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Exploring Creative Software Requirements from Crowd using Morphological Matrix

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Abstract: ***The increasing trend of technology has changed the users' expectation towards software product. In which, the successful of software product is mainly reliant on their creative and innovative features. Thus, creative ideation becomes a focal issue in software development, particularly in requirements engineering process for generating creative and innovative software requirements. Subsequently, software developers realize the benefits of crowd where it involves a wide diversity of stakeholders to express their perceptions or ideas about the software product. The various ideas from the crowd are useful as a source of software requirements, specifically for creative requirements. However, to filter and analyze the large amount and heterogeneous ideas from the crowd is a great challenge. Considering the benefits of morphological approach, thus, in this paper we demonstrate the application of morphological matrix to discover creative requirements from the crowd in a case study.***

Keywords: requirements elicitation, requirements engineering, morphological matrix

I. INTRODUCTION

Besides of its benefits, the increasing trends of technologies inevitably put pressure to software product to compete in the market. The objectives for the software product are not only has to be usable and bring values to the users. It should also provide creative features that beyond the users' expectations. Thus, this is a challenge in software development for identifying requirements for software product. It is crucial as the success or failure of the software product is depending on its requirements. Thus, various techniques are used for eliciting requirements and known techniques are like brainstorming, workshops, survey, and interview. While, other recent techniques have also emerged, for example, viewpoints approach, analogical reasoning, and walkthroughs among others that is based on the co-presence of the stakeholders. Some of these techniques are too costly and time-consuming when employed to a larger number of stakeholders.

The current trend of requirements elicitation is by utilizing crowd as a source of requirements (e.g., Hassan *et al*, 2017b, Murukannaiah *et al*., 2016, Lim *et al*., 2010). Crowd is described as a heterogeneous group of stakeholders, large enough in size for group effects to occur when they interact (Groen *et al*, 2015). Basically, it is a group of people that have common interest in a certain product, discuss about that product, and the discussion is likely to influence opinions and decision-making. Crowd is a beneficial source for software development that has been utilized at the requirements engineering as well as design phase. Yet, in requirements engineering, the challenge is to analyze and discover requirements from the crowd that is known as large and heterogeneous.

Another concern in requirements engineering is that requirements should be imagined and invented by stakeholders, rather than being simply "gathered" from them (Maiden, *et al*.,2010). The needs of creative requirements for improving software product have also been mentioned in the previous research (e.g., Hassan *et. al*, 2017b, Maiden & Horkoff, 2015, Karlsen *et al*., 2009). Sternberg and Lubart (1995) 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)*". Creative requirements also mentioned as important to represent innovative features to support competitive advantage for software industries (Hassan *et al*., 2017b). Creative requirements can be identified by integrating creativity technique at requirements engineering stage during idea generation or requirements brainstorming. Moreover, creativity techniques encourage the collaboration of stakeholders and requirements engineers in order to create creative ideas for the software product.

A morphology approach to elicit requirements from crowd has been presented in our previous work (i.e., Hassan *et al*., 2017a). Further, this paper presents the formation and usage of morphological matrix to explore creative software requirements from crowd. The following sections discuss on related work, continue with the proposed work, discussions and finally the conclusions.

II. RELATED WORK

This section discusses related issues and efforts to support the ideation process towards creative requirements for software product.

Most researchers typically have seen the field of requirements engineering (RE) as a problem solving process. RE practitioners have acknowledged about the importance and the role of creative techniques applied with engineering principles for solving requirements problems (Maiden *et al*, 2010).

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Franco and Assar (2016) reported Creativity-Based Approach for Requirements Elicitation (CARE) have appeared as one promising trend and important subject among practitioners and researchers to tackle the requirements elicitation problem.

Moreover, few researchers have developed software tools to support creative thinking during requirements engineering processes (e.g., Karlsen *et al*., 2009). However, these tools should be integrated within requirements engineering process towards producing creative requirements specification (Nguyen & Shanks, 2009). Thus, Nguyen and Shanks (2009) have developed a framework for understanding the role and potential of creativity in requirements engineering focusing on the product and process perspectives. Three characteristics are essential for a product perspective, which are novelty (i.e. new, original), value (i.e. helpful, useful), and "surprisingness" (i.e. unusual, unexpected). While, for process perspective, Nguyen and Shanks (2009) adopted the analysis from Boden (1991) and Shneiderman (2000). Where, the creative process is as an internal process of exploration and transformation of conceptual spaces in the individual mind. The adoption of creativity techniques in RE helps to examine and incorporate the novelty and "surprisingness" in requirements, as well as discover future technology-enabled solutions to software product.

It is mentioned that morphology analysis is one of the promising method in the creative ideation process (Pidd, 1996; Kim *et al*., 2008). Moehrle (2010) define morphology analysis as a structured invention method by finding all possible alternatives for solving problems and Pidd (1996) described its ability to model complex problems in a non-quantitative manner. The basic idea of morphology analysis is that the subject is broken down into several dimensions, through which the subject can be described as comprehensively and detailed as possible (Kim *et al*., 2008). Morphology has been applied to many areas such as scenario analysis (Kosow and Gaßner, 2008), new idea development (Kim *et al*., 2008; Geum & Park, 2016; Geum *et al*., 2016), technological opportunity discovery (Yoon *et al*., 2014), and business model generation (Im and Cho, 2013; Seidenstricker and Linder, 2014). Yoon and Park (2005)'s work deals with how to build shapes in the morphological matrix. The shape of morphological matrix is developed based on the text mining of patent database. Where, the morphology analysis extracts the specific morphology of the software-to-be. While, Yoon *et al*. (2014) has used text mining techniques to develop shapes of the morphological matrix. Work by Yoon *et. al* (2014) and Guzman and Malej (2014) has shown the potential of the approaches in improving the requirements elicitation process in term of producing creative requirements. The potential of morphology approach in requirements elicitation process have been mentioned in the previous work by Hassan, S., *et.al*, (2017a).

Creative requirements may arise from stakeholders. The larger number of stakeholders involved, the higher number of creative ideas can be derived. Thus, large and heterogeneous stakeholders, like crowd, may bring a lot of creative ideas for software product. Crowdsourced Software Engineering has also rapidly gained increasing interest in both industrial and academic community's touches numerous dissimilar aspects of software engineering. Crowd could be the potential users of the software-to-be where it is designed to meet their requirements. There are a number of studies (e.g., Hosseini *et al*., 2013; Wang *et al*., 2014; Murukannaiah *et al*., 2016; Hassan, S *et al*., 2017) which tries to utilize the power of crowd to improve requirements engineering process. Therefore, crowd can be used as a source of requirements in which about one third of the product's reviews from crowd contain information related to requirements (Pagano & Maalej, 2013; Carreño & Winbladh, 2013). Consequently, product reviews from crowd can be used as a source for the dataset to gather the ideas for the certain software product. Where, the data can be elicited from text (e.g., reviews, reports, transcripts (of chat discussions or phone calls), emails, or any documents) or from product's log data which are collected automatically (e.g., mouse clicks, duration counts, system log outputs, and sensor data).

III. CREATIVE REQUIREMENTS FROM MORPHOLOGICAL MATRIX

This section describes in details the steps carried out to explore creative requirements based on the morphological matrix. The input is derived from the reviews and feedback gets from the crowd. To illustrate the process, users' reviews of Dropbox application obtained from http:///www.g2crowd.com were used as sample data. The reviews were scrapped, collected, and extracted using online web scrapping tool (available at https://www.import.io/) and about 8,926 rows (record) were extracted.

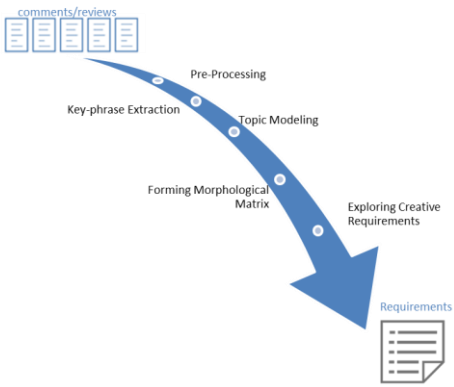

Figure 1: Morphological Matrix for creative requirements

This work utilized text mining techniques to extract keywords from the records and to select the most appropriate values based on the keyword frequency for forming the morphological matrix. Work by Sarkar (2016) is referred for the implementation. For forming the morphological matrix it involves; identifying major dimensions, and identifying possible attributes each dimensions might have. Then, exploring random combinations of attributes for creative requirements identification (i.e., by selecting one attribute from each parameter for each combination).

Figure 1 illustrates the steps and the following paragraphs explain each of the steps.

Text Pre-Processing. For this step, common natural language processing (NLP) techniques such as stop word removal, special character and symbol removal were used. In addition, techniques for identifying and extracting the noun, verbs, and adjectives in the text-based comments were also applied.

Key-phrase Extraction – The Fine-grained Features Extraction. Key-phrase extraction is used for extracting important information from unstructured text documents. Key-phrase extraction can extract the important key and relevant terms or phrases from unstructured text. Collocation technique is used where the collocations are grouped based on pairs of words that are synonyms. WordNet (Fellbaum, 1998) is used as a synonym dictionary. When grouping features together, the word collection with the highest frequency is considered to be the name of the feature. Figure 2 depicted some keywords/phrases extracted using collocation technique.

share file	File anywhere	sharing work
easy use	Great tool	Smart phone
Use dropbox	dropbox allow	sometimes file
Large file	free storage	Space offer
access file	Make sure	Space share
File sharing	File storage	Space start
Cloud storage	able access	storage system
share large	save cloud	storage tool
file share	share across	Sync across
Ease use	Share client	Team collaboration
share document	Share drive	Try share
easy share	Share lot	try solve
storage pace	Share specific	unlimited storage
Make easy	Share store	upload time
share folder	Share tool	use email
able share	sharing collaboration	Use every
way share	Sharing option	Use online
personal use	sharing tool	

Figure 2: Sample of the extracted key-phrases using collocation technique

The key-phrase extraction technique is able to produce varieties of key-phrases (i.e., possible features for the software). Besides, the features extracted consist of combination of two words or key phrases which is meaningful to the requirements engineer. However, there are also features generated that are insignificant to the software development or irrelevant to the requirements context. So, these features need to be filtered out to ensure only the relevant features are gathered before implementing topic modeling techniques.

Topic Modeling – The High-level Features. Topic modeling involves extracting features from document terms. It has been designed specifically for the purpose of extracting various distinguishing concepts or topics from various types of documents, where each document talks about one or more concepts. There are various algorithms for topic modelling; among the popular algorithms are Latent Semantic Indexing (LSI), Latent Dirichlet Allocation (LDA), and Non-Negative Matrix Factorization (NMF).

At this stage, all the extracted key-phrases are groups based on terms that are distinguishable from each other, and these group of words form topics or concepts. These concepts can be used to interpret the main themes and also make semantic connections among words that co-occur together frequently in text data. In this approach, LDA is used to groups the fine-grained features in order to produce topic or high-level features. Figure 3 shows some of the results.

```
Topic #1 with weights
[(u'filepeople', 0.01), (u'niceable', 0.01), (u'payextra', 0.01), (u'variousdevice', 0.01), (u'fileeasily', 0.01),
(u'useapp', 0.01), (u'realestate', 0.01)]
Topic #2 with weights
[(u'alloweasily', 0.01), (u'greatway', 0.01), (u'filefile', 0.01), (u'directlydropbox', 0.01), (u'cloudfile', 0.01),
(u'storedropbox', 0.01), (u'startuse', 0.01)]
Topic #3 with weights
[(u'dropboxeasy', 0.01), (u'teamwork', 0.01), (u'filehost', 0.01), (u'smallamount', 0.01), (u'spacestart', 0.01),
(u'workproject', 0.01), (u'desktopapplication', 0.01)]
Topic #4 with weights
[(u'dropboxneed', 0.01), (u'multiplelocation', 0.01), (u'sharingsoftware', 0.01), (u'shareaccess', 0.01),
(u'mobileapps', 0.01), (u'workwithout', 0.01), (u'foldercomputer', 0.01)]
Topic #5 with weights
[(u'gowrong', 0.01), (u'quicklyeasily', 0.01), (u'pcmac', 0.01), (u'backforth', 0.01), (u'takelong', 0.01),
(u'acrossdifferent', 0.01), (u'cloudaccess', 0.01)]
Topic #6 with weights
[(u'phonelaptop', 0.01), (u'clientshare', 0.01), (u'dislikefact', 0.01), (u'dropboxmany', 0.01), (u'filesharing',
0.01), (u'folderwork', 0.01), (u'withoutneed', 0.01)]
Topic #7 with weights
[(u'usepersonal', 0.01), (u'spacedropbox', 0.01), (u'versionfile', 0.01), (u'needsend', 0.01), (u'workhome',
0.01), (u'computeralso', 0.01), (u'clientfile', 0.01)]
Topic #8 with weights
[(u'needfile', 0.01), (u'problemdropbox', 0.01), (u'useraccess', 0.01), (u'dropboxstore', 0.01), (u'invitepeople',
0.01), (u'colleagueclient', 0.01), (u'easywork', 0.01)]
Topic #9 with weights
[(u'withoutsend', 0.01), (u'offerfree', 0.01), (u'storephoto', 0.01), (u'spaceget', 0.01), (u'dropboxoffer', 0.01),
(u'unlimitedstorage', 0.01), (u'usedaily', 0.01)]
Topic #10 with weights
[(u'benefitrealize', 0.01), (u'supereasy', 0.01), (u'businessneed', 0.01), (u'folderalso', 0.01), (u'getspace',
0.01), (u'dropboxthink', 0.01), (u'partdropbox', 0.01)]
Topic #11 with weights
[(u'getwork', 0.01), (u'documentteam', 0.01), (u'spacewould', 0.01), (u'collaboratecolleague', 0.01),
(u'collaborationfile', 0.01), (u'managefile', 0.01), (u'googledoc', 0.01)]
Topic #12 with weights
[(u'dropboxstill', 0.01), (u'dropboxshare', 0.01), (u'emailattachment', 0.01), (u'fileimage', 0.01),
(u'googledrive', 0.01), (u'lovedropbox', 0.01), (u'filewithout', 0.01)]
Topic #13 with weights
[(u'phototake', 0.01), (u'woulduse', 0.01), (u'dragdrop', 0.01), (u'versiondropbox', 0.01), (u'useprogram',
0.01), (u'keepimportant', 0.01), (u'mayneed', 0.01)]
```

Figure 3: Sample of topics

However, human intervention is still needed for this activity. As for examples, to identify the title for each topic, and remove repeating features in the different topics. The repeating features need to be removed to avoid conflict when building morphological matrix.

Forming Morphological Matrix. The morphological matrix is built by using collocations and LDA. The morphological matrix (as depicted in Figure 4) filled with high-level features (HL) as dimensions or topics, and fine-grained features (FG) as values or attributes.

Results & Discussions: Creative idea is explored based on the relation analysis between parameters and options in morphological matrix. Appropriate combinations are identified and selected as potential creative requirements. As for this purpose, a group of stakeholders may involve in assembling creative requirements for the software-to-be.

	Topic 1	Topic 2	Topic 3	Topic 4	Topic 5	Topic 6	Topic 7
Value 1	File people	Allow easily	Dropbox easy	Dropbox need	Go wrong	Phone laptop	Use personal
Value 2	Nice able	Great way	Team work	Multiple location	Quickly easily	Client share	Space dropbox
Value 3	Pay extra	File file	File host	Sharing software	Pc mag	Dislike fact	Version file
Value 4	Various device	Directly dropbox	Small amount	Share access	Back forth	Dropbox many	Need send
Value 5	File easily	Cloud file	Space start	Mobile apps	Take long	File sharing	Work home
Value 6	Use app	Stored dropbox	Work project	Work without	Across different	Folder work	Computer also
Value 7	Real estate	Start use	Desktop application	Folder computer	Cloud access	Without need	Client file

	Topic 8	Topic 9	Topic 10	Topic 11	Topic 12	Topic 13
Value 1	Need file	Without send	Benefit realize	Get work	Dropbox still'	Photo take
Value 2	Problem dropbox	Offer free	Super easy	Document team	Dropbox share	Would use
Value 3	User access	Store photo	Business need'	Space would	Email attachment	Drag drop
Value 4	Dropbox store	Space get	Folder also	Collaborate colleague	File image	Version dropbox
Value 5	Invite people	Dropbox offer	Get space	Collaboration file	Google drive	Use program
Value 6	Colleague client	Unlimited storage	Dropbox think	Manage file	Love dropbox	Keep important
Value 7	Easy work	Use daily	Part dropbox	Google doc	File without	May need

Figure 4: The Morphological Matrix

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Example: Combination 1

Various Device → Allow Easily → Small Amount → Multiple Location → Cloud Access →Phone Laptop →Use Personal →Invite People →Dropbox Offer →Business Need →Collaboration File →Email Attachment →Photo Take

Example: Combination 2

Pay Extras → Cloud File → File Host → Share Access → Across Different → Client Share → Space Dropbox → User Access→ Store Photo→ Get Space →Document Team→ File Image →Drag Drop

Requirements can be generated from the combinations. For examples, developers can build the application for sharing file that have these features; *Allow easily for various devices, files stored in small amount and multiple location with cloud access functionality. Using by phone and laptop, user can use for personal and also can invite other people and more function offers for business need like file collaboration, email attachment and photo take.* The creative requirements can be added-on to the total requirements for the software-to-be.

Human intervention and decision making are still needed to further analyze each of the requirements that were developed in terms of its feasibility and applicability.

IV. DISCUSSIONS

Generally morphological matrix can be built for the large text-based data from crowd using text mining techniques. The key phrase extraction technique is able to produce varieties of potential features for the software product. Through combination of these features, a large number of creative requirements can be explored. However, some features extracted may insignificant or irrelevant. Therefore, these features need to be filtered out to ensure only the relevant features are gathered before implementing topic modeling technique. Furthermore, there is lack of guideline for generating number of features using key phrase extraction techniques, this flexibility give us a choice on how many features that needs to be extracted from the dataset. Number of topics to be generated and features to be extracted for each topic also can be decided.

Besides that, another issue is the possibility to forego important or creative features if they are neglected due to the frequency of the features are low. This can be improved by adopting other techniques to allow for the identification of non-common features through patterns in addition to the term frequency. It is also suggested to collect ideas from specific groups of users or stakeholders that are interested on that particular software instead of wider crowd.

Type of data collected from crowd is another concern, in which, user's reviews are diverse. Thus, it need to go through a classification process to determine whether it is bug reports, feature requests, user experiences, ratings or simple praise or dispraise. And, the best way to do it is by building an automatic classifier of user reviews. Furthermore, sometimes the ideas are expressed in negative statement such as "We don't like multi user access the file". Although, these negative statement can be filtered out when evaluating the ideas manually, but it would be effective if the process is done automatically.

V. CONCLUSIONS

Crowd-based requirements elicitation can extend the requirements elicitation by covering the total pool of stakeholders to a much higher degree, which will contribute to a better software product development. Other benefits including the diversity of generated ideas from crowd which typically differ from those generated with common requirements elicitation techniques. While, morphological matrix creative-based technique helps requirements engineer or developers to stimulate creativity. However, the proposed approach involves certain steps that still require human intervention. Thus, in future, automated tools to assist the process (for example, to automatically generate potential requirements from morphological matrix) which overcome the technical limitations and reduces the participation of human in the process should be developed.

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