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Title: Developing Solutions For Healthcare : Deploying Artificial Intelligence to an Evolving Target

Year: 2017

Version: Accepted version (Final draft)

Please cite the original version:

Ala-Kitula, A., Talvitie-Lamberg, K., Tyrväinen, P., & Silvennoinen, M. (2017). Developing Solutions For Healthcare : Deploying Artificial Intelligence to an Evolving Target. In H. R. Arabnia, L. Deligiannidis, F. G. Tinetti, Q.-N. Tran, & M. Q. Yang (Eds.), CSCI'17 : Proceedings of the 4th International Conference on Computational Science & Computational Intelligence (pp. 1637-1642). IEEE Computer Society. https://doi.org/10.1109/CSCI.2017.285

Developing Solutions For Healthcare - Deploying Artificial Intelligence to an Evolving Target

Full/Regular Research Papers, CSCI-ISHI

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***Abstract*—The pace of deploying artificial intelligence (AI) techniques to healthcare has been speeding up. Many of the initiatives have been technology driven aiming at finding problems matching the new technology while systematic, demand driven search for solutions has been limited. Here we describe the process of identifying opportunities for deploying artificial intelligence to healthcare and social services on regional and national levels in Finland. The process includes idea generation and elaboration using a design thinking method complemented with architectural design for identifying required AI capabilities for the 34 best use cases. In this paper, we focus on the development of use case "Mobile Solution for Home Care Coordination and Communication" to observe the evolving balance of technology push and demand pull faced in the process.**

Key words—Health Information Systems Innovation; Information Technologies for Healthcare Delivery and Management; Artificial Intelligence in Health Informatics; Design thinking

I. INTRODUCTION

Innovation has become a critical means to enhance quality of services [11]. Digital transformation in healthcare seeks solutions to make healthcare safer, more affordable and more accessible, and has lately been a very rapidly growing area of research [1]. The expertise of medical professionals has made healthcare one of the first domains, to which new artificial intelligence (AI) technologies have been deployed, with varying levels of success. The early attempts to imitate human diagnostic behaviour with expert systems using rules and fuzzy logic were followed with knowledge-based systems with frames, scripts, ontologies and various reasoning systems as well as natural language processing based question-answering techniques. The increasing digitalization of medical patient data and improved adoption of digital imaging and medical devices have shifted emphasis to technologies utilising high volumes of data for machine learning and deep neural networks. Altogether, a vast majority of the effort has been either technology driven, in deploying a specific AI technology, or data driven, in targeting a single medical issue. [18], [16], [7].

In the technology adoption and innovation research the dominant approach for a firm is to find a balance between the technology-driven and market/business-driven approach using a variety of approaches including variants of an innovation funnel and open innovation models. [5], [2], [19]. In these approaches, the technologies available to the firm internally or externally are developed into products and services for the market. In the case of a health or wellbeing related device manufacturer this would mean new product innovations whilst for a hospital this would mean providing new medical services for the patients.

This paper presents one case example how a vision, risen from an identified need in the social and health care sector was developed into solution. Our target was to identify a true pain point in the social and health care sector and utilize AI technologies to develop a solution for it. In this context, the goals of the stakeholders vary from the wish of individuals to live healthy lives and vendors' aim to create global scalable products based on AI to the government's aim to provide wellbeing for the citizens without an increase of the total direct and indirect costs for the government.

The case example described in this paper is part of the project where the University of Jyväskylä and IBM are collaborating to discover ways to utilize Finnish health data with Watson cognitive computing [6] in health and social services and promote citizens' wellbeing. The project funded by Tekes aims, also, to strengthen and develop the Finnish innovation and business ecosystem in this field. Opening new business opportunities for companies to enhance digitalisation is seen as one of the main focus areas. At the same time, there is an important aim to renew social and health care services towards the maximum impact and cost effectiveness. For the purposes of this paper we limit our scope to one identified opportunity, yet there were several of them found in the project. Therefore, the detailed use case presented here is only one of the many use cases developed in the project. We also exclude analysis of the data infrastructure as well as the architectural design of future infrastructure of AI aided healthcare systems.

II. PROCESS, METHODS AND PARTICIPANTS

A. Scope, Aims and Participants

The long-term goal of the entire project was to boost the Finnish economy and help companies create jobs, drive growth in both domestic and global markets and enable cost reduction for public organizations as well as improve citizen wellbeing. The overall approach follows the innovation funnel model (Fig. 1), where a large volume of ideas generated based on the organizational needs and technology inspired ideas are collected, elaborated step by step and filtered until the most promising ideas are available for investment decision making. During this stepwise elaboration process, a user-centric approach was chosen to carry and elaborate the most valuable ideas for the future: how to utilize AI in the field of healthcare and wellbeing in the most engaging way for the end-user and also reach savings in the healthcare costs for different stakeholders.

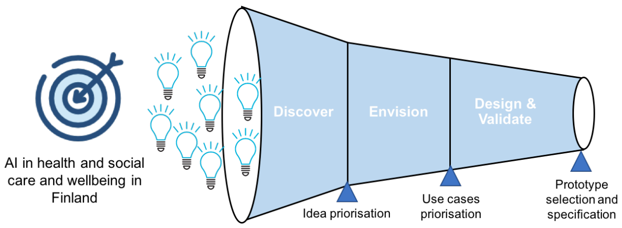


Fig. 1. Process to find, identify and construct great deal of ideas of using AI to several use-cases and to refine few promising ones for further prototype development.

The project followed the design thinking method in several stages, which was tailored for the purposes of the project during the process. Fig. 2 presents the scope of work described in this paper (on white background) while other parts are left out from this paper due to space restrictions.

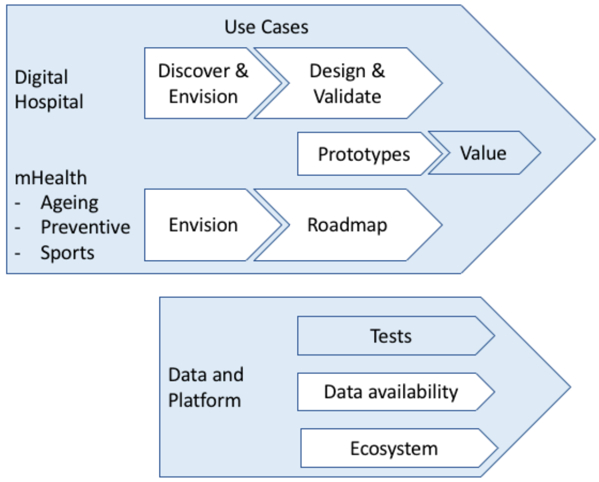


Fig. 2. The areas of work in the project. The scope of this paper is the process for identifying the use cases (on white background) in the digital hospital area and in the three sub-areas (thematic sections) of mHealth..

The process of finding key focus areas, the area specific problems and use cases as solutions for the discovered problems, was carried out as four leading target areas focusing on health care, preventive actions to improve health and wellbeing, aging specific AI technology solutions and solutions designed especially for sports. The stakeholders in the healthcare target area were mainly from governmental organizations and public hospitals as well as firms providing products and services for them, and actors in the mHealth included public organizations, enterprises on the consumer market, third sector actors, non-profit organizations and senior citizens. Fig. 3 presents the main stakeholder groups involved in the workshops in all of the four target areas. The idea pool was generated and processed during several full day workshops to produce specific ideas as use cases. Next chapter presents the whole process in detail as well as methods used.

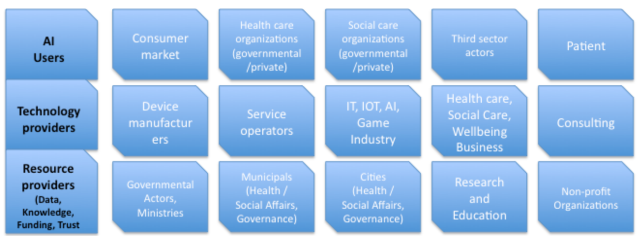


Fig. 3. Stakeholders in MHealth and Digi Hospitals workshops

B. Workshop Process

Work on all the target areas started with a joint kick-off workshop. The general aim on the health care target area is to improve treatment processes both from accuracy and efficiency perspectives and simultaneously reduce healthcare costs with AI and digital solutions. The section of aging focuses on solutions for senior citizens social wellbeing and health, support for aging-in-place and solutions for enhancing autonomy. Preventive wellbeing focuses on the solutions for voluntary and motivated activity of personal health and wellbeing among children, the young and adults. The sport target area focuses on the use of sports and exercise data and their benefits on population health.

The kick-off workshop was followed by discovery, envision and design workshops. The envisioning phase took place in various workshops. In the first, the goal of the process was framed as that of evaluating the suitability of artificial intelligence technology to the Finland's new digital social and health care system and to generate common understanding of AI suitability in the thematic sections. In the second, the aim was to create a shared understanding of present problems which could be solved with the use of AI. In the third, the participants envisioned big ideas for solving the pain points. The basic process followed the design thinking method in several stages, and was tailored during the project according to the needs of the specific domains. Thus also the techniques applied in each phase varied between the target areas. The process applied in these target areas is presented in Fig. 4, including the techniques applied in each workshop. All of the workshops were hosted by the University of Jyväskylä and moderated by IBM consultants and architects.

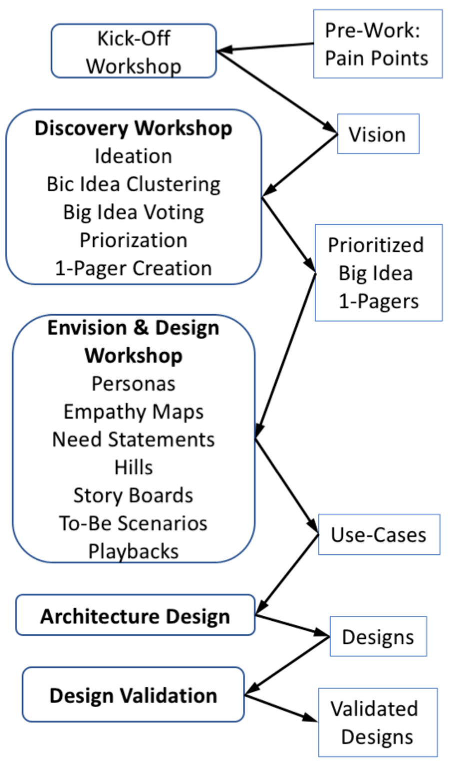


Fig. 4. The tailored process used for identifying opportunities for AI in healthcare and developing them into validated designs.

Of the big ideas documentation, the participants evaluated 25 ideas, documented in 5-10 use cases per area. The result of the envisioning phase was a total of 40 use cases for different target areas. The playback workshop and the validation of the 40 use cases closed the envisioning phase resulting to total of 34 use cases.

C. Modified Design Thinking Method

The process of finding key focus ideas was facilitated through the IBM Design Thinking method which is an adaptation of design thinking methodology. IBM's approach adds to the general design thinking allowing it to adapt to the scale and speed that modern organizations require. It is a framework for teaming and action which helps teams to form intent and deliver outcomes that serve people. The method is designed to be used to provide user experiences and create user-centric outcomes.

Focusing on the user outcomes drives the design towards how much value the user receives, not how many features or functions there are. Empowering diverse teams instead of homogenous ones accelerates ideation, increasing the chance of new innovations. Treating everything as a prototype enables constant improvement.

The method was used to discover pain points, explore new ideas in the field of health and wellbeing, and create a roadmap for the concepts expected to have the most potential to leverage IBM Watson and AI. The method was chosen for the study project in order to identify citizens' real problems and needs within the chosen focus areas (healthcare, preventive actions to improve health and wellbeing, aging specific AI technology solutions and solutions designed especially for sports) and to support creative ideation. The value during the process comes from solving users' real problems rather than purely assessing the technical capabilities. [3], [6]

D. Identifying Chosen Cases for Next Steps

After producing an idea pool in the envisioning phase of expertise workshops, the later phases reduced the number of cases to a small number of ideas to be elaborated. The original plan aimed at producing 1-2 ideas for different target areas which would have been adequate for a single firm searching for a new product idea. However, for a large ecosystem with tens of stakeholders and interests we had to adjust the method to produce more use cases and designs satisfying the needs of the stakeholders. The selection of additional use cases was done in additional workshop where experts from the hospital participants were able to specify their needs on the healthcare sector as well as in the road mapping process, which was a joint process by university researchers and IBM staff. The aim was to find the most promising use cases for prototype development. The criteria were the maturity of the AI technology and the availability of the data (at present, in 1-2 years-time or in 5 years-time), the importance of the problem to be solved and the cost-benefits of the solution for the Finnish health- and social care system. In the end, the case lists of the different target areas were merged. In addition, some of the closely related cases were merged.

The participants and researchers evaluated the use cases from multiple point of view, such as the economic value of the use cases for the national healthcare system and the business value of potential products and services for vendors and service operators as well as their utility for the health and wellbeing of individuals. The resulting designs included architectural descriptions describing interactions of the main modules, where the required AI capabilities of the modules were identified and matched against the Watson cognitive capabilities. As a result of the process we identified 34 use cases, all of them making use of various AI techniques, most frequently data analytics and NLP.

We describe here one pilot project in social and healthcare sector, to generate understanding of the user centred and problem driven approach in an individual design process, what it means in practice and which consequences it may have for the AI adoption processes more generally.

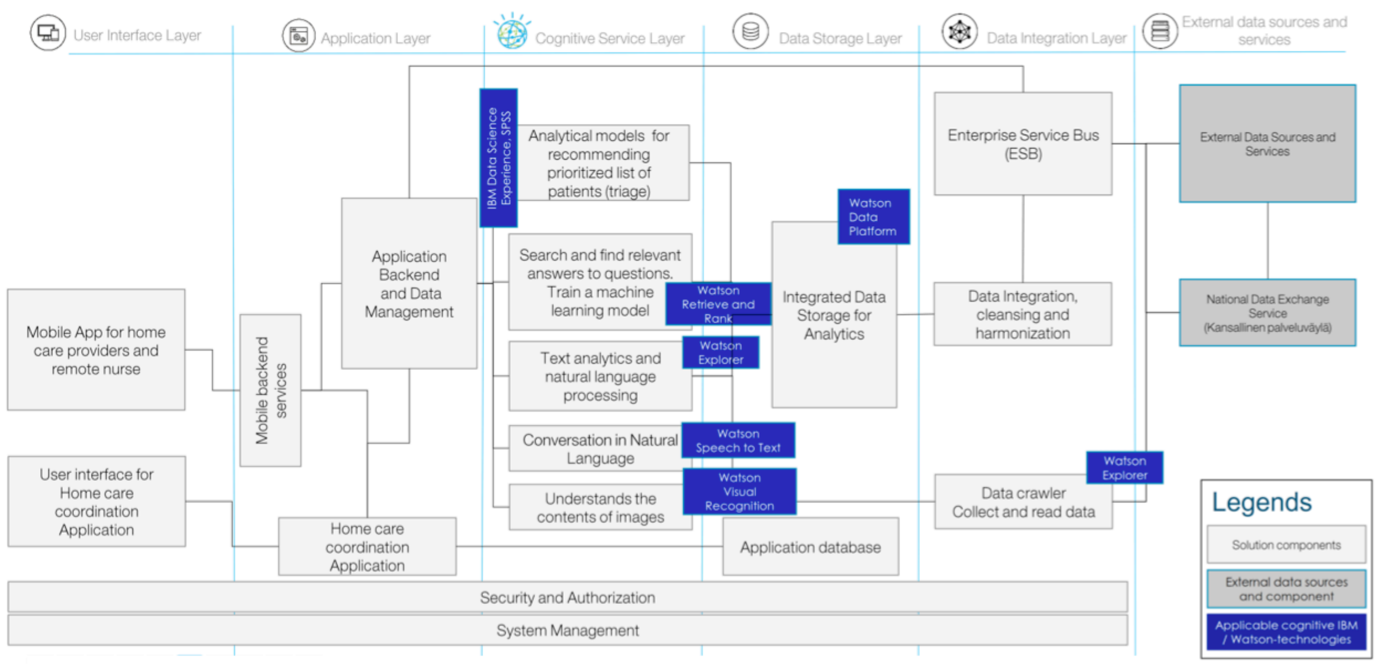
III. Case - Mobile Solution for Home Care Coordination and Communication

This paper focuses on one identified use case "*Mobile solution for home care coordination and communication*". In this use case the pain point was lack of secure and personalized aging in place with sufficient support, which was identified by home care providers, gerontology researchers and expertise by experience participants (senior citizens). The goal of the solution in the use case was to increase efficiency, quality and transparency of elderly home care. End users of the solution were intended to be home care providers and remote nurses. In comparison with other existing digital, but non-AI solutions of home care coordination the use case was novel in three interrelated ways. First the aim was to gather personal health data (data on home monitoring sensors, activity trackers, national electronic health records, previous home care reports) and based on that, to evaluate the home care need and its availability, in real time. Based on the rich health data and the data on labour force on daily basis, the solution allocates the best option for home care visits and schedules automatically the timetable of homecare nurses. This would mean, that the route planning of home care nurses is based on the actual and real time understanding on customers health condition. Another novel feature in the use case was its ability to store the health data in a simple and user-friendly way, of which the homecare professionals could estimate the input of the actual, at home caring, including rehabilitation activities. Third valuable feature of the use case was its ability to facilitate the communication inside the care network (individual homecare nurses, homecare providers, relatives, the elderly person) and through this to provide appropriate care at the right time. Thus, the use case made also use of additional AI capabilities, such as speech UI and use of visual recognition for remote nurse/doctor consultancy.

In the design phase the use case of *mobile solution for home care coordination and communication* had AI capabilities such as analytical models for recommending prioritized list of patients, searching and finding relevant answers to questions by training a machine learning model, text analytics and natural language processing, conversation in natural language and understanding the contents of images. The architecture overview diagram of the solution in design phase is presented in Fig. 5.

After the user centred design phase, it was time to develop the use case further with users, those of home care coordination employees. As the vision for the use case had been developed in a workshop with several participants and design phase based on that vision, there was need to make the implementation plan

Fig. 5. The architecture overview diagram of the use case mobile solution for home care coordination and communication in the design phase.



more detailed and concrete. Knowing that the use case was a combination of versatile AI technologies, various types of health- and wellbeing data, and targeted to three types of user groups, there was the need to limit the scope on the piloting phase. When discussing and planning with the user group the original vision got more focused. According to the user group, instead of evaluating the home care need in real time and scheduling the home care nurses timetable, the possibility to evaluate the home care effectiveness was held as more important and needed. The users did not see it beneficial to coordinate home care nurses' visits based on senior's personal real time health status and possible sensor alarms, but instead plan preventive actions based on the health status. Therefore, the original idea of home care coordination including e.g. route optimization based on real time need eventually reduced to a need to analyse the effectiveness of rehabilitation given in elderly homes for the seniors otherwise living at home and having home care.

On the basis of the need, a pilot study was planned for the purpose. As the target of a rehabilitation phase, spent at elderly home in most cases, is to enhance senior's physical fitness and increase daily activity, it was decided that it would be meaningful to measure senior's daily activity before, during and after the rehabilitation. The measuring period was planned to last for two weeks in each phase, which were to follow each other. Thus, the whole measuring period for one senior would last six weeks in total. It was planned, that senior's physical activity on daily basis and on different activity levels would be compared between these different phases. The original idea from the beginning had been to utilize AI for this analysis and for searching possible patterns in rehabilitation effectiveness. Also, it was seen as possibility to use AI for gathering information about senior's physical activity.

When the target and measured variable for the pilot had been decided, the next phase was to consider how data could be gathered. While pondering also other options, such as machine vision and door alarms, it was seen as most convenient and precise way to measure senior's daily activity with wrist-worn activity meter. Seniors already wore safety bracelets, for calling help and tracking senior leaving his home purposefully. It was believed that these bracelets would not provide physical activity information and adding another bracelet on senior's wrist was not safe (senior might confuse the bracelets in emergency situation and would not be able to call for help). While evaluating other solutions to track physical activity, we discovered that the safety bracelet used in the elderly homes and by seniors at home care already had a feature for gathering person's physical activity data, but that feature was not used. Additionally, the system gathering data from safety bracelets already had an interface for looking the physical activity information over a selectable time period. Therefore, it was decided, that the devices already at use could be used in the pilot as well. The conclusion was that AI technologies would not give any extra benefit for the use case and there would be no need to use AI just for the sake of it.

What this piloting study confirmed was, that introducing technology within complex organizational systems such as healthcare is not a straightforward linear process. The route from an individual use case into a technological solution in healthcare is particularly long, in comparison to other industries. Social and health care organizations are complex systems, involving various types of stakeholders with different types of technological, social and organizational thrives to be aligned [4]. The AI development and the implementation of AI technologies in health and social care faces these challenges.

IV. Discussion and Conclusions

New technology innovation has been considered as an important means to increase wellbeing and resolving efficiency demands [15]. In this paper, the starting point is to identify opportunities to deploy artificial intelligence to healthcare. We described the process of implementing demand-based vision into a solution valuable for users, following loosely the guidelines of design thinking [3], co-creation [17], [8] and employee-driven innovation [10]. The process included involving a large number of stakeholders from a variety of backgrounds for idea generation and elaboration in workshops using a design thinking method and resulted in more detailed pilot study with specific target groups. Somewhat surprisingly, for the specific use case described here, the AI capabilities identified in the first stage of design were not seen producing any extra benefit in the eventual pilot study. Worth noting is that in the piloting phase we chose few AI capabilities, while there still remains several other AI technological capabilities to be tested and evaluated with end users.

Some meaningful observations can be made from the process. First, even though AI was the driving force in the initial planning workshops and the underlying aim was to identify opportunities for using AI in the health and social care sector in Finland, the eventual solution for the use case described in this paper did not use any AI technology rather than a combination of other recent information technology available. This demonstrates, how valuable it is not to look at the possible use cases from the new technology perspective but rather from the viewpoint of what possible solutions there are to solve the problem and meet the need presented in the use case.

Second, as the content of the pilot study created on the basis of the use case revealed: end users already may have the technology needed to meet their needs, but they just are not aware of its features [14], [13]. This relates to a more common scenario where a certain technology is purchased to a certain need and afterwards when some other need emerges, the existing technology's capability to meet also that need is not evaluated. Technologies at use are also updated which may add features and widen their use scope. Especially in this case the technology/solution providers should keep in mind that the user is not the expert on the technology and does not know all the features at use if not told. At present the communication channels [13] for the diffusion of AI innovation to the healthcare domain seem still to be underdeveloped.

During the process, we identified several solutions which could be applied to gain significant efficiency and effectiveness improvements to health care operations and better services for citizens to enhance their wellbeing, including also monetary benefits for the society. However, in this case, the AI was not recognized as the key asset for the proposed solution. Instead, the project generated knowledge of the existing technological solution and its benefits for non-technological savvy end users, those of home care providers. When thinking of the innovation processes models of new technology, particularly in the context of human-centric industry, such as health- and social care, the understanding of current solutions and their full implementation to existing working routines should be the starting point. What was apparently partly missing from the design process, was the communication inside the individual organization between the technology providers and the actors of the operative level, whom however are the ones at the forefront of using new technological solutions. The health and social care professional are the ones that are expected to boost the efficiency of health care sector, with the help of new technologies. The implementation of new technological solutions asks not only investments on the level of organization but more importantly investments at individual level, including working time and personal cognitive load [4], [12]. This is why the efficiency may become a paradox, as long as the argumentation for the new technological solution is the novelty, not the real end user benefit.

The process used the problem-based, user-centred approach for AI development in health-, and social care and involved a wide and active national level stakeholder group. What was unique in the process was the national level understanding of the sectors' major objectives and the joint solutions created to achieve them. This was the direct result of the chosen non-traditional user centred and problem based AI development approach and it is what makes the project unique, in defining AI technologies in the service of health- and social care. As most of the AI development takes place inside the platform economy, following the needs and means of the platform and market owners, such as Google, the work of defining the AI development of the future with real user ecosystem is a novel one. It shows the way for future AI development in health and social care and the need to take into account the user-driven, problem-based approach and particularly the understanding from actors of the operative level. Also, when the input from the users indicate, that AI doesn't offer any additional value for the solution, there should be courage to use the technologies already available, use them effectively and perhaps with some other ways than traditionally designed for.

As the final words, we should note that all the 34 use cases identified did make use AI techniques, and usually more than one. Data analytics and NLP were the most frequently used techniques.

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