Redesign website of engineering faculty in university of Indonesia using fuzzy delphi method and fuzzy cognitive maps

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Abstract. Utilizing website in business process has become essential. But lot of web designer have no respect of using methodology in developing a website cause the quality that website do not meet the needs of its users. On the other hand, usability level of the website could not attract a lot of visitation from any user. On this paper, researcher using Engineering Faculty in University of Indonesia’s website to be studied. To increase the usability of this website, research conducted by redesign the website using Fuzzy Delphi Method to determine the media type to presenting each service and also to determine the services layout of each web page. In addition, this research also uses Fuzzy Cognitive Maps to models the interrelationship between each services and media type. Resulting the prototype of 12 web page for website owned by Engineering Faculty in University of Indonesia with total 36 services provided in this website to gives an optimal information for the user.

1. Introduction

Recently website has become an essential component for company’s business to enable customer finding information that related to the company, that can increase revenue, to save times, and gives professional looks for the company.

However, quoting from Ikechukwu and Damian, revealed that the design of the existing sites on the world wide web is still not widely appreciated by the designers of the site [1]. As a result some quality parameters for the site could not be reached, such as navigation, accessibility, scalability, ability to do maintenance, ease of use, compatibility, interoperability, and security.

One example of a case that can show the unreachable quality parameter can be seen in the declining websites rating of universities in Indonesia in webometrics order in 2013. The ratings decline experienced by the year 2012, ITB ranked 497 and decreased at 600 by 2013, then in 2012 the UGM ranked 440 to 640 rating in 2013, and UI are ranked 581 in 2012 rating decreased to 653 in 2013.

Judging from the results of the assessment performed by webometrics can be seen that the websites of universities in Indonesia still has a low level of accessibility. To improve the quality of the university’s website, a study about the presentation and layout design of a site was conducted and a faculty’s website used as a case study, we expect the differences between the site that made without the methods and a site that is created using a method.

2. Literature review
2.1. Fuzzy delphi method
The Fuzzy Delphi Method is an analytical method based on the Delphi Method that draws on the ideas of the Fuzzy Theory. The Delphi Method is a type of collective decision-making method (Linstone & Turoff, 2002), with several rounds of anonymous written questionnaire surveys conducted to ask for experts’ opinion. As a direct prediction method based on the expert judgment and expert meeting investigation method, it possesses the following properties:

1. Anonymity: To prevent from influencing and encourages objectivity with the prediction process do not see each other, remain anonymous and don’t know how many experts are involved.
2. Feedback: Gives the participants an idea about the main ideas in the group, then make a new judgment, and submit it to the group again.
3. Statistical: Through a statistical process and a splines graph produced, then the majority consensus (50% experts) representing the prediction team’s opinion with the top and bottom quarter percentile (each representing 25% of the experts) represent the prediction deviation.
4. Convergence: Through multiple reverse feedback for the final prediction results.

With respect to the panel size required by DM or FDM, there is absence of consensus [2]. Panel sizes range from small groups e.g. 9 experts [3], 10 experts [4], 13 experts [5], or 31 members [6], to the low hundreds, or even thousands that have been mentioned in Japanese studies reported in Linstone and Turoff (1975). A typical size however is between 8 and 12 [7] or between 10 and 18 members [8]. However, a heterogeneous panel (i.e. a panel that includes members with the same degree of expertise but from different social or professional scale) would require fewer experts, i.e. in the range of 5 to 10 [4]. The panel size of 12 experts who agreed to participate in the study presented in this paper is therefore, within the recommend range.

In this study, triangular fuzzy numbers are used as membership functions, corresponding to the elements in a set, because it is intuitively easy for the decision makers to use and calculate. A fuzzy number is a triangular fuzzy number if its membership function can be denoted as follows (1):

\[
\text{(Kaufmann & Gupta, 1988): } f_A(x) = \begin{cases} 
\frac{x-c}{a-c}, & c \leq x \leq a \\
\frac{b-x}{b-a}, & a \leq x \leq b \\
0, & \text{otherwise}
\end{cases}
\]

where \(a, b,\) and \(c\) are real number and \(c = a = b\)

Fuzzy set theory is related to the unclear perception of human thoughts. Linguistic words can represent this by the approximate reason for this fuzzy theory. A linguistic term can be defined as a variable whose values are not numbers, but words or sentences in natural language. The importance weight can be evaluated by linguistic terms such as very low, low, medium, high and very high. These linguistic terms can be expressed via triangular fuzzy numbers, as shown in table 1.

| Linguistic term       | Not important | Somewhat important | important | Very important | Extremely important |
|-----------------------|---------------|--------------------|-----------|----------------|---------------------|
| Fuzzy number          | (0,1,3)       | (1,3,5)            | (3,5,7)   | (5,7,9)        | (7,9,10)            |

2.2. Fuzzy cognitive maps
FCM is a graph consisting of nodes \(C\) that represent the concepts of the domain in study, connected to each other with weighted arcs \(W(i,j)\) showing how concept i is causally affected by concept j. The weights on the arcs connecting two concepts correspond to fuzzy qualifiers, such as ‘a little’, ‘moderately’, ‘a lot’, or fuzzy numbers can be assigned in order to show the extent to i which a concept affects another. FCMs are used to model and study perceptions about a domain, to investigate the interrelationships among its concepts and to draw conclusions based on the implications of scenarios. The impact among the concepts of a FCM is estimated using the indirect effect i.e. the
impact caused due to the interrelationships among the concepts along the path from a cause variable (X) to an effect variable (Y) and the total effect, i.e. the sum of all the indirect effects from the cause variable X to the effect variable Y [9].

FCMs can be represented by means of an N x N matrix \( E = [e_{ij}] \), where N is the number of the concepts in the FCM with i and j representing concepts in the FCM. Every value \( e_{ij} \) of this matrix represents the strength and direction of causality between interrelated concepts. The value of causality \( e_{ij} \) is assigned values from the interval \([-1,+1]\). According to Schneider, Schneider, Kandel, and Chew (1998):

- \( e_{ij} > 0 \) indicates a causal increase or positive causality from node i to j.
- \( e_{ij} = 0 \) there is no causality from node i to j.
- \( e_{ij} < 0 \) indicates a causal decrease or negative causality from node i to j.

The multiplication between matrices representing FCMs produces the indirect and total effects [10] and allows the study of the impact that a given causal effect \( D_1 \) is causing. Causal effects can be represented with a 1 x N vector [11]. This impact is calculated through repeated multiplications: \( E \times D_1 = D_2 \), \( E \times D_2 = D_3 \) and so forth, that is, \( E \times D_i = D_{i+1} \), until equilibrium is reached, which is the final results of the effect \( D_1 \). Equilibrium is reached when the final result equals to zero, i.e. all cells of the resulting vector are equal to zero (0) and there is no any further casual impact caused by any concept. Different thresholds, depending on the modelling needs, restrict the values that result from each multiplication within the range \([-1, +1]\). Therefore, if a value is greater than (+1) then it is set to (+1), or it is set to (-1) if the resulting value exceeds the lower limit of (-1). The FCM suitability for adjusting web design factors [12], [13] and content presentation is argued by considering that a variety of what – if sensitivity simulations can be performed effectively, according to designers and users intentions.

This research uses FDM as a methodology that requires a round of interview to some experts, and consider median from each expert’s judgment as fuzzy number to show causality form in FCM. Calculated median from expert’s judgement can be easily combine concepts of every relationship, this can be occurred when questioner allows expert to fill negative value that indicates inappropriateness media type to represent each service.

3. Research method

The condition of Engineering Faculty’s website (figure 1) before the research is conducted provides some services that gives a lot information that might useful for its users. These services are News, Profile FTUI, Agenda, Scholarship Information, History of FTUI, Vision and Mission, Head of Faculty’s and Department Profile, Professor’s and Lecturer’s Profile, Program Information, Research, Alumni, until Public Facilities.

![Figure 1. Web’s existing condition.](image-url)
To achieve Engineering Faculty web’s objectives, we use one set of best practice that contains some services to build a university’s website. The adapted best practice is gathered based on the result of a research that was conducted by Utah State University. This best practice contains 54 services that might give some important information related to the university which required by its users, as shown in figure 2.

Figure 2. Proposed services that provided on the faculty’s web.

After collecting those services, questioners are made to gather expert’s opinion about degree of importance of each service and degree of appropriateness between services and proposed media type.

The process of Fuzzy Delphi Method is illustrated as follows:
1. Assume that $K$ experts are invited to determine assessment of importance degree of each service and appropriateness degree between media type and services.
2. Convert the linguistic variables into triangular fuzzy numbers as suggested. Let fuzzy numbers $\tilde{r}^k_j$ be the rating of alternative $i$ with respect to criteria $j$ and $\tilde{\omega}^k_j$ be the criteria weight of the $k$th expert.

$$\tilde{r} = \frac{1}{K} \left[ \tilde{r}^1_j \oplus \tilde{r}^2_j \oplus \cdots \oplus \tilde{r}^K_j \right]$$

$$\tilde{\omega} = \frac{1}{K} \left[ \tilde{\omega}^1_j \oplus \tilde{\omega}^2_j \oplus \cdots \oplus \tilde{\omega}^K_j \right]$$

3. For each expert, use the vertex method to compute the distance between the average of appropriateness degree between media type and services to expert’s judgement. The distance between two fuzzy numbers $\tilde{m} = (m_1, m_2, m_3)$ and $\tilde{n} = (n_1, n_2, n_3)$ is computed by:

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

4. Aggregate the fuzzy evaluations by

$$\tilde{A} = \left( \begin{array}{c} \tilde{A}_1 \\ \tilde{A}_2 \\ \vdots \\ \tilde{A}_m \end{array} \right) \text{ dimana } \tilde{A}_i = \tilde{r}_{i1} \otimes \tilde{w}_1 \oplus \tilde{r}_{i2} \otimes \tilde{w}_2 \oplus \cdots \oplus \tilde{r}_{in} \otimes \tilde{w}_n$$

5. For each alternative option, the fuzzy evaluation is defuzzified by:

$$a_i = \frac{1}{4} (a_{i1} + 2a_{i2} + a_{i3})$$

4. Research result

In the early stages of data processing, the services which were originally numbered 54, eliminated in accordance with their importance. The process of elimination is done by calculating the median value of each service value of significance have been determined by the experts. If one of the service has a
median value less than 0.5, then the service is eliminated, while the rest proposed to be provided in the website.

Below is table 2 which shows some of the FCM-Service-Media. The concept of the FCM-Service-Media represents the degree of appropriateness of each service with media type. FCM-Service-Media on the table shows that to present the "Office of research", which is considered the most appropriate media is text, and the second most appropriate media is picture. Although the text appears to have a strong positive impact on the perception of the user when presented the "Office of research" (median = 0.5), while the use of picture seem not to be too influential, whereas if the audio or video media that is used to present the service of the "Office of research" can reduce the perception of the quality of the user on the website of the Faculty. Therefore, this research uses a method that selects the type of media or combination of media types which most appropriate to present their respective service provided in the website based on the opinions of the experts.

Table 2. FCM-service-media.

| Presented service | President’s office | Board of trustees | Research office | Picture | Text | Audio | Video |
|-------------------|--------------------|-------------------|----------------|---------|------|-------|-------|
| President’s office| 0                  | 0                 | 0              | -0.5    | 0.5  | -1    | -1    |
| Board of trustees | 0                  | 0                 | 0              | -1      | 0.5  | -1    | 0     |
| Research office   | 0                  | 0                 | 0              | -1      | 0.5  | -1    | 0     |
| Pictures          | 0                  | 0                 | 0              | 0       | 0    | 0     | 0     |
| Text              | 0                  | 0                 | 0              | 0       | 0    | 0     | 0     |
| Audio             | 0                  | 0                 | 0              | 0       | 0    | 0     | 0     |
| Video             | 0                  | 0                 | 0              | 0       | 0    | 0     | 0     |

Experts have determined their opinion regarding the importance of each service. Later these opinions changed into the form of linguistic terms to be calculated quantitatively. The process of conversion is done by replacing each expert answer with numbers linguistic terms are predefined (table 3). The numbers of such terms is a linguistic default that was designed by Wang and Chang (2007), which ranges from 0 to 10.

Table 3. Linguistic terms of importance degree of each service.

| Presented service | Expert 1 | Expert 2 | Expert 3 | Expert 4 | Expert 5 |
|-------------------|----------|----------|----------|----------|----------|
| Research office   | L M U    | L M U    | L M U    | L M U    | L M U    |
| President’s office| 3 5 7    | 5 7 9    | 5 7 9    | 5 7 9    | 7 9 10   |
| Board of trustees | 3 5 7    | 3 5 7    | 5 7 9    | 5 7 9    | 7 9 10   |

After the opinions of each experts is converted into a form of linguistic terms, then performed the calculation of weights (table 4) by using equation (3). Where $\omega_j^k$ with k is the expert (i = 1, 2, ..., k), j is the service to jth (j = 1, 2, ..., the j) and K is the number of experts who become participants.

Table 4. Calculated weight.

| Service | Picture | Text | Audio | Video |
|---------|---------|------|-------|-------|
| Research| -0.5    | -1   | -1    | -1    |
|         | 0.5     | 0.5  | 0     | 0     |
|         | -1      | -1   | -1    | -1    |
In addition to the degree of importance, the degree of appropriateness between each service with any proposed media converted into the form of linguistic terms in the same way. Here is Table 5 explains one sample conversion value TFN into linguistic terms taken from the expert 1.

**Table 5.** Linguistic terms of degree of appropriateness from expert 1.

| Presented services        | Picture | Text | Audio | Video |
|---------------------------|---------|------|-------|-------|
| President’s office        | (3 5 7) | (3 5 7) | (1 3 5) | (1 3 5) |
| Board of trustees         | (3 5 7) | (3 5 7) | (1 3 5) | (3 5 7) |
| Research office           | (3 5 7) | (3 5 7) | (1 3 5) | (3 5 7) |

After each data value is converted to match the level of linguistic terms, then the average calculation is done from any content with equation (2) (table 6).

**Table 6.** Average calculation result.

| Presented Services | Picture | Text | Audio | Video |
|--------------------|---------|------|-------|-------|
|                    | Avg     | Avg  | Avg   | Avg   |
| President’s office | L       | M    | U     | L     |
|                   | (3.4)   | 5.4  | 7.4   | (3.2) |
| Board of trustees  | L       | M    | U     | L     |
|                   | (2.6)   | 4.6  | 6.6   | (3.4) |
| Research office    | L       | M    | U     | L     |
|                   | (3.4)   | 5.4  | 7.4   | (3.2) |

Calculation of the distance is done by finding the difference between the value of each expert opinion with the average rating of the degree of appropriateness of each proposed media type has been calculated before. Calculation of the distance is intended to find out whether any opinion given by experts is already consensus (table 7). The calculation is done using the equation (4). Where m is the value of the opinions given by the respective experts and n is the average value of opinions from experts.

**Table 7.** Distance calculation result.

| Presented Services | Picture | Text | Audio | Video |
|--------------------|---------|------|-------|-------|
| President’s office | 0.4     | 0.11547 | 0.663325 | 0.11547 |
| Board of trustees  | 0.4     | 0.4 | 0.326599 | 1.137248 |
| Research office    | 0.4     | 0.11547 | 0.663325 | 2.218107 |

The next step is to do a calculation of aggregate to the degree of appropriateness of each service with media type. The calculation of the aggregate is done by multiplying the average matrix of degree of appropriateness with the weighting which is calculated using the degree of the importance of each service. This aggregate calculations using equation (5) (table 8).

**Table 8.** Aggregate calculation result.
After the aggregate results obtained, the results are then forwarded to the defuzzification. Defuzzification is a way to obtain the crisp value of the fuzzy set. Generally there are five methods to defuzzified a fuzzy set. On this research, defuzzification is done by using defuzzification formula (6) (table 9).

Table 9. Defuzzification calculation result.

| Presented service | Picture | Text | Audio | Video |
|-------------------|---------|------|-------|-------|
| Research office   | 39.43   | 36.9 | 17.94 | 23    |
| President’s office| 32.03   | 37.27| 19.39 | 27.02 |
| Board of trustees | 37.27   | 34.88| 17    | 19.62 |

5. Discussion
On the previous chapter, we obtain a fuzzy evaluation that continued to determining the ranking of each media type for each service. This rank is used to assign appropriate media type to present every service provided on the web.

After each page has determined the content, then determining the layout of each of the content on each page. The determination of this layout is based upon research that has been done by Ahmadi and Kong (2012) which mentions that there are five main sessions on every page of the website: (1) top, (2) main content, (3) left and right menu, (4) bottom, and (5) the gutter such as advertising. This study assumes that the Web page is composed of five areas (figure 3) and the relative importance level [14].

Figure 3. Web page with five relatively importance level area.

During the process of personalization presentation, media type and the services given the ranking based on the maximum value of fuzzy evaluation obtained by each media type to every service. Then the most important service features are positioned within area (1), which covers the centre area of a web page. Then the second most important is placed across the top and moving from the top of the page clockwise to the rest of the areas, with the least important to be positioned in the left margin area (5). There is an upper limit of two service features per area. If more than two service features could be placed within the same area, then by randomly choosing, one should be moved to the next area of lower importance.

6. Conclusion
From this research, we can conclude that:

- By doing a modeling using Fuzzy Cognitive Maps, determination of media type to presents each service can be obtained by calculating the median value of each TFN that collected by doing interview to some experts so aware that the determination of media type to each service can affect the user’s quality perception.
- FDM able to answer the weakness of FCM modeling.
- To be able to improve the usability of a website, FDM is suitable because of the method by using the draft presentation of a site will be better suited to the needs of its users, such as the determination of the type of media for each service as well as determining the layout of each of the content on each web page.
- Shortage of FDM is that web designer cannot determine the content of each web page by using this method, so in this research determination of content to each web page is done by researcher’s personal assumptions.

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Recommendation
- Further research can be done for the determination of the content of each web page, so that web pages of a website be unbiased.
- Interview conducted for data collection used in the method of Fuzzy Delphi should be carried out to the competent and objective expert so that research results can be more valid, reliable, and can be made into best practice for web designers.

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