# **Query Based Learning in Multi-Agent Systems**

#### **Safiye Sencer**

Department of Business Administration, Abant Izzet Baysal University, Bolu, Turkey

**Abstract** - This study focuses on query based learning in multiagent systems which include both data management operations and coordination activities. The study is oriented on agent based and database systems with model driven approach (MDA) which provides arrangement of data within a multi-agent system by letting filter with query based learning which supports the decision mechanism within the system. It uses the similarity measure on maximum entropy approach, which is often to find out interesting and meaningful patterns from databases. At the same time, it may generate a variety of rules, such as classification rules, throughout to learning rules of the query based learning process.

**Keywords:** Multi-agent system, Query based learning, Model driven approach, Entropy

# **1** Introduction

The query based learning system considers the multi agent system's dynamic knowledge base to realize the learning process. In particular, query based learning modeled with system behavior under dynamic conditions with MDA. Model driven approach includes many features of an object oriented programming notation: classes, associations, attributes, methods, primitives and enumerations. It contains sketch, design, analysis of testing and program models. MDA usually uses modeling programming languages which include object oriented approaches like the UML (Unified Modeling Language). The query based learning algorithm brings a new opportunity for agent learning methodology, which is how to build systems, how to obtain decision rules and how to make decisions in multi agent systems.

Some examples of Model driven approach (MDA) used with query structures in some studies are below. Usually, modeling of the main characteristics of events and functions represented in an object dimension display the interrelation attributes in more detail. Various studies consider the simple operation of the query mechanisms within multi-agent systems with a MDA (Song et al. 2006, Philippi, 2006) [1,2]. Some studies include the query operation mostly used in choosing related information in web environment such as query based access issue on web environments [3], [4], [5]. Also some Web database application studies include the query based access with data preparation and type recognition approaches with SQL with relational database within query interfaces and query schemes (author, title, subject for amazon.com) using the data mining approach [6-14]. Modeling of the intelligent query answering mechanism suggested in multi agent systems [15]. Some studies discussed query processing in agent

systems with peer to peer network architecture structure [16,17]. Also, query mechanism discussed in some architectures such as distance learning[18], query agent and answer structure[19], processing and mapping theory processes given in the database within the agent structure[20], NZDIS project and agent based distributed information systems architecture[21].

For the studies carried out with the model driven approach where the agent were represented with model driven. The studies discussed the relationship between components and connector structures with a goal driven approach [22]. Dynamic features such as architectural goal structure and change replacements, interfaces and behavioral specifications were also discussed. The architecture of the autonomous agent was examined and presented related classes and interface by describing the agent structure in grid service and generally mentioned the query structure among these relationships [23], [24], [25]. Static and dynamic modeling components of the agent based information systems applied in the probabilistic model [26].

The model driven approach in the agent-based simulation applied on elements, organization, agents' environment timers, environment space, tasks, goals, organization groups, interaction, and protocol specification. Meta-model and agent behavior of the agent systems expressed in the model driven approach [27]. The model driven architecture analyzed within the ontology structure, discussed the meta model with UML structure and defined the model transformation with the model driven approach and studied on UML [28, 29, 30]. MDA and query structure analyzed agent oriented design and implementation in general via using within UML [31]. The sensor network with query processing is suggested [32]. Mostly, realized studies have considered the query structure not the query based learning mechanism used in MDA.

In this paper, Section 2 discusses agent based query process; section 3 introduces the agent-based query learning system; section 4 suggests the query-based algorithm; section 5 describes query based learning application and section 6 represents the paper's conclusion.

## 2 Agent Based Query Process

The distributed problem solving approach is an ideal solution for multi agent based learning system for information coordination and integration in heterogeneous, distributed and dynamic environments. However agents' their information sources and interrelationships are highly dynamic, inadequate in their network environments. This study focuses on dynamic data management operations and coordination activities among peers and their databases with query based learning system in a multi agent system. In particularly, this paper proposes an agent-based cooperative information system architecture consisting of multi agents, which cooperate with each other to resolve information retrieval and integration problems which presents a query based learning mechanism in multi-agent systems with a model driven approach (MDA).

Query process checks the whole data for try to find goal key conditions. Briefly, the query is analyzed to extract its key phrases and query type (e.g. what, where, when, how, how much) and consider the attributes, relations and selected condition situations. Generally in SQL accomplished the Table 1 situation.

Table 1 General SQL conditions

SELECT	Attributes
FROM	Relations
WHERE	Selection Conditions



Figure 1. Structure diagram of agent based query system

Query based learning mechanism (QLM) system ensures arrangement of data within a multi-agent system by letting them filter with query process for the decision mechanism within the system. Figure 1 represents a conceptual map, which includes the correspondence to semantic associations and relationships among agent based query process, plan and belief structures, which are given in multi-agent structure. Each class includes an attribute and data. The relations between each other functional structure is shown in UML. The main characteristic of the system is a learning mechanism, which is able to evaluate and interpret the automatic SQL query especially the query process, has realized within this structure and the related results. Each task is considered as being an autonomous entity corresponding to a goal or to a sub-goal in hierarchical structure. The agent class realizes query process with support class such as reason and plan. It gives detail information about system structure.

## **3** Agent Based Query Learning System

Query based learning is a part of machine learning which optimizes the performance criterion using current and past situation data. The model defined up to some parameters, and learning is the execution and optimizes the parameters of the model using the past experience. The suggested model able descriptive to gain knowledge from data, derivative to obtain rule from knowledgebase with query then predict future decisions. When interface realizes the query process, consider the following requirements. In order to identify and use the characteristics relevant to the task to be taken into outline in the interface level components are: information and resources; control parameters and activations. Information and resources includes detail information about task, cases, attributes with name, goal, index and hierarchy framework. The dynamic knowledge base presents with input and output interface. Control parameters aim to check and detect some failures in the system with temporal constraints, error toleration and functional limits. During the realization of the query based learning, system realizes some activation such as querying, reasoning, collaborating, planning and acting (Fig. 2).

Suggested learning mechanism used system's static and dynamic variables. Especially, dynamic variables are continuously changeable. If system adapt dynamic situation easily, it will reflect to system ability. Learning activity used the query-plan and reason activity process with system resource and control variables.



Figure 2. Interaction of learning activity

Information gain is measured and evaluated by entropy. The system's feature has the highest gain in entropy, which is chosen as the first splitting feature. This method is robust with regard to noisy data and is capable of learning discrete valued functions. However, it does not handle continuous-valued function and missing values. Moreover, an over fitting problem does not exist for this algorithm. The suggested system learns the knowledge obtained as a result of query as a rule or task. The system fulfils not only the task but also the learning process. Learning process is acquired and the data from the external transition is processed by the agent system of the defined aim during the activities.

Query based learning mechanism consist of knowledge processing, query processing and query optimization. In the whole multi agent system, some situations as an agent, interaction and environment, which will be, affect the system's learning situation. Here, things that facilitate the factor's perceiving of the environment can be listed as predictability, accessibility, dynamics, variability and the current states of the resources. Especially agent numbers, abilities and goals are related to the system's learning ability directly. Also, environmental factors that dynamic, diversity and resource perceived the resource from environment.



Figure 3. Query Based Learning Mechanism

The operation of Query Learning Mechanism is given in Figure 3. The figure explains the database of each agent, the Query operation applied to these databases and operation of query learning mechanism in connection with query optimization and database as a result of this operation. This mechanism creates the rule knowledge to be used by the system through combining the information obtained from database, query optimization and realizing the query process with SQL.

Query based learning mechanism consist of four main step. These are knowledge processing, query processing, query based learning and query optimization.

#### 3.1 Knowledge Processing

Knowledge gathering, storage and classification process is realized in this stage. The criteria and keywords to be used in evaluating the received data are defined in this stage. This stage can also be called pre-query. The keywords, concepts, attribute and relationship knowledge to be analyzed by the agent are determined in this stage before query.

Therefore, the followings are fulfilled in knowledge processing:

- Goal definition
- Data selection
- Data preparation

knowledge can be included in the query process in evaluation from the beginning of the problem understanding to the end when the result inferred by the predictive model is presented to the users while used in practice. It is necessary to understand the project objectives and requirements and then convert them into a data mining problem definition. In the proposed process model QBLS, a domain knowledge base is used especially for the results post-processing and for the missing input values pre-processing in the Use of the Model phase. Some features included in the final model may not be directly provided by users but can be inferred by the domain knowledge base.

In general the external domain knowledge base assists to deal with the vague queries in use of the model phase and with eliminating the illogical outcomes in post processing.

#### 3.2 Query Processing

Query processing includes the query parsing, relational structure and reviewing the query variables. Also it is called as a preparation stage for query based learning. Query parser process translates an input query into a stream of events represented as integers and the XML elements symbolized as knowledgebase. At the same time, the query parser checks the validity of the query and then translates it into an internal form usually a relational calculus expression, or related item equivalent. Relational database uses the set of mathematical terms and SQL terminology, which are roughly equivalent to SQL database terminology. The query variable process behavior reviews in the Table 2. Table 2 the SELECT statement

```
SELECT [distinct] attribute_names

FROM table_list

[WHERE conditions ]

[GROUP BY colum_list

[HAVING conditions ]]

[ORDER BY column_list [DESCENDING OR ASCENDING]]
```

#### 3.3 Query Based Learning

The agent performs two types of query in the process of defining keywords, concepts or attributes during knowledge processing. The first is external query, which is realized among the agents, while the second is the internal query, where the agent scans the knowledge within itself. During these query processes, the SQL approach is applied.

#### **3.4 Query Optimization**

Query optimization consists of similarity measure, diagnosis, rank matched cases and associated rules distance matrix processes. Obtained final results classified and made storage then sent to agent knowledge and rule base system. Then the query results are sent to main system then system evaluate for the next decision position. Query based learning and optimization explained in Section 4 in detail.

### 4 Query Based Learning Algorithm

In this research in the dynamic agent based query based learning structure aimed with interactions among the agents to research in the multi agent system and cooperation and particularly the negotiation during the making decision with interactions. In learning algorithm entropy based weight and feature selection preferred and evaluated in the suggested system. When query based feature selection realized actively, query-learning process could be efficient. Query based feature selection is developed for the numeric prediction task as well as the classification prediction task. Query feature selection is compared and evaluated the query keyword and database attributes.

In particularly, entropy used for feature selection and query based learning.

$$H(P) = -\sum_{i} p_{i} log(p_{i})$$

$$\sum_{i=1}^{n} p_{i}^{=1}$$
(1).

It is a measure of uncertainty in information formulated in terms of probability theory. Entropy measure as weighting calculation method is used which weight includes the parameter that describes how much different alternatives approach one another in respect to a certain attribute. The greater the value of the entropy, the smaller the entropy weight, then the smaller the different alternatives in this specific attribute, and the less information the specific attribute provides, and the less important this attribute becomes in decision making process(in Table 3).

Table 3. Entropy based Feature Selection Algorithm

Procedure Select Features (D, Q, a,  $\psi$ ) D : the whole set D. : first element in D D.,, : last element in D : a predefined threshold ψ F : generate features(Q) For each  $f \in F$ Index[f]=0,  $\psi = \{\text{threshold}(f,d) \mid d \in D_r \cup D_{nr} \}$ For each t∈ ψ  $= \{ d \in D_r \cup D_{rr} | threshold (f,d) > t \}$ S⊕  $= \{ d \in D_r \cup D_r | \text{threshold} (f,d) \leq t \}$ Sø Index<sub>t</sub>=1-Entropy  $((_{S_{\Theta}})^* \frac{|S_{\Theta}|}{|D_r \cup D_{mr}|})$ -Entropy  $((_{S_{\Theta}})^*$ Index[f]=max(Index[f], Indext Return

In Table 3 represents the whole set and A attribute consider the entropy method then evaluate the index value for each data. Then feature selection is realized with this algorithm.

In Table 4 realizes the query based learning process with performance index. Similarity measure, distance matrix and ranking process are used for evaluate the efficiency of query based learning process. Rule base data obtained from entropy based classification. Then results are evaluated with similarity measure.

Mean absolute error is used to measure similarity of query values; sometimes the square root is taken to give it the same dimensions as the predicted value itself. Mean absolute error averages the magnitude of the individual errors without taking account of their sign.

Mean absolute error= 
$$\frac{\left|p_{I} - a_{I} + \dots + \left|p_{n} - a_{n}\right|\right|}{n}$$
 (2)

Mean absolute error averages the level of the individual errors without taking account of their sign.

Especially distance matrix measures the relative of among data then assigns the rules. Distance based matrix occurs from terms which can represent each others distance value that it is determine the data relation the other say, include the next rule base. Table 4. Query Based Learning Algorithm





In here  $A_1$  represents the training set and  $A_2$  represents the test set.,  $\mathcal{Z}$  stands for number of and  $\Delta$  for the symmetrical difference between the two sets. This distance formula gives to the similarity weight value of distance elements. Consequently, for two elements that, the distance value is 1, the highest possible value, whereas for two genes sharing exactly the same set of the sets, the distance value is 0, the lowest possible value. All possible binary pairs of genes from the dataset are considered, and the distances between their sets are calculated, resulting in a distance matrix. Second, this matrix is processed with a clustering algorithm, in which the leaves correspond to input elements. The relevance of each term associated to each class is then calculated using formula 3.

The user-oriented learning system is proposed namely the Query Based Learning System (QBLS), which is based on a data centric model with extensions to provide support for user interaction. The proposed algorithm is evaluated in terms of selected features and the learning accuracy.

# **5** Application

In this section iris.dat set used that features used in query based learning[33]. The data report four characteristics (sepal

width, sepal length, petal width and petal length) of three species of Iris flower. All measurements are lengths in cms. Feature selection based algorithm applied to iris dataset and evaluated the entropy based weight values in Table 5. Then the distance matrix applied the whole dataset and class distribution and percentage values are listed in Table6.

Table 5. Iris feature's entropy based weights

Features	Entropy Based Weights
Petal_width	0.6260
Petal_length	0.3217
Sepal_width	0.0263
Sepal_length	0.0260

Table 6. Each features class numbers and percentages

Features	Class #		Numbers and Percentage								
Petal_width	2	Class 1	56 (37,3%)	Class 2	94 (62,7%)						
	3	Class 1	51 (34,0%)	Class 2	67 (44,7%)	Class 3	32 (21,3%)				
	5	Class 1	51 (34,0%)	Class 2	20 (13,3%)	Class 3	35 (23,3%)	Class 4	16 (10,7%)	Class 5	28 (18,7%
Petal_length	2	Class 1	63 (42,0%)	Class 2	87 (58,0%)						
	3	Class 1	51 (34,0%)	Class 2	66 (44,0%)	Class 3	33 (22,0%)				
	5	Class 1	51 (34,0%)	Class 2	8 (5,3%	Class 3	38 (25,4%)	Class 4	5 (3,3%)	Class 5	48 (32,0%
Sepal_width	2	Class 1	99 (66,0%)	Class 2	51 (34,0%)						
	3	Class 1	99 (66,0%)	Class 2	39 (26,0%)	Class 3	12 (8,0%)				
	5	Class 1	5 (3,3%)	Class 2	5 (3,3%)	Class 3	33 (22,0%)	Class 4	94 (62,7%)	Class 5	13 (8,7
Sepal_length	2	Class 1	58 (38,7%)	Class 2	92 (61,3%)						
	3	Class 1	52 (34,7%)	Class 2	74 (49,3%)	Class 3	24 (16,0%)				
	5	Class 1	51 (34,0%)	Class 2	23 (15,3%)	Class 3	6 (4,0%)	Class 4	27 (18,0%)	Class 5	43 (28,7%

Table 7.	Each	features	Learning	Efficiency	and	Query	Based
Learning	Resul	lt					

Features		Lei	arning Efficie	ency		Query Based Learning Result				
	class 1	class 2	class 3	class 4	class 5	Petal_width	Petal_length	Sepal_width	Sepal_length	
Petal_width	0,8460	1	0,4998	0,4242	0,3791	2,5	5,7	3,3	6,7	
Petal_length	1	0,8479	0,5667	0,4829	0,3935	0,2	1	3,6	4,6	
Sepal_width	1	0,8232	0,4697	0,5025	0,2951	1	3,5	2	5	
Sepal_length	1	0,8848	0,5194	0,5699	0,3824	0,1	1,1	3	4,3	

Table 8. Each features classification efficiency

Features	Class			Classification Efficiency							
Petal_width	2	Class 1	4,4646	Class 2	3,7260						
	3	Class 1	4,4646	Class 2	1,7550	Class 3	3,7260				
	5	Class 1	4,4646	Class 2	3,7260	Class 3	1,7550	Class 4	1,5115	Class 5	2,4124
Petal_length	2	Class 1	4,4646	Class 2	5,4784						
	3	Class 1	4,4646	Class 2	1,4410	Class 3	5,4784				
	5	Class 1	4,4646	Class 2	5,4784	Class 3	1,4410	Class 4	1,5949	Class 5	2,6372
Sepal_width	2	Class 1	1,4818	Class 2	3,4420						
	3	Class 1	1,4818	Class 2	3,9521	Class 3	3,4420				
	5	Class 1	1,4818	Class 2	3,4420	Class 3	3,9521	Class 4	1,4402	Class 5	3,2397
Sepal_length	2	Class 1	4,4362	Class 2	4,2103						
	3	Class 1	4,4362	Class 2	2,5454	Class 3	4,2103				
	5	Class 1	4,4362	Class 2	4,2103	Class 3	2,5454	Class 4	1,4427	Class 5	1,9180

Then query based algorithm (in Table 2) applied and obtained the Table 5 and 6. In Table 7 shows the learning efficiency values and query based learning results. Table 8 represents the each features classification efficiency.

## 6 Conclusion

This study contributes to new prospect for agent learning methodology, which is consider the query based system model and obtaining learning rules for making decision on a great extent on the use of information from objective reality with query based learning in multi agent systems with model driven approach.

Query based learning mechanism focus on the modeling of autonomous intelligent behavior, which activities, supports and/or executes the state changes. The following steps are based modeling the suggested system:

Step 1 Explore environment: The environment of the system is explored to enrich and extend the queried knowledge such that new experience is build up.

Step 2 Query knowledge: Obtained explored environment then query based algorithm used and converted to the learning rules.

Step 3. Learn results: Learning rules evaluated with decision makers experience and take new decisions for the system.

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