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Enhanced Select and Test (eST) Algorithm: Framework for Diagnosing and Monitoring Related Ailments

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***Abstract*—Diagnosis, prediction, machine learning, and decision making are all areas of application of artificial intelligence. Particularly, intelligent (medical) diagnosis systems are now becoming pervasive providing support to healthcare delivery. However, there is a lack of precision and approximation of the algorithms driving such diagnostics systems. Though there is a number of reasoning algorithms for carrying out this diagnostic task, the precision of these diagnostic algorithms are being impaired by their reasoning structures. This paper reviews and provides an enhancement to select and test (ST) reasoning algorithm. This algorithm, adjured to be the most precise among the existing diagnostic algorithms, will be enhanced by employing the use of semantic web reasoning structures. Reasoning at the abduction, deduction, and induction levels are oriented towards rule base reasoning pattern in the semantic web. Also, a series of modularized ontology knowledge bases are stacked together in building a complex but distributed knowledge base for the entire system. The implementation of this enhanced algorithm will be used as a test-bed for diagnosing and monitoring related ailments.**

Keywords-semantic web; inference making; ontology; rule set; monitoring; intelligent systems and diagnosis.

I. INTRODUCTION

Intelligent medical diagnosis is an area of research that leverages on artificial intelligence, and intelligent systems targeted at diagnosis of other systems are becoming pervasive. These intelligent medical systems are also referred to as medical expert systems (MES) and the driving force of these expert systems are reasoning algorithms. Some of such reasoning algorithms are fashioned after mathematical, statistical, fuzzy and rule-based models. To achieve the reasoning of this enhanced algorithm, the semantic web structures are employed. The semantic web is the power of inference making and reasoning over ontologically modeled knowledgebase. Therefore, we use semantic web rule languages to encode our rule systems for effective interoperability with the knowledgebase. As a result, taxonomies, metadata, classifications, context and ontology have been the basic building blocks of the Semantic Web [1]. A combination of a formal ontology for the medical domain with a fine-grained contextual inference making and reasoning algorithm is an exceptional tool in incorporating autonomous (health) systems.

This research in progress argues that employing the use of some semantic web technologies in ST algorithm will yield a higher precision, and an inference making medical diagnostic reasoning system.

II. RELATED WORKS

Expert systems are a program intended to make reasoned judgments or give assistance in a complex area in which human skills are fallible or scarce. Considering the work of [2] which stated that they are computer system that operates by applying an inference mechanism to a body of specialist expertise represented in the form of 'knowledge'. They are employed as decision support systems, and have many implementation approaches which includes; rule-base (MYCIN and PROSPECTOR), data-base approach, descriptive method (INTERNIST and CADUCEUS), and Causal Network method. Also, [3] developed the expert system that carries out its diagnoses by organizing symptoms into three groups namely Key group(Kg), Sub group(Sg) and Unexpected(Ue). Again, [4] designed ASTHMA, an expert system for the diagnoses of asthma. They combined some machine learning algorithms such as Context sensitive auto-associative memory neural network model (CSAMM), Backpropogation model, C4.5 algorithm, Bayesian Network, Particle Swarm Optimization to realize their design. Ex-Dr Verdis is an integrated expert system [5] Heart Disease Program (HDP) is a medical expert system that enables physicians to enter patient’s symptoms, laboratory tests, and physical examination. It then generates clinical data that support the diagnoses of heart disease [6].

Meanwhile, a review of medical reasoning algorithms is discussed here. Scheme inductive reasoning algorithm works based on forward thinking [7]. Pattern recognition is employed in machine learning for assigning some outputs to some inputs base on the coordination of a given algorithm [8]. Hypothetico-deductive reasoning involves generating and testing hypotheses in association with the patient’s presenting symptoms and signs [9] Forward chaining system, includes writing rules to manage sub goals. Whereas, backward chaining systems automatically manage sub goals [10]. Parsimonious Covering Theory (PCT) works on the basis of associating a disorder to a set of manifestations [11]. Certainty Factor (CF) model is used for managing uncertainty cases in a rule based system [12]. Bayesian reasoning algorithms helps in dealing with uncertainties [13]. Fuzzy logic uses linguistic variables to represent operating parameters in order to apply a more human-like way of thinking [14]. Others are: Processing Model for Diagnostic Reasoning [15], Information Processing Approach [16], Select and Test algorithm adjured to be the most approximate [17]. Figure 1 is skeletal model of ST model.

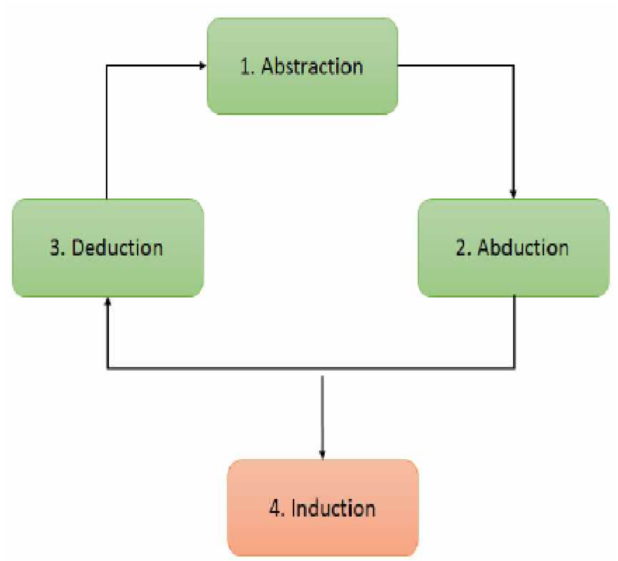

Figure 1. ST Model [17]

III. THE PROPOSE ENHANCED SELECT AND TEST (ST) ALGORITHM

In this section, we present and anatomize our enhanced ST model. The modified model consists of the Abstraction module and the three logical inference modules namely Abduction, Deduction and Induction. More so, the existing ST algorithm data is a-temporal (unable to monitor and store relevant events, that could support diagnostic reasoning, with respect to time of their occurrence), hence, this made us to add a monitoring module to the ST model so as to make it data-gathering procedure consistent and as well temporal. Contrary to the ST model by [17], we modeled our data using ontological approach, and the concept of semantic web rule language is employed for implementing our rule systems.

The following subsections give a breakdown of each of the consisting components in figure 2.

A. Abduction

Our abduction stage improves on the existing abduction module. Except that we enabled a semantic web based reasoning operation in the module. We propose the use of rule engine for this reasoning task. Both the abduction and the deduction stages here uses this rule engines. And compose a rule system for aiding diagnostic reasoning task. A new parameter, ***acceptanceThreshold*** is added to the existing ***likelihoodThreshood*** parameter. This to check if every deduction task passes a given acceptance value before we can conclude that it is correct. The abduction modules gets all diagnoses related to symptoms found, and reasons by hypothesis, studying facts and devising theory to explain it. The process of abduction: The whole process of abduction includes generation, criticism and acceptance of explanatory hypotheses.

B. Deduction

Deductive Reasoning is a process in which general premises are used to obtain a specific inference. A form of logic that identifies a particular item by its resemblance to a set of accepted facts. Deductive reasoning moves from a general principle to a specific conclusion. It is inference by reasoning from generals to particulars. Deductions support their conclusions with TRUE result. They compute their results using heuristics. We modify the existing deduction module to be a rule-base deductive reasoning task. Hence, a coordinated rule system and a reasoned are added to semantically realize the deductive reasoning.

C. Abstraction

The process of mapping descriptive terms understood by patient onto a well-defined symptom entities modeled in the knowledgebase is known as abstraction. In this proposal, we seek to provide patients with a textbox for inputting their entering descriptive terms of how they feel. Our natural language NL-query to Semantic Web SW-query model, then semantically matches their inputs against an ontology of vocabularies in the knowledgebase. The modified abstraction module allows input to be in speech or textual. Patients may voice in their symptoms and this data will be processed by the voice processor.

D. Induction

It entails reasoning from the particular to the general. This may or may not be true. But it provides a useful generalization. At the induction state, we check if likely diagnosis meets diagnostic criteria. While Abduction & Deduction are termed clinical reasoning, Induction is termed clinical decision making. The induction stage in this modified ST model builds on the existing features of the existing ST model. Except that we develop a mathematical model for computing the ***criticalThreshold*** parameters, which is now added to calibrate and alert patient on the status of the ailment.

E. Monitoring Agent

The monitoring agent works continuously in the system. It is more like a daemon which logs events into a Spatial-Temporal-Thematic (STT) ontological database. The essence of agent is to be able to monitor development of the ailment in the patient's body, and then adequately signal the needed alert or logs necessary information that the diagnostic algorithm will mine data from it. Temporal information gathered is a clinical data that helps in tracking the progression of a disease in a patient with respect to time. Spatial information models data that relates with patient and its environment. Thematic data models concepts and terms used in clinical operations.

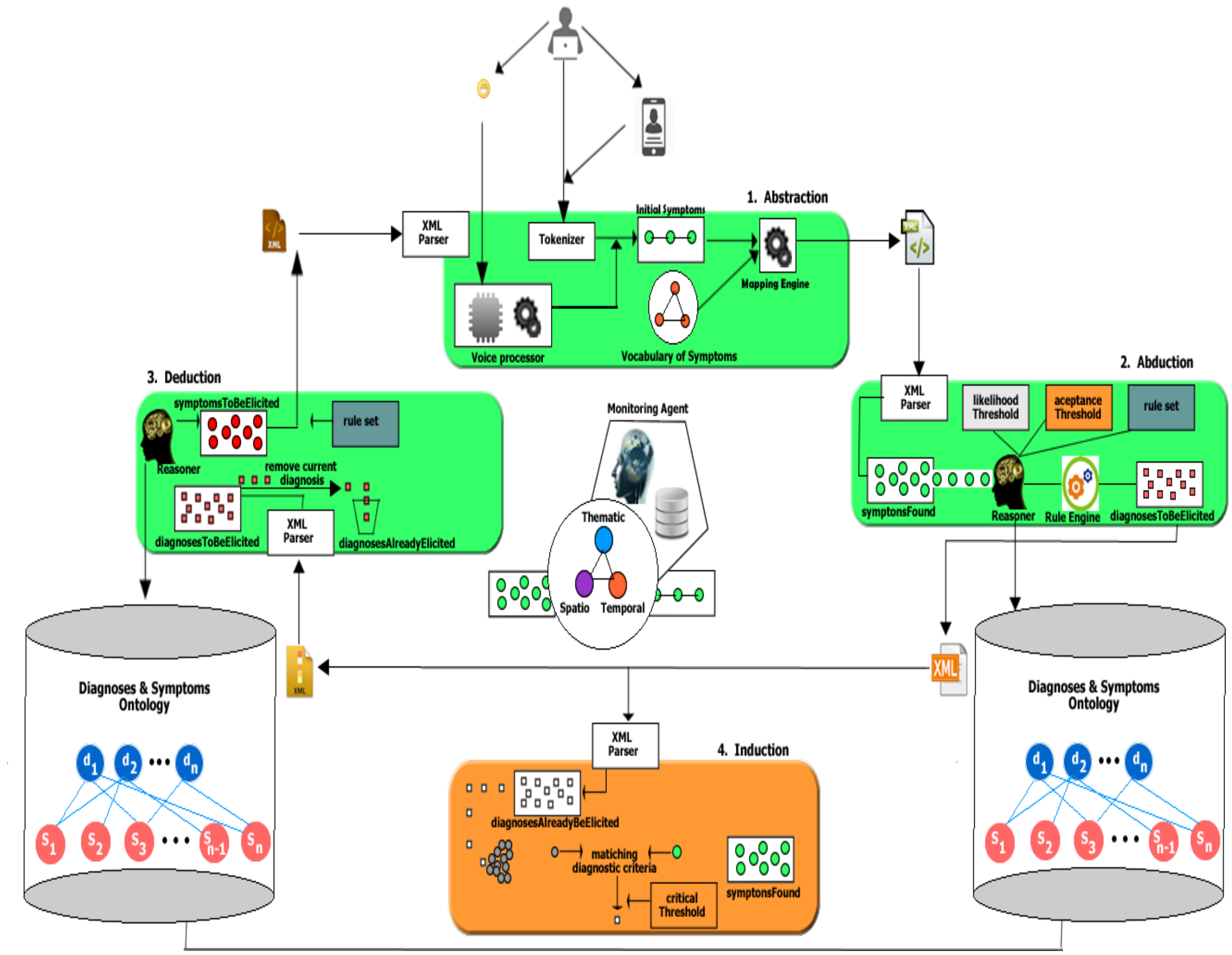

Figure 2. Enhanced Select and Test Model

Figure 3 shows the model that the monitoring module works on. On the left hand side, there are four components: the event monitoring, event selector, data gathering, and data modeling in spatial-temporal-thematic (STT) format. The event monitor receives information from the intelligent personal agent and then sends it to the event selector which appropriately sieve out the right information to store. Then the data gathering and reasoning faculty generates the requisite data base on the event. The last component then models the data in a STT format.

On the right hand side of Figure 3 is the knowledge modeling in OWL2. This will be fully discussed in chapter four. Now, the algorithm for this model will be discussed below.

Algorithm 1 lists out the steps required for performing the monitoring task of the monitoring module. Line 2of the algorithm rightly points out the fact that this monitoring module does its tasks as long as the application is running. The module sources its event data by raising some important questions at random, and then from the intelligent personal agent which shall be discussed in the next section. Once these data are gathered as indicated by lines 4-5, lines6-12 cleans the data, formats it into the required style and then models it in the STT pattern. Afterward, the patient or user is alerted in the case of any information that must be passed across.

IV. The Knowledge Representation Stack of the Enhanced ST Algorithm

The proposed enhanced Select and Test (ST) algorithm discussed above is a rule base expert system. Figure 4 is a structural representation of the facts and coordinated rules system. The structure consists of four layers, and each layer comprises of facts (model with ontological language OWL) and rules (modeled with semantic web based rule languages, SWRL). Appended to these four strata is the monitoring agent knowledge model. The first layer models the knowledge of the abstraction layer. Basically, there are three modularized data representation. These are a thesaurus modeled with OWL, patient's personal profile modeled with XML, and a rule for mapping descriptive terms of patients into a well-defined symptoms entities, modeled with SWRL. The second layer is a knowledge representation for the abduction phase. Knowledge representation at this phase comprises of the facts, modeled with OWL, and rule set for carrying out abduction (modeled with semantic web rule language SWRL). The deduction module is the next phase for knowledge modeling representation. This phase has a rule set modeled in Jess rule language (JessRL), and the facts modeled in OWL also.

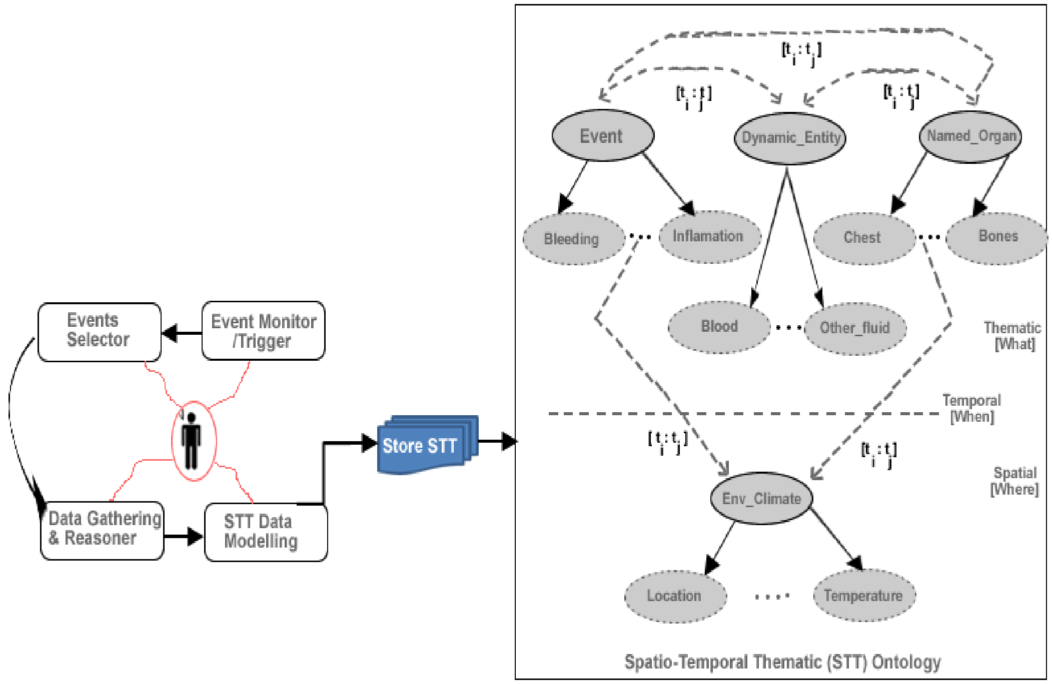

Figure 3. Monitoring agent model

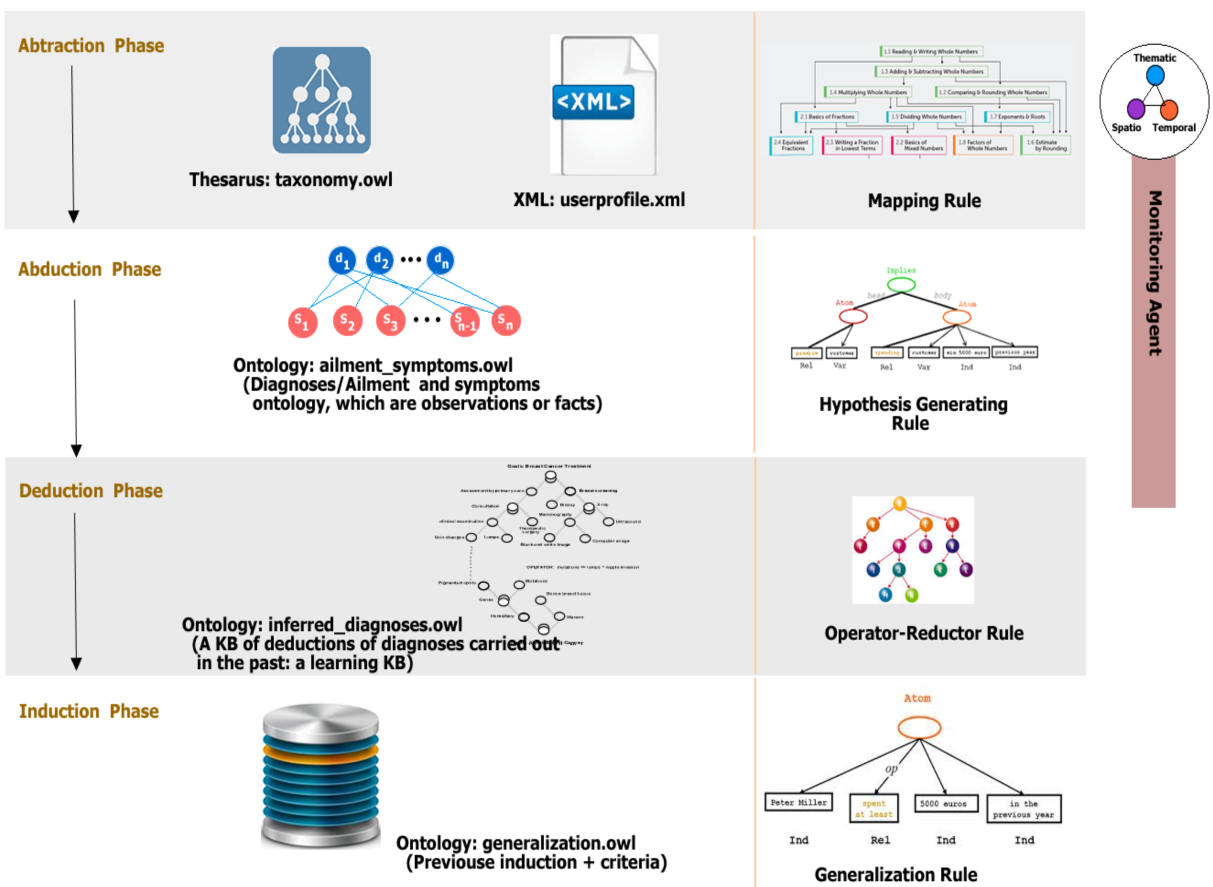

Figure 4. Knowledge Representation Stack for the Enhanced ST Algorithm

Algorithm 1: Monitoring module algorithm

```
Array Q = be set of questions to aid in gathering symptoms or improved feelings
WHILE IN SESSION
    gather data ::
        data1= ask(Q)
        data2=new data from IPA module
    preprocess data::
        eliminate unwanted information from data
        Tokenize and format data1 and data2
    feature extraction ::
        pick out and formulate concepts from data
        encode data as STT // spatial-temporal-thematic
    store STT in ontology
    alert patient with appropriate message
END-WHILE
```

Lastly, the induction phase also comprises of an ontological knowledge base and a rule set for induction, with the rule modeled with the Jena rules. The last component in this structured knowledge model is spatial-temporal-thematic ontological representation of the data generated during the monitoring process.

V. RESULTS AND DISCUSSION

As proof of concept, we listed some common symptoms associated with skin disorders. These symptoms are identifiable with some specific skin disorder disease or ailment. The proposed enhanced ST algorithm proposed in this paper help patient to diagnose the particular skin disorder he/she is suffering from. We note that all D_i and S_j are modeled ontologically alongside the necessary rule sets able to help reason out the set of S_j that could cause a particular D_i

For example, given disease D_i, we will need to cyclically reason through abstraction, abduction, deduction, until a refined result is reasoned out, then we move on to the induction where the real ailment is inductively picked out of the few left after the cyclic refinement.

We need to established D_i manifesting a set of S, $\{S_j \in S_1 \ldots S_n\}$ once our reasoning structure is able to accurately establish this set of S, then considering users/patient's input; a correct diagnoses process is completed.

At the Abstraction layer, users input are collected and stored as symptoms. Furthermore, at the abduction layer, associated skin diseases or disorders of the collected symptoms are reasoned out of the modularized knowledgebase of the abduction layer, alongside its rule sets. These skin disorders or disease retrieved at the abduction layer is then sent to the deduction layer. The deduction layer must then intelligent map out the Di manifesting a set of S, $\{S_j \in S_1 \ldots S_n\}$ for every disorder or disease. This cyclic pattern is continued until it comes to the induction layer. Say at the induction layer, three Di are sent into this module, it is the responsibility of the induction layer to reason out the correct diagnosis from this three Di. This is achieved by reasoning out which one meet the diagnostic criteria.

TABLE I. LIST OF SYMPTOMS

Symptom ID	Symptoms
S_1	actinic keratosis: red, pink, or rough patch of skin on sun-exposed areas
S_2	basal cell carcinoma: raised, waxy, pink bumps
S_3	squamous cell carcinoma: red, scaly, rough skin lesions, typically on sun-exposed areas such as the hands, head, neck, lips, and ears
S_4	melanoma: asymmetrically shaped moles or lesions with irregular borders, or change in color or diameter
S_5	sunburn-like rash that spreads across the nose and both cheeks
S_6	scaly red patches or ring shapes
S_7	disc-shaped rash that doesn't itch or hurt
$\mathbf{S_8}$	fatigue, headaches, fever, and swollen or painful joints
S_9	fever, cough, and runny nose
S_{10}	reddish-brown rash spreads down the body three to five days after first symptoms appear
S_{11}	tiny red spots with blue-white centers inside the mouth
S_{12}	papules: small red, raised bumps caused by infected hair follicles
S_{13}	pustules: small, red pimples that have pus at their tips
S_{14}	nodules: solid, painful lumps beneath the surface of the skin
S_{15}	cysts: painful, pus-filled infections found beneath the skin
S_{16}	usually appear on the neck or face of infants
S_{17}	small, red scratch or bump that eventually begins to protrude
S_{18}	most disappear from the skin by age 10
S_{19}	red, fluid-filled blisters that appear near the mouth
S_{20}	your lips will often tingle or burn before the sore is visible
S_{21}	the sore is painful or tender to the touch

TABLE II. LIST OF RELATED SKIN DISORDERS/AILMENT

Ailment ID	Ailment	Related Symptoms
D_1	Skin Cancer	S_1, S_2, S_3, and S_4
D_2	Lupus	S_5, S_6, S_7, and S_8
D_3	Rubeola (Measles)	S_9, S_{10} and S_{11}
D_4	Acne	S_{12}, S_{13}, S_{14}, and S_{15}
D_5	Hemangioma of Skin	S_{16}, S_{17}, and S_{18}
D_6	Cold Sore	S_{19}, S_{20}, and S_{21}

VI. CONCLUSION

In this paper, we have introduced an enhanced Select and Test algorithm which may be employed in diagnosing disease or ailments that have related symptoms. Though it is a research in progress, however, this paper has introduced the model of the proposed enhanced algorithm. It shows four levels of reasoning: Abstraction, Abduction, Deduction and Induction. Furthermore, the knowledge stack of the modeled was as presented. And finally, a proof of concept was shown so as to explain the implementation of the algorithm.

REFERENCES

[1] R. Cuel, A. Delteil, V. Louis and C. Rizzi. Knowledge Web Technology Roadmap. "The Technology Roadmap of the Semantic Web", 2008.

[2] B. S. Todd. "An Introduction to Expert Systems". Technical Monograph PRG·95 ISBN 0-902928-73-2, Oxford University Computing Laboratory Programming Research Group 11 Keble Road Oxford OXI3QD England. Pp. 3. 1992.

[3] P.S. K. Patra, D. P. Sahu, and I. Mandal. "An Expert System for Diagnosis of Human Diseases". *International Journal of Computer Applications*, Volume 1 – No. 13, pp. 71-73. 2010.

[4] B. Prasadl, K.P.E Prasad, and Y. Sagar. "An Approach to Develop Expert Systems in Medical Diagnosis using Machine Learning Algorithms (ASTHMA) and a Performance Study". *International Journal on Soft Computing (IJSC), Vol.2, No.1 pp. 26-33. 2011*.

[5] A. Keles. "Expert Doctor Verdis: Integrated medical expert system", Turkish *Journal of Electrical Engineering & Computer Sciences, pp. 1032-104, 2014.*

[6] A. Al-Ajlan. Medical Expert Systems HDP and PUFF. King Saud University College of Computer & Information Sciences, Department of Computer Science, pp. 3, 2007.

[7] K. J. Anderson. Factors Affecting the Development of Undergraduate Medical Students' Clinical Reasoning Ability. Medicine Learning and Teaching Unit, Faculty of Health Sciences, University of Adelaide, pp. 18, 2006.

[8] U. A. Umoh, A. A. Umoh, G. G. James, U. U. Oton, and J. J. Udoudo. "Design of Pattern Recognition System for the Diagnosis of Gonorrhea Disease". *International Journal of Scientific & Technology Research (IJSTR) Volume 1, Issue 5*, pp. 74-79, 2012.

[9] S. P. Kumar, A. Kumar, and V. Sisodia. Clinical Reasoning and Sports Medicine-Application of Hypothetico- Deductive Model". J Sports Med Doping Stud ISSN: 2161-0673 JSMDS, Volume 3 Issue 1, 2013.

[10] T. Sharma, N. Tiwari and D. Kelkar. "Study of Difference Between Forward and Backward Reasoning". International Journal of Emerging Technology and Advanced Engineering Volume 2, Issue 10, October 2012.

[11] J. Wainer, and A. M. Rezender. A Temporal Extension to the Parsimonious Covering Theory, 1996.

[12] D. E. Heckerman, and E. H. Shortliffe. "From Certainty Factors to Belief Networks". *Artificial Intelligence in Medicine, 1992.*

[13] J. Gadewadikar, O. Kuljaca, K. Agyepong, E. Sarigul, Y. Zheng, and P. Zhang. "Exploring Bayesian Networks for Medical Decision Support in Breast Cancer Detection". *African Journal of Mathematics and Computer Science Research Vol. 3(10), pp. 225-231, October 2010*.

[14] A. E. Torshabi, M. Riboldi, A. Pella, A. Negarestani, M. Rahnema, and G. Baroni. A Clinical Application of Fuzzy Logic. Fuzzy Logic – Emerging Technologies and Applications, pp. 1-18, 2013.

[15] J. Stausberg, and M. Person, "A process model of diagnostic reasoning in medicine". *International Journal of Medical Informatics, vol. 54*, pp. 9-23, 1999.

[16] P. M. Wortman. "Medical Diagnosis: An Information-Processing Approach". Computers and Biomedical Research, vol. 5, pp. 315-328, 1972.

[17] I. Fernando, and F. A. Henskens. ST Algorithm for Medical Diagnostic Reasoning. Polibits pp. 23-29, 2013.