Development of Knowledge Base in Expert System using Dempster's Rule of Combination[1]

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Abstract— Expert system has been used in many fields such as medicine, agriculture, forestry, public health, economics etc. Expert system represent the expert to provide advice to the user so that no longer need to meet directly with an expert. Knowledge base is the most important and decisive part in expert system. Errors in the knowledge base would result in an incorrect conclusion. However, due to time and budget constraints, an expert will be difficult to gain knowledge from a variety of sources including research then the information derived from the public can be an important source of knowledge for expert system. In this paper we purpose a model for development of a knowledge base in an expert system by combining expert knowledge and information or evidence from the public (tacit knowledge) that expected an expert system that is always factual. The combination of evidence using Dempster's rule of combination.

Index Terms— combination rule, evidence, expert system, knowledge base, tacit knowledge

1. Introduction

Expert systems (ES) are a branch of applied artificial intelligence (AI), and were developed by the AI community in the mid-1960s. The basic idea behind ES is simply that expertise, which is the vast body of task-specific knowledge, is transferred from a human to a computer. This knowledge is then stored in the computer and users call upon the computer for specific advice as needed. The computer can make inferences and arrive at a specific conclusion [14]. Since 1980 AI developed in many areas such as architecture, archeology, finance, education, medicine, the production of goods and food etc. In industrial areas, the application of ES are widely used in comparison to other AI applications [24].

ES are computer programs that solve problems in a non-procedural manner using knowledge from human experts to simulate human reasoning. They are also called knowledge-based systems or inference-based programs [2]. ES typically have a number of several components. One of them is knowledge base that contains the knowledge obtained from the domain expert. Normally the way of representing knowledge is using rules [16]. The knowledge base is the determining factor of the success of an ES [20] and that distinguishes an ES with other systems Knowledge base, containing rules of inference and related factual information, about a particular domain. Along with the inference engine, there is need for a good interface for interaction with an expert who creates knowledge bases and with the naive end-user of the ES. Human knowledge is often inexact and incomplete. It takes a long time for a human apprentice in a trade to become an expert. He acquires knowledge step-by-step. Thus, novices become experts gradually. Heuristics often represent human expertise. They are not guaranteed to be correct all the time, but work much of the time [20]. The knowledge base may be static, preprogrammed and unchanging, or dynamic and capable evolution [3].

2. Knowledge

Knowledge is the whole body of data and information that people bring to bear to practical use in action, in order to carry out tasks and create new information. Knowledge adds two distinct aspects: first, a sense of purpose, since knowledge is the "intellectual machinery" used to achieve a goal; second, a generative capability, because one of the major functions of knowledge is to produce new information [21].

Overview knowledge definitions and models provided by [22] :

- Justified true belief (Socrates and Plato);
- A gradient of data, information, knowledge, understanding and wisdom
- Defined by tacit and explicit spirals: socialization (tacit to tacit) externalization (tacit to explicit), combination (explicit to explicit), and internalization (explicit to tacit)
- Three worlds of knowledge: one–physical/material, two–physiological/ subjective, and three–culture/artifacts

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2.1. Justified true belief

There are three components to the traditional ("tripartite") analysis of knowledge. According to this analysis, justified, true belief is necessary and sufficient for knowledge [10].
S knows that *p* iff

i. *p* is true;

ii. *S* believes that *p*;

iii. *S* is justified in believing that *p*.

The tripartite analysis of knowledge is often abbreviated as the "JTB" analysis, for "justified true belief". The three conditions — truth, belief, and justification — are individually necessary and jointly sufficient for knowledge [15]. From Plato to the modern era, the label of knowledge has required the demonstration of some action or application characteristic. The diagram replaces the Platonic notion of truth with scientific evidence and thereby defines knowledge as the intersection of belief and scientific evidence. By this definition, someone who believes something not grounded in scientific evidence cannot have knowledge. Conversely, someone who understands and has been exposed to scientific evidence, but does not believe in it also cannot be said to have knowledge [17]

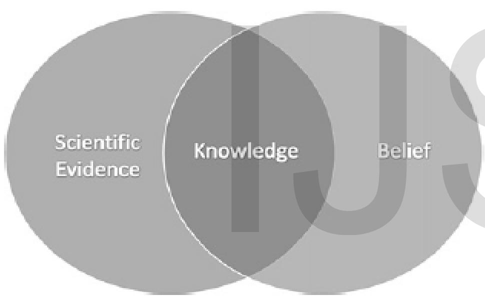
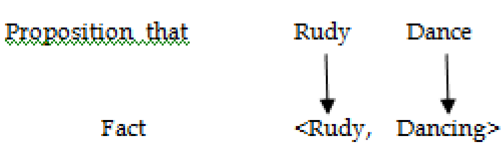


Figure 1. An illustration of a modified version of Plato's Justified True Belief [17].

There are two important theories about the truth of a knowledge, correspondence and coherence theories The basic idea of the correspondence theory is that what we believe or say is true if it corresponds to the way things actually are—to the facts or evidence [6].



A coherence theory of truth states that the truth of any (true) proposition consists in its coherence with some specified set of of propositions. According to the coherence theory, the truth conditions of propositions consist in other propositions [25].

1. *All men are mortal*
2. *Socrates is a man*
3. *Therefore, Socrates is mortal*

2.2. Tacit and Explicit Knowledge

Our knowledge, in an occupation for example, is in three parts: the knowledge we acquire by practising the occupation (knowledge expressed in skill), the knowledge we gain by exchanging experience with colleagues and fellow workers (the knowledge of familiarity) and finally the knowledge we can learn by studying the subject (propositional knowledge), [7]. Knowledge classifying into two kinds: formal scientific knowledge (SK) system or is essentially in explicit format and traditional knowledge (TK) system or is mostly tacit – hard to articulate with formal laguage. The main difference of these two kinds of knowledge systems is their format [19].

Traditional Knowledge	**Scientific Knowledge**
Tacit Knowledge (subjective)	Explicit knowledge (objective)
Knowledge of experience (body)	Knowledge of rationality (mind)
Simultaneous knowledge (here and now)	Sequential knowledge (there and then)
Analog knowledge (practice)	Digital knowledge (theory)

Table 1. Traditional and Scientific Knowledge

The major problems in accessing a human expert in a particular field are unavailability and scarcity of real experts and if the human expert is available then there may be problem for common people in making contact with him [18]. This problem of transferring human knowledge into an ES is called the "*knowledge acquisition bottleneck*" [5]. This in turn may affect expert's efficiency. The other major problems that are being faced by the human expert are the limitation of his memory and processing inability of all the essential knowledge required in the process of decision-making. As a result of researches and developments, day by day, new knowledge in enormous amount is being added in every discipline and thus more relevant and accurate advice can be taken from a human expert if his own knowledge is updated which is not an easy task [18].
A practical limitation of ES today is lack of causal knowledge. That is, the ES do not really have an understanding of the underlying causes and effects in a system. It is much easier to program ESs with shadow knowledge based on empirical and heuristic knowledge than with deep knowledge based on the basic structures, functions, and behaviors of objects [5].

Knowledge share from public as experience and the fact can saves cost, time and research. Many cases where public information can help an expert to solve the problem quickly. Acquisition of knowledge that have been known for many years, should be updated [11]. Knowledge is shared, as it is shared, it is recycled, modified and enlarged [1]. Knowledge can be augmented if it is shared, knowledge sharing may also prove detrimental to knowledge [8].

2.3. Evidence Theory

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Evidence Theory is a branch of mathematics that concerns combination of empirical evidence in an individual's mind in order to construct a coherent picture of reality [4]. Evidence theory which is sometimes called Dempster-Shafer theory, become a method of measuring uncertainty based on belief and plausibility functions [9]. Three basic elements are involved in Dempster-Shafer theory of evidence: frame of discernment (Θ), Basic probability Assignment (m), Belief (Bel) and Plausibility (Pl) functions [13].

- The frame of discernment (Θ) is a set containing all mutually exclusive outcomes of set X. The power set of X, 2^{x}
- Basic probability Assignment (m) is a characteristic function of any set.
  m : $2^{x} \rightarrow [0,1]$; $m(\emptyset) = 0$; $\sum_{x \subset \Theta} m(X) = 1$; $m(x) + m(\neg x) \leq 1$
- The belief function (Bel) represents the believability or the weight of evidence that supports an outcome. The plausibility measure (Pl) represents the plausibility or the weight of evidence that does not oppose a particular set of outcome.
  Bel : $2^{x} \rightarrow [0,1]$ and Pl : $2^{x} \rightarrow [0,1]$
  Bel (A) = $\sum_{B|B \subseteq A} m(B)$
  Pl (A) = $\sum_{B|B \cap A \neq \emptyset} m(B)$ or Pl (A) = 1 – Bel (¬A)

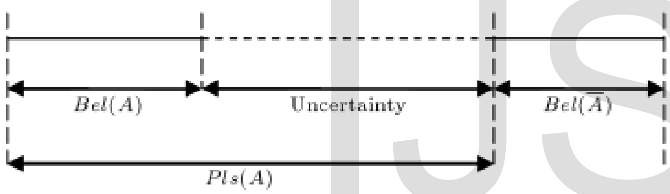

Figure 2. Belief, Plausibility and Uncertainty

Belief Interval is an interval between belief and plausibility functions representing range in which exact belief resides. A narrow belief interval represents more precise beliefs. It can be shown that the belief is uniquely determined if Bel(A) = Pl(A). If BI(A) has an interval [0,1], it means that no information about hypotheses is available; on the other hand, if the interval is [1,1], it means that A has been completely confirmed [12]
Plausibility purpose [23] :
$Pl(x) = m(x) + m(x,\neg x)$ and $Pl(\neg x) = m(\neg x) + m(x,\neg x)$.
Bel(A) and Pl(A) represent the lower bound and upper bound of belief in A. Interval [Bel(A), Pl(A)] is the range of belief in A.
Beliefs from different sources can be combined with various fusion operators to model specific situations of belief fusion with e.g.Dempster's rule of combination. Specifically, the combination is calculated from the two sets of masses m1 and m2 in the following manner:

$$m_{1,2}(\emptyset) = 0$$

$$m_{1,2}(A) = (m1 \oplus m2)(A) = 1/1\text{-}K \sum_{B \cap C = A \neq \emptyset} m1(B)m2(C)$$

where

$$K = \sum_{B \cap C = \emptyset} m1(B)m2(C)$$

K is a measure of the amount of conflict between the two mass sets.

3. Overview knowledge acquisition in ES

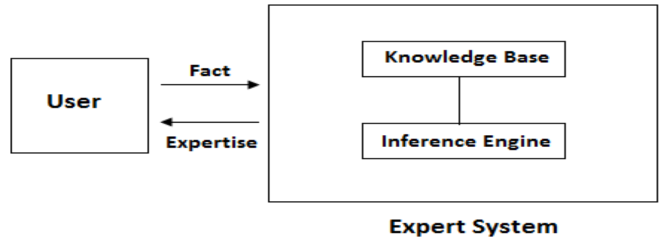

Figure 3. ES diagram

ES diagram illustrate the basic concept of a knowledge-based ES. The user supplies facts or other information to the expert system and receives expert advice or expertise in response. Internally, the expert system consists of two main components. The knowledge base contains the knowledge with which the inference engine draws conclusions. These conclusions are the ES's responses to the user's queries for expertise (Giarratano, 2002).

All source of knowledge (knowledge acquisition) an ES comes from experts (explicit knowledge), which means that an expert must constantly keep abreast of the knowledge that they know. If not, an ES have a slow growing knowledge base or sometimes incomplete. It is very difficult to do especially in the experts who have the expertise rarely, in the area of rapid development and influenced by many factors such as public health, agriculture, environment etc.

In many cases, the solution gave by an ES is nothing new either given at the first consultation and after a year later when many changes occur, that should affect with any suggestions or solutions provided by an ES. The effects are reduced confidence in the advise given by an ES and generate inefficiencies (high cost).

4. Sharing public knowledge to ES

The existence an expert as the main source of knowledge both theory and fact that required in an ES, it is not sufficient in the future. Sharing knowledge from the public knowledge (tacit or traditional knowledge) is needed to improve the quality of ES to solve complex problems and produce an ES that corresponding with the actual conditions. Much knowledge from the public (experience or real fact in the field) may be used to complete the existing knowledge in an ES.

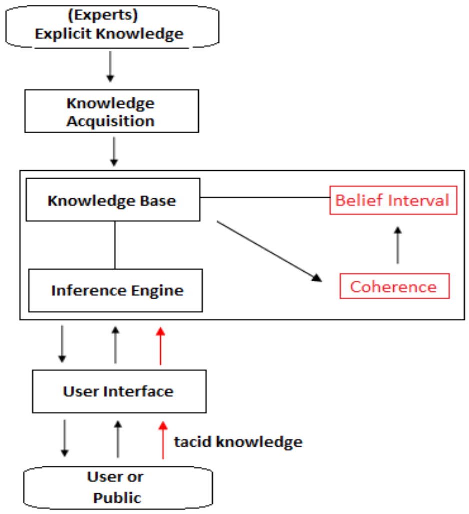

Figure 4. Sharing public knowledge in ES diagram (red color)

A conclusion from ES, a person suffering from Influenza with evidence : (fever, runny nose, fatigue, cough) with the level of illness (expert reference) :

A. Severe (fatigue and cough)
B. Moderate (runny nose)
C. Mild (fever)
D. Non Influenza

A patient (tacit knowledge) with symptoms : he had runny nose for a few days and rash.

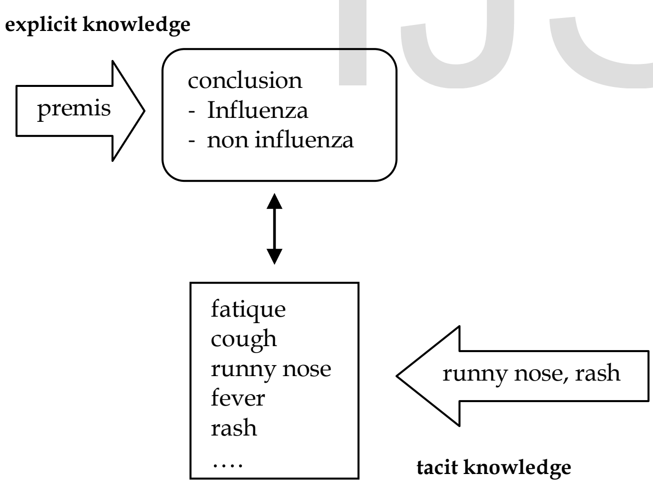

Figure 5. Flowchart knowledge sharing

Step 1.
After consulting, ES conclude that this patient suspected influenza with mild level. Patient can add other symptoms that he felt into ES i.e. runny nose and rash. Knowledge base is indicate that (fever, runny nose, fatigue, cough) $\in$ (influenza) whereas symptom of rash$\notin$(Influenza). Thus the rash rejected as a symptom of influenza.
Bel (x) = 0 no evidence (the symptom rejected)
Bel (x) = 1 full evidence (the symptom accepted)

Step 2.
The patient felt the symptom of runny nose and perceive it as mild level of influenza symptom with a belief corresponding m-values :
$m(x) = 0,5$
$m(\neg x) = 0.3$
$m(\{x, \neg x\}) = 0.2$

patient belief that runny nose cause influenza at mild level with 0.5 degree of support that "x" is true, 0.3 degree of support that "¬x" is true and 0.2 degree support uncommitted. With belief function, can be writing :
$Bel1(x) = m1(x) = 0,5$
$Bel1(\neg x) = m1(\neg x) = 0.3$
$Bel1(\{x, \neg x\}) = m1(\{x, \neg x\}) = 0.2$

With this evidence the plausibility of "x" become :
$Pl1(x) = m1(x) + m1(\{x, \neg x\}) = 0.5 + 0.2 = 0.7$ and
$Pl1(\neg x) = m1(\neg x) + m1(\{x, \neg x\}) = 0.4 + 0.1 = 0.5$

We can write that the patient belief interval is (0.5, 0.7) runny nose as a symptom of influenza in mild level. While expert opinion belief (0.4, 0.5) runny nose is symptom of the influenza in mild level and (0,6, 0,9) at moderate level..

So that combination between two evidence become :

$M1(x) = 0,5$	$m2(x) = 0.4$
$M1(\neg x) = 0.3$	$m2(\neg x) = 0.5$
$M1(\{x, \neg x\}) = 0.2$	$m2((x, \neg x\}) = 0.1$

$$K = 1 - [m1(x)m2(\neg x) + m1(\neg x)m2(x) = 1 - [0.5 * 0.5 + 0.4 * 0.3] = 0.63$$

$$m'(x) = [m1(x)m2(x) + m1(x)m2(\{x,\neg x\}) + m1(\{x, \neg x\})m2(x)]/K = [0.5 * 0,4 + 0.5 * 0.2 + 0.1 * 0.3] / 0.63 = 0.33 / 0.63 = 0.52381$$

$$m'(\neg x) = [m1(\neg x)m2(\neg x) + m1(\neg x)\, m2(\{x,\neg x\}) + m1(\{x,\neg x\})m2(\neg x)/K = [0.3 * 0.5 + 0.3 * 0.1 + 0.2 * 0.5 = 0.28 / 0,63 = 0.444444$$

$$m'(\{x,\neg x\}) = m1(\{x,\neg x\})m2(\{x,\neg x\})/K = [0.2 * 0.1] = 0.02 / 0.63 = 0.031746$$

Then belief that "x" is true is 0.52381, belief that "¬x" is true is 0.444444

5. Discussion/Conclusion

These results illustrate that the runny nose may occur in the influenza with mild level in this patient were generally moderate level at the other patients. Symptoms of influenza for each patient cannot be determined statically because every patient has different symptoms and may be a patient has symptoms that are really different from other patients.
Knowledge base is divided into two parts: 1) the static part that is based on the knowledge of experts containing general

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knowledge (rule) of a particular field (influenza) and 2) the dynamic part that based on the evidence known by the expert or perhaps only known by experts but in reality it has never happened.
The first part is usually used in an expert system that exists today. The second part is used to get information from outside the ES so that the knowledge base will be develop according with the reality found. Information from the public must first be verified with existing reference. If the information is not in reference (no coherence) then information is denied or accommodated to directly verified by experts.
Some benefits gained by using this approach :1) public can share the information they have, 2) can acquire new knowledge without having to change the entire rule or program, 3) expert system can be used in the long term with the knowledge base that is always in accordance with the real situation**.**

Further work

This research will be continued using real data and taking into account conflict of evidence between two sources with certain method of combination rule.

References

[1] Arora Ekta, KNOWLEDGE MANAGEMENT IN PUBLIC SECTOR, Journal of Arts Science & Commerce, Vol.– II, Issue –1, January 2011, ISSN 2229-4686, International Refereed Research Journal 2011,<www..researchersworld.com>

[2] DeTore Arthur W., An Introduction to Expert Systems, Journal of Insurance Medicine, Volume 21, No. 4, 1989

[3] Engle Eric Allen, An Introduction to Artificial Intelligence and Legal Reasoning: Using xTalk to Model the Alien Tort Claims Act and Torture Victim Protection Act, Richmond Journal of Law & Technology, Volume XI, Issue 1, 2004

[4] Fioretti Guido, A Mathematical Theory of Evidence for G.L.S. Shackle, Mind & Society, 3, 2001, Vol. 2, pp. 77-98, © 2001, Rosenberg & Sellier, Fondazione Rosselli

[5] Giarratano Joseph, Riley Gary, Expert Systems Principles and Programming (third edition). Original copyright © 1998 by PWS Publishing Company. All rights reserved. Reprinted for People's Republic of China by Thomson Asia PIC Ltd and China Machine Press and cIne Publishing House under the authorization of Thomson Learning 2002, ISBN 7-111-10844-2

[6] Glanzberg, Michael, "Truth", *The Stanford Encyclopedia of Philosophy*, Edward N. Zalta (ed.), forthcoming, Spring 2013 Edition <http://plato.stanford.edu/archives/spr2013/entries/truth/>.

[7] Go¨ranzon Bo, Tacit knowledge and risks, AI & Soc (2007) 21:429–442 DOI 10.1007/s00146-007-0086-5, ©Springer-Verlag London Limited 2007

[8] Hendriks Paul, Why Share Knowledge? The Influence of ICT on the Motivation for Knowledge Sharing, Knowledge and Process Management Volume 6 Number 2 pp 91–100, 1999

[9] Hwang Chao-Ming and Yang Miin-Shen, Generalization of Belief and Plausibility Functions to Fuzzy Sets Based on the Sugeno Integral, INTERNATIONAL JOURNAL OF INTELLIGENT SYSTEMS, VOL. 22, 1215–1228, © 2007 Wiley Periodicals, Inc. Published online in Wiley InterScience <www.interscience.wiley.com> • DOI 10.1002/int.20246 , 2007

[10] Ichikawa, Jenkins Jonathan and Matthias,Steup, "The Analysis of Knowledge", *The Stanford Encyclopedia of Philosophy*, Edward N. Zalta (ed.), <http://plato.stanford.edu/ archives/win2012/entries/knowledge-analysis/>, *Winter 2012 Edition*

[11] Kabbashi Nassereldeen A., Saedi Mohammed, Jazzar Munif A. and Azman Nur Adibah, Integrated scheduled waste management system in Kuala Lumpur using expert system, African Journal of Biotechnology Vol. 10(81), pp. 18781-18787, DOI: 10.5897/AJB11.2752 ISSN 1684–5315 ©2011 Academic Journals Available online at <http://www.academicjournals.org/AJB>, 2011

[12] Khatibi V. and Montazer G.A., A New Evidential Distance Measure Based on Belief Intervals, Computer Science & Engineering and Electrical Engineering Vol. 17, No. 2, pp. 119{132), © Sharif University of Technology, December 2010

[13] Kronprasert,Nopadon , REASONING FOR PUBLIC TRANSPORTATION SYSTEMS PLANNING: USE OF DEMPSTER-SHAFER THEORY OF EVIDENCE, Dissertation, Faculty of the Virginia Polytechnic Institute and State University, 2012

[14] Liao Shu-Hsien, Expert system methodologies and applications—a decade review from 1995 to 2004, Expert Systems with Applications xx (2004) 1–11, <www.elsevier.com/locate/eswa>, 2004

[15] Matthias, Steup, , "Epistemology", *The Stanford Encyclopedia of Philosophy* , Edward N. Zalta (ed.), <http://plato.stanford.edu/archives/win2011/entries/epistemology/>. *Winter 2011 Edition*

[16] Naser S.S, Kashkas K.A and. Fayyad M, Developing an Expert System for Plant Disease Diagnosis, Journal of Artificial Intelligence 1 (2):78-85, ISSN 1994-5450, 2008

[17] Perla Rocco J and Parry Gareth J, The epistemology ofquality improvement: it's all Greek, BMJ Qual Saf 2011;20(Suppl 1):i24ei27. doi:10.1136/bmjqs.2010.046557, - Published by group.bmj.com, 2012

[18} Prasad. R, Bihar B.R.H, Sinha A.K, Role of expert system in natural resource management GIS Development Pvt Ltd, A-145, Sector - 63, Noida (U.P.)-201301,India,available <http://www.gisdevelopment.net/application/nrm /overview/ma03130.htm, 2009

[19} Rahman Ataur, Development of an Integrated Traditional and Scientific Knowledge Base: A Mechanism for Accessing, Benefit-Sharing and Documenting Traditional Knowledge for Sustainable Socio-Economic Development and Poverty Alleviation, United Nations Conference on Trade and Development (UNCTAD), Geneva, Switzerland, 30 October – 1 November 2000

[20] Sasikumar M, Ramani S, Muthu Raman S, Anjaneyulu KSR and Chandrasekar R, A Practical Introduction to Rule Based Expert Systems, Narosa Publishing House, New Delhi, All rights reserved. Copyright 2007, Narosa Publishers

[21] Schreiber Guus ,Akkermans Hans, Anjewierden Anjo, de Hoog Robert, Shadbolt Nigel, Van de Velde Walter, and Wielinga Bob, Knowledge Engineering and Management, Massachusetts Institute of Technology, A Bradford Book The MIT Press Cambridge,

IJSER

Massachusetts, London, England, 2000

[22] Siemens George, Knowing Knoledge, ISBN 978-1-4303- 0230-8 A Creative Commons licensed version is available online at <www.knowingknowledge.com, 2006

[23] Srivastava Rajendra P, An Introduction to Evidential Reasoning for Decision Making under Uncertainty: Bayesian and Belief Functions Perspectives, International Journal of Accounting Information Systems, Vol. 12: 126–135., 2010

[24] Vizureanu Petricğ, Expert Systems, Published by Intech, Olajnica 19/2, 32000 Vukovar, Croatia, ISBN 978-953-307-032-2, Free online edition of this book : <www.sciyo.com>, 2010

[25] Young, James O, "The Coherence Theory of Truth", *The Stanford Encyclopedia of Philosophy*, Edward N. Zalta (ed.),<http://plato.stanford.edu/archives/fall2008/entries/truth-coherence/>., *Fall 2008 Edition*

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