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ABSTRACT

Information portals are quality-controlled intermediaries, through which consumers can access online information of high relevance and quality. Developing and maintaining a portal's content repository involves resource identification, selection and description processes undertaken by domain experts. Among these processes, the less standardised, manual quality assessment procedures are highlighted, where new solutions are imperative to solve its scalability and sustainability issues. Results of a qualitative analysis implicate that quality assessment is fundamentally a subjective issue that needs human intervention. For this reason, this research proposes a semi-automated quality assessment approach, in which a user-centred quality framework, an indicator-based quality model and a decision support tool are devised to address the identified domain expert needs for intelligent support. The system development methodology within design science framework is adopted by this research and the tool prototyping within the context of health information portals is underway to evaluate the feasibility and usefulness of the proposed approach.

Keywords

Quality assessment, user-centred design, decision support tool, information portals.

INTRODUCTION

Finding reliable, relevant and useful information through online search can be a challenging task given the enormous volume and variable quality of information resources on the Internet. As an alternative to using generic search engines, consumers can opt to use information portals which provide access to filtered resources of improved quality and relevance. Information portals are gateways pointing to Internet-based resources within specified subject areas that are of interest to a targeted user community. As opposed to generic search engines that index the entire Web, information portals only cover the part of the Web, which meet quality criteria for resource selection and are perceived to have value for their target users. Quality control is therefore the essence of such portals (Koch, 2000; Moraga, Caro, Calero and Piattini, 2007), where quality refers to 'fitness for use' (Strong, Lee and Wang, 1997; Tayi and Ballou, 1998).

Health information portals are of particular interest, given that quality becomes a more critical concern when online information is used for making health-related decisions (Burstein, Mckemmish, Fisher, Manaszewicz and Malhotra, 2006). Recent research shows that the application of user-centred and metadata-driven approach in developing health information portals can better meet the information needs of health consumers (Burstein, Fisher, McKemmish, Manaszewicz and Malhotra, 2005). However in such a portal, the content development and maintenance involves laborious processes of resource identification, selection and description with scalability and sustainability concerns. New solutions are imperative to improve the efficacy and efficiency of the portal approach to quality information provision. This research focuses on scalability issues with the quality assessment processes, in which those responsible for portal content development are aided by intelligent tools in their evaluation of multi-dimensional quality aspects of an online resource as part of resource identification, selection and description processes.

This paper begins with a brief overview of user-centred health information portals. It then discusses the quality appraisal activities involved in user-centred resource identification, selection and description processes. The need for intelligent support for measuring quality as the relationship between user and resource is identified, with existing quality assessment approaches for evaluating online information examined against this requirement. As a result, a semi-automated quality assessment approach is conceptualised to complement and enhance the decision-making abilities of those responsible for identifying, selecting and describing resources for a user-centred information portal to address scalability concerns.

QUALITY ASSESSMENT PROCESSES IN USER-CENTRED HEALTH INFORMATION PORTALS

User-centred health information portals

Quality-controlled information portals provide a promising solution to tackle both the information quality and information overload issues in online information provision. Recent research shows that information portals can act as intelligent decision support systems if tailored information can be provided to meet consumers' knowledge and decision support needs (Burstein et al., 2006). In this sense, understanding information consumers and their information needs becomes a priority. What kind of information will portal users find interesting and useful? What factors will affect their quality perceptions and their use of retrieved information? A user-centred information portal, which adopts user needs and values in its design and development (Hopkins, 1995), provides a model to better address these concerns.

BCKOnline (www.bckonline.monash.edu.au) is an example of such a portal. Developed to meet the diverse information needs of breast cancer patients, their families, friends and carers, the portal features a user-centred metadata approach. Resources are described using a metadata schema and corresponding encoding systems based on the outcomes of extensive user information needs analysis (Williamson, 2005). Multi-dimensional resource content quality was observed as a concern that the breast cancer community has with retrieved online information. As a result, the portal provides quality reporting to enable information consumers to make their own quality judgments based on their individual information needs and value systems. BCKOnline portal's positive user evaluation points to individual user information needs being better met by addressing their profiles, information preference, subject interests and quality perceptions (Burstein et al., 2006).

Quality appraisal in user-centred resource identification, selection and description processes

Information portals discussed above fundamentally provide review services to information consumers (Cooke, McNab and Anagnostelis, 1996). The review processes that an online resource goes through are described as resource identification, selection and description processes undertaken by domain experts. In the case of BCKOnline portal, a domain expert is a person "with first hand experience and extensive knowledge of the medical, supportive and psychosocial information needs of the community" (BCKOnline, 2005). They identify and evaluate online resources according to their compliance with a portal's resource selection criteria and create rich descriptions of selected resources based on the use o standardised metadata. Domain experts in that sense play the role as subject and metadata experts with library profession in resource identification, selection and description.

In order to gain a better understanding of the domain expertise involved in resource identification, selection and description processes, a qualitative and reflective study of the domain expert practices associated with the BCKOnline portal was undertaken (Evans, Manaszewicz and Xie, 2009). This involved a series of discussions which included description and reflection on the roles domain experts played in the design and development of the portal, an analysis of the metadata schema from the domain experts' perspective, and a walkthrough of the user-centred resource identification, selection and description processes. Authors of this paper participated in these discussions with domain experts and analysed the portal itself to identify quality dimensions in these domain expert processes, with a view to identify what quality appraisal procedures are involved in domain experts' resource identification, selection and description activities, where intelligent technologies might support quality assessment, and where they might help to build and maintain domain expertise.

The analysis of domain expert processes established that assessing quality in user-centred information portals are analytical processes that need multi-faceted domain expertise to make decisions in relation to resource characterisation, selection and description. Information quality and topical relevance are identified as two major concerns of domain experts when they assess the fitness or usefulness of an information resource for its inclusion in a portal. As illustrated in Figure 1, quality assessment processes start after an online resource being identified as a candidate resource for further evaluation. Domain experts firstly characterise a candidate resource to get an overall opinion about its quality and fitness for meeting portal users' information needs. Whether or not the resource will be included in a portal is then decided according to its compliance with the portal's selection criteria. Once a new resource is selected for inclusion, descriptive and evaluative metadata are manually assigned according to the portal's metadata schema. These metadata descriptions capture the outcome of review processes, revealing the likely relevance and perceived quality of a resource to its intended audience.
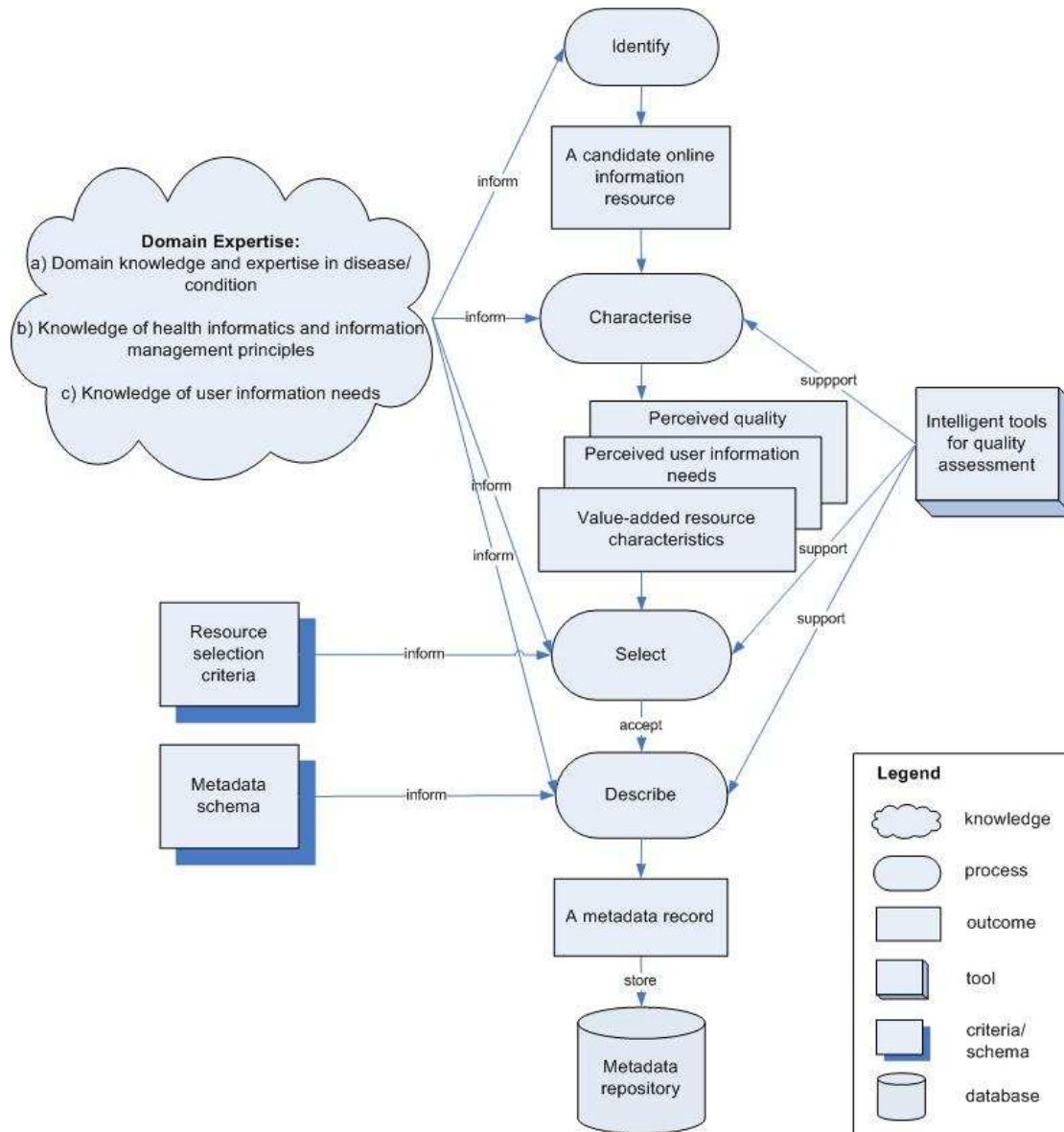
Figure 1: Quality assessment processes analysis

Findings of the domain expertise study also indicate that the role domain experts play in quality assessment processes is based on multi-dimensional expert knowledge and lay experience that can not be entirely replicated by intelligent tools or automated computer programs. It is identified that domain experts who have first hand experience of a certain disease/condition are making extensive use of their knowledge of consumer information needs through the whole processes. They are continually making value judgments based on the collected quality evidence and implicit relationships between the analysed resource characteristics. In addition, collaborations among multiple domain experts are sometimes required to make value judgements regarding the same resource due to the different expertise level they have.

To sum up, quality-controlled content development and maintenance in a user-centred information portal requires significant efforts of domain experts. Quality assessment processes involve domain expert activities in relation to resource characterisation, selection and description. This raises questions as to what parts of the quality assessment processes can be automated or augmented with intelligent tools to improve the scalability and ultimately the sustainability of these kinds of portals. Where is human intervention required? What also are the requirements of an intelligent quality assessment approach for facilitating human-machine collaboration?

METHOD

To address these questions, the system development methodology (Hevner, March, Park and Ram, 2004; Nunamaker, Chen and Purdin, 1990-91) is adopted and applied throughout this study, which involves cycles of reflective concept building, system building and system evaluation (Burstein, 2002). The focus of the research presented in this paper is on the concept building stage with the outcome being the conceptualisation/specification of a semi-automated quality assessment approach which is developed through an analysis and synthesis of existing quality assessment approaches in the relevant literature.

Analysis of existing quality assessment approaches

In the literature, issues involved in quality assessment have been discussed extensively across multiple domains with a considerable number of quality assessment approaches proposed. For instance, in the domain of consumer health informatics (Eysenbach, 2000), quality checklists (DISCERN, 2008), numerical rating instruments (Bomba and Land, 2004; Gagliardi and Jadad, 2002) and scoring systems (Currò, Buonuomo, Onesimo, De Rose, Vituzzi, Tanna and D'Atri, 2004) have been developed to assist information consumers evaluating health information on the Internet. The analysis shows that a quality assessment approach for evaluating online information consists of a quality assessment framework that defines the construct of quality and its measures, and corresponding quality appraisal methods, either qualitative or computational for generating quality values. These two aspects will be discussed respectively in the following subsections.

Quality assessment frameworks

Numerous quality assessment frameworks with hundreds of quality criteria have been published either in scientific journals or on Web sites (Kim, Eng, Deering and Maxfield, 1999; Wang and Strong, 1996). Among these frameworks, a number of consensus criteria for the evaluation of Internet-based information are identified. In the healthcare domain, Silberg et al.'s (1997) four principled quality dimensions of authorship, attribution, disclosure and currency have been widely incorporated in many recent developed quality criteria models. Additional dimensions such as accuracy, completeness, authority, readability and design are also popular across different models (Eysenbach, Powell, Kuss and Sa, 2002; Kim et al., 1999).

However, there can be no gold standard for measuring quality (Gagliardi and Jadad, 2002) as illustrated in the following quote identifying the great difficulty in assessing the quality of online information in a given context:

> '…quality assessment is not a straightforward procedure involving an identification of the presence of absence of different features or facilities. Instead, quality assessment is a complex process involving consideration of a wide range of interrelated issues that are of varying importance depending upon the nature of the source and the needs of the user…Due to the complex nature of quality assessment, it would not be possible to provide a straightforward list of criteria. ' (Cooke, 2001 p. 13)

This research adopts this definition of quality as 'a component of a relationship between user and resource, rather than an appraisal of the resource alone' (Anderson, McKemmish and Manaszewicz, 2003 p. 6). Those using an information portal are respected as final judges of the quality or fitness of an information resource to their situation. A portal's quality assessment framework, which underpins resource identification, selection and description processes, should therefore reflect the information needs and values of portal users.

Computational quality appraisal methods

In the literature, information quality is measured either qualitatively by human analysis or computationally by automation tools. Attention is drawn to computational quality appraisal methods to assess their application to solve scalability issues of the quality assessment processes in user-centred information portals.

The potential of using fully automated tools to assess the quality of online information resources is being explored in a number of studies (Civan and Pratt, 2006; Currò et al., 2004; Griffiths, Tang, Hawking and Christensen, 2005; Knight and Burn, 2005; Price and Hersh, 1999). They all attempt to numerically rank Web resources according to the level of compliance to specific evaluation criteria. A number of computational quality measures based upon various quality assessment models have been developed. A few ad hoc algorithms with a high level of subjectivity have been developed for measuring a subset of quality dimensions, such as completeness (Naumann, 2002).

However, there are some problems with applying these automated quality assessment tools in the context of user-centered information portals like BCKOnline. First of all, some of quality dimensions such as believability and reputation are subjective concepts, which are not possible to define objective measures (Naumann, 2002). The validity of algorithms provided in the literature is limited to the algorithm's high level of subjectivity. Moreover, although some quality assessment frameworks claim to incorporate users' quality perceptions, it is not easy to implement algorithms that tie the assessment phase to users' individual information requirements. In other words, the qualified algorithms should consider not only the

data values, but also the use of data as the context for quality measures. Quality assessment in a user-centred information portal is highly context-based. That is, the quality of an online resource in terms such as fitness for purpose can only be measured in the context of an actual consumer's information needs. As a result, models or tools developed and tested by these studies cannot be applied directly to replace the role domain experts play in the quality assessment in a portal scenario.

A SEMI-AUTOMATED QUALITY ASSESSMENT APPROACH

The domain expertise study and supporting literature analysis indicate that quality assessment is fundamentally a subjective issue that needs human intervention. That is providing intelligent decision support to domain experts is a better solution than replacing human judgments by fully-automated computer programs.

In response to these findings, this research proposes a semi-automated quality assessment approach, by which domain experts' decision making abilities will be enhanced. In this approach, a user-centred quality framework is developed for addressing the diverse information needs and multi-dimensional quality concerns of health information consumers. An indicator-based quality model, which specifies quality dimensions and their associated quality indicators, is built correspondingly to aid resource quality characterisation. The quality framework and the indicator-based quality model are derived from BCKOnline portal's resource selection criteria (BCKOnline, 2005; Burstein et al., 2005), the portal's user-centred metadata schema (McKemmish, Manaszewicz and Cheah, 2004), and Wang, Reddy and Kon's (1995) attribute-based quality data model. Based on them, a decision support tool is devised to enable domain experts querying quality data of their interests to make informed decisions.

A user-centred quality assessment framework

As already highlighted, a general quality framework is not suitable for assessing quality as the relationship between user and resource. Reflecting user-centred design principle, critical quality appraisal should be carried out based on articulated user information needs. Moreover, quality assessment results drawn by domain experts need to be presented in a way to facilitate individual users making their own value judgments. The solution of BCKOnline is to capture evaluation values as quality-related resource characteristics and construct them in the form of a narrative quality report in response to user quality concerns. For instance, the breast cancer community's concerns on the reliability of retrieved online information are encoded as quality elements in the portal's metadata schema, namely credentials, references, review process, evidence-based, currency, purpose and balance (Anderson et al., 2003).

In Figure 2, a user-centred quality framework is presented, in which quality is assessed in the context of perceived information needs of profiled user groups to better address their quality concerns on online health information. Due to the 'unpredictable' user behaviour, this framework is not intended to incorporate the user information needs at the individual level. However, the BCKOnline experience shows that user information needs can be modelled based on profiled user groups, e.g. age group and disease stage (Williamson, 2005). Information needs of the breast cancer community are interpreted as a compound of information preference, subject interests and quality perceptions associated with a user profile. As a result, value-added resource characteristics associated with resource type, topic coverage, content quality and intended audience are incorporated into the portal's resource description schema to assist domain experts assessing the likely relevance and quality.
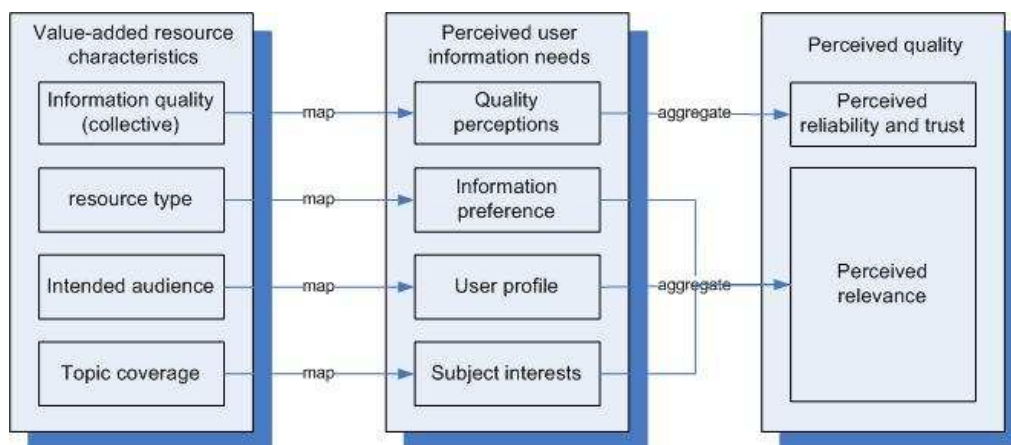

Figure 2: A user-centred quality assessment framework

An indicator-based quality model

In the above framework, a number of quality-related resources characteristics are defined to address portal users' quality concerns of retrieved online information. Values of these characteristics are drawn from domain experts' qualitative evaluation, supported by an indicator-based quality model. Derived from Wang et al.'s (1995) attribute-based approach to specify, store, retrieve and process data quality indicators, it is envisaged that a similar indicator-based quality model can be developed to support domain experts in evaluating, selecting and describing online information resources. The relationship among quality characteristics, quality dimensions and quality indicators is illustrated in Figure 3:
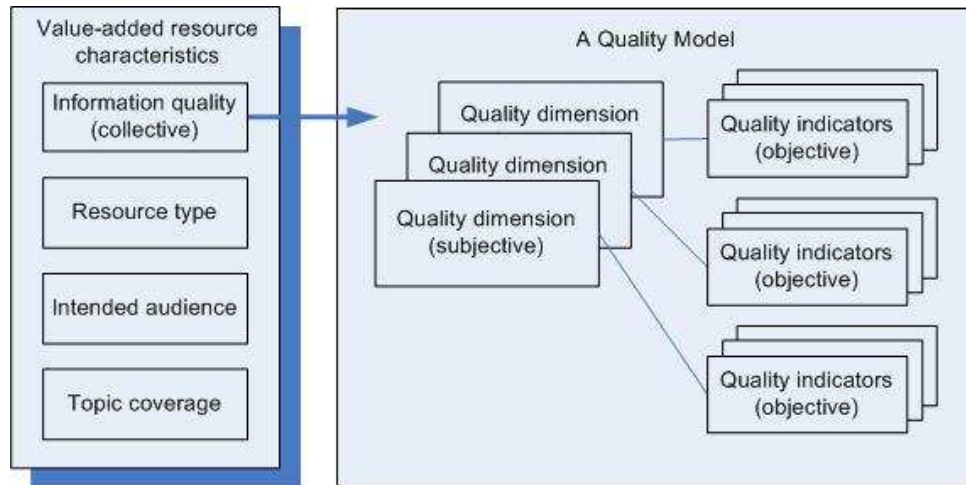
Figure 3: Relationship among quality characteristics, quality dimensions and quality indicators

Derived from what Wang et al. (1995, p.354) described in their model: -

- A *quality dimension* is a qualitative or subjective dimension of information quality that a consumer of information defines when evaluating information quality. For example, authority, accuracy, credibility and currency are such dimensions.

- *Quality indicators* provide objective information about the characteristics of information resources. A quality dimension may have a set of quality indicators associated with it. A quality indicator is objective if it is generated using a well-defined and widely accepted measure.

In the literature, various quality indicators, either direct or indirect (Eysenbach and Diepgen, 1998), have been identified and used to compute quality metrics. Those computer measurable or detectable technical quality indicators (Wang and Liu, 2007) are of particular interest to this research. Drawn on a systematic analysis of previous studies, an initial set of quality dimensions and indicators has been selected for tool prototyping. These quality dimensions, their definitions and corresponding quality indicators are listed in Table 1.

Quality Dimension	Definition	Quality Indicators
Relevance	The extent to which the resource is applicable and useful for the user's information needs.	Resource type, intended audience and topics
Reliability	The extent to which the resource and its source are regarded as true, credible, and up-to-date for the user's information needs.	Indicators of Authority, Accuracy, Credibility and Timeliness
Authority	The extent to which the source of the resource is authoritative.	Ownership of the Website, sponsorship, advertising, underwriting, commercial funding arrangements or support, or potential conflicts of interest, and arrangements in which links to other sites are posted as a result of financial considerations, editorial review process, Web statistics

Accuracy	The extent to which the resource is correct and certified as free of error.	Evidence-based, bias or potential conflicts of interest, third-party labels or seal of certification
Credibility	The extent to which the resource is highly regarded in terms of its source or content.	Authors, their affiliations and relevant credentials, contributors such as publishers, sponsors and developers, references and sources for Web contents, copyright information
Timeliness	The extent to which the resource is sufficiently up-to-date for the user's information needs.	Indicators of Currency, frequency of update, maintenance of site
Currency	The time the resource was created, issued and modified.	Date of creation, date of last update, date on which the resource was made formally available in its current form

Table 1: An initial set of quality dimensions and quality indicators

A decision support tool

Informed by the outcome of the in-depth domain expertise study, domain expert needs for intelligent support in quality assessment processes are described as to:

- Enhance the information available to domain experts or create new information to help their decision-making
- Provide metadata suggestions
- Support learning and facilitate communication among domain experts and support leaning
- Provide information about an automation task and its interrelationships
- Enhance the workflow and the consistency in quality evaluation and description procedures
- Avoid the duplication of effort
- Reduce the workload of maintenance

Focusing on the decision support role intelligent tools can play in quality assessment processes, it is envisaged that an intelligent tool which can automatically collect, aggregate and present quality indicators will be useful in supporting and sustaining resource quality appraisal procedures undertaken by domain experts. For instance, a domain expert's value judgments can be enhanced by knowing a previous assessed content provider's branding, an authoritative third-party's quality seal or certificate, cybermetric indicators such as results of Google PageRank (Google, 2008). A number of intelligent technologies, such as Z39.50 or SOAP for distributed searching, OAI protocol for metadata harvesting, algorithms of Web link analysis, Web popularity analysis and user behaviour analysis can be used in tagging online resources with objective quality indicators.

As a result, a decision support tool is developed consisting of two sub-systems, namely:

- A quality indicator analyser, implemented as a Web browser plug-in tool. In such a tool, values of computer detectable quality indicators are collected or generated automatically through the use of different technological means. Based on these quality indicator values, a quality data object will be created for each Web resource of interest and stored in a quality data repository.
- A quality data retrieval system, implemented as a component of a portal's content management system. It provides domain experts an interface to query relevant quality data to make informed decisions. It comprises a quality data object model, a quality data repository, a quality data querying component, a quality data retriever and a quality data analyser.

The stage of the system building has only recently commenced and will be reported in future papers.

CONCLUSION

This paper presents a multi-disciplinary, exploratory and applied research concerned with finding semi-automated ways to improve the scalability of the quality assessment processes in user-centred health information portals. The research is informed by the outcome of a qualitative domain expert study, which indicates that successful and efficient quality assessment for user-centred resource identification, selection and description requires collaborations between domain experts

and intelligent technologies. An analysis of relevant literature shows that existing quality assessment approaches do not directly address the needs of domain experts for intelligent support in user-centred quality assessment processes, but they form the basis of developing a new quality appraisal approach which not only facilitate human-machine collaboration, but also in alignment with the user-centred design principle.

As a result, this research proposes a semi-automated quality assessment approach, which consists of a user-centred quality assessment framework, an indicator-based quality model and a corresponding decision support tool to facilitate domain experts making value judgments in relation to resource selection and description. This paper reports the concept building stage of the proposed approach. The decision support tool implementation, observation and evaluation in the application domain of health information portals are underway to test the feasibility and usefulness of the proposed approach.

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