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An Ontology Based Expert System for Lung Cancer : OBESLC

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ABSTRACT---Lung Cancer is the second most recurrent cancer in both men and women and which is the leading cause of cancer death worldwide. The American cancer Society (ACS) in US estimates nearly 228,150 new cases of lung cancer and 142,670 deaths from lung cancer for the year 2019. This paper proposes to build an ontology based expert system to diagnose Lung Cancer Disease and to identify the stage of Lung Cancer. Ontology is defined as a specification of conceptualization and describes knowledge about any domain in the form of concepts and relationships among them. It is a framework for representing shareable and reusable knowledge across a domain. The advantage of using ontology for knowledge representation of a particular domain is they are machine readable. We designed a System named OBESLC (Ontology Based Expert System for Lung Cancer) for lung cancer diagnosis, in that to construct an ontology we make use of Ontology Web Language (OWL) and Resource Description Framework (RDF) .The design of this system depends on knowledge about patient's symptoms and the state of lung nodules to build knowledge base of Lung Cancer Disease. We verified our ontology OBESLC by querying it using SPARQL query language, a popular query language for extracting required information from Semantic web. We validate our ontology by developing reasoning rules using semantic Web Rule Language (SWRL).To provide the user interface, we implemented our approach in java using Jena API and Eclipse Editor.

***Keywords:** Semantic Web, Ontology, Lung Cancer, RDF, OWL, SWRL, SPARQL.*

I. INTRODUCTION

Lung cancer is the most common type of cancer and constitutes 24% of all cancer related deaths. About 13% of all new cancers are lung cancers and in US One in 16 people will be diagnosed with lung Cancer. Lung cancer occurs due to the uncontrolled growth of abnormal cells present in lungs which causes growth of tumors or lesions that reduces breathing ability of a person. The important identified reasons behind lung cancer disease are Smoking, Exposure to asbestos, Radon , some hazardous chemicals , exposure to continuous air pollution and Genetic factors etc. Many people with lung cancer were detected in advanced stages but not at early stage so the mortality rate is more in lung cancer patients. It is recommended that people who have family histology of Lung cancer and smokers must undergo tests like LCDT etc., periodically to identify lesions or nodules in the lungs and must consult physicians or general practitioners for diagnosing the disease. [8,9]In general an expert system is an intelligent system that supports decision making capabilities and solves complex problems through reasoning. Expert systems are Artificial intelligence based computational tools that consist of components like knowledge base and inference engine. Knowledge base consists of facts and rules related to a particular field or domain and Inference engine deduces new facts. Similarly in diagnosing any disease, A Medical expert system is a computer program consisting of knowledge regarding medical domain that provides accurate information about disease diagnosis there by it deduces prognosis and treatment plans etc. In our work we have designed an expert system which can consider the symptoms of patients and nodule size to detect the lung cancer patients in early stage thereby we can improve the perpetuity of a lung cancer patient.[1,2,7]Ontology is a main component of semantic web that refers to the science of describing different kinds of entities and relations among entities in a particular domain. The semantic web Technologies like RDF(Resourse Description Format),OWL(Ontology Web language) enables the machine to understand the knowledge stored in an ontology and do the complex work involved in searching , sharing and merging the information on the web. Building an Ontology based Expert system in medical domain is very much needed in present days because medical knowledge is increasingly more composite and uncontrollable.[13].

In this paper we are concentrating on expert system in medical domain and use of ontology as a computational aid by applying semantic aspects for generating rules to diagnose and identify the stage of disease. Here we developed a knowledge base related to lung cancer i.e., lung cancer ontology so that the people will know the details regarding this disease as their initial medical assistance .In general for detecting any type of cancer the physicians or medical experts depends on image analysis of lung nodules where images can be analyzed by radiologists using the scan reports and size of the nodule or nodules in the image which can be obtained through various types of scans like Computer Tomography(CT) and Magnetic Resonance Imaging(MRI).In our work, by taking the size of the nodule from image reports and some important symptoms into consideration our lung cancer ontology expert system (OBESLC) detects lung cancer patients and also identify the stage of patient using staging system by formulizing rules using SWRL language.

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The following diagram depicts the concepts ,data properties and individuals created for OBESLC system using protégé tool

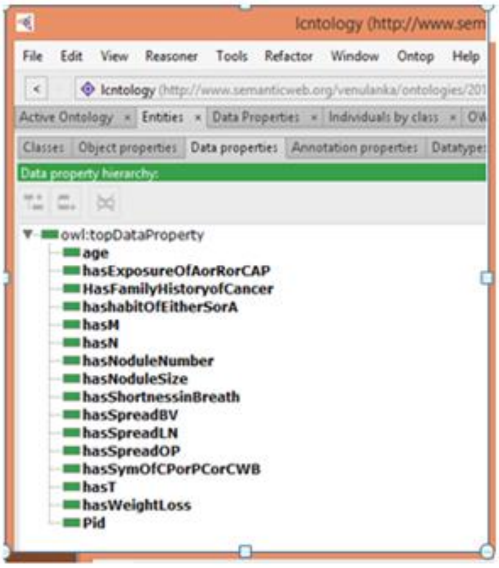

Fig III.b Data Properties in OBESLC

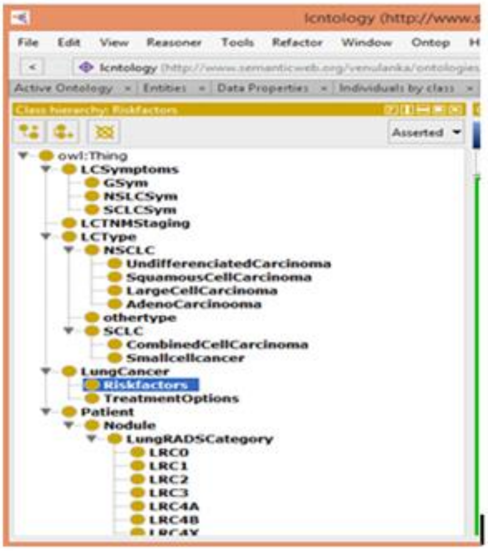

Fig III.c Concepts in OBESLC

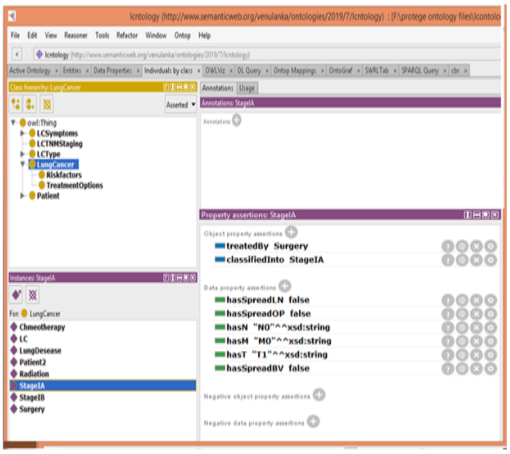

Fig III.d Individuals created for the class LungCancer

Phase 3: Rule generation using Semantic Web Rule Language(SWRL)

The process of generating rules is very much important for reasoning the developed ontology using "Semantic Web Rule language" (SWRL). In our lung cancer ontology reasoning makes the process of diagnosis and detecting the Stage of patient very effectively and efficiently. Here we developed many rules for identifying whether the patient has Lung Cancer or not, If so detecting the stage of Lung Cancer etc. To generate rules 'SWRL tab' must be incorporated through SWRL plug-in in Protégé Tool. [26]

In the OBESLC system First Rule is used to diagnose whether the patient has Lung Cancer or not by considering the symptoms of patient and nodule size in the lung. Here as the disease was identified mainly based on symptoms in the initial diagnosis process we should consider symptoms and the reasons for those symptoms also. So we have divided the Rule1 into four parts as Rule1a,Rule1b, Rule1c, Rule1d where Rule1 will be completed with a combination of Rule1d and one among Rule1a,Rule1b ,Rule1c.The second rule is used to identify the stage of lung cancer according to TNM system, The third rule categorizes the lesion as benign or malignant which is combination of rules to identify the lesion category according to its diameter. The Fourth rule is also combination of several rules allows us to suggest the treatment according the stage of lung cancer patient.

Examples of some rules generated for OBESLC System:

Rule1 -> Lung Cancer Detection

Symptom checking to identify Lung cancer patient

Rule1a : hasWeightLoss(?x, true) ^ hasSymOfCPorPCorCWB(?x, true) ^ hashabitOfEitherSorA(?x, true) ^ Patient(?x) -> probabilityOfHaving(?x, LungDesease)

Rule1b : HasFamilyHistoryofCancer(?x, true) ^ hasWeightLoss(?x, true) ^ hasSymOfCPorPCorCWB(?x, true) ^ Patient(?x) -> probabilityOfHaving(?x, LungDesease)

Rule 1c: hasWeightLoss(?x, true) ^ hasExposureOfAorRorCAP(?x, true) ^ hasSymOfCPorPCorCWB(?x, true) ^ Patient(?x) -> probabilityOfHaving(?x, LungDesease)

To Diagnose Lung Cancer Patient

Rule1d: Patient(?p) ^ probabilityOfHaving(?p, LungDesease) ^ Nodule(?n) ^ hasNoduleSize(?n, ?s) ^ swrlb:greaterThan(?s, 2) -> hasDesease(?p, LC)

Rule2 -> To Identify Stage of Lung cancer

hasSpreadBV(?x, false) ^ hasT(?p, "T1") ^ hasN(?p, "N0") ^ hasSpreadOP(?p, false) ^ hasSpreadLN(?p, false) ^ hasM(?p, "M0") ^ LungCancer(?p) -> classifiedInto(?p, StageIA)

Rule3 -> To categorize the lesion as benignant or malignant

Patient(?p)^Nodule(?x)^foundIn(?p,?x)^hasDiameter(?x,?s)^swrlb:greaterThan(?s,8) ^swrlb:lessThan(?s,15)->hasCategory(?x,LRc4A)

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Rule 4 -> Required Treatment according to the Lung Cancer Stage

LungCancer(?x) ^ classifiedInto(?x, StageIA) -> treatedBy(?x, Surgery)

III. IMPLEMENTATION& RESULTS

To implement our proposed system we use different types of programming languages and computing software like Protégé Editor is used construct the medical ontology of OBESLC system and to update RDF (Resourse Description Framework) files. we make use of Jena API which is a programming toolkit that depends on java programming language to interact with our OBESLC system. Eclipse IDE was used to develop graphical demonstrators for the purpose of user interaction . SWRL language is used for reasoning the ontology by generating rules and to query the developed ontology we make use of SPARQL. This type of implemented system is needed by clinicians, General practioners and medical students so that they can have initial knowledge base of lung cancer disease and can easily diagnose the Lung cancer disease ,Stage identification and suggest Treatment plans to the patients as a part of their initial screening process.

Sample rule execution of OBESLC system in Protégé Tool

Executing a rule in protégé involves the steps like i) Exporting OWL axioms into rule engine

ii) Execution of rule using rule engine iii)Translate the inferred axioms into OWL model.

If we perform all these actions successfully we can able to impose our rules into the ontology and draw inferences according to our proposed rules

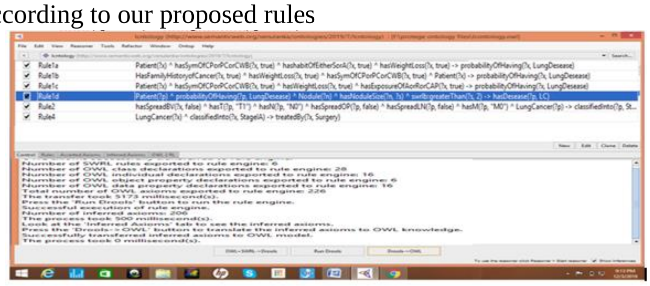


Fig IV.a Rule1d execution in protégé using rule engine and transferring it into OWL Knowledge

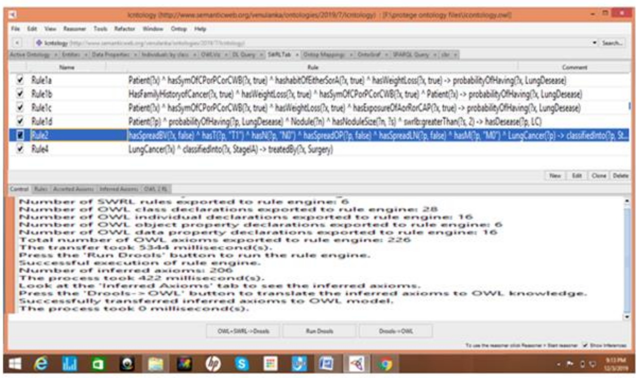


Fig IV.b Rule2 execution in protégé using rule engine and transferring it into OWL Knowledge

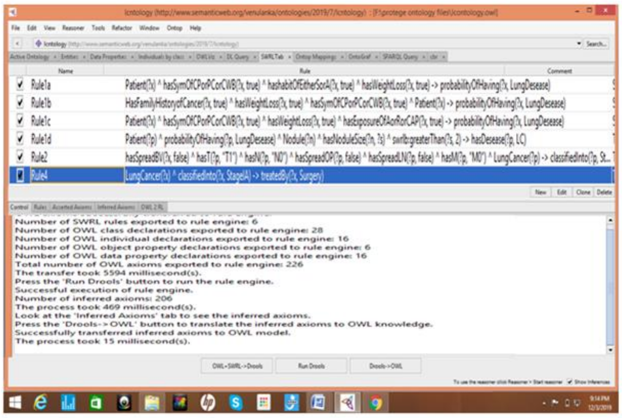
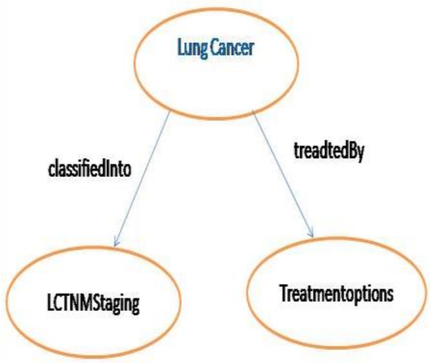


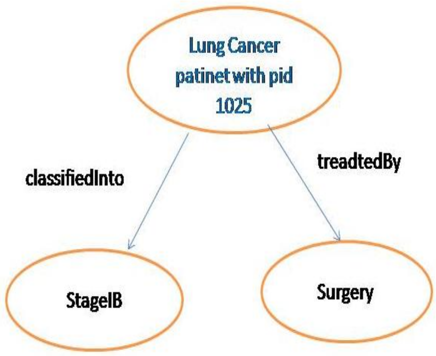
Fig IV.c Rule4 execution in protégé using rule engine and transferring it into OWL Knowledge

Validating OBESLC system by Sample SWRL Rule extraction Using developed demonstrators in Jena with Eclipse editor:

After executing and trasfering any rule into OWL Model, we can extract the same using user interface demonstrators by providing communication between Owl file generated by Protégé Tool and Jena API with Eclipse editor. Here we have shown results of SWRL rules in the developed interfaces for Lung cancer Treatment (d,e,f) ,Lung cancer detection(g) and Lung cancer stage identification(h) respectively.



(d)



(e)

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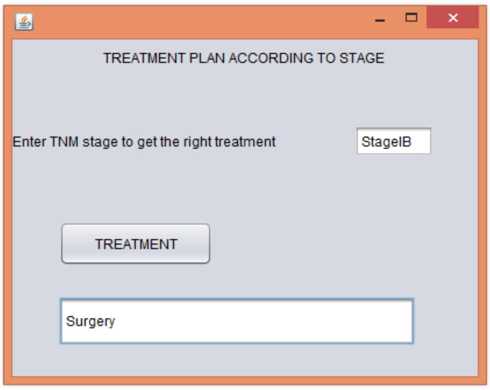
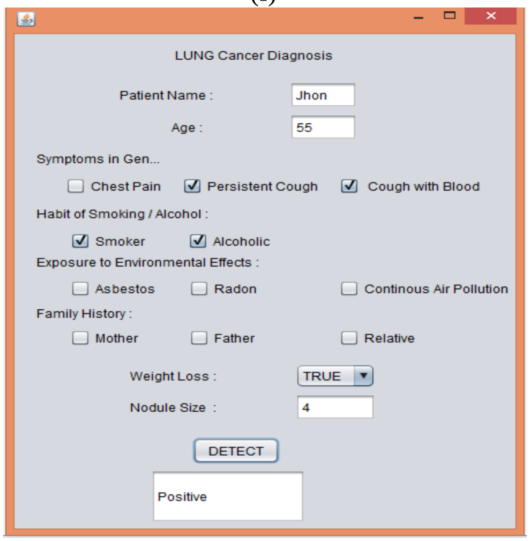
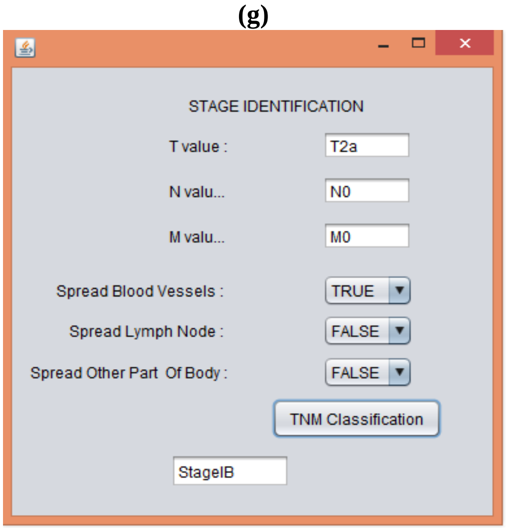


(f)



(g)



(h)

Fig IV (d) Semantic representation of concepts before Rule execution e) Semantic representation of concepts after Rule execution f)The Result of the rule for treatment of lung cancer in developed interface (g) The Result of the rule for detecting lung cancer patient in developed interface (h) The Result of the rule for lung cancer stage identification in developed interface.

Verifying the OBESLC System using SPARQL :

To validate the developed ontology we make use of SPARQL query language which interrogate the ontology and produces the results . SPARQL stands for SPARQL Protocol And RDF Query Language.Querying and extracting information from the knowledge base is an important task in semantic web through which users and applications can interact with data in the ontologies. Here we have presented some sample SPARQL queries through which we can test our rules of OBESLC system by communicating with the developed user interface demonstrators.

Query for Treatment :

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX lc: <http://www.semanticweb.org/venulanka/ontologies/2019/7/lcntology#>
SELECT ?Treatment ?CancerStage
  WHERE { ?CancerStage lc:classifiedInto ?stage.
          ?CancerStage lc:treatedBy ?Treatment }
```

Query for identifying Stage of Lung Cancer:

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX lc:
<http://www.semanticweb.org/venulanka/ontologies/2019/7/lcntology#>
SELECT ?LCancer ?Stage
  WHERE {?LCancer lc:hasT ?t.
     ?LCancer lc:hasN ?n.
     ?LCancer lc:hasM ?m.
     ?LCancer lc:hasSpreadBV ?x.
     ?LCancer lc:hasSpreadLN ?y.
     ?LCancer lc:hasSpreadOP ?z.
     ?LCancer lc:classifiedInto ?Stage }
```

V. CONCLUSION

Developing an expert system using ontology in the field of medical domain produces better results with less complexity. In this paper we have developed OBESLC System (Ontology Based Expert System for Lung Cancer) using state of art semantic web technologies to diagnose, to identify lung cancer stage and to provide treatment plan according the stage of patient. We have successfully implemented(includes verification and validation) the OBESLC system using SPARQL queries ,SWRL rules and used the Apache Jena API along with Eclipse Editor to extract details from ontology and presented the query results to the user with the help of graphical demonstrators.

This system is very much help to the General Practioners and clinicians to assess the disease according to the patient symptoms along with scan(CT,MRI,PET etc)reports. OBESLC incorporates knowledge base of Lung cancer disease through which anybody who are not aware of this disease and especially medical students can have an idea regarding the reasons behind lung cancer attack, Types, stages of lung cancer and treatment plans available. This system contains probabilistic rules to diagnose the disease. In future we can enrich the system by incorporating a machine learning technique to learn from results of this system and use these results for further diagnosing.

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