Journal of Theoretical and Applied Information Technology
31st August 2014. Vol. 66 No.3

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

AN EXPERT SYSTEM TO DETECT CAR DAMAGE BY USING CART METHOD

[1] PRATIWI KUSUMA PUTRI, [2] I KETUT GEDE DARMA PUTRA,
[3] NI MADE IKA MARINI MANDENNI
[123]Department of Information Technology, Udayana University, Bali, Indonesia
E-mail: [1]wiwik_putrii@yahoo.com , [2]ikgdarmaputra@gmail.com, [3]ika_made@yahoo.com

ABSTRACT

The information of car fault by car breakdown symptoms is the important thing to note. In this study created on expert system to detect damage to the car by using Classification And Regression Tree (CART) Method. CART method is a method of classification with decision tree modeling. The input from this study is the data derived from the expert. This study includes three main processes, namely the identification of the input stage. Stage of learning and classification stage. The learning stage produces the decision tree output as a rules detection of car damage. The classification stage produces the output in the form of car damage detection results based on the symptoms that entered by the users.

Keywords: *Expert System, CART, Detection of Damage , Decision Tree, Car Damage.*

1. INTRODUCTION

Due to advancement in technology getting a car is cheap, but maintaining it is very expensive. It is also difficult to get a good mechanic [1]. The proposed system for dealing with the problem is an expert system. An expert system is a system that employs human knowledge captured in a computer to solve problem that ordinarily require human expertise [2]. Expert system seek and utilize relevant information from their human users and from available knowledge bases in order to make recommendations [3].

There are several approaches that could be used in building an expert system. The one that seems right for this case of detecting symptoms of this car is by using the Classification And Regression Tree Method (CART). This method is a method that can be applied to large amount of data, very much variables and through binary sorting procedure [4].

Based on the above, the authors design and create a system that can act as a car mechanic (experts), using a web-based CART approach.

This study includes three main processes, they are the identification of input stage, stage of learning and classification stage. The input identification phase sourced from experts, experts in this study was a mechanic/auto mechanic. The data were provided by expert in the form of car damage diagnosis from damage symptoms. Learning phase involves determining the prospective branch. The calculation scale of suitability which produces output binary decision tree [5]. Classification stage is the stage of user inputs the damage symptoms that produce the car damage's diagnosis, the classification stage here use the rule of decision trees generated by CART algorithm [6].

Deepa ST [1] et al also design expert system rules to detect damage to the car used forward chaining. Rules provide a formal way of representing recommendations, directives or strategies, they are often appropriate when the domain knowledge results from empirical associations developed through years of experience solving problems in an area. In principle, any consistent formalism in which can express knowledge about some problem domain can be considered for use in an expert system. IF-THEN rules turn out to be a natural form of expressing knowledge and have the following additional desirable features. But this rule has the disadvantage, the number of variables and data that are very much will cause the system become not effective for the type of damage that has more damage variable. By Deepa ST [1] et al, we develop the car damage detection expert system which can be more effective for the type that has more car damage by using the CART method.

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Limitation of issues contained in this system is the system is limited to the knowledge base and the data obtained, there are only 34 cars for the type of damage to the system, this system uses the CART method based reasoning to infer where the symptoms are there to draw a conclusion, the resulting output is the possibility of damage caused to the car.

2. CAR DAMAGE

Based on 25 parameter class which is temperature, when engine turn on, smoke, fuel, oil seepage, oil indicator, water reservoir, water radiator, water temperature indicator, water seepage, brake fluid seepage, battery indicator, brake, brake pedal, bums, wheel, the clutch, gear, light, horn, on off, engine off and sudden death, Table 1 is for car damage and the parameter problem [7].

Table 1: Car Damage

No	Car Damage	Parameter Problem
1	Radiator	Temperature engine hot
		There is water seepage on the bottom of the car
		Car suddenly death
2	Radiator Tube	Car Engine Hot
		There is water on the bottom of the car
		Car never sudden death
3	Radiator lid	Engine temperature hot
		Less water reservoir
4	Radiator fan	Engine temperature hot
		Water reservoir exceed the limit
5	Tie rod	Engine temperature hot
		Swing wheel
6	Thermostat	Engine temperature cold
		Fuel wasteful
7	Light	Light off
8	Brake master	Brake not grip
		There is brake fluid seepage
9	Horn	Horn not sound
10	Brake booster	Brake not grip
11	Clutch	Hard to stomp the clutch
12	Clutch master	Gear difficulty to enter
		Brake not grip
13	Battery (ACCU)	Difficult to starter
		Engine sometime turn off
14	Fuel Pump	Difficult to starter
		Car engine suddenly death
15	Depleted gas	Difficult to starter
		Engine death
16	Magneto ignition broken	Engine turned hardly but can turn on
17	Damaged coil	Vehicle difficult turned
		Wasteful fuel consumption
18	Injector or carburetor	Vehicle difficult turned
		Wasteful fuel consumption
		black smoke
19	Throtle Body	Vehicle difficult turned
		Wasteful fuel consumption
		black smoke
		Car engine dies
20	oil Leaks	The sound of metal clashing
		Oil indicator lights up
		There is oil seepage under the vehicle
21	Engine Knocking	Tickling sound while running car
22	Broken car axle	Whoosh sound
23	Clutch Bearings	Gear difficult to enter
24	Car transmission problem	sounded like metal clashing sound clash
		Gear difficult to enter
		Unusual sound like a buzzing sound
25	fan belt	Screeching sound
		Heavy steering wheel
26	Bearing	Steering wheel is not normal, sometimes shake or weight
		Rumbling sound
27	Burshing stabilizer	Steering wheel is not normal, sometimes shake or weight
		Screeching sound when uneven road
28	Shock breaker	Rumbling sound
		Steering wheel is not normal, sometimes shake or weight
		As we passed the bump feels like swinging
29	Plug	Wasteful fuel consumption
		black smoke
		Car engine dies

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30	Power Steering	Screeching sound
		Steering wheel shake
31	Velg	Steering wheel shake
32	Damaged Brake Shoes	Sounds like brake squeal
		Brakes do not grip
33	Car tires	steering wheel shake

3. THE EXPERT SYSTEM

Expert system are classified into six categories [8]. There are Rule-based system, Knowledge-based system, Intelligent Agent (IA), Database methodology, Inference engine, System-user interaction.

Expert system consists of user interface, explanation facilities, knowledge base and inference engine. The expert system structure shown in the figure 1.

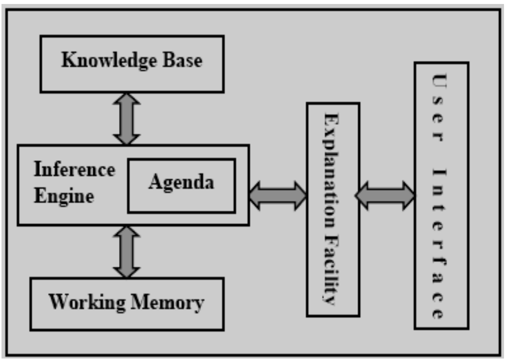

Figure 1 Expert System Structure [8]

4. CLASSIFICATION AND REGRESSION TREE (CART)

CART (*Classification and Regression Trees*) is one of the methods or algorithms of any of the techniques of data exploration decision tree as for the characteristics of this method, which is a binary has two branches for each decision node [9]

4.1 CART Algorithm Steps

The CART algorithm steps are as follow [10]

4.1.1 Determine the Candidate Split

Determine the candidate split of each parameter, that is by looking for a candidate with the right and left split based on class variable [9][10].

4.1.2 Calculate the value of P_L and P_R

Calculate the value of P_L at each candidate split, where PL is a chance left candidate split on on the training data and t_L is left candidate split at a decision node t[9][10].

$$P_L = \frac{amount\ of\ left\ candidate\ split\ t_L}{amount\ of\ training\ data} \quad (1)$$

Then calculate the value of P_R on every candidate split of each parameter. Where P_R is the possibility of right candidate split at training data and t_R right candidate split on decision node t

$$P_R = \frac{amount\ of\ right\ candidate\ split\ t_R}{amount\ of\ training\ data} \quad (2)$$

4.1.3 Calculate the value of $P_{(j/tL)}$ and $P_{(j/tR)}$

Calculate the value of $P_{(j/tL)}$ for each class for every candidate split at every each parameter. $P_{(j/tL)}$ is an possibility of left candidate split at every class and T_L is the left candidate split at decision node t[9][10].

$$P_{(j/tL)} = \frac{amount\ of\ j\ data\ on\ the\ left\ candidate\ split\ t_L}{amount\ of\ j\ data\ on\ the\ training\ data} \quad (3)$$

Calculate the value of $P_{(j/tR)}$ for each class for every candidate split at every each parameter. $P_{(j/tR)}$ is an possibility of right candidate split at every class and T_R is the right candidate split at decision node t

$$P_{(j/tR)} = \frac{amount\ of\ j\ data\ on\ the\ right\ candidate\ split\ t_R}{amount\ of\ j\ data\ on\ the\ training\ data} \quad (3)$$

4.1.4 Calculate the value of $2P_LP_R$

Calculate for value of $2P_LP_R$ on the first candidate split. Where P_L is the possibility of left candidate split on training data and P_R is the possibility of right candidate split on training data[9][10].

$$2P_LP_R = 2 \times P_L \times P_R \quad (5)$$

4.1.5 Calculate the value of $Q_{(s|t)}$

Calculate the value of $Q_{(s|t)}$ on the first candidate split, where $Q_{(s|t)}$ is the sum of all reductions $P_{(j|tL)}$ and $P_{(j|tR)}$. $P_{(j/tL)}$ is an possibility of left candidate split at every class. $P_{(j/tR)}$ is an possibility of right candidate split at every class[9][10].

$$Q_{(s|t)} = \sum_{j=1}^{category} \left| P_{(j|tL)} - P_{(j|tR)} \right| \quad (6)$$

4.1.6 Calculate the value of $\theta_{(s|t)}$

Calculate the value of $\theta_{(s|t)}$ on the first candidate split where $\theta_{(s|t)}$ is the sum of all the reductions $P_{(j|tL)}$ and $P_{(j|tR)}$ times with $2P_LP_R$. Where $P_{(j/tL)}$ is an

Journal of Theoretical and Applied Information Technology
31st August 2014. Vol. 66 No.3

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

possibility of left candidate split at every class, $P_{(j/tR)}$ is an possibility of right candidate split at every class, P_L is a chance left candidate split on on the training data and P_R is the possibility of right candidate split at training data[9][10].

$$\emptyset_{(s|t)} = 2 P_L P_R \sum_{j=1}^{category} \left| P_{(j|t_L)} - P_{(j|t_R)} \right| \quad (7)$$

4.1.7 Draw a decision tree

After getting the amount of conformity the next step is to describe the rule that a decision tree of greatest magnitude specific maximum $\theta_{(s|t)}$ for the main node. Then proceed to the next iteration until the leaf nodes and form a complete decision trees (*fully grown from*) [9][10]..

5. SYSTEM OVERVIEW

The system is divided into two of control room, first systems administrator that is rooms that serve to manipulate (add, modify, and delete) data management such as user data, symptom data, diagnostic data, the data questions and others. Second, room visitors or users that can only access information of a general nature, such as the detection process systems can also view information about car damage. This system is a web-based system to be built with the aim to facilitate knowledge about the damage to the car, so that later created a system that can give information even assist in the detection of a malfunction. The system will provide a diagnosis of any damage suffered by a car based on the symptoms of a given user. The approach set out in this expert system using Classification And Regression Tree (CART) method

. In the process, the user will interact with the system through a debriefing process. The question posed system is presented using a knowledge based tree modeling, then the system asks questions with multiple choice answers corresponding variable parameters that have been analyzed first. The output of this system is the conclusion of what the car suffered damage produced by such methods.

Overview of the system can be seen in the image below:

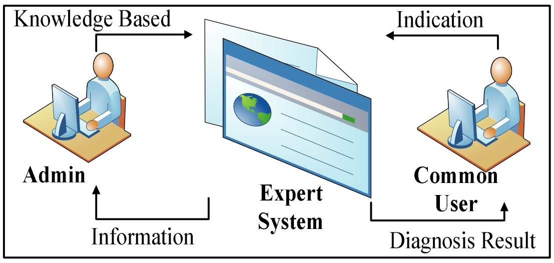

Figure 2 General Overview Process of Car Damage Detection

6. TESTING AND ANALYSIS OF RESULT

Examination of the result of the calculation method of CART based on the result of decision tree generated by the equal system of the decision tree results calculation of the CART manually.

Provision aims to determine the value of θ(s|t) great suitability value of each candidate branch symptom questions at each damage [10]. This expert system is used to construct scale suitability rules. θ(s|t) values vary from each iteration.

6.1 Determine the Training Data

Training data taken from the literature study data and data experts. There are 36 pieces of training data, with 25 pieces parameters of damage symptom and 34 pieces parameters of damage class.

6.2 Determine the Candidate Split

The first step is to determine the candidate split can be seen in table 2.

Table 2 : Table Candidate Split

No	Parameter	Left Child Node (t_L)	Right Child Node (t_R)
1	When Switched On	Good	Tough
2	Temperature	Normal	Hot, Cold
3	Temperature	Hot	Normal, Cold
4	Temperature	Cold	Normal, Hot
5	Sound	Normal	Tickle, Iron Collided, Brake Squeal, Rumble, Squeaking uneven, Hum
6	Sound	Tickle	Iron Collided, Brake Squeal, Rumble, Squeaking uneven, Hum,

Journal of Theoretical and Applied Information Technology
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ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

			Normal
7	Sound	Iron Collided	Tickle, Brake Squeal, Rumble, Squeaking uneven, Hum, Normal
8	Sound	Brake Squeal	Tickle, Iron Collided, Rumble, Squeaking uneven, Hum, Normal
9	Sound	Rumble	Tickle, Iron Collided, Brake Squeal, Squeaking uneven, Hum, Normal
10	Sound	Screeching if uneven	Tickle, Iron Collided, Brake Squeal, Rumble, Hum, Normal
11	Sound	Squeaking	Tickle, Iron Collided, Brake Squeal, Rumble, Squeaking uneven, Hum, Normal
12	Sound	Hum	Tickle, Iron Collided, Brake Squeal, Rumble, Squeaking uneven, Normal
13	Smoke	Colorless	Black
14	Fuel	Normal	Wasteful
15	Oil seepage	There is/yes	No
16	Oil indicator	Turn on	Turn off
17	Water reservoir	Normal	Reduce, Exceed the limit
18	Water reservoir	Reduce	Exceed the limit, normal
19	Water reservoir	Exceed the limit	Normal, Reduce
20	Water radiator	Normal	Reduce
21	Water temperature indicator	Turn on	Turn off
22	Water Seepage	There is/yes	No
23	Brake Fluid Seepage	There is/yes	No
24	Indicator Brake Fluid	Turn on	Turn off
25	Battery Indicator	Turn on	Turn off
26	Brake	Grip	Not Grip
27	Brake Pedal	Normal	Trampling in
28	Bumps	Once	Swing
29	Wheel	Normal	Swing, Heavy
30	Wheel	Swing	Heavy, Normal.
31	Wheel	Heavy	Normal, Swing
32	Stomp the clutch	Normal	Hard, Sound, Deep
33	Stomp the clutch	Hard	Sound, Normal, Deep
34	Stomp the clutch	Sound	Deep, Normal, Hard
35	Stomp the clutch	Deep	Normal, Sound, Hard
36	Gear	Normal	Difficult to enter
37	Light	Turn on	Dim, Turn off
38	Light	Dim	Turn off, Turn on
39	Light	Turn off	Turn on, Dim
40	Horn	Turn on	Weak, Turn off
41	Horn	Weak	Turn off
42	Horn	Turn off	Turn on
43	On off	Yes	No
44	Engine Turn off	Turn on	Turn off
45	Sudden Death	Yes	No

Based on a split candidate performed calculations to obtain the amount of conformity $\theta_{(s|t)}$. As an example of calculating the first candidate split. As for the steps to find the suitability $\theta_{(s|t)}$ is as follow

6.3 Calculate the Value of P_L and P_R

Calculate the value of P_L at the first split candidate by using equation 1. Where there are 27 pieces of split t_L candidate who has a parameter When Switch On-Good and there are 36 pieces of data training.

$$P_L(1) = \frac{amount\ of\ left\ candidate\ split\ t_L}{amount\ of\ training\ data}$$

$$P_L(1) = \frac{27}{36}$$

$$P_L(1) = 0{,}75$$

Calculate the value of P_R at the first candidate split by using equation 2. Where there are 9 pieces of split t_R candidate who has a parameter When Switch On-Tough and there are 36 pieces of training data.

$$P_R(1) = \frac{amount\ of\ right\ candidate\ split\ t_R}{amount\ of\ training\ data}$$

$$P_R(1) = \frac{9}{36}$$

$$P_R(1) = 0{,}25$$

6.4 Calculate the Value of $P_{(J/Tl)}$ And $P_{(J/Tr)}$

Calculate the value of $P_{(j/tL)}$ at each class in the first split candidate by using equation 3

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ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

$$P_{(j/tL)} = \frac{\text{amount of } j \text{ data on the left candidate split } t_L}{\text{amount of } j \text{ data on the training data}}$$

$$P_{(j/tL)\,1.1} = \frac{0}{27} = 0$$

$$P_{(j/tL)\,1.2} = \frac{0}{27} = 0$$

$$P_{(j/tL)\,1.3} = \frac{1}{27} = 0{,}04$$

$P_{(j/tL)}$ values calculated up to the last class. that is the class to-34

$$P_{(j/tL)\,1.34} = \frac{0}{27} = 0$$

Calculate the value of $P_{(j/tR)}$ at each class in the first split candidate by using equation 4

$$P_{(j/tR)} = \frac{\text{amount of } j \text{ data on the right candidate split } t_R}{\text{amount of } j \text{ data on the training data}}$$

$$P_{(j/tR)\,1.1} = \frac{1}{9} = 0{,}11$$

$$P_{(j/tR)\,1.2} = \frac{1}{9} = 0{,}11$$

$$P_{(j/tR)\,1.3} = \frac{0}{9} = 0$$

$P_{(j/tR)}$ values calculated up to the last class. that is the class to-34

$$P_{(j/tR)\,1.34} = \frac{0}{9} = 0$$

6.5 Calculate the Value of $2P_LP_R$

Find the value of $2P_LP_R$ at the first candidate split by using equation 5

$$2PlPr = 2 \times Pl \times Pr = 2 \times 0{,}75 \times 0{,}25 = 0{,}375$$

6.6 Calculate the Value of $Q_{(S/T)}$

Find the value of $Q_{(s|t)}$ at the first candidate split by using equation 6

$$Q(s|t) = \sum_{j=1}^{Category} |P(j|t_L) - P(j|t_R)|$$

$$Q(s|t) = \sum_{j=1}^{34} |P(j|t_L) - P(j|t_R)|$$

$$Q(s|t) = |0-0{,}11| + |0-0{,}11| + |0{,}04-0| + |0{,}04-0| + |0{,}04-0| + |0{,}04-0| + |0{,}04-0| + |0{,}04-0| + |0{,}04-0| + |0{,}04-0| + |0{,}04-0| + |0{,}04-0| + |0{,}04-0| + |0{,}04-0| + |0{,}04-0| + |0{,}04-0| + |0{,}04-0| + |0{,}04-0| + |0-0{,}22| + |0-0{,}11| + |0-0{,}11| + |0-0{,}11| + |0{,}04-0| + |0{,}04-0| + |0{,}04-0| + |0{,}04-0| + |0{,}04-0| + |0-0{,}11| + |0{,}04-0| + |0{,}04-0| + +|0{,}04-0| = 2$$

6.7 Calculate the Value of $\theta_{(S/T)}$

Find the value of $\theta_{(s|t)}$ at the first candidate split by using equation 7.

$$\phi(s|t) = 2\,P_L\,P_R\,\sum_{j=1}^{category} |P(j|t_L) - P(j|t_R)|$$

$$\phi(s|t) = 0{,}375 \times 2 = 0{,}75$$

So the result of first iteration $\theta_{(s|t)}$ at the first candidate split was 0,75. This calculation is done as the number of candidate split, which is 45 times. The following table of calculation result using the method of CART in all of candidate split.

Table 3: Result of Calculation of The First Iteration on The Entire Candidate Split

Candidate Split	P_L	P_R	$2P_LP_R$	Q(s|t)	θ(s|t)
1	0.75	0.94	0.37	2	0.75
2	0.83	0.97	0.27	1.67	0.46
3	0.13	0.94	0.23	2	0.47
4	0.02	0.97	0.05	2.064	0.11
5	0.69	0.94	0.42	2	0.85
6	0.02	0.94	0.0	1.94	0.10
7	0.05	0.08	0.10	2.94	0.31
8	0.02	0.30	0.05	1.44	0.08
9	0.05	0.94	0.10	1.94	0.20
10	0.02	0.97	0.05	1.94	0.10
11	0.05	0.13	0.10	1.94	0.20
12	0.05	0.91	0.10	1.94	0.20
13	0.91	0.94	0.15	2	0.31
14	0.69	0.13	0.42	1.81	0.77
15	0.05	0.86	0.10	1.94	0.20
16	0.02	0.94	0.05	1.94	0.10
17	0.86	0.97	0.23	1.6	0.38
18	0.08	0.97	0.15	1.93	0.30
19	0.05	0.94	0.10	1.88	0.20
20	0.86	0.08	0.24	1.6	0.38
21	0.13	0.05	0.23	2	0.48
22	0.05	0.02	0.10	2	0.21
23	0.02	0.19	0.05	1.94	0.10
24	0.02	0.83	0.05	1.94	0.10
25	0.05	0.91	0.10	1.94	0.20
26	0.91	0.08	0.15	2	0.31
27	0.94	0.97	0.10	2	0.21
28	0.97	0.97	0.05	2	0.11
29	0.77	0.97	0.30	2	0.60

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ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

30	0.13	0.11	0.23	1.93	0.45
31	0.05	0.08	0.10	1.93	0.20
32	0.91	0.97	0.15	2	0.31
33	0.02	0.94	0.05	1.94	0.10
34	0.02	0.08	0.05	1.94	0.10
35	0.02	0.97	0.05	1.94	0.10
36	0.89	0.94	0.19	2	0.40
37	0.92	0.83	0.15	2	0.31
38	0.03	0.19	0.05	1.88	0.10
39	0.05	0.77	0.10	1.88	0.20
40	0.92	0.94	0.15	2	0.31
41	0.02	0.97	0.05	1.88	0.10
42	0.05	0.94	0.10	1.88	0.20
43	0.16	0.97	0.27	1.93	0.54
44	0.80	0.94	0.31	2	0.63
45	0.22	0.94	0.34	1.92	0.67

6.8 Draw a Decision Tree

Describe the rule in the form of a decision tree θ(s|t). The rule of decision tree drawn based on the biggest Q(s|t). That is a candidate split 5th. Candidate split 5th namely.

Table 4: Table Candidate Split 5th

Candidate Split	Parameter	Left Child Node	Right Child Node
5	Sound	Normal	Tickle, Iron Collided, Brake Squeal, Rumble, Squeaking uneven, Hum

Following the result of the decision tree rule based on the first iteration.

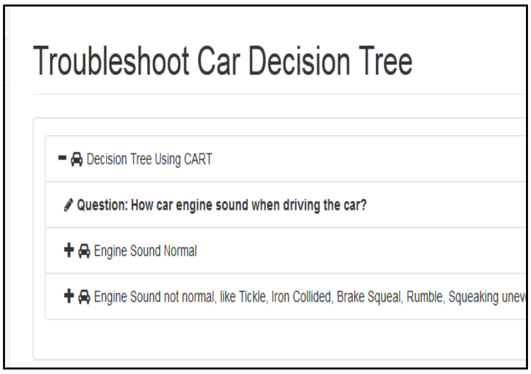

Figure 3 Decision tree rule based on the first iteration

And so on repeated back to step 1 until the end of the leaf nodes formed and form a complete decision tree (fully grown from). To form a complete decision tree takes as much as 56 times iteration. The following is decision tree complete figure (fully grown from).

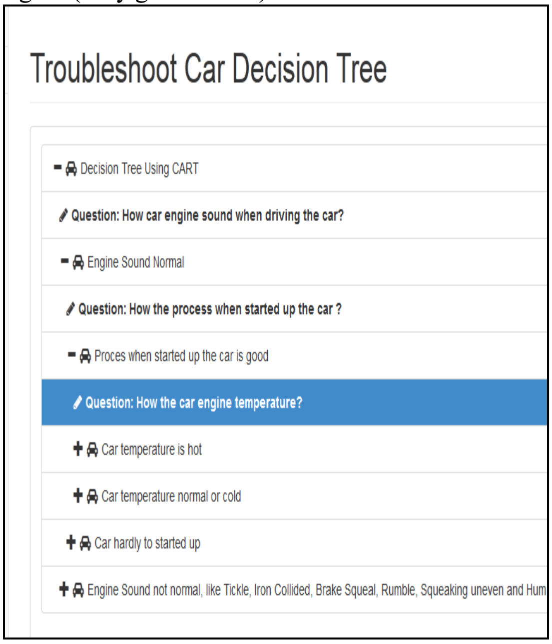

Figure 4 Decission Tree

6.9 Analysis Questionnaire

Questionnaires were distributed to respondents 5 to 34 pieces of the number of questions and 5 choices for the accuracy of the values are 1 very low, 2 low, 3 moderate, 4 high, 5 very high.

Based on the results of the data obtained recapitulation questionnaire respondents answered there is no one that is a very low value and the value of 2 is low, there are 25 answers to the value of 3 is moderate, there are 77 answers to the high value and there were 68 answers with a very high score.

The following table is a table of the results of questionnaires accuracy value of each variable damage based questionnaire.

Table 6 : Questionnaire Result

No	Damage Variable	Accuracy Value (%)
1	Damaged radiator	80
2	Damaged Radiator Hose	76
3	Radiator cap	76
4	Radiator fan	88
5	Tie rod	88

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

6	Thermostat	80
7	Light bulb	92
8	Brake masters	84
9	The car is not damaged or is not found damage	100
10	broken horn	92
11	brake booster	92
12	clutch plate	84
13	Master Clutch	96
14	Battery (batteries)	76
15	Fuel Pump faulty	84
16	gasoline Out	84
17	Magneto ignition broken	88
18	Damaged coil	84
19	Injector	84
20	throtle body	72
21	oil Leaks	92
22	Knocking machine	76
23	Broken car axle	80
24	Clutch Bearings	92
25	Car transmission problem	84
26	fan belt	86
27	Bearing	80
28	Burshing Stabilizer	92
29	Shock breaker	84
30	Plug	80
31	Power Steering	92
32	Alloy Wheels	88
33	Damaged Brake Shoes	80
34	Car tires	92

Based on the questionnaire calculation results obtained from the Assessment Questionnaire Results Diagnosis Expert System Damage Detection Method Using Car Cart has an average of 85.23% with the lowest value of the range is 72% and the highest value is 100%.

7. CONCLUSION

Conclusions drawn from this system is the method Classification And Regression Tree (CART) successfully implemented the answers given by the user and the data provided by the experts. CART method produces shorter rules, but has a high accuracy is the average accuracy of 85.23% thus suitable for detecting damage to the car, because this expert system has a lot of class variable damage.

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