International Journal of Information, Control and Computer Sciences
ISSN: 2517-9942
Vol:9, No:3, 2015

Exploring Social Impact of Emerging Technologies from Futuristic Data

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***Abstract*—**Despite the highly touted benefits, emerging technologies have unleashed pervasive concerns regarding unintended and unforeseen social impacts. Thus, those wishing to create safe and socially acceptable products need to identify such side effects and mitigate them prior to the market proliferation. Various methodologies in the field of technology assessment (TA), namely Delphi, impact assessment, and scenario planning, have been widely incorporated in such a circumstance. However, literatures face a major limitation in terms of sole reliance on participatory workshop activities. They unfortunately missed out the availability of a massive untapped data source of futuristic information flooding through the Internet. This research thus seeks to gain insights into utilization of futuristic data, future-oriented documents from the Internet, as a supplementary method to generate social impact scenarios whilst capturing perspectives of experts from a wide variety of disciplines. To this end, network analysis is conducted based on the social keywords extracted from the futuristic documents by text mining, which is then used as a guide to produce a comprehensive set of detailed scenarios. Our proposed approach facilitates harmonized depictions of possible hazardous consequences of emerging technologies and thereby makes decision makers more aware of, and responsive to, broad qualitative uncertainties.

***Keywords*—**Emerging technologies, futuristic data, scenario, text mining.

I. Introduction

INTRODUCING novel products with new technologies may be worth the ticket to significant competitive advantage, especially for innovative enterprises or entrepreneurs. It offers exiting prospects for business opportunities and job creation, which results economic, societal, and environmental benefits [1], [2]. But alongside the hopes of various advantages, developments involving such emerging technologies also raise prominent concerns over possible adverse societal impacts. By way of illustration, 3D printing technology is currently gaining strength in commercial use and thus becoming influential in numerous industries: fashion, lighting, computer, telecommunication, health care, etc. Yet, there are also crucial and urgent societal issues. Digitization of labor may amplify unemployment rate, and printing out hazardous items may also lead to social chaos [3]. Consequently, a well-developed assessment and mitigation strategy are of paramount importance to deal with such a growing disquiet.

A variety of methodologies both in science and in practice have attempted to address these unintended impacts. In literatures, particularly in the field of TA, approaches, like impact analysis, Delphi analysis, risk assessment, and scenario analysis, have been often incorporated [4]. Whereas, new product development related projects for the European market, for instance, assess the safety and moral issues via impact assessment, failure modes and effects analysis (FMEA), and SWOT [1], [5]. However, suggested approaches utilized by previous literatures and projects pose two major drawbacks: negligence of distinct properties of emerging technologies and excessive reliance on participatory activities. First, due to unprecedented technological features with their socially unaccepted functions, emerging technologies hold high level of unpredictable quantitative uncertainties. Moreover, approaches involving expert participation require an ample amount of time and labor for data collection, and most importantly, input information may possibly be pervaded by personal bias and subjective interpretation.

Thus, this research seeks to remedy these issues by foresighting them with the basis of collective intelligence. In other words, holistic pictures on the future social impacts will be provided according to the wisdom of the crowd: experts and general public. Specifically, a massive number of future-oriented opinions are comprehensively aggregated and then analyzed via text mining technique. Network analysis is then performed with social keywords extracted from collected documents. Based on the interpretation from the networks, socially problematic consequences resulting from emerging technology are comprehensively provided. This paper begins by providing theoretical background of emerging technology and future-related information, namely *Futuristic Data*. It will then go on to brief explanation of proposed methodology.

II. Theoretical Background

A. Nature of Emerging Technology

The term *technology* still has a quite vague definition; however, [6] suggests that it contains at least two distinct meanings: the body of knowledge that constitutes a field of engineering and a collection of technical artifact that a specific technology gives rise to [6]. The information and communication technology, for instance, refers to the latter, whereas computer technology refers to the former. In the perspective of co-evolutionary between technology and society, the implementation in concrete technical device tend to have relatively more direct influence in that a wide variety of consumers actually use the physical products, instead of certain body of knowledge. In this sense, this research would like to focus on the societal impacts that are posed from technical

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artifacts, which is currently being actively developed or at the brink of commercialization.

Numerous literatures have attempted to tackle social consequences of emerging technology in diverse perspectives in TA methodologies. Specialized studies may occur under the name of Social Impact Analysis (SIA); yet they are fairly uncommon in literatures. Including SIA, there are many other variants of TA approaches with the ambitious agenda to cover economy, environment, and privacy dimensions of technology. Palm and Hansson [7] highlights only the ethical implications in the scope of society and names the approach, ethical technology assessment (eTA). This study identifies nine crucial ethical aspects of new technology via check-list approach using historical data. Based on [7], [8] thoroughly investigates the significance of ethical considerations and proposes an ethical impact assessment as an essential part of technology assessment, especially focusing on emerging technologies. Some literatures looked into the way people respond to emerging technology uncertainties and risks, and emphasizes the role of ethical concerns within the evolution of public resistance to new technology [9], [10]. In the field of nanotechnology, there is a large volume of published studies examining early warning signs for environmental, health, and safety (EHS) uncertainties [11]-[13]. They all utilize toxicological substance data and information from previous literatures for the assessment.

There is one consideration that must be carefully weighed. In contrast to the issues of established technologies, those of emerging technologies present considerable challenges for conventional TA methodologies [14]. Consisting of discontinuous development and unprecedented performance features, the intrinsic nature of emerging technologies is far more complicated and ambiguous than one can expect [15]. Their properties are said to be intangible in terms of difficulties in reasonably predicting the magnitude or likelihood of exposure due to lacking resources of precedents [1]. Consequently, adverse outcomes or impacts of emerging technology can be explored only at the later stages of technology development when societal implications can easily be identified and characterized [4]. In such a circumstance, incorporating future-oriented data into the foresight methodologies seems to be more suitable strategy than utilizing empirical data.

B. Foresighting the Impacts of Emerging Technologies

This is now the matter of foreseeing future social reactions to new technologies that we have not yet observed. Thus, when discussing possible adverse impacts of emerging technologies, there is a need of incorporating experts with a wide variety of expertise and stakeholders with diverse perspectives. This broadens the scope of what could happen in the future. Integrating only the useful elements from the previous foresight methodologies, [6] emphasizes the significance of scenario planning by referring as the main methodological inspiration for bringing in the societal context [16]. It is suggested that scenario planning is chosen to be the popular TA methodology utilized in national foresight programs, but quite less recognized in TA literatures. However, some studies give several attempts of applying this methodology for foresighting social challenges and suggest that it can reveal potential trend break, discontinuities or emergent phenomena [6].

TABLE I
ETHICAL ISSUES DEBATED ABOUT DOMESTIC ROBOTS [19]

Topics for debate	RoboMall	RoboButler	SnakeSquad
Integrity	-Ubiquitous surveillance -"Moving CCTV" -Follow a suspect	-Ubiquitous surveillance -The home as a safe haven is threatened -Actions against housebreakers -Social control	-Surveillance of fire fighters -Hazardous environments; responsibility
Economy	-Loss of jobs -Commercialization	-Loss of jobs -Only for the wealthy?	-Possibility for women
Rights		-The right to have a robot vs. The right not to have one	-Status of fire fighters
Security	-Possibility of hi-jacking	-Possibility of hi-jacking -For owner and for housebreaker	

In most literatures, scenario planning serves its purpose on only the fraction of the whole foresight process. Wardak et al. [17], for example, propose a methodology to identify risks of nanotechnology based on scenario analysis approach. They explore potential environmental risks in product life-cycle stage through publicly available data and allow for expert elicitation to obtain scores on risks' likelihood or occurrence and severity. Taking such information into account, specific properties of environmental risks on society are carefully identified and prioritized. But in some circumstances, scenario approach is conducted as one main methodology for generating and assessing future societal implications of new technologies. Stemerding et al. [18] introduce a techno-ethical scenario approach and demonstrate a systematic way of exploring moral concerns in the field of genetic susceptibility screening. Most recently, [19] identifies ethical threats posed from the emergence of domestic robots via iterative participatory workshop methodologies. Then three different scenarios depicting society's response to these new technologies are introduced in detail as summarized in Table I [19]. However, such traditional foresight literatures involving scenario planning have been collecting opinions through participatory activities, such as experts involved workshops and interviews. There is thus in need of a more systematic and forward-looking way to overcome the disadvantages of previous approaches: labor-intensiveness and biased subjectivity.

C. Futuristic Data

Now, there is no need to gather expert scholars, scientists, or even favorite consultants and then discuss potential problems until the most acceptable solution is found. In the twenty-first century, the emergence of information and communication technology (ICT) and Web 2.0 has enabled new generation of methodological innovation in foresight exercises [20], [21]. A study conducted by [20] explores the specific role that ICT may play in qualitative scenario planning. It is, in fact, found to have substantial impact on the early stages of the scenario process,

including: increased participation in terms of both amount and diversity, increased volume and speed of data collected and analyzed, increased transparency around driver selection and analysis, and decreased overall cost of administration. In other words, the usage of ICT has a significant improvement not only in efficiency by reducing time and cost, but also in effectiveness in terms of increased data volume and diversity.

A concept of future-related database has been suggested by a number of literatures [22]-[24]. Schatzmann [23], for instance, collected existing digital collaborative prediction and foresight applications, and subsumed into four categories: databases/wiki, prediction markets, social rating systems, and collaborative scenarios. They also highlight three factors, such as participants' composition, motivation and expertise, which contribute to the quality of base data in foresight process. Moreover, in order to provide the most valid, relevant, and updated information possible, [24] analyzes existing future-oriented database, so called trend database, and identifies four major challenges of utilizing trend database, such as extensiveness, cooperation, linking, and incentive. Based on these concepts, this paper also would like to analyze such future-oriented documents, named *Futuristic Data*, which are established through online collaborative platforms, and argue for new directions in the practice of foresighting societal impacts of emerging technologies.

III. Research Framework

The proposed research process is summarized in Fig. 1. First of all, a massive amount of Futuristic Data is collected for target technology, specifically the one emerges from science driven innovation processes and is now at the brink of commercialization. Then online Foresighting platforms may be chosen from sources suggested by previous literatures, such as studies from [23] and [24]. These include Z_punkt, TrendONE, Shaping Tomorrow, TechCast, iKnow, TrendWiki, etc. [23], [24]. This research aggregated the data from MIT Technology Review, World Future Society, and Future Timeline. Prior to commencing the text analysis, these documents require a detailed pre-processing activities, such as parsing, stemming, and stop word removal. Most importantly, social keywords must be selected with deliberation since they are the main sources of data interpretation in network analysis. On completion of these preliminary procedure, term-document matrix is constructed in terms of documents and social keywords on x- and y-axis, in respective.

Once the matrix generation is completed, k-means clustering is conducted in order to group documents with those with similar social keyword structures. For each cluster, independent network analysis is then performed using social keywords as nodes and co-occurrence values as links. The primary purpose of this analysis is to observe how these social keywords comprising within each cluster are related with one another and interpret them to build possible story lines. Finally a total number of k comprehensive scenarios will be developed that depict a wide range of social consequences arising from emerging technology.

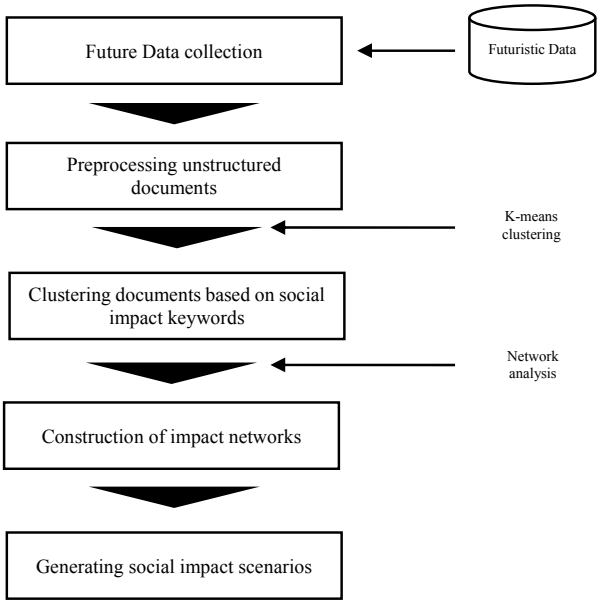

Fig. 1 Overall research framework

IV. Conclusion

Emerging technologies have contributed to shaping the society – it influences our norms and ethical standards and ultimately leads to affecting regulations and legislations [19]. However, literatures tend to fail to realize the significance of the intangible nature of emerging technology and rely overly on the participatory activities in foresight process. Therefore, this study set out to determine the adverse social impacts of emerging technologies by analyzing and interpreting untapped future-oriented knowledge sources flooding through the Internet, so called *Futuristic Data*. To this end, we generate possible hazardous scenarios of new technologies by performing network analysis with a help of data mining technique.

Taken together, this research make several contributions in that it may greatly improve both efficiency and effectiveness of foresight process. Moreover, the result may suggest some implications in diverse perspectives. First, in consumers' perspective, identifying unforeseen social effects may alleviate public skepticism and distrust of emerging technologies. Second, such information can be utilized to support policy making, whether to promote, regulate, or restrict the technologies. Lastly, the result may serve as a valuable information in company's product design process by being technically prepared in advance.

Despite these unique advantages, this study still has a major drawback: uncompleted empirical research. Case study must be carried out in order to find out the feasibility of proposed methodology. Also one inherent limitation is that such an approach may be utilized only as a supplementary method in decision making process.

Acknowledgment

This work was supported by the National Research

Foundation of Korea (NRF) grant funded by the Korea government (MOE). (No. 2014R1A1A2054064)

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