Research on the Collaboration Service Mechanism for Pig Diseases Diagnosis Based on Semantic Web

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Abstract. Distributed knowledge resources for the pig diseases diagnosis have the characteristics of heterogeneous, autonomy and difficult to be shared among different systems. Based on the web-based ontology modeling language, a descriptive model to describe the heterogeneous knowledge resources of the pig diseases diagnosis and a formal model to express the decision services of pig diseases are proposed in this work. Based on the two models, a complex decision task can be automatically divided into many dependent simple decision fragments. The relationships between different fragments, the mapping relationships between each fragment which can be dynamically adjusted according the divided fragments and its distributed knowledge resources can be formally described. The models form a mechanism for cooperative decision for pig diseases diagnosis. The method is proposed by achieving the balanced decomposition of decision task and intelligent schedule of knowledge resources. The method is verified in a pig diseases collaborative diagnosis system. The result shows that the method is superior to the traditional intelligent decision-making method.

Keywords: semantic web; context awareness; collaborative decision; pig diseases diagnosis; agricultural intelligent system

1 Introduction

Nowadays, along with the application of intelligent information techniques in agricultural information systems, the amount of knowledge resources of raising pig in the process of monitoring, production, operation and management grows rapidly [1]. However, these knowledge resources belong to different owners and they are heterogenous in type and representation. The dispersed diagnostic knowledge which has some incomplete issues inevitably reduces the efficiency of knowledge service. Collaborative decision-making is the decision-making process or ability of coordinating different data resources, knowledge resources, terminal devices, applications [2],[3]. The purpose of collaborative decision-making service in the field of pig diseases diagnosis which has heterogeneous knowledge is rapidly positioning associated knowledge resources and making decision. As a result, it can achieve the

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semantic interaction between providers and users of knowledge resources based on function and application of quality.

2 The Semantic Description of Decision-making Services Knowledge Resources

Distributed environment is the basis environment of achieving resource sharing and collaborative decision-making. A wide range of agricultural knowledge resources, the representation model, location, underlying communication mechanism are different. To realize collaborative service in distributed agricultural resources, the paper puts forward a semantic description model that can support the multiple type, shield heterogeneity and adapt to dynamic environment. This model uses OWL as the agricultural knowledge ontology expression language [4], [5], [6] and explains the related agricultural sharing concept model. Additionally, it provides basic terms and relationship for agricultural knowledge resource model and makes up the extension rules and complex definitions using those relationship and terms. This mechanism realizes the concept system of classifying and describing the agricultural mass knowledge. It is the basic for collaborative knowledge resource organization and management and information exchange.

3 Ontology Description of Decision-making Services of Agriculture Knowledge

Semantics heterogeneity brings on differences of understanding the agricultural knowledge resources, described by using same descript mode, between agriculture knowledge resources of providers and users. This will affect the effect of the collaborative decision-making. In order to solve semantic heterogeneity problem, this paper introduces the semantic ontology quaternion group to describe the decision-making service of agriculture knowledge:

$$\mathrm{KR} = \{<\mathrm{kobject}>, <\mathrm{relation}>, <\mathrm{owner}>, <\mathrm{constraint}>\} \tag{1}$$

'kobject' is the agricultural knowledge atom, which is the smallest knowledge resources unit in the entire descriptive model. Expressed as:

$$\mathrm{kobject} = \{\mathrm{ra_i} \mid 1 \le \mathrm{i} \le n, ra \notin \Phi, ra \in \Omega\} \tag{2}$$

'Ra' is the knowledge atom in the field of agricultural knowledge resources; 'relation' means the collection that has reciprocity and affects among the knowledge atom and knowledge entities. Namely:

$$\mathrm{relation} = \{\mathrm{r_{ij}}(\mathrm{ra_i} + \mathrm{ra_j}) \vee \mathrm{r_{ij}}(\mathrm{rm_k}, \mathrm{rm_j}) \mid 1 \le \mathrm{i, j, k, l} \le \mathrm{n}, \mathrm{r} \notin \Phi\} \tag{3}$$

'Rm' means a knowledge entity which is constituted by agriculture knowledge resources.

$$rm = \{ \sum ra_i \cdot ra_j \vee \prod ra_i \cdot ra_j \big| 1 \le i, j \le n;\ ra_i \cdot ra_j \notin \Phi,\ ra_i \cdot ra_j \in \Omega \} \quad (4)$$

'rij (rai+raj)' means the connections among knowledge atoms of agricultural knowledge resource. rij (rmk,rmj) means the connections among knowledge entities. Owner is the identifying information that marked the agriculture knowledge resources owner and application quality. It reflects knowledge resource owner and application effect under the distributed environment. Constraint is resource constraints of agricultural knowledge. It includes some labels of agricultural knowledge entities and related resources, rules or operation collection that is generated by relations among knowledge atoms or entities [7].

4 The Model of Agricultural Knowledge Resources

According to characteristics of agricultural knowledge resources and core idea of collaborative services in complex system, we made the unified description and expression of the agricultural knowledge resources model and defined the model as the seven BNF sub determinant：knowledge pattern, meta-knowledge, rule set, quantitative model, resource label, Ontology Bridge, external link extension. These basic hierarchic group of sub determinants form more complex models of agricultural knowledge resources. Some BNF are shown in Figure 1.

```
<Agricultural knowledge resources model> ::=< knowledge pattern>|<meta-
    knowledge>|<rule set>| <quantitative model>|<resource label>|<ontology
    bridge>|<external link extension>
    <Knowledge pattern> :=< frame pattern>|<production rule pattern>|<example
        pattern>| <descriptive pattern>
    <meta-knowledge>:= <knowledge domain>|<knowledge owner>|<knowledge
        module>| <decision-making item>|<decision-making data item>
  <Rules set> ::=< rule name>|<rule definition>|< rule mark>
  <Quantitative model> ::=< model name>|<model class>|<model expression>
  < Resources label>::=< resources type>|< resources class>|<resource
        owner>|<resources ontology mark>;{< resources ontology marking sentence>;}
  <Ontology bridge> ::=< atom of knowledge resources>|< relation of
        atoms>|<ontology owner>|< resources ontology marks>;{<resources ontology
        marking sentences>;}
  <External link extension> ::=< resources label> ;{< plain text>|<multi-media>|
        <HTML>|<GIS>| <remote sensing image>|<database> ;}
```

Fig. 1. BNF fragment of agricultural knowledge resources model

Knowledge pattern is mostly used to determine the type of knowledge expression. In process of collaborative decision-making, meta-knowledge, rule set and quantitative model mostly are used to establish the generalized mapping relationship between items of rule antecedent facts and conclusions facts, such as these four basic types:'part of', 'kind of', 'instance of', 'attribute of'. Otherwise, pattern matching relationship, include certainty, uncertainty, fuzzy matching, or the accessibility relation that based on the generalized mapping relationship also can be used. This two unit mode separately finished the qualitative analysis and model calculations in the decision-making process.

By OWL mapping between ontology and ontology, between ontology and the information sources, between ontology and knowledge representation methods, Ontology Bridge solve the semantic heterogeneous problem of agricultural knowledge resources naming, attribute and extension. For example, OWL: equivalentClass and OWL: equivalentProperty are used to solve the problem of naming heterogeneity that different information sources denote the same concept according to multiple languages. Rdfs:subPropertyOf is used to solve the problem of attribute heterogeneity. Owl:equivalentClass and owl:equivalentProperty are used to solve the problem of equivalence element and owl:intersectionOf is used to solve the problem of crossed element. Rdfs:subClassOf and rdfs:subPropertyOf are used to solve the problem of contain elements in ontology syntax.and owl:unionOf in global ontology are used to solve the problem of disjoint elements. The solutions of these problems achieve the unified description of knowledge representations that have many types such as production rules, examples, and semantic web. These solutions also can convert variety of types of knowledge to the personalized knowledge representation required by collaborative decision-making [8].

Resource label and exterior extension are made use of combining the information resources and the knowledge resources. It includes plain text, multi-media, HTML, GIS, remote sensing images, database and other resources marks. Moreover, it realizes the knowledge integration of frame, production rule, example, description and other models of knowledge expression.

According to the composition of agricultural knowledge resources and the definition of semantic description system, knowledge resources of agricultural collaborative decision-making service is divided into three layers, decision-making problem layer, correlative information layer, knowledge model layer. Decision-making layer includes definition of atom of agricultural knowledge resources. Such as, decision-making facts, concepts, fact attribute those related to agricultural knowledge rules and the relations among the concepts. Correlative information layer mostly includes related information of different decision-making model, resources label information that related to decision-making project; the efficiency of resource reference, etc. Knowledge layer includes meta-knowledge of agricultural knowledge resource model and related index of model, index of decision-making problem, index of resource correlation. By means of related index, it can accurately locate the related model, decision-making problem, related information resource of each node in a distributed environment [9].

5 The Representation Formalism of Decision-making Service Problem

5.1 Description of Decision-making Problems List

In the semantic description model of decision-making service knowledge resources, decision-making layer provide users with a description of their required decision-making service and the abstract of actual decision-making data item, to realize the analysis of decision-making problem requirement. It means an expression of decision-making problem requirement.

$$R_{dec} = R_s \wedge R_{d1} \wedge R_{d2} \wedge \cdots \wedge R_{dn}, \qquad (5)$$
$$R_d = (UID, RO, RA, RC, RF, RU)$$

R5 means initial limit of decision-making goals. Rd means the restriction of decision-making premise data items. UID is the unique identifier of the decision-making service users. RO is the domain limit of knowledge or resources. RA is the restriction of functional properties of agricultural knowledge. RC means the explanation of the initial value of agricultural knowledge. RF is the restriction of information resources. RU is the memory of decision-making service.

There are a large number of agricultural knowledge resources. These knowledge resources provide decision-making knowledge service for problem of decision-making service. Based on the decision-making goal of decision-making user and the model of agricultural knowledge resources, the formalism representations of decision-making service problem identify the interaction in each step progressively.

$$RU_{UID} = \{Rxt, (<k_1>, Rxt_1), (<k_2>, Rxt_2), \cdots, (<k_n>, Rxt_n)\} \qquad (6)$$

'Ki' means the node identification of decision-making problem flow. 'Rxti' is the node information set of decision-making service problem. When collaborative decision-making occurred, the description of problem and the context information are stored in RU as a unique identification. It provides the problem list that interacts with the user for collaborative decision-making services.

Firstly, according to the domain type, content, owner of knowledge resources, property, states of obtained decision-making services goal,the limited value is initialize and then the decision-making knowledge resources are obtained to calculate the decision-making problem list.

5.2 Matching of Decision-making Problem and Knowledge Resources

It is the key that to determine the knowledge resources related to decision-making problem in the distributed environment and achieve the representation formalism of decision-making service problem. The semantic matching between knowledge resource and user decision-making problem is determined by the matching degreen of the concepts similarities of description terms and functional property constraint.

The concepts similarity is gained by calculating the semantic distance between problem description and description terms of context knowledge resource. The similarity of functional property is get by calculating the problem description and context knowledge resource property [10-12]. The calculate method of concept similarity is as follows:

$$\mathrm{Sim\_question}(\mathrm{Qterm}, \mathrm{Kterm}) = \sum_{i=1}^{n} \omega_i \times \mathrm{Cd\_sim}_i(\mathrm{Qterm}, \mathrm{Kterm}) + \sum_{j=1}^{n} \omega_j \times \mathrm{Ca\_sim}_j(\mathrm{Qterm}, \mathrm{Kterm}) \quad \textbf{(7)}$$

Additionally, ‘Cd_sim(Qterm ,Kterm)’ is the distance similarity of semantic concept. ‘Ca_sim(Qterm, Kterm)’ is the concept property similarity. ‘Qterm’ represents the problem description. ‘Kterm’ is the description of knowledge resources.

$$\mathrm{Cd\_sim}_i(\mathrm{Qterm}, \mathrm{Kterm}) = \begin{cases} 1, & \text{Qterm、Kterm before the i - with the same parent class} \\ 0, & \text{Qterm、Kterm before i not accompanied by a parent class} \end{cases} \quad \textbf{(8)}$$

$$\mathrm{Ca\_sim}_j(\mathrm{Qterm}, \mathrm{Kterm}) = \begin{cases} 1, & \text{Qterm、Kterm before the j - with the same parentclass} \\ 0, & \text{Qterm、Kterm before j not accompanied by a parent class} \end{cases}$$

‘N’ is the maximum depth of ‘Qterm’ and “Kterm” in description model of agricultural knowledge resource ontology. ω is corresponding weight coefficient. $\sum_{i=1}^{n}\omega_i + \sum_{j=1}^{n}\omega_j = 1$.

The functional property constrain matching of agricultural knowledge atoms is decided by the domain of knowledge atom and the decision-making service premise data items constrain. The value of constrain is related to the initial value of agricultural knowledge atom. So the constrain value of decision-making problem need to be converted to the interval form. ‘C(Qterm)’ is the value range of problem description sub-constrain. ‘C(Kterm)’ is the value range of knowledge description sub-constrain. μ_k is the weight coefficient of matching degree of constraint. Then the calculating method of similarity degree of functional property is as follows:

$$\mathrm{Fmatch} = \begin{cases} 1, & C(Qterm) = C(Kterm) \\ \sum_{k=1}^{n} \dfrac{\mathrm{P_k}(C(Qterm) \cap C(Kterm))}{P(C(Kterm))}\mu_k, & C(Qterm) \cap C(Kterm) \neq \Phi; \\ 0, & C(Qterm) \cap C(Kterm) = \Phi。 \end{cases} \quad \textbf{(9)}$$

‘Fmatch’ is weighted sum of ‘Amatch’ and ‘Sim_question’.

$$\mathrm{Amatch} = \mu 1 \times \mathrm{Sim\_question}(\mathrm{R_s}, \mathrm{R_d}) + \mu 2 \times \mathrm{Fmtach}(\mathrm{R_s}, \mathrm{RA}) \quad \textbf{(10)}$$

In above formula, $\mu 1$, $\mu 2$ means the correspond weight of each type matching degree. And $\mu 1 + \mu 2 = 1$.

6 Agricultural Cooperative Decision-making Service Mechanisms

The completion of specific agricultural cooperative decision-making service needs multiple process fragments.In the collaborative decision-making process, it’s necessary to achieve task decomposition of distributed decision-making services, matching of knowledge resources and intelligent invocation of agricultural cooperative decision-making tasks based on the user demand for services, the context memory of agricultural decision-making service problem flow and the message of user interaction decision-making premise items.

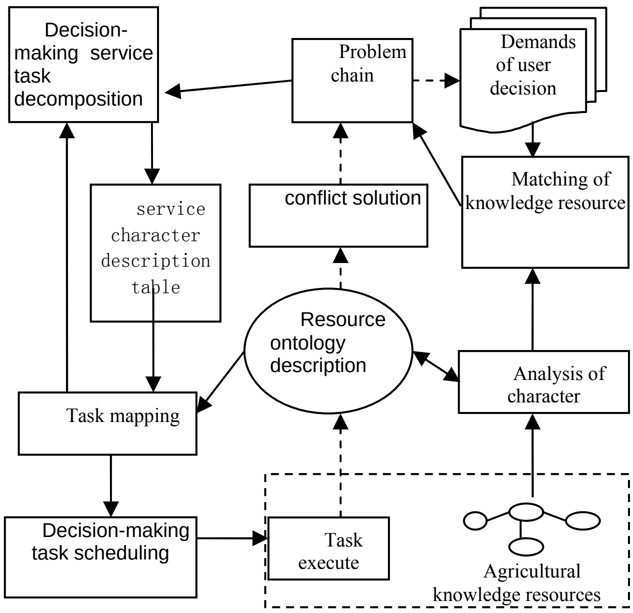

Fig. 2. The collaborative service model of agricultural knowledge resources

Agricultural cooperative decision-making service module has two main functions: the matching of decision-making problems’ knowledge resources and the task decomposition of decision-making services [13-16]. The steps are as follows:

Step 1. Matching of decision-making problem knowledge resources based on the demands of user’s decision-making. Model of knowledge resource ontology description can analyse the agricultural knowledge resource, calculate the matching degree of knowledge resource and create a “decision-making service problem chain”.

Step 2. According to the content of “decision-making service problem chain”, decision-making task decomposition modules analyses the type and class degree of service to determine the character of the agricultural knowledge decision-making service and achieve mapping scheduling of decision-making task. Agricultural knowledge service can be divided into compute-intensive knowledge service, communicate-intensive knowledge service and compute-communicate relative equilibrium knowledge service. By analyzing class degree of knowledge service, the number and character of parallel task is determined and each node’s application quality of service resources is obtained. Finally, the analysis results are published regularly.

Step 3. The decision-making task mapping module divides knowledge service into many sub-tasks, using “service character description table”. These sub-tasks include some dependent or preferred constrain relationship and are mapped as some task sets that adapt to different machine characters and service characters. The goal is to make sure the sub-task can be carried out at suitable node.

Step 4. Agricultural collaborative decision-making service task scheduling module based on the result of task mapping, send task to specific node service queue and schedule the decision-making of distributed nodes to execute decision-making task.

Step 5. In the end the result returns. The conflict resolution is finished and the results return to user.

7 Analysis and application

Based on the agricultural coordination decision-making service mechanism, we use J2EE platform to develop pig diseases collaborative diagnosis system. As the result of the great variety diseases of live pig symptom, although knowledge databases of various nodes follow the unified regulations, the knowledge engineers of system establishment are different, Therefore, the attention points on diagnosis knowledge are different and there are differences on symptom antecedent, the consequent as well as authentication. For this reason, the pig sickness main body is contructed, and by modeling the policy-making service knowledge resources' semantic description, the existing knowledge, the data, the multimedia resources are labeled.So the integrated applications of pig sickness diagnosis knowledge rules and related disease symptom, prevention method and so on are realized in Beijing, Tianjin, Hebei, Sichuan and other providence.

The system not only can recommend users more semantically related concepts based on knowledge of swine, but also can complete collaborative coordination of different expertise for the same diagnosis, and provide various results with recommendations for the diagnosis and disposal program. It’s difficult for the traditional agricultural expert system to finish.

Fig. 3. Collaborative decision-making of swine diseases

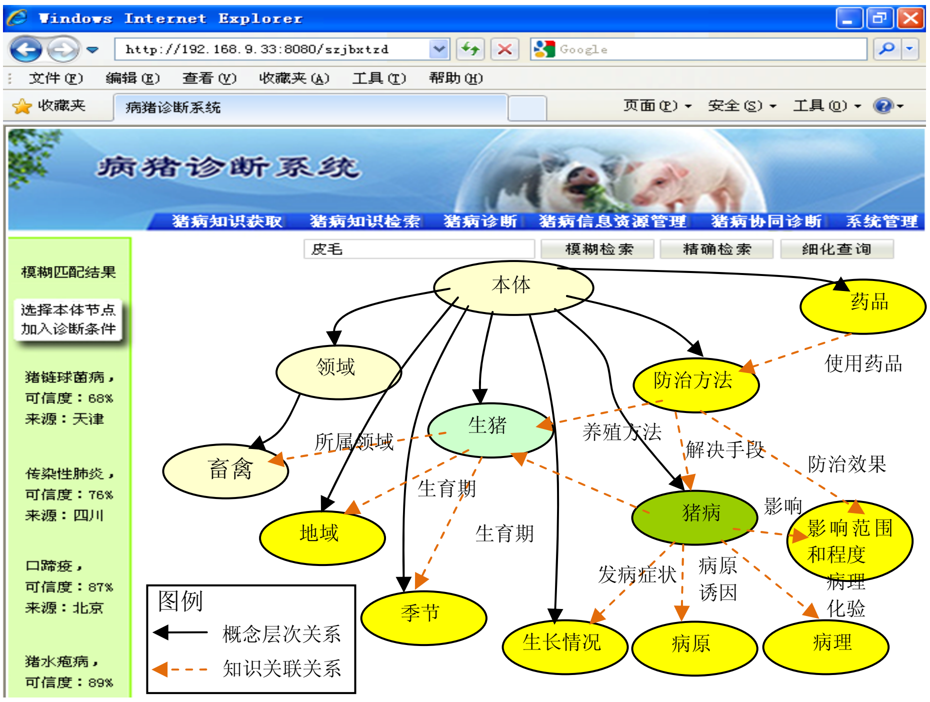

Fig. 4. Ontology-based Collaborative decision-making of swine diseases

Take 4 swine diseases expert systems as the example; take 20 initial symptoms as the example to deduction, the inference experimental result as shown in Table 1. Comparing collaborative decision-making system based on semantic WEB to traditional expert system, the former has remarkable enhancement on the inference conclusion gain rate, the inference conclusion authentication mean value and the inference efficiency. Such as Rg increases 12.5%, Cn increases 14% and Rc improved 13.3%.

Table 1. Results of reasoning test

System	Kb	R(Gbit)	Rn	Cn	Rg	Rc
Beijing	450	1.8	16	87	80	83.5
Tianjin	347	0.7	14	79	70	74.5
Hebei	512	0.9	17	81	85	83
Sichuan	401	1.1	15	82	75	78.5
Coordination	1710	4.5	19	89	95	92

All the knowledge regular strip counts Kb; Amount of connection resources R; Integer Rn in view of 20 initial symptom's inference conclusions (confidence level threshold 60%); Inference conclusion gain rate Rg= Rn/20*100; In view of confidence level of 20 inference conclusion mean values Cn; Inference efficiency Rc= (Rg +Cn) /2

8 Conclusion

In the application service of distributional knowledge resources, how to realize the knowledge resources coordination decision-making service is important. Based on the semantic WEB technology, the paper, proposed a kind of agriculture decision-making service knowledge resources semantics description model which supports the multi-types, shield isomerism, adaptation dynamically. It defines agricultural knowledge resources semantics description as 7 minor BNF. Based on this foundation, the formalized expression method of policy-making question is studied and the demands of agricultural coordination decision-making service are decomposed into many policy-making parts, according to the agricultural decision-making service question class context memory and user's interactive decision-making premise information. As a result, the match between distributional decision-making service task decomposition and the knowledge resources and the intelligent dispatch service of agricultural coordination decision-making task are realized, enhancing the using efficiency and inference efficiency of agricultural knowledge.

The collaborative service of agricultural knowledge resources is a complex engineering system. The collaborative decision-making service based on semantic WEB proposed in this paper took the semantic main body as the foundation of coordination service. The realtionship of the quality of coordination service and the competition of ontology library is high. The future research will focus on the update of the increment of agricultural knowledge resources ontology and the resolution mechanism of coordination service conflict.

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