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Application of the Spherical Fuzzy DEMATEL Model for Assessing the Drone Apps Issues

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Mamta Pandey, Ratnesh Litoriya, Prateek Pandey

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Abstract:
During the past few years, the number of drones (unmanned aerial vehicles, or UAVs) manufactured and purchased has risen dramatically. It is predicted that it will continue to spread, making its use inevitable in all walks of life. Drone apps are therefore expected to overrun the app stores in the near future. The UAV's software is not being studied/researched despite several active research and studies being carried out in the UAV's hardware field. A large-scale empirical analysis of Google Play Store Platform apps connected to drones is being done in this direction. There are, however, a number of challenges with drone apps because of the lack of formal and specialized app development procedures. In this paper, eleven drone app issues have been identified. Then we applied the DEMATEL (Decision Making Trial and Evaluation Laboratory) method to analyze the drone app issues (DIs) and divide these issues into cause and effect groups. First, multiple experts assess the direct relationships between influential issues in drone apps. The evaluation results are presented in spherical fuzzy numbers (SFN). Secondly, we convert the linguistic terms into SFN. Thirdly, based on DEMATEL, the cause-effect classifications of issues are obtained. Finally, the issues in the cause category are identified as DI's in drone apps. The outcome of the research is compared with the other variants of DEMATEL, like rough-Z-number-based DEMATEL and spherical fuzzy number, and the comparative results suggest that spherical fuzzy DEMATEL is the most fitting method to analyze the interrelationship of different issues in drone apps. The findings revealed that highest influenced values feature request (DI_9) 3.12, Customer support (DI_6) 2.91, Connection/Sync ((DI_4) 2./72, Cellular Data Usage ((DI_3) 2.51, Battery (DI_2) 2.31, Advertisements ((DI_1) – 0.3, Cost (DI_5) – 0.5, Additional cost (D_{11}) – 0.5, Device Compatibility (DI_7) – 0.96, and Functional Error (DI_{10}) – 1.2. The outcome of this work definitely assists the software industry in the successful identification of the critical issues where professionals and project managers could really focus.

Keywords: *Drone apps, Issues, Multi-criteria decision making, Spherical fuzzy DEMATEL.*

1. Introduction

As the name suggests, an unmanned aerial vehicle (UAV) is an aircraft that does not have any human pilot on board [1]. Software-controlled flight plans in embedded systems, together with onboard sensors and GPS, allow drones to be navigated from the ground [2]. A majority of small UAVs employ lithium-polymer batteries, while bigger vehicles are powered by plane engines [3]. Cameras are available on several of these drones, allowing the operator to record video or take photos [4]. Licensed pilots are in charge of these drones. Many people like flying drones as a hobby. Drones are also capable of carrying a wide variety of sensors and can go to places where most IoT devices cannot. Predicting the weather, replacing traffic cameras, spotting forest fires, scanning buildings and landscapes for agricultural and structural health monitoring, and conducting search and rescue operations are just some of the many uses for drones [5].

There has been an explosion of drone mobile apps since the introduction of smart drone technology, which allows drones to communicate with onboard computers, data collection devices, smartphones, and the cloud [6]. These programs can be used to control and navigate drones, as well as provide a variety of applications that can be used to perform complex tasks autonomously [7]. There has been an increase in mobile app distribution platforms like the Google Play store and the IOS store as a result of the increasing availability of free and open software development kits and online APIs for drone hobbyists. By 2028, the drone mobile app market is anticipated to be worth USD72320 million [8]. Drone software is a new topic that demands extensive research, yet there are no earlier works on drone apps for the App Store. In this article, a significant number of Google Play Store drone apps will be studied [9, 10]. The paper's goal is to identify the most common complaints from mobile drone app users, as well as the developer's response and the time it takes to respond.

Mobile app development is a very new and vibrant field compared to traditional software development, which is a fairly mature industry [11, 12]. The size, cost, time required for development, and user interface specifications for mobile apps are also different from those for traditional software [13]. Because of this, traditional methods of software development are inappropriate for creating mobile applications. This issue is made worse by the lack of formal methodologies for app development. However, many of the app analytics offered thus far are not software-engineering focused. On the other hand, recognizing the causes and effects that affect the mobile app rating can give project managers a clear understanding of this strategy and assist them in making decisions under pressure [14, 15].

The current situation causes a number of problems with the creation of apps. Users of the apps have reported these problems on associated distribution sites. Recent studies have focused on app difficulties based on user feedback or experiences, which can provide significant information, such as complaints about functionality, privacy concerns, feature requests, and so on [16, 17].

The issues with the drone app form an interconnectivity since these issues are connected to one another and have an effect on the ratings of the app. It's possible to employ a strategy that involves collective decision-making in order to figure out how these difficulties are connected to one another. Due to the inherent difficulties of human experts in communicating their thoughts or their choices, the linguistic analysis of the decisions made by experts is preferable when measured quantitatively. To overcome the inherent ambiguity associated with language, a fuzzy variant of DEMATEL for group decision-making is used. It helps in classifying drone app issues in cause-and-effect groups, to help project managers improve the quality of their decision-making. The spherical fuzzy-DEMATEL approaches have been used to solve the complex group decision-making problems such as strategic planning, e-learning evolution, and R & D [18, 19].

This paper is further organized as follows: Section 2 describes the literature review on software engineering for mobile user reviews and the associated issues in the context of drone apps. Section 3 describes the research methodology. Section 4 elaborates the experimental setup. The research process is discussed in Section 5. Results are discussed in Section 5. Section 6 describes the threats to validity, and Section 7 contains the conclusion and scope of future work.

2. Literature Survey

Two subsections make up the literature review: work that leveraged mobile user reviews, and work focusing on drone apps.

2.1. Work Leveraging Mobile User Reviews

Research on mobile app reviews was pioneered by Harman et al. [11]. In this paper, the author has investigated the correlation between user reviews and number of downloads. They concluded that developers should keep an eye on their user ratings, since they have a substantial association with the amount of downloads. Finkelstein et al. used natural language processing (NLP) tools to examine the link between an app's customer rating, its pricing, its popularity (based on downloads), and the promised attributes retrieved from each app's description [12]. Researchers observed a substantial link between app popularity and customer ratings, as well as a modest link between app pricing and features promised [13].

User reviews were mined for information by researchers in other studies. A study by Nikolas et al. examined low-rated user evaluations of iOS apps in order to assist mobile app developers better understand their behavior [14].

According to their research, the most common causes for bad reviews were demands for new features, functional issues, and applications that crashed, whereas privacy and ethical concerns accounted for the majority of the evaluations that had the greatest influence on an app's rating. In another study, research has examined the influence of privacy and ethical issues on the user evaluations of 59 Android applications [15]. According to their research very small quantity of the apps have privacy and ethical issues. Hoon and Vasa [16, 17] examined the vocabulary of 8.7 million user reviews from the iTunes Store and found a correlation between review length and the rating it received from the reviewers. In another work, Latent Dirichlet Allocation (LDA) was used to analyze more than 12 million user reviews of over a hundred thousand applications in the Google Play Store [18]. In addition to uncovering 10 distinct concerns, they also discovered a major difference between free and paid applications, since premium apps commonly provide a complaint issue concerning the related cost, which is missing in user evaluations of free ones. NLP methods were used to automatically extract the most useful evaluations from a database of mobile applications [19]. Only 35.1% of the app reviews included useful information that developers may utilize for app enhancement, since the number of reviews is sometimes too vast for humans to read or comprehend. Thus, their methodology automates a technique for filtering, grouping, ranking, and visualizing just the relevant parts of the evaluations. Up to 30% of mobile app evaluations may include various themes of information; McIlroy et al. suggested an automated technique for categorizing user reviews, which attained an accuracy of 66% and a recall rate that was 65% for 13 distinct categories [20]. Recent research by McIlroy et al. (2015) found that after a response to an app review, users would boost the review rating 38.7% of the time by 20% [21]. Using NLP, text analysis, and sentiment analysis methods, Panichella et al. suggested a taxonomy of four categories relevant to software maintenance and evolution activities in order to identify app user evaluations, and a method to automatically classify them [22].

The authors used machine learning to integrate these approaches and tested their classifiers experimentally, demonstrating that their method may help developers glean information about user intent from feedback [23]. A program called ARdoc automates the categorization of user reviews. Three real-world mobile app developers and an outside software engineer verified the tool's performance. With accuracy, recall, and F-Measure scores ranging from 84% to 89%, ARdoc performed well [24]. Users' evaluations of mobile applications may be analyzed using a model called User Reviews Model (URM), which was developed by Di Sorbo et al. [25].

It was used in conjunction with Panichella et al. to create Summarizer of User Reviews Feedback (SURF), a novel method for capturing the intent of user reviewers [26]. In order to propose software improvements, SURF creates summaries from sets of user reviews and groups them based on both, the goal and the subjects discovered in user reviews.

In another study, 17 mobile applications were tested by 23 developers and researchers to see whether this method worked. Further, Di Sorbo et al. designed and verified SURF to help developers automate the handling of user reviews. Recently, a mobile-specific taxonomy was developed by manually analyzing 1,566 user evaluations from 39 mobile applications conducted by Ciurumelea et al. Using the URR (User Request Referencer) methodology, the authors developed a method for automatically classifying user reviews in their multi-level taxonomy and then directing developers to the specific artefacts that must be adjusted to answer a given user review, as well. They found that processing user reviews by hand might be sped up by up to 75% [27]. As an alternative technique, Palomba et al. developed CHANGEADVISOR, which gathers together various user evaluations that include change requests and recommends to developers which artefacts to edit in a mobile app in order to meet user input [28]. In this method, reviews are sorted by their content, semantics, and structure using Natural Language Processing (NLP). A validation with the creators of ten mobile applications has shown the utility of this technique for mining huge numbers of user reviews, delivering 81% accuracy and 70% recall when advising modifications. This validation was carried out. Additionally, there are several additional mobile app projects that make use of user evaluations to improve their work. However, Martin et al. has compiled a thorough collection of research on mobile applications, and we encourage the reader to check it out [29].

2.2. Drone Apps Issues

The creation of drone applications must inevitably involve some form of software development that is equally applicable to the creation of mobile applications. The elicitation of the requirement is indicated to be of utmost importance in the context of the development of drone apps from the perspective of requirement engineering [23]. As a preface, we'll go over the typical scenario of a drone app being developed in the software business, followed by a discussion of relevant literature on drone apps.

In this article, we describe an approach for the systematic examination of issues that makes use of the collaborative efforts of groups of people and collective decision-making. It gives a distinct viewpoint by recognizing the reciprocal interaction among concerns, which, in turn, would aid in comprehending the causal relationship that exists between the issues that have been recognized. It would, in turn, aid in comprehending the causal relationship among the issues that have been found.

As the foundational technology upon which to construct our analysis, we make use of Spherical Fuzzy-DEMATEL in addition to other variations of DEMATEL, such as Rough-Z – number based-DEMATEL. The Spherical Fuzzy-DEMATEL approach is a well-established way for determining the interconnections that exist between the many issues or components that are present in a certain setting. This strategy has been implemented in a variety of professional fields, including management, mechanical engineering, chemical engineering, and software engineering.

As of right now, not a single researcher has given any attention to its use in the area of drone app development. Research has shown that drone app development is a relatively new area compared to other forms of software development. The quality of a drone app may be determined by the number of complaints/issues it is exposed to. The more flaws a drone app has, the worse its quality. We've seen how the Spherical Fuzzy-DEMATEL approach may be used in a variety of contexts and believe it's appropriate for use here in analyzing the interrelationships between various aspects of drone apps. The list of issues in drone apps are presented in Table 1.

The DEMATEL method focuses on analyzing the interrelationships between variables and identifying the crucial ones using a visual structural model. Numerous researches on the use of DEMATEL have been conducted in the last ten years, and numerous distinct variations have been proposed in the literature. DEMATEL analyses provide better outcomes than existing methods. Interpretive structure modeling, structure equation modeling, and so on, cannot perform this task.

3. Methodology

Drone app issues are a difficult challenge to solve since there are so many interconnected concerns. This means that a multi-criteria decision-making (MCDM) approach is needed to evaluate drone app concerns, since it takes compromises and competing objectives into consideration. Interpretive structural modelling (ISM) and analytical hierarchy process (AHP) are two of the most often utilized MCDM methodologies in research. The DEMATEL technique is superior to other multi-criteria decision-making techniques such as ISM and AHP because it provides an overall degree of influence of factors or issues, it divides the factors into cause-and-effect groups, and it establishes causal relationships [30].

Additionally, the DEMATEL technique provides an overall degree of influence of factors or issues. The incorporation of fuzzy logic into the DEMATEL methodology accounts for the hazy and imprecise information that is inherently associated with human judgements [31]. The problem of drone apps is investigated using the Spherical Fuzzy-DEMATEL methodology in this particular piece of research. A number of different industries, including management, information technology, and manufacturing, have all made use of the combination of Spherical Fuzzy-DEMATEL [32].

Table 1. List of issues in drone apps [39–41]

S. No.	Drone apps issues (DI)	Description & references
1	Advertisements (DI_1)	This type was also prevalent mostly in mobile games. Ads are a waste of time for most people. After purchasing an in-app purchase to eliminate the adverts, some users say that the ads persist.
2	Battery (DI_2)	Users of the app report that their smartphone battery drains quickly. Some services may have been running even after the app was closed, using more battery power. However, a few people have reported issues with drone batteries. While the battery was completely charged, it dropped to a dangerously low level as soon as the drone took off, according to the report.
3	Cellular Data Usage (DI_3)	In the background, the app transmits a lot of mobile data, but the user is unaware of the content since the app is not under their control. Some users report that they can only connect to their drone after turning off mobile data.
4	Connection/Sync (DI_4)	Drone connection issues or loss of sync during flight have been reported by certain users, resulting in a loss of live streaming video feeds and/or telemetry data.
5	Cost (DI_5)	The price of the app is a point of contention among users. The majority of those who were unable to use the software requested a refund. The software works OK, but some customers say it's not worth the money they spent for it, even if it does what it says. According to a few, the premium applications were not worth the money since there were free alternatives with equal features.
6	Customer support (DI_6)	Customers of the Google Play Store complain about the lack of assistance for the app when they contact the company. In spite of a few negative reviews, customer service appears to be doing a good job. According to some, they didn't get a reply at all. Some customers have also expressed dissatisfaction with customer service. There are reports of customer service responding in a manner that smacks of incompetence.
7	Device Compatibility (DI_7)	The app's lack of compatibility with a user's phone or operating system is a common complaint. These compatibility issues may have arisen due to OS version upgrades, such as when a user changed their Android OS and the app stopped operating, or it might be a hardware incompatibility, such as the app not supporting a certain cell model.
8	Device Storage (DI_8)	Users have reported that the software is too large and takes up too much space on their phone, or that it fails to identify the space and produces a no storage space error message while attempting to save drone-captured films or photographs. This criticism was largely about entertainment, video players, and photography. Feature removal is seldom criticized. Users disliked some software features and suggested removing them. Some reviewers complained that a favorite feature was eliminated.
9	Feature request (DI_9)	Requests for new features from customers are solicited. Users want the app to be able to handle a wider range of drones, while others want to be able to download trial versions of the software.
10	Functional Error (DI_{10})	Many users have expressed dissatisfaction with the way some features operate or don't work at all. "Video recording on my Galaxy S8 but no sound" review complains about the audio functionality not working. Authorization and registration difficulties, as well as not being able to go beyond the login screen, have all been reported by several users.
11	Additional cost (D_{11})	The user complains about the hidden cost to enjoy the full experience of the app.

In this article, we discuss a technique for evaluating the aspects that affect whether or not a drone application is successful. The methodology is illustrated in Figure 1 and explanation of of each major stage of this methodology is given.

Acquisition (A): In order to discover areas for improvement, it is necessary to collect data so that we can run several quantitative and qualitative procedures to acquire a better understanding of the situation.

Identification (ID): Data collected in "A" is critical to identifying potential issues which affect the app rating. We will conduct quantitative and qualitative data analysis based on the collected data. Data can also be converted from a qualitative to a quantitative form.

Relationship Analysis (RA): The number of issues that have been detected in "ID" can range from a few to a significant number.

It is expected that no problems will arise as a result of one's independence and isolation from others. In other words, a problem will have an impact on, or may have an impact on, a number of other problems. As a result, it is critical to do thorough research in order to find connections between issues.

Interpretation (I): It is possible to draw conclusions from the "RA" analysis.

4. Experimental Setup

Section 3's methodology is used to put up an experiment in this section.

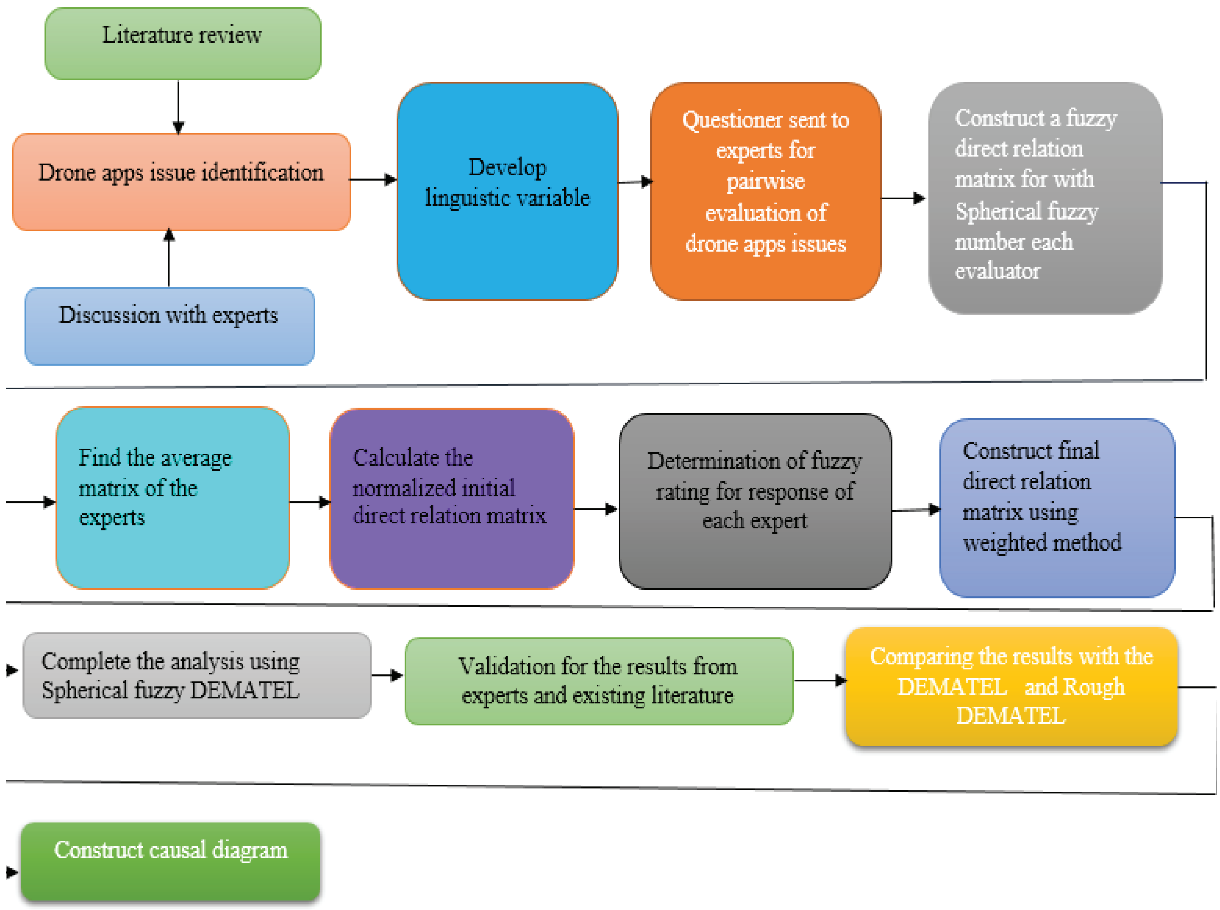

Figure 1. Proposed framework of our research study

4.1. Data Collection and Text Processing

We gathered user feedback on a variety of drone apps by polling various online forums. Nearly 120,000 user reviews were gathered. About 45% of all reviews were determined to be useful after the text cleaning procedure. Consequently, there were around 50,000 reviews available for study. We then used Radian 6, a social media listening tool, to do text processing on certain chosen keywords in order to identify distinct types of customer complaints in various mobile application categories.

After that, we grouped comparable types of user complaints into problems. Information sources and text-processing tools are outlined in the following sections:

1) Collection of user reviews: We gathered customer/users feedback from a variety of app shops, including the Google Play Store, BlackBerry App Store, and others.
2) Filtration of non-English terms and slang: Words like ”kool,” ”nhi,” etc. were cleaned up after going through this process.
3) Text processing: In order to parse the text of testimonials, POS tagger and word2vec are applied. For example, after filtering and analyzing the data, we discovered that terms like ”the battery,” ”slow,” ”login,” ”hot,” and so on occurred rather often.

4.2. Issues Identification

After applying clustering methods to the text data, we found that all of the words that were examined could be classified, in a general sense, as belonging to one of the 11 categories of problems shown in Table 1. For instance, the term “request” refers to an absent feature (the request for a new feature), while the keyword “drain” is associated with the consumption of the user’s battery (energy consumption issues). It has been revealed that these problem categories are compatible with findings from past research carried out in the field of mobile app development.

4.3. Issues Relationship Analysis

To put it another way, issues don’t just appear on their own; they interact with one other. Creating a system without boundaries is practically impossible. There must be some sort of a tradeoff in order to execute drone software well, and this can be altered to suit the needs of different app types and goals. Because of this, it is critical to comprehend the interrelationships between various types of issues.

To identify the issues and other factors that affect the system, Fuzzy-DEMATEL employs an expert opinion-based approach [8]. We used the eight-step DEMATEL method to examine the impact of app issues on each other. First and foremost, we need to identify the problems, which we've done in Section 4.2; however, the problems that we've discovered are in line with those that have been reported in other studies, as shown in Table 2.

When it comes to mobile app issues, we used Spherical Fuzzy-DEMATEL and compared the results to other DEMATEL variants, such as DEMATEL and DEMATEL. Sections 4.4, 4.5, and 4.6 describe the DEMATEL, Spherical Fuzzy-DEMATEL, and rough-Z-number–based DEMATEL, respectively. Section 4.8 illustrates how Spherical Fuzzy-DEMATEL can be used to address the problems that have been identified.

4.4. DEMATEL

Fontela and Gabus invented the DEMATEL approach (the methodology of the Decision-Making Trial and Evaluation Laboratory) [33]. This is an efficient way to examine the direct and indirect relationships between the components of a complex system [34]. The foundation of DEMATEL is graph theory, which allows for an efficient analysis of all system relations as well as the construction of a map between various systems components [35]. The interdependence between components may be better understood by studying the total-relation matrix [36]. There are several domains where DEMATEL has been effectively used, including supply chain [37], risk assessment [38], service quality analysis [39], management [40], and so on. The fundamental phases of the DEMATEL technique for making judgments in evidence theory are as follows, laying the groundwork [41]:

Step 1 – Prepared pair-wise comparison scale

Step 2 – Construction of initial direct relation matrix

Step 3 – Construction of normalized direct relation matrix

Step 4 – Construction of total relation matrix

Step 5 – Separation of sum of row and sum of columns in total relation matrix

Step 6 – Calculation of prominence and relevance vector

Step 7 – Analysis of interrelationship

4.5. Rough-Z-number

A rough-Z-number is proposed to combine the advantages of the Z number and the rough number in order to improve the manipulation capability of uncertainty, reliability, and subjectivity for MCDM applications [42]. This is motivated by the Z-number's advantage in representing individual risk assessment's uncertainty and reliability and the rough number's advantage in manipulating subjectivity among different evaluation values [43]. The Z-number is introduced to replace the fuzzy part of the fuzzy rough number in the Z-number [44]. Alternatively, the Z-number and rough number can be integrated into it. In general, a Z-number is an ordered pair of fuzzy numbers; however, this is not always the case. It can be denoted by the symbol $z = (\tilde{A}, \tilde{B})$ [45, 46]. Initially, as a fuzzy constraint on the values, component $\tilde{A}$ is used, whereas component $\tilde{B}$ is a measure of reliability for component A. As a result, component B is used as a measure of reliability for the initial component $\tilde{A}$.

In the following example, a Z-number is translated into a classical fuzzy number, which is detailed below.

$$\alpha = \frac{\int a\mu\tilde{B}(a)da}{\mu\tilde{B}(a)da} \tag{1}$$

Where $\int$ symbol indicates an algebraic integration. A weighted Z-number is calculated by multiplying the dependability component by the restriction component. The irregular fuzzy number can be converted into regular fuzzy number as following –

$$\tilde{z} = \left\{ < a, \mu_z(a) > | \mu_z(a) = \mu_z\left(\frac{a}{\sqrt{\alpha}}\right), a\epsilon[0,1] \right\} \tag{2}$$

4.6. Spherical Fuzzy Sets (SFS)

The following is a summary of certain terminology and fundamental operations that are necessary for the present research. The References section contains descriptions of all of the operations that were created for SFSs [47].

Definition 1: An SFS $\tilde{A}_s$ for the universe of discourse X may be found by using the formula:

$$\tilde{A}_s = \{(A, \mu_{\tilde{A}_s}(A), \vartheta_{\tilde{A}_s}(A)\ \pi_{\tilde{A}_s}(A) | a\epsilon A)\} \tag{3}$$

Where

$$\mu_{\tilde{A}_s}(a) = A \to [0,1],$$

$$\vartheta_{\tilde{A}_s}(a): A \to [0,1] \pi_{\tilde{A}_s}(a): A \to [0,1]$$

And

$$0 <=, \mu^2_{\tilde{A}_s}(a) + \vartheta^2_{\tilde{A}_s}(a) + \pi^2_{\tilde{A}_s}(a) <= 1 \forall\ a\ \epsilon\ A$$

For each a, $\mu_{\tilde{A}_s}$, $\vartheta_{\tilde{A}_s}$ and $\pi_{\tilde{A}_s}$ are referred to as the membership degree and the hesitancy degree of a to $\tilde{A}_s$. Some numerical operations were constructed by studying the relationships between SFS and Pythagorean fuzzy set (PFS).

Definition 2: Let A_1 and A_2 be two distinct universes, respectively, and $\tilde{X}_s = (\mu_{\tilde{X}_s}, \vartheta_{\tilde{X}_s}, \pi_{\tilde{X}_s})$ and $\tilde{Y}_s = (\mu_{\tilde{Y}_s}, \vartheta_{\tilde{Y}_s}, \pi_{\tilde{Y}_s})$ be two different spherical fuzzy sets from the universe of discourse D_1 and D_2. The fundamental operations are described below.

$$\tilde{X}_s \oplus \tilde{Y}_s = \{(\mu^2_{\tilde{X}_s} + \mu^2_{\tilde{Y}_s} - \mu^2_{\tilde{X}_s}\mu^2_{\tilde{Y}_s})^{1/2}, \vartheta_{\tilde{X}_s}\vartheta_{\tilde{Y}_s}, ((1-\mu^2_{\tilde{Y}_s})\pi^2_{\tilde{X}_s} + (1-\mu^2_{\tilde{X}_s})\pi^2_{\tilde{Y}_s} - \pi^2_{\tilde{X}_s}\pi^2_{\tilde{Y}_s})^{1/2}\} \tag{4}$$

Multiplication:

$$\tilde{X}_s \otimes \tilde{Y}_s = \{\mu_X\mu_{\tilde{Y}_s}, (\vartheta^2_{\tilde{X}_s} + \vartheta^2_{\tilde{Y}_s} - \vartheta^2_{\tilde{X}_s}\vartheta^2_{\tilde{Y}_s})^{1/2}, ((1-\vartheta^2_{\tilde{Y}_s})\pi^2_{\tilde{X}_s} + (1-\vartheta^2_{\tilde{X}_s})\pi^2_{\tilde{Y}_s} - \pi^2_{\tilde{X}_s}\pi^2_{\tilde{Y}_s})^{1/2}\} \tag{5}$$

We can define spherical weighted arithmetic mean (SWAM) for aggregation purpose as follows:

V = (v_1, v_2,...V_n) where v is defined as a weight and $v_i\ \epsilon\ [0,1]$ and $\sum_{i=1}^{n} v_i = 1$

$$SWAM_v = v_1\tilde{X}_{s1} + v_2\tilde{X}_{s2} + \cdots v_n\tilde{X}_{sn} \tag{6}$$

Table 2. Language (linguistic term) and spherical fuzzy numbers

Linguistic term	Abb	μ	ϑ	π	SI
No influence	NI	0	0.3	0.15	0
weak	W	0.35	0.25	0.25	1
Moderate	M	0.6	0.2	0.35	2
Strong	S	0.85	0.15	0.45	3

4.7. Spherical Fuzzy-DEMATEL

In traditional DEMATEL [48], experts' hesitation is ignored. This is the first time that the Spherical Fuzzy version of DEMATEL [49, 50] has been described in the literature for tackling this issue [51]. As a demonstration of the method's applicability, a case study is provided in the following section.

Step 1: Attribute identification and selection of subject/ area expert

Assumptions are made that there are m specialists in the field of decision-making who will weigh in on the issue, as well as other factors that should be taken into account. It's important to understand the decision-makers' degrees of competence and the rationale for their selection. In the same way, the selection of attributes should be justified, for example, by citing scientific studies in the linked literature or using them in real-world industrial scenarios. There should be an adequate representation for each attribute that contains sub-attributes.

Step 2: Construction of direct influence matrix

An expert, or decision-makers, are questioned about their preferences or opinions on the effect of attributes on the decision-making process. The score index (SI) for corresponding values is described in the Eq. (7) [52]

$$\mathrm{SI} = \sqrt{|100 * [(\mu - \pi)^2 - (\vartheta - \pi)^2]|} \tag{7}$$

Step 3: Calculation of experts/decision maker's weight.

It is presumed that m decision-makers have his/her weight, which represents his/her experience and degree of knowledge. Spherical fuzzy describes the n^{th} expert presented their decision $D^n = (\mu_n, \vartheta_n, \pi_n)$ and weigh coefficient can be calculated by Eq. (8) [53]

$$\alpha_n = \frac{1 - \sqrt{\{(1-\mu_n)^2 + \vartheta_n^2 + \pi_n^2)/3}}{\Sigma_n(1 - \sqrt{\{(1-\mu_n)^2 + \vartheta_n^2 + B\pi_n^2)/3}} \tag{8}$$

Where $\sum_{n=1}^{m} \alpha_n = 1$ and $0 <= \mu_n^2 + \vartheta_n^2 + \pi_n^2 <= 1$.

Step 4: Calculation aggregation relation matrix T.

The spherical weighted arithmetic mean (SWAM) is used to combine the various decision-makers' direct impact assessment matrices. After this procedure, the result is the T matrix, which aggregates the direct influence matrix. T's matrix form may be found in Equation (9)

$$T = \begin{bmatrix} 0 & \mu_{12^T}, \vartheta_{12}^T, \pi_{12}^T & \cdots & \mu_{1n^T}, \vartheta_{1n}^T, \pi_{1n}^T \\ \mu_{21^T}, \vartheta_{21}^T, \pi_{21}^T & 0 & \cdots & \mu_{2n^T}, \vartheta_{2n}^T, \pi_{2n}^T \\ \cdots & \cdots & \cdots & \cdots \\ \mu_{n1^T}, \vartheta_{n1}^T, \pi_{n1}^T & \mu_{n2^T}, \vartheta_{n2}^T, \pi_{n2}^T & \cdots & 0 \end{bmatrix} \tag{9}$$

Step 5: Calculation of initial direct influence matrix.

The aggregated direct influence matrix (T) must be divided into three submatrices since there are three factors in each comparison. Depending on the degree of membership, non-membership, and uncertainty of the group being studied, distinct matrices may be used for matrix operations. It will be possible to generate the first matrix of direct impact by normalizing and recombining each of these matrices in the same matrix. In Equation, the normalizing procedure is carried out (10). In matrix form, the result of this step is indicated in Equation (10).

$$A^\mu = \begin{bmatrix} 0 & \mu_{12} & \cdots & \mu_{1n} \\ \mu_{21} & 0 & \cdots & \mu_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ \mu_{n1} & \mu_{n2} & \cdots & 0 \end{bmatrix};$$

$$A^\vartheta = \begin{bmatrix} 0 & \vartheta_{12} & \cdots & \vartheta_{1n} \\ \vartheta_{2n} & 0 & \cdots & \vartheta_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ \vartheta_{n1} & \vartheta_{n2} & \cdots & 0 \end{bmatrix};$$

$$A^\pi = \begin{bmatrix} 0 & \pi_{12} & \cdots & \pi_{1n} \\ \pi_{2n} & 0 & \cdots & \pi_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ \pi_{n1} & \pi_{n2} & \cdots & 0 \end{bmatrix} \tag{10}$$

Step 6: Calculation of total influence matrix (T_i).

$$T_i = \begin{bmatrix} (\mu_{11}, \vartheta_{11}, \pi_{11}) & (\mu_{12}, \vartheta_{12}, \pi_{12}) & \cdots & (\mu_{1n}, \vartheta_{1n}, \pi_{1n}) \\ (\mu_{21}, \vartheta_{21}, \pi_{21}) & 0 & \cdots & \mu_{2n^T}, \vartheta_{2n}^T, \pi_{2n}^T \\ \cdots & \cdots & \cdots & \cdots \\ (\mu_{n1}, \vartheta_{n1}, \pi_{n1}) & (\mu_{n2}, \vartheta_{n2}, \pi_{n2}) & \cdots & 0 \end{bmatrix} \tag{11}$$

Step 7: Computation of Spherical Fuzzy row and columns sums.

The sum of row and columns of Spherical Fuzzy numbers can be obtain by using Eqs. (12) and (13).

$$R_i = \Sigma_{i=1}^{n} (\mu_{ij^T}, \vartheta_{ij}^T, \pi_{ij}^T) \tag{12}$$

$$C_j = \Sigma_{j=1}^{n} (\mu_{ij^T}, \vartheta_{ij}^T, \pi_{ij}^T) \tag{13}$$

And Spherical Fuzzy numbers can be defuzzified by using Eq. (14)

$$S_d = (2\mu - \pi)^2 - (\vartheta - \pi)^2 \tag{14}$$

Step 8: Evaluation of prominence and relative vector and preparing network relation map

1) **Research Process:** The main flow of our study is depicted in Figure 1 and explained in detail afterward.

Application of Spherical Fuzzy-DEMATEL on Wearable apps issues analysis

Step 1: Attribute identification and selection of subject/area expert

Assumptions are made that there are m specialists in the field of decision-making who will weigh in on the issue, as well as other factors that should be taken into account. It's important to understand the decision-makers' degrees of competence and the rationale for their selection. In the same way, the selection of attributes should be justified, for example, by citing scientific studies in the linked literature or using them in real-world industrial scenarios. There should be an adequate representation for each attribute that contains sub-attributes.

Step 2: Construction of direct influence matrix

An expert or decision-makers are questioned about their preferences or opinions on the effect of attributes on the decision-making process.

Step 3: The decision-makers' competence and knowledge level are represented by the weights they are assigned. SF depictions of the decision-makers are provided $N_1 = (0.6, 0.2, 0.3)$, $N_2 = (0.7, 0.4, 0.1)$ and $N_3 = (0.5, 0.5, 0.5)$, Eq. (7) is used to calculate the weight coefficients. The weight of the first decision-maker is calculated as follows:

$$\alpha_1 = \frac{1-\sqrt{\{(1-0.6)^2+0.2^2+0.3^2)^{/3}}}{\left(1-\sqrt{\begin{array}{l}\{(1-0.6^2)^2+0.2^2+0.3^2)^{/3}\\ +(1-\sqrt{\{(1-0.7^2)^2+0.4^2+0.1^2)^{/3}}\\ +(1-\sqrt{\{(1-0.5^2)^2+0.5^2+0.5^2)^{/3}}\end{array}}\right.}$$

$$= 0.36$$

Similarly, we can compute weight of other decision makers.

Step 4: The aggregation relation matrix is calculated using Eq. (8)

$$\mu_{12}^{T} = \left[1-\prod_{n=1}^{10}(1-(\mu_{ij}^{n})^2)^{\alpha n}\right]^{1/2}$$

$$= 0.87$$

$$\vartheta_{12}^{T} = \prod_{n=1}^{10}\vartheta_{ij}^{n} = 0.25$$

$$\pi_{12}^{T} = \left[\prod_{n=1}^{m}(1-\mu_{ij}^{n})^2)^{\alpha 1} - \prod_{n-1}^{m}(1-\mu_{ij}^{n}) - \pi_{ij}^{n})^2)^{\alpha 1}\right]^{1/2}$$

$$= 0.48$$

We will now put into practice the steps of the approach that were outlined in Sections 3.1 and 3.2 in order to determine the extent to which certain mobile app issues are connected to one another, as follows:

Step 6: Prominence and relative vectors have been calculated. Sum of rows and columns of total relative matrix is known as prominence and relative vectors respectively [53].

Step 7: The values of prominence and relative vectors have been defuzzified using Eq. (14) and resultant values are mentioned in Table 7.

4.8. Assessment

Results have been examined using MAE (in Table 9), which provides a numerical measure of how closely two issues are related in terms of their prominence and relative vector. By calculating uncertainty and fuzziness, MAE is able to handle it.

$$\text{MAE} = \frac{1}{N}\sum_{i=1}^{N}|w_y^i - w_n^i| \qquad (15)$$

Where N represents the number of influencing issues, w_y^i represents the values of positive side of issues, w_n^i represents the value of negative side of issue.

Table 9 displays the issues MAE after being computed using both the positive (prominence) and negative (relative) sides of the argument. As a result, the lower MAE shows that issues calculated from both the positive and negative sides are more comparable, based on Spherical Fuzzy-DEMATEL, than rough Z number–based-DEMATEL and DEMATEL to determine the relationship between cause and effect.

To put it another way, SFN-DEMATEL has the ability to improve the overall well-being of a problem in mobile apps when compared to most existing solutions. Comparing SFN-DEMATEL to rough Z number–based-DEMATEL and DEMATEL, the latter is better suited to identify the issues in drone apps that inherently have a language assessment process since it better addresses subjectivity. SFN-DEMATEL was found to be more accurate than rough Z number based–DEMATEL and DEMATEL when it comes to identifying issues in drone app development.

4.9. Comparative Analysis of Spherical Fuzzy–DEMATEL with Rough Z Number–based DEMATEL and DEMATEL

There are a few studies on drone app development that have been offered in the literature. However, a handful of these strategies take into account the relationships between the most important issues in drone apps and explain why selecting the appropriate issue to improve is drone app.

Spherical Fuzzy-DEMATEL has the ability to obtain the whole relationship between influential concerns and identify the issues in a drone app, unlike existing approaches. The optimization of the drone app can be reduced to simply fixing the issues that the Spherical Fuzzy-DEMATEL has revealed.

Table 3. Expert evaluation on influences

	DI_1	DI_2	DI_3	DI_4	DI_5	DI_6	DI_7	DI_8	DI_9	DI_{10}	D_{11}
DI_1	**0**	M; S; M	M; M; W	M; M; M	M; S; M	S; S; NI	M; S; S	S; W; M	S; M; NI	M; NI; S	W; M; S
DI_2	S; S; NI	**0**	S; S; M	M; S; M	M; M; M	M; M; NI	M; S; M	M; M; NI	M; S; M	S; S; M	S; S; M
DI_3	M; NI; M	S; W; M	**0**	M; M; NI	M; S; M	S; M; M	S; S; NI	S; NI; NI	S; W; M	M; S; M	W; M; S
DI_4	S; S; M	S; S; NI	W; M; S	**0**	M; NI; M	M; S; M	W; M; S	M; M; M	W; M; S	M; M; NI	M; S; M
DI_5	M; M; M	M; S; M	M; NI; M	M; S; M	**0**	S; S; NI	S; S; M	M; S; M	S; S; M	M; M; S	W; M; S
DI_6	M; M; NI	W; M; S	S; W; M	S; S; NI	W; M; S	**0**	M; S; M	S; W; M	S; NI; NI	S; W; M	S; S; M
DI_7	S; W; M	S; S; M	S; NI; NI	M; S; M	S; W; M	S; S; M	**0**	S; S; M	S; S; NI	S; M; M	M; S; M
DI_8	M; M; S	M; S; M	M; M; M	M; NI; M	S; NI; NI	M; M; S	S; W; M	**0**	S; M; M	S; S; NI	M; S; M
DI_9	W; M; S	S; M; M	M; S; M	S; S; NI	S; S; M	M; S; M	M; NI; M	M; M; S	**0**	S; NI; NI	M; M; M
DI_{10}	M; S; M	M; M; S	S; M; M	W; M; S	M; S; M	M; M; M	S; NI; NI	W; M; S	M; NI; M	**0**	M; S; M
D_{11}	M; S; M	M; NI; M	M; S; M	M; M; NI	M; S; M	M; NI; M	M; S; M	M; S; M	M; M; NI	M; S; M	0

Table 4. Aggregation direct influence matrix

	DI_1	DI_2	DI_3	DI_4	DI_5	DI_6	DI_7	DI_8	DI_9	DI_{10}	D_{11}
DI_1	0	0.4236	0.2279	0.8751	0.5543	0.6181	0.7175	0.2465	0.9164	0.8109	0.9106
DI_2	0.5	0	0.3217	0.5571	0.2529	0.7134	0.9106	0.3903	0.4251	0.1965	0.8101
DI_3	0.476	0.7179	0	0.8664	0.8166	0.1261	0.8101	0.7206	0.8723	0.2529	0.2529
DI_4	0.672	0.8109	0.4251	0	0.3434	0.2279	0.3223	0.9202	0.6623	0.8166	0.8166
DI_5	0.7867	0.1965	0.5631	0.9164	0	0.2529	0.1261	0.6309	0.476	0.7134	0.3434
DI_6	0.4057	0.3263	0.8419	0.4251	0.3425	0	0.6212	0.6801	0.672	0.1261	0.8166
DI_7	0.601	0.2262	0.7451	0.2254	0.3255	0.8101	0	0.5235	0.8101	0.5571	0.672
DI_8	0.397	0.8102	0.1332	0.8723	0.1261	0.3255	0.2746	0	0.3223	0.8101	0.7867
DI_9	0.381	0.4215	0.7621	0.6623	0.1212	0.9201	0.2005	0.4262	0	0.3223	0.4057
DI_{10}	0.763	0.1604	0.7642	0.6523	0.1238	0.1238	0.3005	0.8016	0.7134	0	0.9202
D_{11}	0.8166	0.1965	0.8101	0.9106	0.8723	0.2529	0.7206	0.8723	0.8166	0.1261	0

Table 5. Total influence matrix

	DI_1	DI_2	DI_3	DI_4	DI_5	DI_6	DI_7	DI_8	DI_9	DI_{10}	D_{11}
DI_1	0	0.8664	0.8166	0.1261	0.8101	0.7206	0.8723	0.2529	0.8664	0.8166	0.6181
DI_2	0.473	0	0.4236	0.2279	0.8751	0.5543	0.6181	0.4236	0.7621	0.6623	0.7134
DI_3	0.243	0.3843	0	0.1261	0.3255	0.2746	0.1261	0.3255	0.2746	0.1261	0.8101
DI_4	0.541	0.449	0.1442	0	0.381	0.4215	0.7621	0.6623	0.1212	0.9201	0.3223
DI_5	0.1261	0.3255	0.2746	0.1261	0	0.763	0.1604	0.7642	0.6523	0.1238	0.1261
DI_6	0.6181	0.7175	0.2465	0.9164	0.8109	0	0.7175	0.412	0.2005	0.8166	0.9164
DI_7	0.7134	0.9106	0.3903	0.4251	0.1965	0.7134	0	0.2279	0.8751	0.4236	0.4251
DI_8	0.1261	0.8101	0.7206	0.8723	0.2529	0.1261	0.8101	0	0.2746	0.1261	0.6181
DI_9	0.2279	0.3223	0.9202	0.6623	0.8166	0.2279	0.3223	0.2746	0	0.1212	0.1261
DI_{10}	0.2529	0.1261	0.6309	0.476	0.7134	0.2529	0.1261	0.2005	0.2005	0	0.7621
D_{11}	0.7621	0.1212	0.4215	0.5543	0.7621	0.1261	0.8101	0.9201	0.3255	0.2746	0

Table 6. Computation of prominence and relational values

	r				c				r + c	r − c
	μ	ϑ	π	Score	μ	ϑ	π	Score		
DI_1	0.7435	0.0135	0.5651	1.0567	0.8312	0.0186	0.6	1.056	2.16	-0.3
DI_2	0.79	0.0196	0.5266	0.8723	0.8114	0.0167	0.6001	0.476	3.57	2.31
DI_3	0.831	0.032	0.5235	0.6181	0.8125	0.0176	0.6002	0.672	2.84	2.51
DI_4	0.7209	0.0184	0.4786	1.1264	0.8105	0.0166	0.6001	0.8101	1.97	2.72
DI_5	0.7177	0.0187	0.4886	0.397	0.8304	0.0186	0.6002	0.8419	2.95	-0.5
DI_6	0.3223	0.1261	0.9106	0.2529	0.2529	0.1261	0.8101	0.3255	2.77	2.91
DI_7	0.1261	0.2746	0.9106	1.8101	0.8166	0.6309	0.476	0.8419	1.98	-0.96
DI_8	0.1261	0.8664	0.9106	0.397	0.9106	0.3903	0.4251	0.2529	2.62	2.5
DI_9	0.3255	0.3255	0.2746	1.5623	0.9106	0.3903	0.4251	1.7664	2.21	3.12
DI_{10}	0.2529	0.2529	0.8664	0.5651	0.8664	0.8166	0.2746	0.6623	1.57	-1.2
D_{11}	0.7621	1.1264	0.2529	0.1261	0.6001	0.476	0.8101	0.2529	0.1261	-0.5

Table 7. Rank factors of cause and effect issues

Drone apps issues	Rank
DI_1	6
DI_2	5
DI_3	4
DI_4	3
DI_5	7
DI_6	2
DI_7	8
DI_8	5
DI_9	1
DI_{10}	9
D_{11}	7

Table 8. Cause-effect classification and ranking of issues using DEMATEL, Rough Z number DEMATEL and Spherical Fuzzy –DEMATEL

Category	DEMATEL	Rough Z number based DEMATEL	Spherical Fuzzy DEMATEL
Cause	DI_1	DI_9	DI_9
	DI_6	DI_6	DI_6
	DI_4	DI_4	DI_4
	DI_3	DI_3	DI_3
	DI_2	DI_8	DI_8
Effect	DI_{11}	DI_{11}	DI_{11}
	DI_9	DI_1	DI_1
	DI_5	DI_5	DI_5
	DI_7	DI_7	DI_7
	DI_{10}	DI_{10}	DI_{10}
	DI_8	DI_2	DI_2

Table 9. The MAE of issues importance calculated from positive side, negative side

	DEMATEL	Rough Z number DEMATEL	Spherical Fuzzy DEMATEL
MAE	0.32	0.29	0.15

As a result, optimizing these difficulties can have a positive impact on the overall success of drone apps.

Spherical Fuzzy-DEMATEL vs. rough Z number–based-DEMATEL: When attempting to describe linguistic phenomena, a fuzzy system is the most effective method, as opposed to a Rough z number based DEMATEL, which might lead to misunderstanding or misinterpretation.

Spherical Fuzzy-DEMATEL vs. DEMATEL: In the evaluation of linguistic words, the evidence theory is not well suited for hypothesizing that each component of a discernment frame must be mutually exclusive, even though both Spherical Fuzzy-DEMATEL and DEMATEL are capable of handling the subjectivity of expert evaluations.

Therefore, as compared to rough Z number–based DEMATEL and DEMATEL, Spherical Fuzzy-DEMATEL is more relevant to identification of the issues in drone apps which inherently have a linguistic assessment.

Table 10. Pair-wise comparison of the importance of DEMATEL, rough Z number–based DEMATEL, and Spherical Fuzzy-DEMATEL using the Spearman correlation coefficient

	DEMATEL	Rough Z number based DEMATEL	Spherical Fuzzy DEMATEL
DEMATEL	1	0.7708	0.8174
Rough Z number based DEMATEL	0.7709	1	0.7544
Spherical Fuzzy DEMATEL	0.8873	0.8709	1

This is because rough Z number–based-DEMATEL and DEMATEL do not take into account fuzzy logic.

Table 8 presents a cause-and-effect breakdown of various issues using Spherical Fuzzy-DEMATEL, rough Z number–based DEMATEL, and DEMATEL as a basis. Drone app issues identified by Spherical Fuzzy-DEMATEL, rough Z number–based-DEMATEL, and DEMATEL all include the identical DI_9 as well as the other four DI's discovered by Spherical Fuzzy-DEMATEL: DI_6, DI_4, DI_3, and DI_8.

Furthermore, the Spearman rank correlation coefficient is calculated between each pair of methods in Table 10 to accurately reflect the similarity of prominence and relative vectors of methods.

As a result of the fact that a higher Spearman correlation coefficient indicates a more significant ranking similarity of methods, the ranking of similarity of Spherical Fuzzy-DEMATEL is higher up on the list than either of the other two methods.

5. Results and Discussion

The conclusion of this research indicates complex interdependencies between numerous issues and underlines the multifaceted nature of drone apps. As a result, the impact and sensitivity of the issues categories suggest that they may be classified as cause-and-effect issues. These findings might be used by the developer of the drone apps to determine which issues demand urgent care and which ones can be put off for a later time. The findings of this study might have a significant impact on the quality of drone apps and their popularity among app users. Developers may utilize the findings in this research to enhance the entire process of their app development, even if the study does not explicitly provide a solution. Issues with drone apps are shown in a causal-effect diagram (Figures 2(a) and 2(b)). Figure 2(a) shows the impact of various kind of issues on a drone app's rating. With the strength of 3.12, Feature request (DI_9) seems to be most influential issue, whereas battery consumption (DI_2) is the most influenced issue, with strength of -1.2.

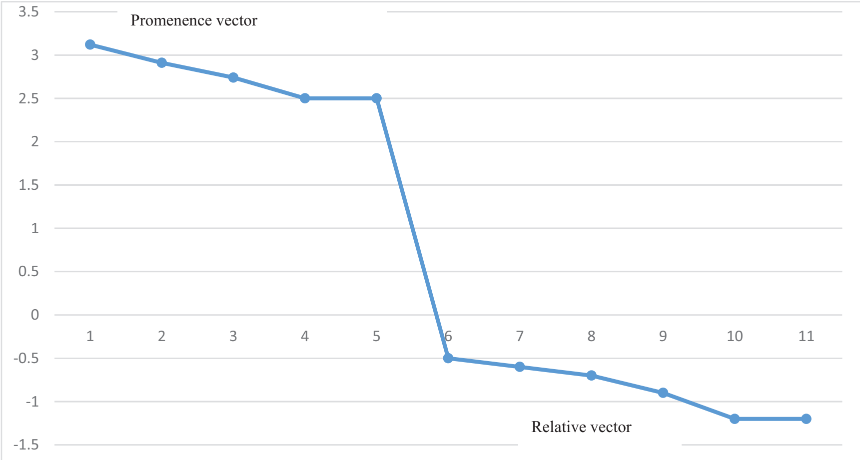

Figure 2(a). Cause-effect order diagram of drone app issues using Spherical Fuzzy-DEMATEL

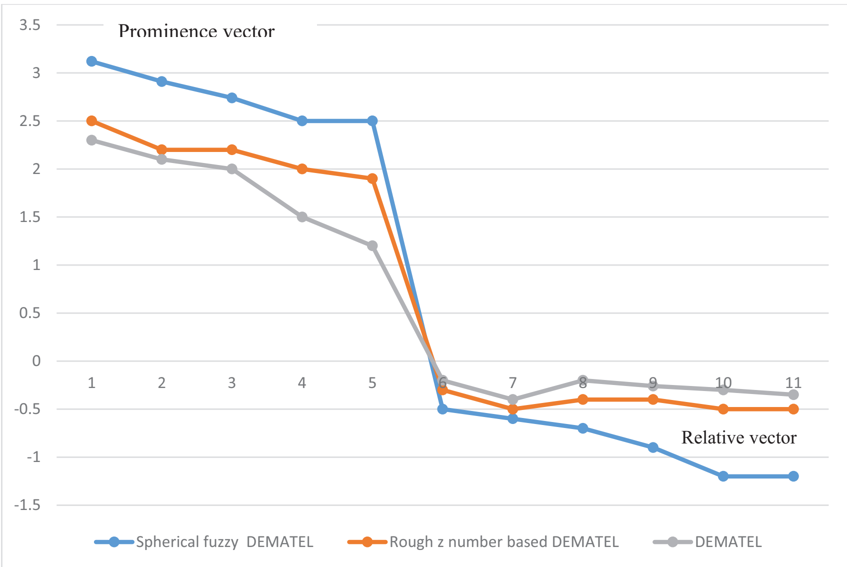

Figure 2(b). Comparative cause-effect order diagram of drone app issues

The most influential drone app issue is represented by the issue with the highest rank, while the issue with the lowest rank has the greatest influence. Figure 2(b) depicts the comparison of DEMATEL, Z number-based DEMATEL, and Spherical Fuzzy-DEMATEL.

The Spherical Fuzzy-DEMATEL strategy has fared the best out of the three methods. Prominence and relative vectors are both represented by positive and negative values, respectively.

Few studies in the literature have already looked at various aspects of drone apps. The importance of examining the interrelationship among different issues of drone app development must be examined in order to effectively apply drone app development methods. Drone app issues are intertwined in important ways. This work will assist project managers to make better drone app development choices. The causal diagram provides useful interrelationship information that can be used to plan the app's launch and deploy it as quickly as feasible.

6. Threats to Validity

There are a few potential threats with this research. In specific, our study only includes 15 different issues, but in the future, we may include many more issues. Incorporating the findings of this study into multi-criteria decision-making approaches, such as ANP and fuzzy ANP, might be helpful in determining which approach would be most suited to investigate the drone app's issues.

7. Conclusion

Developing drone apps has become an essential element of software development. Due to a lack of formal scientific methods for the creation of drone apps, many issues arise in the corporate world. Drone app development, unlike its predecessors, web apps and desktop applications, is amateurish and in the midst of an evolutionary process. There are several issues with drone applications, and this study aims to identify them. Using the technique described here, every strategic choice in the creation of a drone app may be verified to ensure that the quality of the app is not compromised.

This study might assist software companies in determining the main cause of app issues. A total of eleven issues with drone apps have been identified in this research. These issues, as was indicated before, are: advertisement (DI_1), battery consumption (DI_2), cellular data usage (DI_3), connection/ sync (DI_4), cost (DI_5), customer support (DI_6), device compatibility (DI_7), device storage (DI_8), feature request (DI_9), functional error (DI_{10}), and additional cost (DI_{11}). The Spherical Fuzzy-DEMATEL approach was used to divide these problems into cause-and-effect groups after recognizing them. As previously noted, the reason group includes functional errors, feature requests, connection and sync, user interfaces, battery drainage, performance, and security. Aside from costs, uninformativity, and app crashing, there are eight other difficulties in the impact category, such as device compatibility issues and installation problems. When Spherical Fuzzy-DEMATEL is compared to other techniques such as DEMATEL and Z number-based DEMATEL, a superior result is achieved. Although the results of prominence and relative vectors are similar, the two quantitative values of these two viewpoints are clearly distinct. It was necessary to measure performance using the mean absolute error (MAE). According to the findings, "feature request" is the most significant issue associated with drone apps, although "battery consumption" is the issue that is most influenced by the other issues. Since this investigation and its findings are founded on the accumulated expertise of the software engineering experts, gaining further experience will have the impact of reducing the influence of biases. In the future, research might focus on finding and adding new problems caused by drone applications, and then figuring out how the effects of these new problems interact with those already known.

List of Abbreviations

AHP	Analytical Hierarchy Process
ANP	Analytical Network Process
DEMATEL	Decision Making Trial and Evaluation Laboratory
DI	Drone app issues
GPS	Global Positioning System
IoT	Internet of Things
ISM	Interpretive structural modelling
LDA	Latent Dirichlet Allocation
MAE	Mean Absolute Error
MCDM	Multi-Criteria Decision-Making
NLP	Natural Language Processing
PFS	Pythagorean fuzzy Set
SFN	Spherical fuzzy numbers
SFS	Spherical fuzzy Set
SWAM	Spherical Weighted Arithmetic Mean
SURF	Summarizer of user reviews Feedback
UAV	Unmanned Aerial Vehicles
URR	User Request Referencer
URM	User Reviews Model

AUTHORS

Mamta Pandey – Mahatma Gandhi Institute of Technology, Hyderabad, India, e-mail: mamtapandey_cse@mgit.ac.in.

Ratnesh Litoriya* – Medi-Caps University, Indore (Madhya Pradesh), India, e-mail: litoriya.ratnesh@gmail.com.

Prateek Pandey – Jaypee University of Engineering and Technology, Guna (Madhya Pradesh), India, e-mail: pandeyprat@yahoo.com.

*Corresponding author

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