified information model of the research results is shown in Fig. 2, including the traceability information. During the method comparison approach, we have managed traceability by recording the identifiers of the activities of the algorithm from interviewed organizations that are mapped to the activities of the reference method (see Table 2). For instance, this allows to trace the activity in the reference method named `Publish register entry in external register` to activities present in five out of the six organizations (`O2` to `O6`); more accurately, in the case of organization `O4` the activity is `A5. Keep record of used algorithms`. This example is also illustrated in Fig. 2. This traceability supports and reinforces the evidence-based nature of the reference method.

5.2 Implications

The lack of scientific literature on algorithm registers shows how this is a relatively new domain where there is still much knowledge to be discovered. Our study is one of the first to dive into the organizational aspects of algorithm registers. The main goal of this research was to contribute to the algorithm register management process, as current research efforts towards the implementation of AI is asymmetrically biased, with little focus on managerial viewpoints [32]. Although some examples of algorithm registers exist, no concrete guidance apart from generic guidelines exist that can help organizations to set up an algorithm register in their organization [52]. With our reference method, we aim to provide this missing guidance for organizations that are working on managing an algorithm register. Moreover, having an algorithm register contributes towards the realization of responsible AI principles [47]. Therefore, we contribute towards addressing the lack of proven methods to translate responsible AI principles into practice and answer the call for closing the AI accountability gap [40].

As discussed above, the domain of AI accountability and algorithm registers is still novel and the existing literature, while providing valuable contributions, remains unstructured. As a result, the current or recommended organizational practices remain implicit or scattered across several publications. The research method we have applied builds upon established techniques in the discipline of method engineering, showing the opportunities they offer to organize research results, so the knowledge can be structured (e.g., as a PDD) and traced back to its sources (e.g., through a method comparison table).

5.3 Limitations

All case studies were performed in the Netherlands, meaning that different regulations and legal environments of other regions were not taken into account affecting the generalizability of this study. Additionally, only a limited number of organizations participated in the study. As algorithm registers are a recent phenomenon, there is a limited number of organizations to include. Moreover, many of these organizations are in the initial phases of implementing an algorithm register and therefore have limited and similar knowledge on the process.

Furthermore, only organizations willing to discuss their algorithmic practices were included, potentially introducing selection bias. However, the interviews were performed with representatives from various organizations and in different roles, therefore facilitating diversity in included perspectives.

Lastly, RM4AR is proposed as a fully assembled method instead of a method component repository. A situational perspective might be more fitted for certain organizations. However, in the current context where organizations often find themselves in the initial stages of managing algorithm registers, a descriptive method such as RM4AR is more fitting.

5.4 Future research

In future research, the method can be improved as the algorithm register gains more momentum, the knowledge increases and processes behind the algorithm registers develop further. Moreover, future research could look into aligning this perception or changing parts of the algorithm register to further support responsible AI. Finally, this paper provides researchers in the field of method engineering with a guide for developing and recommending reference methods. While the context of algorithm registers is applied in this paper, our approach to construct a reference method can also be applied to other domains.

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