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An Efficient Methodology for Exploring Valuable Knowledge with New Evaluation for Knowledge Quality

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Abstract

The recent trend has been using hybrid approach rather than using a single intelligent technique to solve the problems. Meanwhile in an information technology era, knowledge is always changing, hence the flexibility in approach and in thinking is a must. Since, the on-going conversation about semantic knowledge (much information with many relations) is much more important than coming up with the right answer (information), for that performing some inferences is needed for exploring creative diverse information. Where the knowledge is an appropriate collection of actionable information. So by combining much information with many relations, more novel and useful information are found as knowledge. Since the demand for Business Intelligence (BI) applications continues to grow even at a time when the demand for most Information Technology (IT) products is soft. Business intelligence systems provide actionable information delivered at the right time, at the right location, and in the right form to assist decision makers. This paper introduces an efficient methodology for storing the explored creative information/knowledge with many relations as a graph structure with a new evaluation of the creative information/knowledge quality. That through the implementation of *Oriented Directed Acyclic Info Graph (ODAIG) Algorithm* to generate the actionable information quality. Different experiment done shows that, this methodology has a good promotion on results.

Introduction

Due to the increasing availability of large amount of data in many fields of science, business environment and in many IT applications, most recent researches tend to use semantic knowledge. This semantic information/knowledge derived to improve exploring new valuable knowledge (creative information) which hidden around data. Where knowledge consists of a many valuable information with many relations. The Information Technology (IT) systems designed to gather, process, or distribute information.

Business Intelligence as a term replaced decision support, executive information systems, and management information systems. Where Business Intelligence systems combine data gathering, data storage, and knowledge management with analytical tools to present complex internal and competitive information to planners and decision makers.

Recently, there has become a large research community that shares the vision of sharing data and knowledge among humans and machines. So, the demands on delegation of many tasks to intelligent software agents are increasing [1]. Hence for any agent, to deal with a wide range of situations, it needs to have a sufficiently Data Warehouse and a flexible inference engine. So, efficient intelligence techniques should be used in designing and implementing such agents [2,3].

Basically, the creative information's generation process is a form of knowledge explored through experience, these acquired knowledge through experience is similar to the data mining concept (discovery of new knowledge through data analysis), but with intelligence that entails learning and creativity [4,5]. With regard to creativity, there are significant challenges to make agents capable of generating diverse creative information dynamically. Furthermore, representing knowledge in a way that allows generating more valuable information with relations [6]. Where the Knowledge defines as; the understanding required to convert data into information and to apply it to real-world situations. And the Information defines as; the value derived from data through the application of knowledge [7].

The elementary theory of exploring new knowledge, is to integrate the learning process based on the principles of information association (Similarity, Contiguity, Contrast and Causality) [8], with an efficient structure of representing the knowledge. Therefore, the fundamental goal of knowledge representation is to represent knowledge in a manner that facilitates the inferencing from knowledge, which based on the principles of information association as linking principle between information [9]. These principles have an important behavior for generating diverse information through the dynamic exchange of varied knowledge. By combining much information with many relations, more novel and useful information are found. Representing such combination requires a special structure (called actionable information map) [10,11].

This paper aims to introduce an efficient actionable information map as a graph structure for diverse information and their relationships, with *Oriented Directed Acyclic Info Graph (ODAIG) Algorithm*. Moreover, formulating a new evaluation for the quality of the creative information generated, with Creative Information Quality (CIQ) algorithm by allowing agents to link diverse information dynamically. These diverse information generated from an intelligent inference mechanism based on the principles of information associations; similarity, contrast, contiguity and causality.

The remainder of this paper is organized as follow: Introduction gives a brief overview on the related works in exploring new information with relations, basic concepts and hypotheses and details about the proposed intelligent mechanism for exploring new creative information with causal map is discussed with the experimental results.

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Related Work

The development of information technology takes giant leap in last decade. It provides fast, convenient powerful computing and communicating approaches which facilitate information gathering, sharing, analyzing and archiving. That is, used to generate new knowledge with creativity, where creativity is one of the key factors to explore new information as knowledge [12].

Some studies have reported that certain information protocols can elevate both information quantity and information quality [13]. However, another work reported no relationship between information quality and information quantity [14]. Hence, most previous information literatures were inconsistent in the arguments.

Briggs and Reinig [15] provided a theoretical explanation (Bounded Information Theory) to clarify the relationship between information quantity and information quality, and they recommended guidance for the development of information techniques for improving the quality of information. A good information was defined as one that is feasible to implement and would attain the goal. Reference [16] devised an automated decision agent called Semantic Information Learning Agent (SILA), which constructed a map of generated information that can learn and share their knowledge, that use an information generation protocol to construct a tree-like actionable information map. Whereas, [8] focuses on the process of "linking" among distributed knowledge, clearing that linking principle has an extreme importance in creative thinking and problem solving.

The outcomes of these researches pointed out that, the methodology of representing knowledge plays an important role in elevating both information quantity and information quality. There are many structures for representing knowledge tree-like, graph-like as a map, and so on.

For instance, cognitive maps that follow personal construct theory, provides a basis for representing an individual's multiple perspectives. This theory has spawned many fields and has been used as a first step in generating cognitive maps. Brahim Chaib-draa [17] has identified five generic "families" of cognitive maps:

- Maps that assess attention, association, and importance of concepts. With these maps, the map maker searches for frequent use of related concepts as indicators of the strategic emphasis of a particular decision maker or organization, for example, and looks for the association of these concepts with others to infer mental connection between important strategic themes. That also might make judgments about the complexity of these relationships or differences in the use of concepts.
- 2. Maps that show dimension of categories and cognitive taxonomies. Here, the map maker investigates more complex relationships among concepts. And it might dichotomize concepts and construct hierarchical relationships among broad concepts and more specific subcategories. Maps of this type have been used to define the competitive environment and to explore the range and nature of choices perceived by decision makers in a given setting.
- 3. Maps that show influence, causality, and system dynamics (causal maps). These maps allow the map maker to focus on action; for example, how the respondent explains the current situation in terms of previous events and what changes she expects in the future. This kind of cognitive map is currently, has been, and is still the most popular mapping method.

4. Maps that show the structure of argument and conclusion. This type of map attempts to show the logic behind conclusions and decisions to act. Here, the map maker includes causal beliefs, but looks more broadly at the text as a whole to show the cumulative impact of varied evidence and the links between longer chains of reasoning.

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5. Maps that specify frames and perceptual codes. This approach suggests that cognition is highly conditioned by previous experience and that experience is stored in memory as a set of structured expectations.

Causal maps lately have received much attention, where many researches had introduced various approaches to causal maps that based on simple inference mechanisms about the consequences of a causal maps. In the meanwhile, the definition of a precise semantic interpretation of qualitative causality has received very little attention.

In [18] author used the Bayesian network approach to make inferences in causal maps. Thus, it used probability theory as is the case usually in artificial intelligence. However, its approach is applicable only in the acyclic case because circular relations or causal loops, common in causal maps, violate the acyclic graphical structure required in a Bayesian network.

Basic Concepts and Hypotheses

Basically, appropriate Information/knowledge plays a very prominent role in effective Business Intelligence systems that combine operational data with analytical tools to present complex and competitive information to planners and decision makers. The objective is to improve the timeliness and quality of inputs to the decision process.

Business intelligence is a form of knowledge that *simplifies information discovery and analysis*, making it possible for decision makers at all levels of an organization to more easily access, understand, analyze, collaborate, and act on information, anytime and anywhere [19]. Business intelligence system provides the consolidation and analysis of data, and the capacity of processing data into the executable decision making information. In this scenario knowledge repositories and knowledge management systems have evolved for generating and managing the knowledge. BI is defined as a broad category of applications and technologies for gathering, storing, analyzing, and providing access to data to help enterprise users make better business decisions [20].

Business Intelligence is the use of high-level software intelligence, to provide agents capable of generating diverse actionable information dynamically for better business decisions. In addition to integrate the learning process based on the principles of information association (Similarity, Contiguity, Contrast and Causality). By employing reinforcement learning agents, which not only have a high reproduction capability of human-like behaviors (externally) but also human-like thinking (internally). Based on the fundamental human's association capabilities (similarity, contiguity, Contrast and Causality) during information generation [21], implementing these capabilities is done in an agent's inference mechanism.

The associations are accordingly introduced to the inference mechanism of information agents in order to allow autonomous information generation. This can further enhance the number of information generated by removing the limitations, as mentioned in the Bounded Information Theory [15].

The basic architecture of an intelligent instructable agent, is

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working by information protocol which is adopted to facilitate the progressive construction of actionable information map. In addition to the capability of generating information. That is, could possibly be advanced in the following directions:

- 1. Learning capability for understanding the task. Moreover, the causality among the generated information should be easy to characterize.
- 2. Continued adoption of additional external stimuli as Knowledgebase (KB).

So, this paper demonstrates how to construct an efficient actionable information map as a graph structure for diverse information and their relationships, using *Oriented Directed Acyclic Info Graph (ODAIG) algorithm.* Based on an automated decision agent called Semantic Ideation Learning Agent (SILA), in which the diverse ideas generated from this inference mechanism founded on the principles of information associations; similarity, contrast and contiguity introduced in [16]. That considered as a novel information protocol which is adopted to facilitate the progressive construction of actionable information map with elevating both information quantity and information quality.

Moreover, formulating a new evaluation for the quality of the creative information generated, using Creative Information Quality (CIQ) algorithm by allowing agents to link diverse information dynamically. These diverse information are generated from an intelligent inference mechanism, which based on the principles of information associations; similarity, contrast, contiguity and causality.

An Intelligent Mechanism for Exploring Valuable Creative Information with Causal Map

The aim of this study is to provide an information protocol to facilitate the construction of information map through many sessions by intelligent agent. That elevates both information quantity and information quality to such an extent that unprecedented.

Actionable Information Agent Learning (AIAL)

This map provides an environment in which agents can learn and share their knowledge based on an inference mechanism for recommending the intelligent agent [16] to generate diverse information that was adapted as in Figure 1.

The AIAL is equipped to experience learning capability by utilizing a reinforcement learning method based on Q-learning (design agent's inference engine) [22-24], together with the capability of semantic information association of human thinking (similarity, contiguity and contrast). Information association sought to comprehend the emerging unity of reason and cause by means of linking. So the association principles provide the effective information-linking strategies that used for autonomous information generation based on the causality among the generated information, where information association plays an important role in linking and generating diverse creative information. By linking the information in a long-term memory internally with various participants' knowledge externally, diverse and evolving creative information are generated with their relations as a map structure.

Similarity principle links information with similar attributes; conversely, contrast principle links different information based on their dissimilarity. The reasoning relationship between different information can be linked using the contiguity principle. However, these principles can differ according to the context and type of information that is exchanged [25].

The creative information generated with associative semantic relations between information, are obtained as a result of analyzing the semantic structures of information association sources by using the causal map approach. Since a graph data structure is a good potential source of information about direction of causal flow, a novel Oriented Directed Acyclic Info Graph (ODAIG) is introduced, for building an efficient actionable information map that represent diverse information and their relationships. This map provides an environment, in which agents can learn and share their knowledge.

The proposed Oriented Directed Acyclic Info Graph (ODAIG) algorithm

The basic concept of a graph theory is the many to many relationships between entities (each entity may have multiple predecessors or multiple successors). A graph may be undirected i.e. there is no direction (arrowhead) on any of the lines (known as edges) that connect two entities, or directed graph i.e. its lines (known here as arcs) may be directed from one entity to another [26,27].

Whereas the decision graph has a new vision in the problem solving process for elevating both information quantity and information quality. Given the Vertices as a partial problem solving states (creative generated information) and the Arcs as the steps in a problem solving process (causal relationships), the Directed Acyclic Graph G = (V, A) would be represented as a collection of vertices (entities) and a collection of directed arcs that connect pairs of vertices with no path re turning to the same vertex (acyclic), Where V is the set of vertices or states of the graph and A is the set of arcs between vertices.

The ODAG algorithm in Figure 2, based on two sets of data, the first set represents the vertices in a one dimensional array Vertex (V) where each item (creative information instance) in this array is annotated with the Creative Information Label (CIL), Session number (Sno), Number of parents (Np), Creativity value (Cv) and its Weight (W). The second set represents the arcs in a two dimensional array Adjacency (V, V) where each item (creative information relation) is annotated with the link (0 or 1) and the relationship type (similarity, contrast, contiguity and causality).

In the initial state, there is no item in both arrays, and then the algorithm will be fed with the subsequence information from the inference algorithm and the available number of sessions.

At every round, once the inference algorithm delivers the parent, the generated creative information, its creativity value (number of sibling from the ontology) and their relationship to the ODAG algorithm,



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Input	
-The i	nitial output of the inference algorithm (parent,
instan	ce information, relationship).
- vert	ex vector of N object and adjacent matrix of N X N Object.
-Avai	lable number of sessions.
Outpu	<u>it:</u>
Action	able Information Map (AIM) using ODAG structure
Proce	dure:
Initial	session=1
While	(session <= available number of sessions)
fore	ach Vertex in Vertex-Vector
If	(Vertex.CIL != instance information)
	add Vertex(instance information)
	Vertex.Np +=1
	Vertex.Sno= session
	Add Arc()
	Adjacent[parent , instance information].link =1
	Adjacent [parent , instance information].relation= relationship
Е	lse
	Vertex.Np +=1
	Add Arc()
	Adjacent[parent ,instance information].link =1
	Adjacent [parent, instance information].relation= relationship
ei	id if
End	for
sess	ion +=1
For	each instance idea in vertex-vector
infe	rence algorithm(instance idea, 0, 0)
end	tor

Figure 2: The Proposed Oriented Directed Acyclic Info Graph (ODAIG) Algorithm.

then the ODAG algorithm spontaneously allocate this generated creative information instance in Vertex (V) vector if it is not already exist then set round number and ignoring weight, simultaneously it allocates their relationships to its parent in Adjacency (V,V) matrix, an illustration example is shown in Figure 3.

Subsequently the vertices with highest creativity value (Cv) in the vertex (v) of all the previous sessions, would be the initial states to the next sessions until reach the limited number of sessions, and complete the structure of graph, as illustrated in Figure 4.

New evaluation of Creative Informations Quality (CIQ) algorithm

After complete the information map construction process as vertex (v) vector and adjacent (v,v) matrix, a Creative Information Quality (CIQ) algorithm is introduced to collect an efficient information from the map.

Whereas each generated creative information instance in Vertex (V) is annotated with CIL, Sno, Np, Cv and its W, then the Creative Information Quality (CIQ) algorithm used to compute it's weight (W) based on Sno and Np, as illustrated in Figure 5 and Figure 6. Furthermore, it filters the top n (a user-specified number) of generated creative information as regard as its W of highest value.

Experimental Results

Validation of the proposed algorithms is done via a prototype system in order to clarify the relationships between information quality and information quantity. This relationship come out in term of the number of generated information with higher Cv value vs. the number of sessions, using .NET technology to achieve our study and analysis.

Case study

In Figure 3 and Figure 4 an example of a complete graph structure after several sessions has been recognized by our system. Subsequently the vertices with highest creativity value (Cv) in the vertex (v), where Vertex (V) is annotated with CIL, Sno, Np, Cv and its W, where W is computed as follow:

 $W_i = \sum_i (Vertex.Sno * Adjacent [i,j].link)$

The creative information quality depends on its W; Figure 7 shows a number of creative information with high quality after many sessions. So the decision graph (information) has higher quality and quantity than the decision tree.

Conclusion

In this paper, an efficient actionable information map as a graph



Figure 3: An example of allocating the generated creative ideas in Vertex(v) and their relationships in Adjacency(V, V).



Figure 4: An example of a complete graph structure after five sessions.

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Algor	rithm 2: Creative Information Quality (CIQ)
Input	<u>:</u>
- Acti	ionable Information Map as vertex vector and adjacent matrix
Outp	<u>ut:</u>
- list o	of competitive information to planners and decision makers
Proce	edure:
For	r j=1 to Vertex.count
For	r i=1 to Vertex.count
v	/ertex[i] .W+= Vertex[i].Sno * Adjacent [i,j].link
Ene	d for
End f	for
-sort	Vertex-Vector by W and stored into stored-list[]
-filter	rs the top n competitive information according to W of highest value







Figure 7: Number of the explored creative information after many sessions in two experiments.

structure for diverse information and their relationships, called *Oriented Directed Acyclic Info Graph* (*ODAIG*) *Algorithm* was introduced. Moreover, a new evaluation of Creative Information Quality (CIQ) algorithm by allowing agents to link diverse information dynamically. Whereas, the creative information generated with associative semantic relations between information, are obtained as a result of analyzing the semantic structures of information association sources by using the causal map approach. Since a graph data structure is a good potential source of information about direction of causal flow.

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