J. Eng. Technol. Manage. 32 (2014) 147–159

Contents lists available at ScienceDirect

Journal of Engineering and Technology Management

journal homepage: www.elsevier.com/locate/jengtecman

Characterizing the emergence of two nanotechnology topics using a contemporaneous global micro-model of science

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ARTICLE INFO

JEL classification:
O33

Keywords:
Emergence
Emerging technologies
Hot topics
Graphene
Science mapping

ABSTRACT

This study presents a methodology that can be used to characterize emergent topics within the context of a contemporaneous, global micro-model of the scientific literature. To illustrate its effectiveness, two known emergent nanotechnology topics (graphene and dye-sensitized solar cells) are characterized. We show that the model and methodology are suitable for characterizing the emergence of topics as they are emerging. In addition, we show that the two topics follow two different patterns of emergence – one where topic is not focused but then grows explosively, and one in which the topic quickly becomes an area of focus and grows steadily.

Introduction

Identification of emerging topics in science and technology is a topic that has been gaining interest in recent years. Although the industrial sector relies heavily on traditional market research for this type of information, those at the science end of the spectrum have relied on studies of the scientific literature to characterize emerging topics. To date, nearly all such studies have been retrospective (cf., Guo et al., 2011; Tu and Seng, 2012) – that is they have sought to characterize topics that have clearly emerged rather than topics that are at the point of emergence today. In addition, most such studies

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http://dx.doi.org/10.1016/j.jengtecman.2013.07.001

consider only the literature on the topic rather than a broader body of literature, and thus they lack context within which to interpret results.

This study presents a model and methodology that can be used to characterize emergent topics within the broad context of all of science. The model is contemporaneous – at each year the model only reflects the literature that was available through that year. In addition, the model is global, comprised of all scientific disciplines, and is highly detailed, consisting of tens of thousands of document clusters representing individual research problems. This type of model is correspondingly called a contemporaneous global micro-model of science.

The model and methodology are tested using two emerging topics (based on ex-poste term-based queries) from nanotechnology. Query results are located within the model and the document clusters in which they appear are analyzed. If the query results are concentrated in clusters with characteristics associated with emergence (novelty and growth), we claim that it was possible to identify that the topic was emerging while it was emerging rather than retrospectively. In addition, we compare the patterns of emergence of the two emerging topics to determine if there is a common pattern or if many patterns may exist.

The balance of this article proceeds as follows. First, we provide a working definition of emergence. The contemporaneous global micro model is then introduced, followed by a description of the two emergent topics used as examples. This is followed by hypothesis and analysis sections that focus on whether the emergent literature (from the query search) is concentrated in novel and growing document clusters from the model. Implications focus on how this model might be used to identify instances of emergence as they are emerging.

Emergence

The concept of emergence is, of itself, both interesting and fraught with difficulty. Of the many studies that have characterized "emerging topics" or "emerging technologies", few, if any, have attempted to define emergence. This should not be surprising because there is no universal definition of emergence. Rather, the term "emergence" is used in a variety of ways in different fields (Corning, 2002; de Haan, 2006). Regarding emergence as it relates to topics in science and technology, Alexander et al. (2012) provide a comprehensive history of the term and its usages. Goldstein (1999) ascribed the following properties to emergence: radical novelty; coherence, correlation, wholeness; global or macro; dynamical (not pre-given wholes); and ostensive, perceivable. Upon comparing these properties with those from other definitions, we find that there is nearly universal agreement on two properties associated with emergence – novelty (or newness) and growth. We find two additional properties on which there is less, but still moderate, agreement – emergence is noticeable and unexpected. Overall, there are four properties that can be associated with emergence – newness, growth, noticeability, and unexpectedness. The following sections examine whether these properties can be used to identify emerging topics as they are emerging.

A contemporaneous global micro-model of science and technology

This section starts with a short discussion of the theoretical basis for our model. We then focus on three important aspects of the model (contemporaneous, global and micro). The majority of the discussion will be on the micro-structural nature of the model, especially as it relates to the detection of emergence.

Theory

The theoretical basis for our contemporaneous global micro-model of science is based on Kuhn's argument that scientific inquiry (and inquiry in general) is inappropriately framed as a search for truth. Rather, it is a social activity aimed at problem solving. As such, the words and concept symbols (such as cited references) used in the scientific literature can be used to identify socio-cognitive structure, represented as the research communities that are working on a problem and the cognitive symbols that signal the identity and beliefs of those groups.