The Use of Structured Expert Judgment Methods to aid in Parameter Estimations for Data Sparse Problems

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ABSTRACT

For safety critical industries, such as nuclear and rail, understanding and quantifying risk is essential towards the continuous improvement of safety. In these industries, risk models provide an effective way to model possible routes towards system failure. Probabilistic Safety Assessment (PSA), used in the nuclear industry, requires quantitative input of failure parameters into models in order to quantify the probability of sequences leading to Core Damage, and to estimate the overall Core Damage Frequency (CDF). In most instances, quantitative information is available from operational experience and wider industry data. However, for some model parameters there is little relevant data available. Structured Expert Judgment (SEJ) is a method which can be applied in these cases to rationally augment the data using expert opinion. This paper gives an overview of the method of the classical approach to SEJ. Mock workshops have been run to for an example problem. The modelling of the probabilistic data collected from the experts during the SEJ process is then explored, in particular to examine whether or not the assumption of using lognormal distributions to represent expert opinion is valid.

Structured Expert Judgment is a data gathering technique which has been studied in detail by Roger M Cooke. It is a data technique which is used for problems where there is not relevant scientific data and/or sparsely available data (variables cannot be observed or calculated), Cooke & Goossens, (1991).

For SEJ a diverse group of experts are selected from the area of interest. The first stage is to pose seed questions to the experts. These are questions whose answers are known by the assessors but unknown to the experts. By comparing their individual responses and the true answers, descriptive mathematical scores can be derived for each expert. These mathematical scores describe their expertise and their ability to report data probabilistically and can be applied as weightings in elicitations of unknowns by these experts to determine well-informed and rational data outcomes for sparse data, Bedford & Cooke (2001).

The response data given by experts has been elicited as three values. The middle bound represents their true belief of the question-value and the upper and lower values are the highest and lowest values they believe, respectively. The modelling of this information is of interest as it is used to determine the scores for each expert. The lognormal distribution has been explored as a model for representing experts' beliefs. Only two points are required to define a unique lognormal distribution, and so the elicitation of three points gives three different potential lognormal distributions. Figure 1 shows examples of the lognormal distributions estimated for the same questions from the example SEJ workshop that has been run.

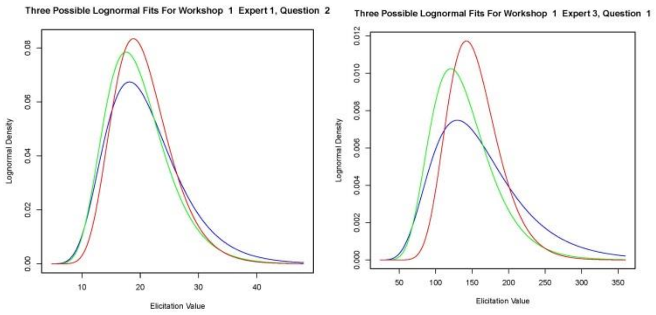

Figure 1. Sample of lognormal graphs for Experts 1 and 3

The lognormal modelling shows close agreement for the three possible curves in the left hand graph, but poorer agreement in the right hand graph. This analysis has been performed across the ten questions asked of 3 experts from both workshops. Overall, some graphs show no agreement in the lognormal distributions estimated (such as the left hand graph in figure 1), and some show significant variation in the lognormal distributions estimated (such as the right hand graph in figure 1). On this evidence it is not possible to make conclusive statements about the suitability of the lognormal distribution to model experts' opinions. The most that might be said is that in some instances the expert is clearly thinking in terms of a lognormal distribution, while in others the data that he/she has supplied is consistent with a lognormal distribution. Further analysis is required to make more definitive statements.

REFERENCES

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Cooke, R.N. and Goossenns L.H.J.2001. Probabilistic Safety Analysis: Foundation and Method.