Futures 52 (2013) 59–73

Contents lists available at ScienceDirect

Futures

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

NEST: A quantitative model for detecting emerging trends using a global monitoring expert network and Bayesian network

Seonho Kim, You-Eil Kim, Kuk-Jin Bae, Sung-Bae Choi, Jong-Kyu Park, Young-Duk Koo, Young-Wook Park, Hyun-Kyoo Choi, Hyun-Moo Kang, Sung-Wha Hong *

Technology Opportunity Discovery Lab., Department of Information Analysis, Korea Institute of Science and Technology Information, 66 Hoegi-ro, Dongdaemun-gu, Seoul 130-741, South Korea

A R T I C L E I N F O

Article history:
Available online 24 August 2013

Keywords:
Weak signal
Emerging trend
Qualitative analysis
Quantitative analysis
Bayesian network
Delphi study

A B S T R A C T

The analysis of changes in the research and development (R&D) environment and developing foresight of future technologies are increasingly recognized as important to support policy decision making and efficient resource distribution. Many futurists are developing foresight of future technologies based on Delphi studies, unfolding history, brainstorming, expert surveys, trend analysis, data mining, and so on. However, formalizing these processes is still a necessary task. In this paper, we introduce the NEST (New and Emerging Signals of Trends) model developed by the Korea Institute of Science and Technology Information (KISTI). The NEST collects information from worldwide expert networks and detects the weak signals of emerging future trends systematically, based on massive data analysis, inference techniques, and Delphi studies, to support the development of foresight of future research and technology. The NEST model combines quantitative and qualitative approaches. In the quantitative approach stages, NEST uses clustering, pattern recognition, and cross-impact analysis using a Bayesian network. In the stages of qualitative approaches, NEST conducts environmental scanning, brainstorming, and a Delphi study.

1. Introduction

The importance of utilizing the knowledge created from mass collaboration has become more significant than ever before. Successful collaborative and social networking applications, such as Wikipedia, Twitter, and Facebook, are good examples of this trend. These applications greatly influence our lives including our style of learning, working, communicating, and decision making. Information presented by mass media, articles, news, workshops and conferences is also allowing us to understand our markets, politics, and the global environment [1–3]. Predicting the future using this knowledge has long been a research interest of many futurists.

Developing foresight of future technology is a promising application of collaborative and social networking, because the essential stages of the foresight process, such as analyzing an R&D environment and inferring future changes, require expert

* Corresponding author. Tel.: +82 2 3299 6133; fax: +82 2 3299 6117.
E-mail addresses: haebang@kisti.re.kr (S. Kim), yekim@kisti.re.kr (Y.E. Kim), baekj@kisti.re.kr (K.J. Bae), sbchoi@kisti.re.kr (S.B. Choi), jkpark@kisti.re.kr (J.K. Park), ydkoo@kisti.re.kr (Y.D. Koo), ywpark@kisti.re.kr (Y.W. Park), hkchoi@kisti.re.kr (H.K. Choi), kang1@kisti.re.kr (H.M. Kang), shong@kisti.re.kr (S.W. Hong).

0016-3287/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.futures.2013.08.004

knowledge and a deep understanding of phenomena from all over the world and in all areas, such as politics, sociology, engineering, natural sciences, and religion. Traditional studies of future trends depend mainly on qualitative approaches, such as Delphi studies [4–6]. One of the most notable cases of the use of a Delphi study for developing foresight in technology is the case of Japan [7]. Some researchers have used off-line interviews, data analysis [8], data mining [9], literature reviews, and brainstorming [10]. Recently, however, more futurists and information scientists have viewed collaborative knowledge and social networks as a key source for future studies [11–13].

The Korea Institute of Science and Technology Information (KISTI) [14], founded in 1962, is a government-funded national information research institute of Korea. KISTI's mission includes archiving scientific information, including academic papers and patents of major countries, scientific factual data, and so on, and operating computing resources such as super-computers and a high-speed R&D network to support scientists. Also, one of its major missions is to analyze scientific information to support the nation's policy makers and decision makers of small and medium sized enterprises (SMEs).

A group of researchers in KISTI has focused on forecasting future technology mainly based on Delphi studies and expert' brainstorming. However, the qualitative approaches of developing foresight, such as Delphi studies, interviews with intellectuals, workshops, and brainstorming, are not sufficient to fulfill the needs of KISTI in several aspects. The first reason is the high cost of conducting the research. Employing intellectuals and experts from all areas of technology and science and conducting online/offline surveys is expensive. The second reason is the slow process speed of research. The interactive procedures of Delphi studies, holding workshops and conferences, and conducting brainstorming take time and it is very difficult to finish the whole process in a year. However, KISTI needs to perform all the processes of developing foresight on an annual bases or anytime a request arrives. The third reason is that the qualitative methods rely on subjective opinions of intellectuals and experts. Based on the experts and intellectuals employed, the results of foresight are different and inconsistent for repeated trials. This aspect is also related with the difficulties that KISTI experienced when answering specific detailed requests of policy makers and SMEs, because even experts and intellectuals have limited knowledge and information to which the can refer. The last reason is that there is a need to utilize environmental monitoring data collected by the Global Trends Briefing (GTB) network [15], which will be described in Section 3.1, and the computing resources KISTI possesses, such as high performance computers, to obtain consistent and fast results. For these reasons, it is necessary to develop a sophisticated systematic model, which combines quantitative and qualitative approaches for developing foresight. Therefore, another group of KISTI researchers is trying to develop a sophisticated systematic foresight development model, the NEST (New and Emerging Signals of Trends) model, which works on the analysis of large volumes of environmental change data to support the first group.

In this paper, we introduce KISTI's collaborative environmental analysis model—NEST—using the Bayesian network for developing foresight regarding future technology, which will be useful for supporting the decision-making of groups or nations and for establishing an R&D strategy. This model is designed to find the weak signals of future changes. Weak signals are events, accidents, or strange occurrences that are thought to be the beginning of future changes [16,17]. Whilst the concept of weak signals began to be discussed a quarter of a century ago in strategic management literature and its importance has been widely perceived, actual research on modeling the analysis and detection processes still needs to receive significant attention [18].

The objectives of the NEST model include:

(1) establishing a systematic process for the identification of weak signals of future trends in research and technology;
(2) building a reference system supporting future technology researchers and decision makers;
(3) utilizing unstructured data, such as information from mass media, news, conferences, workshops, academic papers, the Internet, and so on, for environmental scanning;
(4) utilizing quantitative methods as well as qualitative methods.

The purpose of the NEST model is not to automate the process of developing foresight or weak signal detection. Rather the research goal of the NEST model is to build a supplementary information system that provides researchers of future technology and policy-makers with the information about environmental changes and hints of possible weak signals for future changes in research and technology.

The concepts of 'finding weak signals' and 'finding future trends' are used similarly in this paper because the NEST model is a network-based trend detection model in which related signals are connected with each other and weak signals can be found by tracing back the sub-network representing the future trends.

The next section presents the results of a literature review on related research. Section 3 presents a detailed description of the NEST model and its components. In Section 4, a Delphi study is performed in order to evaluate the results of NEST, and determination of emerging technology trends is discussed. We then conclude the paper in Section 5.

2. Previous research

All events and changes readily observed in human societies can be explained by analyzing the environments in which the changes occur. However, recognizing and understanding such environments is a difficult task. Such social phenomena can be understood with reference to Heijden's Iceberg Model [19]; that is, the events above the surface of the water that we face every day are the results of social trends, patterns, and structures below the surface of the water. Thus, the detection of