Technologies for Qualitative Meta-synthesis of Community Consensus

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Abstract—**Systems methodologies toward wicked problems or societal complex systems usually call for a collaborative problem solving process. The products (solutions) of that process refer to somewhat collective intelligence. In this paper, some technologies for collective intelligence, or so-called qualitative meta-synthesis of community consensus, are addressed. Two technologies, CorMap and iView, conduct exploratory analysis toward those topics or ideas created bottom-up and facilitate human-machine interaction by visualization of the analytical process based on different algorithms. Those technologies are oriented to support collaborative deliberation undertaken by Web 2.0 tools.**

Keywords—**Qualitative meta-synthesis, CorMap, iView, community consensus**

I. INTRODUCTION

Many system methodologies, including soft OR methods had been proposed to deal with wicked problems, especially those complex societal problems as reductionism methods have not worked well since 1980s [1, 2]. Referred as problem structuring methods, those methodologies also provide rationales of decision support systems for those problems' solving [3, 4]. Group work is a normal state during the problem solving process. Different kinds of computerized support tools have been built to facilitate different kinds of group activities. One large category of those tools facilitates communication and information sharing. Many tools, such as groupware, GSS, CSCW, CMC and even some knowledge management tools belong to this category. The spectacular emergence of the Internet enabled unprecedented opportunities for such kind of group work. Emails, instant messaging, chat rooms, blogs, wikis, etc. brings more information. However, the vast amount of information also increase information overload. Another category of supporting tools for group work, especially for argumentation, deliberation and sensing-making for problem structuring and then for feasible scenarios and consensus building among community had already been explored, such as QuestMap (gIbIS based, now as Compendium) supporting the dialogue mapping approach to deal with social complexity [5], Decision Explorer and Group Explorer based on strategic options development and analysis (SODA) [6] , augmented informative discussion environment (AIDE) [7], etc. Those IT supports also drive the developments of system methods [4]. For example, scholars at Lancaster University proposed Wisdom process to facilitate session includes brainstorming, cognitive mapping and dialogue mapping [3]. The cognitive mapping phase provides a macro view of the problem discussed by the group and the dialog mapping phase helps the group develop consistent micro views.

Recently support to facilitate, expand, or enhance one's ability to work with one or more kinds of knowledge, from which to make some senses, distill insights or gain knowing, etc. has been drawn much attentions, especially as Web 2.0 becomes a popular term and is eagerly expected for better job of harnessing the vast collective intelligence potentially available. Ref. [8] reports a study using Collaboratorium, same as QuestMap based on IBIS methodology. The researchers argue that current open-source/peer-production (OSPP) technology is not capable of collaborative deliberation, since the coverage of a topic is created bottom-up and then generally unsystematic. That kind of technology is more time-based, while collaborative deliberation requires logic-based postings. Such a study again tells the differences between two categories of support tools for group work, which had already addressed in [4]. The practice of those tools based on soft OR methods or IBIS-methodology for collaborative work during wicked problem solving helps to gain structures of wicked problems while sacrifice freedom of wild thinking and then may lead to loss of novel ideas, the typical disadvantages of consensus built top-down.

In this paper, two technologies on qualitative meta-synthesis for consensus built bottom-up are addressed. Firstly, meta-synthesis system approach is addressed briefly to elicit the meaning of qualitative meta-synthesis.

II. META-SYNTHESIS SYSTEM APPROACH

The meta-synthesis system approach (MSA) is one of those system approaches proposed by a Chinese system scientist Qian Xuesen (Tsien HsueShen) and his colleagues in 1990 [9]. An understanding about MSA is simplified as from confident qualitative hypothesis to rigorous quantitative validation, which reflects a general process of knowing and doing in epistemology. In 1992 Qian proposed a concept - Hall of Workshop for Meta-Synthetic Engineering (HWMSE) as a platform for MSA practice [10]. The concept of HWMSE reflects the emphasis of utilization of the breaking advances in information technologies (IT) to help harness the collective knowledge and creativity of diverse technical group experts by synthesizing data, information, quantitative models, knowledge, experiences into an interdisciplinary problem-solving process for both proposing hypothesis and quantitative

validating. At that time, email, newsgroup, or those Web 1.0 technologies just started to spread worldwide.

According to Qian's original idea, HWMSE has three components, human expert system, machine system and knowledge system. Many studies during the initial 10-year trials including those demos of HWMSE focused more on software engineering technologies and did not explain how the relevant three systems interact with each other to solve the problems clearly and logically. Then those studies are not enough to show how to apply collective intelligence to complex problem solving process using MSA. Moreover, too many discussions into details of machine system development distort the understandings of the capabilities of HWMSE, which really led to doubtful impressions, especially from those people who were expecting a breakthrough in system studies as system engineering was adopted into China for only 20 years.

Perplexed opinions toward MSA and HWMSE have been getting along with MSA studies in recent 15 years. On the other hand, more concerns in complexity research also draw attentions to the approach itself [12]. As it went into the 21st century, more in-depth research was carried out. Explicit explanations of MSA, such as three types of meta-synthesis, using the case of policy making on macroeconomic problems were given for the 1st time [11]. The three types of meta-synthesis denote qualitative meta-synthesis, qualitative-quantitative meta-synthesis and meta-synthesis from qualitative understanding to quantitative validation, which actually indicates a working process of MSA to complex problem solving. Ref. [13] discussed how to achieve three types of meta-synthesis by a synchronous-asynchronous-synchronous process while each type of meta-synthesis can be achieved at the respective phase. Activities held in Synchronous Stage I denote to achieve qualitative meta-synthesis, i.e. perspective development or hypothesis generation for meta-synthetic modeling. Divergent group thinking is the main theme at that stage.

Technologies which are oriented to acquire constructs or ideas toward the concerned problems are considered as qualitative meta-synthesis technologies. Then various problem structuring methods can be regarded as qualitative meta-synthesis methods. Those methodologies or the technologies used by those methodologies such as IBIS define normative frameworks followed by the users. Then the output (such as ideas, options) are given directly by users; no further augmented computational analysis is conducted toward those logic-based deliberation process. Next, two technologies for qualitative meta-synthesis are addressed. Those technologies apply different computational analyses toward the ideas created bottom-up.

III. QUALITATIVE META-SYNTHESIS TECHNOLOGIES

Ref.[14-15] systematically described two data analysis technologies, CorMap analysis and iView analysis, which aim to implement qualitative meta-synthesis for confident hypothesizing. The meta-data for both technologies is with such a structure as

<topic, userID, text, keywords, time>

Such metadata indicates the corresponding *userID* posts one *text* (e.g. one comment, one blog, the title of a paper, a reply to one question) with a set of *keywords* under the *topic* at the point of *time*. By word segmentation and filtered feature keywords used in text summarization, or even human's identification, a variety of human ideas and opinions can be transferred into one piece of record with that structure. The keywords for a blog may also denote the labels or tags of that blog. The keywords are articulated as attributes of the *userID* or the *text*. Here, only basic steps are depicted; the details of mathematics of both analytical technologies are omitted.

A. CorMap Analysis

CorMap analysis denotes a technology of exploratory analysis of textual data. A general CorMap analysis process is as follows:

1) Construct a frequency matrix based on a contingency table of the meta-data. Two frequency matrices can be generated. The element of one matrix denotes the frequency of keyword *i* referred by the human *j* relevant to the topic. The element of another matrix denotes the frequency of keyword *i* referred by the text $j, i = 1, 2, \ldots, m$, $j = 1, 2, \ldots, n$.

2) Conduct correspondence analysis by performing a series of transformations and singular value decomposition (SVD) towards the transformed matrix to acquire the coordinates of both humans (or texts) and keywords which then can be mapped into 2-dimensional or 3D space for visualized analysis.

As a result, a pair of participants with more shared keywords may locate closer in the 2D space.

3) Calculate the total inertia of the contingency table to describe the level of association, or dependence between two categorical variables in terms of the singular values and how much that mapping into 2D space accounts for the total variation using the largest two singular values.

As correspondence analysis is only a method for exploratory analysis, the visualized association is not a confirmatory one, and 2 dimensions may not visualize more than 75% of the association between humans and keywords. It is very important to check the value to avoid misuse of the association.

4) Conduct clustering with the spatial relations acquired in Step 2). Simply, k-means clustering of keywords is usually carried out.

5) Calculate the centroid of each cluster and find the keyword which is the closest to the centroid as the label of the cluster.

The above two steps can be done iteratively to see what kind of keyword-grouping is appropriate for ideas clustering and concept extraction for qualitative meta-synthesis.

6) Calculate an appropriate number of clusters. A given cluster number may facilitate clustering analysis. Step 6) can be taken before Step 4).

The above process shows the essential analytics during CorMap analysis. Such kind of analysis can be applied to any combination of the concerned participants, and may help to

"drill down" into those community thoughts to detect some existing or emerging micro community. If applied to an individual user, CorMap analysis may help to unravel personal thinking structure.

B. iView Analysis

Given the same dataset used by CorMap analysis, iView analysis mainly applies network analysis methods to depict the scenario of the topic. The iView analysis is based on the construction of iView network. A general iView analysis process is as follows.

1) Construct the iView network. The iView network mainly includes 3 kinds of networks, keyword network, human network and text network.

In a keyword network for iView analysis, the link between the vertices (keywords) denotes the co-occurrence of keywords among all texts or humans. Such a network is referred as an *idea map* contributed by all participants. This topological network is a weighted undirected network where the weight of edge denotes the frequency of co-keywords.

In a human network, the link between vertices (humans) denotes keywords-sharing between participants. The strength between two participants indicates the number of the different keywords or the total frequencies of the keywords they share.

Three types of text networks are built during the iView analysis. All are directed networks. The text network Type I denotes the directed link from text *j* to text *i* indicating a kind of citing the keyword which originally appears in text *i*. In the text network Type II, the link denotes to cite the closest text including the concerned keyword. In the text network Type III, the semantic meaning of link expands to a variety of attitudes, e.g. oppose, support, etc. instead of the citation of keywords in both Type I & II text networks. Text network may help to show how the ideas grow and spread.

2) Conduct a variety of network analysis to acquire the characteristics of iView networks. The basic analyses usually include cutpoint, centrality (degree and betweenness), etc.

A variety of network analysis aims to get more senses, such as expose different perspectives of a collective vision of all the community or the influential people by centrality analysis, etc. The underlying mathematics applied is mainly from graph theory and social network analysis.

3) Conduct clustering of nodes in the iView network for detection of network structure.

With use of community structure detection methods, clustering of keywords of iView's idea map may help to understand the major points from those keyword clusters easier instead only by frequencies of individual keywords.

4) Assign a label to each cluster. Several ways may be tried. Select the vertex with maximum centrality of degree or betweenness in that cluster. If the weight of links is considered, differences may happen even with one kind of measure of centrality of nodes.

5) Visualize the network and various analytical results.
Step 5) may happen after each previous step.

The pair of idea map and human net could be regarded as one kind of structure about the dedicated topic. The exploited network analysis aims to detect basic concepts and main themes, influential people and the potential micro communities emerged. The information could be regarded as the constructs of the concerned topic and may be helpful to quickly get a rough understanding of the interesting topic or a consensus of the existing community. Actually either idea map or human network is the one-mode projection (such as the sharing keyword between humans) of an original bi-partite network.

A different algorithm is applied to the text network Type III due to the different semantic meanings of the link, which will be introduced in the future publication.

C. Features of both CorMap and iView Analysis for Qualitative Meta-synthesis

Either CorMap or iView analysis shows different perspectives toward the same set of data based on different mechanisms with the same aim to acquire constructs of the problems from those textual data for one topic. Both analytical technologies share common features:

- By a variety of transformations of original textural data sets to expose the hidden structure;
- Visualization of analyzing process to facilitate human's understanding;
- Adoption of a series of algorithms or methods instead of application of individual one;
- Exhibition of support for a problem structuring process. Firstly, give a rough imagine of the issue; secondly, draw a scenario of the issue using clustering analysis to detect the structure; meanwhile, an optimal of clusters is achieved; thirdly, extract concepts from clusters of ideas. Thus, a category of concepts instead of a mess of diverse ideas is acquired step by step;
- Facilitation of human-machine collaboration. Each step leaves rooms to facilitate analysts' direct manipulations and results' visualization.

Both technologies can be applied to qualitative meta-synthesis to wicked problems. Due to different mechanisms of each technology, one may be more effective to human's understanding at one time. It is the human to make appropriate use of each technology during the discovery process.

IV.   SIMPLE EXAMPLES OF BOTH TECHNOLOGIES

Both CorMap and iView analysis may be applied simultaneously toward one problem. During the exploratory analysis process, it is not always that both technologies produce efficient detection of some useful or potential constructs to describe those problem or solutions. Sometimes, they may be complementary to each other. Whatever, different perspectives are useful for wicked problem solving. Next we show very simple examples of each analysis which had already published.

A. iView analysis about Knowledge Science Research

Figure 1 shows the idea map of iView analysis of an academic conference on knowledge sciences (KSS'2006) [16]. As knowledge engineering, knowledge management and even

knowledge creation have been widely accepted in academics, business and industry, knowledge science is still a rather young area where diverse explorations are being undertaken. How to acquire a vision about knowledge science both efficiently and effectively is help for people who want to get a rough picture.

As the publications at those relevant conferences on the interesting topics represent the latest achievements and humans' thinking about the topics, iView analysis is applied to conference publications.
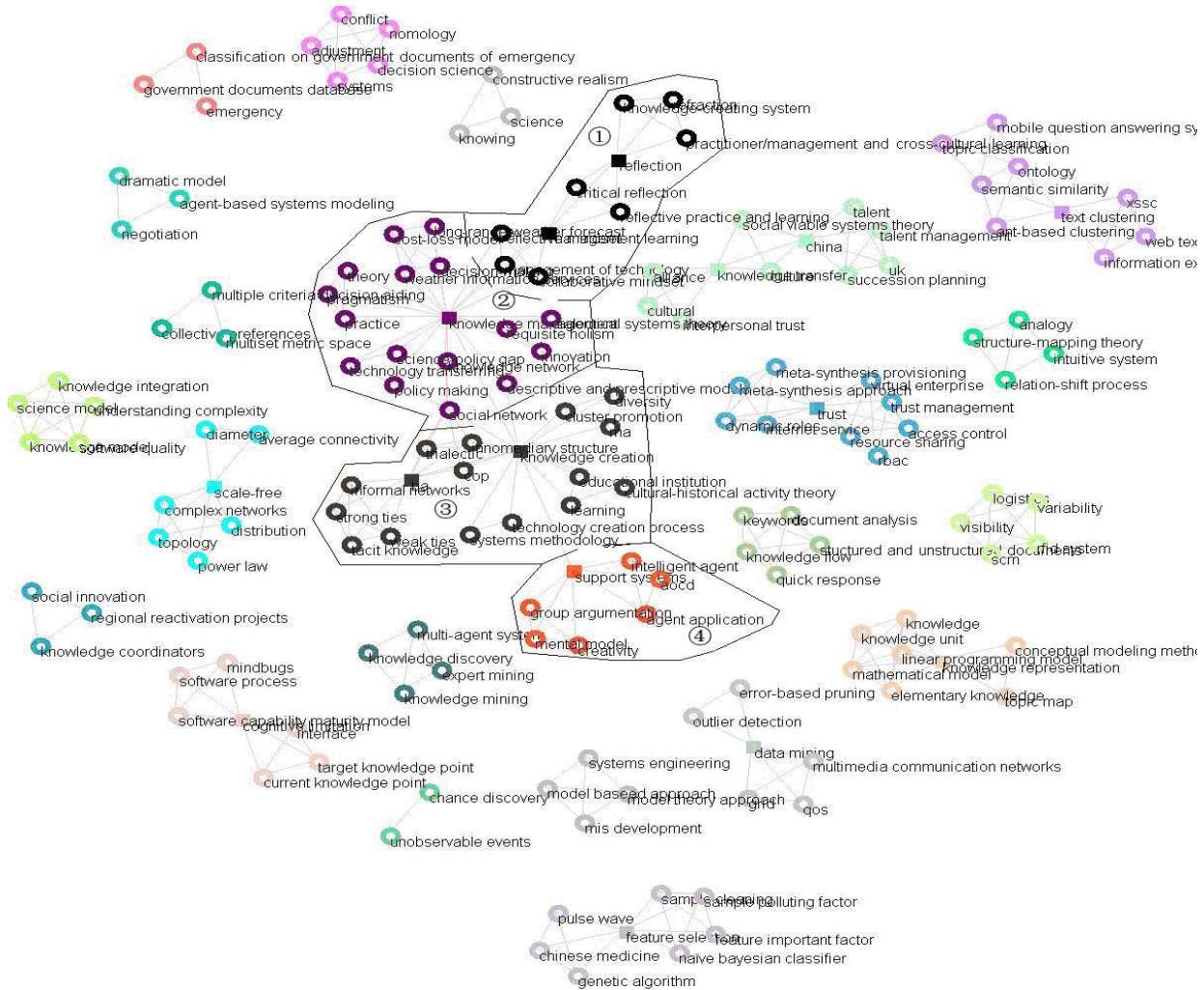

Figure 1.   Idea map of KSS'2006 (keyword network) [16]

The largest component (in the middle of Figure 1) including 51 keywords is split into 4 clusters. The central lower cluster (Cluster No. 3 with vertex in dark green) contains keywords about the mechanism of knowledge creation. The right lower cluster labeled as No.4 (vertex in orange) is a cluster of keywords mainly about computerized support. The central cluster labeled as No. 2 (vertex in purple) includes a cluster of keywords about knowledge management and its practice. The keywords belonging to the upper cluster labeled as No. 1 (vertex in black) is mainly oriented toward system thinking on knowledge. Such a way is to detect the major topics of knowledge science concerned by KSS'2006. The 6 cutpoints detected at the largest component, "knowledge creation" and

"ba" within Cluster 3, "support systems" (Cluster 4), "knowledge management" (Cluster 2), "management learning" and "reflection" (Cluster 1) also perfectly explain the topics of knowledge science studies discussed at KSS'2006.

B.   CorMap Analysis towards Social Risk Perception

When social psychologists study social risks, initially they may carry out a small-scale word association test to acquire images and perceptions toward a set of impressive social concerns. Then they design questionnaires to carry out large-scale investigations and develop structure equations to depict the relations among risk factors. The processing of those word association tests is often taken manually, especially the coding

of events. Some hypotheses had to be thought for design of questionnaire. To facilitate their processing of word association test, both iView analysis and CorMap analysis were taken to a test implemented by social psychological researchers in the Fall of 2007. Both analytical results provided different helps for those researchers [17]. Figure 2 shows a CorMap of the people at different ages and their word association in social risk perception. We can see that "age_above50" is far away from the other three groups. Categories "age_30_39" and "age_25_29" are adjacent. The youngest and the oldest are far away in the CorMap. The mapping to 2D space still accounts 100% of the total variation. Different colors of words show the clustering of those words (the number of clusters is 4).

Different kinds of CorMap analysis were taken, such as words and people with different professions. Those kinds of CorMap analysis provide great help for social psychologists.
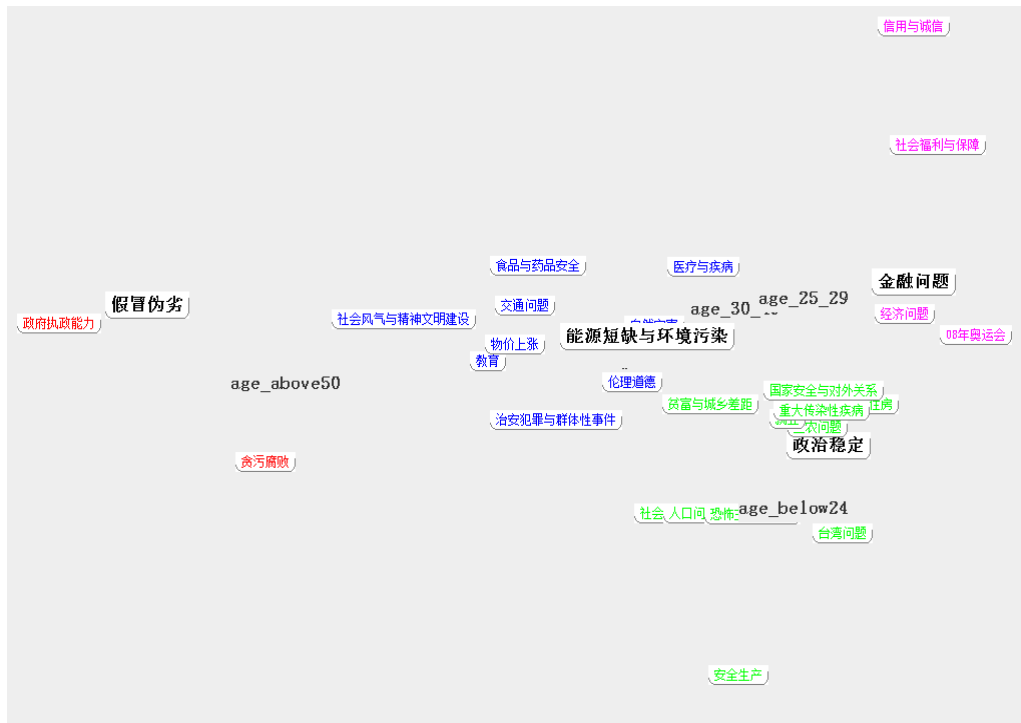

Figure 2.   CorMap of the people at different ages and their word association in social risks
(4 clusters of words while all words are of 30 categories) [17]

V.   CONCLUDING REMARKS

Collaborative group work to wicked problems or complex societal problems is a normal state and many computerized support technologies have been developed. One large category is oriented to communication and information and sharing. Those open-source/peer-production technologies, such as chat rooms, wikis and blogs have enabled an unprecedented explosion of information sharing which may also be regarded as one kind of information overload. For effective problem solving, another category of tools oriented to problem structuring and sense-making whose design rationale mainly come from those system methodologies including soft OR methods is also studied. Most of those tools, especially those soft OR based or IBIS based actually define a normative framework to undertake logic-based collaborative deliberation, since wide ideas or topics created bottom-up are regarded as

unsystematic. Moreover OSPP tools sometimes are concerned of time-based events.

In this paper, two technologies for qualitative meta-synthesis for perspective development or community consensus are addressed. Both technologies conduct exploratory analysis toward those topics or ideas created bottom-up. The commons of both technologies are textual computing based and facilitation of human-machine interaction by visualization of outputs of a series of operations based on different algorithms, i.e. from transforming of original textual data into rough imagine, from rough image into concrete structures by different idea clustering and finally extract concepts from idea clusters, which reflects the human's cognitive process. Simple examples show the results of each technology toward wicked problem solving. As Web 2.0 technologies have become popular, both qualitative meta-synthesis technologies may be helpful to acquire useful information, such as options, which may be as

the start point during a collaborative deliberation facilitated by the Web 2.0 tools.

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