# Morphological Approach in Creative Requirements Elicitation from Crowdsourcing

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***Abstract*—Creativity is a subject that gained increasing interest in requirements engineering field. Creative-based requirements elicitation helps in generating requirements in original and innovative ways. Lately, crowdsourcing has been emerged in requirements elicitation after realizing the benefits of crowd. Crowdsourcing allows a wide diversity of stakeholders able to express their perceptions about product. However, to analyze the large amount of ideas from crowd would be a great challenge. This work focuses on how ideas gathered from the crowd and then analyzed using morphological approach in deriving requirements for the software product. Furthermore, the involvement of crowd in the approach helps in eliciting creative ideas for producing an innovative software product.**

***Index Terms*—Creativity; Crowdsourcing; Morphological Approach; Requirements Elicitation.**

## I. Introduction

Generally, the success of a software product relies on upon how well it fits the users' requirements and its environment [1]. Traditionally, software requirements were come from stakeholders and the requirements engineer needs to elicit them. However, recent understanding describes the requirements engineering process as inherently creative. In which, several authors have stressed the significant of requirements engineering as a creative problem solving process [2]. It is mentioned that the software requirements should not just simply elicited from stakeholders, it should be imagined and invented by stakeholders as well. This is important where innovative products represent a competitive advantage for companies. Additionally, idea finding at requirements elicitation activity is highly potential for importing established creativity techniques [3].

Some well-known requirement elicitation techniques like brainstorming, workshops, interview, and scenarios. While new techniques continue to emerge to fulfill the 'unusual' demands, for example, viewpoints combination, analogical reasoning, and open community. The choices of techniques used are depend on how details the information or requirements need to be gathered, its type, and how much information and requirements needed from stakeholders. Those types of requirements can be categorized in terms of 'breadth' coverage and 'depth' coverage. However, some techniques are able to cover the breadth and depth very successfully, but it becomes too costly or time-consuming when employed among larger numbers of stakeholders. However, technology now enables us to elicit requirements from very large and heterogeneous groups of stakeholders, so-called "crowds". There are a number of studies which attempted to utilize the power of the crowd and end-users to solve requirements engineering problems [4]. The issue is how to analyze and derive requirements from the large amount of data.

Thus, this work aims to enhance requirement elicitation in the software development. Our work focused on how data gathered and analyze from the crowd using morphological matrix. Then, it can be used by requirements engineer team or selected stakeholders to facilitate them generating creative requirements towards producing innovative software product.

The organization of the paper is as follows; in the next section, we examine related work. In section III, our proposed approach is described and continues with a discussion in section IV. Finally, a conclusion is drawn in section V.

## II. Related Works

This section presents and briefly discusses efforts in related fields.

### A. Creative Requirements

Sternberg and Lubart defined creativity as "the ability to produce work that is both novel (i.e. original, unexpected) and appropriate (i.e. useful, adaptive to task constraints)" [5]. While, Kneller said that "an idea is creative when it brings a new insight to a given situation. The process of creativity includes the ability to change one's approach to a problem, to produce ideas that are both relevant and unusual, to see beyond the immediate situation, and to redefine the problem or some aspect of it" [6].

Several researchers have highlighted requirements engineering field is seen as a problem solving process. Requirement engineering practitioners have acknowledged and agreed on the importance and the role of creative techniques in solving requirements problems [4]. There are creativity support techniques and tools emerged in requirements engineering for idea finding leading to the specification of more creative requirements [7]. The integration of creativity techniques within requirements engineering activities will advance the requirements engineering domain. And recently, number of tools to support creative thinking for requirements engineering processes has increased as requirements practitioners become increasingly interested in creative-based techniques [4].

Nguyen and Shanks developed a framework for understanding the role and potential of creativity in requirements engineering focused on the product and process perspectives [7]. Three characteristics were essential for a product perspective: novelty (i.e. new, original), value (i.e. helpful, useful) and 'surprisingness' (i.e. unusual, unexpected). For process perspective, they adopt the analysis

by Boden [8] and Shneiderman [9]. In which, they described creative process as an internal process of exploration and transformation of conceptual spaces in the individual mind. Furthermore, existing requirements quality frameworks can be expanded by incorporating novelty and 'surprisingness' enable the discovery of creative requirements and future technology-enabled solutions to business.

In other disciplines, research about creativity has been the main focus for a longer period of time compared to the research in software and requirements engineering. It has been explored from other dimensions such as design, arts, psychology, literature, among other areas. Recently, several authors in the field of requirements engineering had accentuated the consequentiality of treating requirements elicitation as a creative problem solving process [2]. They pointed out that an effective creative requirements process should have characteristics of creative process as mentioned by Boden which are exploratory, combinational and transformational through the introduction of pre-defined rules to search a requirements space in different ways or change the space to discover novel and useful requirements [8].

Creativity does help in capturing requirements in original and innovative ways. Well-known techniques are creativity workshops and brainstorming sessions, as well as some techniques have been specifically designed for requirements elicitation. As reported recently by Franco and Assar [10] that Creativity-Based Approaches for Requirements Elicitation (CARE) have appeared as one promising trend and important subject among practitioners and researchers to tackle the requirements elicitation problem. It encourages collaboration between stakeholders and requirements engineers in order to create innovative ideas for new software product.

### *B. Elicit Requirements from Crowd*

The term 'Crowdsourcing' was defined explicitly: "Crowdsourcing represents the act of a company or institution taking a function once performed by employees and outsourcing it to an undefined (and generally large) network of people in the form of an open call." . In addition, Howe reported that the crowdsourced work can be either by working individual or cooperation [11].

Crowdsourcing has been emerged as distributed problem-solving model based on the combination of human and machine computation [4]. In which, it has been applied to a wide range of creative and design-based activities [12][13].

Work by Lim and Finkelstein proposed a StakeRare to facilitate requirements elicitation in large scale software projects. It involves a social network consisting of the crowd members for contributing ideas to a product [14]. The StakeRare's method includes:

i. constructing a social network of stakeholders,
ii. recommending requirements to stakeholders via collaborative filtering, and
iii. prioritizing requirements based on stakeholders' project influences.

While, Hosseini's work summarized the main features of the crowd and crowdsourcer in crowdsourced requirements elicitation [15]. Their work shows preliminary result that shows the relationship between these features and the quality of the elicited requirements. On the other hand, Wang also used crowdsourcing to elicit requirements [16]. They focused on solving the problem of recruiting stakeholders with specific domain knowledge proposing a participant recruitment framework, based on spatiotemporal availability.

A survey conducted by Mao, mentioned that crowdsourced software engineering has rapidly gained increasing interest, where the crowd could be the potential users in which the software is designed to meet their requirements [4]. Recently, in Murukannaiah work, they investigate the link between human personality and creative potential in requirement acquisition task [3]. In which, these factors are of specific importance to Crowd RE as the crowd are usually not trained in requirements engineering, and a main motivation to involve them is to get advantage from their creativity.

*Crowd* is described as a heterogeneous group of stakeholders, large enough in size for group effects to occur when they interact [17]. Generally, these people have a common interest in a particular *product* and they like to discuss about that product. The discussion or interaction can be in any medium, they generate (natural language) *text data*, including online forums, reports, transcripts (of chat discussions or phone calls), emails, manually documented protocols, and documents. With the current technology, we can capture the data automatically for example, by using the product *log data*, including mouse clicks, and sensor data. These two types of data can be analyzed through *text mining* and *usage mining* respectively [18]. Thus, the outcomes from these mining activities from the crowd allow deriving creative requirements.

### *C. Morphological Analysis*

Morphological analysis was introduced by Zwicky in his work [19]. The advantage of morphology analysis is on its ability to model complex problems in a non-quantitative manner [20]. Major morphology analysis research fields mainly on its application. In which it has been applied to many areas such as new idea development [21][22], technological opportunity discovery [23], and business model development [24][25]. The basic procedure of morphology analysis is as follows [26]:

- Identify the fundamental dimensions (also termed as 'functions' or 'parameters') of the subject where the features of the subject are broken down into a number of attributes.
- List all possible attributes (also termed as 'shapes') in which each attribute can manifest itself. To form a morphological matrix, labels attributes from left to right and the dimensions from top to bottom.
- Examine all combinations that can produce different sets of attributes.
- Try to find practical instances for each combination.
- Eliminate the infeasible combinations and list the remaining combinations in order of importance.

Morphology analysis plays an essential role in deriving promising opportunities for new development of product or technology by matching product and technology morphology [28]. Experts are basically involved in construction of morphology. However, realizing its benefits, more efforts attempt to support the morphological analysis towards more systematic and automatic way.

Since performance of new software products and services is predominantly reliant on their creativity, this makes the creative idea generation process a focal issue for the innovation process. But, the creative idea generation process is sometimes called 'fuzzy front end' due to its unknowable and uncontrollable factors [27]. Therefore, a systematic approach is necessary, and the adoption of creativity techniques in the approach can increase the ideas generation

process. By adopting these techniques, the causes of problems can be considered thoroughly, and new solutions will be identified in a systematic manner. Among many techniques have been employed, morphology analysis has been believed as a promising method in the process of creative ideation [20][21][28][29]. Morphology analysis is a structured invention method by discovering all possible alternatives for solving problems [29].

Earlier, Yoon *et al*. [28]'s work deals with building shapes in the morphological matrix, in which the shape is developed based on the text mining of patent database. In their study, keywords are extracted from product documents and then text mining is applied to produce the occurrence frequency of each word and the co-occurrence frequency. They used text-mining to select the most appropriate values based on the keyword frequency. More advanced work on morphological matrix conducted by Yoon is where they applied it on LED heat-dissipation technology and LED lamps, in which, experts then review and select appropriate shapes from the results of text mining [23].

The previous related work that integrates text mining and morphological analysis worth the effort, the extracted information from the text mining only provides indirect indications for the expert judgment. Consequently, building of morphological matrix is still requiring experts to decide appropriate solution. Yet, it does helpful to support experts in exploring ideas for decision making.

## III. PROPOSED WORK

Our work focuses on developing an approach for discovering creative idea from crowds in requirement elicitation stage. The suggested approach can be utilized by the stakeholders and requirements engineer as an alternative way to elicit creative requirements from the crowds in producing innovative software product. The overall process of the proposed approach is composed of few main steps as illustrates in Figure 1. The following sub-sections detailing out each step in the proposed approach.

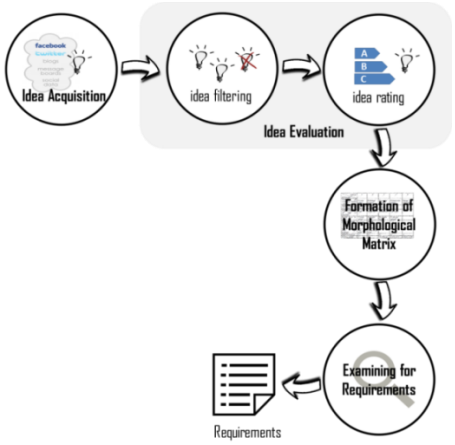


Figure 1: An overview of the proposed approach

### A. *Ideas Acquisition from Crowdsourcing*

The crowdsourcing is open to everyone for those who has interest to the product, not based on specific users, demographic, or personality. Crowd can use any available medium, for example, online feedback, social media, and forum. No specific format or template is used by the crowd to express their idea. Using specific format or template sometimes will restrict or limits their ideas. Then, in certain duration of time, all the text-based ideas are obtained and gathered.

### B. *Idea Evaluation*

Human decision is required for this step. In which, selected or specific stakeholders are responsible to review the ideas. Specific stakeholders can be representatives from development team, management team, marketing, and customer relationship management (CRM) team. Those people are important in decision making in terms of the feasibility of the product, customer satisfaction, and competitive advantage. Idea evaluation consists of two sub-activities:-

i. Idea filtering – need to exclude ideas unrelated to software-to-be
ii. Idea rating – rate the selected idea. Rating can be based on novelty and usefulness, based on widely accepted definition of creativity [30]. Additionally, innovative is also essential for the software product Thus, they can rate each idea for its novelty, usefulness, and innovative.

### C. *Formation of Morphological Matrix*

Text mining and morphology analysis is the techniques used in this proposed approach. Text mining is utilized to extract keywords as an input to build morphological matrix. The morphology analysis extracts the specific morphology of the software-to-be. A morphological matrix involves; identifying major dimensions of a task, identifying possible attributes each dimensions might have, and then exploring random combinations of attributes (selecting one attribute from each parameter for each combination).

In the proposed approach, the dimensions or high level feature (HL) of morphology are developed using feature extraction and topic modeling from text mining tasks. Values or fine-grained features (FG) are then identified. The morphological matrix is constructed based on the HL and FG. Figure 2 shows an example of the morphological matrix formed with dimensions or HL (i.e., labeled with 'Topic') and values or FG (i.e., labeled with 'Value'). The combination of the contents in the matrix denotes certain concepts of new product or service.

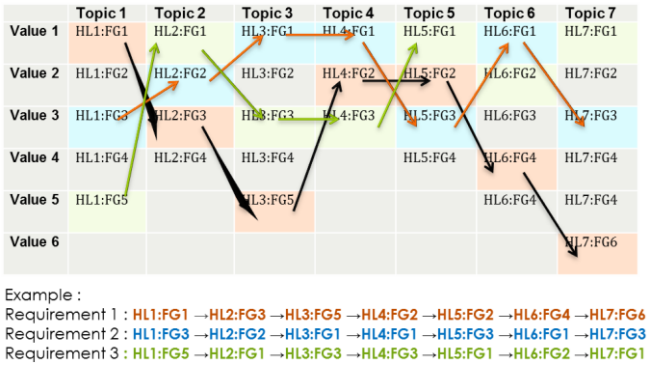


Figure.2: An example of the morphological matrix

The combinations (i.e., potential software requirements) are considered to be possible solutions for innovation. However, this combination still seems to be ambiguous and thus requires to be clarified by the experts or stakeholders.

*D. Examining for requirements*

Selected or specific stakeholders involve in examining the ideas obtained from the matrix towards in assembling creative and innovative requirements for the software-to-be. The sub-activities are:-

i. Explore creative idea – creative idea is explored based on the relation analysis between combinations in morphological matrix.
ii. Find segments of opportunity – select the most appropriate combinations as a chance for new innovative requirements.
iii. Evaluate the creative and innovative requirements

A list of innovative and creative requirements will be an output for this process.

## IV. DISCUSSION

This section discusses the feasibility as well as challenges in adopting the proposed approach.

We expect the proposed approach of creative requirements elicitation from crowdsourcing able to produce requirements that are novel, useful, and innovative. The closest work to us is Crowd RE [3]. In which, they proposed a sequential process, where crowd workers in one stage will review requirements from the previous stage and produce additional requirements. However, in Crowd RE, the selection of idea is based on stakeholders' personality. Moreover, specific format (i.e., user story) is used for expressing their ideas. In terms of idea acquisition, we believe that interesting and creative ideas can come from anybody that has interest to that product regardless their personality. In our work, we not restricted to certain group of people, especially if the product is for public market. Though, it might need to be considered if developing software for a specific customer. Besides, by using specific template or format will just limits them in idea generation. Therefore, in our approach, ideas are collected from various medium without using any specific template so as to encourage creativity. However, at the moment, we only focus on text-based idea.

Idea and requirements are something that is subjective that need to be well-defined for its clarity and evaluate in term of feasibility. Hence, human decision is still required in our proposed approach especially in idea evaluation and assessment. Shneiderman [31] also emphasized the role of the human and social environment and professional domain in the creative collaborative process including creating, exploring, composing, and evaluating solutions. It is useful to come out with certain criteria as a guideline or reference to preselect those ideas that seem most appropriate to the needs

One of the big challenges in crowdsourcing is where we have to deal with large amount of data (i.e., in form of feedback, suggestions or comments). Furthermore, the data gathered from crowdsourcing come from various multidisciplinary. Hence, it is often difficult to get started to explore ideas from the data. This is where the morphological matrix plays it role. It is ideal to explore large number of options or possibilities from an idea. For forming morphological matrix, idea collected should be grouped or categorized into a manageable size and at similar level of detail. Therefore, few matrixes will be produced or a complex matrix can be divided into sub-matrixes to allow detail study of the section [26].

The combination of values in the matrix turns out to be the requirements that can be considered for the software-to-be. Yet again, human decision is required for examining the combinations for a list of requirements.

Further, the proposed approach also highlight on eliciting potential innovative requirements for product from crowd during idea acquisition. As recently, invention is claimed to be an essential part of the requirements engineering activity. Thus, the proposed approach applied to requirements engineering process in order to find creative requirements and facilitating innovation in the software product.

## V. CONCLUSION

Crowdsourcing in requirements elicitation has benefits in covering total pool of stakeholders to a much higher degree. While, creative-based requirements elicitation approach contributes to a better software product. A combination of these will leads to the need of morphological approach for analyzing the large amount of ideas in deriving creative and innovative requirements. Thus, the proposed approach will help developers, especially requirements engineer in finding ways to take stakeholders out of conventional settings as in traditional requirements engineering. Additional benefits include: the diversity of generated ideas from different stakeholders which typically differ from those generated with standard requirements elicitation techniques; different ways of thinking about requirements; the amount of requirements generated in a short time; improvement of communication between stakeholders, as well as encouraging and facilitates the creativity processes.

Currently, we are working on automating some steps of our proposed approach. Specifically, we are developing tools for idea acquisition from crowd using text mining techniques and the formation of morphological matrix.

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