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A User Information System for Diagnosing Faults in Passenger Cars

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ABSTRACT

Transportation plays a vital role in the development of any nation. The density of motor vehicles especially passenger cars and other commercial vehicles is increasing day by day. The vehicle experts may not be available particularly on long express highways in the vicinity of unidentified location where car failure takes place. The purpose of the study is therefore, to identify the root causes which help in car failure diagnosis and evolve a user information system. Eight major causes, forty four sub causes and 142 sub-sub causes have been identified. A cause and effect diagram has been developed through a process of iterative-interactive consensus driven methodology, as advocated by second generation system design paradigm. A user information system was developed which provide support to the car owners, drivers and inexperienced mechanical engineers in case of non-availability of the experts. The system has been tested and gave promising results.

KEYWORDS: Failure, Diagnosis, User information system, Cause and effect diagram.

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1. INTRODUCTION

Today transportation is the prime need for the development and growth of human being. The mode of transport facility provides better accessibility to banks, offices, hospitals, markets etc., with benefits that result in positive multiplier effects such as the socio-economic opportunities and new possibilities in employment and additional investments. Roads are the dominated mode of transportation in India and work as the lifeblood of the Indian economy. They carry almost 90% of the country's passenger traffic and 65% of its freight. The vehicles used for transporting passengers or goods depend upon the distance, weight quantity and volume.

Now a day the vehicles are the subject of status and hobbies rather than necessity for people. The vehicle manufacturers are increasing their production every year. The number of motor vehicle production is increasing gradually every year and expected to rise in forthcoming years too. About 90.78 million motor vehicles were produced globally in the year 2015 out of which India shares about 4.1 million excluding the production of three and two wheelers. In the financial year 2014-2015 the total production of vehicles were 23.4 million including passenger, commercial and three / two wheelers by Indian automobile industries.

As per the increasing demand Indian automobile companies are doing their expansions and the well-known foreign vehicle manufacturers too entering into the Indian market. Further the size of this market is expanding leaps and bounds which is a good signal for the better future of automobile industry. Therefore, automobile industries can be seen as an area of many employment opportunities for automobile and allied engineers particularly in India.

If a car is being compared with a human body it is being observed that there are several similarities as well as dissimilarities exist between them.

There are several systems in a car similar as in a human body, each performing some important role in the proper functioning of the car. For example if accumulation of heat took place in a human body due to problem in circulatory system, it results in an increase in body temperature causing human discomfort and disturbances in the functioning of the internal organs. So attempts are required to reduce the body temperature first by cooling the body and then diagnose the cause and if attention is not paid in time can cause severe damage to internal organs and may tend to death. Similar is the case with the car, if proper dissipation of heat is not taken place through the car engine the average temperature of the car increases and disorder took place in the normal functioning of the engine and if attention is not paid in time it can tend to severe damage to engine components. So proper cooling of a car engine is desired and cannot be neglected. It is clear with this example that the cooling system of a car is analogous to the circulatory system of a human body. There are several

systems of the car which are analogous to the systems in a human body although some of the analogies are as shown in Table 1.

Table 1- Analogies between a human body and a car

System Category	Human Body	Car
Primary	Heart	Engine
	Brain	Software
	Lungs	Air Filters
	Eyes and Ears	Array of advanced safety sensors
Secondary	Digestive system	Fuel system
	Endocrine system	Computer system
	Nervous system	Electrical system
	Respiratory system	Air induction system
	Urinary system	Exhaust system
	Skeletal system	Chassis system
	Muscular System	Power transmission system
Auxiliary	Organs control	ECU
	Knee	U-joint
	Hand	Steering
	Nostrils	Intake and exhaust manifold
	Social Security Number	VIN (Vehicle Identification Number)

Although there exist several similarities between a car and the human body; there are some basic differences exist between a human being and a car. A car is the creation of humans and it was created to make their transport easier and comfortable while cars do not create anything as such. Humans have different organs made of flesh and blood performing different functions while cars do have mechanical parts. Life is just not mechanical unlike cars for humans. Humans have feelings and emotions and can express their happiness, sorrow, pain, love, anger etc. while cars have no feelings and emotions and just work as per the details fed into their mechanical brain or operated by a human being. Humans have the capability to understand situations, and behave according to their consciousness but cars cannot do so. Cars do not have original thoughts unlike humans and in addition have limitations to their performance because they need humans to guide them. The differences between the few activities performed by a human being and a car are shown in Table 2.

Table 2- Differences between the activities of a human body and a car

Activity	Human Being	Car
Intelligence	Natural	Artificial
Age	Appreciated with time	Depreciated with time
Energy Source	Food and Drinks	Fuels

As like our body that needs regular check-up, diagnosis of disease and its treatment by a doctor for a healthy living, a car too need regular check-up, fault detection and remedy of the fault through preventive maintenance by an expert auto mechanic for smooth running and long life of the vehicle and would save money on repairs in future. The analogies between the maintenance of a car

and the treatment of a human body can be categorized in general, preventive and breakdown as shown in Table 3.

It is often frustrating to encounter any form of car-trouble particularly if the car owner is in a hurry or far away from an auto shop. Such type of incidents can be avoided with the regular car check-ups. Regular car repair and maintenance can help preventing the possibility of being stuck in such miserable situations. Maintenance of a car can range from basic car maintenance to an overall. Unfortunately, car maintenance work shops are still using traditional maintenance techniques with insignificant changes for automation.

When a vehicle comes across any fault, the driver would have to call either an automobile engineer or a roadside mechanic simply because he has no technical skill or knowledge to diagnose such faults. Dependence on the expert can be minimized if its expertise can be documented into computer system.

Basically car failure detection is a complicated process and requires high level of expertise. A diagnostic assistance system for car failure proved to be a very useful tool for equipment servicing and further it increases the worker's satisfaction.

Cho et al. initially proposed an expert system using fuzzy relations to deal with uncertainties imposed on a fault section diagnosis of power systems[1]. Gelgele et al. developed a prototype named EXEDS [expert engine diagnosis system] for an automotive engine using Knowledge Pro, an expert system development tool[2]. The developed prototype was to assist auto mechanics in fault diagnosis of engines by providing systematic and step-by-step analysis of failure symptoms and offering maintenance and service advice. As the developed model was restricted to engine only would not be useful for other important systems of the vehicle. Al-Taani also presented a knowledge based system for car failure diagnosis using CLIPS expert system language[3]. He claimed that the developed system can be extremely useful in consistent car failure detection although it is expected to improve it by adding sufficient domain knowledge.

Kim et al. devised a fault detection and diagnosis [FDD] method using decentralized and centralized approaches to enhance the reliability and safety for longitudinal control of an autonomous al-terrain vehicle[4]. Further Kim et al. developed a knowledge based hybrid failure diagnosis system for urban transit consisting of both electrical and mechanical entities for improving the reliability and efficiency of the maintenance process[5].

Table 3- Analogies between the maintenance of a car and the treatment of a human body

Maintenance / Treatment category	Human Body	Car
General	- Check height to weight ratio - Check age - Check eyesight - Check belly fat - Check extra thin - Check breathing - Check insufficient / extra sleeping - Check whether getting tired soon etc.	- Check all lights are working, - Check air pressure in tires - Listen for any strange sound inside and out - Check tires have enough tread - Check different fluid levels like antifreeze solution, power steering fluid, coolant fluid, wiper fluid, gear oil and fuel quantity - Check leakage of any fluid - Check battery leak - Check engine belt, timing belt - Check loose connections, rusting terminals - Check spark plug - Parking in shade etc.
Preventive	*Scheduled check up by the regular physician:* - Haemogram test - Blood Sugar test - Liver function test - Kidney function test - Lipid profile - Uric acid test - Chest X-ray - ECG Test - Hepatitis-B Test - TSH for thyroid - Abdomen ultrasound - Child / Adult vaccinations - Eye Checking etc.	*Scheduled inspection in company workshop:* - Washing and waxing - Changing clutch cables - Changing brake liners - Changing oils - Changing spark plug - Replace engine and cabin air filters - Replace wind shield wipers - Wheel balancing - Alignment check etc.
Breakdown	- Brain surgery - Organ transplant - Bypass surgery - Body joints replacement etc.	- Dead battery - Flat tire - Empty fuel tank - Engine belt / Timing belt broken - Coolant pump failure - Transmission failure - Car collision etc.

Apart from vehicle and power systems the computer based expert systems are increasingly used to improve the medical services by the precise diagnosis of human diseases. In this reference P. Patra et al. an analytical model for the diagnosis of common human diseases. In both cases there was a necessity to test the developed model on several more databases although databases are typical proprietary and difficult to obtain[6].

Sharma et al. presented a car failure fuzzy fault diagnostic system which uses fault tree analysis to represent knowledge of the casual relationships between various components of a car engine and process operation in the whole system[7]. The researchers reported that fault tree analysis is useful for system reliability and fault identification related risk involved in the system, since it illustrates the failure logic of a system and shows combinations and sequences of failure which can lead to a failure condition under consideration.

Jindal et al. developed a prototype model of car failure diagnosis expert system although with very limited utility[8]. Mostafa et al. also presented a Knowledge Based System (KBS) for car failure and malfunction diagnosis[9]. They reported the developed CFMDAS is utilized to assist inexperienced mechanics or drivers who face sudden failure in the car and provide decision support system. They also claimed the CFMDAS is considered as an interactive training tool that can provide expert guidance in car fault detection. Widodo Budiharto developed a model of expert car diagnosis system able to diagnose the failure of the car using Bayesian approach[10].

Moon et al. developed a parallel model based fault detection algorithm for an electronic parking brake [EPB] system which consists of an electronic control unit with built-in current sensor and braking force sensor[11]. The said algorithm detects severe failures of the force sensor and warns the driver in advance to prevent accidents due to failures.

Olanloye et al. presented an expert system for motorcycle fault diagnosis which serves as a guiding tool to the owner of the rider especially when the automobile or mechanical engineer is not readily available[12].

S. Adsavakulchai presented an expert system for car failure detection using Visual Basic and Microsoft Access as tools to help inexperienced mechanic as the decision support system[13]. The investigators concluded saying that the car detection failure system devised by them is helpful although it might not give complete guide as human expert.

E. Roanes-Lozano et al. developed a friendly graphical user interface in order to ease the communication with the application and its use in remote using any smart device with internet connection[14]. In these systems the diagnostic devices provide user centered diagnostic services and prevents accidents caused due to the engine malfunction by providing real-time communication with the use of wired system and Bluetooth module.

2. PROBLEM STATEMENT

A considerable amount of work is being carried out in the development of a decision support system for the diagnosis of faults in a car using knowledge based experts system. Although it is being observed that in reference to the fault diagnosis of a car either the work is being restricted to the engine failure only or if the whole car is being considered a very few system parameters are considered.

With this inference of literature survey it seems that there is a possibility of developing a more versatile user information system using different approach for car failure diagnosis by taking into consideration the maximum variants of car failures.

3. METHODOLOGY

It is evident from the reviewed literature that all the possible failure causes plays a vital role to keep the vehicles in good condition. To know all possible causes the cause and effect diagram has been developed. The synoptic procedure is given in following three steps.

Step 1: Listing and categorization of general observations during car failures

Step 2: Listing, categorization of various car failures with their causes and drawing of cause and effect diagram using Normal Group Technique (NGT)

Step 3: Algorithm and computer programming of user information system for car failure diagnosis

4. DEVELOPMENT OF CAUSE AND EFFECT DIAGRAM USING NGT

For the data collection it is recommended to distribute the questionnaires amongst the experts and recollect the responses from them for further use[15]. In view of this a workshop was conducted to know the possible causes of vehicle failure. In this workshop domain expert from automobile sector, eminent persons from academia and the experienced workers of all leading automobile workshops were invited.

Following triggered question was asked to all the domain experts at the beginning of the workshop as shown below.

"What are the causes of vehicle failure? Explain any four common causes in your opinion".

In all 220 causes were reported by the 55 workshop participants in the first phase of the workshop. After excluding repeated and irrelevant causes a list of 186 causes was finally selected. All causes were coded, merged and key worded.

In the second phase of the workshop a set of 186 causes were distributed to all experts. They were asked collectively to separate and categorized them under main causes as per the relevance. Total 8 main causes of car failures were identified with 44 sub causes and 142 sub-sub causes.

In the third phase of the workshop all the main causes were distributed amongst the participants and suggested to give a weight-age in 10 point scale (10 most and 1 least) with their opinion. In all 55 sets were collected. The average score of each cause was then plotted as shown in Fig. 1.

It is seen that battery and Ignition failure is the most common cause of car failure followed by engine failure. The differential failure is the least occurring failure.

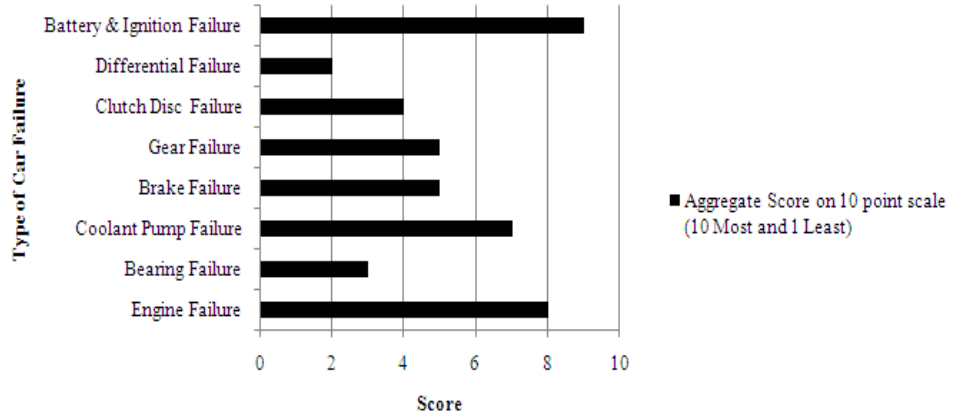

Fig. 1- Average score of each failure by the workshop participants

The enlisted various car failures suggested by the workshop participants are then represented in the form of cause and effect diagram. All the causes of the car failure came out in the exercises carried out in the above described workshop are also presented in the form of Cause and Effect diagram for the thorough and systematic diagnosis of car failures as shown in Figure 2. The cause and effect diagram is useful for system fault identification as it illustrates the failure logic of a system and shows the combinations and sequence of failures. The nomenclatures of the legend used to represent Cause and Effect diagram in Fig. 2 are as shown in Appendix (Refer Table A1).

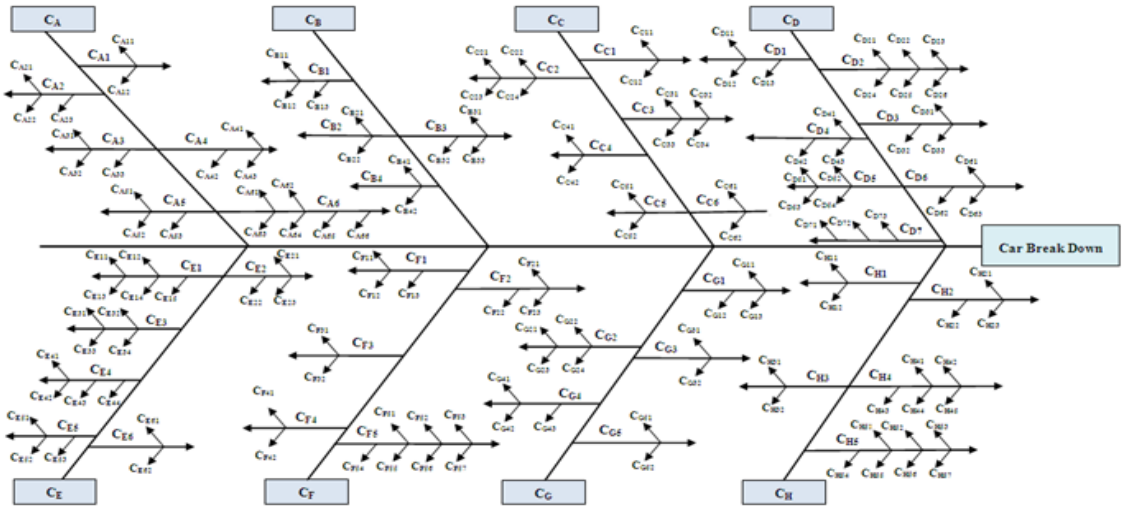

Fig. 2- Cause and effect diagram for car failure diagnosis

5. PROCEDURE OF CAR FAILURE DIAGNOSIS

A computer program is written in C^{++} to diagnose the fault in a car due to large number of fault parameters. The flow chart of the car failure diagnosis is as shown in Fig. 3.

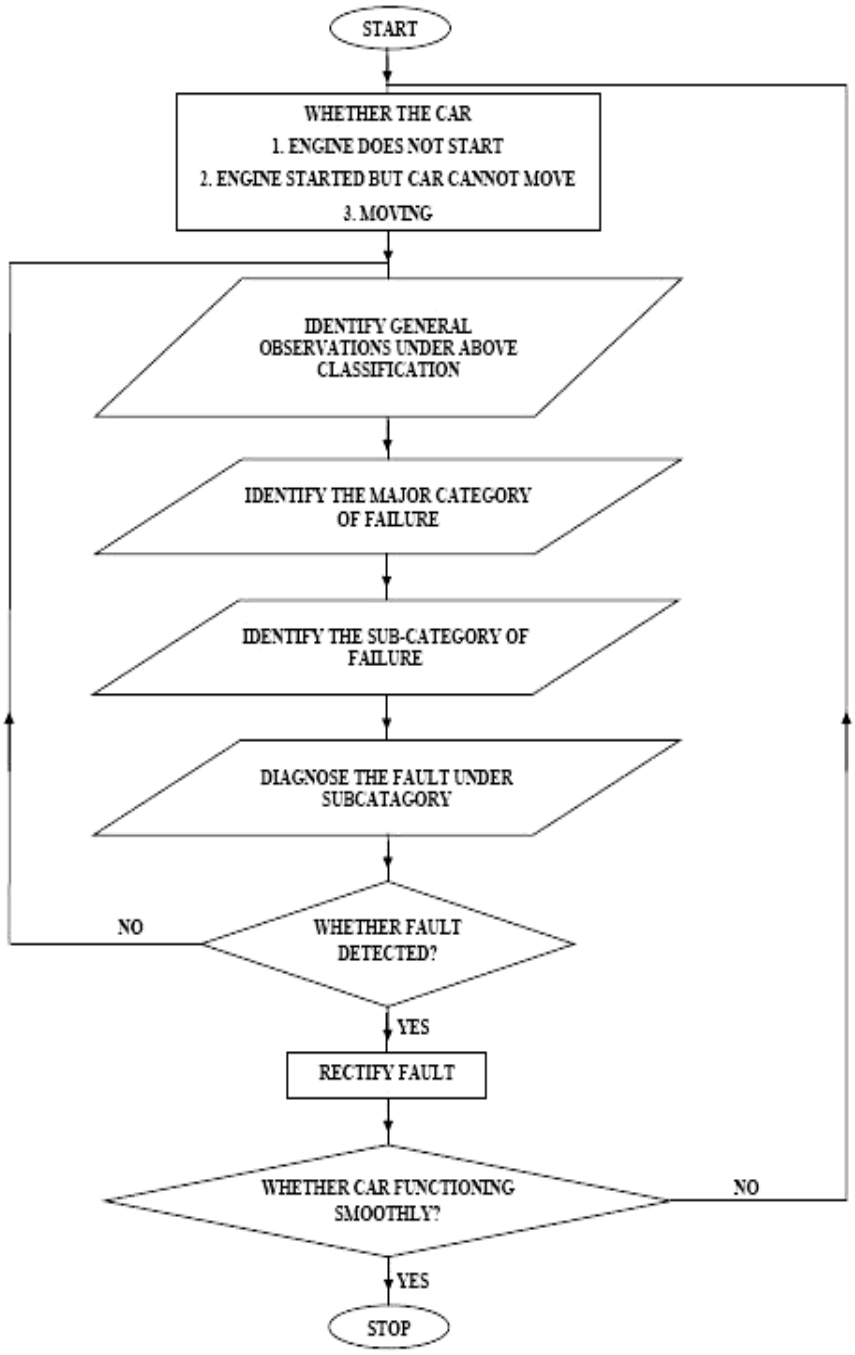

Fig. 3- Flow chart of the car failure diagnosis

The logic is developed by linking the cause and effect diagram with the general observations in case of car failure as shown in Appendix (Refer Table A2). Car failure can be occurred in any one of the situations.

i) Engine does not start

ii) Engine started but car does not move from its place

iii) Car is moving

The user first of all will select the position of the car on the computer display while failure took place. As soon as the user selects the failure position the normal symptoms under that category will display. The user has to select the right symptom which he observed on the failure of a car. On selecting an observation, the relevant possible major causes of car failure/s will display.

The user then can select given single/multiple car failure option by which the sub causes for the given type of failure will display. Further the sub-sub causes can be displayed after the selection of a particular sub cause. Thus user can identify finally the root cause of the failure by following the step by step instruction given by the proposed knowledge based user information system and can take proper remedial action. The display on the computer screen during the execution of user information system is as shown in the Fig. 4.

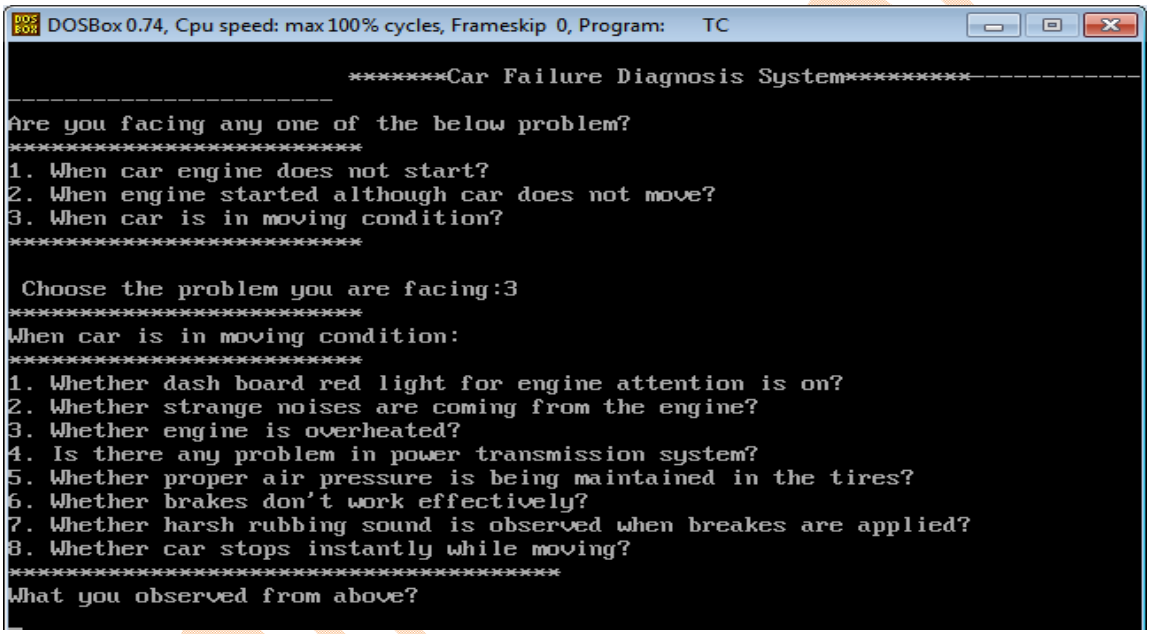

Fig. 4- Execution of user information system for car failure diagnosis

The developed user information system for car failure diagnosis is found suitable for precise diagnosis of nearly all types of car failures. It gives step-step by step guidance to the user including drivers, mechanics and students for training. The proposed knowledge based user information system for car failure diagnosis is observed to be a dynamic, consistent, unbiased, time saving and economical fault detection technique. It improves the productivity and can work continuously without stopping. It improves the driver's knowledge and can be used as a training tool for inexperienced mechanics and students.

6. DISCUSSION AND CONCLUSION

A user information system for car failure diagnosis using cause and effect diagram is presented in this paper. During the preliminary phase of collecting the data a workshop of vehicle experts and mechanics was conducted. The deliverables of the workshop was used to draw the cause and effect diagram for a car failure diagnosis. Nearly all major types of car failures are considered for its diagnosis in this proposed user information system. It seems as an important and convenient tool for fault finding in cars by the owners, drivers, inexperienced mechanics and for student's training. Due to the dynamic and time saving properties of this system a car mechanic may do more work in less time, thus earning more.

Currently the proposed user information system can carry out the diagnosis in most of the areas of car failure adding sufficient domain knowledge particularly, engine failure, bearing failure, coolant pump failure, brake failure, gear failure, clutch disc failure, differential failure and battery failure. As the system is developed with limited resources and in given time frame there may be chances that some of the facts might be missed. Although it is very clear that the proposed user information system is more reliable in fault diagnosis as nearly all the major causes responsible for the car failure are being considered. It is expected that after refining errors the developed user information system can be used as an efficient tool for car fault diagnosis and may be used for any car.

7. FUTURE SCOPE

Further work can be done to add the rest of the domain knowledge to cover all the car problems and to develop the proposed user information system in the form of mobile app.

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APPENDIX

Table A1- Causes of car failures

Leg.	Meaning	Leg.	Meaning
C_A	Causes of Engine Failure	C_{C51}	Worn out shaft, bushes and bearings
C_{A1}	Neglecting oil changes	C_{C52}	Damaged impeller blades
C_{A11}	Improper oil type	C_{C6}	Seal leakage
C_{A12}	Insufficient oil quantity	C_{C61}	Seal wear
C_{A2}	Flooding of engine	C_{C62}	Faulty bearing
C_{A21}	Driving through flood water or water sump	C_D	Causes of brake failure
C_{A22}	Heavy rainstorm	C_{D1}	Bad fluid pressure
C_{A23}	Water passes through intake manifold	C_{D11}	Fluid leak
C_{A3}	No start	C_{D12}	Inadequate pressure
C_{A31}	Breaking of engine belt / timing belt	C_{D13}	Inadequate fluid level in reservoir
C_{A32}	Faulty spark plug	C_{D2}	Rusty steel brake lines
C_{A33}	Empty fuel tank	C_{D21}	Older vehicle
C_{A4}	Overlooking oil leaks	C_{D22}	Exposed to road salts and moisture
C_{A41}	Deterioration of sealing	C_{D23}	Abrasive particles
C_{A42}	Wearing of suspension bushes	C_{D24}	Inadequate antirust coating
C_{A43}	Steering components	C_{D25}	Non-replacement of brake liners for a long time
C_{A5}	Disregarding the engine oil light	C_{D26}	Excessive use of brakes
C_{A51}	Sensor defect	C_{D3}	Bad master brake cylinder
C_{A52}	Catalytic converter defect	C_{D31}	Seal damage
C_{A53}	Less oil pressure	C_{D32}	Master piston wear
C_{A6}	Ignoring the cooling system	C_{D33}	Low fluid in the reservoir
C_{A61}	Avoiding regular flush	C_{D4}	Dirt or rust in the brake system
C_{A62}	Avoiding preventive maintenance	C_{D41}	Rusted brake disc
C_{A63}	Overheating of engine	C_{D42}	Chemical break down of oil
C_{A64}	Low coolant	C_{D43}	Oil impurity
C_{A65}	Failing electrical cooling fan	C_{D5}	Brake fluid boiling
C_{A66}	Blockage in cooling system	C_{D51}	Overheating of brake due to mountain driving
C_B	Causes of bearing failure	C_{D5}	Overheating of brake due to aggressive driving

		2	
C_{B1}	Looking closure	C_{D5} 3	Overheating of brake in racing cars
C_{B1} 1	Inadequate lubrication	C_{D5} 4	Overheating of brake due to riding for a long time
C_{B1} 2	Faulty installation	C_{D6}	Faulty ABS modulator
C_{B1} 3	Improper adjustment	C_{D6} 1	Defective sensors
C_{B2}	Poor adjusting	C_{D6} 2	Unresponsive brake pedal
C_{B2} 1	Over tightening	C_{D6} 3	Sporadic behavior from brake
C_{B2} 2	Misalignment	C_{D7}	Faulty power brake booster
C_{B3}	Poor metallurgy	C_{D7} 1	Leakage in vacuum hose
C_{B3} 1	Material defects	C_{D7} 2	Brake fluid leakage
C_{B3} 2	Worn out	C_{D7} 3	Leakage in diaphragm
C_{B3} 3	Spalling (Fatigue)	C_E	Causes of gear failure
C_{B4}	Poor quality	C_{E1}	Wear
C_{B4} 1	Low quality steel	C_{E1} 1	Metal to metal contact during operation
C_{B4} 2	Poor heat treatment	C_{E1} 2	Moderate wear due to inadequate lubrication
C_C	Causes of coolant pump failure	C_{E1} 3	Excessive wear due to rough running
C_{C1}	Bearing overload	C_{E1} 4	Abrasion due to foreign particles present in lubrication oil
C_{C1} 1	Over-tightened belts	C_{E1} 5	Corrosive wear due to chemicals present in the oil in contact
C_{C1} 2	Sudden overload due to rapid vibration	C_{E2}	Plastic flow
C_{C2}	Broken water pump housing and shaft	C_{E2} 1	Cold flow caused by heavy load on gears
C_{C2} 1	Cracked or broken fan blades	C_{E2} 2	Ripping due to high contact stresses under cyclic operation
C_{C2} 2	Cracked or bent pulleys	C_{E2} 3	Riding due to plastic flow of surface or sub-surface materials
C_{C2} 3	Overloaded bearing	C_{E3}	Pitting
C_{C2} 4	Excessive vibration and unbalance	C_{E3} 1	Initial pitting due to improper fitting of gears
C_{C3}	Cooling system contamination	C_{E3} 2	Distractive pitting due to surface overload
C_{C3} 1	Electrolysis	C_{E3} 3	Spalling due to excessively high contact stresses
C_{C3} 2	Additive gels	C_{E3} 4	Case crushing due to very high residual stresses in the gears
C_{C3} 3	Abrasive particles	C_{E4}	Fracture
C_{C3} 4	Water with High Mineral Content	C_{E4} 1	Fatigue breakage occurs due to excessive tooth load
C_{C4}	Thermal Shock	C_{E4} 2	Overload breakage caused by excessive load
C_{C4} 1	Adding cold coolant to the overheated engines	C_{E4} 3	Poor strength of the gear material

C_{C42}	Starting engine before adding coolant	C_{E44}	Random fracture due to flexure stresses in the gear teeth
C_{C5}	Excessive Vibration	C_{E5}	Scoring
C_{E51}	Frosting occurs due to heat in gear mesh	C_{G23}	Excessive resistance in the tires
C_{E52}	Moderate scoring due to excessive heat in gear mesh	C_{G24}	Spinning tires that suddenly catch either off-road or on track
C_{E53}	Destructive scoring	C_{G3}	Excessive burned ring and pinion
C_{E6}	Improper lubrication	C_{G31}	Excessive heat
C_{E61}	Incorrect lubrication viscosity	C_{G32}	Lubrication failure
C_{E62}	Incorrect lubrication level	C_{G4}	Normal ring and pinion wear
C_F	Causes of clutch disc failure	C_{G41}	Wrong lubricant type
C_{F1}	Flywheel damage	C_{G42}	Water entering into differential
C_{F11}	Gear slippage caused by failing of pilot bearing	C_{G43}	Vibrations caused by U-joints
C_{F12}	Excessive heat generated by unnecessary clutch driving	C_{G5}	Pitted bearing and race
C_{F13}	Vibrations due to spring mount mechanism of flywheel	C_{G51}	Excessive preload
C_{F2}	Incorrect driving practices	C_{G52}	Insufficient lubrication
C_{F21}	Incorrect gear selection while driving	C_H	Causes of battery and ignition failure
C_{F22}	Tow-starting or push-starting	C_{H1}	Acid stratification
C_{F23}	Repeated harsh clutch engagement at high engine rpm	C_{H11}	Battery not in use
C_{F3}	Incorrect clutch installation and adjustments	C_{H12}	Car used for travelling only short distances
C_{F31}	Dropping clutch disc on the floor during installation	C_{H2}	Accumulation of sulfation
C_{F32}	Incorrect alignment of pressure plate	C_{H21}	Undercharging of battery
C_{F4}	Premature clutch failure	C_{H22}	Irregular charging of battery
C_{F41}	Defective pressure pin	C_{H23}	Low electrolyte levels
C_{F42}	Material defects	C_{H3}	Sludge or mud formation
C_{F5}	Exclusive clutch slippage	C_{H31}	Normal expansion and contraction of plate material
C_{F51}	Worn down clutch facings to rivet heads	C_{H32}	Loss of plate capacity
C_{F52}	Heavily contaminated clutch facings with oil or grease	C_{H4}	Hot climate
C_{F53}	Burnt or disintegrated clutch facings	C_{H41}	Positive grid growth
C_{F54}	Clutch facing not in contact with entire surface	C_{H42}	Positive grid metal corrosion
C_{F55}	Overheated clutch pressure plate	C_{H43}	Negative grid shrinkage
C_{F56}	Diaphragm spring fractured or worn-out	C_{H44}	Buckling of plates
C_{F5}	Wear induced ridges on guide cams	C_{H4}	Loss of water

7		5	
C_G	Causes of differential failure	C_{H5}	Ignition faults
C_{G1}	Burnt ring and pinion	C_{H5_1}	Fouled spark plug
C_{G1_1}	Insufficient quantity of oil	C_{H5_2}	Bad plug wire
C_{G1_2}	Improperly set differential	C_{H5_3}	Weak ignition coil
C_{G1_3}	Decomposition of oil at high temperature	C_{H5_4}	Alternator failure
C_{G2}	Broken ring and pinion	C_{H5_5}	Bad ignition switch
C_{G2_1}	Continuous hammering by already broken gear piece	C_{H5_6}	Loose electrical wiring
C_{G2_2}	Excessively applied power	C_{H5_7}	Rusting of battery terminals

Table A2- Observations when a car failure takes place

S. No.	Symptoms	Type of Failure/s
	Case-I: When car engine does not start	
1	Whether the battery is dead?	C_H
2	Whether the battery cables are loose or corroded?	C_H
3	Whether the starter relay wiring connections are bad?	C_H
4	Whether the ignition switch is bad?	C_H
5	Are the spark plugs / fuel pumps are faulty?	C_A, C_H
6	Whether the starter drive or teeth on the flywheel damaged?	C_F, C_H
7	Whether the bad alternator is not charging the battery?	C_H
8	Whether the ignition coil is bad?	C_H
9	Whether the fuel tank is empty?	C_A
10	Whether the engine belt / timing belt OK?	C_A
	Case-II: When engine started although car does not move	
11	Whether any one or more tires are flat?	C_M
12	Whether gear shifting mechanism is working properly?	C_E
13	Whether clutch disengagement and engagement is fairly done?	C_F
14	Whether power is transmitted uninterrupted up to differential?	C_G
15	Whether the differential is working fairly?	C_G
	Case-III: When car is in moving condition	
16	Whether dash board red light for engine attention is on?	C_A
17	Whether strange noises are coming from the engine?	C_A, C_B, C_C
18	Whether engine is overheated?	C_A, C_C
19	Is there any problem in power transmission system?	C_E, C_F, C_G
20	Whether proper air pressure is being maintained in the tires?	C_M
21	Whether brakes don't work effectively?	C_D
22	Whether harsh rubbing sound is observed when brakes are applied?	C_D
23	Whether car stops instantly while moving?	C_A, C_H

'C_M' represents miscellaneous faults