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ORIGINAL ARTICLE

Integration of Fuzzy Delphi Method with Artificial Neural Network for Social Media in Malaysia Disaster Response

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***Abstract*:** The evolution of social media technology is rapidly growing. Information can be shared across the world through the social media. During a disaster, social media provides a clear and precise picture of the situation especially, in the disaster zone where victims at the scene can plan their exit before emergency responders arrived at the catastrophe site. Social media could also ease the disaster response agencies task, as the push information are given by the victims or public who is concerned about the calamity. In response to the push information, the agencies involved may provide new solutions or suggestions and locate the coordinates of the victims through the agencies website. On the other hand, it also able to help disaster response team to prepare the necessary equipment for rescue procedure and other essential assistance. Hence, it reduces the risk of death and destruction of property at the catastrophe area.

Keywords: social media, disaster, emergency response, information

1. Introduction

Social media has become very popular that allows people to share their lifetime events at finger tips. Besides that, it also can be used as a platform to promote business or services by the government or non-government agencies. The main advantage of social media is the ease of access at any time to log into the social media pages without limits. The advances in the internet technology provides the latest news rendering the society to use social media rather than the traditional media.

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In addition, the technological advancement has caused the world community to change their existing device to the most advanced device available in the market, at an affordable price. Therefore, it is not surprising nowadays to see students own a smartphone with internet access based on the chosen telecommunication provider. With the lowest data package, they can get online for at least a month to virtually stay in touch with their friends in the cyberspace.

The government agency has taken steps to reach out to the community through various social media platforms. The public community is now able to communicate with the government agencies at the social media sites if they want to make a complaint or suggestions to improve their services. This has provided new opportunities for the community to reach out to the government agencies. It is also an added advantage for the business sector as it provides space to promote their items and it could reach more people through this platform.

2. Advantages and challenges of social media for disaster response

Social media is a platform that enables users to reach wide-spanning audiences for various intention such as business, social interactions and education. In regard to disaster response purposes, social media popularity, efficiency and ease of use has been demonstrated in the 2014 flood case in Kelantan, Malaysia. During the flood occurrence, the social media created a pool of timely reports about the disaster, injuries, and help requests. Hence, communication through social media had offered an alternative opportunity for first responders and disaster relief organizations to collect information about the disaster, victims, and their needs.

However, the collected information presents a challenge as the information might be replicating, overloaded and manipulated by others. Thus, it is important that the collected information should be aggregated and evaluated to pose high be prioritized for decision-making.

Besides, it also presents a challenge to aggregate and process the requests from different social media. Given the amount of information received, it need to be filtered before the information is disseminated to the victims or the public involved in order to prevent false information and panic among victims and the public. Many studies are made to simulate such situations and to come up with workable solutions (Boyd, D., & Crawford, K., 2012).

Social media with its different platforms may provide real opportunities for disaster risk management. They improve the collaboration, engagement and information sharing among different stakeholders (the affected population, NGOs, volunteers and government).

The data received from the different platforms is not filtered by a proper filtration system especially the validity of the information. Thus, it is a necessity to ensure that the received data is efficiently filtrated in order to send out a reliable data to the rescue agencies. This helps the disaster response agencies to create a plan such as the evacuation planning process in the disaster zone in a more organized way and also to assess the severity of the catastrophe that they are facing.

Currently, there are no applicable methods for evaluating the level of precision of information submitted through the social media. Reliability of the information might be affected because of stress due to the severity of the incident at the scene.

At the same time, a message can be sent out by those who are not under pressure but may want to report the disasters. Although it is intended as a notification but sometimes it also can be in the form of needing to be the first source of information or to get people attention.

This situation makes the rescue process difficult by the emergency response team. The initial assessment on all the information transmitted via rescue agency media social must be made in advance. It requires a relatively long time to evaluate the severity of the disasters.

According to the American Red Cross, 60% of the victims received information about disasters through social media sites comprises of various networks such as of Facebook (18%) and Twitter (15%) (Harman, 2011). Youth nowadays are more inclined to communicate or transmit information through social media sites because it is easy and quickly delivered (Maxwell, 2012).

Most of the traditional media are paralyzed when disaster strikes due to a power failure caused by the event. Thus, another alternative source of information that can be used by the public is through social media and it is more efficient compared to the traditional media (Ahmad, Mohamad Zani, & Hashim, 2015).

Why do we need social media during disasters? There are several factors why people use this channel during disasters and the reasons are as follow:

2.1 Convenience

Social media provide nearly immediate access to up-to-date information, community interaction, and support for the public during disasters. These features are convenient (Liu, Jin, & Austin, 2011). Most of the people in the world, carrying the smartphone with them in their pockets where the capability to log on to any desired social media application with the tap of a finger. Further, free public library computers, personal computers, laptops, tablets, and mobile phones provide previously unparalleled access to information and support through social media for a large number of the public in a significant number of places at almost any time (Smith, 2012).

2.2 Social norms

Social norms impacted the social media use in general, dictating that individuals are more likely to use a particular medium if (1) their friends and family frequently use it and/or (2) if they trust and ascribe a high level of credibility to the social media (Liu et al., 2011). The result from a consistent research found that people turn to existing social networks during disasters including social media networks created before the disasters (Spiro et al., 2012).

2.3 Information seeking

Disasters often breed high levels of uncertainty among the public (Mitroff, 2004), which prompts them to engage in heightened information seeking (Boyle, Schmierbach, Armstrong, & McLeod, 2004; Procopio & Procopio, 2007). As predicted, information seeking is a primary driver of social media use during routine times and during disasters (Liu et al., in press; PEW Internet, 2011). Social media is becoming a popular channel selection to convey information rather than the traditional media (i.e., television, radio) since it is at the fingertips of the public or the victims at the catastrophe site to share and to inform the current situation (Haddow, G., & Haddow, K. S., 2013).

2.4 For timely information

Social media provide real-time disaster information, which no other media can provide (Kavanaugh et al., 2011; Kodrich & Laituri, 2011). Social media can become the primary source of time-sensitive disaster information, especially when the information provided by the official source is slow or unavailable (Spiro et al., 2012).

3. Methodology

3.1 *Fuzzy* Delphi technique

This study used *Fuzzy* Delphi technique, which was introduced by Murray, Pipino, and Gigch (1985) and was developed by Kaufman and Gufta (1998). *Fuzzy* Delphi is a combination of *fuzzy* set theory and the Delphi techniques. This show that *Fuzzy* Delphi technique is not a new technique, however, it is an instrument of "improving" the existing Delphi technique (Rihuan et al., 2013).

The study was conducted using *Fuzzy* Delphi technique to get an expert consensus on the content of the environmental disaster response using social media. The findings only focus on the analysis of the results from *Fuzzy* Delphi technique and not the interview.

This study involves 15 expert respondents consisting of professors, government officers and researchers who are involved directly in the disaster management environment. The instrument used was a questionnaire containing 14 items in four sections that are distributed to the respondents to get their consensus from the respondents that representing the experts. The experts were asked to state the level of acceptance of each item whether they Strongly Agree, Agree, Unsure, Disagree and Strongly Disagree. Data from the Likert Scale were then translated into *fuzzy* numbers (see Table 4) and the data was analysed using Microsoft Excel and SPSS 24.

3.2 Artificial Neural Network

Neural networks are adaptive networks which are composed of simple elements operating in parallel. These elements are inspired by biological nervous systems. As in nature, the network function is determined largely by the connections between elements.

Commonly, neural networks are adjusted or trained so that a particular input leads to specific target output. Neural networks have been trained to perform complex functions in various fields of applications including pattern recognition, identification, classification, speech, vision and control systems.

The author analyses the data by using both the *Fuzzy* Delphi technique and Artificial Neural Network analysis. This is aim to find out the discrepancy of expertise opinion on disaster response in Malaysia through social media.

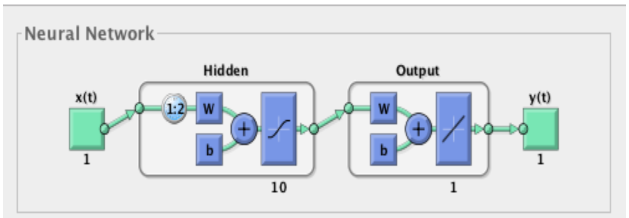

Figure 1: Architecture of Artificial Neural Network.

3.1 Selection of expert

In a study using *Fuzzy* Delphi technique, the number of expert respondents is based on Jones and Twiss (1978) and the number of experts for the Delphi study is between 10 to 50 experts are required. Confirmation of the number of experts for this method is also in line with the view from previous studies that the number of experts allowed is between 10 to 15 expert agreement and high uniformity (Adler and Ziglo, 1996) as shown in Table 2. In this study, the number of experts involved is 15 people with specialist comprises of the following criteria as listed in Table 1:

Government officers and researcher who have served more than ten years and are directly involved in the disaster.

Table 1: List of experts for this study.

Expert	Total
Consultant Emergency Physician	2
Senior Civil Defense Officer	2
Senior NADMA Officer	2
Researcher	1
Senior Medical Officer	2
Senior Assistant Medical Officer	2
Senior Nurse	2
Senior Fire and Rescue Officer	2
Total	15

Table 2: Selection of expert.

Jones and Twiss 1978	10 - 50	
Adler and Ziglo 1996	10 - 15	✓

3.2 Validity and Reliability Questionnaire Item

Testing is necessary to ensure the validity of the elements that can help provides an answer to the research questions. An item or tool survey is said to have a high validity value if the items in the questionnaire can measure what should be measured (Hair et al., 2006). In contrast, Marican (2005) argued that the validity is being used to measure the accuracy of the measurement used in the study.

The aim is to determine whether the questionnaire contains all the features or ideas that can measure the outlined concept. The findings of the research would be meaningless if the measurement tools cannot measure what should be measured.

Marican (2005) also pointed out that reliability is a concept which refers to the consistency and stability of a size/gauge survey/questionnaire over time towards a notion. It increases reliability to find out the scale of giving the same answer when it is used to measure the similar concept in the population/sample/ different sample.

Reliability is the degree that shows measurements carried out are independent of any mistakes and therefore produces consistent results (Now, 2000; Zikmund, 2003). The reliability test of the questionnaire is needed to see the appropriateness and understanding of the respondents to the items in the questionnaire.

The term in the questionnaire is based on the suitable Alpha Cronbach value. Hair et al., (2006) states that the most acceptable minimal Alpha Cronbach value is 0.7. However, Majid (2004) argued that the Alpha Cronbach reliability value can be classified into three classes, with 0.60 Alpha value indicates that the reliability index is at the minimum acceptable value. Table 3 shows the α Cronbach Validation for this study.

Table 3: α Cronbach Validation

Item	Domain	Total Item	α Cronbach
1	Use of social media during disaster.	3	.684
2	Use of social media in the future for disaster response.	2	.710
3	Information from social media is more effective rather than traditional media.	5	.670
4	The most social media suitable to be used during disaster occur.	4	.687

(Sources from Hair. J, et al., 2006 – minimum 0.7, Majid et al., 2004 Alpha Value minimum 0.6).

3.3 Data analysis procedures

For the *Fuzzy* techniques to be used in the Delphi study, there are steps that need to be met for this study to be considered as the empirical study. The following steps need to be observed:

Step 1

The assumption of X invited the experts to determine the importance of the criteria for the assessment of the variables to be measured with the use of linguistic variables.

Step 2

Converts all linguistic variables into numbering triangle *Fuzzy* (triangular *fuzzy* numbers) as shown in Figure 1. Assume that the numbers are *fuzzy* variables r_{ij} variable for

each of the criteria for expert K for i = 1, ..., m, j = 1, ...n, k = 1, ..., k and $r_{ij} = 1 / K (r^1{}_{ij} \pm r^2{}_{ij} \pm r^K{}_{ij})$.

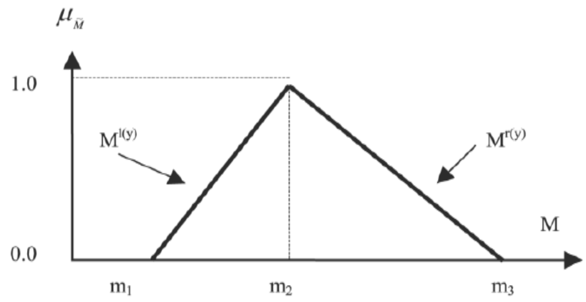

Figure 2: *Fuzzy* Triangular

Table 4: *Fuzzy* linguistic variable 5 shows the scale in *Fuzzy* Delphi method.

Level agreement	*Fuzzy* Scale	Linkert Scale
Strongly disagree	0.0, 0.1, 0.2	1
Disagree	0.1, 0.2, 0.4	2
Moderate agree	0.2, 0.4, 0.6	3
Agree	0.4, 0.6, 0.8	4
Strongly agree	0.6, 0.8, 1.0	5

Step 3

For every expert, use the vertex method to calculate the distance between the average r_{ij}. (Chen, 2000). The distance of two *fuzzy* numbers m = (m_1, m_2, m_3) and n = (m_1, m_2, m_3) is calculated using the formula:

$$d(\tilde{m}\tilde{n}) = \sqrt{\frac{1}{3}\left[(m_1 - n_1)^2 + (m_2 - n_2)^2 + (m_3 - n_3)^2\right]}$$

Step 4

Cheng and Lin (2002), state that if the distance between the average of the specialist's evaluation data is less than the 0.2 threshold value, all the experts are considered to have reached a consensus. Furthermore, among the expert m x n, if the consensus group reached more than 75% (Chu & Hwang, 2008; Murry and Hammons, 1995), then can go to step 5. If otherwise, a second round of *Fuzzy* Delphi Method will be applied or the item is removed.

Step 5

Aggregate *fuzzy* assessment with:

$$\tilde{A} = \begin{bmatrix} \tilde{A}_1 \\ \tilde{A}_2 \\ \vdots \\ \tilde{A}_m \end{bmatrix} \quad i = 1, \ldots, m$$

Step 6

For each alternative, *fuzzy* evaluation Ai = $A_1 = (a_1, a_2, a_3)$ is defuzzication with $a_1 = \frac{1}{4}(a_1 + a_2 + a_3)$. Alternative ranking order of preference can be determined according to the value of a_1. Additionally, an alternative order of preference ranking can be determined according to the value of a_i.

3.4 *Fuzzy* Delphi data interpretation methods

In *Fuzzy* Delphi, all the data need to be evaluated before it can be accepted or rejected. In this study, three conditions were used in considering the acceptance of each item agreed upon by the experts whether the item is discarded or accepted by the consensus of the experts.

First condition

In order to accept the constructed item, each expert's agreement will be evaluated based on the triangular *fuzzy* numbers. The level of importance will be filtered using distance threshold, d with a value of < 0.2 will be accepted. (Chen, 2000; Cheng and Lin, 2002).

Second condition

The second condition of accepting the constructed item will be based on the consensus decision making. The consensus making rules used in this study was super majority threshold with 75% and above of expert will be accepted. (Chu and Hwang, 2008; Murray & Hammons, 1995).

Third condition

Identification of the importance level of a factor of an item can be done through pseudo partition which was built by consulting an expert. However, to prevent from a bad partitioning, a threshold can be set. In this study, a α-cut of 0.5 was used as the threshold value. The value of 0.5 was selected because it is a middle point of an interval (0, 1). Thus, it reflected the logical reasoning that only those elements from the support of a fuzz set with "sufficient large" membership grades in a fuzz set were included (Bodjanova, 2006). Figure 1 shows the Score Average *Fuzzy* with the indication of acceptance of the construct or the item measured based on the expert agreement.

α-Cut = 0.5										
0.0	0.1	0.2	0.3	0.4	**0.5**	0.6	0.7	0.8	0.9	1.0
Fuzzy Numbering										

Figure 2: Location of α-cut in the numbering *Fuzzy*

4. Result

This study used 15 experts in the related field to answer the *fuzzy* questionnaire, aligned with Adler & Ziglio (1996), which is in between 10 and 15 experts. The process of distributing this questionnaire was via face-to-face, email, and social media such as WhatsApp application. All 15 respondents completed the questionnaires and were accepted for data analysis.

The findings for the demographics of the experts are shown in Table 5 – Table 7.

4.1 Demographic data

Based on the analysis shown in the Table 5 to 7, the panel fits in with the description to participate as the experts in assessing the role of social media in disaster response. This is because, according to Pill (1971) and Oh (1974), in selecting experts for Delphi study, experts should have a background and experience in related fields of study, can contribute their opinions to the needs of the study, and are ready to revise their initial assessment to reach a consensus among the experts.

Therefore, experience and qualifications in the relevant field, as indicated in the Table 5 to 7, most of the experts involved is related to the disaster response. On the other hand, they are qualified to evaluate the role of social media in this study because they have the knowledge and are involved directly and indirectly in the management of disaster response.

4.1.1 Race

Table 5 shows the races of the expert that participated in this study. 93.3% of the experts are Malay.

Table 5: Distribution of experts' race.

Race	*n*	%
Malay	14	93.3
Indian	1	6.7
Total	15	100

4.1.2 Level of experts' education

Table 6 shows the highest level of experts' education chosen for this study. 53.3% of the experts have the highest education level at master degree and above.

Table 6: Level of experts' education.

Education level	*n*	%
Certificate/Diploma	1	6.7
Degree	6	40
Master and above	8	53.3

4.1.3 Service sector

Table 7 shows that the central government sector is the highest number of experts that have been enrolled in this study representing 86.7% of experts.

Table 7: Service sector by expert.

Agency	*n*	%
Central government	13	86
Local government	1	6.7
Student	1	6.7
Total	15	100

4.2 Findings of the expert's consensus about social media enhancing disaster response

Based on the *Fuzzy* Delphi and approach, the defuzzification value for each item of the questionnaire is between 0.6 (minimum value) and 0.8 (maximum value). Therefore, by comparing this defuzzification value, score one is determined with the highest logical value based on the value.

4.2.1 Expert's consensus in the use of social media during disasters

In relation to the expert consensus on the domain of Social Media Use During the Disaster (Table 8), 15 experts have reached an agreement with Item 1.3 that has fulfilled the three conditions namely the threshold value of less than 0.2, the percentage of the agreement exceeds 75% α-Cut value is greater than

0.5 as set forth in the process of accepting an expert consensus.

Table 8: Expert's consensus in the use of social media during disaster.

1. Domain: Used of social media during disaster					
Item		<0.2	(%)	α-Cut	Rank
1.1	Inform the authorities about disaster occur via social media	0.440	100	0.422	Reject
1.2	Information reported from public are reliable.	0.190	100	0.467	Reject
1.3	Social media to be used as information sharing.	0.179	80	0.653	Accept

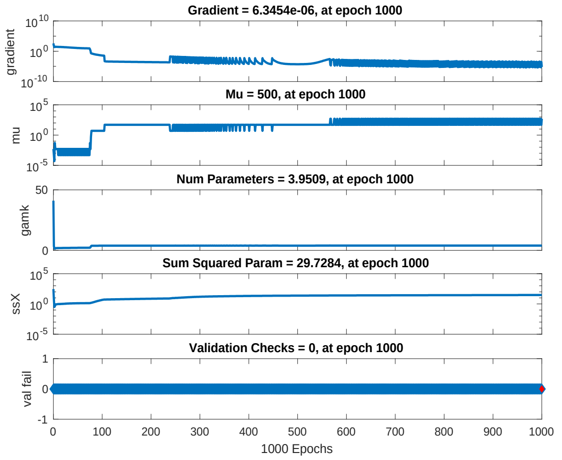

Figure 3: Frequency of expert's consensus in the use of social media during disaster from Artificial Neural Network analysis.

This shows that social media has the role of information sharing during disasters, therefore, disaster response agency can relay the information based on the information that they receive through the official rescue agencies social media site.

On the other hand, item 1.1 and 1.2 were rejected because they did not meet the three conditions that have been set. However, any information provided by the public must first be verified to ensure that the information submitted is genuine and up to date.

The refining of the identity of the source/informer needs to be created by the disaster response agencies through their official social media site. Apart from that, awareness campaigns on using social media sites should be conducted to every society level to avoid abuse of the social media usage.

4.2.2 Expert's consensus about the use of social media in the future to obtain information related to emergency

The expert's consensus is consistent with the domain 2, the Use of Social Media in The Future for Disaster, whereby both statements agreed upon by all three set conditions. This shows the need to create disaster-related applications and it should be flagged in Malaysia to facilitate the community to channel the information regarding any disasters that occur in their residential areas as Malaysia often experiences floods and landslides (Mohamed Shaluf, I., & Ahmadun, F. L. R, 2006).

Table 9: Expert's consensus in the use of social media in the future for disaster response.

2. Domain: Use of social media in the future for disaster response					
Item		<0.2	(%)	α-Cut	Rank
2.1	Apps related disaster to be download in future on smartphone.	0.147	100	0.720	Accept
2.2	Social media in future to share information with others during disaster or after disaster	0.130	93	0.640	Accept

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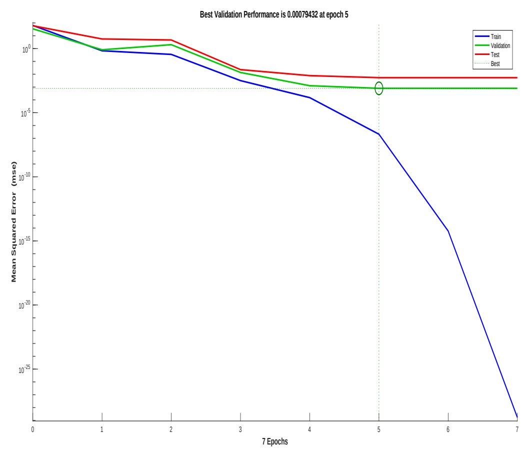

Figure 4: Validation of expert's consensus in the use of social media in the future for disaster response from Artificial Neural Network analysis.

4.2.3 Expert's consensus on information from social media is more effective compared to the traditional media

Almost all of the 15 experts have reached the consensus for items 3.1, 3.3 and 3.5 in which the information from social media is fast, easily accessible and rich with information about the disaster that took place at the specific time.

Table 10 also shows that the panel experts disagree with items 3.2 and 3.4 whereby the social media is more accurate and reliable than the traditional media. This shows that it is vital to ensure any information channelled through social media should be filtered before the information is being received.

Every information sent by the sender who is at the disaster scene must contained the following particulars:

i. Name of the sender.
ii. Mobile phone number.
iii. Disaster location / crisis / emergency
iv. The number of victims that can be seen.
v. Image or video from the incident site.
vi. GPS location of the incident.

This information can help to locate whether the information being send is true and having a disaster apps in a smartphone should be the basic menu in the future smartphone technology.

Table 10: The expert's consensus on information from social media is more effective than the traditional media.

3. Domain: Information from social media is more effective compared to the traditional media.

	Item	<0.2	(%)	α-Cut	Rank
3.1	Information via social media is faster.	0.171	79	0.707	Accept
3.2	Information from social media is accurate.	0.187	75	0.351	Reject
3.3	Information from social media is accessible.	0.209	84	0.653	Accept
3.4	Information from social media is reliable.	0.228	91	0.391	Reject
3.5	Information from social media is huge.	0.239	96	0.653	Accept

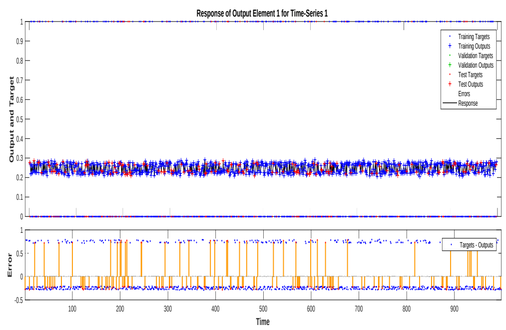

Figure 5: Error of expert's consensus on information from social media is more effective than the traditional media from Artificial Neural Network analysis.

4.2.4 Expert's consensus about the most suitable social media to be used during disaster

Table 11 shows the decision of the expert in determining which social media sites are appropriate to be used during the disaster. WhatsApp is the social media site that reaches the highest deal and meets the criteria that have been set. WhatsApp is not just being used to send messages, but also has better added-value features and has the same capacity as Facebook.

Table 11: The expert's consensus in the most suitable social media to be used during disaster.

4. Domain: The most suitable social media to be used during disaster.					
	Item	<0.2	(%)	α-Cut	Rank
4.1	WhatsApp	0.196	87	0.680	Accept
4.2	Facebook	0.269	60	0.560	Reject
4.3	Twitter	0.209	80	0.653	Accept
4.4	SMS	0.136	100	0.667	Accept

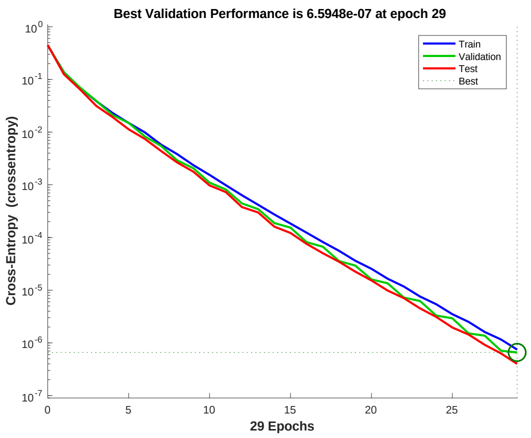

Figure 6: Performance of expert's consensus in the most suitable social media to be used during disaster from Artificial Neural Network analysis.

The expert panel has rejected Facebook as social media site as the update platform for disaster events. However, the experts accept Twitter and as well as SMS other than WhatsApp application. Since it is a current trending, it is suggested that disaster response agency at the community level become the administrator in checking every information that needed emergency assistance.

This bilateral communication can help the disaster response team to provide faster response and to reduce the rate of death due to the catastrophe. In addition, a disaster warning system can also be installed in the existing social media platform such as on WhatsApp in creating warning notifications to the local community at the most disaster-prone area.

5. Discussion and Implications

The analysis using *Fuzzy* Delphi technique and Artificial Neural Network analysis in this study, has enable the author to suggest, based on the consensus, suggestions and expert comments, the development of application through smartphone for disaster early warning system to the people at the disaster-prone area in Malaysia. The relevant items had been arranged according to the priorities refinement of refined sentences.

Table 12 and Figure 7 showed the results of the analysis using the *Fuzzy* Delphi technique and Artificial Neural Network analysis on the appropriate items to be included in the module according to the priorities based on the common consensus of the expert.

Every domain that has an expert consensus can be the basis for promoting disaster early warning system to be installed in the smartphone applications to the people in the disastrous areas.

Table 12: List of consensuses from the experts based on priorities.

Domain 1 : Used of social media during disaster	
1.1	Social media to be used as information sharing.
Domain 2: Use of social media in the future for disaster response.	
2.1	Apps related disaster to be downloaded in future on smartphone.
2.2	Social media in future to share information with others during disaster or after disaster
Domain 3: Information from social media is more effective compared to the traditional media.	
3.1	Information via social media is faster.
3.2	Information from social media is accessible.
3.3	Information from social media is huge.
Domain 4: The most suitable social media to be use during disaster.	
4.1	WhatsApp
4.2	SMS
4.3	Twitter

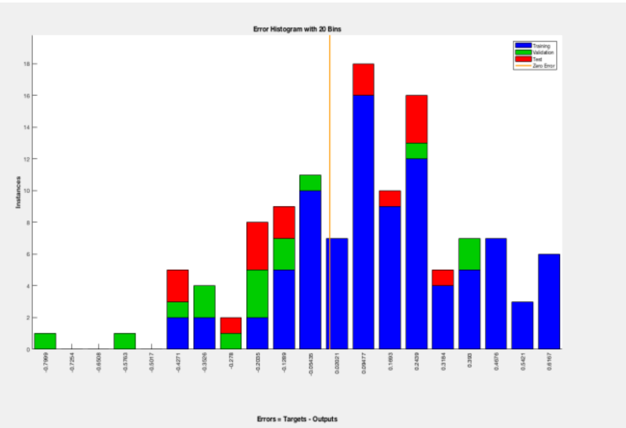

Figure 7: Histograms of expert's consensuses from the experts based on priorities from Artificial Neural Network analysis.

Each element in the domain is the recommended component that is needed in developing the application for a disaster warning system via social media that can be downloaded to the smartphone. The finding shows that WhatsApp application is the most suitable social media to be flagged as disaster early warning system in Malaysia in enhancing disaster response by the rescue agency.

6. Conclusion

As a result of the observation done on both methods, the Fuzzy Delphi Technique and the Artificial Neural Network show the compatibility between the two methods used.

The findings of this study have provided the apex of the disaster response in Malaysia through the application of social media sites that can be introduced in the future. The rescue agencies will need information from the scene to facilitate the management of disaster response in Malaysia.

The ever-expanding technology is now able to be recruited based on the domains that have been agreed by the experts in disaster management field. This result is not only for the current catastrophe, but is also able to be used for daily life in the future.

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