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THE DEVELOPMENT OF AN EXPERT CAR FAILURE DIAGNOSIS SYSTEM WITH BAYESIAN APPROACH

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ABSTRACT

In this study we propose a model of an Expert System to diagnose a car failure and malfunction using Bayesian Approach. An expert car failure diagnosis system is a computer system that uses specific knowledge which is owned by an expert to resolve car problems. Our specific system consists of knowledge base and solution to diagnose failure of car from Toyota Avanza, one of the favorite car used in Indonesia today and applying Bayesian approach for knowing the belief of the solution. We build Knowledge representation techniques of symptoms and solution froman experts using production rules. The experimental results presented and we obtained that the system has been able to perform diagnosis on car failure, giving solution and also gives the probability value of that solution.

Keywords: Expert Systems, Car Failure, Knowledge-Base, Bayesian Approach

1. INTRODUCTION

The Expert System (ES) is a computer system that emulates the decision-making ability of a human expert in a restricted domain. The Expert System is one of the leading Artificial Intelligence (AI) techniques that have been adopted to handle such task. The required AI techniques for such domain have to be capable of emulating the human brain's diagnostic processes (Russel and Norvig, 2010). The Expert System is one of the well-known reasoning techniques that is utilized in diagnosis applications domain. In ES, human knowledge about a particular expertise to accomplish a particular task is represented as facts and rules in its knowledge base (Salama *et al*., 2012). It seeks and uses the information provided by a user. Reasoning process is then performed over the represented knowledge using heuristic approaches for a solution (Folorunso *et al*., 2012).

In the research and development of this expert system, the methods used for knowledge representation is Rule Production (Production System). In the production rule, there are one or more rules/rules that are designed to solve one problem. To obtain the confidence of an expert system diagnosis is correct, then the use Bayesian that provide value possible truth diagnosis expert system. Possible values obtained based on the calculation of the weight of the symptoms experienced by users and the prior value of the damaged equipment. With the possibility of true values of the probability calculations Bayesian user will more easily take a decision on damages. For these reasons, it is done research entitled "Analysis and Design of Expert System for Diagnosing Damage On Four Wheels Vehicles with Bayesian Probability Approach" to the maximum in order to give a more precise diagnostic possibilities because it can diagnose the onset of damage to the car so that the damage does not getting worse.

Application of an expert system for diagnosing damage to the car has also been carried out such as (Salama *et al*., 2012) Car failure detection is a sequence of diagnostic processes that necessitates the deployment of expertise. The Expert Systems (ES) is one of the leading Artificial Intelligence (AI) techniques that have been adopted to handle such tasks. The Expert Systems is a knowledge-based system that consists of two main modules: the knowledge base and the inference engine and can be shown in **Fig. 1**.

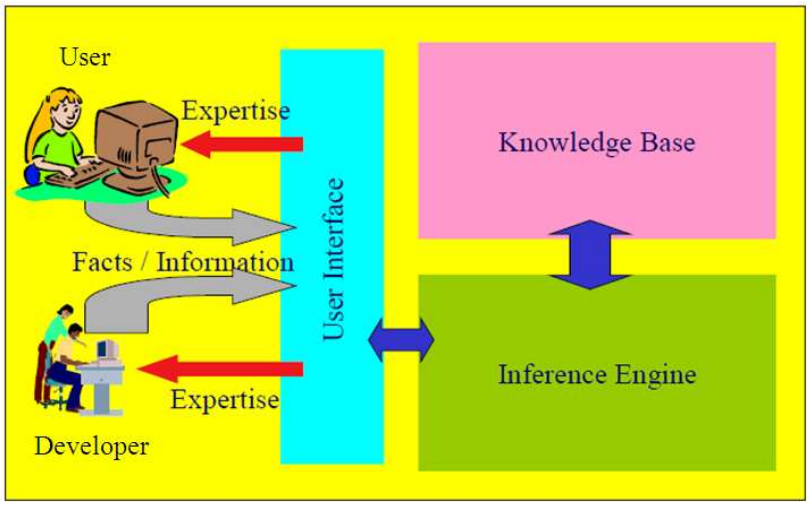

Fig. 1. Basic functionality of an Expert Car Failure Diagnosis System

1.1. Literature Review

1.1.1. Car Diagnosis Principles

The knowledge needed for accurate diagnostics is in two parts:

- Understanding of the system in which the problem exists
- Having the ability to apply a logical diagnostic routine

The routine is represented by **Fig. 2**. The loop will continue until the fault is located.

There are six stages usually in diagnosis the car (Denton, 2006):

Stage1: Take a quick look to check for obvious problems such as leaks, broken drive belts or lack of coolant. Run the vehicle and confirm that the fault exists.

Stage 2: Is the driver available to give more information? For example, does the engine overheat all the time or just when working hard?

Stage 3: Consider what you now know. Does this allow you to narrow down what the cause of the fault could be?

Stage 4: The further tests carried out would now be directed by your thinking at stage three. You don't yet know if the fault is a leaking head Gasket, the thermostat stuck closed or some other problem. Playing the odds, a cooling system pressure test would probably be the next test.

Stage 5: Let's assume the problem was a thermostat stuck closed - replace it and top up the coolant,

Stage 6: Check that the system is now working.

Also check that you have not caused any further problems such as leaks or loose wires.

1.2. The Knowledge Base

An expert system may completely fulfill a function that normall requires human expertise, or it may play the role of an assistante to a human decision maker. The decision maker may be an expert in his own right, in which case the program my justify its existence by improving his productivity. Buchanan (1983) define knolwde acquisition as the transfer and transformation of potential problem-solving expertise from some knowledge source to a program. Knowledge representation is a substantial subfield I its own right, which shares many concerns with bot formal philosophy and cognitive psychology. It is concerned with the ways in which information might be stored an associated in the human brain, usually from a logical, rather than a biological, perspective.

An expert system can be distinguished from a more conventional application program that:

- It stimulates human reasoning about a problem domain, rather thant simulating the domain itself
- It performs reasoning over representations of human knowledge, in addition to doing numerical calculations or data retrieval (Jackson, 1999)

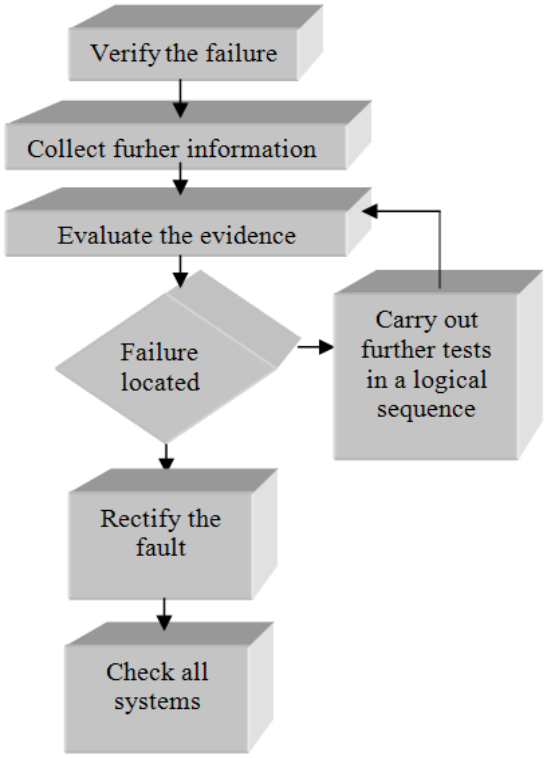

Fig. 2. Flowchart of diagnosis car failure system

The knowledge Base consists of some encoding of the domain of expertise for the system. For this research, consider is only for the production rules for our knowledge base. These rules occur in sequences and are expression of the form:

$$\text{If } < \text{conditions} >, \text{then } < \text{actions} >$$

If the conditions are true then, the actions are executed. When rules are examined by the inference engine, actions are executed if the information supplied by the user satisfies the conditions in the rules. Conditions are expressions involving attribute and logical connective 'and'. The rule-based expert systems have a wide range of applications for diagnostic tasks where expertise and experinence are available but deep understanding of the physical properties of the system is either unvavailable or too costly to obtain. In the rule-based systems, knowledge is represented in the form of production rules (Angeli, 2010).

1.3. The Inference Engine

The inference engine in this study operates by the method of forward chaining. In order to execute a rule-base expert system using the method of forward chaining, we merely need to fire (execute) actions whenever they appear on the action list of a rule whose conditions are true. This involves assigning values to attributes, evaluating conditions and checking to see if all of the conditions in a rule are satisfied. A general algorithm of this might be:

While Values for attributes remain to be input
    Read Value and assign to attributes
    Evaluate conditions
    Fire rules whose conditions are satisfied
End while

The conditions are only evaluated at the time they might change and that the rules are checked to see if all of their conditions are satisfied, only when they might be ready to be fired, not before.

We can represent the basic component in the rulebase system of this inference engine as follows:

$$\text{Attribute}: x1, x2, \ldots., xn1$$
$$\text{Conditions}: c1, c2, \ldots., cn2$$
$$\text{Rules}: R1, R2, \ldots., Rn3$$
$$\text{Actions}: A1, A2, \ldots., An4$$

We only need to execute an action when a rule containing it is fired. We fire a rule only when all of its conditions are satisfied. To detect this we shall assign a counter to each rule and use it to keep track of exactly how many of the conditions in the rule are currently satisfied. Thus, we only check to see if a rule is ready to fire when one of its conditions has become true. In turn, a condition needs to be evaluated only when all of its attributes have been defined and one has changed. The failure at the car can be divide into 5 types:

- The failure at the engine systems
- The failure at the cooling systems
- The failure at the brake and leg's car
- The failure at the transmission systems
- The failure at the electricity

The Bayes probability theory is used to calculate the probability of occurrence of an event based on the effect obtained from testing. Bayes probability of the relationship between the probability of hypothesis Hi with the fact (evidence) E has occurred and the probability of evidence B provided that the hypothesis Hi has occurred. This theorem is based on the principle that if there is additional information or evidence the value of probability can be improved, so that the theorem is useful to modify or improve the value of the possibility that there be better evidence-backed information or additional evidence. Bayes theorem equation mathematically written as Equation 1:

$$p(Hi \setminus E) = \frac{p(E \setminus Hi) * p(Hi)}{\sum_{k=1}^{n} p(E \setminus Hk) * p(Hk)} \quad (1)$$

Where:

P(Hi\E) = The hypothesis probability Hi is true if given an evidence E

P(E\Hi) = The probability E if E raised and known that Hypothesis Hi is true

P(Hi) = Hypothesis probability without consider any evidence/fact

P(E) = The probability of evidence E

If there is a new symptoms, the formula become Equation 2:

$$p(Hi\}E, e) = p(Hi \setminus E \frac{p(e \setminus E, Hi)}{p(e \setminus E)} \quad (2)$$

Where:

e = The old evidence, E is the new evidence

p(Hi\E, e) = The probability of hypothesis Hi if the new evidence E from the old evidence e

p(e\E, Hi) = The conditional probability between the old evidence e and the new evidence E if the hypothesis Hi true

P(e\E) = The conditional probability between the old evidence e and the new evidence E without consider any hypothesis

Example

If a car is experiencing the symptoms of a heat engine and this expert system calculates possibility that a faulty radiator. Possible overheat engine if the radiator was broken Equation 3:

$$p(\text{heat engine} \mid \text{raduator}) = p(HE \mid R) = 0.9 \quad (3)$$

The possibility radiator damaged without consider others symptoms Equation 4:

$$p(\text{radiator} \mid \text{damage}) = p(R) = 0.33 \quad (4)$$

The possibility water of reservoir tube decrease if the radiator damaged:

$$p(\text{water of reservoirtube\_decrease} \mid \text{radiator}) = p(\text{wrestube} \mid R) = 0.5$$

The possibility the pipe of radiator damaged without consider other symptoms Eqution 5:

$$p(\text{radiatorpipe\_damage}) = p(R) = 0.33 \quad (5)$$

The possibility of water of radiator decrease if the radiator damaged Equation 6:

$$p(\text{water of radiator dectease} \mid \text{radiator}) = p(\text{wradiator} \mid R) = 0.6 \quad (6)$$

The possibility of the cop of radiator damaged without consider other symptoms Equation 7:

$$p(\text{radiator\_damage}) = p(R) = 0.33 \quad (7)$$

The possibility or the radiator damaged because of the overheat of engine Equation 8:

$$p(\text{radiator} \mid \text{over heeat\_engine}) = \frac{p(HE \mid R) * p(R)}{(p(HE \mid R) + p(\text{wrestube} \mid R) + p(\text{wradiator} \mid R))} * pR = 0.45 \quad (8)$$

This value indicate that the failure happened in the radiator with the beliefness 0.45 in the range of 0-1. After the next observation, it found the new symptom, that the water of reservoir tube decrease, so the next calculation become.

The possibility of the radiator damaged caused by overheat engine and the water of reservoir tube decrease Equation 9:

$$p(\text{radiator} \mid \text{over heeat engine, wretube}) = \frac{p(HE \mid R) * p(R)}{(p(HE \mid R) + p(\text{wrestube} \mid R) + p(\text{wradiator} \mid R)) * pR} = \frac{0.9 * 0.33 + 0.5 * 0.33}{(0.9 + 0.5 + 0.6) * 0.33} = 0.7 \quad (9)$$

and after deep observation, we got a new evidence that the water in radiator decreased. The possibility radiator damaged because of the engine is over heat and water in the reservoir decrease and water in the radiator also decreased is Equation 10:

$$p(\text{radiator} \mid \text{over heeat engine, wretube, wradiator}) = \frac{p(MP \mid R) * p(R) + p(AresK \mid R) * p(ARadK \mid R) * p(R)}{p(MP \mid R) * p(R) + p(AresK \mid R) * p(ARadK \mid R) * p(R)} = \frac{0.9 * 0.33 + 0.5 * 0.33 + 0.6 * 0.33}{0.9 * 0.33 + 0.5 * 0.33 + 0.6 * 0.33} = 1 \quad (10)$$

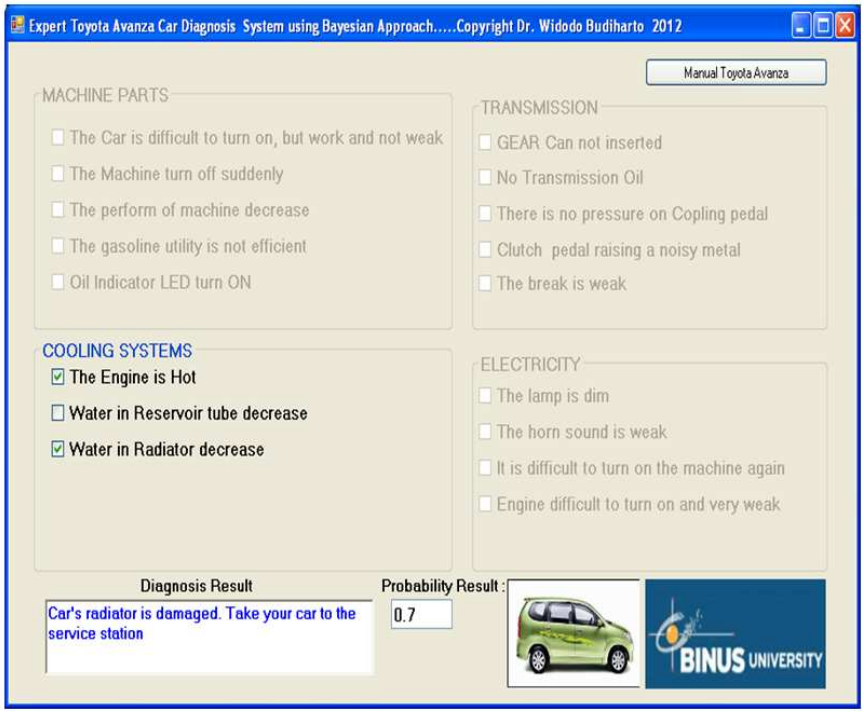

Fig. 3. Application result using Bayesian

Table 1. Symptoms and its probabilities

Failures	Symptoms	Probability
Fuel pump (0.5)	The car can't start	0.7
	Engine suddenly dead	0.2
Injector (0.3)	Engine performance decrease	0.4
	Engine difficult to turn on	
	Overheat engine	0.9
Radiator (0.33)	Water in reservoir decrease	0.5
	Water in radiator decrease	0.6

By seeing the symptoms, we know that the failure comes from the radiator and this give the level of beliefness that the radiator is damaged to 100% as shown in **Fig. 3**. **Table 1** show the symptoms and its probabilities in Toyota Avanza car in Indonesia.

1.4. Experimental Results

The experiment conducted using Toyota Avanza Car (Popular family car in Indonesia) shows that 90% the application able to diagnose the symptoms of the car failure such as fuel pump, dead injector and overheat engine. Diagnostic problems are considered as ill-strucured problems where there are no effiction algorithm solution because all the symptoms for all faults are not known in advance. The effectiveness of diagnostic reasoning lies in the ability to infer using a variety of information and knowledge sources.

2. CONCLUSION

Based on the experimental result and evaluation of our proposed model, the expert car diagnosis system able to diagnose the failure of the car. The Bayesian approach assist system in making decision more accurate.

3. REFERENCES

Angeli, C., 2010. Diagnostic Expert Systems: From Expert's Knowledge to Real-Time Systems. In: Knowledge-Based Systems, Akerkar, R. and P. Sajja (Eds.), Jones and Bartlett Learning, Sudbury, ISBN-10: 0763776475, pp: 50-73.

Buchanan, B., 1983. Constructing and Expert System. In: Building Expert Systems, Hayes-Roth, F., Waterman, D., and D. Lenat (Eds.)., Addison-Wesley, London, ISBN-10: 0201106868, pp: 127-169.

Denton, T., 2006. Advanced Automotive Fault Diagnosis. 1st Edn., Routledge, ISBN-10: 0750669918, pp: 271.

Folorunso, I.O., O.C. Abikoye, R.G. Jimoh and K.S. Raji, 2012. A Rule-Based Expert System for Mineral Identification. J. Emerg. Trends Comput. Inform. Sci., 3: 205-210.

Jackson, P., 1999. Introduction to Expert Systems. 3rd Edn., Addison Wesley, Harlow, ISBN-10: 0201876868, pp: 542.

Russel, S.J. and P. Norvig, 2010. Artificial Intelligence: A Modern Approach. 3rd Edn., Prentice Hall, Upper Saddle River, NJ., ISBN-10: 0132071487, pp: 1132.

Salama, A., M. Mostafa and Sharifuddin, 2012. Implementing an Expert Diagnostic Assistance System for Car Failure and Malfunction. Int. J. Comput. Sci., 9: 1-7.