

Emerging Technologies To Enhance Optimization In The Process Industries

Oluwatobi Yusuf

Illinois Institute of Technology

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ABSTRACT

Emerging technologies are regarded as one of the most successful technological innovations and are also often viewed as breakthrough innovation that possess the potential to create a new industry or transform an existing industry. This paper put into focus emerging technologies to enhance optimization in the process industries. The paper highlighted emerging technologies and process optimization concepts where both were defined. Types of process optimization of topological optimization defined as the physical nature of a particular design and parametric optimization defined as the operation of variables of a specific process or piece of equipment were also explained. In this review, emerging technologies and optimization was highlighted. Relationship with emerging technology as a multi-agent optimization system, mitigating uncertainty in processing industries were also highlighted where experimentation, ethical concerns and continuous Improvement were discussed on briefly under mitigating uncertainty in processing industries..Conclusively emerging technologies is a valuable tool for processing industries. It can also be regarded as one of the most successful technological innovation.

INTRODUCTION

Emerging technologies according to Day and Shoemaker (2009) have been identified among one of the most successful technological innovations, based on the fact that they possess the potential to create a new industry or transform an existing industry. It is however believed that Emerging technologies are small improvements of existing technologies. It is however widely accepted that even the most “revolutionary” ET’s such as internet technologies are actually created and developed from many small inventions and improvements. With the recognition of emerging technologies, it is also believed that internal processes that evolves the emergence of emerging technologies are not known and remain unclear. Economic growth development has been linked to ETs (Groen and Walsh, 2013; McDermott and O’Connor, 2002) as it is believed that ETs provide productivity gains to businesses.

Optimization techniques has been used by some researchers to study technological innovations. Deb and Srinivasan(2006) once proposeda technology design methodology known as “innovization” in order to extend optimization algorithms usage so as to design principles relating to decision variables and objectives so as tenable a deeper understanding of the problem to be obtained. Apart from the trial of Deb and Srinivsan (2006), Engler (2009)also made use of a genetic algorithm to simulate innovation processes among competing firms. The fact however remains that these trial or attempts by Engler is in early stages, this strategy has however shown the potential of optimization theory in describing and interpreting innovation and emerging technologies (Engler, 2009).In addition to the above-mentioned points, some researchers (Mourtziset *al.*, 2015; Alhmariet *al.*, 2016) also posited that emerging technologies can also be used to experiment with production systems and processes and production resources. However, even with this, it advisable that such efforts should be used at the level of abstracting and in the case of lack of definite digital parameters for a technological process. The benefits technology emergence enhancement in processing industry major is to increase efficiency and production (Bagaleet *al.*, 2023). In addition, processing industries can also reduce delays, lower mistakes, and speed up process completion by automating routine and manually performed tasks (Choi *et al.*, 2021).The complexity of the ETs in processing industries and the evolving landscape of

innovation requires a nuanced exploration of how its value can be used. In addition, the use of ETs to enhance optimization in processing industries presents profound challenges due to the uncertain value and complex landscape of innovation. Thus, this study seeks to explore the emerging technologies to enhance optimization in the process industries.

Emerging technologies and process Optimization concepts

Emerging technology is considered by several scholars to be based on the potential significance and its impact on the economy (Archibugi, 2017; Rotolo *et al.*, 2015). Millea *et al.* (2005) however highlight the market dimension of ETs by stating that "a technology is still emerging when it is not yet a must have". With the various definition attached to ETs, one significant agreement among scholars in its definition is the fact that ETs are characterized by their novelty, growth, coherence and conceptual autonomy, salient impact, and uncertainty based on the fact that ETs possess the potential to create new markets and also transform existing ones (Adner and Levinthal, 2002; Day and Schoemaker, 2000). Bailey *et al.* (2022) perception of emerging technologies is based on the fact that ETs is not just "emerging" because it is new, but also because its impacts and uses are still evolving and have not yet been grounded into well-defined patterns. Rosenberg (2009); Rotolo *et al.* (2015) however opined that by definition, ETs are uncertain, immature, and unproven, but promise significant value.

The use of specific methods in order to determine the most cost-effective and efficient solution to any particular problem or design for a process is known as optimization. Optimization technique is an essential quantitative tools used in the industry to take decision. The use of optimization in design, construction and analysis of chemical plants coupled with other industrial process can be resolved through the use of the optimization with the objective to find the values of the variables in the process that yield the best value of the performance criterion.

Types of Process Optimization

Topological Optimization

According to Fleur (2016) topological optimization is defined as a process equipment arrangement. This literally means that optimization is the physical nature of a particular design. Fleur (2016) posited that in a process industries, topological optimization needs to occur before the existence of parametric optimization whether when it comes on the improvement of a new process unit design or upgrading an existing unit. In topological optimization, significant impact

is felt on the overall profitability and not just that, significant impact is also felt in operating conditions as it helps to reduce some possible operating conditions and coupled with the fact that it also eases the process of parametric optimization, but implements realistic and significant constraints on the process. However, for an effective topology optimization constraints against parametric optimization, there is need for topological optimization to depend and focus on the design stage process. In the optimization of a conceptual flow sheet, topology find it easy to remain unchanged compared to an existing plant where topology changes have substantial associated costs (Fleur, 2016).

Parametric Optimization

Parametric optimization is a form of optimization that has to do with the operation of variables of a specific process or piece of equipment. Without parametric optimization, it is difficult for an effective and efficient topology to be fixed. Parametric optimization first requires determining the overall objective function's decision variables that are subject to operating condition design change or further optimization could be proceeded to develop a clear and distinctive objective function based on operating conditions for those decision variables. As the efficiency of the optimization process is contingent on allocating time for the key variables, the approach to parametric optimization must be well thought out and justified (Fleur, 2016). In the usage of parametric optimization, the topology of the plant remains unchanged, unless if the result used in the optimization of the process condition gives room for the elimination of process equipment (Mannino, 2015). Changes do occur in parametric optimization which most times requires a form, of corresponding changes in utilities (Turton, 2009).

Emerging technologies and optimization Relationship

It is believed among several scholars that the use of technology in optimizations just to compliment some parameters of existing technologies. The relationship between emerging technologies and optimization ranges from having the same goals and objectives which is to obtain the best technologies and products for the satisfaction of consumer's needs. Thus, the two are meant to actually satisfy demands. In optimization, an ET is a better or optimal solution to a higher-level optimization problem. According to Altshuler (2009), it is posited that optimization and emerging technologies have the same basic properties to resolve technical conflicts. Thus,

the two tends to solve and derive a solution to an existing or infeasible technical problem. With this, ET's can be treated as optimization procedures. Another relationship between the two is also based on the fact that optimization is essential in the ideation and elementary stages of ET development coupled with the fact that new concepts and new models for ET's are actually based and formed through the adoption, application and combination of integrated expanded knowledge and resources obtained from optimization processes. Thus, it is logical to state that in the first stages of ET development, elements such as learning, searching, selecting and recombining activities can be viewed and termed as optimization activities. Emerging technologies development is not limited to several optimization activities but also stretches to a series of optimization processes with the ultimate goal to improve people's welfare. This opens up the possibility to describe the development of ET's from optimization perspective.

Emerging technology as multi-agent optimization system

Emerging technologies as optimization processes entails more than one inventor or developer. The existence of emerging technologies involves great effort of an entire society. The emergence and development of emerging technologies is a complex, dynamic system which is composed of many heterogeneous agents with each of these agents finding ways and actions to optimize individual or system objectives under each resource constraints faced. The aforementioned action can be grouped into three types which includes: individual search, cooperation and competition. The mentioned three groups created an action to select new technologies among which the best ET's emerge. The complex technological innovation network faced by innovation agents and the optimization problems is shown in figure 1. Expatiating on the below diagram, emerging technologies are jointly invented and thus, selected by innovation agents and at any time these networking agents are driven by individual or common optimization objectives and are subject to their resource constraints including economic, knowledge, institutional and cultural limitations, optimization problem is then resolved through these optimization interactive methods by individuals which formed the agents and thus, knowledge is then expanded and as new knowledge and resources are channeled in to resolve this issue, the previous optimization obstacles then becomes constantly transformed and remodeled, and better new solutions (technologies and products) are developed for use which then becomes dominant over every other methods to solve the optimization process.

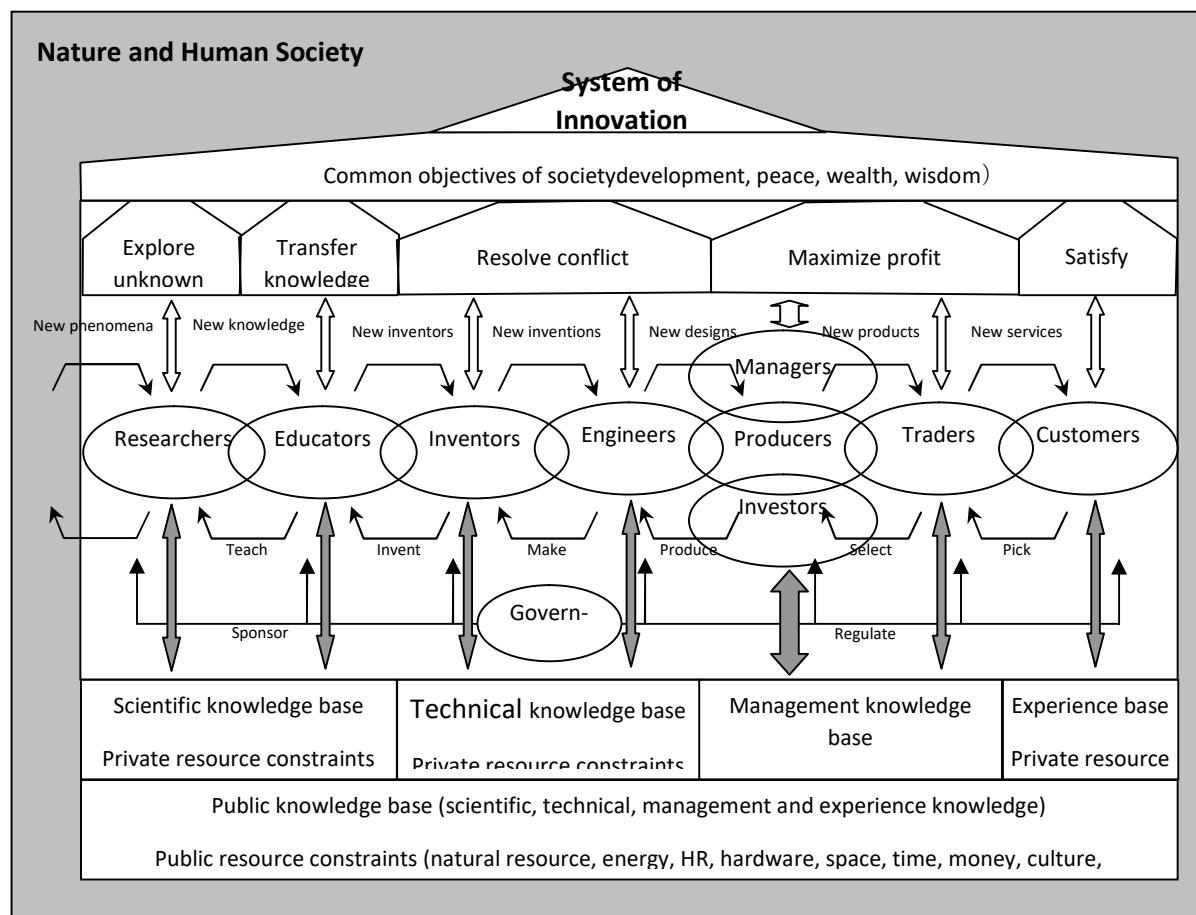


Fig. 1 Technological Innovation as a Multi-agent Optimization System

Source: Anonymous

Trends in Emerging Technologies in Process Industry

Impacts of emerging technologies is being experienced in process industry. In the study of Ding *et al.* (2019), several trends in emerging technologies was discovered for process industry. The use of process optimization which is powered by advanced techniques (AI) is being adopted at a high rate in order to improve efficiency and profitability. Furthermore, digital twinning has also emerged as a valuable emerging technologies tools for real-time optimization and prediction which has created room for prediction and thus, allow processing industries to make informed decisions. Zhang *et al.* (2021) findings has also revealed that the concept of circular economy is also gaining popularity in the industry as most process industries and companies now strive to minimize waste and use resources more efficiently. Also the use of biocatalyst such as the use of enzymes and microorganism has been recognized to be sustainable and more efficient compared

to traditional chemical catalysts (Wijker and Wittmann, 2020) this is also supported by developments in synthetic biology which has allowed for the enablement of engineering biological systems to put in place specific chemical transformations in the process industry that will reduce waste products through conversion to valuable chemicals.

Mitigating Uncertainty in Processing Industries

Experimentation

To determine the application of emerging technologies, experimentation is required (Chesbrough, 2020; Galende, 2006). The use of experimentation before introduction in the processing industry is often regarded as the initial step in identifying areas where the new technology can be applied. Lyly-Yrjänäinen *et al.* (2019) findings also reveals that uncertainties customer references coupled with uncertainty about value to customer are significantly mitigated by using mock-ups early in the development process. Anderson and Wynstra (2010) in their findings also posited that making use of experimentation before introduction of emerging technologies is needed as this will serve as an effective tools to reduce uncertainty about the value of high-value purchases in business markets. Through experimentation, processing industries can introduce these technologies to customers, potentially revealing latent and unmet customer needs—those needs that consumers may have but are not yet aware of or have not expressed. Furthermore, these ETs have the potential to not just reveal these latent needs, but also fulfill them (Rocafort, 2017). Once the loopholes have been identified, technologies to be used can then be developed to meet up with newly discovered need in order to open up new market opportunities (Zhou *et al.*, 2005). Predicting the use of ETs is challenging (Gillier and Piat, 2011), based on the fact that there are unexpected application of some of these innovations. Thus, the discovery of emerging technologies as a new application should not be over looked as it can also help to reveal previously unknown applications (Galende, 2006).

Ethical concerns

There is need to put into consideration the ethical concerns of emerging technologies into focus. Given the high stakes (potential financial loss, reputational damage, or operational disruptions) and unpredictable nature of these technologies, conducting experiments without the full awareness and consent of customers can lead to significant risks. With this, it should be known that transparency about before or during the use of ETs and their associated risks is an ethical obligation and a practical necessity in order to establish and sustain trust in long-term business

relationships. With this, ETs can occasionally addvalue co-destruction,' particularly when the results fall short of customer expectations (Lintula *et al.*, 2018). Having a proper and well detailed ethics discussion on emerging technologies be use in process industries, for ethical experimentation, will aid to add value to this discourse (Brey, 2012).

Continuous Improvement

Continuous improvement is crucial for the ongoing co-creation. Processing industries by involving their customers in their iterations, can dynamically with this adapt to changing needs and preferences. Findings of Lindgren and Münch (2016) made it known that continuous experimentation and improvement of emerging technologies that has been put in pace has not gotten to maturity stage in practice. It however plays a major role in driving ongoing improvement of ETs and fostering innovation. It is advisable for technology providers to continually experiment in order to discover new use applications for their technology beyond the initial development scope. The findings of Yaman *et al.* (2017) deduced that compared to other industries, software development companies in particular knows how to respond positively to continuous experimentation. Thus, it has helped them to systematically collect data on customer value, better understand their products' value and address user needs.

Conclusion

Based on the reviewed study on emerging technologies to enhance optimization in process industries, it can be concluded that emerging technologies is a valuable tool for processing industries. It can also be regarded as one of the most successful technological innovation. The study highlighted the relationship between emerging technologies and process optimization in the processing industries. However, emerging technologies in this study is ambiguous in nature.

Recommendation

Further research is needed on emerging technologies and optimization process by creating an abstract knowledge and concepts and the process of learning with a lot of detailing which needs to be done in depth.

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