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A Fuzzy Analytic Hierarchy Process for Security Risk Assessment of Web based Hospital Management System

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ABSTRACT

Security has become an important issue while developing a web application. This is the reason; it is getting great attention from academia as well as industry. Moreover, due to the huge cost invested in and privacy sensitivity of a healthcare web application, its usability and security are highly required. However, identification and selection of the appropriate model for enhancing security risk of web based healthcare management system has become very difficult for software industry. Factors of security risk play an important role when it comes to integrate security and usability during software development. The factors have their own significance while integrating usable-security. This is generated through seriousness of patient data. Hence, practitioners need to recognize the signification of factors while development of a healthcare web application to cater the end user's requirement. Hence, the author has assessed security risk of a healthcare web application. For the same Fuzzy Analytic Hierarchy Process has been used. In addition, the author has also given the impact of each and every factor of usable-security. This will provide an aid to practitioners for enhancing usability as well as security of a healthcare web application during its design itself.

Key words: Security Risk; Web Applications; Fuzzy Logic; Analytic Hierarchy Process.

1. INTRODUCTION

In perspective of Vision 2030, KSA Government want to give the best hospitality to our patients. Many studies have been reported on recognition and categorization of the techniques available for enhancing security of an internet software [1-2]. Further, there is continuously been a hole between idea and exercise. The author of the paper has tried to improve the available work for assessing usability and security. Usability has been considered an important factor of security in perspective of a healthcare web application. For integrating usability and security both in an internet application during its development itself, zeroing in the essential factors of usability as well as security are required [3-4]. For this, it is essential to map factors of with factors of security and assess the influence of the factors for improving usable security of a healthcare web application.

Measurement of factors of usability as well as security is essential in order to improve it [5-6]. With the help of IT interventions, it creates more sustainable. To focus in this type of challenges during web based software development, the proposed work believes that usability and security be well-maintained with other quality factors including reliability and efficiency etc. Results may allow experts for making suitable choice and taking actions accordingly [7-8]. But, for taking an appropriate action, developers and practitioners should identify the factors of security as well as usability. In addition, there should be an attempt to establish a mapping between these factors. Hence, to evaluate the priority of security risk factors, this paper takes Fuzzy AHP methodology.

Finally, this paper is systematized as: Section 2 discusses about need and importance of usable security assessment. Priority of security risk factors is computed in section 3. Section 4 discusses about significance of the work and conclusion is presented in section 5.

2. NEEDS AND IMPORTANCE

Various literatures have been reported on identifying and prioritizing factors of web application security through Fuzzy AHP [9-10]. In 2019, Alenezi et al have prioritized attributes of security risk with the help of Fuzzy Analytic Hierarchy Process. But only a few research is found on ranking security factors affecting usability of security and trade-offs between them for a web based application. Success and failure of an application's security totally depends on end user's approval [11-12]. It is important to assess factors of security risk of a healthcare web application during its development itself [13-14]. The examination of arrangement has been done with the help of Fuzzy AHP [15-16]. MCDA plays an important role for various inconsistent estimation objects [17-18].

AHP is used for assessing an opinion. However, many researchers emphasized that Fuzzy Analytic Hierarchy Process adds more value for delivering clear choices [19-20]. In addition, it is also used as an essential tool to compute priority approved by decision makers. Further, AHP works with decision inputs collected from expert's [21-22]. The work in this paper has used Fuzzy AHP to zero out ambiguity in assessment [23-25]. The work presented here contribute a way for estimating security risk with the help of Fuzzy Analytic Hierarchy Process. The author has collected opinion of 101 practitioners. This paper calculates the prominence of security risk factors by taking as input these opinion from experts, interrelations of their weight and ranks. With the help of the findings of this work, policies have been chalk down to help integrate and improve security risk to a healthcare web application in future.

3. MEASUREMENT OF SECURITY RISK FACTORS

Weights and ranking of factors of security risk play a significant role for designing a healthcare web application. Prioritization of security risk factors for a healthcare web application is tackled by Multi Criteria Decision Making technique [8-9]. Different factors have different impact on usable- security. Many techniques are available for addressing the related problem including AHP technique and many more methods. AHP is significantly used by researchers to help in priority assessment [10-11].

It is a fact that during the design phase itself the factors of security risk should be identified. For this, it is expected from the security experts that they must have beforehand knowledge of the related factors. Categorization of these factors will help to avoid any unembellished problem related to security [4]. This paper uses Fuzzy AHP for evaluating ranks and weightages of security risk factors [8-9]. The weightages and rankings of factors of security risk will help developers to select development guidelines. These guidelines will help expert to achieve and maintain optimum level of usable-security. Figure 1 deliberates the security factors of web application with respect to a healthcare web application that are related to usability.

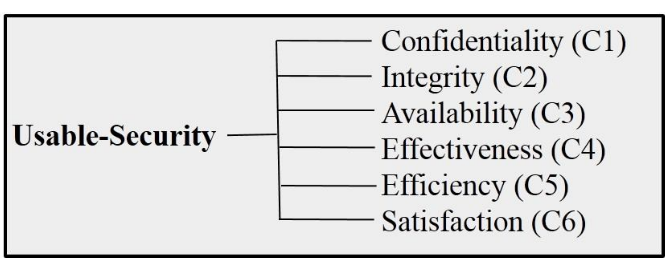

Figure 1: Hierarchical View of Security Risk Factor

The hierarchy of security risk factors is given in figure 1. These factors are recognized through a deep literature review and then expert's opinion. The work presented here measured factors of security risk which have previously been discoursed with the impact of security on usability [8]. For relating usability with security, crucial security and usability factors have been considered in this unit. With the help of a questionnaire, authors have been taken 101 exerts choices. From the expert's opinion, to calculate the weights of factors of usable-security, Triangular fuzzy numbers (TFNs) given as equations (1-3) are used. TFNs [η_{ij}] are well-known as:

$$\eta_{ij} = (l_{ij}, m_{ij}, h_{ij}) \ldots\ldots\ldots\ldots\ldots (1)$$

$$where\ l_{ij} \leq m_{ij} \leq h$$

$$l_{ij} = min(J_{ijd}) \ldots\ldots\ldots (2)$$

$$m_{ij} = (J_{ij1}, J_{ij2}, J_{ij3})^{\frac{1}{x}} \ldots\ldots\ldots\ldots (3)$$

$$and\ h_{ij} = max(J_{ijd})$$

Here, J_{ijk} shows the relative importance of the opinion Fi and F_j s given by the expert *k* and *i* whereas j shows a pair of conditions mentioned by experts. After having the Triangular Fuzzy Numbers, a pair-wise fuzzy comparison matrix is constructed as n *x n* matrix. The same is shown in Table 1.

Table 1: Example of Fuzzy Pair Wise Comparison Matrix

η_{ij} =

	Atr 1	Atr 2	Atr 3	Atr 4	…… ……..	Atr n
Atr 1	(1,1,1)	F_{12}	F_{13}	F_{14}	…… ……..	F_{1n}
Atr 2	F_{21}	(1,1,1)	F_{23}	F_{24}	…… ……..	F_{2n}
Atr 3	F_{31}		(1,1,1)		…… ……..	
Atr 4	F_{41}			(1,1,1)	…… ……..	
. . . .	. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
Atr n	F_{n1}	F_{n2}	F_{n3}	F_{n4}	…… ……..	(1,1,1)

The size of the judgment matrix is 6x6, the group size to fulfill an acceptability of uniformity is 101 experts [8]. This work has taken the choices of developers as well as academicians. Pair-wise comparisons have been prepared quantitatively after qualitative assessment. The matrix obtained by accessing decisions of practitioners has been shown as Table 2.

Table 2: Fuzzy Pair-Wise Comparison Matrix

	Confidentiality (C1)	Integrity (C2)	Availability (C3)	Effectiveness (C4)	Efficiency (C5)	Satisfaction (C6)
Confidentiality (C1)	1,1,1	1.0, 1.5, 1.9	0.5, 0.6, 1.0	0.4, 0.6, 1.0	0.2, 0.3, 0.4	0.3, 0.5, 0.9
Integrity (C2)	-	1,1,1	0.6, 0.7, 0.8	0.3, 0.4, 0.6	0.3, 0.4, 0.5	0.2, 0.2, 0.3
Availability (C3)	-	-	1,1,1	1.0, 1.3, 1.6	0.3, 0.4, 0.8	0.8, 0.9, 1.0
Effectiveness (C4)	-	-	-	1,1,1	0.5, 0.9, 1.6	0.6, 1.1, 1.7
Efficiency (C5)	-	-	-	-	1,1,1	0.4, 0.6, 1.2
Satisfaction (C6)	-	-	-	-	-	1,1,1

After this, the defuzzification is performed to produce a computable value based on the Triangular Fuzzy Numbers. Equation (4) is obtained using [9-10] which is an alpha cut method. Alpha threshold value may take any discrete value ranging from 0 to 1. In this study, the author has taken alpha threshold value as 0.5. $\mu_{\alpha,\beta}$ will be strong alpha-cut set if it has of all the fundamentals of a fuzzy set whose membership functions have principles strictly better than a quantified value.

$$\mu_{\alpha,\beta}(\eta_{ij}) = [\beta.\eta_{\alpha}(l_{ij}) + (1-\beta).\ \eta_{\alpha}(h_{ij})] \qquad (4)$$

where $0 \leq \alpha \leq 1$ ***and*** $0 \leq \beta \leq 1$

such that,

$$\eta_{\alpha}(l_{ij}) = (m_{ij} - l_{ij}).\alpha + l_{ij} \qquad (5)$$

$$\eta_{\alpha}(h_{ij}) = h_{ij} - (h_{ij} - m_{ij}).\alpha \qquad (6)$$

α and β have been used to reflect practitioners views. With the help of equation (4) (α and β at 0.5), computed values are presented Table 3. As α and β can vary between 0 and 1, these values are based on fifty-fifty chances.

Table 3: Defuzzified Pair-Wise Comparison Matrix

	Confidentiality (C1)	Integrity (C2)	Availability (C3)	Effectiveness (C4)	Efficiency (C5)	Satisfaction (C6)
Confidentiality (C1)	1.0000	1.4900	0.6900	0.6400	0.3000	0.5300
Integrity (C2)	.6700	1.0000	0.6800	0.4100	0.3700	0.2000
Availability (C3)	.4500	1.4800	1.0000	1.3000	0.4900	0.8500
Effectiveness (C4)	.5600	2.4200	0.7700	1.0000	0.9700	1.1000
Efficiency (C5)	.3000	2.6900	2.0300	1.0400	1.0000	0.7200
Satisfaction (C6)	.9000	4.9200	1.1700	0.9100	1.3900	1.0000

Further, the eigen value and eigenvector have been calculated. The aim to compute eigenvectors is to assess the weights of particular factor. Here the author has made an assumption that μ is the eigenvector and λ is the eigenvalue of fuzzy pair-wise comparison matrix η_{ij}. Equation (7) reflects the linear transformation of vectors. Here, *I* represents the unitary matrix.

$$[\mu_{\alpha,\beta}(\eta_{ij}) - \lambda I].\ \mu = 0 \qquad (7)$$

Table 4: Impact of Security Risk Factors

	Weights	**Percentage**	**Priority**
Confidentiality (C1)	0.0960	9.60 %	5
Integrity (C2)	0.0810	8.10 %	6
Availability (C3)	0.1510	15.10 %	4
Effectiveness (C4)	0.1750	17.50 %	3
Efficiency (C5)	0.2420	24.20 %	2
Satisfaction (C6)	0.2550	25.50 %	1

The weights and percentage has been presented in Table 4. In real situation, many security risk attributes may contribute in the process of developing a healthcare web application [8-10, 12]. For the study, six security risk factors are identified and further prioritized. The hierarchy of factors of security risk is created and their weights have been evaluated through Fuzzy-AHP technique. This research presented a hierarchy, which will prove to be very significant for designing security risk[7]. The results will assist developers to identify the significant security risk factors. This will again help in development of secure and usable a healthcare web application. This will help developers to gain customer's trust by lowering maintenance cost.

4. DISCUSSION AND FINDINGS

It is established that increasing security should not decrease usability of a healthcare web application. In other words, security risk has become an issue today. In a healthcare environment, a healthcare web application is multifaceted. Security is an important quality factors and due to its nature it must receive full consideration while designing and developing web a healthcare web application. The author has computed six factors of security risk for the healthcare web application development. Some of the significant findings of the work are given as:

- For enhancing secure life span of a healthcare web application its usable security should be taken into consideration.
- By focusing on confidentiality, integrity, availability, effectiveness, efficiency, and satisfaction while developing a healthcare web application, usable security can be improved.
- Satisfaction has come out to as an important factor of usable-security.

As a broader view, the article has prioritized the factors of usable-security. It supports that the security risk factor, user satisfaction has highest priority while developing secure and usable a healthcare web application.

5. CONCLUSION

The work identifies factors of security risk factors which affects usability as well as security of web application of a healthcare web application. A hierarchy of factors has been proposed. Further, the opinion of 101 practitioners from web development industry and academia on six security risk factors has been considered. With the help of this opinion, weight of each security factor has been computed using Fuzzy AHP. The study also concludes that user satisfaction is most crucial factor among all the six security risk factors. In order to get optimal maintenance of the healthcare web application developers must focus on user satisfaction.

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