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Intelligent Conversational Agents in Patient Self-Management: A Systematic Survey Using Multi Data Sources

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Abstract

Intelligent conversation agents (ICAs) have been used for patient self-management and support in recent years. This study systematically reviewed ICA resarch and innovation in academic and industrial institutions using bibliometric and patent analysis. We reported the types of diseases and patients, and the ICAs delivery approaches for patient-self-management. We identified the gaps in the productivity and focused areas.

Keywords:
self-management, patients, conversational agent

Introduction

The Intelligent conversational agent (ICA) (e.g., Amazon Alexa and Apple Siri) is an application that enables natural language communication with users [1]. The human-like communication nature of ICAs is making themselves very popular. Clinical analysts foresee that ICAs can potentially improve patient care in terms of symptom management, caregiver engagement, and patient support [2]. A recent systematic review on conversational agents in healthcare has shown that ICAs has addressed health issues related to psychotherapy support, education, self-monitoring, and data collection for consumers (e.g., patients), caregiver, or healthcare professionals [3]. However, no study to-date has explicitly focused on how ICAs support patient self-management in a non-clinical setting.

Patents are associated with research and mirror technology development and investment trends in a particular domain [4]. Analyzing patent records, thus, will help understand the state of the art of technology development and the landscape of the innovations. This study aimed to use data from both publications and patents to systematically investigate ICA research and innovation for patient self-management in home settings.

Methods

Data Collection

The research publications were retrieved from five citation databases (i.e., PubMed, Scopus, CINAHL, EMBASE, ACM D-Library). The granted patent and published applications were retrieved from the Derwent Innovation Index (DII) which has a comprehensive coverage of 40 worldwide patent-issuing authorities. The searches in citation databases and DII were executed with the same search strategies in August 2018. The search term consists of three parts, the ICA related terms, self-management related terms, and patient related terms. The ICA related terms included about 100 synonyms and term variations (e.g., voice-activated interface, conversational assistant, chatbots). The self-management related terms included about 20 synonyms and term variations (e.g., self-management, self-care, self-efficacy, supportive care). The patient related terms included 13 synonyms and term variations (e.g., patients, caregivers, sufferer, and survivor). In addition, this study collected publications identified through citations of retrieved research papers and from grey literatures.

Screening Critiria

The title and abstract fields of the retrieved publications and patent were screened by three of researchers (i.e., ZX, FY, & YQ) via Covidence [5]. Disagreement was resolved among researchers in group discussion. A publication or patent was included if it 1) adopted natural language interaction either in written, graphical or voice-activated communication modality, 2) was designed for patients, caregiver or customers. A publication or patent was excluded if it 1) discussed only partial techniques of ICAs such as automatic speech recognition, natural language understanding, dialogue management, response generation, or text-to-speech synthesis; 2) had limited and predefined interaction model (e.g., Voice-Activated-Dialing which only allows number as input); 3) had missing titles or abstract.

Data Abstraction and Analysis

For publications, we extracted the following data fields: authors, publication year, affiliation, title, and abstract. For patent, we extracted the inventor, priority date, assignee, title, and abstract. All included patent applications were filed before 2018 because patent applications are generally published 18 months after the earliest priority date.

In this study, VOSviewer [6] was employed to extract and visualize the key terms from both the title and abstract fields for included publication and patent records. We set the threshold of minimum key term occurrence as 3 for publication records and as 1 for patent records in mapping graph, for appropriate visual effects. In addition, the synonyms and variations of an extracted key term were merged and controlled for visualization using a thesaurus (e.g., "child" and "kid" merge to "child").

Results & Discussion

Data Description

We retrieved a total of 1835 publications from PubMed (N=751), EMBASE (N=137), CINAHL (N=29), Scopus

(N=687), ACM Digital Library (N=231), 535 patent records from DII, and 12 additional records from the citations of the patents. We included 91 publications and 21 patents in the analysis after title-abstract screening and removal of duplicate records. The publications were contributed by 128 institutions from 28 countries, whereas the patents were from 22 patent assignees (i.e., 16 companies and 6 individuals) from 5 countries. The United States is the leading country in the numbers of publications and granted patents. Particularly, the Northeast University and Boston University have had the most research productivity. Regarding the patents, Koninklijke Philips N.V. from Netherlands had three patents and each of the rest assignees have had less than three.

Topic Mapping

The key terms extracted from the publications and patents were visualized and compared based on types of diseases and patients and delivery approaches to patent self-management.

The Types of Disease and Patient

Compared with patents, the publications reported more types of diseases and patients (Fig 1). The publications reported that ICAs were developed to address chronic conditions (e.g., "diabetes", "cancer", "stroke", "hypertension"), mental disorders (e.g., "autism", "dementia", "post-traumatic stress disorder"), and emotional issues (e.g., "depression", "anxiety", "stress", "mindfulness"). The targeted users included "child", "elderly", "young", "woman", "mother", and "pregnant (women)". As displayed in Fig 2, the patents have focused on health conditions such as diabetes, communication disorders, and skin issues (e.g., "lesion"). Patterns have not specified the types of targeted patients but used a general term "user" instead.

The Delivery Approach of Self-Managment Support

The topics related to health interventions in the publications included "psychotherapy", "neurorehabilitation", "virtual interviewer" whereas the patents tended to be uniquely designed with customized support (e.g., "interaction plan", "first conversation", "user profile", "patient relationship model") based on user data ("user data", "medical record") and dialogue context (e.g., "dialogue context", "context pattern"). This customized support has not been observed in publications.

Nevertheless, the publications and patents under review demonstrated common interests such as patient's decision-making support (e.g., "patient coaching" and "health consultation") and user/patient behaviors (e.g., "behavior change", "behavioral intervention" in the publication and "dialogue behavior" in the patents). They also discussed multi-modal interaction modality in ICAs. Specifically, publications described "multimodal interaction", "embodied agent" and the patents discussed "graphical interface", "voice interface", "animation".

Conclusions

To our knowledge, this is the first study that has systematically examined ICA research and innovations for patient self-management using data extracted from both publications and patents. We have found that the ICA research and innovation in patient self-management is in its infancy. The total numbers of publications and patents are small. The ICAs to-date have mostly focused on patient coaching, consultations for decisional support and behavioral changes. In addition, the academia and industry have focused on different types of diseases and patients, and on various delivery approaches to self-management support by ICAs. However, they also share some common topic interests, such as multi-modal interaction ICAs. The diversity may lead to a broad spectrum of ICA applications in health care whereas the commonality may indicate the topical trends in the near future.

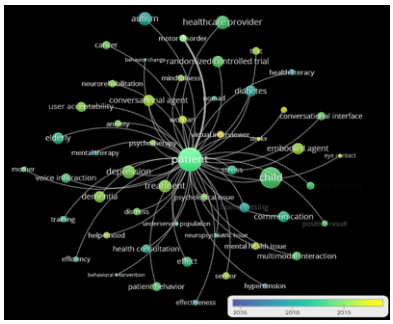

Figure 1 – Publicaiton Keywords Mapping

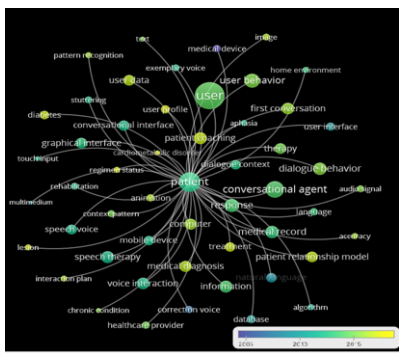

Figure 2 – Patent Keywords Mapping

References

[1] M. McTear, Z. Callejas, D. Griol, The dawn of the conversational interface, in: The Conversational Interface, Springer International Publishing, Cham, 2016: pp. 11–24. doi:10.1007/978-3-319-32967-3_2.

[2] M. Coyne, L. Matchstick, C. Franzese, The Promise of Voice: Connecting Drug Delivery Through Voice-Activated Technology, (2017).

[3] L. Laranjo, A.G. Dunn, H.L. Tong, A.B. Kocaballi, J. Chen, R. Bashir, D. Surian, B. Gallego, F. Magrabi, A.Y.S. Lau, E. Coiera, Conversational agents in healthcare: a systematic review., *J. Am. Med. Inform. Assoc.* **25** (2018) 1248–1258. doi:10.1093/jamia/ocy072.

[4] B. Fabry, H. Ernst, J. Langholz, M. Köster, Patent portfolio analysis as a useful tool for identifying R&D and business opportunities—an empirical application in the nutrition and health industry, *World Patent Information*. **28** (2006) 215–225. doi:10.1016/j.wpi.2005.10.004.

[5] J. Babineau, Product Review: Covidence (Systematic Review Software), *J. Can. Health Libr. Assoc.* **35** (2014) 68–71. doi:10.5596/c14-016.

[6] N.J. van Eck, L. Waltman, VOS: A new method for visualizing similarities between objects, in: R. Decker, H.-J. Lenz (Eds.), Advances in Data Analysis, Springer Berlin Heidelberg, Berlin, Heidelberg, 2007: pp. 299–306. doi:10.1007/978-3-540-70981-7_34.

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