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Ontology Based RT-Delphi with Explanation Capabilities

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ABSTRACT

Real-Time (RT) Delphi approach is widely used method for knowledge acquisition process. The current RT-Delphi approach ignores considering the unifying domain concepts and their attributes. This limitation can provide the contradiction of the domain experts' judgments and increasing misunderstandings when talking about specific topics. In addition, the current RT-Delphi ignores the explanation capabilities for consensus results, which it is vital for policy/decision makers to be more confidence. The core of this research is to develop ontology-based RT-Delphi with explanation capabilities. We applied the developed approach in to two crucial important case studies in Egypt, which are food security and water security.

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1. INTRODUCTION

In real high complexity and uncertainty, futures anticipation is a crucial source for helping policy/decision makers in long-term decision making [1]. The anticipation of the future can make more reasonable by enhancing the quality of available information and knowledge [2]. Futures studies represent a multi-disciplinary research that integrated both quantitative and qualitative analysis to find the future major drivers [3], [4].

Delphi method overcomes different disadvantages of the traditional knowledge acquisition methods. It based on large-scale participation approach. It represented a controlled debate with anonymity and independent of subjectivity characteristics [5].

Delphi method represented a well structured process for eliciting knowledge from the domain experts. A series of questionnaires are applied by a controlled debate. By Delphi questionnaire, domain experts can response and they can refine their answers as the group's expert's judge progresses. Also, policy Delphi seeks to generate different views for evaluation a major policy issue. Seeking for a consensus judgments is not the objective. It not represents decision analysis or decision making tool, but it can to generate all possible options and providing evidence for consideration [6].

In RT-Delphi, all opinions are made anonymous and the domain experts move toward consensus. it has the following 5 advantages (in comparison to traditional Delphi): Round-less approach then significantly saves time and cost, experts have instantaneous access to the website, flexibility in the number of participants and it can be easily applied to problems formulated in a matrix design [4], [5].

The process of knowledge acquisition requires an agreement on the concepts and their attributes of a specific domain. Unfortunately, domain experts have different specialties that created some problems for the expert panel session [7].

The domain ontology is crucial in order to harmonize the meaning of concepts and provide richer relationships between them. This paves the way towards the knowledge acquisition process by minimizing the chances of misunderstandings when debating a certain concept or a problem [8], [9]. It provides for reducing the contradiction of the experts' judgments by defining a common language between domain experts and avoiding misunderstandings when talking about specific topics. Ontology describes domain concepts and their attributes and all relationships that hold between these concepts [10], [11].

The explanation facilities for the knowledge-based model indeed influence policy/decision maker confidence in acceptance the consensus results [12]. Explanation with "Why" and "What if" analysis provides policy/decision maker to be more confident about the consensus results of the domain experts [13].

The paper structure is organized as follows: in Section 2, we discuss the problem addressed. Then in Section 3, our proposed solution is explained in details including the inputs, output and the approach itself. Also, in Section 4, we give a case study. Finally in Section 6, we conclude and suggest possible future work.

2. PROBLEM ADDRESSED

When the steps of conducting a RT-Delphi were stated above, it was clear that the current RT-Delphi approach ignores considering the unifying domain concepts and their attributes. This limitation can provide the contradiction of the domain experts' judgments increasing misunderstandings when talking about specific topics. In addition, the current RT-Delphi ignores the explanation capabilities for consensus results, which it is vital for policy/decision makers to be more confidence.

3. SOLUTION PROPOSED

3.1. The Developed Framework

As shown in Figure 1, the developed framework consists of four main sub-systems, which are model-based, data-based, knowledge-based and graphical user interface sub-systems.

a. Data-based subsystem

It consists of two components, which are: database (DB) and database management system. The DB consists of historical and future data of the domain key variables, all related drivers, participators, questionnaires and generated scenarios. DBMS provides the capabilities of data storing, retrieving and report generating. The web impact on this sub-system appears in the quick access to data anywhere, at anytime, and in improving the data and result communications.

b. Knowledge-based subsystem

It consists of two components, which are: knowledge-base and knowledge-based management system. The knowledge based management system provides knowledge acquisition, retrieving, saving and communication capabilities between all other sub-systems. The Knowledge-base consists of three sub-components, which are RT-Delphi, ontology and explanation. Ontology component provides to build a knowledge repository for a specific domain. It consists of two parts, which are ontology knowledge base (ontology KB) and ontology building editor. The developed ontology architecture represents its concepts and the relationship between them. It consists of six sub-anthologies, which are: model drivers, model variables, participators, questionnaires, planning bedrock, policy, which are consist of different concepts.

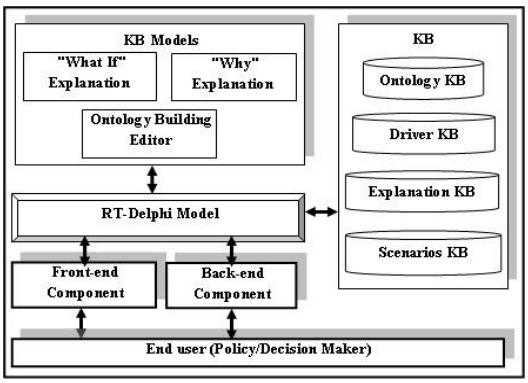

Figure 1. Conceptual model of the developed framework

The explanation sub-component consists of "What if" and "Why" analysis. "What if" analysis is used for generating and evaluating alternative scenarios that can reduce the uncertainties associated with the long-term. Also, the "Why" analysis increases the confidence of policy/decision makers about the consensus results. Final, the domain expert knowledge consists of two main categories, which are experts' judgment and its justifications. Final, Expert justifications represent the core of "Why" explanation.

c. Web-based user interface, visualization and report generation sub-system

A report generation, visualization and justification sub-system provide the policy/decision decision maker capabilities for reporting consensus summary information, consensus justifications and the visualization capabilities. Explanation or justification capabilities give more faith in results, more confidence in the system, and to present the different assumptions underlying the system explicitly.

The inputs of the enhanced ontology-based RT-Delphi are based on the knowledge of nominated and weighted domain experts. The two major outputs are the consensus results and its explanation reports.

3.2. The Developed Methodology

Below, we shall explain the developed methodology. It based on the integrating of ontology KB, explanation KB with traditional RT-Delphi. There are two types of information represented in knowledge acquisition matrices of the developed ontology-based RT-Delphi, which are a guide-information that contains 4 items for each question: (1) median response of the expert group (2) the number of responses made (3) justifications that the other experts have given for their responses, which are being ordered by values. On the other hand, the second type is the judgment information that allows the experts to add a new numerical answer and type his/her justifications for their own answer(s).

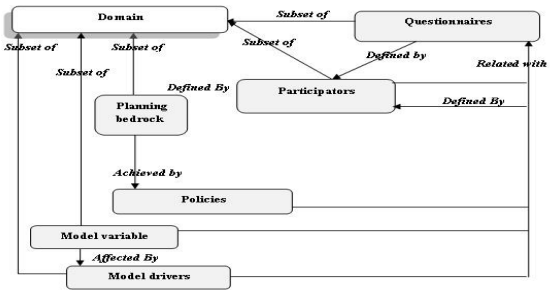

Figure 2. Conceptual model of Ontology KB

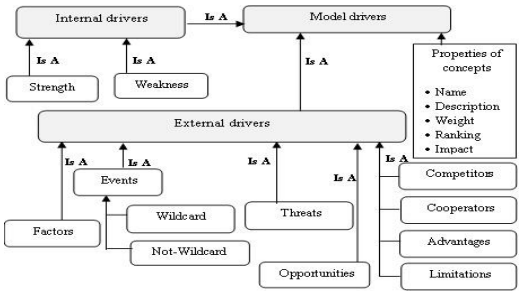

Figure 3. Conceptual model of Drivers KB

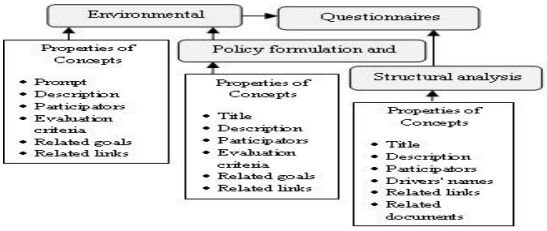

Figure 4. Conceptual model of Questionnaires KB

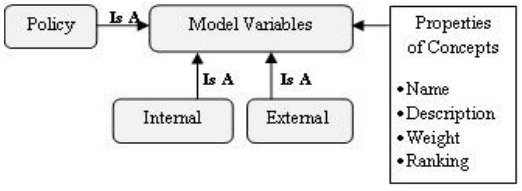

Figure 5. Conceptual model of Variable KB

A group of the domain experts can fill in the structural analysis matrix over a period of time determined by the domain analysts, in the questionnaire's design step. When the relationship is direct influence, the filling-in direct influence is low (1), medium (2) or high (3). In addition, zero value (0), appears if there is not a relation. Figure 2, Figure 3, Figure 4 and Figure 5 show sample of conceptual model of ontologies.

In addition, the developed methodology enhances the current RT-Delphi by integrating a formal ontology in order to harmonize the meaning of concepts and provide richer relationships between them. This paves the way towards the knowledge acquisition process by minimizing the chances of misunderstandings when debating a certain concept or a problem. It provides for reducing the contradiction of the experts' judgments, also it provides a powerful explanation's capabilities of the results ("what if" and "why") and also

it affords futures scenarios visualization and report generation capabilities. Figure 6 and Figure 7 show the flowchart of "why" and "what if" explanation.

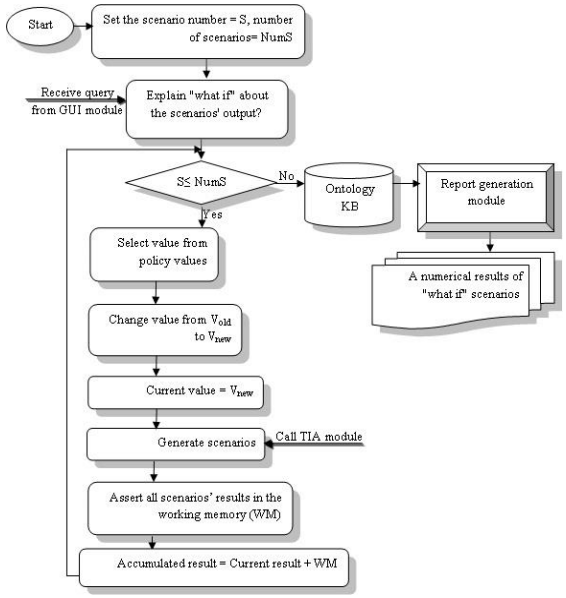

Figure 6. "What If" Explanation Flowchart

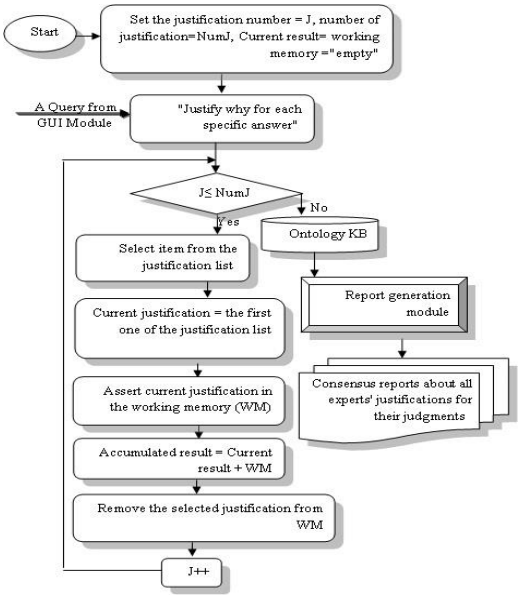

Figure 7. "Why" Explanation Flowchart

Moreover, we developed a powerful content and security management and enhanced the RT-Delphi matrices with adding a new dimension "3D RT Delphi". Maintaining anonymity between all participators can help them to focus attention on ideas and the integrated DB and KB to help for storing data and knowledge in an efficient manner that facilitates the retrieval and manipulation of information and knowledge that can provided for building a knowledge repository for a domain. Also, it provides the capabilities to import DB, which generated by a time series forecasting engine.

By "Why" and "What if" Explanations, the consensus result may provide practice that is required for the system policy/decision makers. This can reduce the uncertainties associated with experts' judgments. Each value in knowledge acquisition (KA) matrices is associated with different experts' justifications and ordered by their judgment values. Domain experts can easy change the positive or negative impact values in the decision making matrix and can run the system again to measure the impact of this change. This can provide to reduce the uncertainties associated with the long-term strategic decision. Figure.6 shows the flowchart for both "Why" explanation.

3.3. The Developed Tool

The developed tool provides to make the information and knowledge manipulation more efficient in data gathering, as well as provide enhanced group memory for alternative generation and evaluation. It provides the capabilities of defining domain participators, their roles, weights and communications. Also, it creates a large-scale asynchronous or synchronous participation network. As shown in Figure 8, the two major components of the developed tool are the back-end and front-end components.

Back-end component provides data security and management functionality that enable the defined domain analysts to build and manage his/here ontology and questionnaires. But the front-end component provides knowledge acquisition, output presentation and explanation capabilities.

As shown in Figure 9, there are three main layers in the developed tool, which are: the data access layer (DAL), the business layer and the presentation layer. These layers provide security, communication and managing all system's operations. The data access layer (DAL) provides simplified access to data stored in the system database. The business layer describes the functional algorithms, which handle information's exchange between a data access layer and a user interface. Finally, the presentation layer represents the design of the user interface pages. The developed tool phases are build a formal ontology, design domain questionnaires, knowledge acquisition, scenarios generation, visualization and report generation phases.

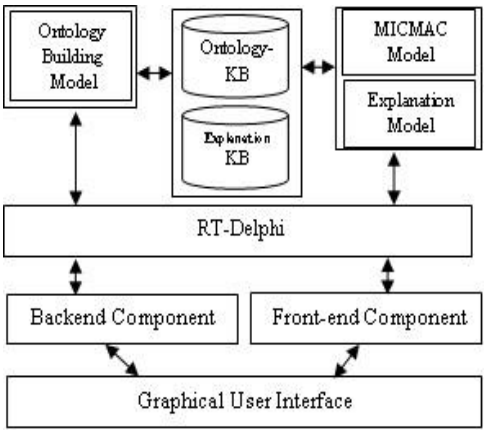

Figure 8. The Developed Tool Components

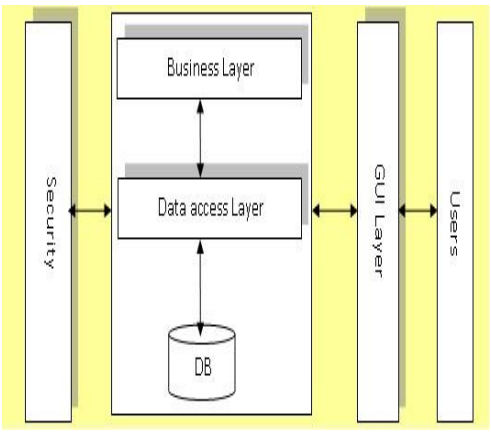

Figure 9. The Developed Tool Architecture

4. CASE STUDY

4.1. Case one: Egypt Water Security

In Egypt, water security tops the national agenda whereby studies reveal that estimations of available water and water needs for different purposes are heading towards an increasing gap between water supply and demand. This case-study builds on our research to support policy/decision makers in Information and Decision Support Centre (IDSC) - Egyptian Cabinet for the Egypt's water security research. In this case study, we aim to develop for identifying, analyzing and foreseeing potentials of Egypt's water security as ground to thinking of pilot solutions aimed at evading problems. Twenty five domain experts share to identify the major drivers of the Egypt's water security. Based on the consensus results of 25 domain experts about the issue of Egypt's water security, the most important drivers affecting Egypt's water security were identified as follows:

a. The trend of relations between countries of the Nile basin towards either cooperation or struggle (weight value = 90%, # of accepted experts = 25).
b. Impact of external powers stimulating conflicts or cooperation (weight value = 85%, # of accepted experts = 25).
c. Shifting of some Nile basin countries to irrigated agriculture and minimizing pressure on the blue water (weight value = 85%, # of accepted experts = 23).
d. The nature of change in the economic conditions in countries of the Nile basin (weight value = 80%, # of accepted experts = 20).
e. Some of the Nile basin countries constructed water reservoirs or control utilities (weight value = 75%, # of accepted experts = 21).
f. High impact of climate change on the water yield of the Nile basin (weight value = 75%, # of accepted experts = 20).
g. The impact of the separation of South Sudan on the Egyptian water yield from the Nile basin (weight value = 70%, # of accepted experts = 17).
h. Political stability or instability in domestic policy of the Nile basin countries (weight value = 70%, # of accepted experts = 17).

Table 1. Case 1: Consensus Results

Diver Name	Type
A	Key wildcard event
B	Key wildcard event
C	Key wildcard event
D	High Influence, low Dependent
E	High Influence, Low Dependent
F	Low Influence, Low Dependent
G	Low Influence, Low Dependent
H	Low Influence, Low Dependent

As shown in Table 1, we integrate the structure analysis model Impact Matrix Cross-Reference Multiplication Applied to a Classification (MICMAC) to identify the more influences, dependant drivers and the key drivers.

4.2. Case Two: Egypt's Food Security

In this case, the developed ontology-based RT-Delphi integrated with MICMAC method to identify the major drivers in the Egyptian milk production domain. In this case, the number of the domain experts is fifteen. Also, other participators are domain analysts and policy/decision makers are seven and they are selected from faculty of agriculture at Cairo University and the animal production research institutions [14]. The eleven wildcards, which are suggested from the domain experts, wildcards are listed in ERT-Delphi MICMAC as shown in Table 2.

The consensus results of the structural analysis is: World financial crises (E1), The Dissemination of the Epidemic diseases (E2) Bad weather conditions (E3) and Price of animal feeding goes up (E4) wildcards are the key wildcards for the future of the Egyptian milk production.

Table 2. Case 2: Consensus Results

Diver Name	Type
Global temperature	Low Influence, Low Dependent
New animal disease	Low Influence, Low Dependent
Global economic goes up	High Influence ,Low Dependent
World financial crises	Key wildcard event
Economical instability	Low Influence, Low Dependent
Dissemination of the Epidemic diseases	Key wildcard event
Major road accidents	Low Influence, Low Dependent
Major natural wildcards	Low Influence, Low Dependent
Significant pollution increasing	Low Influence, Low Dependent
Bad weather conditions	Key wildcard event
Climate change in the Egyptian Delta	Low Influence, Low Dependent

5. CONCLUDING REMARKS AND FUTURE WORKS

a. We developed a novel RT-Delphi approach that utilizes the knowledge-based and explanation capabilities.
b. The developed framework creating an efficient large scale participation network for future anticipation. Also, it provides the distributed interaction capabilities and helps in building and managing knowledge repositories for decision making process.
c. We applied the developed framework and its represented web-tool to help policy/maker for addressing two crucial national issues, which are Egypt's food security and Egypt's water security.
d. The next step in our research is to apply interval-based RT-Delphi. The current RT-Delphi not provides interval judgments are not flexible for experts to place their expectation in extended space of imagination.

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Dr. Ahmed Omran, in 2001, he graduated from the Department of Decision support, Faculty of computers and Information, Cairo University, Cairo, Egypt. In 2003, he awarded an MSc degree from the Faculty of Computers and Information, Cairo University, Cairo, Egypt. In 2009, he received a PhD degree from the Faculty of Computers and Information, Cairo University, Cairo, Egypt. Through his experience in the Artificial Intelligent, Decision Support Systems and Data-mining approach, he has diverse knowledge in most of the related research field activities and published numerous of papers in several international journals and conference. Dr.Omran worked as a researcher, in different research institutes, for 11 years, and started his career as a researcher in the central laboratory for expert systems (ClAES). After 6 years, he promoted to position of Assistant Professor in computer science department, Faculty of computers and Information, Fayoum University with increasing responsibility in research and teaching. Dr.Omran worked as a consultant for information and decision support systems in different national and multi-national organizations for more than 8 years, started his career in UN-FAO. After that he promoted to The Egyptian Cabinet, the Presidency of the Arab Republic of Egypt and League Arab States with increasing responsibility in consulting activities. Dr. Omran now is a member in SRGE (Scientific Research Group in Egypt).

Professor Motaz Khorshid obtained his first PhD in Computer Sciences/ Operations Research and the second PhD in Management Sciences from Paris University, France. His M.Sc. was in Industrial Engineering from Cairo University and the B.Sc. in Engineering from Ain Shams University, Egypt. Professor Khorshid worked as a former Egyptian minister of higher education and minister of state for scientific research, a Vice President of Cairo University(CU) and the British University in Egypt (BUE), a Chief Technical Advisor for socioeconomic development Planning Support systems (DPSS)in the United Nations (UNDESA/UNDP), a Dean and Vice Dean of the Faculty of Computers and Information of Cairo University, and as a Senior Research Scientist in Kuwait Institute for Scientific Research (KISR). Professor Khorshid is currently professor in Cairo University (CU). Professor Khorshid has developed several Social Accounting Matrices (SAM) and Economy-wide Models for a number of the Arab Countries. His research interest is focused on computer aided Modeling and Decision Support Systems (DSS), computer Simulation Methodology, Economy-wide Modeling and Analysis, Management of Higher Education and Scientific Research. Professor Khorshid has been awarded the "Academic Palm" from the government of France.