A fault tree-based Bayesian network construction for the failure rate assessment of a complex system

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Technological progress have made that modern systems have become more complex, especially regarding their structures. This made it difficult to estimate the reliability characteristics, especially the failure rate of such systems. Therefore, it is necessary to develop appropriate approaches to provide better estimate. The purpose of this paper is to propose a method, for evaluating the failure rate of complex systems, based on Bayesian networks. The approach developed allows taking into account all the links, interactions and factors that may affect, directly or indirectly, the correct operation of such systems.

Some studies have shown that the modelling of complex systems using Bayesian network is very expensive. Indeed, it is necessary to establish long questionnaires and involve a large number of experts, add to that the time constraint. For these reasons and to take into account all factors affecting the system shutdown and their interactions, it is more appropriate to introduce the fault tree technique, which is more explicit and less complicated to establish, in order to facilitate the Bayesian network construction.

The transformation of the fault tree to the Bayesian network is made through a passing algorithm; it is composed of two stages: a qualitative stage where all components and logic gates of the fault tree are transformed into nodes in the Bayesian network following the same links and dependencies between components. The second step is quantitative; it serves to obtain the prior probability tables for the roots of Bayesian network nodes, in other words the elementary events and components in the fault tree. It also allows obtaining the conditional probability tables for the remaining nodes of the Bayesian network, in other words, the logic gates and the main events in the fault tree. Note that other nodes which are not included in the fault tree can be added to the Bayesian network, for example, the operators' behaviour and adverse weather conditions. Once the network is built we can perform Bayesian inference, they allow computation of the marginal probability of a node taking into account the interactions between the different nodes. In our case, it consists in the computation of the failure rate of a complex system. We opted for the junction tree method of Jensen which programmed in the MATLAB software.

The approach is applied to estimate the failure rate of a turbo-pump, located at the pipeline of the Algerian company of petroleum "Sonatrach". The results obtained have shown the effectiveness of our methodology.

Key-words: *Failure rate estimation, fault tree, Bayesian network, dependencies, complex system.*

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