

On the Growing Opportunity to Use Sentiment Analysis to Support Artificial Intelligence Applications in Healthcare



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Abstract

Sentiment analysis involves the automatic assessment of emotional content in communications. Primary analysis has focused on identifying positive, negative, or neutral emotional states. More sophisticated analyses identify states associated with specific human emotions, such as anxiety, hostility, or confidence. There are at least two clear opportunities to employ sentiment analysis in healthcare applications: (a) preparing documents for participants in clinical trials, and (b) patient monitoring. Successful applications of sentiment analysis may increase clinical trial retention and help identify those patients who would benefit from intervention.

Introduction

There has been a long-standing interest in assessing emotional states in communication [1,2]. Early applications, from the 1960s, were quite limited at least in part because of the expense and relatively slow processing power of existing computers. Now, five decades since Gottschalk & Gleser [2] introduced, in 1969, the concept of assessing a person's psychological states based on the words and phrases that he or she used, the tools for analyzing sentiment have advanced to a more practical and general utility across the field of healthcare.

Modern sentiment analysis programs use natural language processing and other artificial intelligence (AI) tools to automatically process text-based communications [3]. The analysis is conducted generally by looking for words and phrases that are associated with specific identified sentiments, and possibly with the results of natural language understanding algorithms that seek to put the words and phrases in context. These approaches are described generally by the terms lexical and contextual, where the former is at the level of words and phrases outside of the context of the communication. One example to illustrate the difference between *lexical* and *contextual* interpretation comes when comparing the sentences "I'm anxious to meet you" to "I'm eager to meet you." In context, each is normally viewed as meaning the same thing, but lexically the former evokes anxiety while the later evokes confidence. Both lexical and contextual processing has been shown to be impactful on human behavior and opinion (e.g.,

[4-7] and many others) and thus both lexical and contextual approaches to sentiment analysis are presumed valuable.

Opportunities in Healthcare

From my own experience over 20 years with sentiment analysis [8] and also AI applications in medicine and healthcare (e.g., [9-12]), I believe there are at least two immediate opportunities to apply sentiment analysis in health care for the benefit of patients and healthcare providers, as well as pharmaceutical and medical device companies: (a) Preparing documents for participants in clinical trials, and (b) Patient monitoring.

Clinical trials are often costly and time consuming [13]: costs often exceed \$2.5 billion and require more than a decade from first clinical trials to an FDA approval. One of the many reasons that clinical trials face such hurdles is patient/subject retention. The average dropout rate in clinical trials is approximately 30% [14] and many trials fail to meet enrollment goals [15]. Patients feeling respected is known to be associated with greater retention [12]. In part, patients report greater satisfaction when receiving understandable documents [16], with information regarding the clinical trial they are considering [17], along with information about the principal investigator [18]. I believe these observations lay the foundation for a broader approach to ensuring that patients feel respected and appreciated, which can come in more carefully choosing the exact language of the documents that are provided. Sentiment analysis tools may be helpful in identifying

the likely emotional reaction of clinical trial candidates to the materials that the clinical trial is presenting and may be helpful in crafting alternative language that conveys the same information but with increased likelihood of imparting feelings of confidence, compassion, and optimism. This may be particularly appropriate given that most documents provided to potential participants are replete with medical terms that are likely to increase anxiety for those without a familiarity with medical terminology. Affecting retention rates positively by improving patient sentiment may become an important ingredient in reducing the cost and duration of clinical trials.

Separately, there are increasing opportunities to employ out-patient care, reducing the burden on hospitals and other care facilities; however, monitoring patient health, even at a distance, remains crucial. New research is showing that patients, including the elderly, may be willing to relate to avatars or other "virtual agents" [19], which are essentially digital characters. Avatars have been used to help Type II diabetics adhere to medication schedules [20], while Rehm et al. [21] identified opportunities for using avatars in mental health interventions. For this latter application, it is important to identify changes in the subject's emotional state that could reflect changes in mental health. Sentiment analysis tools offer the potential to track interactions with an avatar, entries in an electronic diary, or other communications, to establish baseline variations in evoked emotions. Then, using statistical quality control techniques, changes in those evoked emotions that are suggestive of the need to intervene may be identified. For example, a communication two days post-surgery about a patient's perceived levels of pain might suggest the need for further investigation or treatment if the patient's communication reveals increased level of evoked anxiety or depression, or a trend to higher levels of these expressed emotions. When combined with emotion-recognition based on facial features [22,23], a more accurate representation of the patient's emotional well-being may be constructed.

Conclusion

The opportunities to employ artificial intelligence to support more effective health care will assuredly grow in coming years. Many of the existing opportunities focus on diagnostics, genetic analysis, or other important aspects of providing quality care. But these are purely clinical rather than emotional in character. Yet, a patient's emotional state may be associated strongly with a willingness to participate in research and his or her well-being during care. Sentiment analysis has not received as much attention as other AI concepts in the context of providing superior healthcare. My hope is that it receives greater attention in the future.

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Conflict of Interest

David Fogel serves as chief scientist of Trials.ai, a technology company that employs artificial intelligence methods to improve the design and execution of clinical trials. He also serves as a director and co-founder of Effect Technologies, Inc., which offers sentiment analysis tools for a wide variety of applications, including those in healthcare.

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