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What Do People Complain About Drone Apps? A Large-Scale Empirical Study of Google Play Store Reviews

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Abstract

Within the past few years, there has been a tremendous increase in the number of UAVs (Unmanned Aerial Vehicle) or drones manufacture and purchase. It is expected to proliferate further, penetrating into every stream of life, thus making its usage inevitable. The UAV's major components are its physical hardware and programming software, which controls its navigation or performs various tasks based on the field of concern. The drone manufacturers launch the controlling app for the drones in mobile app stores. Few drone manufacturers also release development kits to aid drone enthusiasts in developing customized or more creative apps. Thus, the app stores are also expected to be flooded with drone-related apps in the near future. With various active researches and studies being carried out in UAV's hardware field, no effort is dedicated to studying/researching the software side of UAV. Towards this end, a large-scale empirical study of UAV or drone-related apps of Google Play Store Platform is conducted. The study consisted of 1,825 UAV mobile apps, across twenty-five categories, with 162,250 reviews. Some of the notable findings of the study are (a) There are 27 major types the drone app users complain about. (b) The top four complains observed are Functional Error (27.9%), Device Compatibility (16.8%), Cost (16.2%) and Connection/Sync (15.6%). (c) The top four issues for which the UAV manufacturers or Drone app developers provide feedback to user complaints are Functional Error (40.9%), Cost (33.3%), Cost (16.2%), and Device Compatibility (23.1%). (d) Developers respond to the most frequently occurring complaints rather than the most negatively impacting ones.

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1. Introduction

An unmanned aerial vehicle (UAV) (commonly called a drone) is an aircraft without a human pilot on board. Drones can be navigated via control from the ground, through software-controlled flight plans in their embedded systems, functioning along with onboard sensors and GPS. Small UAVs mostly use lithium-polymer batteries, while larger vehicles rely on conventional airplane engines. Some of these drones are equipped with cameras that allow the user to record videos or capture pictures. These drones are controlled by certified operators. Also, there exist many drone hobbyists.

Drones can also carry various kinds of sensors and reach places that most IoT (Internet of Things) devices cannot. Drones can also be used to predict the weather, replace traffic cameras, detect forest fires, scan buildings and landscapes to aid in the agriculture and structural health monitoring, and search rescue operations.

With the invention of ‘smart drone’ technology through which drones can interact with onboard computers, data collection devices, smartphone applications, as well as cloud there came a flood of drone mobile apps. These apps range from controlling and navigating drones to providing different applications to facilitate complex tasks autonomously from simple instruction via an app. With more and more free and open software development kits and web APIs that are currently accessible to drone enthusiasts, there has been a surge in the mobile app distribution platforms such as the Google Play store and the IOS store. The drone mobile app industry is expected to be a billion-dollar industry by 2020. Even though the drone software field requires significant researches, there exist no previous works on drone apps of any App Store. This paper proposes to study a large number of drone apps from the Google Play Store. The paper aims to uncover the issues mobile drone app users frequently complain about, the most negatively impacting types, the developer reply to the categories and the time taken to respond.

2. Related Work

Previous works on reviews of mobile apps affirm that user reviews play a vital role in the triumph of an app. Kim et al. (2011) [8] found that reviews of an app influenced its purchase the most. Ha and Wager (2013) [3] found that users who are evaluating the apps are doing so only when they are either extremely satisfied or dissatisfied. Fu et al. 2013 [2] have performed Topic Modelling on 1 and 2-star ratings to discover what the most common types of complaints are in each category of apps. Khalid et al. 2013 [6] studied app store 1 and 2-star reviews to identify what iOS app users frequently complain about. Khalid et al. (2015) [7] studied low rated reviews of 20 free iOS apps and found that functional error, feature request, and app crash were the categories that were often complained about, whereas privacy and ethical, feature removal and hidden costs complaints were the most impactful ones. Martin et al. (2017) [10] provides a survey paper that contains a more exhaustive list of studies conducted on iOS Apps. Hassan et al. (2018) [4] study 4.5 million reviews with 126,686 developer responses of 2,328 top free apps from the Google Play Store in an attempt to explore more about the dynamic nature of the review-response mechanism and that responding to a review often has a positive effect on the rating that is given by the user. Noei et al. (2018) [11] studied 435,628 reviews from 49 apps (of 10 categories) from the Google Play Store, performing topic modeling to identify the categories of user feedback. Mahmoudi et al. (2018) [9] studied 19 Android wearable apps reviews, and conclude that Functional errors, Lack of Functionality, and Cost categories receive most complaints whereas Installation Errors, Device Compatibility, and Privacy & Ethical Issues are the ones with a higher negative impact. Hu et al. (2019) [5] investigated 68 hybrid apps from the Google Play Store and iOS app store to determine whether they achieve consistent star ratings and user reviews across app platforms.

3. Methodology

We used a google play store scrapper to collect Drone-related apps, the drone app’s reviews and replies dataset from the Google Play Store [1]. The metadata is also collected for a selected group of apps.

3.1. App Collection

Since there is no defined category provided for drone apps, we used an open-source scraper [1]. We searched on the Google Play Store for the terms such as ‘Drone’, ‘UAV’, ‘Drone Controllers’, ‘Drone Simulators’ and ‘Drone Games’ etc. We executed a Breadth-First-Search and crawled all the related apps including their ‘docid’, ‘hreflink’, ‘developer’, ‘appPrice’, ‘appSummary’ and ‘appScore’. In order to get wider coverage and to increase the number of apps being scraped, the free and paid apps were scraped separately using the price: ‘free’ and price: ‘paid’ options in the search method provided in the scraper. We were able to collect 1825 apps in total.

3.2. Noise filtration (Pre-processing)

The dataset was composed of total 1825 apps. Most of the collected apps were related to UAVs. However, some unrelated apps also slipped through the collection process. For example, few apps such as ‘AndroBagPipe’ had the word drone (‘drone’ related to bagpipe music) in the app description, but the app were not related to UAV. Few apps such as ‘UAVAthletics’ had word UAV (university name was UAV -University of Antelope Valley) but the app was related to athletics. On the contrary, some apps which were related to UAV and drones did not have the major terms ‘Drones’ and ‘UAV’ terms in ‘title’ or ‘docid’. Hence raised the problem of how to determine which apps were drone-related and which were not. To solve this, we created a GUI tool for manually sorting out the apps. Two members from the lab manually graded apps as related to Drones or not. Some of the apps were tricky to label, since they were not directly related nor supported but played a small role. For example, a drone was a feature in a game. A hundred apps were found disputed. The issues were resolved through discussion and voting between the three external members. A total of 970 apps were found to be drone related

3.3. Meta-Data and Review Collection

As a next step of the methodology, the meta-data of the 970 UAV app was collected. The Metadata includes attributes such as number of minimum installs, score, number of reviews, genre, price, currency, in-app purchase, developer details, price details, version, updated dates and App permissions details. Review Collection was implemented for the 970 apps. Some of the apps did not had any review at all, 752 distinct app reviews were collected. A total of around 162,250 app reviews were scraped.

3.4. Review Selection

Manually going through the 162,250 reviews to identify users' complain is a challenging task. We selected a representative statistical sample of reviews through a systematic process. The first step in the ‘Review Selection’ process was to select the app categories. The app categories were sorted in descending order according to the number of apps in each of them. The top ten Categories were: *Game, Entertainment, Tools, Photography, Maps and Navigation, Education, Lifestyle, Shopping, Video Players* and *Productivity*. The *Shopping* category did not have paid apps and *Productivity* category paid apps did not contain any reviews at all. To minimize bias, we skipped these two categories. Subsequently, from the selected categories, 8 apps (top 2 apps with highest number of reviews in each subcategory were chosen) from each category: (a) Two free apps of app score less than or equal to 3, (b) Two free apps of app score greater than 3, (c) Two paid apps of app score less than or equal to 3 and (d) Two paid apps of app score greater than 3 were chosen. Some subcategories apps did not have reviews. Hence a total of 66 apps with reviews were selected. After the selection of UAV apps, we proceeded to the collection of their reviews. Among all the reviews, the 4- and 5-star ratings mostly contain good remarks about the app and do not contain any information about bugs that is useful to the developer. Hence we filter the reviews that have a rating of below or equal to 3 alone for our study. These are the reviews that contain useful information such as functionality errors and complaints about the usage of the apps. Among all reviews, these accounted for about 51,475. Manual Classification of all the reviews is a tedious

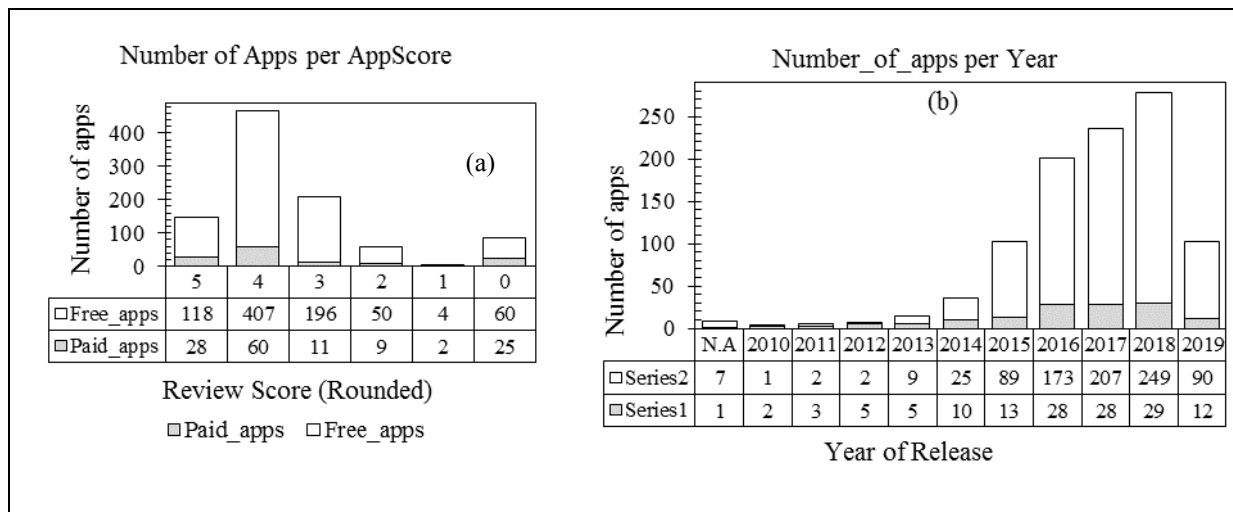


Fig. 1. (a) Number of Apps per Year; (b) Number of Apps per AppScore

and a time-consuming process. Hence we selected a random statistical representative sample of reviews [12] for each app and classified them alone manually. The sample reviews are selected to achieve a 95% confidence level and a 5% confidence interval [7]. We developed a python code that used selenium to access the sample size calculator and then saved the sample size on the database. We then extracted the sample size reviews from each app and started classifying them to their respective Complaint types. The total of all apps sample size came up to 4802 reviews, among which 1364 reviews had developer replies.

3.5. Review Complaint Types

The selected reviews have to be classified into their respective complaint types. An app user may complain about a lot of issues in their one review itself. Hence a review can be classified into more than one complaint type. We have to decide upon the set of overall ‘Complaint Types’ that can possibly exist. The complaint types that applied to our drone apps were discussed and decided upon referring to previous works. Thus, we came up with 27 distinct Complaint types for the reviews. They are as follows: additional cost, advertisements, app crash, battery, cellular data usage, connection & sync, cost, customer support, device compatibility, device storage, feature removal, feature request, functional error, installation problems, lack of functionality, missing notification, network problem, performance, privacy ethical, resource-heavy, spam notification, user interface/other issues, update/version issues, uninformative, uninteresting content, unresponsive and usability. We then added three more extra types which were not necessarily complaints but just users seeking or giving information. They are information seeking, information giving and problem discovery.

4. Exploratory Analytics

4.1. App per Year

Out of 970 apps, 8 apps did not have app release date data. So, on analysis of 962 apps, the Number of Drone or UAV apps had a steady increase over the years as shown in Fig. 1 (a). Also, the number of paid apps was slightly higher than the number of free apps, which changed drastically since the year 2013. The number of free apps released in one year reached a peak in 2018 with 249 free drone-related apps and 29 paid apps which occupies 25.6% of the total 970 drone-related apps (our dataset of total drone-related apps in Google Play Store till date – 2010 to 2019s). The number of drone-related apps was remarkably high in the years 2017 (232 apps) and 2018 (274 apps).

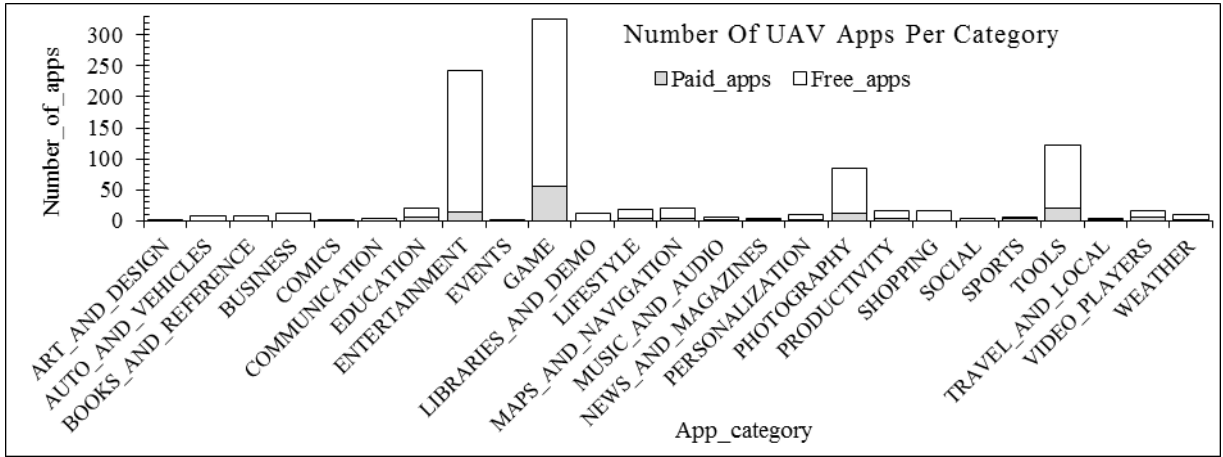


Fig. 2. Number of UAV Apps Per Category

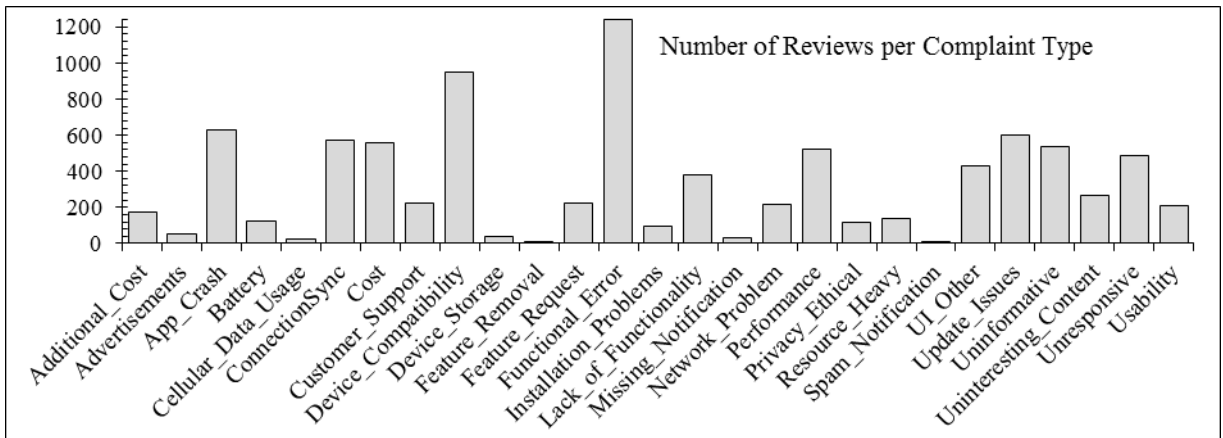


Fig. 3. Number of Reviews Per Complaint Type

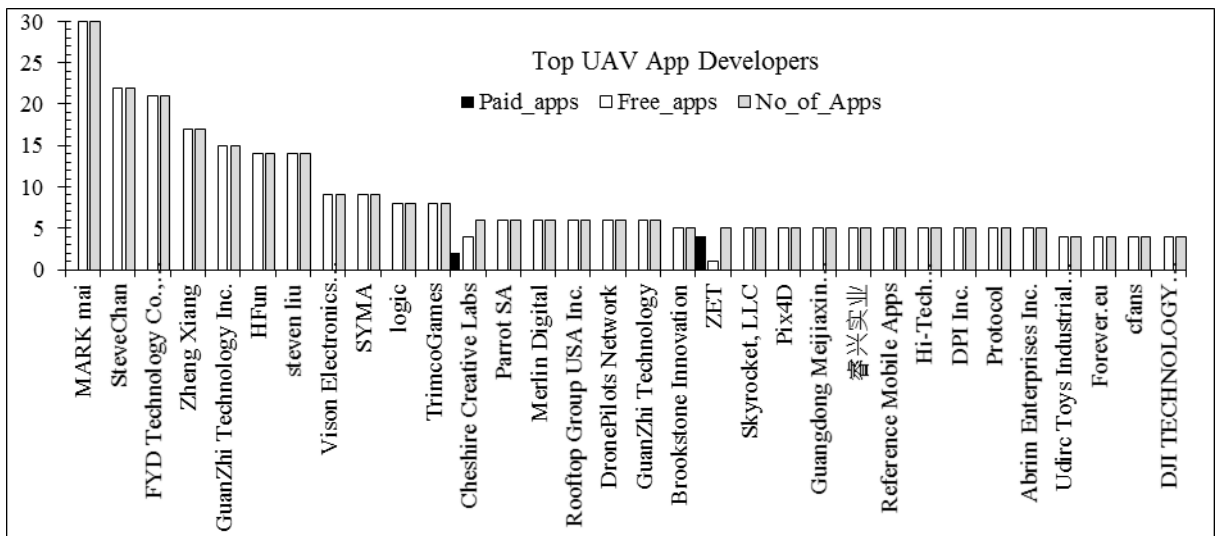


Fig. 4. Top Developers of Drone Apps

4.2. Apps per AppScore

We also wanted to find whether the majority of apps scored low ratings or high ratings. As can be seen in Fig. 1 (b), most of the apps have an average score of 4. The apps with a score of 5 had a very small number of installs.

4.3. Apps per Category

Out of 970 apps, apps fall under 25 categories of Google play store's explicitly defined 35 categories. As can be seen in Figure 2, most of the drone apps fall under Games, Entertainment and Tools categories. Apart from the above mentioned three categories, which were apps related to drone games or drone controller or drone simulation apps, drone supporting apps were found in the Photography category. Shopping category contained apps such as 'Drone Store' where users can buy drones at the lowest price online, get discount coupons for drones & drone products and also get a stream of aerial photos from around the world, view tutorials for DJI products and get to know about global events. Weather category contained apps to help users determine ideal conditions before flying a drone outdoors. For example, an App titled 'UAV Forecast for DJIQuadcopter UAV DronePilots' helps users view the weather forecasts, GPS satellites, solar activity, No-Fly Zones and flight restrictions.

4.4. Apps per Developer

The major developers of Drone Apps are listed in Fig. 4. An important thing to note is that all the major developer's apps are available for 'free'. Also, the top manufacturer may not necessarily be manufacturing a greater number of apps. The developers/manufacturers producing high-quality mobile apps have developed a few apps. For example, DJI (4 apps), Parrot (6 apps) and Yuneec (4 apps) have produced only a few apps but have proved to rule the industry by their quality of drones and apps.

5. Descriptive Analytics

After all the reviews in the sample size dataset are categorized into their respective complaint types, we proceeded to examine the results. As for the user reviews, the percentage of reviews in each complaint type was calculated. Thus, it can be seen from Fig. 3 that the most frequent complaints were Functional Errors, Device Compatibility, App crash, Update Issues and Connection/Sync Issues. The least frequent problems were Cellular Data Usage, Feature Removal, and Spam Notification. A summary of the reviews in each complaint type is provided below.

1. *Additional Cost*: This complaint type occurred mostly in the 'Game' category of apps. Customers complaining about additional costs often mention that the app is free initially but later has too many in-app purchases which make it a "pay to win" type of game. Hence they say they quit playing in all.
2. *Advertisements*: This type also occurred mostly in game apps. Generally, users do not like to waste time seeing ads. Some users complain that the ads are too many and continue even after buying an in-app purchase to remove it. *App Crash*: App crashes occurred mostly in explicit drone apps. These include drone controller apps such as 'Video Players', 'Entertainment', 'Photography' & 'Education'. Most complaints were of the app crashing when trying to fly or as soon as they open the app. A certain number of the users mention that the app crashes particularly on their device (for particular hardware or OS). Also, for the case where the app crashed during mid-flight, it caused their drone to drift off without control (RTH also fails) causing the drone to hit and fall. Hence users tend to question the reliability of the app. Almost 13% of the complaints were about the app crash. In some instances, users actually appreciated the features of the app and felt that they would have given a 5-star rating only if the app did not have crashing issues.
3. *Battery*: Customers complain about their mobile battery being drained very soon when using their app. They also specify that the app has some services that run in the background even after closing the app which might

have consumed more battery. Whereas, a few have about drone battery problems. They mention that the drone battery was fully charged but drops immediately to a dangerously low level as soon as the drone takes off.

4. *Cellular Data Usage*: Only 0.54% of the complaints are of this category. In these, the users complain that the app sends a lot of mobile data in the background, though the users are not aware of what data is being communicated since it is out of control. Few others say that they are able to connect to their drone only after switching off mobile data.
5. *Connection/Sync*: Nearly 12% of customer complaints are about connectivity or sync issues. They state that they were unable to connect to the drone or lost connectivity/sync during flight disrupting the video feed or telemetry data transmission.
6. *Cost*: Users criticize the app cost. Most of the people for whom the app did not work, demanded a refund. According to some other users, even though the app works fine, they feel as though the app is not worth the amount of money they paid. Few also mentioned that similar apps with the same kind of functionalities were available for free and the paid apps were not worth the cost.
7. *Customer Support*: The google play store customers complain about the support not being available for the app when they reach out for help. While some reviews suggest that the support is taking too long to respond, some say they did not receive a response at all. Few users have also complained about customer support being very unprofessional in their response behavior.
8. *Device Compatibility*: This complaint type occupies a significant 19.74% in the percentage of overall complaints. Users either complain about the app not being compatible with their phone or their operating system. It is evident from the reviews that these incompatibility problems might have risen due to OS version updates, such as the user upgraded their android OS and then the app stopped working or it could be a hardware incompatibility such as the app not supporting for the particular mobile model. The users were able to identify these by testing the app in different android OS versions and on different mobile phones. Many reviews also stated that the iOS version of the same app was working marvelously while the android version was a complete failure, suggesting the developers to improvise their support for android devices.
9. *Device Storage*: Very less feedback 0.81% is about device storage problems. User has either complained that the app is too huge in size and takes too much storage space (resource-heavy) on their phone or that the app fails to recognize the space and throws a no storage space error message when trying to store videos or images the drone was capturing. This complaint type occurred mostly in entertainment, video players & photography. Feature Removal: is one of the least complained about the topic. The feedbacks were about the user not being fond of specific features and suggesting developers remove it from the app. Some reviews complained about the feature that they liked being removed in successive updates.
10. *Feature Request*: Customers provide suggestions asking for some features to be added to the app. Some users request the app to support more varieties of drones, while some others ask for features like making trial versions available for the app. A few others mention the conversion of units such as temperature units being only available in F units and suggest that it would be nice to flip between units such as Celsius or Fahrenheit. Some people also have asked to improve their app to support more altitude in drone flights.
11. *Functional Error*: Most of the feedback belongs to the category of functional errors. 25.86% of the total reviews belong to this complaint type (the highest percentage among all complaint types). Users complain about some feature not functioning or working properly. For example, “Video recording on my galaxy s8 but no sound” review complains about the audio feature not functioning in the app. Many users have also mentioned log in issues such as not able to get past the login page, authorization and registration issues.

6. Threats to Validity

We chose to analyze Android apps because there are readily available APIs to mine the Google Play store. Our study was apps that are visible to US customers only. Our selection of mobile apps excluded mobile apps with a lesser number of downloads & reviews and reviews of 4-star and 5-star ratings since the paper focus only on negative feedback to study what users complain about drone apps. Hence, it is unclear how our results will generalize to all mobile apps. We used publicly available APIs to mine the Google Play market. Hence, we could not thoroughly evaluate the accuracy of the crawling API. The reviews of the drone app are tagged manually into their respective complaint types. During this process, human error or subjectivity may have led to incorrect tagging. This threat was addressed by random inspection and the corresponding tags by the second and third authors of this article. Also, the paper does not identify the stakeholders and categorize the drone app user complaints accordingly.

7. Future Work

We propose to accomplish the following tasks in the future: a) Identifying the stakeholders of the reviews and perform review analysis on the individual stakeholder perspective. b) Perform similar review analysis on UAV or drone-related apps of other mobile app platforms. c) Apply machine learning on the manually categorized user reviews dataset to enable the automatic classification of upcoming new user feedback into their respective complaint types, since it is a tedious process to classify the reviews manually.

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