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# Digital Medical Interview Assistant for Radiology: Opportunities and Challenges

Kerstin DENECKE[a,1], Paolo LOMBARDO[b] and Knud NAIRZ[b]

[a] *Bern University of Applied Sciences, Bern, Switzerland*
[b] *Inselspital Bern, Bern, Switzerland*

**Abstract.** Background: Personal contact between radiologists and their patients is scarce due to time constraints and logistical reasons which impacts on patient knowledgeability and satisfaction, but also on examination and diagnostic quality. Objective: We illuminate medical history interviews from a radiologist's perspective and discuss its impact on the diagnostic quality. Based on these insights, we develop a digital medical interview assistant (DMIA) for radiology that is intended to collect information helping in improving radiological diagnostics. Methods: Conditions, issues, problems in the radiological examination process are assessed to collect requirements and to specify questions for a digital medical history interview. Results: A DMIA with conversational user interface is developed using the scripting language RiveScript. It is accessible through a social media messenger (Telegram messenger). An initial assessment of usability demonstrates a good usability. Conclusion: To overcome the information gap in radiology, a DMIA can simulate an assessment interview. It is still necessary to remove existing barriers in interaction with the DMIA for example by facilitating data entry options.

**Keywords.** Medical history interview, anamnesis, radiology, dialog-based system, chatbot, conversational user interface, intelligent system

## 1. Introduction

Radiology is a high-throughput medical discipline that has been highly streamlined to cope with the corresponding workload, to provide the necessary, very specialized professional skills, and to come up with the expectations of its prime customers. The linearity of the diagnostic process generally does not allow for a personal interaction of radiologist and patient, because usually (out-)patients have left the premise, when the radiologist starts the medical reporting based on the acquired images. For some radiology exams patients are requested to fill out questionnaires about their health status and eligibility to the imaging modality, which are then provided for the diagnostic process together with the images. Hence, in radiology information about the medical indication and health status generally comes from the referral, from health records, from questionnaires, but not directly from the patients. However, it seems obvious that the best information about their health could be provided by the patients themselves during a short medical history interview. Currently, such interviews are conducted only under special circumstances, such as in interventional radiology. Personal contact between

[1] Corresponding Author: Kerstin Denecke, Bern University of Applied Sciences, Institute for Medical Informatics, Bern, Switzerland, E-Mail: kerstin.denecke@bfh.ch

radiologists and their patients is normally scarce due to time constraints and logistical reasons. Lack of interaction may not only impact on patient knowledgeability and satisfaction, but also on examination and diagnostic quality. Studies show that short medical history interviews are a very efficient way to address these issues.
To address this shortcoming, we illuminate in this paper the topic of medical history interviews from a radiologist's perspective and discuss the existing workflow of a radiology examination and its impact on the diagnostic quality. Based on these insights, we aim at developing a digital medical interview assistant (DMIA) for radiology that is intended to collect information helping in improving radiological diagnostics. Computerized medical history systems or DMIA are tools that help in collecting relevant data on patients' medical history [1]. Although such systems have been available for three decades, they have remained unused in routine clinical practice [2]. The advantages of DMIA include potential time savings, as patient history can be collected outside of the doctor-patient encounter; the administrative burden of entering this information is reduced; the time available to the patient is increased; and the data collected can be automatically added to medical records available for automated processing for decision support [3].

Barriers to DMIA use from the perspective of healthcare providers include (1) lack of workflow and protocols related to patient-generated health data, (2) lack of platforms able to handle the complexity of a medical interview, and (3) data storage, accessibility, and usability [4]. With this work, we want to address the challenges of limited patient satisfaction with the radiological examination by using a conversational user interface (CUI) for realizing a DMIA collecting information relevant for the diagnosis process of radiologists. A CUI realizes interaction with a user by means of a text-based dialogue. Since this is similar to human-human interaction or to chatting through a social media messenger, it is assumed that the interaction is more intuitive, and individuals get familiar with it more quickly. Through a human-like conversation, a bond of trust can be created which supports willingness to disclose personal health information. The main contributions of this work are as follows:

- Analysis of problems and needs for medical history information in radiology,
- Basic set of question for medical interview in radiology,
- Introduction of a prototype of a DMIA specifically designed for radiology.

## 2. Methods

We analyzed conditions, issues, problems, and questions where information on the medical history is most needed in the radiological workflow from the physician's point of view through observation, expert interviews, work experiences and literature search. Two of the authors are working since years in radiology departments of multiple hospitals and thus possess experiences with the radiology workflow. Furthermore, existing data collection forms used in radiology departments to collect patient information were reviewed. There are no standard forms in use. Instead, they reflect the daily practice in a radiology department. Since forms are normally generated as a result from working experience, there are no references to cite (but examples from the partner hospital are available upon request).

From the results of this requirements analysis, we developed a concept for implementing a DMIA into the radiological workflow. The DMIA exploits a conversational user interface to facilitate user interaction and data collection. A first

prototype of a DMIA was developed and tested in a usability test with 5 subjects. Results are described in the following.

## 3. Radiology process and its challenges

In the three German-speaking countries (Germany, Austria, Switzerland) inhabiting 100 million people there are approx. 110 million radiological examinations per year (numbers from: https://www.radiologie.de/deutsche-radiologie-zahlen). Consequently, radiology is a very efficient discipline designed to cope with this high throughput. A typical radiological examination is characterized by a very standardized sequence and a strict division of labor between three different professional groups: administration, technologist, and physician [5].

1. Treating physicians refer patients to the radiology department where the administrative staff is responsible for scheduling.
2. Radiologists, i.e. physicians, then decide about the modality and the examination protocol in the absence of patients.
3. On the day of the examination, administration organizes patient arrival and, if necessary, hand out questionnaires for determining appropriateness of the chosen examination.
4. Next, radiological technologists care about the pre-examination preparation, subsequently perform the medical imaging and image transfer, and then arrange the patient's dismissal.
5. Based on the recorded images and available information, radiologists start their diagnosis-process and document the results in the radiological finding report.
6. In parallel and after the examination, billing will be administered by qualified personnel.

This workflow holds true for most radiology exams, independent of the chosen modality (such as X-ray, computer tomography, magnetic resonance tomography, fluoroscopy etc.). Only ultrasound exams implicate a direct contact of patient and radiologist [6] (while in the USA a sonography would be conducted by radiographers). Besides, in interventional radiology a pre-operation discussion between physician and patient is mandatory. Normally, only steps 3 to 5 are performed in the presence of the patient, thus implicating that communication between patients and their radiologists are not considered feasible and essential by design.

The sequence of the process steps and the information provided to the radiologists is hard-wired by the IT-infrastructure. Most radiological institutes have a RIS (radiology information system), which administers scheduling, patient personal data, registration forms, filled questionnaires, health risks, and previous reports and a PACS (picture archiving system) for storing acquired images from the examinations. Further health information might be provided by an EHR (electronic health record).

The current workflow implies that information to support diagnostics would be ample and easily accessible, e.g. by clearly written and formulated medical indications and anamneses from the referrers, by well documented and matching previous findings in the RIS, by meaningful prior exams and images in the PACS, and by a lucid, well-structured and well-maintained patient history in the EHR [7,8]. In a radiologist's reality there may be unrelated or no prior exams in RIS and PACS, a bulky EHR, hard to decipher hand-written referrals, a lot of time-pressure to cope with, and a patient, who would have been

able to provide necessary anamnestic information, already left [5]. Thus, the current design of the radiological diagnostic process deliberately relinquishes a major information resource to support the quality of diagnostics.
A study showed that by introducing a short medical interview of radiologists and their patients has both an impact on patient satisfaction and on the quality of the examination [6]. However, it is not feasible to generally implement an anamnestic interview in the radiology process due to the following reasons:

- Ways between reporting rooms may be too long and logistics to bring physicians and patients together at the right time may be hard to administer.
- Flow of work for radiologists may be constantly disrupted.
- Additional physicians would have to be hired to manage the additional workload and therefore introduction would be too expensive.

Hence, we propose to close the information gap by an alternative method utilizing a DMIA to conduct medical interviews and, in this way, collect valuable information from patients.

## 4. Medical interview in radiology

The term *anamnesis*, or 'medical history' of a patient, derives from the Greek ἀνάμνησις, 'recollection' and is understood as the evocation of a reminiscence; it is the first step in the diagnostic pathway [13, 14]. The anamnesis consists of a whole series of questions aiming to collect all events and problems of the patient's present and past medical history. The purpose of the anamnesis is to collect all the information about the patient that is fundamental in creating a comprehensive picture of the patient and his current health problem, to allow a series of diagnostic hypotheses to be elaborated and then verified with confirmatory, objective, radiological or laboratory tests.

The 'classic' anamnesis takes place in a personal interview between doctor and patient. It can be divided into: Family history, Physiological history, and Pathological history, remote and forthcoming. The family anamnesis includes the health status or illnesses of other members of the individual's blood family. The physiological anamnesis considers the information about the patient's habits such as the place of residence, lifestyle, type of work done, general habits. Diet, quality and quantity of sleep, smoking habits, heavy exposure, pollution, regularity of bowel movements are important too. The subject's previous illnesses including hospital stays and operations, any problems arising at birth or during the delicate periods in life namely childbirth, breastfeeding, teething, or puberty are examined in the anamnesis.

Creating a good level of cooperation and comprehensive communication between the doctor and the patient is essential. With the person being at ease in an appropriate environment, the communication of details that he or she would have considered unnecessary related to the symptoms manifested is enforced. It is beneficial and of mutual interest to create a good dialogue to achieve the best diagnosis and therefore the best therapy for the patient. The more precise information given contributes to a greater chance of an accurate diagnosis [13, 14].

A reworking of facts and symptoms reported by the patient and attention that grasps beyond mere appearance is important for a critical analysis of the doctor during the interview. A current problem represents the simple listing of a patient's symptoms and facts that are given as answers to 4 of the so called "5 W's": "what" is felt, "where" can the discomfort be specified, "when" it arose, and "how" it is manifested. In case of

unclear communication of the patient, in case of a newborn child for example or a patient speaking a different language as the doctor, a so-called heteroanamnesis is carried out, meaning that the patient's closest family members must answer the doctor's questions.

The basis for the diagnosis of fresh injuries to the entire locomotor system, despite the enormous developments in imaging procedures, remains the patient's history and clinical examination. The description of the mechanisms of the accident already provides important clues, as revealed by the case history. All the anatomical detection of lesions of individual parts of the examined bone and of the capsular ligaments of the exanimated articulation must be covered by the clinical examination. We conclude that conducting a medical interview in the context of a radiological examination would be a complex process, resulting in important information relevant for diagnosis.

## 5. DMIA for radiology: concept and prototype

We want to develop a DMIA to support radiologists to collect basic information about patient's current health complaints and medical history. From the information on anamnesis and the radiological workflow described before, we derived requirements towards the DMIA and a first set of interview questions.

### *5.1 Requirements*

Our DMIA should collect information from patients in an easy manner, in a secure way and considering data security. The DMIA is supposed to ask a standardized set of questions but should also provide information on the examination to prepare the patient for giving consent. Data processing has to consider relevant legal regulations. Furthermore, collected information must be summarized for radiologists in an appropriate format. The DMIA should be integrated into the radiological workflow. It must connect to existing systems (EHR, RIS) to identify patients and to store collected data. A good dialogue has to be established between DMIA and user, encouraging a patient to provide detailed answers to the questions.

### *5.2 Concept*

In the current early prototype state, we decided not to make a complete integration with a hospital information system. Instead, we developed a web application to realize the required administrative tasks which are patient administration and appointment management. To facilitate access to the DMIA, we decided to integrate a conversational user interface (CUI) and integrate with an existing social media messenger. As proof-of-concept we used the Telegram messenger. We envision the following use case: After scheduling an appointment in the appointment management tool, a QR-code is generated to be shared with a patient. After scanning the QR code, a DMIA session is started in the Telegram messenger. Once the interaction with the DMIA is completed, the chatbot protocol is available in the administrative platform to be assessed by a radiologist. When fully integrated with the hospital information system, the collected information is stored in a structured format in the patient record. For this purpose, natural language processing is used to extract the relevant facts from the free text answers.

### *5.3 Prototype*

We describe the developed DMIA using the categorization of chatbots proposed on Adamopoulou et al. [15]. Our DMIA is a closed domain chatbot since it focuses on radiology only. It is an interpersonal chatbot targeting at collecting information from the user. Its goal is task-based, i.e. it only collects information on the patient's medical history relevant for the radiological diagnostic process. The input processing and response generation method is rule-based. It is developed using an open-source platform, which is RiveScript. RiveScript (https://www.rivescript.com) is a scripting language for CUI. In a set of rules, the questions to be asked and answers to be given are specified. Our CUI was connected to the Telegram messenger using Botfather.

The current prototype contains 12 questions out of which 4 are only asked to collect more details in case they apply. The DMIA (see Fig. 1) asks for the reason of the visit to the radiology department, on the injury, on previous examinations of the injury by another radiologist. It further requests details on possible symptoms: pain on a scale of 1–10, current health state, weight loss or weight gain. Finally, the system asks about allergies, in particular against radiopaque material. Answers are either free text or yes / no.


**Figure 1.** Screenshot of the DMIA to collect information from a patient. The DMIA asks whether the patient was visiting the radiology department before and whether he or she has pain.

### *5.4 Usability test*

To get a first impression on the usability of the DMIA, we conducted a usability test with five persons using the System usability scale (SUS) questionnaire [16]. SUS consists of a 10 item questionnaire with five response options for respondents; from "Strongly agree" to "Strongly disagree". The questionnaire addresses ease of use, confidence of using the system, complexity of interaction etc.

The test was conducted in video conferencing sessions since personal meetings were impossible due to the Corona situation. In pre-session interviews demographic data was collected (age, gender, personal judgment of technical competence). The participants received a QR code to start their personal chat session. After completing the chatbot interview, a post session interview was conducted, and they were asked to fill the SUS questionnaire. Average age of participants (2 female, 3 male) was 39.2 (with youngest 17 and oldest 73). Two never underwent a radiology examination before, the other three persons had at least one radiology assessment. 2 participants consider themself as technophile or used to technologies, three claimed that they are not used to technologies like mobile devices. SUS score was high, between 90 and 100 (average 96), reflecting a very good usability.

## 6. Opportunities and challenges of DMIA and CUI in radiology

In this paper, we concentrated on the principles of medical history interviews and on a first attempt to digitalize them using a CUI. Our current prototype allows to collect information from a patient relevant for completing the radiological diagnostic process. This could help in overcoming the information gap in radiology and in this way, increase patient safety and improve patient experience. Our approach is similar to digital questionnaires used to collect information on the medical history. Benefit of a CUI is that the conversation is more human-like; the chatbot can motivate to continue answering questions or can provide help. Our current implementation is a proof-of-concept and thus very simple. To increase the user experience and to facilitate interaction, additional technologies could be integrated. We can imagine to include answer options with nonverbal communication (e.g. picking the region with pain from an image of a human body). In this way, complex terminologies for example for localizing pain or the trauma such as lateral or medial could be avoided.

The current solution has several limitations and requires improvement. The dialog flow is fixed in rules and the input from patients to the DMIA is not yet validated. To validate the entered free text and to create a structured form out of the conversation protocol, natural language processing is required. In case the given answer does not contain relevant information, the DMIA should repeat the question or ask for clarification. This would further require integration of artificial intelligence (AI) to create questions on the fly and depending on the (not predictable) user input. The analysis of the radiological anamnesis demonstrated that the medical interview can be extremely complex. In the current stage, we decided to implement a rule-based system, since the conversation flow is predefined, and no unexpected behavior can occur. In contrast, AI-based systems might create responses that are not going along with the clinical practice. In general, AI applications are predicted to have a profound impact on future radiology

[9,10]. Huge efforts are undertaken to establish AI-supported image analysis and interpretation, but also to apply AI to optimize the workflow with respect to operational and financial targets [11, 12]. In future, we want to assess how much AI is necessary and useful to reliably collect information from a patient and to achieve a good user experience.

In its current implementation, we use the social media messenger Telegram. A benefit is that persons who use this messenger already, do not have to install another application which could increase the willingness to use the DMIA. However, a limitation is that the conversation is stored by Telegram, which might lead to legal issues. We are aware that a DMIA for radiology would be a medical device according to the European Union Medical Device Regulation and Medical Device Regulations valid in Switzerland and be subject to the regulations as a software as a medical device (SaMD). Recently, a medical triage chatbot in use in the UK's National Health Service raised the discussion about lack of regulations of AI in healthcare [17]. We will consider this issue in a later stage of development.

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