Assessing vulnerability of buildings to blast using interval probability theory

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Vulnerability to bomb blast is a socio-technical or "soft" or imprecise phenomenon that requires both learning from past experience and a calculus that permits incomplete knowledge. Grounded theory has been used to learn from past experience and to generate a hierarchical causal tree. These members of the hierarchy are called "holons", conveying the idea that they are both wholes and parts. The generation of this hierarchy has been reported elsewhere and is not the subject of this paper.

The main objective of this study was to use interval probability theory to arrive at an interval value for the top level holon "vulnerability" from a number of lower level holons, each of which is characterized by an interval number and a weight, reflecting importance. Different ways of combining connectives and dependencies between lower level (child) holons were explored, in order to arrive at the interval for an upper level (parent) holon. This aspect of the work is a novel contribution. Proposing a method for converting the final two valued vulnerability assessment back to a linguistic label having a level of confidence was another objective with a novel character. The final objective was to demonstrate that the computerized hierarchy could be used as a management tool.

The evidence for proneness to failure is first given a linguistic label that is related to a fuzzy set. Next, the confidence in that assessment is treated as a horizontal line that cuts the relevant fuzzy set at a lower and upper bound, thus creating an interval number for a holon. The combining of two weighted interval numbers treated the weights as influences on the upper level holon. This was extended to the combining of more than two weighted interval numbers, ensuring that the result was independent of the order of combination. In addition, the combination of evidence also depends on the dependency relationship between holons.

Interval probability theory was found to be a very useful tool for the qualitative assessment of a socio-technical system, not only with respect to the assessment of overall vulnerability, but also for identifying aspects that need improvement. The model yielded results that were intuitively satisfactory. The interval values for the top level holon "vulnerability" were also shown to be satisfactorily and realistically sensitive to changes in the evidence (of proneness to failure) and confidence (in the assessment) of lower level holons.