

An Evaluation Methodology of Quality for Health Web Sites based on Fuzzy Linguistic Modelling

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Abstract

A methodology to evaluate the quality of health Web sites is presented. The evaluation methodology is composed of a quality criteria set and a computation instrument to generate quality assessments. The quality criteria set is based on both technical criteria and criteria related with the content of information on the Web sites. Quality assessments are defined using users' perceptions on the health Web site quality. We assume a fuzzy linguistic modelling to represent the users' perceptions. The methodology is entirely user-oriented, as the quality criteria are derived from the needs expressed by the users, and evaluations of Web sites are calculated from the users point of view.

Keywords: Quality Assessment, Health Web Sites, Fuzzy Linguistic Modelling.

1 Introduction

The use of health Web sites as a source of information by citizens is rising day by day. The Web has become an important medium for health information consumers and health related web sites are now amongst the most frequently accessed sites on the Internet. A 2003 US survey from the Pew Internet and American Life Project showed that searching

for health information online using general-purpose search engines is the third most common use of the Internet following email and product research, and that 80% of adult Internet users have searched for health information [4].

The explosion in the number of health Web sites available, coupled with the extraordinary growth of health information consumers, has aroused the interest, and in some cases the concern for the quality issues on the Web. This has involved the development of various initiatives, under different approaches, to evaluate the quality of health Web sites [15]. However, despite the fact that Web sites are designed with the aim of being useful to its users, many of these initiatives do not consider the quality perceived by them. Furthermore, from the information consumer's perspective the quality of a Web site may not be assessed independently of the quality of the information contents that it provides. Specifically, the quality of medical information on the world wide web has been an area of increasing concern and many studies have been conducted to describe and analyze consumer health information on the Web [5, 9, 12].

The development and implementation of a method for evaluating the quality of Internet health Web sites could provide lay people with a tool to identify quality Web sites more easily, and in such a way to help users in their search of health information through the Web and possibly to improve their life quality.

In this paper we present a methodology to assess the quality of health Web sites. The

methodology is composed of a quality criteria set related with the health Web sites and a computation instrument to generate quality assessments. This methodology is qualitative and user-oriented by two reasons: i. we have carried out a qualitative research with users to get the set of criteria, and ii. it generates linguistic recommendations about the quality of health Web sites based on users' perceptions. To represent the users' perceptions we use an ordinal fuzzy linguistic modelling [7] and to compute the quality assessments we use tools of computing with words based on the linguistic aggregation operators LOWA [7] and LWA [6].

The paper is set out as follows: Section 2 presents the foundations of the fuzzy linguistic modelling and fuzzy computing with words. Section 3 describes the details of the model to evaluate quality of health web sites. Finally, Section 4 draws our conclusions.

2 Foundations of Ordinal Fuzzy Linguistic Modelling

The *ordinal fuzzy linguistic approach* [6, 7] is a very useful kind of fuzzy linguistic approach used for modelling the computing with words process as well as linguistic aspects of problems. It is defined by considering a finite and totally ordered label set $S = \{s_i\}, i \in \{0, \dots, \mathcal{T}\}$ in the usual sense, i.e., $s_i \geq s_j$ if $i \geq j$, and with odd cardinality (5 or 7 labels). The mid term represents an assessment of "approximately 0.5", and the rest of the terms being placed symmetrically around it. The semantics of the label set is established from the ordered structure of the label set by considering that each label for the pair $(s_i, s_{\mathcal{T}-i})$ is equally informative. For example, we can use the following set of seven labels to provide the user evaluations: $\{EH = \textit{Extremely_High}, VH = \textit{Very_High}, H = \textit{High}, M = \textit{Medium}, L = \textit{Low}, VL = \textit{Very_Low}, EL = \textit{Extremely_Low}\}$.

In any linguistic approach we need management operators of linguistic information. An advantage of the ordinal fuzzy linguistic approach is the simplicity and quickness of its

computational model. It is based on the symbolic computation [6, 7] and acts by direct computation on labels by taking into account the order of such linguistic assessments in the ordered structure of labels. Usually, the ordinal fuzzy linguistic model for computing with words is defined by establishing i) a negation operator, ii) comparison operators based on the ordered structure of linguistic terms, and iii) adequate aggregation operators of ordinal fuzzy linguistic information. In most ordinal fuzzy linguistic approaches the negation operator is defined from the semantics associated to the linguistic terms as $Neg(s_i) = s_j \mid j = \mathcal{T} - i$; and there are defined two comparison operators of linguistic terms: i) *Maximization operator*, $MAX(s_i, s_j) = s_i$ if $s_i \geq s_j$; and ii) *Minimization operator*, $MIN(s_i, s_j) = s_i$ if $s_i \leq s_j$. In the following subsections, we present two operators based on symbolic computation.

2.1 The LOWA Operator

The *Linguistic Ordered Weighted Averaging* (LOWA) is an operator used to aggregate non-weighted ordinal linguistic information, i.e., linguistic information values with equal importance.

Definition 1. [7] Let $A = \{a_1, \dots, a_m\}$ be a set of labels to be aggregated, then the LOWA operator, ϕ , is defined as $\phi(a_1, \dots, a_m) = W \cdot B^T = \mathcal{C}^m\{w_k, b_k, k = 1, \dots, m\} = w_1 \odot b_1 \oplus (1 - w_1) \odot \mathcal{C}^{m-1}\{\beta_h, b_h, h = 2, \dots, m\}$, where $W = [w_1, \dots, w_m]$, is a weighting vector, such that, $w_i \in [0, 1]$ and $\sum_i w_i = 1$. $\beta_h = w_h / \sum_2^m w_k, h = 2, \dots, m$, and $B = \{b_1, \dots, b_m\}$ is a vector associated to A , such that, $B = \sigma(A) = \{a_{\sigma(1)}, \dots, a_{\sigma(m)}\}$, where, $a_{\sigma(j)} \leq a_{\sigma(i)} \forall i \leq j$, with σ being a permutation over the set of labels A . $\mathcal{C}^m$ is the convex combination operator of m labels and if $m=2$, then it is defined as $\mathcal{C}^2\{w_i, b_i, i = 1, 2\} = w_1 \odot s_j \oplus (1 - w_1) \odot s_i = s_k$, such that, $k = \min\{\mathcal{T}, i + \text{round}(w_1 \cdot (j - i))\}$ $s_j, s_i \in S, (j \geq i)$, where "round" is the usual round operation, and $b_1 = s_j, b_2 = s_i$. If $w_j = 1$ and $w_i = 0$ with $i \neq j \forall i$, then the convex combination is defined as: $\mathcal{C}^m\{w_i, b_i, i = 1, \dots, m\} = b_j$.

The LOWA operator is an "or-and" operator [7] and its behavior can be controlled by means of W . In order to classify OWA operators in regard to their localisation between "or" and "and", Yager [18] introduced a measure of *orness*, associated with any vector W : $orness(W) = \frac{1}{m-1} \sum_{i=1}^m (m-i)w_i$. This measure characterizes the degree to which the aggregation is like an "or" (MAX) operation. Note that an OWA operator with $orness(W) \geq 0.5$ will be an *orlike*, and with $orness(W) < 0.5$ will be an *andlike* operator.

2.2 The LWA Operator

The *Linguistic Weighted Averaging* (LWA) operator is another important operator which is defined to aggregate weighted ordinal linguistic information, i.e., linguistic information values with non equal importance.

Definition 2. [6] The aggregation of a set of weighted linguistic opinions, $\{(c_1, a_1), \dots, (c_m, a_m)\}$, $c_i, a_i \in S$, according to the LWA operator Φ is defined as $\Phi[(c_1, a_1), \dots, (c_m, a_m)] = \phi(h(c_1, a_1), \dots, h(c_m, a_m))$, where a_i represents the weighted opinion, c_i the importance degree of a_i , and h is the transformation function defined depending on the weighting vector W used for the LOWA operator ϕ , such that, $h = MIN(c_i, a_i)$ if $orness(W) \geq 0.5$ and $h = MAX(Neg(c_i), a_i)$ if $orness(W) < 0.5$.

3 Assessing Quality of Health Web Sites

In this section we present the methodology to assess the quality of Health Web sites. This is a user-oriented evaluation methodology of a qualitative and subjective nature that is based on the evaluation judgements provided by the users. Previously, we review some material related to evaluation in health web sites.

3.1 Quality Evaluation of Health Web Sites

Nowadays, there isn't a clear and unambiguous definition of the concept of quality on the World Wide Web. Web quality is a complex

concept and its measurement or evaluation is multi-dimensional in nature [1]. Specifically, the quality of health Web sites is very variable and difficult to assess. We can find health web sites established by scientific organizations, health provider institutions, commercial sites, patients' associations, personal webs, etc. In practice, it has resulted in a wide variety of quality evaluation models, most designed under an ad hoc approach.

As we said at the beginning, from the information consumer's perspective the quality of a Web site may not be assessed independently of the quality of the information contents that it provides. Quality of Internet health information is essential because it has the potential to benefit or harm a large number of people [15]. The quality evaluation of health Web sites is a matter of great importance and it has already been studied by different authors [2, 3, 11, 13]. In this sense, a number of organizations and different authors have developed methods and tools for evaluating and rating the quality of such Web sites. Some approaches focus on setting ethical standards and promoting the "good" whereas other more pragmatic approaches concentrate on sifting huge amounts of information into manageable chunks. Some approaches address general ethical principles about the nature of health related content whereas others focus on the mode of delivery and the integrity of the use of the web as a medium for the dissemination of information [17]. Most of the published papers relating to health Web sites quality assessment are based on the selection of a quality criteria set, mainly established with independence of the users' satisfaction [13].

3.2 A Methodology for Evaluating the Quality of Health Web Sites

To help users discriminate between "good" and "bad" health Web sites, we have developed a methodology for evaluating and rating the quality of health Web sites. We consider that the direct participation of the user is necessary to achieve better results of evaluation on the World Wide Web. In this section we

present a model that is qualitative and user-oriented by two reasons:

- i. the chosen criteria have been obtained by a qualitative study carried out with the users; and
- ii. it generates linguistic recommendations on the quality of the health Web sites based on users' perceptions.

The use of a user-centered approach to evaluate Web sites would mean that users are more pro-actively approached to determine their needs which could be used in a redesign of the site [1, 10].

A possible way to facilitate the user participation is to embed in the Web quality evaluation methodology those tools of Artificial Intelligence that allow a better representation of subjective and qualitative user judgements, as for example, a soft computing tool called fuzzy linguistic modelling [19]. The use of fuzzy linguistic modelling could increase the user participation in the evaluation of the quality of Web sites, because it is a user-friendly tool that helps users to express their judgements in a more natural way [8].

The methodology proposed contemplates two main components to evaluate the quality of the health Web sites: a user-driven evaluation scheme and a user-centered measurement method.

- *Evaluation Scheme:* The evaluation scheme contains the quality dimensions and criteria set relevant to the user, to analyze the quality of health Web sites.
- *Measurement Method:* The measurement method is based on fuzzy linguistic modelling techniques and generates quality evaluations associated to the health web sites.

After visiting a health Web site, users are required to express their evaluation judgements on the evaluation scheme by means of linguistic evaluation judgements. Then, an overall linguistic recommendation concerning the

quality of that health Web site is obtained by combining the linguistic evaluation judgements provided by its different visitors.

3.2.1 Evaluation Scheme

We develop an evaluation scheme for analyzing the quality of health Web sites. This evaluation scheme is based both on technical criteria of Web site design, and on criteria related with the Web sites content. These criteria are assessed subjectively by users who visit occasionally the Web site.

The quality evaluation of Web sites focusing on the user-perceived quality of the stored information is a difficult task that has seldom been studied [14]. The evaluation scheme necessarily requires the inclusion of dimensions easily understandable by any information consumer rather than dimensions that can be measured objectively with independence of the consumers.

We have carried out a qualitative study with patients and physicians visiting Web sites related with a particular health. This qualitative study is based on the focus group technique [16]. Analyzing the patients and physicians' responses evaluating the quality of health Web sites we have established a set of quality dimensions to include in a health Web site quality evaluation scheme. The quality dimensions of the evaluation scheme do not play the same role to measure the quality of a Web site because some dimensions should be more influential or important than others.

Therefore we define a user-driven and weighted evaluation scheme of health Web sites that contemplates six quality dimensions:

- *Credibility:* this dimension is related to those aspects that offer reasonable grounds for being believed, allowing users to assess the degree of a Web site credibility. We have identified some quality criteria associated with this dimension, as for example: Web sites owners (the identification of the institution or organization); sponsorship (disclosure of sponsor-

ship and the nature of the support provided).

- *Content*: this dimension is composed of those criteria related to health information provided by Web sites. Accuracy of information is the most obvious criterion for quality of content, and users have the right to expect that sites will provide accurate information. We assess accuracy of Web sites content by considering what visitors think about the information that the Web site provides. Other criteria have been included, for example: authorship (requires to disclose the information authors and its qualifications); bibliography (literature used to gather information content); and date (the last update of content posting).
- *Usability*: this dimension refers to Web site quality features and functionality for improving ease-of-use during the users' visit. Quality criteria included: navigation mechanism (navigation tools provided by the Web site so that visitors can reach the information they want); design (logical organization of elements in such a way that visitors easily understand how to use the Web site).
- *Security*: this dimension is related to how the Web site deals with confidential or private information. The Web site must clearly display about a statement or a privacy policy regarding confidentiality of personal data hosted.
- *External links*: dimension refers to connections from a web site to other external sites, forming a web-like structure of information between sites. Criteria relating to this dimension include the information relating to the linked source and alerts when users move to an external Web site.
- *Interactivity services*: this dimension refers to the interactive services provided by Web sites, for example web forums or online health questions.

3.2.2 Measurement Method

The measurement method of the health Web sites quality that we define is like a decision making method in which the search alternatives are Web sites. Firstly, we define a quality evaluation questionnaire that provides questions for the quality criteria belong to the dimensions proposed in the evaluation scheme, i.e., there are fourteen questions: $\{q_1, \dots, q_{14}\}$. The concept behind each question is rated on a linguistic term set S . We use the following set of five linguistic terms to rate all the questions: $\{VH = \text{Very_High}, H = \text{High}, M = \text{Medium}, L = \text{Low}, VL = \text{Very_Low}\}$.

Furthermore, we assume that each quality criteria does not have the same importance in the evaluation scheme, i.e., it is assigned a relative linguistic importance degree for each quality criteria:

$$\{I(q_1), \dots, I(q_{14})\}, I(q_i) \in S$$

For example, criteria belong to dimension such as credibility and content would be more important than the rest. These importance degree could be obtained from a set of users' judgements.

Assuming a set of health Web sites

$$\{Web_1, \dots, Web_T\}$$

and a group of users

$$\{u_1, \dots, u_L\}$$

that have filled in the questionnaire for the Web site Web_t .

Let $\{q_1^{l,t}, \dots, q_{14}^{l,t}\}$ be a set of linguistic evaluation judgements ($q_i^{l,t} \in S$) provided by each visitor u_l when he/she searched and found information relevant in Web_t .

Then, based on the user evaluation judgements, the computation method generates for Web_t , its quality assessment $r^t \in S$ using the linguistic aggregation operators LOWA and LWA in the following steps:

1. Aggregation per quality criterion

Given a health web site Web_t , and a group of users

$$\{u_1, \dots, u_L\}$$

that have filled in the questionnaire, calculate for each quality criterion q_i the global quality assessment $r_i^t \in S$ by means of LOWA operator ϕ :

$$r_i^t = \phi(u_1(q_i), \dots, u_L(q_i)),$$

where $u_j(q_i) \in S$ is the linguistic preference provided by the u_j on quality criteria represented by the question q_i .

2. Aggregation per health Web site

Calculate the quality assessment $r^t \in S$ by means of LWA operator Φ :

$$r^t = \Phi((I(q_1), r_1^t), \dots, (I(q_{14}), r_{14}^t))$$

4 Conclusions

In this paper we have presented a methodology for evaluating the quality of health related Web sites based on the users' perceptions and built with tools of fuzzy linguistic modelling. This methodology is qualitative and user-oriented because we have carried out a qualitative research with users to get the set of criteria, and it generates linguistic recommendations about the quality of health related Web sites based on users' perceptions. Our study represents an important first step in developing a model to assess the quality of the health web sites. The intended users of this model will be Internet web users including health care professionals and health information consumers. The application of the model will help users to discriminate between sites, by means of rating the quality of health Web sites.

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References

- [1] A.M. Aladwani, P.C. Palvia (2002), Developing and validating an instrument for measuring user-perceived web quality. *Information & Management* 39), 467–476.
- [2] G.K. Berland, et al. (2001). Health information on the internet: Accessibility, quality, and readability in english and spanish. *Journal of American Medical Association* 285(20), 2612–2621.
- [3] M. Craigie, B. Loader, R. Burrows, S. Muncer (2002). Realibility of health information on the internet: An examination of expert ratings. *Journal of Medical Internet Research* 4(1), doi:10.2196/jmir.4.1.e2.
- [4] S. Fox, D. Fallows (2003). Pew internet and american life project. *ch. Internet health resources*, online Washington DC.
- [5] A. Gagliardi, A.R. Jadad (2002). Examination of instruments used to rate quality of health information on the internet: chronicle of a voyage with an unclear destination. *British Medical Journal* 324, 569–573.
- [6] F. Herrera, E. Herrera-Viedma (1997). Aggregation operators for linguistic weighted information. *IEEE Transactions on Systems, Man, and Cybernetics, Part A: Systems and Humans* 27, 646–656.
- [7] F. Herrera, E. Herrera-Viedma, J.L. Verdegay (1996). Direct approach processes in group decision making using linguistic owa operators. *Fuzzy Sets and Systems* 79, 175–190.

- [8] E. Herrera-Viedma, G. Pasi, A.G. López-Herrera, C. Porcel (2006). Evaluating the Information Quality of Web Sites: A Methodology Based on Fuzzy Computing with Words. *Journal of American Society for Information Science and Technology* 57:4, 538–549.
- [9] L. Hoffman-Goetz, J.N. Clarke (2000). Quality of breast cancer sites on the world wide web. *Canadian Journal of Public Health* 91, 281–284.
- [10] E.K.R.E. Huizingh (2000). The content and design of web sites: an empirical study. *Information & Management* 37(3), 123–134.
- [11] P. Impicciatore, C. Pandolfini, N. Casella, M. Bonati (1997). Reliability of health information for the public on the world wide web. *British Medical Journal* 314, 1875–1879.
- [12] A.R. Jadad, A. Gagliardi (1998). Rating health information on the internet: navigating to knowledge or to babel. *Journal of American Medical Association* 279, 611–614.
- [13] P. Kim, T.R. Eng, M.J. Deering, A. Maxfield (1999). Published criteria for evaluating health-related web sites: a review. *British Medical Journal* 318, 647–649.
- [14] S.Y. Rieh (2002). Judgment of information quality and cognitive authority in the web. *Journal of the American Society for Information Science and Technology* 53(2), 145–161.
- [15] A. Risk, J. Dzenowagis (2001). Review of internet health information quality initiatives. *Journal of Medical Internet Research* 3(4), doi:10.2196/jmir.3.4.e28.
- [16] D.W. Stewart, P.N. Shamdasani (1990). *Focus groups: Theory and practice (applied social research methods)*. Newbury Park, CA: SAGE Publications.
- [17] P. Wilson (2002). How to find the good and avoid the bad or ugly: a short guide to tools for rating quality of health information on the internet. *British Medical Journal* 324, 598–602.
- [18] R.R. Yager (1988). On ordered weighted averaging aggregation operators in multicriteria decision making. *IEEE Transactions on Systems, Man, and Cybernetics* 18, 183–190.
- [19] L.A. Zadeh (1975). The concept of a linguistic variable and its applications to approximate reasoning I-II-III. *Information Sciences* 8, 199-249, 301-357; *Information Sciences* 9, 43-80.