Towards a process model for cross-domain AI development – Insights from neuroradiological imaging

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Abstract: When applying artificial intelligence (AI) in the workplace, the domains of development and deployment are usually separated. In this paper we give emphasis to cross-domain AI development and show how this impacts the definition of project goals, collaboration and use of AI applications. The field of analysis is the medical diagnosis of epilepsy. As an outcome we summarize initial insights for process design of cross-domain AI development, i.e. involving numerous experts from different domains and institutionalizing continuous feedback loops across domains.

Keywords: artificial intelligence, development, design, process, domain expertise

1. Introduction

When applying artificial intelligence (AI) in the workplace, the domain of AI development is often separated from AI usage (Bangert 2021; Viaene 2013). Unintended consequences are that implicit knowledge of domain experts is omitted, that AI-supported solutions bypass the perceived main concerns of users, or that the development neglects side-effects for other activities and workflows which tend to be disrupted. This bears high risks of failure or malpractice and is a core reason for missing technology acceptance (Mao et al. 2019). Negative consequences are especially severe where the use of AI is directly related to human life such as healthcare (Dewey & Wilkens 2019; Wilkens 2020; Meske et al. 2022).

Different approaches for connecting the separate domains already exist. User-centered design aims at a higher quality and greater acceptance of AI while involving end users (Bernardo et al. 2018). Apprenticeship learning, end-user interactive machine learning (ML) and modeling tools for the structured acquisition of expert knowledge should enable the transfer of knowledge from domain experts to machine learning applications (Amershi et al. 2011; Miao 2014; Webb 1996). However, the implementation of AI in work processes poses demands that go beyond a dyadic relationship between end-user and ML application (Benbya et al. 2020). These include following aspects. 1) The involvement of further stakeholders from strategic management and decision making bring in further perspectives on technology development with respect to the overall strategy. 2) Third party domain experts, e.g. specialists who provide correct labels for data or salespeople can also provide relevant impetus for the development process as they are pivotal for sufficiently understanding outcomes of the new technology. 3) HR specialists can reflect on and anticipate changing job demands with respect to employees' competencies facing changing job profiles, e.g. with respect to data proficiency, collaboration, multiple role concepts etc.

Cross-domain development for AI in the workplace is therefore not exclusively a task of technology development. The process also includes tasks of organizational and

personnel development. The complexity of this development process requires a comprehensive scientifically based orientation framework (van den Broek et al. 2021). Our paper aims at developing such a framework at least as a blueprint further research can elaborate on. For this purpose, we present findings from a research project in a cooperative network of the healthcare industry. As research outcome we introduce a preliminary process model for cross-domain AI development and its usage.

2. Approaches to cross domains of expert knowledge

The separation of development and domain knowledge is a recognized problem within data science and AI research (Mao et al. 2019; Viaene 2013). Therefore, there are already a number of research papers dealing with the relationship between expert knowledge and ML applications. A distinction should be made between research a) that is primarily concerned with the transfer of expert knowledge from domain knowledge to ML models, b) that aims at the involvement of end users leading to positive outcomes, and c) that is concerned with the design of the development process and thus the relationship between ML and domain experts (see Figure 1).

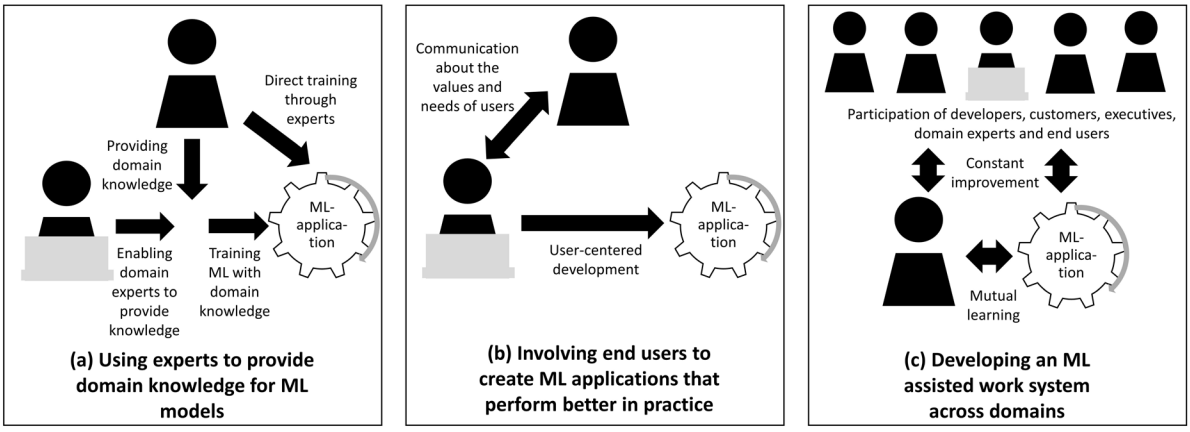

Figure 1: *Three approaches for cross-domain utilization of expert knowledge*

a) Research on knowledge transfer from domain experts to ML models explores how communication of domain experts with ML models can be designed without high dependency on mediating activities of data scientists. Solutions are mainly seen in digital tools that compensate for a lack of data science knowledge of domain experts. These tools aim, e.g., to make expert knowledge machine-readable without the need for computing specialists (Miao 2014) or to enable domain experts to provide direct support for ML models as learning apprentices (Webb 1996). Domain experts are considered in this research as data providers who can contribute to the effectiveness of an ML application if their lack of data science knowledge is compensated.

b) User-centered design research takes a different approach: end users of the ML application are placed at the center of the development and involved in the process at an early stage. The focus is not on transferring their expert knowledge into the ML applications, but on understanding their contextual knowledge, their capabilities and their approach and tailoring the ML application to them. For example, Bernardo et al. (2018) use insights from a hackathon and a creative workshop with their target audience to identify two distinct personas that characterize their target audience and to which their ML applications can be customized. Other user-centered approaches focus

primarily on the explainability of ML models. This can be used, e.g., to provide data-based support for decision makers who are not data specialists (How & Chan 2020).

c) A third approach to dealing with the separate domains examines how the development process can be designed and what role is assigned to domain experts and developers. Research in this field is currently not able to derive specific and universally applicable recommendations for the design of the development process. This may also be due to the fact that different objectives exist. One vision, based on the principle of interactive machine learning, sees a large pool of domain experts in the role of directly influencing AI systems to make them as powerful as possible. Developers are seen in the role of developing the applications with which domain experts interact with ML (Pinhanez 2019). In contrast, van den Broek et al. (2021) show that alternating phases in which expert knowledge is added and excluded again can lead to particularly high-performance ML systems. Moreover, the authors emphasize that developers need to understand context-specific values, and routines. In this context, other authors have identified a key challenge in establishing common ground between developers and domain experts. In cross-domain development, it is particularly the regular discussion between domain experts and developers that leads to initial objectives being revised and new objectives being developed that unite more perspectives (Mao et al. 2019).

The following case analysis builds on this state of the art while giving emphasize to the question how cross-domain development can be organized to structure this dynamic process and what lessons can be learned in principle for involving different stakeholders with different domain knowledge and data science knowledge.

3. Research methods

The field work takes place within the research project “HUMAINE - Human-centered AI network" (www.humaine.info) and refers to a pilot project in neuroradiological imaging. A participatory action research (PAR) approach (McTaggart 1991) is employed to develop a framework for cross-domain AI development. This is based on the scientific monitoring of a multidisciplinary process for the integration of an AI assistance in neuroradiological examinations. The focus of the investigation is the joint implementation of an analysis method by Bülow et al. (2022) and the resulting collaborative work. The authors propose a combination of multidisciplinary methods to identify potentials for AI development projects. The socio-technical approach serves as a starting point as goals are collaboratively defined and core aspects for their implementation are elaborated. The approach aims at I) to investigate how the chosen path of cross-domain development influences goal clarification, collaboration and goal achievement, II) how the cross-domain approach can be standardized and transformed into a process model.

4. Case description: The use of AI in neuroradiological imaging

The goal of AI development within the pilot project on neurological imaging is to develop a method for reducing false-negative diagnoses of specific lesions in the brain while using AI for augmenting individual diagnosis and re-adjusting the overall workflow. Correct detections of specific lesions depend on expert knowledge and many years of expertise and thus they are often not detected during initial radiological examinations. This false-negative exclusion wastes valuable time until patients are correctly

diagnosed and treated. AI-assisted software is intended to augment radiologists' diagnosis of abnormalities even if they lack specific training in this field for many years.

A multidisciplinary project team is formed to implement this project. This team includes AI developers, software developers, service providers and project managers, as well as neurologists, radiologists and radiographers, and scientists from various disciplines (see Table 1). The neurologists, radiologists and the radiographer represent the perspectives of end-users and medical professionals involved in the diagnostic process. A direct involvement of patients is not possible at this stage in the project.

Table 1: *Participants in the cross-domain development team*

technology development	expert knowledge (practitioner)	expert knowledge (science)
project management service provider software-development AI-development	neurologist radiologist radiographer	social science, work science, management studies, psychology, sales- and mechanical engineering, computer science, explainable AI

Cross-domain development is realized in regular collaborative meetings with all stakeholders. Primary focus is a holistic approach that includes all participants and stakeholders involved. First, the team members define and commit to common objectives and the prerequisites for successful implementation. There is an intensive exchange about the application context, workflows and processes as well as about the respective needs and goals. The diagnostic process is first examined across several physicians, from general practitioners up to treatment. All actors involved, their activities and the flow of information are examined. Further stakeholders are identified and the integration into current economic framework conditions is outlined. A goal-oriented approach is derived starting from a common understanding of the initial situation and the perspectives of the stakeholders involved in the project. Aspects to be explored in greater depth and dependencies in terms of subject matter are uncovered, and criteria to be considered are coordinated with all involved parties. From joint consideration cross-domain work groups are formed to pursue these specific sub-projects.

5. Insights on the application of cross-domain AI development

The development process in the case described has yielded key insights into I) how the approach to cross-domain development influences project goals and collaboration and II) how cross-domain development, as a process, can be organized.

I) Effects of cross-domain development can be classified into three categories.

Shared understanding of the problem context and holistic goal development: A major goal of cross-domain development teams is to integrate the perspectives of experts from multiple domains into a common approach (see section 2 c)). Application of cross-domain development in the case-study demonstrated a demand for unification not only for development approaches but also for identified issues, goals and dependencies. Individual perspectives of domain experts and stakeholders presented heterogeneous perceptions of the context and necessary approaches. Therefore, a joint examination of the originating situation was necessary to reach a mutual understanding of the problem context as well as the perspectives and approaches of the involved project partners. Individual goals were combined into a holistic project goal, which

served as the basis for joint approaches and respective cross-domain efforts. During the development process the continuous incorporation of new insights furthered the clarification of strategies and shared responsibilities.

Synergies between technical development and work organization by involvement of domain experts: An application of user-centered design (see section 2 b)) that stakeholders' requirements for a complex sociotechnical process vary widely. Identification of respective needs and capabilities facilitated the development of integrated user-centered approaches. Through cross-domain development a socio-technical process was designed to pass critical returns from technical AI components to participants who have no access to the components or output. Close collaboration between subject matter experts, software and AI design experts, and work design experts enabled a combination of technical and human skills with respective requirements throughout the process. This user-centric solution resulted in integration of an additional stakeholder with a new role to facilitate the intertwined process. It is expected that the redesign of the generation and distribution of information and value throughout the process will strengthen information sharing and collaboration for the participants involved as systemic effects for interactions outside the developed process.

Benefits beyond project goals: As part of cross-domain development, strategies are developed to advance the goals within the scope of the project. In addition, problems in cross-domain processes were identified. Combining the stakeholders involved, possible strategies could be outlined to improve the basic conditions for this and similar projects. These strategies include, but are not limited to, refinancing and classifying technical support systems in healthcare and communication development between medical practices. These changes are beyond the scope of the original project. However, through cross domain development, both the need for these changes and actor constellations could be identified to initiate a higher-level improvement process.

II) Observations in the radiology case provide some initial insights into on how the process of cross-domain-development can be organized.

1. Establishment of a development team with regular meetings consisting of several domain experts, AI developers, software developers, customers (the patient's perspective is missing in the radiology case) and external consultants if necessary (corresponds to section 2 c)).
2. Development of a mutual understanding of the problem-context. This starts by exploring the perspectives of each participant (problem, solution strategies, and specific issues) and continues with identifying overlap and contrasts in individual goals and strategies. The result is the development of joint approaches.
3. Agile development approach that includes the re-evaluation of strategies and the continuous adoption of new insights. It includes the definition of roles and interrelationships in the project team. It can also lead to reassessments and improvement strategies outside the scope of the project scope.

6. Discussion and outlook

The concept of cross-domain development has promising implications especially for the development of complex AI-solutions and their integration in work environments.

The case study was able to show that the multi-perspective view and the regular exchange prevented a too narrow understanding of the problem from emerging. The holistic and shared understanding of the problem is more aligned with overarching objectives of the stakeholders involved (e.g., improving health care) than with facilitating individual stakeholders. It also makes it more likely that the ML solution will be used by all involved parties. Cross-domain development thus stands out from other approaches to collaboration between developers and domain experts.

The approach of cross-domain development applied in the presented case will be further developed as the project progresses. By applying it to additional case studies, effects on the respective development processes will be observed and generalized findings will be derived and transferred into a comprehensive process model.

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