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A Linguistic Approach to Consensus Building in Digital Libraries

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Abstract

In recent years, libraries have shifted from their traditional function as repositories of printed materials to the creation of online communities where many individuals may share and discuss current events in real time. Despite these benefits, technologies to facilitate user agreement while making judgments in these novel virtual settings still need to be developed. Here, we provide a contribution consisting of a new linguistically-preferred consensus-reaching tool that incorporates the benefits of a new digital library to address the main issues that this type of organization faces (low and intermittent participation rates, difficulty establishing trust relations, etc.). (Rich and diverse knowledge due to a large number of users, real-time communication and so on). The tool includes feedback and delegation options that help the process move more quickly and more reliably toward a consensus.

1. Introduction

There is no academic institution without a library; they are crucial for the dissemination and development of knowledge and culture among faculty, students, and the general public1. Because of their central location in the academic community, libraries also serve a larger social function by uniting individuals around shared interests. Themes. This goal is aided and made easier by modern technology, especially with the advent of digital libraries2, 3.

A digital library (DL) is an online repository of knowledge and the services related to it that is made available to user groups via various electronic means2. Digital libraries (DLs) are the natural progression of traditional libraries in today's information age. Such additions provide for increased accessibility to a wider range of consumers. Given that the ultimate goal of a DL system is to allow users to access human knowledge at any time, from any location, using any combination of network-connected devices, regardless of physical proximity, language, or culture, it stands to reason that DL users should have the final say on matters of significance. Therefore, we may examine this issue as a problem of collective decision making. When people need to make a decision on how to proceed as a group, they engage in group decision making (GDM). No one member of the group can be held responsible for this

Choice at this point. This is due to the fact that not just one person or one social group mechanism, such social influence, is responsible for the final result.4, 5. Several attempts at developing suitable models to handle and resolve GDM issues have been made in the specialist literature. Fuzzy set theory6, an effective tool for modeling and dealing with nebulous or imprecise choices, alternatives, and views of several decision makers5, 7, has helped to provide novel outcomes for some of these approaches. However, there are cases when a linguistic approach is required4, 8 since the preferences of the experts cannot be measured accurately in a quantitative form but may be in a qualitative one. The linguistic approach is an approximation method that uses linguistic variables (those whose values are not numbers but words or sentences in a natural or artificial language) to express qualitative features as linguistic values.

However, it is evident that involving a very large number of people in a decision process is a difficult task; however, with the emergence of new electronic technologies, we are at the start of a new stage where traditional decision models may leave some space for a more direct participation of the "webzines." Web 2.0 is a major change in the way the Internet is used since it allows users to create and share information freely. It is a problem, however, to create more advanced Web 2.0 apps with improved "participation architectures" that enable data sharing with their users, user trust as co-developers, collective intelligence harnessing, etc., 9. They should be able to get with such Web 2.0 Community pitfalls as10, 11:

Strong user base.

- User diversity, including a range of demographics and linguistic vocabularies.
- People only seldom or rarely join in.
- The fluidity of Web 2.0 frameworks, such as the possibility that the user base may shift over time.

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• Challenging dynamics in forming trustworthy relationships.

Delegation12 is another significant technique that has been regularly employed in decision processes with several participants. In reality, conventional democratic systems depend on delegation to streamline decision making: when not everyone has a voice in the ultimate decision (and instead delegates authority to others), consensus may be reached more quickly and with less friction. The implications and applications of delegation are now the topic of significant research13, 14, despite its widespread usage in many diverse decision making situations.

2. Preliminaries

In this part, we provide some background on DLs, Web 2.0, and GDM issues in general. Web 2.0 and digital libraries 2.1 some attempts at explaining how these new technologies are being put to use may be found in the specialist literature. Electronic democracy, electronic participation, electronic government, and electronic public discourse. As a matter of fact, advances in Web technology have enabled the development of many services where people from all over the globe may meet, share ideas, and contribute to growing bodies of work. Web 2.020, an umbrella term encompassing a variety of approaches to Web development and design, has recently emerged as a means by which users may more effectively communicate, share data, engage with one another, and work together in the digital realm. Users of Web 2.0 Communities, which may take the shape of online message boards, blogging collectives, social networking services, and so on, are able to pool their resources to create extensive online content via virtual teamwork9.

The phrase "Web 2.0" was developed to characterize the ideas and practices that persisted after the dot-com bust of the late '90s. The ones that made it through the crash, he said, all appeared to have certain characteristics: they were collaborative, interactive, and dynamic, with people contributing material as much as they consumed it. Web 2.0 is more of a centralized center for conversation than a network for disseminating written content. Instead of a series of individual speeches, it is a matrix of conversations. This Web is user-centric in ways that previous versions of the Web were not. According to3, DL2.0 can be seen as a reaction from librarians to the increasingly relevant developments in information and communications technology (i.e., Web 2.0 and social software) and to an environment that is flooded with information available through these technologies. Openness and trust toward library users, and the creation of new communication channels and services in sync with societal shifts are all reactions to the advent of Web 2.0 technologies, which have made DL 2.0 possible. Other forms of user participation made possible by Web 2.0 include blogging, tagging, social bookmarking, social networking, podcasting, and so on. The range of perspectives and expertise brought to bear on the task of creating online material and documents is invaluable. Wikipedia21 is one of the best instances of successful cooperation since its online community has contributed millions of entries in dozens of different languages. It's obvious that in Wikipedia is such a large project that there are often moments when important choices must be made both the project's infrastructure and the information being developed.

• Suggest various goods and services to people. Common recommender systems use their user populations and the explicit and implicit information they generate to improve in efficacy and power22. When it comes to decision-making, systems like this are a potent complement to DL 2.0. Online retailers like Amazon.com23 are reaping the benefits of recommender systems, which draw on the expertise of their customer base to provide specific product suggestions for each individual customer. Additionally, new recommender systems are being created that make advantage of social networks' inherent organizational structure and user community.

• Take part in Online Forums and Discussion Groups. Web forums and message boards, where users may exchange information and debate various subjects of interest, have become the backbones of many online communities. Simple methods of collective decision making, such as referendum or voting are often utilized in many of these communities. Online survey and polling tools like PollDaddy24, for instance, let people weigh in on which solution is the best in a specific choice scenario. Beyond the apparent benefit of finding new friends who share your interests, DL communities also include a few unique traits that set them apart from more conventional groups. We'll go through a few of these traits and how they could play out in GDM scenarios below. Strong user base. You may easily locate online communities with thousands of people; for example, the library at Spain's Open University has tens of thousands of registered users. This may be seen from two different angles. One positive aspect of a big user base is the increased depth and breadth of information it often brings. This might be considered as an obvious benefit, since decision-making is often executed more effectively when a deep understanding of the assessed issue is available. However, it may be challenging to manage a big and varied set of views in order to extract and utilize that information; for instance, certain users may find it difficult to use traditional numerical preference representation formats; hence, linguistic ones should be developed.

• A varied clientele. In DL communities, not only is there a vast user population, but the user base is also quite diverse.

This means that we can't just assume everyone will have no trouble using the new features being added to websites. One glaring instance is the prevalence of star ratings: a few readers may find it challenging to communicate their preferences regarding a collection of options using numerical ratings, and it may be useful, therefore, to supply tools that can cope with natural language or linguistic evaluations. Very few people join up or pay in. Many DL communities have a sizable audience, but most of those people don't become involved in what's going on behind the scenes. It might also be challenging to encourage them to do so 11. Many people who join a DL community are passive observers who consume the output but do not (or cannot be bothered to) give anything to it. If just a minority of users participates to a decision and it does not represent the consensus of the community, this may be a major problem.

GDM problems under fuzzy linguistic preference relations

A GDM situation consists of a problem to solve, a solution set of possible alternatives, X = {x1, x2, xn}, (n ≥ 2), and a group of two or more experts, E = {e1, e2, em}, (m ≥ 2), characterized by their own ideas, attitudes, motivations and knowledge, who express their opinions about the set of alternatives to achieve a common solution. One of the difficulties in this field is determining the best way to portray the data. There are situations when a purely quantitative analysis of the data might be inappropriate, necessitating a qualitative strategy instead. For instance, while attempting to quantify events associated to human perception, we are often forced to apply words in natural language rather than numerical values; for instance, when judging the quality of a football player, adjectives like "good," "medium," and "bad" could be employed. The ordinal fuzzy linguistic approach25 is based on the concept of linguistic variable26, 27, and 28 and is one way to deal with qualitative assessments. It's a useful kind of fuzzy linguistics since it simplifies the representation of problems in language and reduces the number of words used in computation. Some of the many applications where it has been proved to be useful include decision making, online quality evaluation, information retrieval, recommender systems, political analysis, and many more besides. S = is, i = 0, 1, 2, g, where si s j if i j is an odd-cardinal, finite, totally ordered label set. (Usually 7 or 9 labels). The remaining sentences are symmetrically organized around the expression "approximately 0.5," which stands for "about halfway." The semantics of the label set may be inferred from its ordered structure [25] if it is assumed that each label for the pair (si, sgi) is equally informative. The following seven terms may be used to describe different linguistic features:

$S = \{s_0 = N, s_1 = VL, s_2 = L, s_3 = M, s_4 = H, s_5 = VH, s_6 = P\}$, where N = Null, VL = Very Low, L = Low, M = Medium, H = High, VH = Very High and P = Perfect.

This method may be used to construct automated and symbolic language aggregation operators, such as the LOWA operator 4, for example. There are a variety of approaches that may be used in GDM. These approaches fall somewhere along a range that goes from guide from top-down to bottom-up deliberation. Methods that are more in line with the directive range suggest that decisions are made by a select few. In contrast, the decision is made by everyone who has a stake in the matter using procedures that are farther down the spectrum, in the participatory range. Here, we present a consensual decision model with two distinct procedures (see Fig. 1) to facilitate group decision making.4, 6, and 7: Reaching a consensus. Methods for maximizing consensus among specialists about potential approaches are discussed here5. This step is often taken before the actual selection is made, and it is usually led by a moderator figure. Since the consensus process works to prevent "winners" and "losers," it is an essential part of finding solutions to GDM issues. For a group to reach consensus, the majority must back a certain course of action while the minority still gives its stamp of approval. In other words, in order to reach agreement, the proposed course of action must be adjusted such that it satisfies the concerns of those in the minority. It's crucial because in any decision-making process, it's ideal for experts to agree on a narrow range of solutions before moving on to the next step.

• Method of choosing. This method explains how to compile a list of viable solutions based on the experts' evaluations of those solutions. There are two stages: gathering information and using that information. The preferences offered by the experts inform the aggregation step, which then forms a collective view. During this stage, information gathered worldwide is used to rank all available options.

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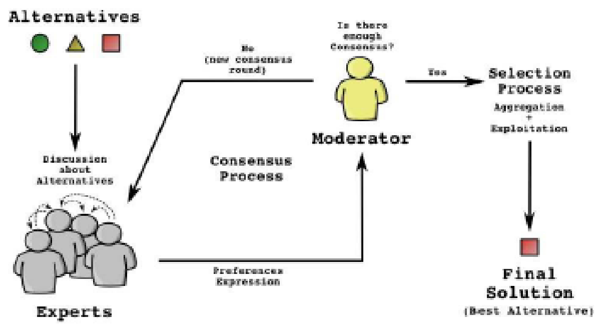

The original GDM model is shown in Fig.

The experts' preferences are assumed to be expressed in terms of Fuzzy Linguistic Preference Relations.

An FLPR Ph is a fuzzy set defined on the product set, and it is provided by an expert eh. X X, where X is a set defined by some membership function in the language: Ph: X X S, where Ph(xi, xj) = ph i j is regarded as the degree to which the expert eh prefers the option xi to the alternative xj from a language standpoint.

In addition, we think of consensus as a quantitative variable, with 100% agreement and 0% disagreement being the two extremes29. The present level of agreement in the decision process may be quantified using a range of consensus degrees. We assume in this consensus model that experts will have different points of view on any nontrivial GDM problem, and that as a result, decision making will need to be seen as an iterative process consisting of multiple discussion rounds during which experts will be expected to adjust their preferences in light of the guidance provided by the moderator. This implies that it may take many rounds of discussion before consensus is reached. Each iteration includes a calculation of the consensus measures and a verification of the current level of agreement among experts. In order to get everyone on the same page, its common practice to give everyone in the group advice (feedback information) about where they stand in terms of consensus, which issues and alternatives are causing the most contention, which has the most divergent preferences and how changing those preferences would affect the group as a whole. The moderator's role is threefold in this scenario: (i) calculating the consensus measures; (ii) assessing the amount of agreement; and (iii) providing guidance to experts who could benefit from rethinking their positions.

3. A linguistic consensus tool for digital libraries

Consensus procedures that use cutting-edge forms of web-based decision-making have been the subject of various efforts at modeling. In30, for instance, we saw the introduction of a web-based consensus support system for GDM. It was planned for the expert-driven GDM procedures to use the prepared support system. Utilizing only a basic web service. As a result, it couldn't be utilized to manage Web 2.0 decision frameworks, where we often find a large but disengaged population. A theoretical model to address all these issues was recently given by Alonso et al. 31. We provide a new tool in this part that uses the theoretical model described in part 31 as its foundation. To improve library patrons' ability to reach a consensus while choosing amongst several options, it has been tailored to take into account DL's characteristics (see Section 2.1). The features of the offered instrument include:

• It can function without a mediator being present. The program itself serves as the virtual moderator, making it possible to operate in situations with fluctuating participation and contribution levels.

• It creates a model of the user's preferences and trust relationships based on their language usage.

• It lets you give varied amounts of weight to employees, students, and academics' comments based on their relative levels of experience.

• It utilizes a feedback mechanism to sway specialists' ideas about the available options (the virtual moderator suggests solutions that align with the specialists' viewpoints).

• It offers a trust-based delegation method, which reduces the need for communication while making computation simpler. Address problems that the delegation scheme could cause in the consensus-reaching model by implementing a trust-checking method.

It relies on a number of modules, all of which must be implemented in order to function (see Fig. 2):

• The Initiation Board. The consensus process experts who will be using this module as their starting point. Therefore, this section introduces the many solutions to the issue, X = x1, xn, to the specialists involved. While just a few of experts are shown in Fig. 2, this number will often increase when applied to the DL community. Once the experts eh E is aware of the options that may be implemented, they are requested to provide their thoughts on the matter using a fuzzy linguistic preference relation Ph. Module for Computing Neighbors. Each expert's global current preference relation and set of neighbors (other experts who share their views) are calculated. Professionals are given this data for review. We utilize a distance metric specified in31 to determine the surrounding areas. To determine the global

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current preference relation, the LOWA operator 4 is applied to each of the local FLPRs.

• Input/output Module. The system will provide various simple feedback guidelines to the experts in order to facilitate the updating of the preferences of the experts who have not delegated (in order to attain a higher degree of agreement). After that, the users will alter their inclinations. Voting and Agreement Module. The system will compute a variety of consensus measures7 to determine the current consensus state. If the level of agreement is high enough, we move on from the consensus phase to the selection one.

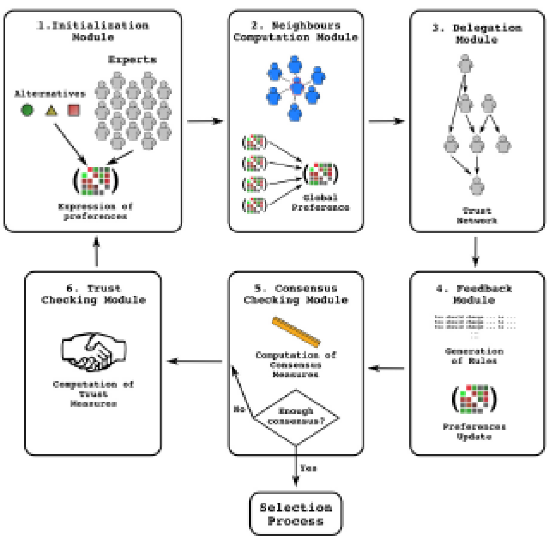

Fig. 2. Scheme of the implemented modules.

4. A real world application: UNED digital library consensus tool

Although the primary objective of this work is to propose a theoretical model that might be modified to deal with comparable GDMproblems, in this part we discuss the application of the system in a real-world DL in order to test and assess the given tool. In particular, we highlight its relevance to one of Europe's most influential DL groups: academic DL from Spain's Open University (UNED).

UNED has more than 260,000 students, making it Spain's biggest university and the second-largest in Europe after the Open University in the United Kingdom. The UNED library currently has several 2.0 features available. Because of this, the situation is ideal for implementing our system. To reduce friction and improve agreement on major matters, new methods have had to be implemented in this massive system, which involves thousands of people. Given the breadth of the UNED DL's coverage, decision-support tools like these are very useful. Some of these circumstances are well suited to the consensus approach presented in this article. Consider the funding distribution dilemma as an example of a contentious subject. The DL users (students, faculty, staff, etc.) might be portrayed as the experts in a GDM dilemma where they must weigh the relative merits of the available solutions in order to allocate funding. We represent potential solutions as the library's assets (staff, books, databases, the internet, etc.). When our method is used, it allows for the selection of a consensus solution from among many potential outcomes. Than if we used more conventional models like simple and direct voting procedures. The new technology may be easily integrated into an existing DL online community like the one at UNED DL. Like polls and discussion boards, it may even be its own tab. To do this, the application makes use of two distinct user interfaces: one for the website administrator and library managers, and another via which regular users may share their preferences. The former paves the way for managers to identify the issue (by writing a description of the choice that must be made), the alternatives, and such specifics as the language set that will be used. The following raw information was utilized for our case study: Human Resources (HR), Physical Resources (PR), Digital Resources (DR), and Online Resources (WR) are all possible paths to take.

• A scale from "Very Low" (VL) through "Low" (L), "Medium" (M), "High" (H), and "Very High" (VH) in terms of language proficiency.

• 0.8 is the bare minimum for agreement.

The user interface, on the other hand, is built as a client that talks to a server where the actual work is done based on the user's input or delegation. Users will then be tasked with evaluating the relative financing needs of each resource couple. An assessment of (HR-SR) of "H" indicates that HR requires more funds than SR; an evaluation of "M" indicates that HR and SR need the same funds, and so on. As a result, in the setup section, users are asked to provide their own ratings in a form (Table 1).

In this table, we provide the results of a survey of our users.

	HR	SR	IR	WR
HR	-	L	H	M
SR	H	-	VL	L
IR	L	VH	-	M
WR	M	H	M	-

Second, the neighborhood comparison module generates a group of neighborhoods by comparing each rating to a fuzzy distance measure, as in: •

Neighborhood 1: 1, 53, 96, 275, 356, 584, 789, 866, 1248, 1302, 1788, 1956, 2345,

• Area Codes in Neighboring Area 2: 2, 45, 87, 134, 287, 673, 815, 1343, 1886, 2169, 2436,.

Users may then choose the delegation they like. While they are free to choose anybody else, the algorithm suggests they find someone in their immediate vicinity. After that, the feedback module gives suggestions to the users, based on a comparison of their individual preferences and the group's overall preference (calculated in the second module), such as:

Warning: the present degree of agreement is insufficient. If you want to make a difference, you should give the HR-WR combination an "H" or "VH" instead of an "M" rating. Users may now make new selections in the preferences menu. Last but not least, the system evaluates the consensus: Level of agreement: 0.62 (which is lower than the Minimum Consensus Level). A new round of consensus must begin since it is still low (as it often is before the first two or three rounds). But first, it runs through its built-in trust testing module and, if required, issues warnings like the ones below:

The user you gave authority to has revoked his permission. Please reevaluate your choice to delegate. Thus, users that receive the warning message are allowed to delegate in other expert or continue in the process themselves. Once the consensus level is high enough, the selection process computes the final ranking and it is presented to the administrator in order to manage the funding distribution. In this case, the ranking is the following: {IR, HR, SR, WR}.

5. Concluding remarks

In conclusion, it is important to note that the proposed tool utilizes pre-existing processes (delegation and feedback reinforcement) that are employed in actual decision making situations, despite managing a succession of more or less complicated interactions. In addition, all variables' calculations are quite elementary, and the computational complexity is minimal. The tools have a minimal complexity. Some of the tool's modules, such the delegation or preference modification processes, may slow down the resolution process, as is the case with real-world decision making challenges. Since such procedures are only effective for a limited period throughout each cycle, this is not a significant issue. Even if an expert misses one of the consensus rounds, the process may still be completed in a timely manner since they are not required to offer their preferences, delegate, or even amend their ideas. Each user has access to a web page that contains all the data supplied to the experts at any moment throughout the procedure. Therefore, it is the experts' responsibility to educate themselves about the resolution procedure, his neighbors' views, and the delegation plan. In conclusion, the work described herein introduces a novel consensus mechanism tailored for use in DL communities. In particular, it employs conventional mechanisms that are really used while selecting choices: For the purpose of expressing and managing experts' preferences, it employs fuzzy language preference relations. It was developed with a delegation system in mind to handle a huge user population. This delegation technique reduces the complexity and time of computing user preferences by building a trust network based on expert-provided language trust assessments. In addition, this delegation approach addresses the intermittent contribution issue that plagues almost every online community (in which many people do not consistently contribute but do so on occasion). The model also includes a feedback system to assist the experts in adjusting their choices in order to reach a high degree of agreement as soon as possible.

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