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EEG ONTOLOGY BASED PERFORMANCE ANALYSIS USING SPARQL

Sandeep Rani[*], Aditya Khamparia[**] and Babita Pandey[3*]**

Abstract: Neuropsychiatry is a medical field deals with brain and its behavior. The notation and their meaning related to neuropsychiatric varies from various sources to individual, which creates hindrance in knowledge sharing and reusability. Therefore, there is need of knowledge representation method which uses common notations and their meanings and removes the ambiguity. Ontology is best solution. Ontology design is an important part of medical informatics to enable reusability among different ontologies at various levels. This paper presents a representation of medical knowledge in the form of EEG based neuropsychiatric ontological. This means, methods used to collect and formalize the development of a knowledge base are described. Descriptive part of the knowledge base is realized as an ontology and procedural knowledge realized through set of production rules. The intent of this paper is to predict relations among heterogeneous entities and retrieve suitable inferences from their properties with the help of rule based sequences.

Key Words: EEG, SPARQL, DL-Query, neuropsychiatric. comparator

1. INTRODUCTION

Ontology play very important role in medical diagnosis due to various advantages such as its capabilities of knowledge representation, reusability and knowledge sharing. Knowledge representation field is dedicated to represent the knowledge in order to design formalisms that will make complex systems easier to design and build. Reusability refers that once ontology it can be used by many applications .Sharing refers to sharing information among different disciplines.

In medical world often knowledge comes from different sources that have their own distinctive terminology and meaning which divide the world according to their own needs. These medical information from varies sources contain their own notations which is difficult to remember. This is the major bottleneck when developing common medical diagnostic applications. Ontology is very successful tool to deal with such problems. Therefore our intent is to develop an ontology governed diagnostic system for neuropsychiatric disorder. In EEG, ontology helps in representing the complex knowledge and information more easily of patients, their disease symptoms and details of disease to be diagnosed. This ontology helps user to provide efficient treatment details to patient and get updates regarding sign and symptoms to maintain the consistency of diseases with respect to varied symptoms. Our paper has been organized as follows. Section 2 describes the literature review of different ontologies in medical domain. Section 3 deals with different ontological framework of EEG ontology. Section 4 focuses on describing procedural rules for ontology.

[*] Department of Computer Applications
[**] Department of Computer Science and Engineering Lovely Professional University, Phagwara, India
[***3] School of Computer Application, Lovely Professional University, Punjab, India, email: shukla_babita@yahoo.co.in
Corresponding Author

Section 5 describes the performance analysis with respect to experimental and other group test and finally Section 6 deals with conclusion.

2. LITERATURE REVIEW

Various researchers have described ontologies for different diseases in medical field. Here the detailed surveys of all existing ontologies have been detailed with their advantages and disadvantages as shown in Table 1.

Table 1
Ontology usages in various domains

Authors name	*Application area*	*Advantages*	*Disadvantages*
C. Y. Alexander (2006) [1]	ontology on biomedical field	One benefit is that user able to manage the clinical data and knowledge that stored in computable forms.	Sometime creating and maintaining ontologies is difficult task as compare to workers.
A. Anjum et al., (2007) [2]	Ontologies in Medical Data Integration: A Case Study	With the help of ontologies and their capability user can solve any type of semantic and heterogenic data	When new information sources are added to ontologies then maintenance problem will occurs
Y. L. Franc et al.,(2012) [3]	Neuroscience Ontology	It allows the joining of models like computational and experimental	ontology were only determined by domain experts
V.D.Mea and A. Simoncello (2012) [4]	ontology-based on health	A hierarchical structure is present in ontology where each concept has a name, a text description, and inclusion and exclusion relationships.	Improper classifications between classes and their properties. It is main reason for confusion.
R. K. Saripalle (2013) [5]	Current status of ontologies in Biomedical and Clinical Informatics	Knowledge sharing in the same domain Reuse the already build ontology	Medical informatics is still missing between biomedical and computer
W.Ceusters et al.,(2005) [6]	Ontology Based Integration of Medical Coding Systems and Electronic Patient Records	We can compare healthcare records and interoperable through record	Data structure which are likely to make such decision-support systems unworkable for medical use
M. Gangwar et al.,(2013) [7]	Intelligent Computing Methods for The Interpreta-tion of Neuropsy-chiatric Diseases Based on Rbr-Cbr-Ann Integration	These techniques develop a combined methodology and which works efficiently.	ANN model is very fast but it has one disadvantage that it is not compatible with other techniques.
J. Kemppinen et al.,(2013) [8]	A Clinical Decision Support System for Adult ADHD	Flexible, user friendly and effective platform	It is very costly work
M. Austin et al., (2008) [9]	The Benefits of an Ontological Patient Model in Clinical Decision-Support	Existing software are developed and combined in ontology for medical applications.	Lot of irrelevant fields would be present to describe the patient
A. Jovic et al.,(2007) [10]	Ontologies in Medical Knowledge Representation	Knowledge sharing and support for automatic reasoning is main benefit of ontology	Representation of actionable knowledge that requires negation-as-failure.

Table 1 Contd…

X.Yang (2007) [11]	Ontologies and how to build them	Expressive power of natural languages and graphics representations are advantage of this	Both two approaches bottom-up and top-down both have some drawbacks.
S. Murugan et al.,(2013) [12]	Ontology Based Information Retrieval - An Analysis	The semantic search has improved the information retrieval by retrieving more appropriate information than that of keyword based search.	The existing traditional keyword based search is not suitable in most of the cases.
M.A Musa et al., (2014) [13]	ontology knowledge map for enhancing health care services: A case of emergency unit	Electronic Health Record (EHR) Cost is very low as compare to electronic Storage media.	Most of the emergency unit of hospitals are takes much time in the process.
V.B. Gounot et al., (2012) [14]	Ontology and medical diagnosis	Web Ontology Language description logic (OWL-DL) is used for solve difficult problems	Sometime data is missing during Process of cases
C.M. Grulke et al.,(2012) [15]	Toward a Blended Ontology: Applying Knowledge Systems to Compare Therapeutic and Toxicological Nano scale domain	Knowledge tools are effective in identifying trends in research and gave good results	No literature that indicates some of the most significant features of Nano particles
N.C.Hsieh et al.,(2015) [16]	Ontology Based Integration of Residential Care of the Elderly System in Long-Term Care Institutions	It is stress-free and flexible system which gave the benefit to elders	Some time employees can not estimate the required resources
M.Revati et al., (2011) [17]	A Novel Search Engine to trace Medical Information Needs using Medical Domain Ontology	Medical Information Retrieval System (MIRS) techniques to improve its usability and search result quality through search engines	Some time it gives many irrelevant result in medical field
H.Fujita et al., (2012) [18]	Mental Ontology Model for Medical Diagnosis based on some Intuitionistic Fuzzy Functions	Virtual Doctor system gave advantage for medical cases	It provides the less quality experience as compared to real doctor and more efforts are required for practical experience.
J.Lozano et al.,(2014) [19]	Ontology View extraction: an approach based on ontological meta-properties	Improve the performance and of data and result	This is less flexibility.
M. Gangwar et al., (2014) [20]	Classical and intelligent computing methods in psychiatry and neuropsychiatric: an overview	These methods provided efficient and accurate results	These are expensive methods
G.G.Yener and E. Basar(2013) [21]	Brain oscillations as biomarkers in neuropsy-chiatric disorders: following an interactive panel discussion and synopsis	These methods are non-invasive and non-expensive	This is not sufficient to explain all aspects of Information processing within the brain.

Table 1 Contd…

R.C. Teeple et al., (2009) [22]	Visual Hallucinations: Differential Diagnosis and Treatment	It is accurate diagnosis required before effective treatment	Some causes of visual hallucinations are not defined
R.M.Bilder et al., (2009) [23]	Cognitive ontologies for neuropsychiatric phonemics research	Classifying a new and improved neuroimaging or cognitive phenotype	Not worked on large data set
H. Liu et al.,(2013) [24]	Current sustained delivery strategies for the design of local neurotropic factors in treatment of neurological disorders	It offers brilliant compatibility and biocompatibility over the synthetic polymers. polymers offer a great choice and flexibility for developing microspheres	It is not independent not efficient way there is no available data concerning the therapeutic
D.Awad et al.,(2012) [25]	Ontology-based Solution for Data Warehousing in Genetic Neurological Disease	Ontology is used for share vocabulary	Main difficulty is that some time hybrid ontologies are worked due to heterogeneity information sources
P.Alexander et al., (2012) [26]	Ontologies for the Study of Neurological Disease	Number of related domains in addition to neurological diseases, and will be complemented by ontologies of nervous system	Result is not relevant many times

3. ONTOLOGY FRAMEWORKS

Our proposed work uses an ontology editor protégé, for creation of EEG ontology. It is useful in diagnosis of neuropsychiatric diseases. There are various parameters or symptoms used for detection and diagnosis of EEG are oversleeping, muscle weakness (MW), motor activity (MA), difficulty in movement (MO), difficulty in locomotion (LO), difficulty in using toilet (UT), difficulty in climbing (CS) etc. Various combinations of EEG parameters with muscular physiology, cognitive and psychological parameters are used as symptoms which are acting as instance for disease diagnose like ADHD, Dementia, Delusion, Dystonia, mental disorder, mood disorder, OCD, Sensory processing disorder and Hallucination. The description of proposed ontology is shown in figure 1 and figure 2 with onto graph and OWL viz representation.

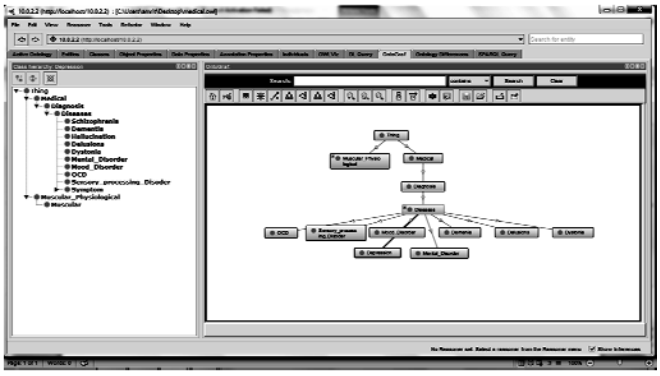

Figure 1 Onto graph representation of neuropsychiatric domain

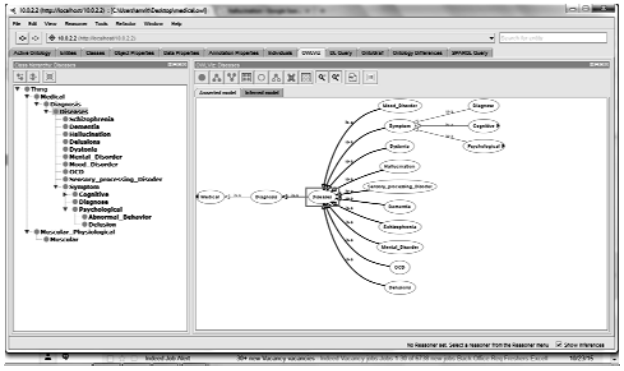

Figure 2 OWL viz representation of neuropsychiatric domain

4. PROCEDURAL KNOWLEDGE

Ontologies reasoning and deducing inference from them can be performed easily with the help of semantic rules. The EEG ontology presents a detailed taxonomic overview of complete

neuropsychiatric disorder diagnosis including relations among concepts. It represents descriptive knowledge about the domain. The knowledge representing sufficient and necessary conditions that some action can be done is called procedural knowledge.

4.1 Production Rules

Production rules are combination of antecedent (if) and consequent (then). Whenever assertions depicted in antecedents are true then only the assertions or statements specified in consequent also get hold. Production rules support modularity during construction and also a formal way of presenting knowledge and supports realization of EEG ontology. An example for separate rules from the diagnosis of various neuropsychiatric disorder as shown in Figure 3.

- If (MW^MO^UT^CS^HD^LD^VD^DW^HA) ->ADHD
- If(OS^MW^MO^UT^DM^FM^JG^LD^RS^SD^HL^AG^AB) -> DEMENTIA
- If(DM^JG^VD^DW^AG^AX^AN) -> DELUSION
- If(MW^MO^UT^CS^W^LD^SD^VD^DW^HA^AG^AX^ST^AN) ->then DYSTONIA
- If(AG^AX^ST^AN^AB)->MENTAL DISORDER
- If(OS^MO^LD^RS^DW^HA^AX^ST) -> MOOD DISORDER
- If(OS^DM^JG^RS^FR^AN) ->OCD
- If(OS^MO^UT^CS^W^DW^HD^SD^FR^AX^ST) -> SENSORY PROCESSING DISORDER
- If(DM^SD^HL^AB) -> SCHIZOPHRENIA
- If(VD^HL^FR^HA^AG^AX^ST^AN^AB) -> HALLUCINATION

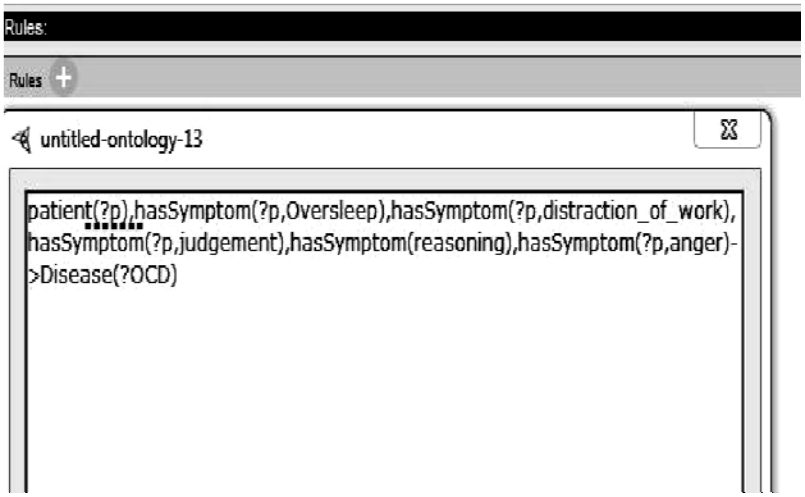

Figure 3 Production rules for EEG

5. PERFORMANCE ANALYSIS OF SPARQL AND DL-QUERY

Query answering is important in semantic web, since it is used as a tool via which users and applications can interact with ontologies and data. Our approach primarily focus on to present an EEG ontology for diagnosis of neuropsychiatric disorder for answering SPARQL queries under OWL to describe a prototypical implementation based on the Pellet reasoner and use this implementation to investigate various diseases and retrieve them based on their sign and symptoms, also to improve query performance for different kinds of SPARQL-OWL queries. Most of

researchers have predicted that SPARQL queries differ to SQL queries in terms of meaning or semantic and performance but they both have similar familiarity in representation of their syntactic structures. DL query allows the user to quickly test the definition of classes to see that they assume the appropriate subclass. Different methodologies and procedures are evaluated by medical practitioners by performing an Emperical and Control experimental survey based on their domain. Our project deals with Electroencephalography ontology creation for patients having neuropsychiatric disorder. Due to ease of information retrieval and management of knowledge base for different applications ontologies are acting as efficient knowledge based expert systems.

5.1 Test Group

Ontology behavioral examination is performed by taking a person group with both having domain expertise knowledge and basic computer skills was chosen. For neuropsychiatric disorder a pure domain ontology being constructed on basis of suggestions received from highly qualified/efficient medical practitioners or users in medical domain. Most of the users that participated in the experiments were department colleagues and thesis students of University, India. These persons have awareness of computer and neuropsychiatric disorder. But they vary in their conceptual understanding and degree of skills among them. Their task has been divided so that some of them aware regarding tool utilization while others having lack of knowledge in ontology management.

5.2 Information Retrieval Tasks

Various efficient queries using SPARQL has been designed for medical domain ontology to retrieve information. These queries are arranged in hierarchical structured way, according to classes which they belong or instance of their classes having common attributes and relations.

Such queries are shown with different examples. Like, for any class identification of number of objects which belong to it. For example, “What are the symptoms of disease with Dystonia?” as shown in Figure 4. The obtained result is a total instance of Dystonia, which person can easily track and identify the number of objects which is supported by interface.

```
SPARQL query:

PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFEX uni <http://www.semanticweb.org/aditya/ontologies/2016/1/untitled-ontology-12>
SELECT *
            WHERE { ?Dystonia  uni:hasSymptom ?Symptoms}
```

Figure 4 SPARQL Query 1 for Dystonia.

Person is provided with specific values of object for class and asked to determine the value of another objects which belongs to same class. For example “What are the numbers of symptoms of disease Dementia for the patient having registration number #765?” (Figure)

For solving this each person has to determine a unique function or objects and gathered a well-defined value suggested by person for retrieving the information.

```
SPARQL query:
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFEX ab <http://www.semanticweb.org/aditya/ontologies/2016/1/untitled-ontology-12#>
PREFIX ns2: <http://www.semanticweb.org/aditya/ontologies/2016/1/untitled-ontology-12/Dementia>
SELECT DISTINCT *
            WHERE
            { ?s a ab: patientReg = #765.
              ?s ?p ns: hasSymptom Dementia.
            }
```

Figure 5 Query 2 demonstrations.

In this case person must know upper class behavior and need to determine behavior of subclass connected to this instance. For example, "In which year particular patient affected with the disease, like delusion, mood disorder and Hallucination?" shown in (Figure 6) .Serial or sequential relations between objects represented which identifies the possible selected value for solving queries.

```
SPARQL query:
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFEX ab <http://www.semanticweb.org/aditya/ontologies/2016/1/untitled-ontology-12#>
PREFIX ns: <http://www.semanticweb.org/aditya/ontologies/2016/1/untitled-ontology-12/#delusion>
PREFIX ns1: <http://www.semanticweb.org/aditya/ontologies/2016/1/untitled-ontology-12/#mooddisorder>
PREFIX ns2: <http://www.semanticweb.org/aditya/ontologies/2016/1/untitled-ontology-12/#Hallucination>
SELECT DISTINCT YEAR
            WHERE
            { ?s a ab: patientReg.
              ?s ?p ns: delusion.
              ?s ?p ns1:moodisorder.
              ?s ?p ns2:Hallucination.
            }
```

Figure 6 Demonstration of Query 3.

According to class behaviour and hierarchy query relation is shown. Here, one upper class is represented and by using this class needs to retrieve its lower sub class which is linked to it. For instance, "Identify various symptoms of Cognitive and Physio-psycho parameter?" (Figure 7)

Individual upper class represents relation with lower sub class which identifies or classifies the exact symptom in hierarchical order.

```
SPARQL query:
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFEX ns <http://www.semanticweb.org/aditya/ontologies/2016/1/untitled-ontology-12#>
SELECT DISTINCT *
            WHERE
            {
             { ?Cognitive ns: hasSymptom ?symptom}.
              UNION
              {?PhysioPsycho ns:hasSymptom ?symptom}.
            }
```

Figure 7 Query 4 demonstrations.

Here we need to identify the number of instances (objects) for which class has been classified or identified. Like, determine the number of patients having common symptom of muscular parameter like OS, MO, MW, LO, CS? shown in (Figure 8).

The retrieved result obtained from query is number which person used for identification of object to be predicted and compute if desired feature is obtained.

```
SPARQL query:

PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFEX ns <http://www.semanticweb.org/aditya/ontologies/2016/1/untitled-ontology-12#>
SELECT PatientReg
                WHERE
                {
                  ?s a ns:hasSymptom MuscularParameter: {OS, MO, LW, LO,CS}.
                 }
```

Figure 8 Query 5 demonstrations.

5.3 Performance Analysis

In describing Electroencephalography ontology, each query analysis and time taken for computation is governed by Task Load Index (TLX) provided by NASA agency. Based on experimental results, it was seen that persons to whom practical hands on training given or who have skills of computer knowledge based tools performs better and obtained lesser TLX and response time. Figure 9 shows SPARQL and Ontograph shows lower TLX on an average of all five different query executions with respect to other query tools like DL-Query and OWL2Query. SPARQL achieves much higher performance compared to DLQuery. This figure illustrates that a person achieves solution of problem or task faster with the help of SPARQL compared to DL-Query. An average user spent approximately 55.3% less time with SPARQL and Ontograph and had 11.9% lower TLX compared to DL-Query and 34.7% lower when compared to OWL2Query. The comparison shows that SPARQL is one of best suitable query aid tool for use in case of Electroencephalography (EEG) ontology in comparison to other query aid tools and procedures.

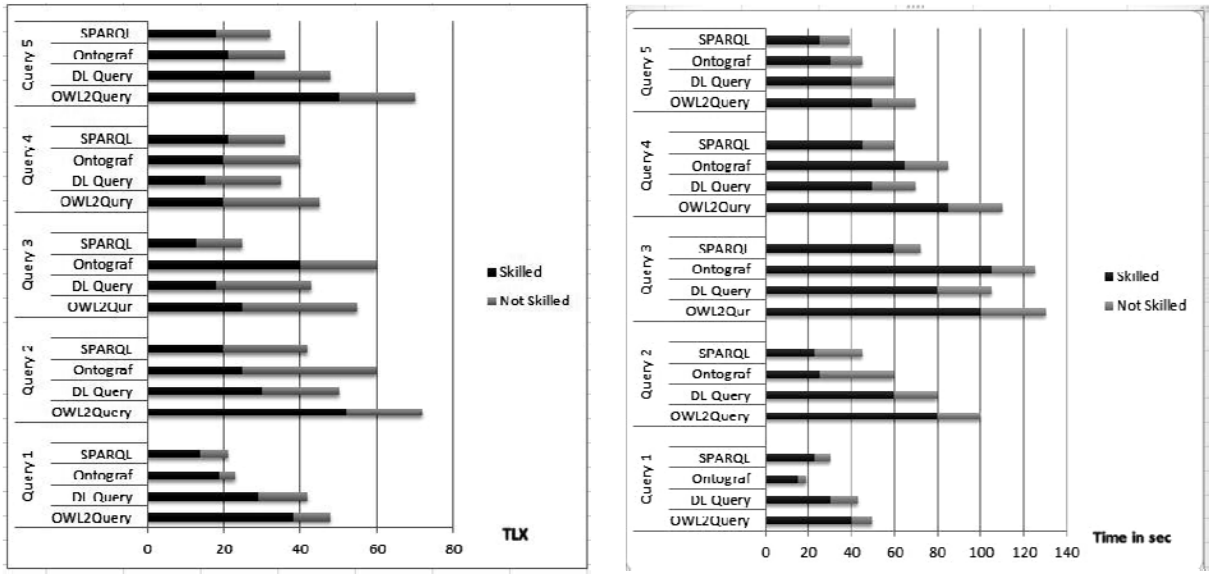

Figure 9.Comparitive scenario of TLX and Time for different Queries in Onto Graph, DL-Query, OWL2 Query and SPARQL.

6. CONCLUSION

This paper presents the results of work related to the collection and formalization of knowledge related to neuropsychiatric domain. Major concentrated on descriptive EEG ontology and ontological representation of procedural knowledge to help of production rules. We also presented some preliminary results of a comparative evaluation of some ontology tools from which interesting patterns are extracted. Ontology evaluation is being used for result analysis and methods used to identify information retrieval type. Our future prospects focus on the development of intelligent extended ontology with advanced interpreters that enables reasoning with inclusion of action based knowledge into an ontological form. Due to this ontology will be able to integrate descriptive, procedural and actionable knowledge.

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