App Review Analysis

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***Abstract*—App reviews are a valuable source of information for developers as they can tell developers about the bugs and the problems they are facing while using the app. In popular apps which have millions of users, there are thousands of reviews that are written every day. These reviews also contain junk or irrelevant reviews which are not helpful to the developers and manually reading each user review and finding the relevant review is very difficult. This mapping study aims at identifying and analyzing review existing research on app review analysis, app review mining, etc. After reviewing attentively we screened 68 studies that were relevant to our 4 research questions. We devised a taxonomy to classify all identified studies. By following Peterson's methodology we formulated 4 research questions. The results of this mapping study signify that Natural Language Processing is the most extensively used technique for app review mining. The results of this mapping study signify that Natural Language Processing is the most extensively used technique for app review mining. This study covers the literature review on app review analysis from the last 5 years. All the techniques and approaches have been mentioned in this study which is helpful for the new researchers and they will be able to get an overview of this area of research when conducting their research.**

I. Introduction

In the last 10 years, the use of smartphones has increased and smartphone app usage has also increased. There are millions of apps on the play store and app store and with the passage of time, the apps are updated. With each update of the app, there are some bugs that users face when operating their apps. There is an option to give reviews and ratings to the applications and users can tell about the issues they are facing while using the app. Similarly, these reviews also contain information about some features or some new features which the users want or think should be in the app. These reviews are extremely important for the app developers as they contain valuable information and giving importance to these reviews is very essential in order for the app to be successful because if reviews are not addressed and given importance the rating of that app will go down and it is seen that users generally do not prefer to download an app which has low ratings. In the case of applications with a large audience, there is a large no of reviews and it is not possible for the developer to go through each review one by one. It will take weeks in this way to read all the reviews and the productivity will decrease and a lot of time will waste. Therefore it is necessary to automate this process so that only relevant reviews which are asking for change requests or discussing some bug issues are only seen by the developer because there are spam sentences or reviews with only praises or contrary abusive reviews so there is a need to automate this process. In this paper, we will do a review on app review analysis what techniques have been used so far for mining reviews and what is the state of art nowadays. First of all, let's discuss app reviews. App reviews are basically like feedback that users can give how they feel after using the app were there any performance issues or any suggestions or improvements which can be done all these things can be discussed in the application review under the download page. The reviews can also be in the form of star ratings with 1 as least and 5 as maximum. In the last 5 years, many techniques have been proposed for mining app reviews automatically in different studies by researchers. Most of the researchers have used machine learning and natural language processing for mining app reviews. App review analysis has gained a lot of interest in the research community recently and there are a plethora of studies written on this topic whether they are review studies survey studies short articles or magazines. However there a very few systematic studies especially mapping studies. This mapping study will cover the studies which are between (Jan 2017- May 2022) and it will help new researchers to know the techniques of app review mining that are used most commonly or least commonly. Our contribution is basically to give a detailed explanation of the studies which have been written in app reviews analysis. In this study, we have added a systematic mapping protocol starting with the search string, research questions, inclusion-exclusion criteria, and study selection process in the form of a Prisma flow chart. This research study has five sections. Section 2 discusses the literature review. Section 3 tells us about the research method the research questions which we have used, and inclusion-exclusion criteria. In section 4 we will discuss the results and lastly, in section 5 we will conclude our study.

II. Literature Review

In this section, we will discuss survey papers that were published in the last 5 years and what motivated us to contribute to this topic. In [59] the authors have made a survey of mining and prioritizing tweets from Twitter that are related to software applications. As Twitter is a major platform where software users post tweets regarding the apps they are using and the issues they are facing. Sometimes they discuss the bugs or some features which are missing in an app so they

are an important source of information for the developers of the app. There are a lot of irrelevant tweets also which are not helpful. Manually reading tweets and finding a relevant tweet from thousands of tweets will take a lot of time. In this survey report, the author took opinions from 84 software engineering researchers about what keyword is given more priority in tweets prioritization. This is a[42] survey made on app store analysis. It has listed all the areas which have been explored in this field so far and the least researched areas have also been mentioned which will help new researchers to explore more in these areas. The time span of the research was between 2000 till 2015. A key finding in this research was that the no of apps and apps usage increased tremendously in 2015. This [25] survey paper focuses on the state-of-the-art methods which are used in app review mining from the play store and app store. The main motivation behind writing this paper is to find existing methods that can discern relevant user reviews from irrelevant reviews. This study also helps researchers to find a better tool that can mine app reviews. [16] is a systematic literature review that also discusses the proposed solution of app review analysis of the challenges in this field and its future aspects in it. The author discussed several challenges in this paper like there are some vocabulary words that have a positive meaning in one context and negative meanings in some other contexts for e.g. unpredictable is a positive word in a movie or book review will have a positive sense while it can be considered negative in some other app review. Similarly, most reviews are written in a vocabulary that is totally different from a developer's perspective. Similarly fake reviews is also a problem for e.g if some user reviews mentions a problem which is not in the app and give bad rating new customers will also not download that app based on those reviews or ratings so it is also a big issue. On contrary there can be fake good reviews of a product which is bad so in this case user reviews can also mislead the new customers. Lastly in [1] Jaceb Dabrowski wrote an SLR with a time span between 2012-2022 covering all the literature written on app reviews in this period. The author followed Kitchenham's methodology for writing an SLR. 182 papers were screened and they were studied carefully so that each research question is answered. The objectives of this SLR were to find NLP, Data mining techniques that are used in app reviews, and to write the results what all techniques achieved in app review mining. The screened studies were from good conferences and journals like ICSE, TSE, EMSE. This SLR also highlighted the importance of app reviews and what is the need of doing it.

III. Research Methodology

A mapping study is done so that we can give an overview on what has been done till today in this area of research what are the challenges and what are the future aspects and what needs to be solved. A mapping study is slightly different to an SLR. A mapping study follows Peterson approach while an SLR follows Kitchenham's approach similarly a mapping study do not have a quality assessment criteria while an SLR has a quality assessment criteria.

We have written a mapping study. A mapping study has 5 steps. In the first step, we define our research questions. Secondly, we conduct our search process by writing relevant queries and finding maximum studies related to the topic. Thirdly. we screen studies according to our research questions this is a very important step and it takes time. In the fourth and fifth step we select a data extraction form and fill that form for each and every screened study.

A. Research Questions

Primary research question in our mapping study is what are the current state of the art methods which are used in app review mining. In Table 1 we have written our 4 research questions.

B. Data Sources

We have considered four databases as our primary data source for our screened studies. We did not consider google scholar as our database as the results were less mixed. In table 2 all the electronic databases we considered are listed.

C. Search terms

Identifying a search term that is relevant is necessary if we want the maximum related no of studies to come in our search results when we execute a query. Following are the PICO of our search term.

Population: App, game, user Intervention: Review, feedback Outcome: Mining, analysis We have created a generic search string on the basis of PICO and we used these terms interchangeably to search in four databases. Generic Search String: "app review mining" OR "user review mining " OR "user feedback mining" OR "online review mining " OR "game review mining" OR "app review analysis"

D. Inclusion and exclusion criteria

We selected our studies which were screened in the end on the basis of inclusion and exclusion criteria. We included studies that were peer-reviewed, articles, and journal studies. Books, short articles, and magazine articles were not included.

TABLE I
Example Table

Identifier	Research Question
RQ1	Why do we require app review analysis and what is the benefit of using it?
RQ2	Is the technique proposed by the researcher better than the state of the art?
RQ3	Which methods are used for app review analysis and what is the state of the art nowadays?
RQ4	How has app review analysis evolved and benefited developers in bug removal?

TABLE III
SEARCH PROCESS

Database ID	Database Name	Search String
ED1	ACM	Title:(”app review” OR ”user review” OR ”user feedback” OR ”online review”) OR Abstract:(”app review” OR ”user review” OR ”user feedback” OR ”online review”) ”filter”: Conference Collections: ICSE: International Conference on Software Engineering,Publication Date: (01/01/2017 TO 05/31/2022),ACM Content: DL
ED2	IEEE	(”All Metadata”:app review mining) OR (”All Metadata”:game review mining) OR (”All Metadata”:app review mining) OR (”All Metadata”:game review mining) OR (”All Metadata”:user review mining) OR (”All Metadata”:user feedback mining) OR (”All Metadata”:app review analysis) OR (”All Metadata”:game review analysis)
ED3	SPRINGER	”app review” OR ”user review” OR ”user feedback” OR ”online review”
ED4	ScienceDirect	”app review mining” OR ”user review mining ” OR ”user feedback mining” OR ”online review mining ” OR ”game review mining” OR ”app review analysis”

TABLE IV
STUDY SELECTION PROCESS

Database	Search Results	Screened Studies
IEEE	121	26
ACM	26	11
ScienceDirect	26	10
Springer	569	14
Other	10	7

TABLE V
INCLUSION AND EXCLUSION CRITERIA

Identifier	Inclusion Criteria
IC1	Articles and journals which are peer-reviewed.
IC2	Studies in which app review is used directly or indirectly.
IC3	Studies mostly related to software engineering only exceptions are there.
IC4	Most recent studies are included.
IC5	Articles published between (2017- May 2022)
	Exclusion Criteria
EC1	Short articles, books, and magazine articles
EC2	Articles that are not in the English Language
EC3	Articles with low-quality scores.
EC4	Studies with unclear results and findings

TABLE II
DIGITAL SOURCES

Database	Search Results
IEEE	121
ACM	26
Science Direct	26
Springer	569

E. Prisma Flow Chart and Data Extraction Form

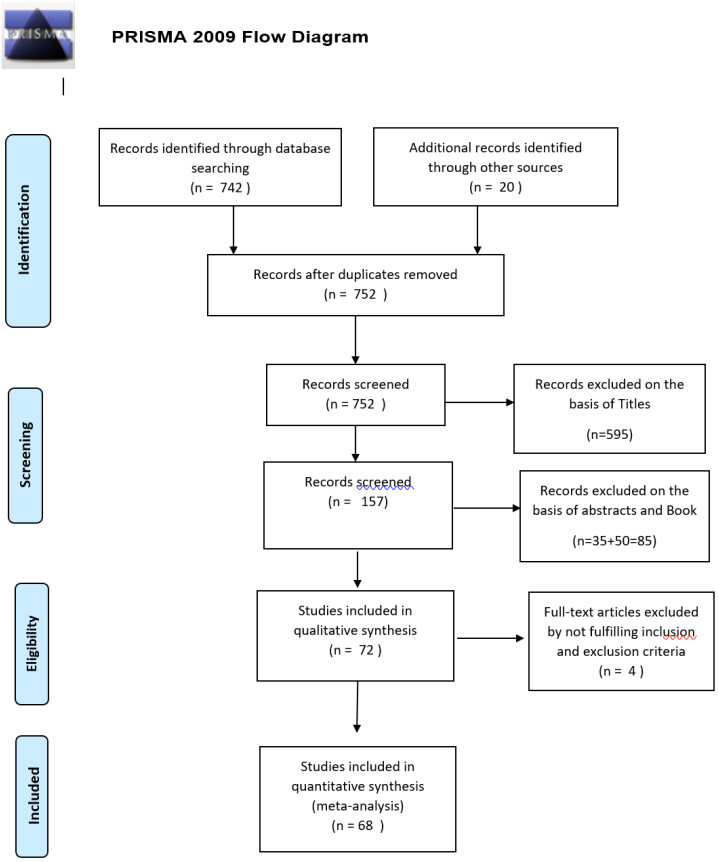

Fig. 1. Prisma Flow Chart

Mapping Study_ Data Extraction Form

Study Identifier			Notes:	
Title				
Year				
Author(s)				
Publication Venue	○ Journal	○ Conference	○ Other_____	
Research Question				
RQ1	RQ2	RQ3	RQ4	
Fulfillment of inclusion Criteria				
IC1	IC2	IC3	IC4	IC5
Quality Assessment score				
QC1	QC2	QC3	QC4	
Multi criteria evaluation Method				
Solution Type	Single	Hybrid		
Uncertainty Consideration	Yes	No		
Criteria				
Primary Criteria				
Secondary Criteria				
Criteria Type	Subjective	Objective	Combined	
Application Domain	IaaS	PaaS	SaaS	General
Validation				
Contribution	Integration	Utilization	Extension	New method
Description / Summary				

Fig. 2. Data Extraction Form

IV. Results and discussion

In this section, all the research questions will be answered one by one.

A. RQ1

Why do we require app review analysis and what is the benefit of using it?

App reviews are a valuable source of information for the developers as they can tell developers about the bugs and the problems they are facing while using the app. In popular apps which have millions of users, there are thousands of reviews that are written every day. These reviews also contain junk or irrelevant reviews which are not helpful to the developers and manually reading each user review and finding the relevant review is very difficult. By reading app reviews the developers will be able to know the concerns of the user and will be able to make changes in the code to remove the bugs or in case of feature requests add an additional feature.

B. RQ2

Is the technique proposed by the researcher better than the state of art? In 68 screened studies some of the studies were survey papers while in the rest of the studies some techniques were proposed to mine user reviews. These techniques included Caspar. IDEA, SAFE. Among them, CASPAR is the best approach because its accuracy was 82% precision was 92.9%, and recall of 34.2%.

C. RQ3

Which methods are used for app review analysis and what is the state of art nowadays? User reviews can be mined manually but it is a tedious task. Mostly machine learning and NLP methods are used for app review analysis. CASPAR is the state of the art technique and tool for app review analysis.

D. RQ4

How app review analysis has evolved and benefited the developers to remove bugs?

App review analysis has evolved tremendously and developers give it importance and attention because if the users concerns are not addressed it will result in low rating of the app and as the new audience downloads an app by looking at the rating and reviews so by seeing a lower rating they will no t download the app and hence the app traffic will decrease and no developer wants this thing to happen to their apps.

V. Conclusion

In this research study we performed a systematic mapping study on app review analytics for software engineering. By doing systematic search we screened 68 studies that were relevant to our research questions. These studies indicate that there is a growing interest in app review analytics research. We limited our studies to four good databases which are IEEE, Acm, Springer, and ScienceDirect. The studies were from reputed conferences and journals like IEEE Transactions on Software engineering, ICSE, etc. As the mobile apps are increasing day by day so it indicates that the research in this domain will increase as the time passes.

This mapping study lists all the methods and techniques which are used to mine app reviews. Most of the techniques used are machine learning and NLP. This mapping study also tells us why app review is important and why developers need to read the reviews of the app for software evolution. The approaches for mining app reviews are effective and are used practically in extracting app reviews. This work will be a source of help for the researchers to know the current trends in app review analysis and can do their research by considering it as their base study.

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