

# Discovering Knowledge from Mobile Application Users for Usability Improvement: A Fuzzy Association Rule Mining Approach

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*Abstract*— The usages of mobile application have increased rapidly in recent days. It is also becoming more popular in recent business applications where multiple users are connected through a mobile application to complete the business circle. In this aspect, the demand of quality mobile application is increasing. Usability is the main quality factor for enhancing the quality of application. For this reason, the usability improvement is getting more priority for this kind of application. So, discovering the experiences of the users can lead to improving the usability of mobile application. For this, we introduce Fuzzy Association Rule algorithm (FAR) based on fuzzy association rule mining to discover the experience from the mobile application's users. To validate our approach, we consider a supply change management system where multiple users are linked through the mobile application. In this paper, we examine twelve usability factors that are extracted from ten usability evaluation models to improve the usability. After conducting our experiment, we get knowledge from the users of the mobile application that can be used for the improvement of usability. We get several experiment outcomes and knowledge that can be implemented in practices.

**Keywords**- *Quality Software; Usability Improvement; Fuzzy Association Rule Mining; Usability Factor; Quality Mobile Application*

## I. INTRODUCTION

Nowadays, mobile applications have become more popular in developing countries. It has been using in the business application where multiple users are linked and completed the business transactions. So the importance of quality is getting more priority for this kind of application. In this aspect, usability is considered as a major factor for software quality improvement [1] [2] [3]. Usability of the software should increase with the help of user's usage experience. So, the usage experience of current application's users plays a vital role for the improvement of usability.

As an important data mining approach, association rule mining has been used to discover users' behaviors or experience [4] [5]. Fuzzy association rule is one of the widely

used solution to find out the relation between users' experience and usability factors [6]. It discovers the knowledge from the users that can improve the usability according to usability factors and users' demands.

In our work, we have prepared survey questionnaire to get the usage experience from users. Fuzzy association rule mining approach is used to generate rules (i.e., the knowledge to be used to improve usability) from the users' survey feedback and usability factors [4]. The application, Supply Management System (SCM), is used as a case study. In this application, multiple users are connected to complete the business circle through the mobile application of SCM.

As mentioned above, SCM system is developed for mobile application for providing products and services to suppliers and customers [7]. By installing this application in smartphones, this software is keeping up a better integration and adaption to their internal operations. Although it's not easy to evaluate usability since this application is generally featured with complex logistics support, and materials management functions within an organization and also maintains a chain throughout the whole system via mobile application. So, evaluation of the usability for mobile application is relatively necessary for ensuring the quality of SCM. More recent research emphasizes on the usability of SCM along with additional aspects such as risk, performance, and integration. With the help of fuzzy association rule mining approach, our introduced FAR algorithm explores the rules of usability factors and users' usage experience that helps to improve the usability of SCM mobile application users.

The rest of the paper is organized as follows: Section II discusses the usability evaluation models and proposes usability model for mobile application; Section III describes our methodology for usability improvement; Section IV analyzes the experiments and results; Finally, section V concludes the paper.

## II. USABILITY EVALUATION MODELS

In order to capture usability factors for mobile application, we have investigated ten usability evaluation models. In these evaluation models, survey questions were used according to usability factors. This section seeks the usability factors for the evaluation of mobile application. By the usability factor extraction algorithm (i.e., algorithm I), we have extracted and listed the usability factors in the table III.

TABLE I. USABILITY EVALUATION MODEL

Usability Evaluation Model	Source	# of Survey Questions
System Usability Scale (SUS)	John Brooke in 1996 [8]	10
Software Usability Measurement Inventory (SUMI)	Jurek Kirakowski et al. in 1990 [9]	50
Computer System Usability Questionnaire (CSUQ)	Lewis, J. R. in 1995 [9]	7
Questionnaire User Interaction Satisfaction (QUIS)	Chin, J.P. et al. in 1988 [10]	27
Usability Metric for User Experience (UMUX)	Kraig Finstad in 2010 [11]	10
After Scenario Questionnaire (ASQ)	Lewis in 1995 [12]	7
Single Ease Question (SEQ)	Lewis in 1995 [12]	7
Subjective Mental Effort Question (SMEQ)	Jeff Sauro et al. in 2009 [10]	1 with 9 verbal forms
Website Analysis and Measurement Inventory (WAMMI)	Jurek Kirakowski et al. early 1990 [13]	20
Standardized User Experience Percentile Rank Questionnaire (SUPR-Q)	Jeff Sauro in 2014 [14]	13

Table I shows the details of ten famous usability evaluation models (i.e., found in literature [1] [2] [3]). In details, the famous usability evaluation model, System Usability Scale (SUS) was developed and published by John Brooke in 1996 [6] used for the evaluation of desktop and mobile application. SUS has strong reliability value (i.e., 0.85). SUMI questionnaires are used for measuring usability of developed software as well as different versions of the same software. Even it also used for a prototype of the software. However, SUMI is not capable of measuring usability of newly developed software. CSUQ is used for mailed survey. For CSUQ question, there is a comment option and survey respondents can put their comment about every question. QUIS usability evaluation is used for user subjective satisfaction. It contains 27 questions and each question contains 9 scale distribution. UMUX is also used for subjective assessment of an application. ASQ contains scenario based survey questions for usability evaluation. Moreover, it helps to analyze satisfaction of task completion with time. ASQ has strong reliability value, i.e., 0.96. SEQ is also similar to the evaluation model ASQ. The reliability value is 0.84 which combines the task completion rates and times. SMEQ is reliable and easy to use questionnaire. It is supposed to measure satisfaction. WAMMI is a web analytics service that measured and analyzed website user experience usability evaluation model [12]. The reliability value of WAMMI is

between 0.90 and 0.93. SUPR-Q is a comprehensive usability measurement for the users of website. The reliability value of usability is 0.87.

TABLE II. USABILITY FACTORS FROM MODELS

S N	Usability Evaluation Model	What they are supposed to measure	Selected Usability Factor
1	SUS [6]	Supportability, Inconsistency, Learnability, Confident	Efficiency, Satisfaction, Learnability
2	SUMI [7]	Efficiency, Affect, Helpfulness, Control, Learnability	Satisfaction, Efficiency, Helpfulness, Learnability
3	CSUQ [8]	Satisfaction, Efficiency, Learnability, Effectiveness	Satisfaction, Efficiency, Learnability, Training Effectiveness
4	QUIS [10]	Satisfaction	Satisfaction
5	UMUX [11]	Speed, Time, Effectiveness, Efficiency, Satisfaction	Effectiveness, Satisfaction, Efficiency
6	ASQ [12]	Helpfulness, Satisfaction, Support, Operability	Operability, Helpfulness, Satisfaction, Human Engineering
7	SEQ [12]	Task Effectiveness, Satisfaction	Effectiveness, Satisfaction
8	SMEQ [10]	Satisfaction	Satisfaction
9	WAMMI [13]	Confident, Understand functions, Guides, Attractiveness, Controllability, Efficiency, Helpfulness, and Learnability	Reliability, Understandability, Efficiency, Helpfulness, Learnability, Attractiveness, Usability Compliance
10	SUPR-Q [14]	Usability, trust, appearance, and loyalty	Attractiveness, Satisfaction

Table II shows the usability factors extracted from usability evaluation models according to the Algorithm I. These factors are used to find out the rules (i.e., the usage experience of the user can be used for the improvement of usability). Table III proposes the selected the usability factors for mobile applications. Survey questions are prepared from these proposed twelve factors for evaluating mobile applications. Table III also illustrates the description of proposed usability factors.

TABLE III. PROPOSED MODEL FOR USABILITY EVALUATION OF MOBILE APPLICATIONS

Proposed Quality Factors	Description
Operability	It indicates the capability of the mobile applications to enable the user to operate and control the functions of user interfaces.
Efficiency	Once users have learned the functions of the mobile application, how quickly they can perform tasks of that application.
Effectiveness	It means the accuracy and completeness of a function with which users achieve specified goals of the specific functions.

Learnability	The capability to learn the content of mobile applications comprehensively and also can gain knowledge and skill by comfortably.
Training	Training means how mobile applications resources teach users to use the applications.
Satisfaction	Satisfaction refers to the subjective responses from users about their feelings when using the mobile applications.
Understandability	Understandability suggests that applications user can understand a task easily.
Helpfulness	It provides useful guidance to the application's user properly for a task.
Attractiveness	Attractiveness means the glamor of a user interface for the applications users who are involved in the applications.
Reliability	The ability of mobile application to perform the tasks consistently which are required functions without any degradation or failure.
Usability Compliance	Usability compliance refers to the capability of the mobile applications to adhere to standards, conventions, style guides or regulations relating to usability.
Human Engineering	Human Engineering indicates management of human and their affairs. It refers to making any changes based on an original issue to do different things.

<b>Algorithm I Usability Factor Extraction</b>	
<b>Input:</b> N usability models including u usability factors	
<b>Output:</b> UF, usability factors	
<b>Method:</b>	
Let UF = UM <sub>i</sub> ; i = 2;	
Repeat {	
For each factor f in UM, check if it has been included in UF with the same name, if not, then {	
Check if UF has similar factor	
If not, then {	
f is added to UF	
}	
i = i + 1;	
}Until(i>N)	

Algorithm I extracts the usability factors from the usability evaluation models (i.e., listed in the table II). The output of this extraction algorithm is listed in the table III with the description. In our proposed method, these extracted usability factors are used to get the user experience with the help of survey questionnaire.

### III. METHODOLOGY

Fuzzy association rule mining is an important approach to discover information from the users' data. In our method, fuzzy association rules are generated from the usability survey questionnaire and the patterns used to get the knowledge from users' experience for usability improvement. Algorithm II gives the rules (i.e., the knowledge from users' experience) after compiling the survey data from a user associated with usability factors.

The inputs of FAR algorithm are user's answer dataset D(A, U), Where, A is a nonempty set of finite user's answer ( $a_i \in A, i = 1, 2, 3, \dots, n$ ), which includes different measurement approaches (For ascending order, 1 as lowest weight and 5 as highest weight and descending order, 5 as lowest weight and 1 as highest weight).

<b>Algorithm II FAR Algorithm</b>	
<b>Input:</b> D(A, U), $\mu(a_i)$ , Sup, Con	
<b>Output:</b> Fuzzy association rules	
<b>Method:</b>	
For each user in U {	
If $a_i$ is category, then support(i) = 1.	
If $a_i$ is number-linguistic, then support(i) = $\mu(a_i)$ .	
T <sub>ij</sub> = (a <sub>i</sub> , u <sub>j</sub> )	
DT = (T <sub>ij</sub> , support(i)).}	
For each item in DT {	
If support(i) > Sup, Then Add (T <sub>ij</sub> , support(i)) to L;	
While L is not null {	
Lnew = 0;	
Generate candidate set C from L.	
For each candidate C <sub>k</sub> in C {	
If support(k) > Sup, Then Add (C <sub>k</sub> , support(k)) to Lnew.}	
L = Lnew.}	
For each item in L {	
Compute the confidence of each item	
If confidence > Con, then construct fuzzy association rules	

U is a nonempty set of finite users ( $u_j \in U, j = 1, 2, 3, \dots, m$ ), membership function : which maps the user's answer data into linguistic variables (L, M, R. i.e. agree, undecided, disagree. as shown in Fig 1), and two thresholds: minimum support Sup, and minimum confidence Con. Finding rules from user's answer data must satisfy these thresholds, where Sup=0.5, and Con=0.8. The FAR algorithm includes three steps. Firstly, it transforms the user's answer data into a new dataset which stores the support of each answer. Secondly, it generates the candidate items of the rule which satisfy the mentioned thresholds. Lastly, it constructs the fuzzy association rules from the selected candidates in the second step.

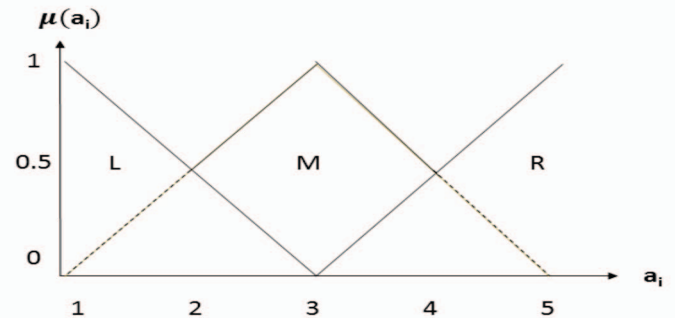


Fig 1. Membership function  $\mu(a_i)$

### IV. EXPERIMENTS AND RESULTS

The survey was conducted in a renowned mobile phone and accessories distribution company in Bangladesh. Henceforth this company is defined as WSDT, whole sale Distribution Company. They distribute different types of mobile phones and accessories to 64 districts of Bangladesh. In total, 49 questions ([https://github.com/sagarwhu/FAR/blob/master/FAR\\_SurveyQuestions.pdf](https://github.com/sagarwhu/FAR/blob/master/FAR_SurveyQuestions.pdf)) are adapted for our survey according to usability factors. The target population for our

survey comprised 151 WSDT employees who use different modules by the mobile application (i.e., part of SCM system) on a daily basis. 70.2% of the respondents who are sales officers participated in the survey as maximum respondents and also performed the major tasks of the SCM via mobile application to conduct business smoothly. Table IV explains the rules along with the confidence of our proposed usability factors.

TABLE IV. EXTRACTED RULES FROM MOBILE APPLICATIONS USERS

#	Factors	Rules	Confidence
1	Attractiveness	{{(OrganizationMenu, agree)} => {{( EasyUnderstandingEverything, easy)}}	0.86
		{{( Presentation Attractive, agree)} => {{( EasyUnderstandingEverything, easy)}}	0.86
2	Effectiveness	{{(TaskEff,agree)} => {{(EffectivelySatis, always)}}	0.83
		{{(EffectiveInfo, agree)} => {{(EffectivelySatis, always)}}	0.83
		{{(ScreenInfoOE, clear)} => {{(EffectivelySatis, always)}}	0.83
3	Efficiency	{{(user, sales officer)} => {{(Recoverability, agree)}}	0.86
4	Human Engineering	{{(AcceptanceOfNV, agree)} => {{(ReleaseOfNV, Wonderful)}}	0.86
5	Helpfulness	{{(Terms, Consistent), (HelpMessages, Always)} => {{(EasyTo , Always)}}	0.83
6	Operability	{{(Easy-Use, Disagree), (Stopped-Unexpectedly, Never)}=> {{(Agree-Use, Disagree)}}	0.83
7	Reliability	{{(Confident, Agree), (Presentation Screen, Clear)}=> {{(Recommended, Agree)}}	1
8	Learnability	{{(Long Time, Agree), (Complex-Learn, Agree)} => {{(Learn, less-interest)}}	0.83
9	Satisfaction	{{(Comfortable, Agree)} => {{(Work Satisfaction, Always)}}	1
10	Training	{{(Complex Material, Sometimes)} => {{(Technical Support, Required)}}	0.83
11	Understandability	{{(U- Information, Agree)} => {{(U-Function, Agree)}}	0.83
12	Usability Compliance	{{(Help-Information, Helpful)} => {{(Documentation-Guide, Agree)}}	1

The proposed FAR approach uses minimum support (i.e., 0.5) and minimum confidence (i.e., 0.8). From FAR approach, the rules are generated listed in table IV. As an example, for the factor understandability, the generated rule is (i.e., mentioned in the table IV), “If the presentation method of information is clear and understandable, then it will be easy for the user to complete the task, with a confidence of 83%”. Another rule for the satisfaction factor is, “If the user became productive using this application as average, then the user always is satisfying his task, with a confidence of 100%”. These rules are meaningful for the developer of the application to improve the usability of the mobile application. Our finding suggests that proposed rules (i.e., knowledge we got from the users) can be used to improve the usability of mobile application.

## V. CONCLUSIONS

Association rule mining is the common data mining approach used to discover knowledge from the users. This approach has wide applications for survey datasets. In this paper, we investigated ten famous usability evaluation models and proposed usability improvement model for the mobile application. Our proposed FAR approach discovers knowledge from the users that can be used to improve usability. As a case study, the mobile application part of SCM system is used to collect data from the users.

The main contribution of this study is to discover and analyze the rules that can improve the usability of the mobile application based on an effective fuzzy association rule mining algorithm FAR. It extracts the significant knowledge from the users’ survey data. This knowledge can be used to enhance the quality of the mobile application.

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