Abstract - The synchronization of terrorism in many countries, especially in Arab states, makes it imperative for the leaders to redirect their investment compass in a proper way. This is especially true when considering whether to strengthen bilateral economic relations among nations, as critical decisions are influenced by certain variables that are based on heterogeneous and vague information, such as information found in minutes of meetings held between the heads of state and envoys and other decision makers. In addition, the content in the minutes of meetings suffers from the presence of question marks and exclamation marks. Applying a fuzzy ontology method is one of the possible solutions to address the lack of conceptual clarity. A fuzzy inference system's (FIS) greatest strength lies in its ability to handle imprecise data. This paper will present nonverbal communication's place as an integral part of minutes of meeting thought.

Keywords: Fuzzy logic, FIS, Ontology, Bilateral meetings

1 Introduction

Political decision makers, in terms of creating and strengthening the economic bilateral relationship with other countries, need to organize different factors and indicators from different domains to support and guide them with expertise knowledge and certain information to make better decisions. This is necessary because decision support systems require large-scale data analysis facilities for making efficient decisions. Making the right decision at the right time with the most up-to-date data is very important for political decision support. The main objective of applying ontology is to help the political decision office retrieve the information it really needs as quickly as possible. Also, analysis of heterogeneous information from internal and external sources will help a political decision maker to know the main factors that affect the promotion of economic relations. Ontology methods can capture information from several different systems to facilitate sharing with different parties and identifying the shared information. The proper decisions in strengthening economic cooperation with other countries are very important for many reasons, such as security, stability, and the prosperity of the country, both locally and globally. Sometimes, the political relationship is excellent, but the investment in the country is successful. Political decision makers have to keep all data up to date, which may delay the decision-making process and cause heavy financial losses to the state. In either case, political decision makers need to make proper decisions to strengthen economic relationships with friendly nations to achieve successful investments in the right places.

1.1 Overview

Regions may experience complications, especially the Middle East, which has faced complications such as fighting terrorism, striving for peace, and aspiration to lift the economy, particularly in light of the descent of oil prices. All of these challenges force the heads of state to rethink their investment compasses, especially when it comes to strengthening their bilateral economic relationships. The world’s increasing interconnectedness and the recent increase in the number of notable regional and international events pose ever-greater challenges for political decision-making processes. Many times, the response of a decision maker is to question the wishes of the other nations that his or her country already has some economic bilateral relations with; thus, the answer becomes a silent thought, or some sentences include question marks or exclamation marks. Such question marks, and exclamation marks at the end of sentences must have scientific logical parameters. Silent thoughts and question marks require someone to analyze them, as the people from the information systems require clear variables to add into the system. This is especially true, for example, Alshayji et al. [9] presented the “MATLAP” system; which has the ability to convert linguistic variables to fix the number by conducting fuzzy logic methodologies. To be more precise, we need to depict these variables in a database rather than in documents.

1.2 Current Challenges

Unfortunately, in reality, most of the concept of political and investment information are a linguistic variable, that is, a variable with values in words rather than numbers. Also, these kinds of concepts, which are located inside the minutes of meeting documents, contain the presence of question marks and exclamation marks. These kinds of information held during the official talks, along with silent thoughts, are unknown information, and we can consider them as vague
information. This makes it extremely difficult for the decision maker to understand the concepts that exist in the documents in the political domain. For example, Alshayji et al. [5] identified some concepts that influence decisions to strengthen economic relationships with other countries, such as the agreements concept [4], the nuclear affairs concept, and the peace in the Middle East concept; these ideas are also presented by Alshayji et al. [7]. The decision-maker who is considering whether to strengthen economic relationships requires structured information. Examples of information that may be assessed in the decision-making process include competency questions such as "What is the result of the bilateral meeting?" The types of answers may involve a description such as "strong positive", "positive", "neutral", and "negative". In addition, such as "silent thoughts" or "question marks" and "exclamation marks," which are included at the end of the sentence, make obstacles for the decision maker to understand the intent of the speech. In this situation, the political decision maker could describe the bilateral relationship between the two nations in several phases, such as "very good" at a specific time, "good" in another time, or "weak" at the current time. Or sometimes the result of the bilateral meeting is unclear in other words, the result of the bilateral meeting is fuzzy at the current time because some answers contain question marks and exclamation marks at the end of some sentences, in addition to the presence of "silent thoughts." This kind of information obscures the thoughts of the decision-making process.

1.3 Problem formulation

A serious problem that the political or investment decision-maker faces is the difficulty of building an efficient political decision support system (DSS) with heterogeneous and vague information in the political and investment domains, especially regarding the decision to strengthen bilateral economic relationships with friendly nations. Typically, these critical decisions are influenced by heterogeneous and vague information from different domains. Most of the political decision maker’s documents use linguistic variables whose values are words rather than numbers and therefore are closer to human intuition. A natural language is needed to describe such information, which requires more human knowledge for interpretation.

1.4 Proposed solutions

A popular way to handle scattered data is to construct the so-called fuzzy ontology as presented by Inyaem et al. [14]. The fuzzy membership value \( \mu \) is used for the relationship between the objects in question, where \( 0 < \mu < 1 \) and \( \mu \) corresponds to fuzzy membership relationships such as "low," "medium," or "high" for each object. The purpose of fuzzy control is to influence the behavior of a system by changing the inputs to that system according to the rule or set of rules under which that system operates. The purpose of applying fuzzy systems is to enable one to weigh the consequences (rule conclusions) of certain choices based on vague information.

1.5 Contribution knowledge

The fuzzy inference system contributes to understanding the context and perspectives that are important to the impact of political variables on strengthening bilateral economic relationships. The proposed technique efficiently utilizes algorithms to access, integrate, and manage the contributed information at the international level. Using object paradigm ontology and Protégé-OWL methods to contribute to understanding the domain as well as the relation between objects, the technique also contributed significantly to simplifying the concept by extracting the main variables that affect the decision process [5]. These methods facilitate implementation. In addition, they enhance the clarity of the natural concepts and encourage us to shed light on other, more difficult domains, such as a parliament. Utilizing fuzzy logic contributed to the understanding of linguistic and imprecise data. The utilization of the fuzzy cognitive mapping (FCM) scheme provides insight into the interdependencies variables (vague data). FIS is a high-level technical computing language and interactive environment for algorithm development, data visualization, data analysis, and numeric computing. Its contribution lies in the secret of the calculations that automate dealing with imprecise language and vague information.

2 Methodology

2.1 Proposed ontology

Ontology facilitates the communication between the user and the system, and the success of the information systems is based on integration of information. Different methodological approaches for building ontology have been proposed in the literature [10, 12, 14, 18].

Two approaches are described in this paper. The first is adopted from the ontology modeling approach of Noy and McGuinness [19] and Fernandez-Lopez [13]. The second approach Process of Construction of Fuzzy Ontology is adopted from Inyaem et al. [14]. The main framework is to complete the construction of fuzzy ontology for a specific domain involves the following steps: 1) input unstructured data; 2) specify the definition of related concepts in the domain and their relationships; 3) clarify the generation of domain ontology; 4) extend the domain ontology to fuzzy ontology; and 5) apply the fuzzy ontology to the specific domain.

We will use the same developed model of fuzzy ontology for several reasons: 1) the authors used this model in the terrorism domain, which is considered an integral part of the political domain because terrorism undermines political stability; the model includes political variables such as “stability” and “terrorism” and 2) the author used linguistic
variables and ambiguous concepts that are roughly equivalent to vague variables used in the political domain.

However, more sub-steps (processes) will be added within the main steps used by the Inyaem model [14]. The five new processes (sub-steps) are as following: 1) construct object paradigm (OP) ontology; 2) apply ontology language OWL-editor from the World Wide Web Consortium (W3C); 3) construct fuzzy cognitive map theory (FCM); 4) apply fuzzy causal algebra method; and 5) apply fuzzy inference system (FIS).

2.2 Mechanism for using new sub-steps of fuzzy construction

Alshayji et al. [6] used an object paradigm (OP) ontology to identify important concepts and capture a high level for ontology conceptualization of knowledge to facilitate the work of decision processes [4, 5, 6, 8]. More details of OP were presented by Alasswad et al. [2]. Accordingly, this paper presents the concept of the bilateral meeting concept by using an OP ontology, the OWL editing tools ontology, and then proceed to integrating fuzzy logic with ontology. Alshayji et al. [8, 9] used OWL to present the concept in the political domain [4, 5]. More justification for using Protégé was presented by Alshayji et al. [5], Islam et al. [15], and Noy & Guinness [19]. On the other hand, the third and fourth processes, which involve Fuzzy Cognitive Mapping (FCM) and causal algebra, are especially applicable in the soft knowledge domains (e.g., political science, military science, international relations, and political elections at government levels). Alshayji et al. [7] demonstrated the causal inter-relationship between certain variables in the domain, such as “stability” and “terrorism,” in addition the processes of fuzzy ontology construction presented in investment domains and the agreement ontology in political domains, respectively [4, 5, 6, 8].

2.3 Justification for using new sub-steps of fuzzy construction

In this regard, and coinciding with the previously mentioned process, the new sub-steps are added for two key reasons: to accelerate the application process for the construction of fuzzy ontology and to simplify the extraction of the most variables that in some way affect the political decision-making process. Political decision-makers would thus be aided by a system that would allow them to formulate constructive rule conclusions by dealing with vague variables as described and drawing rule conclusions in the form of an IF-THEN statement- an if-antecedent (input) and then-consequent (output). Because of this situation, and along with FCM and causal algebra propagation, the fifth process the "fuzzy inference" includes displaying what is going on in the political mind in the form of a calculation through the use of fuzzy sets and linguistic models consisting of assets of IF-THEN fuzzy rules. Fuzzy systems enable one to weigh the consequences (rule conclusions) of certain choices based on vague information. Rule conclusions follow from rules composed of two parts: the “if” (input) and the “then” (output). Fuzzy logic toolbox graphical user interface (GUI) tools enable us to build a fuzzy inference system (FIS) to aid in decision-making processes. For the purposes of the ontology, we refer the readers to Alshayji et al. [8]. Figure 1 depicts the complete process of the construction of fuzzy ontology. In addition fuzzy uses will be present in the next section.

2.4 Fuzzy logic uses

Fuzzy logic is used to present imprecise information (Jun et al. 2008). More recent work on developing models based on fuzzy logic was presented by Basha and Ameen [11] to identify predictor variables that are significant in the act of purchasing. Alshayji et al. [5] used fuzzy logic to propose bilateral relation domains to help decision processes in the political domain. To begin with, an ontology can be converted into fuzzy ontology, where any relationship is a fuzzy relationship accompanied by its weight as defined in Table 1 by Muhammad and Bulaish [18].

<table>
<thead>
<tr>
<th>Interpretation</th>
<th>Relation Name</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linguistics</td>
<td>Synonym</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>Related Term</td>
<td>0.5</td>
</tr>
<tr>
<td>Semantic</td>
<td>Same as</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>Kind-of</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>Part-of</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>Contains</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>Associates</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Table 1: Weight associated with linguistic and semantic relation by Muhammad and Bulaish [18].
3 Specifying the related concepts – Illustrative case: meeting documents

Bilateral meetings (minutes of meetings) occur between friendly countries through the meetings of heads of state or envoys, some time minutes of meetings documents contain “question marks,” and “exclamation marks” whether the prime minister or the minister of foreign affairs. We consider that it is possible to convert this matter to such a parameter, but most of the time, the terminology is too difficult to analyze and understand. For instance, it is important not to limit the answers to sentence such as "do you expect that the division will happen to the country a!", this question has exclamation marks at the end of the sentence, so we notice here that the content of the concept is to find some information indirectly rather than question." Those sentences create difficult challenges for the programmers and analysts in information systems. such previous sentences must be converted into other parameters and in different degrees so that we can finally get accurate results for the outcome of the final interview. In other words, we can depict the power of the political relationship by understanding such variables. Undoubtedly this change was made for plural agreement with variables. This shed light on the proper planning needed to build and strengthen the investment relationship between nations.

3.1 Specifying the definition of related concepts

In this section we will apply the proper ontology to identify some concepts of "question marks," and “exclamation marks found in bilateral meetings. So we can understand the formal talks between friendly countries. The proper ontology was identified by Alshayji et al. [5], who used the loan as case study, in this section, we will use the bilateral meetings as a case study. To capture all concepts of bilateral meetings, the "result" class is linked to the "negative" class through the "hasWeak" tuple type. In addition, to capture the "positive" result, the "P-strong" class is linked to the "positiveAnswer" class. To be more semantically precise, the engineering process links link with all concepts that related to bilateral meetings.

According to the OP, the process starts with the selection of the concept, followed by the analysis of its spatial and temporal dimensions. The aim is to have a clear conceptualization of the bilateral concept while extracting the concepts that exist within the bilateral meetings document. This is done by considering all official talks in order to create a bilateral meetings ontology. The result of the bilateral meetings concept will be more identified by using OP ontology, through which we will analyze the ‘results’ concept. Mainly, each result has a different type such as “negative answer,” “positive answer,” “neutral,” etc. In addition, the result is submitted on a specific date. This date requires analysis in order to track change over time, as OP considers the temporal dimension, thus enables changes over time. To monitor minutes results, the “MinutesResult” class is
linked to the “position,” “CountryName,” and “Title” through the tuple types “hasPositionType,” “hasCountryName,” and “hasSubject,” respectively, as these descriptions can change only if changes happen to the minutes’ results. (See Figure 2)

![Figure 2: Engineering the result ontology](image)

Figure 2: Engineering the result ontology

We considered the important information in the bilateral meetings concept. This information enhances the semantic presentation, and such enhancements may also significantly affect the quality and performance of the implemented software system. Thus, more details enable an ontology to provide a more faithful presentation.

### 3.2 Using OWL ontology

The construction of the bilateral relation “result” is also presented by the Protégé OWL editing tool in Figure 3.

![Figure 3: Result of bilateral meetings ontology by Protégé OWL](image)

Figure 3: Result of bilateral meetings ontology by Protégé OWL

At this stage we have 1) input unstructured data; 2) specified the definition of related concepts in the domain and their relationships; and 3) clarified the generation of domain ontology. In the next section, we will extend the domain ontology to fuzzy ontology.

### 4 Extending ontology to fuzzy ontology

At this point, it is important to understand and specify the classes in bilateral meetings domain and generate fuzzy ontology.

#### 4.1 Fuzzy Set and Membership

In this section, we will integrate fuzzy logic in our ontology. Fuzzy logic, as presented by Abulaish & Dey [1] and also Alshayji et al. [5, 8, 9] has different properties. More fuzzy concepts in the same domain have been presented [5]. Integrating information with rich concepts undoubtedly helps political decision-makers make correct decisions. Answering whether to “prevent” or “redirect” the bilateral economic relationships requires also considering the concept of an “investment indicator.”

### 4.2 Fuzzy Cognitive Map Theory

FCM is a fuzzy-graph structure for representing causal reasoning with a fuzzy relationship to a causal concept [7]. Justification for its use is described in subsection 2.3; more justification can found in the literature [7, 17]. Signed fuzzy non-hierarchic digraphs and metrics can be used for further computations, and causal conceptual centrality in cognitive maps can be defined with an adjacency matrix [7, 16].

### 4.3 Use of Fuzzy Casual Algebra

This work seeks to clarify the relationships between concepts and to elucidate the positive or negative effects on each concept while clarifying knowledge of the relationships. Furthermore, an FCM structure allows systematic causal propagation, and arrows sequentially contribute to the convenient identification of the causes, effects, and affected factors [7, 16]. Figure 7 has seven variables that describe the impact of some conditions on bilateral economic relationships and causal variables. For example, (C1→C2, C1) are said to impact C4. This is apparent because C1 is the causal variable, whereas C4 is the effect variable. Suppose that the causal values are given by p {none ≤ some ≤ much ≤ a lot}. Causal relationship between concepts and the effect of these relations were presented by Alshayji et al. [9]. The FCM appears below in figure 4.

![Figure 4: A fuzzy cognitive map on the impact of strengthening economic bilateral relationship](image)

Figure 4: A fuzzy cognitive map on the impact of strengthening economic bilateral relationship

### 5 Inference system in the political domain

Incorporating the concept of specific domain, this step applies a method that can deal with dismantling each variable to several parameters. Decision-makers would be aided by a system that would allow them to formulate constructive rule conclusions by dealing with several parameters (membership)
for each variable. Alshayji et. al previously described the advantage of GUI tools in MATLAB [9] and the capability of building a productive graphical fuzzy inference system (FIS). There are five primary GUI tools for building a fuzzy inference systems: 1) the FIS editor; 2) the membership function editor (MFE), which allows users to define and shape the membership function associated with the input and output variables of the FIS; 3) the rule editor, for editing the list of rules that define the behavior of the system (IF-THEN); 4) the rule viewer, for diagnosing the behavior of specific rules and viewing the details (it is a technical computing environment); and 5) the surface viewer, which generates a 3D surface from two input variables and displays their dependencies. Further figures were presented by Alshayji et al. [9].

5.1 Data and modeling scenario

As mentioned in section 2.2 we need to collect all input/output data in a form that can be used by inference. Alshayji et al. [9] also presented the five primary GUI tools for building, editing, and monitoring FISs. Therefore, a need emerges for giving different interpretations according to the context. Table 1 presents the proposed “InvestmentIndicatorName” class with linguistic and semantic properties.

<table>
<thead>
<tr>
<th>Country name</th>
<th>Investment Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Encourage</td>
</tr>
<tr>
<td>B</td>
<td>Encourage</td>
</tr>
<tr>
<td>C</td>
<td>Encourage weakly</td>
</tr>
<tr>
<td>D</td>
<td>Prevent</td>
</tr>
<tr>
<td>E</td>
<td>Caution</td>
</tr>
<tr>
<td>F</td>
<td>Redirect</td>
</tr>
</tbody>
</table>

Table 1. Fuzzy logic assigned to “CountryName” and “InvestmentIndicator”

For example, input 1 is “Bilateral Meetings result.” In this step, we need to add the parameters for the “Bilateral Meetings” input, so we need to define all inputs and their values. The second step uses the membership function editor. In the third step, which involves the rule editor, we need to construct the rules; for example, we construct the first two rules as follows:

if (Bilateral Meetings result is strong negative), then (investment is redirect) (1).

if (Bilateral Meetings is strong positive), then (investment is encourage strongly)

These rules are verbose. The result is an extremely compressed version of the rules in a matrix where the number of rows is the number of rules and the number of columns is the number of variables, as follows:

1100000000003,1 (1): 1
2220000000003,3 (1): 1

Using such functions in the political domain provides the opportunity to choose a membership value with infinite accuracy. Reading across the first row, a literal interpretation of rule 1 is “input 1 is MF1” (the first value for the membership function associated with input 1). This means that from the first input (bilateral meeting result) we select {strong negative}, the value for the membership function associated with input 1. Continuing across, MF1 from input 2 was selected, and so on. Obviously, the functionality of this system does not depend on how well the operator named the variables and membership functions and does not even bother with variable names. The next step is to use the rule viewer to display the whole fuzzy inference process. The construction of the rules editor is presented in Figure 5.

Figure 5. the rules in the Rule Editor, in the verbose form

The decision will depend on the input values for the system. The defuzzified output (value) and the Fuzzy inference diagram containing calculation was displayed previously by Alshayji et.al [9]. The fourth step is using rule viewer was presented by Alshayji et.al [9]. Some information about inputs, memberships, and output (variables in the system) is presented in the following system:

ows:Name="Investment3,"Type="mamdani,"Version=2.0, NumInputs=13,NumOutputs=1,NumRules=8,AndMethod="min, "OrMethod="max,"ImpMethod="min,"AggMethod="max,"DefuzzMethod="centroid,"(Input1),Name="bilateral meeting,"Range=(01),NumMFs=3,MF1="weaknegative"; "trimf"(-0.5 0 0.5),MF2="positive";"trimf"(0 0.5 1), MF3="strongpositive";"trimf"(0.511.5),(Input2),Name="Political stability."

The fifth step is using a surface viewer that generates a 3D surface from two input variables and displays their dependencies.

6 Conclusion and Future Work

This paper focuses on developing a fuzzy inference system in the political domain to handle imprecise data by controlling information uncertainty. We have built a fuzzy
inference system that has stronger abilities for expressing uncertain linguistic variables. Our further research lies in the automatic generation of fuzzy ontology from more fuzzy systems. In addition, more research needs to be done about "question marks", "exclamation marks" and "silent thought". In further research, we need to improve the application and development of technical political centers. We will present the intended functions of such political centers and the challenges that hinder their work.

7 References


