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Technology and value network evolution in telehealth

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ABSTRACT

The wearable industry is growing and diverse. However, despite the variety in device producers and served purposes, many wearables include biosensors that can measure health parameters, such as heart rate. This makes them potentially useful or even disruptive for healthcare; particularly, for its remote delivery mode that is referred to as telehealth. Wearables and consumer technologies can bring changes to the current value network of telehealth industry by creating new business roles and attracting new stakeholders. However, traditionally regulated telehealth industry may be reluctant to accept unregulated non-medical devices. Furthermore, apart from the potential impact of wearables, the future of the industry is affected by other factors, which need to be understood. This article analyzes a potential evolution of the telehealth value network. For that, we first identified the current trends in the evolution of telehealth technologies and products based on the quantitative analysis and review of three different types of literature – scientific publications, patents, and press releases. Furthermore, we discussed the actors that can drive the future telehealth industry by taking a key role in its value network. The study indicates that technologies and products brought by consumer companies will be used in telehealth for the self-management of chronic diseases and wellness. To facilitate the interaction of the previously separated unregulated consumer and regulated medical domains of telehealth, a new health data aggregation role may emerge and take a central position in the value network. While several candidates for this role can be identified, currently, none of them has the full required expertise.

1. Introduction

According to Ericsson, there will be 29 billion connected devices by 2022 (Ericsson, 2016), with more than a half of them belonging to the Internet of Things (IoT) domain that can be divided into two groups – industrial IoT and consumer IoT. The latter one will be largely comprised of wearable devices, which, according to forecasts, will become the second best-selling consumer electronics product after smartphones by 2020 (Chandran, 2015). Given this considerable market potential of wearable devices, it is not surprising that multiple companies from various industries, such as a smartphone, fitness garments, and information technology, engage in a competitive race for their share of the wearable electronics market. The diversity of manufacturers and their approaches results in the development of wearables fulfilling different functions, ranging from step counting to GPS navigation, and being implemented in various form factors, such as eyeglasses, wristwatches, or integrated into clothing. However, perhaps the largest share of the existing wearable device models is worn on skin surface and equipped with one or several biomedical sensors, which make them usable for tracking health parameters, such as heart rate or blood oxygen saturation. Such devices are expected to play a prominent role in transforming the healthcare industry by empowering users to collect timely information on health-related parameters, manage them, and share this information with healthcare professionals upon necessity (Metcalf et al., 2016).

Wearables can affect healthcare in a way that notably differs from the changes that other digital technologies have brought to the industry. Until now, digital innovations in healthcare have mostly taken place on a hospital side (e.g., the deployment of health information systems) and did not change the way patients interact with a healthcare provider. Emerging wearable devices, on the contrary, may start a new wave of healthcare digitalization, which would focus to a greater extent on the end users of health services, that is, on patients and citizens in general, who would get valuable tools for managing own wellness and diseases. In particular, wearable devices may unlock new applications and drive the adoption of telehealth, which is also referred to as telemedicine and can be defined as a remote healthcare delivery mode that relies on the information and communication technologies (World Health Organization, 2010). The importance of telehealth for improving the efficiency and accessibility of healthcare services has been

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long realized (Lin, 1999) but only a few applications have received wide adoption (Zanaboni and Wootton, 2012).

By enabling ubiquitous biomedical sensing, consumer wearables may greatly affect telehealth and bring changes to its current value network, namely, create new roles and attract new actors. However, it remains unclear whether the medical field will acknowledge and accept the technologies brought by non-medical companies and whether consumer wearables will have real value in healthcare and telehealth. Therefore, the potential impact of wearables on the value network of telehealth is still to be evaluated. Moreover, the future of telehealth is affected by other technological and economic factors that need to be considered to understand possible evolution paths of the industry.

This article aims to suggest a potential future value network of telehealth. In order to do that, we first study the evolution[1] of telehealth technologies and products and identify the trends that may influence the future structure of the industry architecture. Furthermore, after a potential value network is defined, we discuss the actors that can drive the telehealth industry by taking its key business role. To get a comprehensive understanding of the past and potential future evolution of telehealth, this study proposes a research framework that can be used to analyze the industry development from different viewpoints using various types of literature, including research publications, invention patents, and press releases. The proposed framework is suitable for technological subjects and enables more extensive exploration in comparison to a single source-based analysis.

This study contributes to state of the art in several ways. First, the comprehensive analysis of telehealth technological evolution based on multiple information sources enables its multifaceted understanding, which can serve as a foundation for further studies on the industry development. Furthermore, the suggested value network provides stakeholders with greater awareness of the potential changes in the industry structure and allows more informed decision making on their future telehealth strategies. Finally, the proposed framework can be used by researchers for exploring other technological areas.

The paper is further structured as follows. Section 2 introduces the research framework along with the data and methods for their analysis. Section 3 analyzes the transformation of telehealth on the layers of scientific research, invention, and product, and summarizes that analysis by identifying the trends in the evolution of telehealth technologies and products. The past and potential future value networks of telehealth are analyzed in Section 4. Finally, Section 5 discusses the stakeholders that can drive the future telehealth value network.

2. Research approach

2.1. Research framework

The research framework used in this paper for analyzing the evolution of telehealth is presented in Fig. 1. The framework shows (a) four layers, which were studied separately for getting a comprehensive understanding of telehealth development; (b) the data used for the analysis of every layer together with their source; as well as (c) the methods employed for analyzing the data. For every layer, the research identified the key topics in several consecutive time periods and detected the changes between the periods that allowed tracing the evolution of telehealth. The arrows between the layers of the same time period show their interconnectedness. The disruption framework of Kilkki et al. (2018), which was substantially adapted and augmented, served as an initial starting point for our research framework.

2.2. Data and methods

In order to assess the recent evolution of telehealth industry, we considered a time span of 15 years, from 2002 to 2016, which was further divided into three five-year intervals, 2002–2006, 2007–2011, and 2012–2016 and analyzed separately. The periods before 2002–2006 were not considered because of a limited number of documents available for the analysis. Comparison between the time intervals allowed detecting the trends and tracking the dynamics of the changes in telehealth.

Analysis of telehealth on different layers can provide a more complete understanding of an industry and its evolution in comparison with a single source-based study. Thus, while the topics of scientific research illustrate the interest of researchers and indirectly public and private funding bodies that financed the research, the analysis of inventions allows identifying technologies that were considered as important for the future products and services by commercial organizations and inventors working for them. Further, product layer analysis complements the explorative study of an industry and its evolution by inspecting the products that found real applications. Finally, the study on an industry architecture layer provides a higher level view on the industry, showing the ways stakeholders collaborate to create the value.

2.2.1. Scientific research layer

The key topics of the Scientific research layer of telehealth and their evolution were studied by analyzing research publications derived from Scopus bibliographic database by applying a keyword search on the title, abstract, and keywords of articles. In order to keep a technological focus of the research, only engineering and computer science publications were considered, while purely medical articles that typically report the outcomes of clinical trials were filtered out. The following Scopus query was used for deriving research publications:

TITLE-ABS-KEY ("telehealth" OR "telemedicine" OR "tele-health" OR "tele-medicine") AND (LIMIT-TO (SUBJAREA, "ENGI") OR LIMIT-TO (SUBJAREA, "COMP"))

Since “telehealth” and “telemedicine” are often used interchangeably (Fatehi and Wootton, 2012), both terms and their spelling variants were used as keywords. After the search had been completed, author-supplied keywords of found papers were extracted to find the most common keywords and track changes of research focus in terms of the keywords over time, similarly to Li et al. (2009). The idea of using author-supplied keywords as the indicators of publication content has already proven its usefulness in some studies (Cunningham and Kwakkel, 2011; Ferreira et al., 2014). After extracting the keywords, they had been aggregated, and the keywords that have the same meaning were merged (e.g., “wearable electronics” and “wearables”). After that, given our interest in the technological evolution of telehealth, the keywords referring to the technological developments were selected. Finally, in the end, a review of research publications was conducted to get a better understanding of the main research directions related to telehealth technologies, as well as their evolution over time.

2.2.2. Invention layer

The evolution of telehealth industry on Invention layer was measured by analyzing utility patents granted by the United States Patent and Trademark Office (USPTO). The US patent office was selected because of a high significance of the US market, meaning that foreign inventors are likely first to try to protect their intellectual property rights in the US rather than in another market abroad. Furthermore, the data on granted US patents is easily available for a free download from the USPTO website.[2]

[1] In this paper, the “evolution” refers to gradual development of a technology, product, or value network from simple to more advanced state due to the use of innovative technological and business approaches.

[2] http://www.patentsview.org/download/.