Brain Inspired Cognitive Artificial Intelligence for Knowledge Extraction and Intelligent Instrumentation System

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***Abstract*— Artificial intelligence evolves with the development of computers even rely on computational development. The ways and processes of human thinking developed by Psychologists and welcomed by computational experts produce the science of Artificial Intelligence. This continues with the development of cognitive science that encourages the development of Artificial Intelligence to Cognitive Thinking Intelligence, a new pathway to the science of Artificial Intelligence that can emulate human cognitive abilities even if not 100%. Emulation of human cognitive abilities is developed based on the modeling of system interaction with the environment and information fusion, which can be used to conduct *Inferencing*, so when this occurs repeatedly it will produce knowledge that grows. This process is called Knowledge Growing System which is Brain Inspired Cognitive Artificial Intelligence and can be used for information extraction and when applied to instrumentation system will realize Intelligent Instrumentation System.**

Keywords*— *Artificial Intelligence ; Cognitive Artificial Intelligece; Knowledge Extraction

I. INTRODUCTION

Although it is impossible to emulate 100%, human intelligence is imitated by the development of artificial intelligence. Development of artificial intelligence begins with the development of Smart System and continues to Knowledge Based Artificial Intelligence and then Computational Artificial Intelligence. The difference lies in the design approach, the acquisition of knowledge and the main characteristics of its superiority. However, all of those AI systems do not clearly store knowledge. Smart systems mimic human behavior, otherwise knowledge based systems and AI computational mimic human thinking. Our research is to imitate human cognitive abilities as a continuation of Computational AI development. Three terms of concern [1], namely Inferring, Inferencing and Knowledge Extraction.

Inferring is defined as to derive by reasoning; conclude or judge from premises or evidences. It needs premises or evidences. Second, Inferencing is the practice of inferring the meaning of an unfamiliar word or expression from the meaning of familiar words occurring with it in a context together with one's knowledge of or beliefs about the world. It requires knowledge. The process of obtaining an inference to become new knowledge is called as Knowledge Extraction. These are the processing of information on the human brain modeled by Wicken, Welford and Whitting. All three models just describe the mental process within human brain and heavily focused on how brain's memories work in the existence of information or sensory inputs perceived by sensory organs or sensory system. It is not shown how perceived information is processed to obtain knowledge regarding the observed phenomenon or external object or something that causes stimuli (stimulus).

Based on the understanding of the three models and the psychology perspective on human thought models by Galileo, Piaget, Feynman and Pooper, Cognitive Psychology and Decision Cycle model, developed Human Inference System (HIS) based on constructivism that is learning theory or knowledge formation through experience and interaction. HIS model is a model of growth and extraction of knowledge as a result of system interaction with the environment.

II. INFORMATION FUSION

A. Basic Theory of Information Fusion

Human obtains various information from his five senses. From the set of information, obtained knowledge that is the result of information fusion as the observation of the five senses. This process is called Knowledge Growing. If the process is repeated because of repeated interactions with different situations, then the knowledge obtained more perfect.

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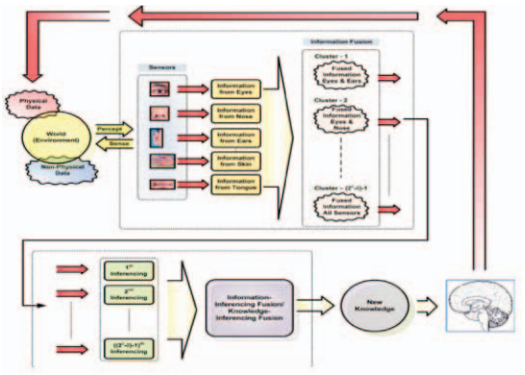

Fig. 1. HIS Model for Information Fusion [1,2]

Adopting the concept of human information processing models and human information fusion model, our *Human Inference System* (HIS) as the basis for our cognitive agen called KGS is depicted in the figure 1. We assume that any new information is a product of fused information that is perceived by two or more sensory organs or sensors. Based on HIS concept, we generalize the model to a system that is equipped with a set of sensors $n = 1,...,i,...\delta$. Therefore, the number of fused information is λ, so the number of fused information can be obtained by using $\lambda = \left(2^{\delta} - \delta\right) - 1$.

B. *Mathematical Model of Information Fusion's Computation [2]*

Bayesian method based on Bayes Probability rules commonly used for inferencing process, referred to as Bayesian Inference Method (BIM) with the following mathematical model:

$$P(Bj \mid A) = \frac{P(A \mid Bj)P(Bj)}{\Sigma jP(A \mid Bj)P(Bj)} \quad (1)$$

Where :

P(Bj|A) : *posterior probability*, the probability of hypothesis B when A is occured
P(A|Bj) : *prior probabiliy* , the probability of indication A when B is occured
P(Bj) : *prior probability* when B is occured.

And then to obtain process of information fusion, formula (1) is enhanced become (2) :

$$P(A_i \oplus B_j) = \max_{j=1,\ldots,m} \frac{\sum_{i=1}^{n} (P(B_j \mid A_i))}{n} \quad (2)\ [3,4]$$

Where n is number of sensor.

if $P(V^i_j) = P(B_j|A_i)$ and $P(\psi^i_t) = P(B_j \oplus A_i)$, $n = \delta$, formula (2) can be writen as (3) :

$$P(\psi_t^i) = \frac{\sum_{i=1}^{\delta} (V_j^i)}{\delta} \quad (3)[3,4]$$

Where :

V^i_j : sensor respond to hypothesis
δ : number of sensor
$P(\psi^i_t)$: best value of hypothesis at each observation time

III. Application of Information Fusion for Extracting Knowledge

A. *Extracting Knowledge for C4ISR in joint Military Operation*

In military operations, knowledge of the Weather, Field of Operation and Enemy's power is instrumental in determining operational command decisions. Figure 2 show the graphic result of information fusion from inteligence information which received by C4ISR system.

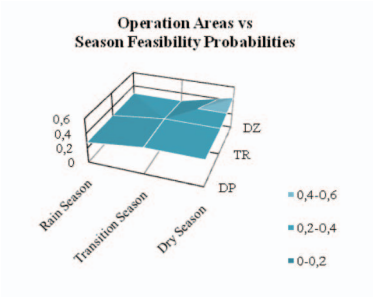

Fig. 2. Information fusion product for weather condition [4].

From the graphic,it can be inferred that logistics dropping will be safe and secure if it is conducted in Dry Season. By inferring information presented in the graphic depicted in Figure 2, decision maker can obtain a situational awareness to make a precise decision regarding current situation and conducts logistics dropping safely and securely.

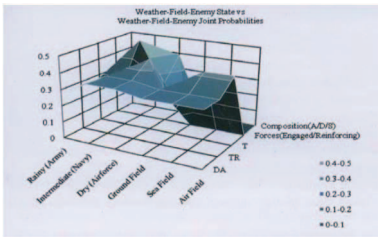

Fig. 3. Joint declaration of weather, field and enemy resulted of Information Fusion.

Figure 3 is the result of a Fusion of information from weather, field and enemy situations that can be used to make decisions and command. The execution of military operation will have better probability to be accomplished if it is done in Dry Season. By means of Air and or Sea Field while anticipating the enemy's Navy and Air Force Engaged /

Reinforcing joint forces with Composition of Attack, Defense and supporting troops.

B. *Extracting Knowledge for C4ISR in Coast Guard Operation [4]*

A3S has been tested on the construction of the software on one of the government agencies of the Republic of Indonesia . This software is used to help making decisions according on input from the indications and possible events which may occure , related to duties of the agency. The program is created using programming language Visual C.

The course of this program can be explained as follows : The input of this program is indicative of field observations and hypotheses, which is a probability of occurrence (or action) which is experienced by the object being observed. Information from observations and hypotheses are then fused with A3Sequation, to see the possibility of events being experienced. The results of this program is in the form of graphs, showing aspects of the probability of occurrence based on the observation that observed in a certain time .

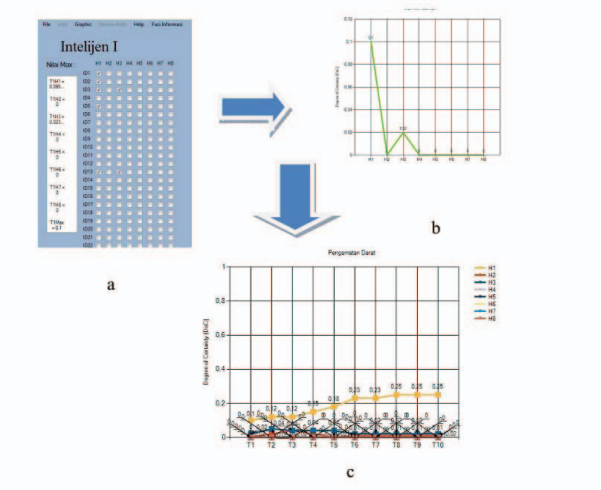

Fig. 4. Output Result of A3S method (a) data input (b) graphical representation of one observation time (c) Graphical representation of all observation time

In each observation time , the user enters the data in the associate table (Figure 4a) . Entered data is indicative of the potential fit between the hypothesis according to the information available. In each observation time , the program will calculate the probability the greatest value of each hypothesis (Figure 4b) . The end result of this program is the graph of the overall observations, which demonstrate the greatest possible relationship hypotheses and indications occur.

Figure 5. show the details of observation result from A3S computation for this software. Observations conducted over 10 times . The observations show that the value of the DoC in H_1 rose significantly during the observation period . So it can be said that in these observations H_1 is the best hypothesis generated in this observation .

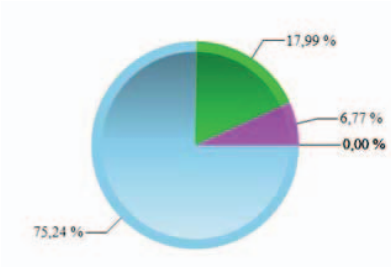

Fig. 5. 1st Hypothesis is the best possibility hyphothesis which may occur (75.24%) followed by 2nd hypothesis (17.99 %) and 3rd Hypothesis (6.77%).

From the observed indications, the greatest possibility is 1st Hypothesis, that is Piracy (75.24%), followed by the possibility of 2nd Hypothesis that is Illegal Mining (17.99%) and 3rd Hypothesis is Illegal Fishing (6.77%).

C. *Knowledge Extraction For Heart Condition Detection* [5]

One of the most popular health detection devices is the Electrocardiogram (ECG). The ECG perform interpretation of heart signal to see the observed heart health condition. The development of ECG capability to perform continuous detection, while considering the previous condition is expected to further help the diagnosis of heart disease more fully. Therefore, we need a system that can receive information input of cardiac diagnosis done at one time, store the result, and fuse the information with diagnosis result done at the next time.

We have done preliminary research to use Information Fusion Computation to doing Knowledge Extraction for detect the heart condition. For now, the observation is limited to diagnosys Heart Block condition and Arrythmia. Figure 6 show the computation process of Information Fusion to detect heart condition based on ECG graph result.

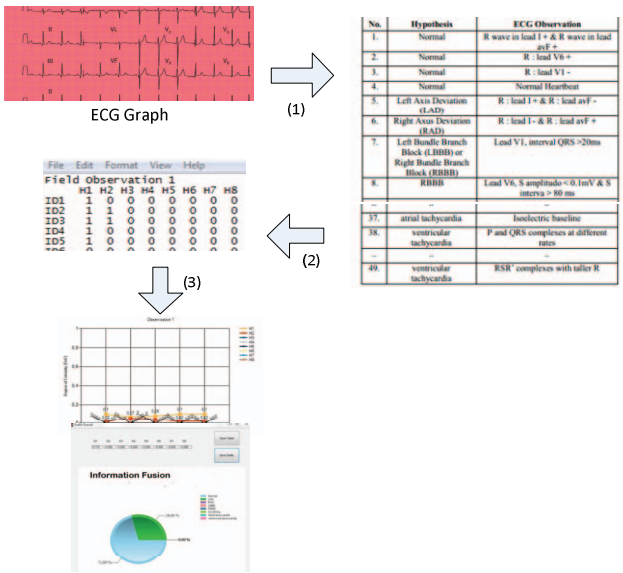

Fig. 6. Information Fusion Computation to doing Knowledge Extraction for detect the heart condition

First, the system will detect the ECG reading result. From these results, the relationship between indications read by the results of the graph with the possible hypothesis of heart conditions is found. In this research there were 49 indications and 8 hypotheses representing the possibility of a normal heart condition, heart block and arrythmia[6]. Using A3S computations, correlations between indications and hypotheses were calculated to see the possibility of hypotheses indicating cardiac conditions. The results of this correlation are shown in graphical form showing the results of observations over time and graphs that show the value of hypothesis presentation.

By looking at each correlation between the hypothesis and the indication of each observation time, using the A3S formula, the results of the observations can be summarized as depicted in Figure 7.

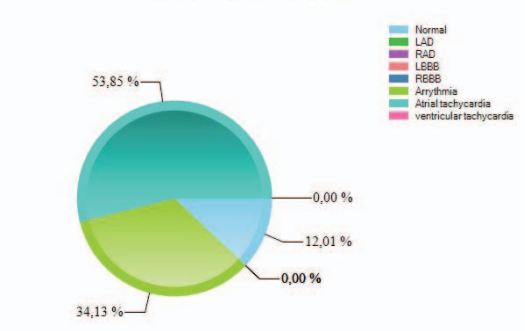

Fig. 7. Knowledge obtained by applying A3S from the results of observation [5]

Figure 8 shows the result from all observation time. From the graphic it can be seen that observation result show that the heart condition which have been observed have 53,85% *Atrial Tachycardia* condition which tend to have 34,13% of *Arrythmia* condition and 12,01% Normal Condition. Another example of observation result can be seen at Figure 8 which show the condition for Arrythmia with tend to have *atrial tachycardia* condition.

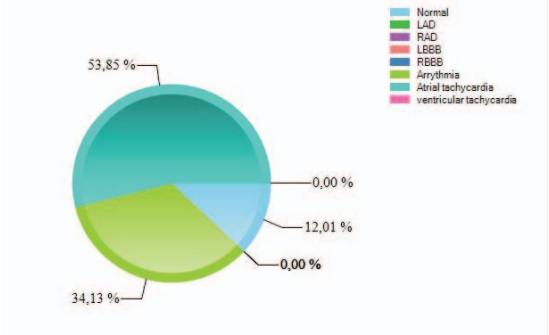

Fig. 8. Atrial Tachycardiac, tend to have 34.13% Arrythmia.

IV. Concluding Remark

Cognitive Artificial Intelligence (CAI) is based on Information Fusion and proven to be used for Knowledge Extraction and produces an instruments which capable of mimicking human cognitive intelligence.

Next to develop this Information Fusion Computation, CAI software is being developed to assist the decision-making process for monitoring the condition of the transformer[7]. In hardware security, CAI has also been developed as a system for side chanell attact counter-measure[8].

After applying this A3S algorithm in form of software for decision-maker's tools, currenty we are doing research to design a kind of processor which equipped with algorithm of A3S, called Cognitive Processor[9]. With A3S algorithm, cognitive processor can be used as a main control for an autonomous system, which have ability to grow it knowledge continuously, as time passes

Acknowledgment

This paper is a compilation of many papers written by Adang Suwadi Ahmad and his group in Cognitive Artificial Intelligent Research Group. Many thaks to Arwin D.W.Sumari, Catherine Sereati, Karel Bachri, Dony, Septafiyansyah for doing reseach with Adang Suwandi Ahmad on Cognitive Artificial Intelligent Concept and System.

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