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Battery life Checking by Applying Pearls Message Passing

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Abstract: The study deals with Pearls Message Passing algorithm for battery life checking problem. The Battery life was checked and decided that whether battery is working at its peak performance or lost its performance, or otherwise . The graph representing the different nodes like battery life, performance, reasons, Heat, light fluctuation and low performance. It also graph presenting the conditional probabilities applied with assumption otherwise we can modify the program so that we can apply the probabilities on runtime given by the user. The network has the potential to detect new nodes also and decides why the performance has been decreased and whether the battery is out of order, infected by heat and light fluctuation or not working. The network also has the node named with out of order which shows that battery has lost all of the performance so we can say the battery life is over and now it needs to be replaced. The work can be extended to perform more complex task and with additional list of reasons or accidental events occur during the life of a battery. The idea can be implemented by the laptop manufacturers and mobile phones as they are the potential application as the Intel Company has already implemented its system in microprocessor checking

Keywords: Battery Life, Belief Propagation, Message Passing

1. INTRODUCTION

The batteries (Electrical) are the cell or more than one cell which is used to obtain electrical energy on demand when needed. It is an electrochemical device which converts stored chemical energy to electrical energy. Batteries now have become the important source of electrical energy for the household appliances and the devices where the conventional electrical source may not be the suitable or convenient. The batteries are of two types, primary and secondary batteries, the first one category works like a disposable battery, once use and then dispose of the battery, while the later category deals with the reusability mean multiple times use of the batteries hence these are called rechargeable batteries. The batteries are made for finite life as the chemical and physical changes affect the life and working mechanism of batteries. The loss of active material which they are made is also the big reason for battery life. The laptops and mobile phones are the heavy users of these types of batteries, because they have given the mobility to computing and communication.

2. LITERATURE REVIEW

Carter *et al.*, (2012) presented a study of increasing battery life in electric vehicle. Various goals have been described where the control energy algorithm has been defined. The lead acid batteries have been examined and tested on a vehicle by using two additional goals. The first goal states the improvement of vehicle's efficiency and the range. The second goal is reduction of the current peaks in battery so that the battery life can be increased. The hybridization benefits have been compared with other achievable which will increase the size of the battery and compared against supercapacitor mass. The identified impact factors have been identified as energy from regenerative braking and the supercapacitor characteristics. The results show that the supercapacitors are effective while reducing the battery currents. However, it has been reported that the range extension benefits are limited one. The 50% increase has been found when supercapacitors are cost effective for the current prices while testing on vehicle.

3. THE NETWORK

The present research is an attempt to use the graph theory and represent the belief propagation for checking of the batteries used in laptops. The modeling can be used with slight modifications to other type of batteries used in various appliances. The original algorithm of belief propagation (BP) was proposed by the (Pearl

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1988). The belief propagation is popular for computing the approximate marginal probabilities in graphical models as well as the loopy models of graphs. There are so many applications where Belief propagation has shown the promising results. In this paper we use the Belief Propagation algorithm to identify the marginal probabilities of involved factors in the battery life. The model has been created for the limited states showing the states of the battery life affecting reasons, like heat and light fluctuation, performance and out of order and other affecting reasons in the life of a battery during the course of time. The designed graph and its probabilities distribution is shown below in **(Fig. 1a).** defining the battery life states.

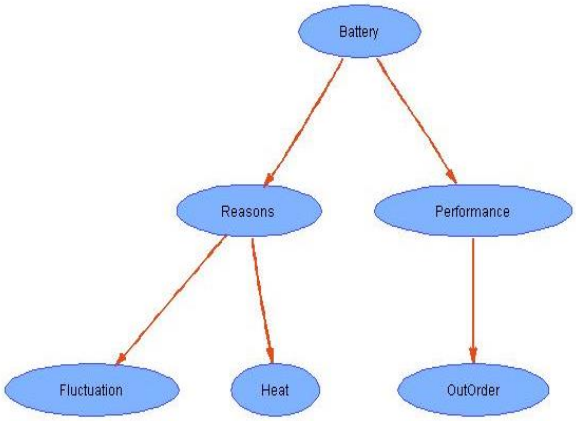

Fig. 1(a): Graph showing the initial probabilities

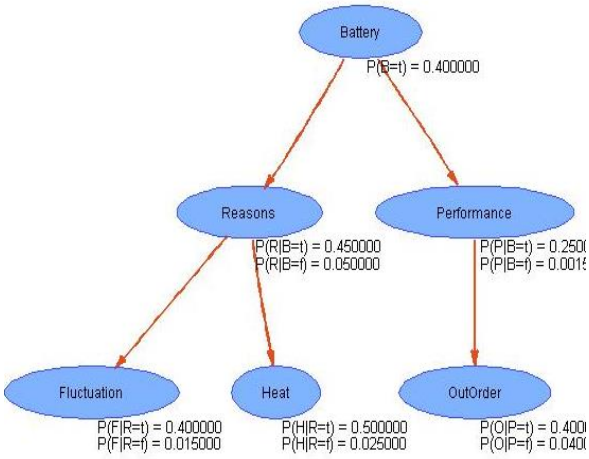

Fig. 1(b): Graph showing the initial probabilities

4. MATERIALS AND METHODS

In this diagram we have drawn the Direct-Acyclic Graph in which every state of the battery (node) represents the state of the battery and dependency is shown with the edges. The graph was created by the MATLAB object biograph which is available from the new versions like (2007a). It has been created with the adjacency matrix in which it is shown that which one state is depending upon the other one. The variables have been used are battery life, Performance, Reasons and Out of Order as shown in **(Fig. 1b)**. The graph structure is not enough so to model completely the probability distribution is necessary, for this purpose we have given the probability parameter which is also shown in **(Fig. 1).** The probabilities have been given randomly from my side, while the original probability values can be given in real problems so that the actual results can be seen. The value is given to each node given that the probability of its parents.

4.1 Probability Distribution

Probability distribution computation of variables by giving specific is called probabilistic inference by local independencies among the nodes (Pearl 1988). For this purpose I have created the network by applying the different variables. The message passing has been done by the lambda and pi values as proposed in. The conditional probabilities are shown in the empty pi charts and were saved in the variables of the MATLAB structure variables, like nodes and edges. The conditional probabilities are shown in the **(Fig. 2).** below.

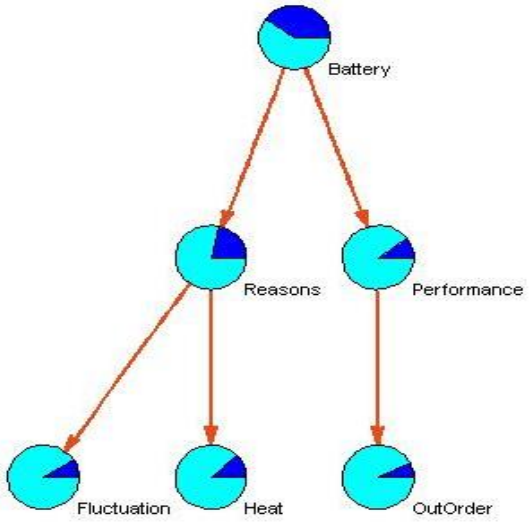

Fig. 2. Probabilities shown in pi charts

Now we are interested to see that, what are the reasons behind the low performance of the battery, so for this we infer the result and update our network with the value that reasons are truly available that can slow

down the performance of the battery. Now if the reasons are available then the probability of the lower performance and the probability of being out of order of the battery are also increased. In particular if the battery has been used for the time it is itself a reason of the lower performance of the battery, and if the reasons are strongly available then the probability of the other nodes are automatically increased. The performance is also depending upon the reasons or usage then one can infer that it may go out of order or if it is out of order then the reasons might be the lower performance and long usage of the battery. This has been shown while the reasons are available in the following **(Fig. 3).**

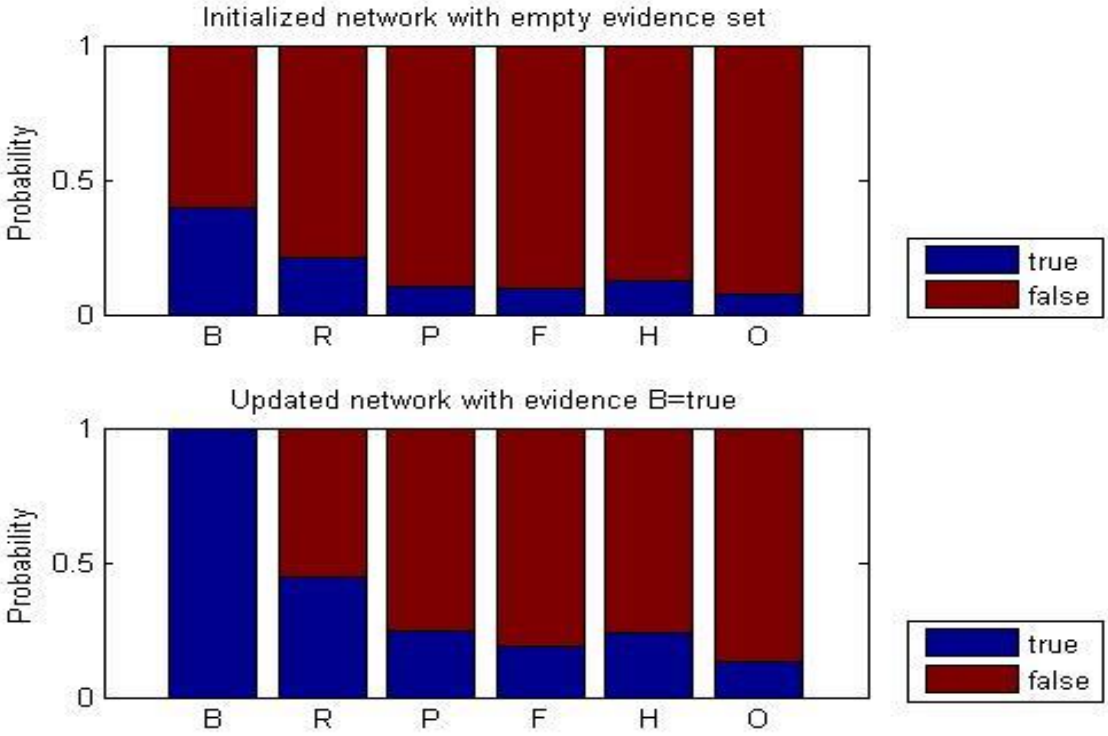

Fig. 3(a). Performance evidence is low mean true (stacked bar chart)

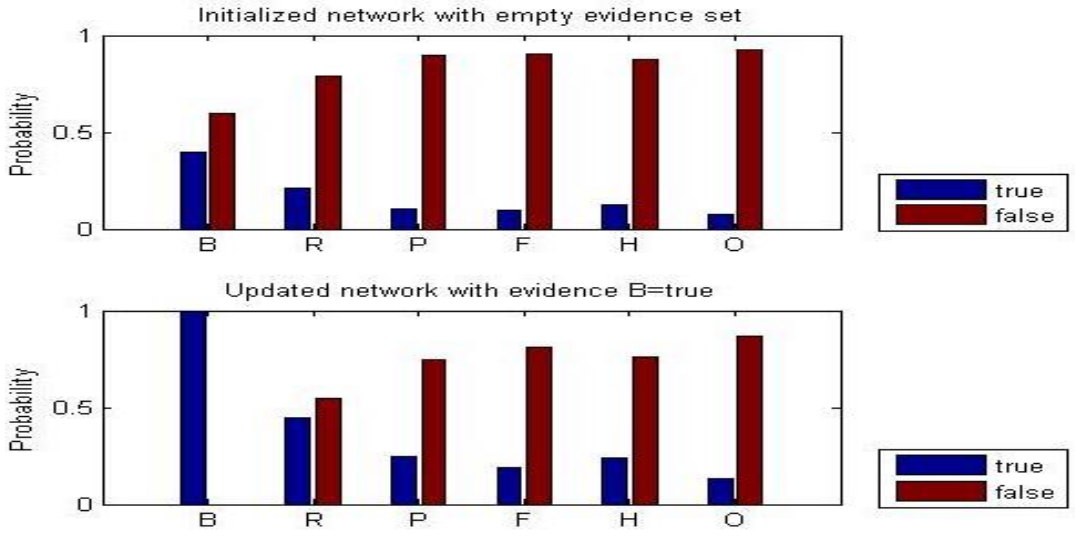

Fig. 3(b). Performance evidence is low mean true (grouped bar chart)

Now suppose that the battery has not shown any lower performance, but it goes for the out of order so in this case we will instantiate the network again and out of order will be understood true and the network will be initiated again with the new evidence. The new evidence is out of order = true. Given the out of order battery the low performance is always increase because of the node O (out of order) depends upon the low performance the P node. Now finally suppose that the reasons are available, and battery has a very low performance then it is obvious that the battery is out of order and then the status is updated that (O= true) and (R= true). Now the probabilities are compared with different situations. These probabilities are plotted by the bar charts, the availabilities of reasons and availability of low performance can increase the probability of performance or out of order or it can be increased by the usage direct manner or indirect manner. Again, we can compute by the availability of reasons like light fluctuation available or not available, by having the reasons value false which is compared as the previous value which was false already, the process of checking is shown below in **(Fig. 4).**

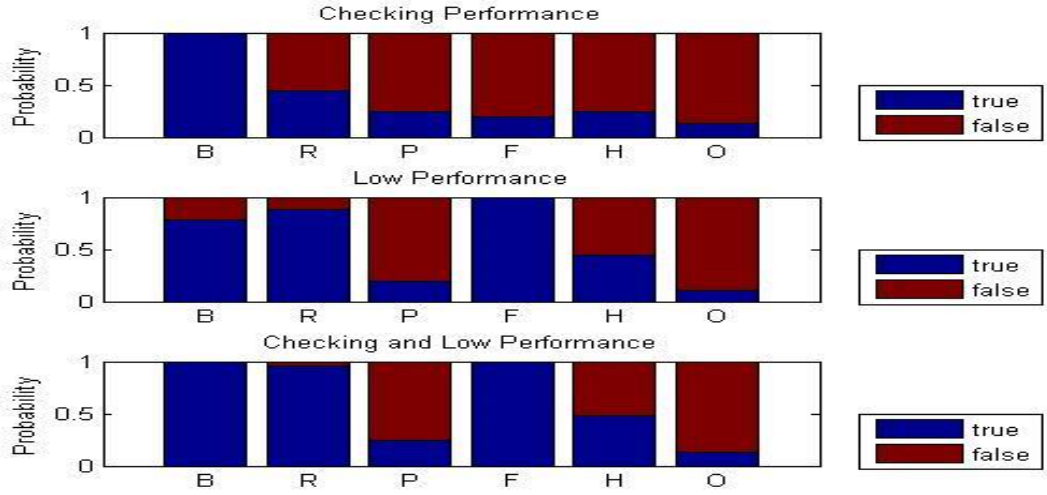

Fig. 4. Probability showing with reasons and without reasons

Now the conditional probabilities can be calculated by the 3D diagram having the conditional probabilities shown in following figure 5.

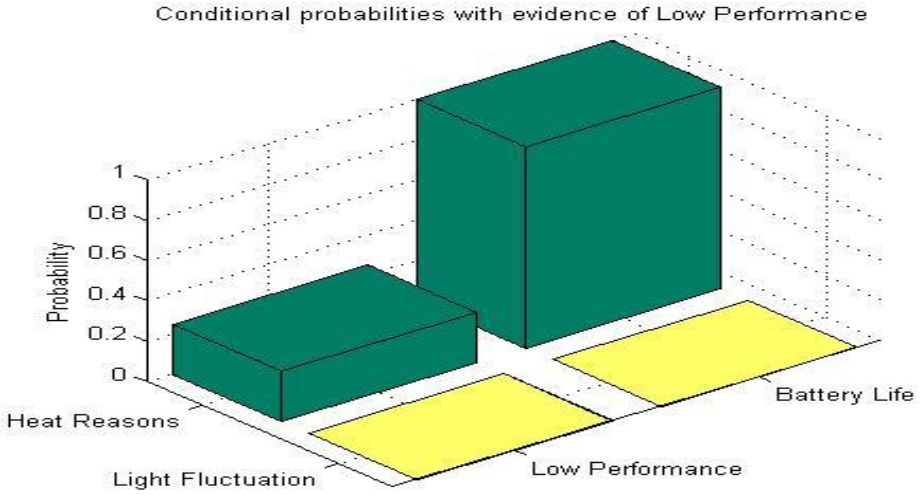

Fig. 5. Probability showing with reasons and without reasons

In this we can check the conditional probabilities with reasons and without reasons, in which clearly has shown that battery life is depending upon the reasons and without reasons. We can conclude that the battery life can go of the performance by the availability of reasons and un-availability of reasons.

4.2 The Extended Network

The network can be extended by applying the new beliefs and propagating the new ideas and conditional probabilities, as other reasons are available like heat and light fluctuation, Not working so we can have another node low performance, and we can model this belief in the Bayesian Network, here I have introduced the new node named with low performance and the network has been updated according the adjacency matrix. The updated network has been shown in the following figure 6.

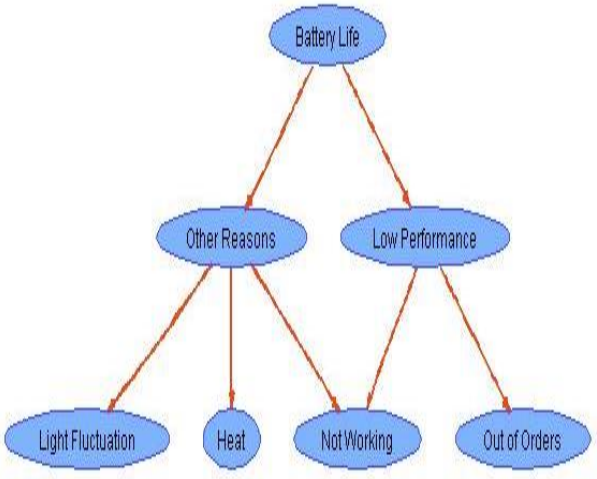

Fig. 6. Expanded Network

4.3 Singly-Connected

When the new node has been created then the network has been connected more than single, there may be any chain connected among the nodes. The network must satisfy the singly-connected network we have to manage the adjacency matrix. We can combine the adjacency matrix corresponding to the node's reasons and performance into one entry associated to the new node performance reasons. The new node performance reasons can take up to four values, all combinations possible values of the node's performance and reasons. Then I have re arranged the new probability distribution considering that performance and reasons are independent. The expanded network is singly connected is shown below in **(Fig 7).**

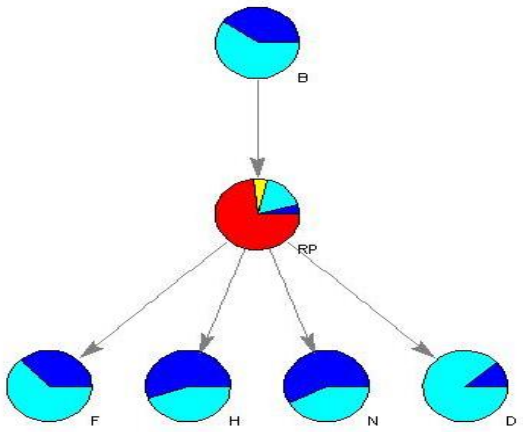

Fig. 6. Singly Connected Expanded Network

Now if the battery is giving very low performance then the battery must be checked for the low performance and the original reasons behind this phenomenon. As the nodes performance depend upon the reasons and now this is called performance reasons.

5. RESULTS AND DISCUSSION

The individual probabilities must be calculated to consider the appropriate value combinations. So, the first two elements are similar to the sum of the third element. When battery is out of order then there are the chances that battery has shown the lower performance and some reasons like heat or light fluctuation must have occurred because the out of order battery shows the strong likelihood of the low performance or sudden occurrence of other reasons. As the network shows the out of order is depending upon the low performance and reasons.

If the battery has been detected during the light fluctuations mean reasons then the usage or low performance likelihood has been automatically decreased, while the other competing node or factor is increasing the likelihood of the competing is decreased that happens here.

6. COMPARISON WITH EARLIER STUDIES

Battery life estimation, battery remaining capacity and performance degradation is considered a time series factor, Stochastic process theory and mathematical algorithms have been employed. In two methods have been used for battery estimations in which first trained dataset and then estimated based on training data and another one is based on the parameter values such as battery charge and discharge values and the speed of discharging of the current. Another study also presented

the comparison of two classifiers namely SVM and Artificial Neural Network (ANN) based estimation for the battery life. The neural network-based estimation produced less than 10% errors of battery estimation when testing of battery of ten minutes. The SVM based estimation produced the same results but SVM needs more time for testing for the same rate of accuracy. None of the previous methods can be fully compared with the current study fully as the current study applied pearl message passing method; a statistical approach the Bayesian method for the battery estimation.

7. CONCLUSION

The experiments were done on the applying six nodes and few possibilities, while the work can be extended into more nodes and complete list of reasons which affect the battery life during the usage of the battery or the accidental events of the battery life. The system can be implemented to the number of electronic device manufacturing companies specially the laptop and mobile phones companies as the Intel Company has already implemented in its microprocessor checking. The network can be extended up to the most configured or complex system batteries.

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