Evaluating the Digital Quality in Airlines Using Tools of Fuzzy Computing with Words

E. Herrera-Viedma
F.J. Cabrerizo
L. Hidalgo
Dept. of Computer Science and A.I.
University Of Granada
{viedma,lhidalgo}@decsai.ugr.es,
cabre@correo.ugr.es

S. Alonso
Software Engineering Dept.
University Of Granada
salonso@decsai.ugr.es

J.M. Moreno
Dept. of Information and
Communication Engineering
University of Murcia
jmmr@dif.um.es

Abstract

In this work we present a model to evaluate the digital quality in airlines. Digital quality of an airline is defined using passengers' perceptions on the quality of digital services provided through its Web site. We characterize the concept of digital quality of airlines by means of subjective quality indicators measured on their Web sites. We assume a fuzzy linguistic modelling to represent the passengers' perceptions. We apply automatic tools of fuzzy computing with words based on the LOWA and LWA operators to compute global digital quality evaluations of airlines.

Keywords: Quality, Airline, Web Site, Fuzzy Linguistic Modelling.

1 Introduction

The aviation market worldwide has experienced an increasingly rapid growth in both passenger and goods traffic. In both cases, this can be attributed to different reasons such as the rapid increase in number of airlines and airline fleet size, technical improvements that allow to increase the flight frequency (advances in flight control and speed), a largest number of airports, deregulation politics, etc.

However, we should to point out that the contribution of the new Web technologies has been very important in the development of airline industry, and specially, in the case of passenger airlines. The Web creates value on both sides. On the other hand, through the use of the internet-based ticketing, airlines are able to reduce labor costs and in some cases eliminate commissions altogether so as to improve profit margins [26]. And, on the other hand, some airlines also offer discounts to customers who purchase their tickets online [8]. Almost all airlines are providing ticketing, flight information, allowing booking of flights and planning of itinerary on their Web sites. Web sites of airlines have become an integral part of business operations and are being leveraged to enhance business efficiency, effectiveness and competitive advantage. Using Web possibilities many airlines have been able to strengthen their customer focus and improve the quality of products and services [8, 26]. Therefore, the Web site of an airline is a key element of their operation and future development [6, 8, 16, 26].

At this moment, in the airline industry the competition is ever increasing as airlines try to acquire and retain customers. Price has initially been used as the primary competitive weapon. However, airlines are able to respond quickly to competitors' price changes [14]. Therefore, airlines' competitive advantages based just on price are not sustainable [5]. To acquire and retain customers in such a highly competitive market, it is of strategic importance for airlines to understand their relative level of quality in terms of critical elements affecting their competitive advantages.

Usually, the quality of an airline has been analyzed using traditional quality criteria related to safety, flight frequency, comfort, operating cost, price, ..., [4, 7, 13, 21]. However, a few studies incorporate the new digital dimension that represents the Web sites of the airlines.

Nowadays, any analysis of quality of an airline should incorporate digital quality criteria related to the digital services that it offers through its Web site. *Digital quality* plays an important role in the quality map of an airline given that its performance depends very much on its Web site, and specially knowing that customers are more likely to visit and purchase at Web sites that exhibit highly desirable qualities [20].

The main of this paper is to present a model to evaluate the digital quality of an airline. This digital quality model presents a set of digital quality criteria related to the Web sites of airlines and a computation instrument of quality assessments. We assume that the digital quality of an airline is measured through passengers' perceptions on the digital services offered through its Web site. Passengers are invited to fill in a survey built on the set of digital quality criteria. To measure quality, conventional measurement tools used by the customers are devised on cardinal or ordinal scales . However, the scores do not necessarily represent user preference. This is because respondents have to internally convert preference to scores and the conversion may introduce distortion of the preference [24]. For this reason, we use an ordinal fuzzy linguistic modelling [10] to represent the passengers' perceptions and tools of computing with words based on the linguistic aggregation operators LOWA [10] and LWA [9] to compute the quality assessments.

The rest of the paper is set out as follows: Section 2 presents the foundations of the ordinal fuzzy linguistic modelling and fuzzy computing with words. Section 3 describes the methodology to evaluate the digital quality of airlines. Finally, Section 4 draws our conclusions.

2 Foundations of Ordinal Fuzzy Linguistic Modelling and Fuzzy Computing with Words

The *ordinal fuzzy linguistic approach* [9, 10] is a very useful kind of fuzzy linguistic approach used for modeling the computing with words process as well as linguistic aspects of problems. It is defined by considering a finite and totally ordered label set $S = \{s_i\}, i \in \{0, \ldots, \mathcal{T}\}$ in the usual sense, i.e., $s_i \geq s_j$ if $i \geq j$, and with odd cardinality (7 or 9 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 nine labels to provide the user evaluations: $\{T = Total, EH = Extremely\_High, VH = Very\_High, H = High, M = Medium, L = Low, VL = Very\_Low, EL = Extremely\_Low, N = None\}$.

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 [9, 10] 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 [10].

Definition 1. Let $A = \{a_1, \ldots, a_m\}$ be a set of labels to be aggregated, then the LOWA operator, ϕ, is defined as $\phi(a_1, \ldots, a_m) = W \cdot B^T = \mathcal{C}^m\{w_k, b_k, k = 1, \ldots, m\} = w_1 \odot b_1 \oplus (1 - w_1) \odot \mathcal{C}^{m-1}\{\beta_h, b_h, h = 2, \ldots, m\}$, where $W = [w_1, \ldots, w_m]$, is a weighting vector, such that, $w_i \in [0, 1]$ and $\Sigma_i w_i = 1$. $\beta_h = w_h / \Sigma_2^m w_k, h = 2, \ldots, m$, and $B = \{b_1, \ldots, b_m\}$ is a vector associated to A, such that, $B = \sigma(A) = \{a_{\sigma(1)}, \ldots, a_{\sigma(m)}\}$, 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, $k = \min\{\mathcal{T}, i + round(w_1 \cdot (j - i))\}$ $s_j,\ s_i \in S,\ (j \geq i)$, 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: $\mathcal{C}^m\{w_i, b_i, i = 1, \ldots, m\} = b_j$.

The LOWA operator is an "or-and" operator [10] and its behavior can be controlled by means of W. In order to classify OWA operators with regards to their localisation between "or" and "and", Yager [27] 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 [9].

Definition 2. The aggregation of a set of weighted linguistic opinions, $\{(c_1, a_1), \ldots, (c_m, a_m,)\}$, $c_i, a_i \in S$, according to the LWA operator Φ is defined as $\Phi[(c_1, a_1), \ldots, (c_m, a_m)] = \phi(h(c_1, a_1), \ldots, h(c_m, a_m))$, 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 Evaluating Digital Quality in Airlines

In this section we present the model to evaluate the digital quality of the airlines through of their Web sites. Previously, we review some aspects on evaluation of quality in airlines.

3.1 On Evaluation of Quality in Airlines

There exist many studies conducted on the quality evaluation of airlines in terms of quantifiable and objective measures. Some reflect the capabilities and offerings of airlines in serving their customers, such as competitiveness [4, 25], safety [13], service quality measured by on-time performance or flight frequency [4, 7]; and others reflect organizational aspects of airlines such as operating cost [19], productivity [18], operational performance [21].

However, in a highly competitive environment, where all airlines have comparable fares, competitive advantages of airlines lie in the subjective quality perceived by passengers [5]. Passenger satisfaction is a key quality indicator for the operation of an airline [2]. Ostrowski et al. [17] presented an empirical study that shows that continuing to provide perceived high quality services would help airlines acquire and retain customer loyalty. Quite a few studies have been conducted on the quality evaluation of airlines in terms of subjective criteria related to the passenger satisfaction. In [5, 23, 24] we can find some quality evaluation models for airlines based on passenger surveys which use subjective quality criteria, such as comfort and cleanness of

seat, courtesy of crew, extended travel service, etc.

On the other hand, as aforementioned Web sites of airlines contribute to the achievement of sustainable competitive advantages among passenger airlines, and therefore they are key elements of their operation and future development [6, 8, 16, 26]. Consequently, the Web site of an airline represents a new quality dimension to be considered in the quality map of the airline. This new quality dimension is called in this paper *digital quality*. There are many approaches on evaluating digital quality focused on Web sites in different kinds of industries or organizations (see a review in [11]), but quite a few approaches on the airline industry. In fact, we only know the preliminary proposal developed by C. Shchiglik and S.J. Barnes in [22]. They presented a Perceived Airline Website Quality Instrument (PAWQI) that evaluates airline digital quality based on customers' perceptions. This instrument uses a survey of 25 queries, quantitative assessments based on a 5-point Likert scale, and is focused on New Zealand airline industry.

However, given the increasing reliance of airlines on Web sites and new Web technologies, there is a need for the development of methods of evaluating digital quality in airlines.

3.2 A Model to Evaluate the Digital Quality in Airlines

PAWQI was developed from other perceived Web site quality instrument called WebQual instrument which was defined for auction and bookshop Web sites [1]. This practice is usual in the definition of Web quality evaluation models because in Web quality evaluation there is not a general theoretical foundation or framework [11].

We use the information quality framework [12] defined in the context of management information systems as basis of our model to evaluate airline digital quality. It has been satisfactorily applied to previous quality models for personal Web sites [15], mobile Internet services [3] and Web sites that store Web documents [11]. In this information quality framework is established that the quality of the information systems cannot be assessed independently of the information consumers' opinions (people who use information). This framework defines four major quality dimensions [12]:

1. *Intrinsic quality.* The main criterion of this dimension is the accuracy of the information. If a reputation for inaccurate information becomes common knowledge for a particular information system, this system is viewed as having little added value and will result in a reduction of use. Other criteria of this dimension are: believability, reputation and objectivity.

2. *Contextual quality.* It highlights the requirement that information quality must be considered within the context of the task in hand; it must be relevant, timely, complete, and appropriate in terms of amount, so as to add value to the tasks for which the information is provided. Therefore, some criteria of this dimension are: value-added, relevance, completeness, timeliness, appropriate amount.

3. *Representational quality.* It requires information systems to present their information in such a way that it is interpretable, easy to understand, easy to manipulate, and is represented concisely and consistently. Some of its criteria are: understandability, interpretability, concise representation, consistent representation.

4. *Accessibility quality.* It requires the information system to be accessible but secure. Some criteria of this dimension are: accessibility and secure access.

We adapt this information quality framework to develop our model to evaluate the digital quality in airlines. However, given that airline Web site framework is different to those frameworks considered in [3, 11, 12, 15] before presenting it, we will take into account the following considerations: i) the Web site of an airline is its main e-commerce support, and

therefore criteria as security and convenience for ticket purchasing are important [22, 30]; ii) the information in the Web site of an airline is changing and updating constantly, and therefore criteria as up-to-date, timely and accuracy are important [22]; iii) the Web site of an airline should support the interaction between the company and passengers from the sale of ticket until the end of travel, and therefore it is good that presents passenger aid tools; and iv) the Web site of an airline should enable people to use anywhere, any time and using any mobile Internet devices (PDAs, phones) [26].

Taking into account these considerations, we define a model to evaluate the digital quality in airlines focused on their Web sites that present two elements: *evaluation scheme* that contains the quality criteria and a *computation method* to generate digital quality assessments of airlines.

3.2.1 Evaluation Scheme to Characterize the Digital Quality in Airlines

According to the information quality framework [3, 11, 12, 15] the evaluation scheme contains the following four quality dimensions together with their digital quality criteria:

1. *Intrinsic digital quality:* In this dimension we consider quality criteria such as accuracy and believability of information provided.

2. *Contextual digital quality:* In this dimension we consider quality criteria such as relevance and timeliness of information provided, and also convenience for ticket purchasing.

3. *Representational digital quality:* In this dimension we consider quality criteria such as understandability of information provided, use of multimedia information, and permanent availability of information.

4. *Accessibility and interaction digital quality:* In this dimension we consider quality criteria such as easy to navigate, security of data and transactions, promptness of access, use of mobile Internet tools and passenger aid tools.

3.2.2 Computation Method to Generate Digital Quality Assessments in Airlines

Firstly, we define a quality evaluation questionnaire that provides questions for each one of the digital quality criteria proposed in the evaluation scheme, i.e., there are thirteen questions: $\{q_1, \ldots, q_{13}\}$. For example for the quality dimension *believability* the question q_2 can be: "What is the degree of believability of information provided in your opinion?". The concept behind each question is rated on a linguistic term set S. For example, we can use the set of nine linguistic terms proposed in Section 2 to rate all the questions. Furthermore, we assume that each digital 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 dimension: $\{I(q_1), \ldots, I(q_{13})\}$, $I(q_i) \in S$. For example, according to [22, 30] criteria such as accuracy and security should be more important that the rest. These importance degree could be obtained from a set of experts or passengers' judgements [22, 30] .

Then, assuming that we have a group of passengers $\{e_1, \ldots, e_L\}$ that have filled in the questionnaire and given an airline $\mathcal{A}_m$, the computation method generates its digital quality assessment $r^m \in S$ using the linguistic aggregation operators LOWA and LWA in the following steps:

1. Calculate for each digital quality criterion q_i the global digital quality assessment $r_i^m \in S$ by means of LOWA operator ϕ:

$$r_i^m = \phi(e_1(q_i), \ldots, e_L(q_i)),$$

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

2. Calculate the digital quality assessment

$r^m \in S$ by means of LWA operator Φ:

$$r^m = \Phi((I(q_1), r_1^m), \ldots, (I(q_{13}), r_{13}^m)).$$

4 Conclusions

In this work we have introduced the concept of digital quality as a new dimension that should be taken into account in the quality map of an airline. We have presented a model to evaluate the digital quality of airlines based on passengers' perceptions and built with tools of fuzzy linguistic modelling.

We have assumed the Web site as the key element of digital quality of an airline. In the future we extend the concept of digital quality to other new Web technologies, such as mobile Internet, which are being incorporated in the operation of airlines.

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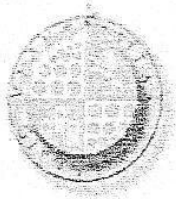

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Editors:

Luis Martínez
Department of Computer Sciences
Jaén University
Campus Las Lagunillas s/n
23071 Jaén, Spain
e-mail: martin@ujaen.es

Bernard de Baets
Department of Applied Mathematics,
Biometrics and Process Control
Ghent University
B-9000 Ghent, Belgium
e-mail: Bernad.DeBaets@UGent.be

Luis Gonzaga Pérez
Department of Computer Sciences
Jaén University
Campus Las Lagunillas s/n
23071 Jaén, Spain
e-mail: lgonzaga@ujaen.es

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