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# Expert System for Deciding a Solution of Mechanical Failure in a Car using Case-based Reasoning

# Expert System for Deciding a Solution of Mechanical Failure in a Car using Case-based Reasoning

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**Abstract**. The research implements a Case-based Reasoning method into an expert system to help mechanical team in an automobile service station in relation with making a specific decision to address customer complaints. A number of mechanistic criteria and potential alternatives are designed, using knowledge-based as a system backbone which is elaborated into four main general phases known as retrieving similar problems, reusing knowledge, revising solution and retaining experiences to fortify a best solution. Technically, an on line application system are constructed by *Object-oriented Software Engineering* (OOSE) model to serve end-users interactively. The result of this study indicates an on line expert system where the application not only can be effectively utilized by specialized team but also be able to serve as a knowledge bridge for other.

## 1. Introduction

The Indonesian Association of Automobile Industry (Gaikindo) stated that in 2010 the amount of sold car were 764.710 units and 894.164 units in 2011, then it continued raising significantly in the following year (2012) at about more than 1 million units sold, the trend was not stop but continued in 2013-2014 which increase about 68.000 for accretion per year [1]. These indicates that the rate of demand for this sector experienced some significant escalation. This phenomenon is leading to the need of supplementary facilities availability provided by each related agent. This fact also gives a numerous challenges or even chances for software designers and programmers to gain business value by producing applications such as an expert system to identify damages and find a proper solution.

Detecting car process failure is a complex process and requires a high level of expertise in its completion. Any attempt made in the development of an expert system to deal with car failure detection must overcome various difficulties, especially according to the standards contained in the manual. In the previous study described for some of the needs of expert systems and some problems in developing a knowledge-based system, the detection process undertaken in the detection of car engine failures and some difficulties involved in system development. Then describes some of the components involved therein which will then be described as the type of failure, the cause, and some recommendations of results to be made.

Since 2010, along with the increasing of vehicle amount, the existing companies in mechanical reparation business sector in Indonesia become more needed. Although there are a lot of technology and other auto-system are developed and implemented by large companies where the main knowledge of troubleshooting mechanical failure is only being in the high-cost systems and its experts. However, there is still a gap between service capacity and daily requirement. The aim of this study concerns to design and develop an expert system which can play an effective role whenever the automobile user faces mechanical failures by using an online application. In this context, a specific type of car is used as a case study.

## 2. Methods

System configuration was designed to identify information system needed by expert system including data flow, data processing and selecting components (hardware and software system), then analyzing database design, decision model, dialog model, and communication network based on a proposed systems performance. Designing model, using data sources which ware obtained by observation, interview and reviewing relevant literatures, model integration into a system using a recommended system by Amin and Ramdhani [2].

Conducting all four CBR phases for the research object. This process will provide a solution which has been developed and adapted to solve some similar problem in troubleshooting mechanical failures of a specific vehicle. Developing an end-product (online application) by object-oriented software engineering method as a result. To design the model applied in the development of this expert system is done by conducting field studies to the car service company to conduct interviews and ask some questions to the head of service and mechanics who have experience about some things that are very relevant relevance to some problems that will be developed on This expert system model is certainly in accordance with the guidelines issued by the car company's international standards.

## 3. Results and discussion

The application made is basically a reference/ recommendation for mechanic to take a decision in repairing car. The decision is a selection of several alternative actions may be selected, which process is a particular mechanism expected to result in the best decision [3]. Preparation of decision model is a way to develop logical relations that bases the decision problem into a model, which reflects the relationship between the involved factors, so that the application program must be able to describe the accurate problem solving in tackling the engine damage problem.

The Information technology is designed by aim of simplifying the complexity of a human's workload [4]. By this general objective, the cutting edge tool of technology is taken into account massively at almost all professions by developing an expert system (ES) as a supporting facility in analyzing problem.

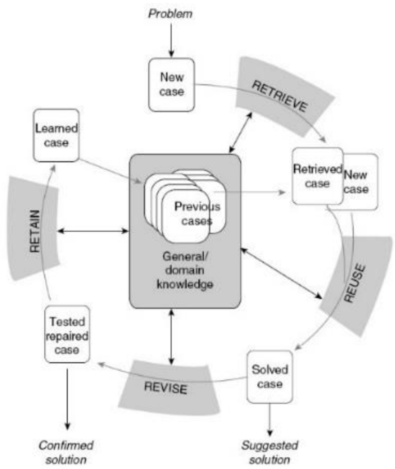


**Figure 1**. CBR Cycle [5]

ES is a computer program that employs the knowledge of human experts to solve problems that usually would require human intelligence [6] [7]. ES attempts to reach a level of performance by means of solving problems comparable to that of a human expert in some specialized application domain [8]. ES consist of two main parts: the knowledge base and the inference engine. The knowledge base contains the ES knowledge which can be catalogued as: factual and heuristic. Factual knowledge can be typically found in books, articles, journals, etc. Heuristic knowledge is more experiential and it is rarely discussed. The heuristic knowledge is derived from good training, good judgment, and plausible deduction in the field. These two kinds of knowledge are organized and represented as rules IF-THEN. The inference engine manipulates the information stored in the knowledge base in order to form a line of reasoning using a search pattern technique. This engine was built into program modules according to the problem-solving designed method [7]. Moreover, ES also become one of the well-known reasoning techniques that was 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 [9]. The norms in the design of technology devices, that should be utilized and adapted quickly by users [10].

Case-based Reasoning (CBR) is an approach for solving problems based on solutions of similar past cases [5]. Moreover it is stated that CBS approach focused its attention on solving problems and dealing with new situations by considering previous experiences similar to current situation [5]. Technically, CBS is trying to collect similar past cases with new problem and attempt out to modify a solution in order to be in line with new case [5]. CBR consist of four main phases (Figure.1.):

- RETRIEVE the most similar case or cases;
- REUSE the information and knowledge in that case to solve the problem;
- REVISE the proposed solution; and
- RETAIN the parts of this experience likely to be useful for the future problem solving.

### 3.1. *Similarity Value Estimation phases for each case*

*3.1.1. Phase -1.* Input of failure category and failure indication are the first phase which should be clearly done by a technician, they are grouped as a targeted case (Table 1).

**Table 1.** Input Target Case

| Failure Category | Failure Indication |
|---|---|
| Engine | A1 |
| Engine | A5 |
| Engine | A7 |
| Transmission | B3 |
| Transmission | B4 |

*3.1.2. Phase -2.* Searching similar case in the database. Table 2 below is an example of searching result of past cases at the case-based.

**Table 2.** Case Base

| Case | | Diagnosis | Result |
|---|---|---|---|
| Case code | Indication | | |
| KS0001 | A1, | Empty fuel | Check fuel tank, fill if empty |
| KS0002 | A1, A10, A2, A3, B1, | No/ malfunction ignition | Check the electrical coil, if it is fail, replace spark plug and coil, recheck power on battery |
| KS0003 | A1, A6, E2, | Compression leakage | Use a compression tester, set it down to the tread of sparking plug slot, cranking the engine to quantify pressure of standard psi at each motor type. |
| KS0004 | A1, A2, A4, D2, T1, T2, | Unclean/ defective sparking plug | Clean the sparking plug or replace if it produces insufficient ignition |
| KS0013 | A5, | Malfunction Capacitor Discharge Ignition | Replace Capacitor Discharge Ignition with recommended specifications |
| KS0016 | A7, | Defective Valve Seal | Replace valve seal using removal tool |
| KS0017 | A7, D2, | Malfunction automatic couple machine | Clutch replacement. |
| KS0019 | A1, A9, | Clutch housing comp Incompatibility | Setting the couple or replace clutch housing comp. |

*3.1.3. Phase -3.* Weighting priority for each case attribute is listed in Table 3 below

**Table 3.** Weighting Priority

| Failure category | Weight | Failure indication | Weight |
|---|---|---|---|
| Engine | 4 | A1 | 9 |
| Engine | 4 | A5 | 7 |
| Engine | 4 | A7 | 4 |
| Transmission | 2 | B1 | 10 |
| Transmission | 2 | B4 | 7 |

*3.1.4. Phase -4.* A case similarity is processed by using similarity formulation as follow:

$$Sim\ (S,T) = \sum_{i=n}^{n} f(S_i, T_i) \times W_i \qquad \dots (1)$$

**Table 4.** Quantifying Similarity

| Case code | A1 | A5 | A7 | B1 | B4 | *Similarity* |
|---|---|---|---|---|---|---|
| KS0001 | 1 | 0 | 0 | 0 | 0 | 0.40 |
| KS0002 | 1 | 0 | 0 | 1 | 0 | 0.86 |
| KS0003 | 1 | 0 | 0 | 0 | 0 | 0.47 |
| KS0004 | 1 | 0 | 0 | 0 | 0 | 0.46 |
| KS0013 | 0 | 1 | 0 | 0 | 0 | 0.43 |
| KS0016 | 0 | 0 | 1 | 0 | 0 | 0.37 |
| KS0017 | 0 | 0 | 1 | 0 | 0 | 0.37 |
| KS0019 | 1 | 0 | 0 | 0 | 0 | 0.40 |

Table 4 illustrates that the highest similarity value is at KS0002, then the diagnosis and potential solution used to target case will be taken from diagnosis and solution of KS0002. In this case, the result or solution is showed by Table 5.

**Table 5.** Sample Solution for Targeted Case

| Case code | Diagnosis | Solution |
|---|---|---|
| KS0002 | No/ dis-function ignition | Check the electrical coil, if it is fail, replace spark plug and coil, recheck power on battery |

*3.1.5. Phase -5.*

**Table 6.** Member of Degree using Fuzzy Logic

| Low | Moderate | High |
|---|---|---|
| $0 \le x \le 0.5$ | $0.45 \le x \le 0.75$ | 0.7-1 |

A model of degree member using fuzzy logic (Table 6) is formulated as comparable value which is in this study used to identifying the similarity criteria of diagnosis and solution for the targeted case. Since the process of quantifying similarity of KS0002 is (SIM) = 0.86 (Table 4) then the value is categorized as High. Thus for next used formulation is:

$$\mu(High) = \frac{x - 0.7}{0.15} = 1 \qquad \dots (2)$$

The results can be concluded that the similarity level of the past case towards the similarity value (0.86) having a high similarity level after compared to targeted case.

### *3.2. Designing end-product*

Object-Oriented Software Engineering (OOSE) is a software design technique that is used in software design in object-oriented programming. OOSE is developed by Ivan Jacobson in1992. OOSE is the first object oriented design methodology that employs use cases in software design. OOSE is one of the precursors of the Unified Modeling Language (UML), such as Boosch and OMT. It includes: requirements, analysis, design, implementation, and testing model [11] [12].

In this study, the application system was designed by many artifacts on every phases of software development, considering the limitation, author will only figured out the two of all design, these were preliminary use cases (Fig.2.) contained 7 use cases (About, Product, Failure Category, Failure Indication, Failure diagnosis, Case Similarity and Contact) which provided many functions and class diagrams which were elaborated into 7 classes (Fig.3.) including class of Indication, class of History, class of User, class of Diagnosis, class of Case-base, class of Category and class of Image.

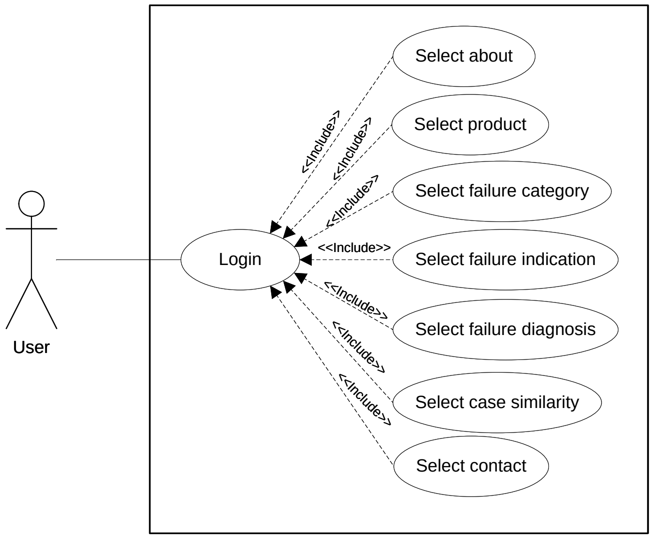


**Figure 2.** Use case diagram

Based on requirement analysis, the designed application covers process performed on the application program, which was furtherly designed into the use case diagram. The use case diagram illustrated the application page to be accessed by the end user, namely: login users, product description, damage category and diagnosis and damage similarity calculation.

Class diagram illustrated the application ability to describe class structure and description, package and object and their relationship. In addition, the class diagram described the relationship between classes in an application made such as class name, class attribute and the operations performed by the classes, which then will produce a clear relationship between member identity in creating database and designing system so that they will collaborate to achieve goal. The relationship pattern between user and user history will appear after accessing the system; the resulted image related to the diagnosis performed by the system.

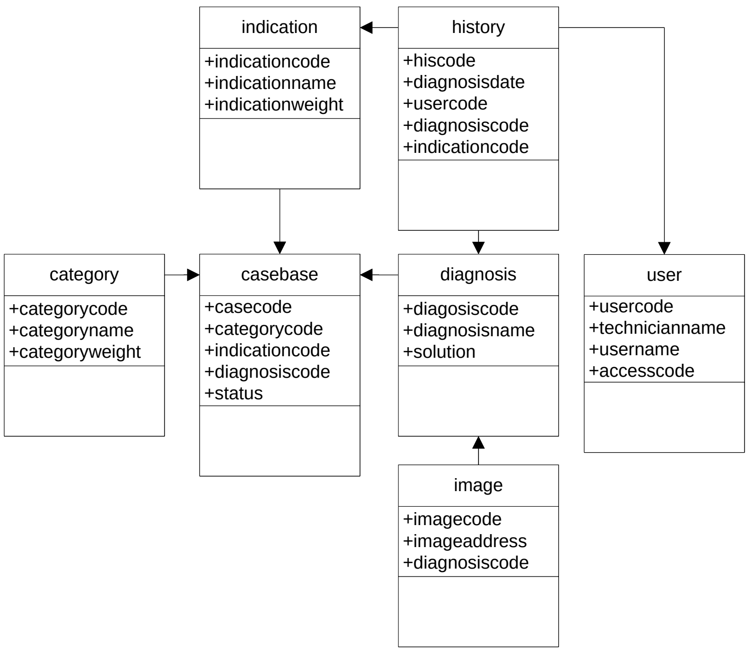


**Figure 3.** Class diagram

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## 4. Conclusions

Through this study, the authors propose an expert system supported by a CBR method for a technical support or mechanical team in a car repair shop in identifying and deciding a solution of a failure. Apart from specialized technicians, the end product is also dedicated to all users whenever they find such a mechanical failure at their vehicle. The application is designed as a dynamic system towards any changes and updating. Some authorized experts can easily update the database for system and knowledge improvement.

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