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Abstract

Recent advances in Internet and Web technologies and the advent of Web 2.0 have made it possible to share information and knowledge surrounding human activities, which can be obtained from massively deployed sensors and the Web resources. This survey provides a comprehensive overview of mining experiential knowledge bearing on human activities, with an emphasis on the use of the Web. Starting from definitions of activities and experiences, we elaborate on various views of human activities in cognitive science, including knowledge representation schemes. We then describe two activity detection techniques arising from different types of information sources: sensor-driven approaches for the physical space and text-driven approaches for the cyberspace. Focusing on experiential knowledge of human activities that can be discovered from unstructured text, we review and summarize the existing body of literature on experiential knowledge filtering, context identification for knowledge, and knowledge distillation. There is no doubt that the vast amount of information on human experience including activities is going to help detecting, recognizing, and understanding human activities of various sorts. We illustrate potential applications of experiential knowledge in different domains, such as information retrieval, service recommendation, and semantic Web. Following the survey of on-going research on capturing and utilizing human activities and experiences, we finally present challenging research issues for further research.

Contents

1

Introduction

Active user participations and interactive communications among users in the Web 2.0 era have made it possible to elicit a vast amount of user activity information and personal experiences from the Web. User activity data are also available through ubiquitous sensors of various kinds and mobile devices that have become a commodity. At the same time, such accumulation of big data and their availability call for a more advanced analytics technology that enables correct understanding of individual and/or group activities, situations, and intents of the users in various domains and applications. As human activities of various sorts are expressed in natural language and recorded on the Web in the form of weblogs, social network messages, and even news articles and electronic boards, text mining and semantically oriented techniques have become more critical than ever for human-oriented decision making and intelligent applications. There is no doubt that the knowledge distilled from the vast amount of human experience data, most of which are available on the Web, is going to help understanding human behaviors in general as well as in specific contexts such as location and time, which are essential for intelligent agents. Some recent studies have already begun to take a stab at eliciting useful experiences from the Web [110, 169].

Our main motivation for this survey lies in the observation that we are only on the verge of utilizing the vast amount of information on human experiences stored on the Web. In other words, such precious resource has not been explored and utilized enough for intelligent tasks. In particular, our interests rest on human activity-related information that has been recorded in the form of blog posts, online community services, and online social media although increasing availability of more structured sensor data will play a complementary role. As this kind of information will continue to grow in the future with the increasing social dynamics and mobility of computing and communication devices such as smart phones, the time is ripe to investigate the possibility of constructing an activity knowledge base out of the vast amount of textual data. While there are many challenging issues to be tackled in natural language processing (NLP) before we can process free text and generate error-free activity knowledge in a logical form, the current state-of-the-art NLP technology allows us to extract key knowledge elements that can be used for many intelligent applications that do not require formal inference capabilities.

Moreover, understanding human activities in varying situations would help in interpreting user behaviors and intents in various user interactions involving online activities and social media as well as any context-dependent mobile applications in daily lives. A major question is how to turn the vast amount of activity-related information embedded in text into a form that can be readily available with sufficiently detailed granularity and utilized for various intelligence-enabled applications. An example along this effort is Activity Streams [4] that has been adopted by Facebook, MySpace, etc.; it helps distinguishing people's activities such as blogging, updating status, and posting photos. However, the major challenge that awaits technological innovations is the process of identification, extraction, interpretation, abstraction, and aggregation of elements of experience at various granularity levels.

To set the stage, we begin with a definition of experience, excerpted from the Oxford Advanced Learner's Dictionary:

- The things that have happened to you that influence the way you think and behave
- An event or activity that affects you in some way

This definition has a few elements that affect the process of experience mining and the associated techniques when it is done automatically. First, something must "have happened" in the past if it is to be considered as experience. This is particularly important especially when a textual description is analyzed and discerned for existence of an experience. Second, an experience must have a context because it must have happened. A real event or activity, as in the second line, cannot happen in a vacuum without a context regardless of whether or not it is described explicitly or assumed implicitly. Third, in order for an activity or event to become an experience, it must have influenced the way the experiencer think or behave. This aspect has two ramifications in detecting experience from text: there must be an experiencer, again explicitly or implicitly, and the experiencer must have either perceived the activity or event or participated in it. Without one of the conditions, there is no way the experiencer would be affected either mentally or physically.

The three characteristics of experience mentioned above are critical in an operational setting. To illustrate this point, let us take a look at the following sentences.

(1) "*I thought I was going to* ***walk up Table Mountain*** *today, but Kees and Ian, a couple* ***staying*** *at the guest house asked me to* ***go to the vineyards*** *with them today.*"
(2) "*One day Chris and Levi* ***took a drive*** *out to Milton Florida to visit Chris' family at his farm.*"
(3) "*I saw people* ***playing FIFA*** *on a TV here.*"

The three boldfaced parts in the first sentence are candidates for an experience, but the second one is the only one to be qualified as an experience because the first and third one did not actually happen. The sentence in (2) illustrates the second point in that the phrases, "One day" and "Milton Florida," serve as the temporal and directional contexts for the driving activity. Note that "his farm" is not a locational context for the activity because it is part of the description for the purpose. The final point about the characteristics of experience is shown in the sentence (3) where both "I" and "people" are the experiencers.

However, they are affected differently: the former mentally via visual perception but the latter physically by actually playing a game.

The next issue we must address is how to define experiential knowledge, which is the eventual goal to elicit from data and the product of the mining process to be used in applications. The current version of Wikipedia defines experiential knowledge as "knowledge gained through experience as opposed to a priori (before experience) knowledge" or "knowledge that can only be acquired through experience." For our discussion in this survey, we posit that experiential knowledge is obtained by aggregating individual experience instances and distilled into tendency through abstraction, grounding, organization, and linking in such a way that the result can be used more directly with a reasonable level of confidence for decision making. This operational characterization of experiential knowledge is based on the characteristics of experience so that the distillation process is also described in terms of experience mining.

As in the definition of experience, human activities and events where people are engaged in are the major sources from which human experience can be extracted. As such, we begin Section 2 with an introduction to Activity Theory to provide a framework for understanding human experiences in a socio-cognitive mind set. At the same time, it makes it amenable to view and assess existing data collections and mining techniques and develop future technologies with an eye on their fundamental appropriateness. Also introduced in the section are the notions of episodic memory and activity frames that have been developed primarily for artificial intelligence. Episodic memory constructed from episodes (experience instances) is rooted in earlier studies of the script theory and conceptual structures. These early studies done on a small scale are significant enough to give an insight on more contemporary research for which a much larger amount of data and various advanced statistical techniques are available to generate more practical results.

Section 3 introduces key issues in capturing, recording, and processing human activity- or experience-related data in physical space. Such data have been produced by a variety of sensor technology and made available for direct consumption by ubiquitous systems or for analysis to understand human behaviors or to develop intelligent applications. While the research community in this area has been largely separated from that of text mining or NLP, our expectation is that they need to be merged together to complement each other. The ubiquitous computing community that has been transformed into the IOT (Internet of Things) among others, for example, can benefit greatly from research in text mining and vice versa. The difference in data granularity has called for different technology and goals, but they need to help each other as the data on each side is far from being complete in understanding human behaviors and developing useful and robust applications. Also included in this section is a discussion of what kinds of Web resources are available from the data acquisition point of view to set the stage for the next section devoted to a comprehensive discussion of experience knowledge mining techniques and related issues.

This book culminates in Section 4 which introduces a variety of text mining techniques that are related to experiential knowledge mining one way or another. Its coverage spans from linguistically oriented techniques to statistically based machine learning techniques for different purposes, such as event and activity extraction, named entity recognition, and context identification, which are essential techniques for experience mining, which is a prerequisite for experiential knowledge mining. The final two subsections of this section are devoted to the techniques for relational and procedural knowledge mining, which are considered as experiential knowledge mining proper as opposed to component techniques.

Having introduced all the underlying theories and key techniques for experiential knowledge mining, Section 5 attempts to show how such knowledge can be used in practical applications. Experiential knowledge would be useful for virtually all possible domains where experienced humans play a certain role. Even in the art and design area, which requires human ingenuity and creativity, experiential knowledge can usefully provide the data necessary for verifying conjectures, observations, and assumptions that may go into the creative processes [165]. Aside from these areas, experiential knowledge can play a central role in directly helping humans perform their tasks by, for example, making intelligent recommendations tailored to the right context and situation. Even for mundane applications like search engines and community question answering, availability of past experiences garnered from Web resources provides essential evidence to support decision making.

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