Methodology of fuzzy usability evaluation of Information systems in Public administration

MILOSLAV HUB, MICHAL ZATLOUKAL
Department of System Engineering and Informatics
Faculty of Economics and Administration
University of Pardubice
Studentská 84, 532 10 Pardubice
CZECH REPUBLIC
miloslav.hub@upce.cz, michal.zatloukal@student.upce.cz

Abstract: This paper suggests methodology of usability evaluation of information systems in public administration based on fuzzy logic theory. The first part of this paper is devoted to the problem formulation. The following parts of this paper formulate the methodology of usability evaluation aimed to public administration information systems. The authors introduce new ways how to evaluate the user interface with help of vague terms. Fuzzy Usability Evaluator – an application that is able to operate with the vague nature of evaluating is also introduced.

Key-Words: Usability, information systems, public administration, fuzzy logic, methodology, software quality, software engineering

1 Introduction

A usability becomes extraordinary important in today's information age. The discipline dealing with it - usability engineering is quite new in terms of history, experience and number of trained people. Yet, it became very popular.

An importance of usability evaluation increased rapidly in last 10 years [12]. In contrast to the past, users are no longer forced to use particular product that does not fully satisfy their needs or requirements, just because there does not exist any other. That is also why the measuring of usability had been underestimated.

At present, the usability is a fundamental part of software engineering [13]. It can reveal qualities of product as well as lack of functionality, which usually arises during the design phase of a product. Moreover, the usability testing is not only limited to testing the quality of use of software products, it can test almost any kind of product that has an user interface such as remote controllers as well as a cell phones [3], [6]. Besides new techniques of usability data analysis occur nowadays [11], [17], [18].

2 Problem Formulation

Although usability studies are widespread, the issue of Web sites usability evaluation remains still a very young and unexplored area of interest. There is not any clear consensus how to measure usability obtaining a significant score for the Web site usability, taking also in mind that users' language is full of vague expressions, ambiguities and uncertainty [14].

Measuring the usability results from a need to have:

- an objective indicator of quality of use,
- a value that can be compared to the other similar values.

2.1 The Goal of the Research

The goal of this work is to create a methodology easing the user's ability to evaluate the usability by using his natural language, which is full of vague expressions. Since it is not appropriate to express vagueness, uncertainty or ambiguity (as natural parts of communication, decision making and other common processes that human beings are surrounded and interact with) using classical binary logic, this work presents a completely new approach for usability evaluation based on fuzzy logic.

The model will be based on a set of Web usability guidelines, which is going to be selected thoroughly and sensitively according to the characteristics of the target environment. The output of the model should be a single real number representing the overall score of particular Web site. This score could be used either as a measure of usability as a part of overall quality or as well as an input for comparative analysis[1].

The proposed methodology is going to be developed for Web sites of Public administration (WSPAs), but it is not only limited to them, if the input criteria will be modified according to the characteristics of different environment.

[1] Comparative analysis is defined as item by item comparison of two or more comparable alternatives, processes, products, sets of data, systems, etc. [21].

2.2 Problem Decomposition

In order to achieve the goal proposed in this paper, a problem definition should be first analyzed.

The initial problem is to perform a "*usability evaluation of Information systems in Public administration using fuzzy logic*". Apparently, such definition seems to be complicated at first sight. Hence, it is appropriate to decompose it. The proposed initial problem decomposition is presented in Table 1.

Table 1: Initial problem decomposition

Notation of decomposed part	Auxiliary question	Decomposed part	Area of interest	Methods
Subject / task	What task is about to be performed ?	*"Usability evaluation"*	Usability engineering	Usability testing, questionnaires
Object	On what object is to be the task performed ?	*"of Information systems"*	Information systems	Structure of the Information system
Environment	In what environment will be the task performed ?	*"in Public administration"*	Public administration	Characteristics of the environment, its users and relationships of the system
Methodology	By the help of which method, is the task going to be performed ?	*"using fuzzy logic"*	Fuzzy sets and systems	Operations with fuzzy sets, fuzzy numbers, fuzzy inference system, fuzzy rule base

According to the presented decomposition, the problem should be first defined per parts, described individually, then synthesized and solved as a complex problematic.

2.3 Web site Usability Evaluation

Measuring the usability aspects of the system's user interface[2] with the help of particular methodologies is called the usability evaluation [2], [13]. As stated in [5], the usability evaluation can reveal the problems of the design and allows also better understanding of the targeted users [13]. According to [15]:

"The usability is measured by how easily and how effectively it can be used by a specific set of users, given particular kinds of support, to carry out a defined set of tasks, in a defined set of environment"

Literature [13] recommends measuring usability by having a number of test users, selected to being as representative as possible, who performs a set of tasks on tested system.

Testing aspects of Web site's usability is in fact the same as a testing of any another interface. Web site usability evaluation differs from general usability testing of some software product by different set of guidelines, tasks and possibly also by a broader spectrum of users of such system. Therefore, a Web site usability definition is very similar (if not the same) to the one presented above.

Guidelines list well-known principles for UI design, which should be followed in the development project [13]. Various usability guidelines exist and have been established by different authors. These can be found for instance in [16], [12], [5], [9]. Each of them focuses on how to satisfy users by presenting usable Web design. However, there is no general agreement about which Web guidelines are correct. Additionally, contradictions exist among guidelines [5], which might be caused by many factors, for instance as follows:

- specifics of particular Web environment,
- changes in the technology,
- relative propriety only for a specific group of users, etc.

There are many Web design recommendations, which provide Web developers with useful usability guidelines. Following list contains several commonly used and empirically validated Web usability guidelines. Each of them affects one of the aspects of Web site quality such as readability, understanding the navigation, understanding the content, Web design quality, recency, etc.)

- The content should represent 50 - 80% of the page [12].
- Update content often [4], [12].
- Too many colors in the design reduce their functionality, which affects the readability [1].
- Minimizing the use of the users' memory is one of the major usability recommendations [12].
- The font size has a major influence on the legibility of Web page [8].
- The number of images in the Web pages should be minimized unless they are necessary [12].
- Minimize animated graphics, which could negatively affect the readability [4].
- Download speed should be no more than 10 seconds [12].
- Use consistent navigation elements [4].

2.4 Environment of the Public Administration Information Systems

Constraining the problematic to the environment of Public administration will ease the complexity of the

[2] The user interface is the aggregate of means by which people – the users – interact with the system – a particular machine, device, computer program or other complex tools [2].

initial problem; a set of affecting factors – specific input variables, will be chosen in order to retain all characteristic aspects and to develop a realistic model of such environment.

Public administration (i.e. state administration and local authorities) can be broadly described as the development, implementation and study of branches of government policy [16]. It is linked to pursuing public good by enhancing civil society and social justice. Public administration in contrary to the state administration has a decentralized, local character.

Among many other responsibilities, a local authority usually administrates its Web site where various kind of information is presented.

2.4.1 Information Systems in Public administration

Various systems can be considered as Information systems in Public administration (ISPA). It is evident, that there exist also information systems focusing on other areas of interest; for instance corporate, transportation, educational, mobile, family, industrial, chemical etc.

An Information system (IS) is according to [19] the system of people, data and activities that processes the data and information in a given organization, including manual processes or automated processes. Usually the term is used as a synonym for computer-based information systems, which is only the Information technologies component of an Information system.

A definition coming from [22] defines ISPAs as a set of ISs that serve the execution of Public administration and support its activities. ISPAs should also provide public information services.

2.4.2 Web Portal of Public administration (WPPA)

Since the common definition of IS presented above does not particularly determine any particular framework, the one that is accessible with minimal restrictions for maximum users should be chosen. Such platform can be easily evaluated, tested; the selected group of tested subjects would be highly representative.

Authors assume to use the Web-based ISPAs, since the Web platform is recently the most dynamical environment for presenting any kind of information.

A Web portal is a site that functions as a point of access to information on the World Wide Web (WWW). Portals present information from diverse sources in a unified way. Aside from the search engine standard, Web portals offer other services such as e-mail, news and other features [21]. A WPPA could be perceived as a virtual environment in which citizens meet the Public administration, where portal represents one initial point, which allows access to services and information provided by Public administration [10] (see Fig. 1).

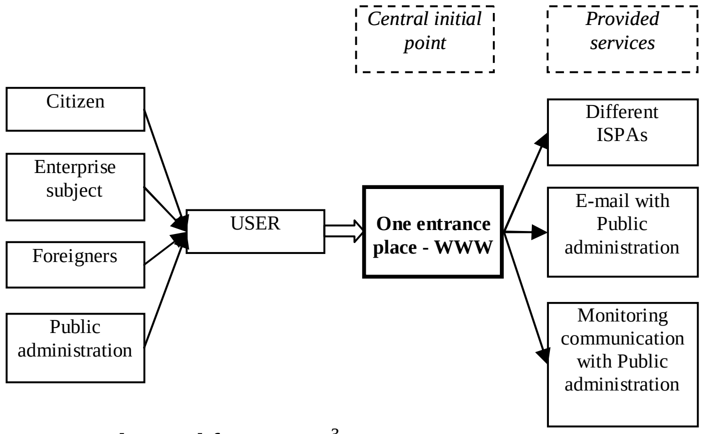

Fig. 1: Web portal functioning[3]

The most suitable type of Information system to perform the proposed goal will be the Web portals presenting the municipalities (generally local authorities): cities, small towns, villages, districts or any other Web sites that presents some urban area or municipal territory, which also falls within Public administration.

The reasons leading authors to choose this particular type of IS are following:

- it has large number of users due to its accessibility,
- it is not subject to any restrictions of use,
- it is free of charge,
- to understand its content does not require any special knowledge,
- the representative group of typical users can be easily chosen,
- it is constantly available,
- testing its usability has a utility, which can result in increasing the quality, if the results of evaluating reveal any problems,
- the results of evaluation can be compared to other similar Web sites.

2.5 Fuzzy logic

As cited by [19], classes of objects of the real world do not have precisely defined criteria of membership. Such classes, however imprecisely defined, play an important role in human thinking [19].

Fuzzy variables are more attuned to reality than crisp variables [7]. In fact, it is a paradox that data based on fuzzy variables provide more accurate evidence about real phenomena than those based upon crisp variables.

High levels of uncertainty (e.g., “She might be married, but perhaps she is divorced”), imprecision (we might report a length as 2m when it is actually 2.324 m), ambiguity (e.g., “He is tall”), vagueness, fuzziness and complexity of real-world problems lead to recognition

[3] Source: Mihaliková, E. (2006). Portals in public administration and assumptions of its efficiency.

that classical dichotomy logic is not sufficient for solving such problems. Ways of expressing uncertainties according to [14] include theory of probability, fuzzy logic, Bayes' theorem and Dempster-Shafer theory. He also remarks that each theory has its advantages, disadvantages and problems. Although any convincing argument cannot be presented, he finds fuzzy system theory as the most suitable to deal with uncertainty, ambiguities and contradictions, having as the only presented theory a clean mathematical framework provided by fuzzy sets. However, for many scientific fields, the fuzzy logic is the only suitable apparatus, while the other theories fail.

When the function takes any real value between zero and one, it indicates partial degrees of membership of the element x into the set $\widehat{A}$. This generalized characteristic function is known as membership function $\mu_{\widehat{A}}$ defined by (1) as:

$$\mu_{\widehat{A}} : X \rightarrow [0,1] \quad \text{where } x \in X. \qquad (1)$$

The membership is defined over the closed interval [0, 1] and since it can be partial, the set is known as fuzzy set $\widehat{A}$, while the notation $\mu_{\widehat{A}}(x)$ indicates the membership of the element x into the fuzzy set $\widehat{A}$. Thus, the fuzzy set $\widehat{A}$ might be represented as (2):

$$\widehat{A} = \{[x, \mu_{\widehat{A}}(x)] | x \in X\}. \qquad (2)$$

The basic concept which makes possible to treat fuzziness in a quantitative manner is based on a membership function [20]. Each membership function defines a fuzzy set and receives a linguistic label (name) that assigns the linguistic value to the set.

The membership functions may be of almost any shape, very often they are triangular (piecewise linear), s-shape (piecewise quadratic) or normal (bell-shaped). They may also be trapezoidal with an interval within which the membership is equal to 1.

The variable described by fuzzy sets and defined over specific context-dependent universe of discourse is known as linguistic variable. Linguistic variables are discrete fuzzy sets. They consist of the name of the discrete fuzzy set (e.g., speed), the names of its members – linguistic values (or linguistic terms), and for each linguistic value, a membership function exists [14].

For example, a variable such as speed, defined in the context of a car, has universe of discourse between 0 kilometers per hour and 220 kilometers per hour. Such linguistic variable "speed of the car", can be divided into three fuzzy sets (granules[4]), whose linguistic values are "low speed", "medium speed" and "high speed".

As discussed above, fuzzy sets are helpful to describe vague concepts, since they do not posses sharply defined boundaries [20]. It is very important to point out, that the representation of the concepts in terms of a membership function depends not only on the concept itself, but also on the context of the idea. For example, the idea of "high speed" can by interpreted in several contexts. The driver of the car may consider the speed of 180 kilometers per hour as "high speed", while the pilot of the racecar considers "high speed" somewhere around 300 kilometers per hour. Thus, the concept of "high speed" would be defined with different membership functions for each concept.

Fuzzy numbers are a special kind of fuzzy set whose members are numbers from the real line, and hence are infinite in extent [14]. They represent numbers of whose values somewhat uncertain. For instance, the proposition "Age is about 25" is a fuzzy number, but the proposition "Speed is fast" is a discrete fuzzy set.

As defined above, the function relating member number to its grade of membership is called a membership function and it can be best visualized by a graph such as Fig. 2. The membership of a number x_0 from the real line is often denoted as $\mu(x_0)$. The number $x_0 = -2$ on Fig. 2 has grade of membership 0.25.

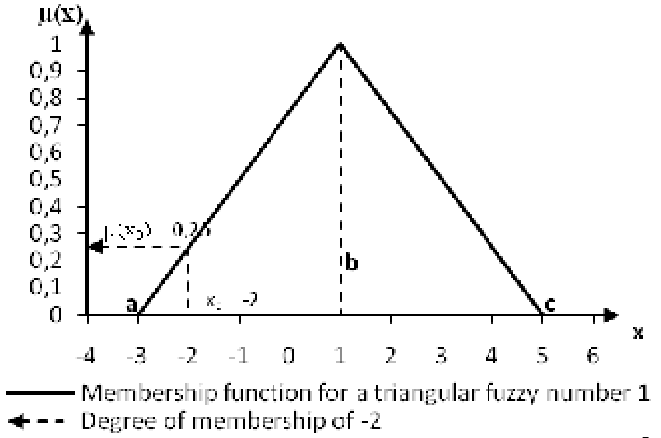

Fig. 2: Membership function for a triangular fuzzy number 1[5]

Fuzzy controllers in contrary to classical controllers are capable of utilizing knowledge elicited from human operators [7]. Since it is also very difficult to express such knowledge in precise terms, an imprecise linguistic description of the control problem can be used instead. This linguistic description consists of a set of control rules that inheres in the knowledge base.

A general fuzzy controller as stated in [7] consists of the following elements:

- fuzzy rule base (knowledge base),
- fuzzy inference engine,
- fuzzification module,

[4] Granularity represents number of membership functions [7]

[5] Source: Siler, W., & Buckley, J. J. (2005). *Fuzzy Expert Systems and Fuzzy Reasoning*.

- defuzzification module.

In general, fuzzy controllers are special type of expert systems[6] [7]. The range of control problems vary from complex tasks to simple goals as maintaining a prescribed state of a single variable [7].

The process of drawing conclusions from existing data is called inference. In inference process new truths are inferred from old ones [14].

The purpose of the inference engine is to combine measurements of input variables with relevant fuzzy rules in order to make inferences regarding the output variables. The given fuzzy inference rules are used in the form such as (3):

if (this is true) then (do that). (3)

A typical example of a fuzzy control rule is (4):

IF speed is very high AND torque is high THEN gear ratio is very small. (4)

A fuzzy controller operates by repeating a cycle of the actions as that one shown on Fig. 3. For instance, [7] defines the process of inference as follows. First, measurements are taken (e.g., the facts are evaluated, the simulation is executed, etc.) of all variables that represent the process.

Next, these measurements are converted into appropriate fuzzy sets to express measurement uncertainties (see Step 1 on Fig. 3). This step is called a fuzzification. The fuzzified measurements are then used by the inference engine to evaluate the control rules stored in the fuzzy rule base (see Step 2 on Fig. 3). The result of this evaluation is a fuzzy set (or several fuzzy sets) defined on the universe of possible actions (see Step 3 on Fig. 3).

This fuzzy set is then aggregated (see Step 4 on Fig. 3). In the final step of the cycle the aggregated set is converted into a crisp value that is in some sense the best approximation of such fuzzy set. This conversion is called a defuzzification (see Step 5 on Fig. 3). The defuzzified values represent actions taken by the fuzzy controller in individual control cycles [7].

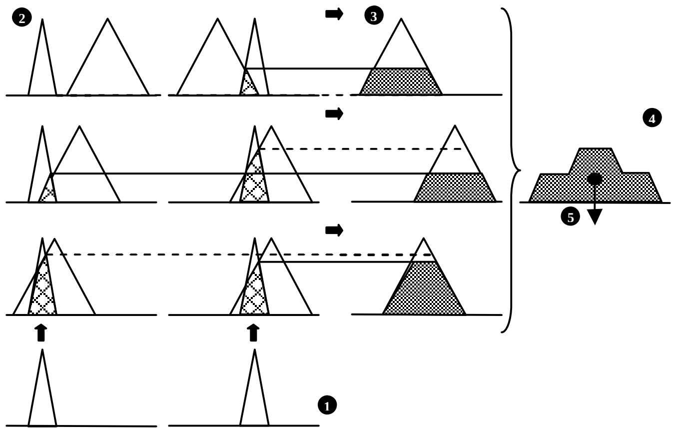

Fig. 3: The process of fuzzy inference with fuzzified input measurements[7]

3 Problem Solution

According to facts mentioned above, there is a need to create usable and reasonably accurate methodology helping to evaluate Web site's usability representing several of commonly acknowledged Web site usability guidelines.

The results of background research helped to gain the idea how to solve the initial problem. As stated previously, the definition of the initial problem itself is very difficult, therefore the problem was decomposed and its parts were described separately. Authors suppose that the coherence between usability and fuzzy theory is the most difficult objective, since there is no scientific background or research studies regarding this approach for measuring the usability.

An own set of suitable criteria (based on commonly accepted guidelines for Web usability) will be chosen. Such set however small might seem, retains all major characteristics of target environment and approximates the result of usability evaluation accurately. It is necessary to remark, that no standard usability score scale have been created. Authors are not trying to create any kind of standard scale, but rather to experiment with the results of this interesting and promising area of interest.

Rather than performing a complicated general analysis, there is a need to create a realistic model solving the problem and an interactive application, so this can be put in operation and used repeatedly without expert knowledge of the fuzzy theory. Fuzzy theory is a powerful apparatus helping to manage the uncertainties, but very truly, its advanced techniques are very difficult to understand, especially for people who are only interested in finding the more suitable way how to evaluate the usability of the Web sites. Thus, the entire fuzzy inference engine should be hidden, not visible for those who does not need or want to deal with it.

---

[6] Expert systems are defined as computer programs, designed to make available some of the skills of an expert to non-experts [14].

[7] Source: Klir, George J. and Yuan, Bo., *Fuzzy Sets and Fuzzy Logic: Theory and Applications.* Upper Saddle River : Prentice Hall, 1995.

Commonly known working environment should be used. Such environment must offer both simple and advanced operations, as well as a graphical user interface (GUI), graphical outputs, and simple database. Microsoft Excel was chosen as a fully convenient environment for the purpose of this research. The results can be easily interpreted in graphical form or in form of summaries. Furthermore, Microsoft Excel allows structuring the information transparently. Sure, in future the special adjusted software can be developed, but the aim of this research is to verify hypothesis the fuzzy logic can be used for usability evaluation.

For the purposes of this work an application Fuzzy Usability Evaluator (FUE) has been developed. FUE is a WPPA usability evaluator using fuzzy logic. With FUE, one can:

- evaluate the usability,
- collect the results of usability testing,
- use the results to get the score for evaluated Web site,
- extend the rule base,
- extend other knowledge obtained by testing,´
- use own set of characteristics (input variables) for use in different environment,
- display the outputs in graphical way,
- work in advanced mode to get detailed results.

FUE is an analytical application consisting of multiple collaborating modules providing a good visual and computation feedback to a person controlling it – the evaluator. FUE is a lightweight application that does not require highly educated or experienced operator trained for particular environment (such as MATLAB, Simulink, etc.). There is large potential making FUE very scalable, customizable tool for evaluating the usability of particular environment. FUE can be considered as an expert system, since it consists of the powerful computation engine, several databases containing expert knowledge giving FUE new possibilities how to deal with uncertainty, vagueness. FUE requires less from target users while it offers a lot to the evaluators.

The reason FUE was created, was the lack of transparency, ease of use, usability of powerful all-in-one tools such as MATLAB.

FUE consists of several modules; each of them has a different function. In current version of FUE, there are nine modules:

- Overview
- Questionnaire
- Detailed questionnaire
- Evaluation
- Inference
- Scales
- Linguistic convertor
- Score collector
- Evaluation base

3.1 Vague nature of user's language

What does it mean "to be fast"? What quantitatively expressed single real number means to be "exactly" fast? Different person has different answer and *opinion*. As a result of this question, highly imprecise answer would appear, yet expressed with a number.

What would be the answer, if the question was "To what degree do you consider the information comprehensible instantly and simultaneously"? It is apparently possible to state the answer as a single number that is member of some scale (say 0 – 100). But would this number have a significant level of accuracy or would it be just an *opinion* or a feeling about some state of the variable?

In case of such question, it would be more appropriate to use answers (i.e. evaluations) such as "very well" or "quite easily". These evaluations are in principle vague, imprecise, does not stand for any single value that would be commonly accepted. There is thus another question – what number (set of numbers) stands for "very well" or "quite easily"? The problem of evaluation seems to be even more complicated - answering a complex question with the vague expression. How can this be more accurate?

The solution how to treat uncertainty that inhere in users' evaluations, however fuzzy, vague or imprecise the idea seems to be, is to express them in form of fuzzy numbers (as defined above).

As a result of evaluating desired amount of tested users, a set of evaluations expressed in users' natural language is obtained. Each criterion is evaluated by one expression that is then converted to the form of the fuzzy number (fuzzy measure). Such measure is then compared to the appropriate membership function of particular criterion; process can be treated as a fuzzy controller and the computation of crisp output continues as described earlier according to Fig. 3.

All the procedures necessary for evaluating the usability of WPPA are performed in FUE. An *evaluator* working with FUE first collects the evaluation data in module Questionnaire. This data is then decomposed and converted in Detailed questionnaire with the help of other modules Linguistic convertor and Scales. Evaluation process is then represented graphically in module Evaluation, where the *evaluator* obtains better idea about the conversion.

It is important to present the mechanism of converting the users' evaluations to the form of fuzzy numbers. For this purposes, set of (testing) users define the empirical scale. This scale is stored in module Scales and represents the numeric counterparts of particular evaluations expressed as fuzzy numbers. The scale is defined on range from 0 to 100 dividing this universe of discourse to finite number (24) of subranges, i.e. ranges of particular evaluations denoted as normalized evaluations. User is free to use any expression representing some evaluation. Such expression is converted to one of 24 normalized evaluations that represent the same value of variable (i.e. the same meaning). This conversion is performed by Linguistic convertor that consists of several databases containing various expressions.

The process of definition the scale consists of getting word and numeric (score) answer as a result of the evaluation of particular criterion. The *evaluator* should instruct the user to evaluate the criterion in two ways: first by word and then by numeric expression. User must not assign the score directly to the word evaluation by choosing for instance some value from 0 to 100, since there is a risk to incline to some well-known patterns such as “average is equal to 50”, “very bad means 0”. User should rather try to evaluate the same fact separately (e.g. Evaluate the speed by which the Web site's elements are loaded) by assigning some score and a word evaluation, e.g. Loading speed is “quite low”, Score for Loading speed is 27 (or 30, 10, 15). Thus, we can assume that users’ word evaluations about some criterion may be quite uniform, but there will be variance among the score values assigned by different users to such meaning.

Every normalized evaluation will consist of some center value (calculated as a mean of all obtained score values for particular evaluation) and of its left and right border (that is calculated as a standard deviation). All necessary attributes are then defined and the expression can be expressed as a fuzzy number.

When the scale becomes representative (i.e. sufficient amount of testing users provided their evaluations and scale is well defined), regular usability evaluation can be initialized.

It must be noted that the nature of evaluating is purely subjective. There are no criteria requiring user to qualify an objective measure. That is however impossible, since human brain does not work as a measuring device or a computer. The persons who evaluate are either common users or experts. Their only task is to qualify an evaluation. To deal with the uncertainty and the process of getting an overall usability score is clearly a task of the inference system implemented to FUE.

3.2 Criteria of evaluation

As previously stated, the presented set of input variables (i.e., characteristics, criteria, guidelines, etc.) are all based on current usability studies and experts’ recommendations, in addition to other common recommendations for legible Web UIs. An extensive survey of Web design literature written by recognized experts was conducted to identify key aspects that impact quality and usability of Web UIs. Presented combination (mix) of characteristics was not previously used in any research or literature.

The used criteria including the questions that are users asked are listed in Table 2.

Table 2: The list of used criteria

No.	Criterion	Evaluating question
1	Accessibility	Specify to what extent is the Web site’s content legible (readable) and viewable for you.
2	Instant comprehension	To what degree do you consider the information comprehensible instantly and simultaneously?
3	Information retrieval	Qualify your level of satisfaction when searching for any kind of information (no matter if you finally found what you were looking for).
4	Recency	Specify to what degree is the information found on the Web site actual.
5	Navigation simplicity	Specify the degree to which you find the Web site's navigation simple and comprehensible.
6	Design preference	How much does the graphic design of the Web site fulfill your expectations or meet your requirements?
7	Orientation	Evaluate the level of certainty of your current location and progress through the Web site at any moment during the session.
8	Amount of graphics	Qualify your level of satisfaction with the amount of graphic elements appearing on the Web site.
9	Loading speed	Evaluate the speed by which the Web site's elements are loaded.

3.3 Fuzzy inference process

Let's assume that together with the scale definition, testing users also helped to define the fuzzy rule base. Each set of evaluations creates the right side of the fuzzy rule (rule antecedent). The left side of such rule (rule consequent) is determined by human expert (e.g. web design expert, web administrator or *evaluator*) by assigning a linguistic value (low, medium, high) to linguistic variable Usability as a result of particular combination of evaluated criteria.

Human expert chooses linguistic value of particular criterion according to the highest degree of membership that the evaluation (fuzzy number) for the criterion has with the membership functions of such criterion. Let's assume that user evaluated Recency (criterion No. 7) as "very good". Human expert defines a new fuzzy rule and decides how to deal with the fact that Recency is "very good". He can either check the highest degree of membership (intersection) of fuzzy number "very good" with membership functions of linguistic variable Recency in module Inference, or he uses particular graph in module Evaluation to have clear idea about the situation. According to that, he states that linguistic variable Recency is "high". At the end, he also defines the consequent of such rule, according to his expert knowledge and experience. This approach could be denoted as best-fit rule generation (RG), since the appropriate linguistic state of criterion is selected according to the highest degree of membership.

There is however possibility to define another rule(s) from the same evaluation by choosing always the highest/lowest possible state of linguistic variable (Recency is "high"/"low" and was evaluated as "very good") for each criterion (except those where fuzzy number has no intersection with the particular membership function, degree of membership is equal to 0), even if the degree of membership of such intersection is not the highest. Such approaches could be denoted as highest grade RG and lowest grade RG respectively. The reason of this is to create versatile fuzzy rule base covering the most of the possible situations that can appear during the inference process.

Each new evaluation can be used to define new fuzzy rule, FUE's inference module is thus still learning and its results are more accurate.

Overall usability score for particular WPPA is obtained as the best possible approximation of multiple rules that helps to interpret the evaluation. Computation of the output represents the score of the particular evaluation. Such score is a number that lies between 0 and 100 representing overall usability of the tested WPPA.

3.4 FUE in action

The process of fuzzy usability evaluation starts with evaluating the criteria (see Table 3). The evaluation expressions are provided by users of target information system. The form of the expressions has no particular way. Users are free to use any words. This way offers a better way of opinion formulation for evaluators on opposite of standard ways that use numeric evaluation based on some scale or selection from defined statements.

Table 3: Evaluation of criteria

Usability evaluation questionnaire		
No.	**Full question**	**Evaluation**
1	Specify to what extent is the Web site's content legible (readable) and viewable for you.	very very well
2	To what degree do you consider the information comprehensible instantly and simultaneously?	absolutely easily
3	Qualify your level of satisfaction when searching for any kind of information (no matter if you finally found what you were looking for).	very good
4	Specify to what degree is the information found on the Web site actual.	easily
5	Specify the degree to which you find the Web site's navigation simple and comprehensible.	above average
6	How much does the graphic design of the Web site fulfill your expectations or meet your requirements?	fully
7	Evaluate the level of certainty of your current location and progress through the Web site at any moment during the session.	great
8	Qualify your level of satisfaction with the amount of graphic elements appearing on the Web site.	optimal
9	Evaluate the speed by which the Web site's elements are loaded.	very quickly

The conversion is performed by Linguistic convertor, a database that consists of number of expression with the same meaning as the universal ones. Further information about the conversion is summarized in Detailed questionnaire (see Table 4) that provides better feedback to evaluator.

Table 4: Conversion of evaluations

Criterion	Evaluation	Hedge	Evaluation adjective	Converted hedge	Converted evaluation adjective	Converted evaluation
Accessibility	very very well	very very	well	very very	good	**very very good**
Instant comprehension	absolutely easily	absolutely	easily	extremely	good	**extremely good**
Information retrieval	very good	very	good	very	good	**very good**
Recency	easily		easily		good	**good**
Navigation simplicity	above average	above	average	above	average	**above average**
Design preference	fully		fully		good	**good**
Orientation	great		great	very very	good	**very very good**
Amount of graphics	optimal		optimal	very	good	**very good**
Loading speed	very quickly	very	quickly	very	high	**very high**

As a visual feedback, *evaluator* can use module Evalution to see the fuzzy number (grey triangle on Fig.) representing the evaluation and its intersection points with the particular criterion (Fig. 4 illustrates the situation for criterion Accessibility).

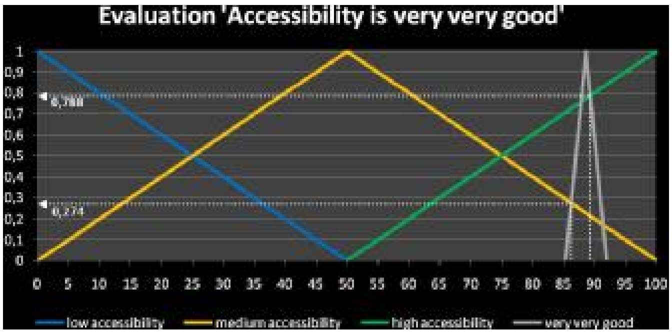

Fig. 4: Evaluation represented graphically

An overall output is then displayed in module Inference. The usability score is a single value between 0 and 100 representing the quality of use of a target information system. The result of evaluation from Fig. 4 is depicted by Fig. 5. The output is calculated as a center of gravity of area lying under the orange line.

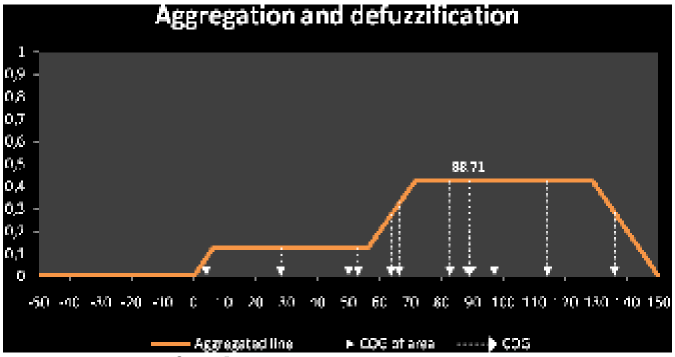

Fig.5: Output of evaluation

Evaluator used an empirical scale whose parameters were obtained as described previously. Its form after getting inquiring 30 users is depicted on Table 5.

Table 5: Empirical scale

Empirical evaluation				
Evaluation	**Range**		**Mean**	**Standard deviation (σ)**
	From (mean-σ)	**To (mean+σ)**		
extremely (-)	0,00	4,17	2,08	2,08
very very (-)	5,83	14,17	10,00	4,17
relatively very (-)	13,96	21,04	17,50	3,54
very (-)	14,64	26,79	20,71	6,07
quite (-)	25,54	35,80	30,67	5,13
relatively (-)	25,00	33,33	29,17	4,17
more or less (-)	21,67	38,33	30,00	8,33
(-)	21,57	31,63	26,60	5,03
approximately (0)	40,16	65,17	52,67	12,50
more below (0)	33,33	41,67	37,50	4,17
slightly below (0)	42,85	48,15	45,50	2,65
below (0)	36,46	43,54	40,00	3,54
slightly above (0)	52,83	61,17	57,00	4,17
more above (0)	58,33	66,67	62,50	4,17
above (0)	60,15	65,18	62,67	2,52
0	47,88	58,34	53,11	5,23
relatively (+)	65,10	75,47	70,29	5,19
quite (+)	72,17	75,83	74,00	1,83
more or less (+)	66,67	83,33	75,00	8,33
relatively very (+)	74,34	85,66	80,00	5,66
very very (+)	85,37	92,04	88,70	3,33
very (+)	76,96	85,54	81,25	4,29
extremely (+)	93,43	98,97	96,20	2,77
(+)	68,96	76,04	72,50	3,54

4 Conclusion

This paper shows fuzzy logic is a very promising way of usability evaluating. The evaluators can use the language they are commonly using therefore the measuring of their opinion is more straightforward.

The solution how to deal with the initial problem Fuzzy Usability Evaluator, groups the methodology necessary for evaluating the usability of the WPPAs is introduced. FUE is not a usability validator on first place, detecting the deviations from usability standards (guidelines), but rather an evaluator, providing the information about quality of use of the Web site from usability point of view.

Acknowledgments
This paper was created with a support of the Grant Agency of the Czech Republic, grant Nr. 402/08/P202 with title Usability Testing and Evaluation of Public Administration Information Systems.

References:

[1] Badre, Albert N., *Shaping Web Usability: Interaction Design in Context.* Boston : Addison-Wesley Professional, 2002. p. 304. ISBN 0201729938.

[2] Dix, Alan, et al., *Human-Computer Interaction.* 2nd. Upper Saddle River : Prentice Hall, 1998. p. 656. ISBN 01-32398-648.

[3] Dhillon, B. S., Engineering Product Usability: A Review and Analysis Techniques. In *WSEAS TRANSACTIONS on CIRCUITS and SYSTEMS.* Issue 2, Volume 4, 2005. p. 86-94. ISSN 1109-2734.

[4] Flanders, Vincent and Willis, Michael, *Web Pages That Suck: Learn Good Design by Looking at Bad Design.* 1st. s.l. : Sybex Inc., 1998. p. 288. 078212187X.

[5] Ivory, Melody Yvette, *An Empirical Foundation for Automated Web Interface Evaluation.* UC Berkeley Computer Science Division. 2001. PhD Dissertation.

[6] Kaharoca, Adem, et al. Usability Evaluation of Cell Phone User Interfaces. In *WSEAS TRANSACTIONS.* Issue 8, Volume 3, 2006. p. 1582-1588. ISSN 1709-0832.

[7] Klir, George J. and Yuan, Bo, *Fuzzy Sets and Fuzzy Logic: Theory and Applications.* Upper Saddle River : Prentice Hall, 1995. p. 592.

[8] Laarni, Jari, "Effects of Color, Font Type and ord Style on User Preferences and Emotions." [ed.] C. Stephanidis. *Human Computer Interaction International.* 2003, pp. 31-32.

[9] Lynch, Patrick J. and Horton, Sarah, *Web Style Guide: Basic Design Principles for Creating Web Sites.* 6th edition. New Haven : Yale University Press, 1999. p. 176. ISBN 0300076754.

[10] Mihaliková, Eva, "Portals in public administration and assumptions of its efficiency." *Studia Negotia.* 2006, 2.

[11]Mosqueira-Rey, E., V. Moret-Bonillo, V. Engineering Product Usability: A Tool for the Analysis and Interpretation of Usability Data. In *WSEAS TRANSACTIONS on COMPUTERS.* Issue 10, Volume 5, 2006. p. 2372-2379. ISSN 1109-2750.

[12]Nielsen, Jakob, *Designing Web Usability: The Practice of Simplicity.* Thousand Oaks : New Riders Publishing, 1999. p. 419. ISBN 156205810X.

[13] Nielsen, Jakob, *Usability Engineering.* San Francisco : Morgan Kaufmann Publishers Inc., 1995. p. 362. ISBN 0125184069.

[14] Siler, William and Buckley, James J., *Fuzzy Expert Systems and Fuzzy Reasoning.* 1st. s.l. : Wiley-Interscience, 2005. p. 424. 0471388599.

[15] Shackel, Brian, *The concept of usability.* Poughkeepsie : s.n., 1981. In Proceedings IBM Software and Information Usability Symposium. pp. 1-30.

[16] Shneiderman, Ben, Plaisant, Catherine, *Designing the User Interface: Strategies for Effective Human-Computer Interaction.* 4th edition. New York : Addison Wesley, 2004. p. 672. ISBN 0321197860.

[17] Tanja Arh, Borka Jerman Blažič, A Case Study of Usability Testing – the SUMI Evaluation Approach of the EducaNext Portal. In *WSEAS TRANSACTIONS on INFORMATION SCIENCE & APPLICATIONS.* Issue 1, Volume 5. 2008. p. 175-181. ISSN: 1709-0832.

[18] Tao, Yonglei, Automated Data Collection for Usability Evaluationin Early Stages of Application Development. In *Advances on applied computer and applied computational science. Proceedings of the 7th WSEAS International Conference on APPLIED COMPUTER & APPLIED COMPUTATIONAL SCIENCE (ACACOS '08).* Hangzhou, 2008. p. 135-140. ISBN 978-960-6766-49-7.

[19] Zadeh, Lofti Asker, Fuzzy Sets. *Information and Control.* 1965, 8, pp. 338-353.

[20] Zadeh, Lofti Asker., Fuzzy Sets and Systems. *International Journal of General Systems.* 1990, Vol. 17, 2, pp. 129-138.

[21] Comparative analysis definition. *BusinessDictionary.com.* [Online] [Cited: May 25, 2008.]http://www.businessdictionary.com/definition/comparative-analysis.html.

[22]Pojmy aneb ztraceni v ISVS? *ISVS.CZ - Informační Systémy Veřejné Správy.* [Online] [Cited: 20 June 2008.] http://www.isvs.cz/isvs-teorie/pojmy-aneb-ztraceni-v-isvs.html.