An Expert Opinion Elicitation Method Based on Bayesian Intervals Estimation and Computational Searching Algorithms: an Application to Oil Refinery Risk Analysis

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Eliciting Expert Judgments

- *Scarcity of data in probabilistic risk analysis;*
- *One of the main drawbacks of these methods is the time required for their application;*
- *The application of an excessively time-consuming elicitation method may be prohibitive in practice;*

Eliciting Expert Judgments

- *The present paper presents an elicitation method;*
- *It is an attempt to capture the expert beliefs while being efficient, providing basis for aggregation, empirical control, and reasonable completeness, without losing simplicity;*
- *As a result, a set of Bayesian interval estimates of the unknown quantity is defined and inferences about its PDF underlying the expert beliefs are performed;*
- *An application to an oil refinery from Brazil is presented.*

Presentation outline

- *Bayesian interval estimation and computational searching algorithms;*
- *Proposed method;*
- *Example of application;*
- *Conclusions;*

Computational Searching Algorithms

- *In the computational context, searching algorithms such as sequential, Fibonacci and binary are well-known;*

- *The binary searching algorithm:*

While θ is different of θ^m do:

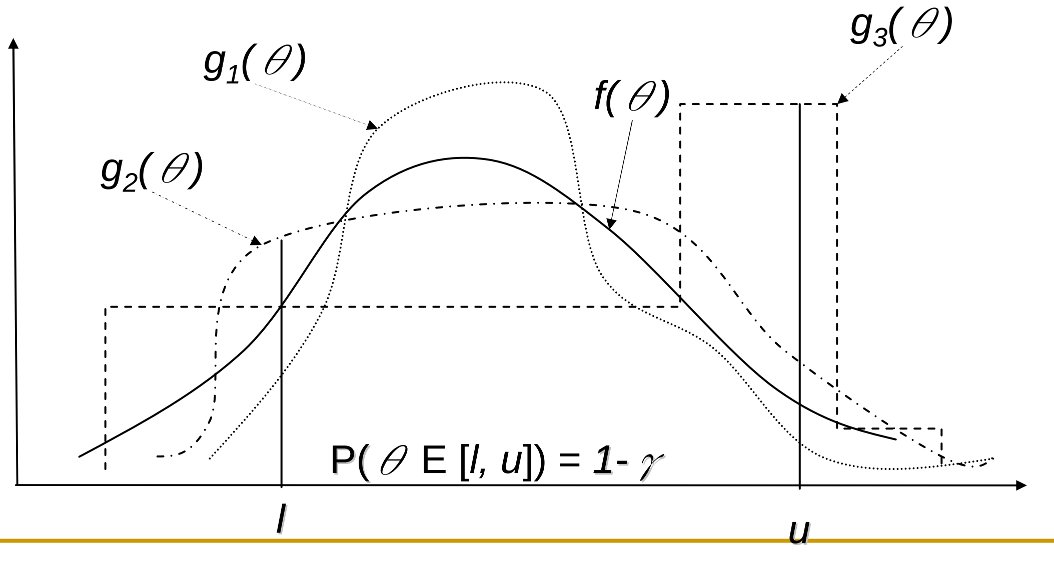
i. If $\theta < \theta^m$ then $u = m$.

ii. Else if $\theta > \theta^m$ then $l = m$.

iii. Do $m = Int\left(\frac{l+u}{2}\right)$.

Bayesian Interval Estimation

- *In practice, a PDF reflecting uncertainty about a parameter θ, f(θ), may be so much expensive or much consuming*;
- *In these cases, it may be more convenient for general orientation regarding the uncertainty about θ to simply describe intervals C of given probability, 1-γ, under f(θ)*;



Proposed Method

- *The questions at the i^{th} iteration of the method can be formulated as follows:*
  - *Decision question: Given the previous decision ($\theta \in C_{i-1}$), do you think that θ lies inside the subinterval $[m_i, l_i]$ (or $[l_i, m_i]$)?*
  - *Uncertainty question: What is the credible level, α_i, for this decision?*

- $C_0 = [min, max]$ *where* $P_0 = P(\theta \in C_0) = \alpha_0 = 1.0$;

- *Each C_i is defined by performing the binary search algorithm to find θ in the interval [min, max];*

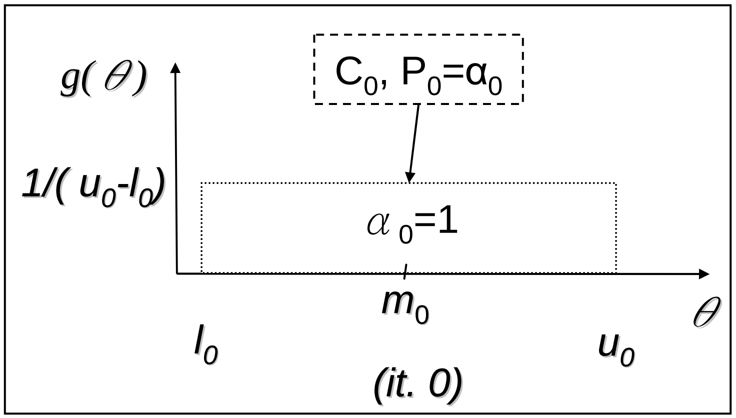
- $P_i = P(\theta \in C_i) = \alpha_i P_{i-1}$;

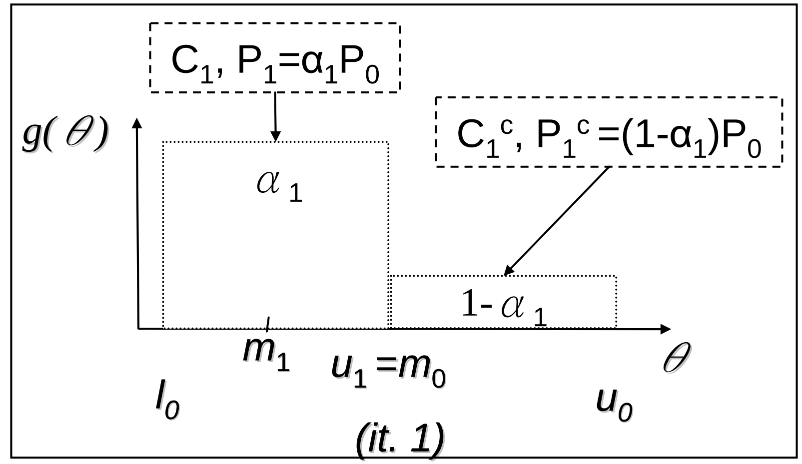
- *Each pair (C_i, P_i) composes a Bayesian interval estimate for θ under $f(\theta)$, the supposed PDF underlying the expert beliefs about θ.*

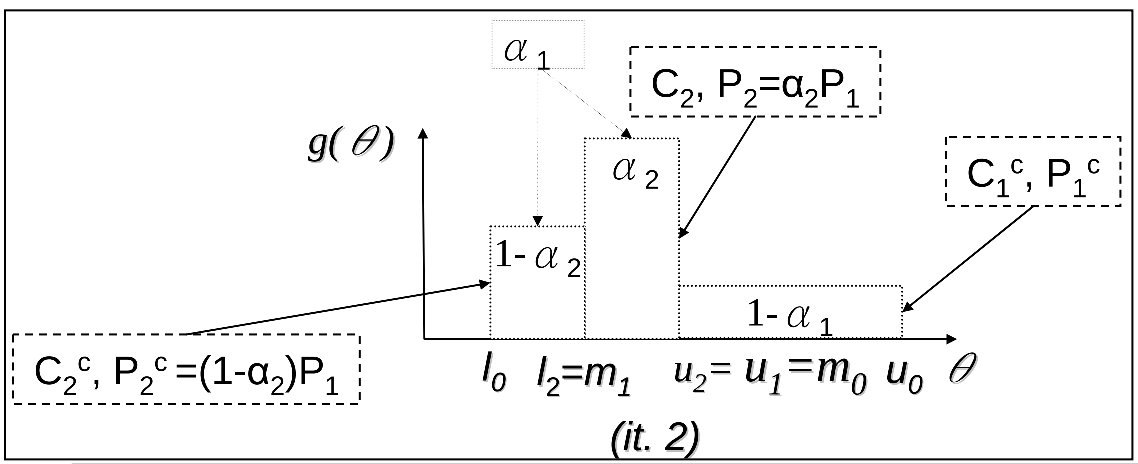
- *Stop criterion: when the expert is no longer able to decide which partition of C_i to take, for instance.*

Proposed Method

- *Some iterations:*







At the end of the it. 2 we have three Bayesian interval estimates:

$P(\theta \in [l_0, l_2])=\alpha_1(1-\alpha_2)$

$P(\theta \in [l_2, u_2])=\alpha_1\alpha_2$

$P(\theta \in [m_0, u_0])=1-\alpha_1$

Example: Oil Refinery

- *Complex system involving the chemical process of cleaning and refining crude oil extracted from wells and mines;*

- *A refinery produces various derivatives of oil as lubricants, asphalt, coke, diesel, gasoline, LPG, naphtha, kerosene, and so on;*

- *Rarely data sources are available to quantify all the parameters involved in a quantitative risk analysis of an oil refinery.*

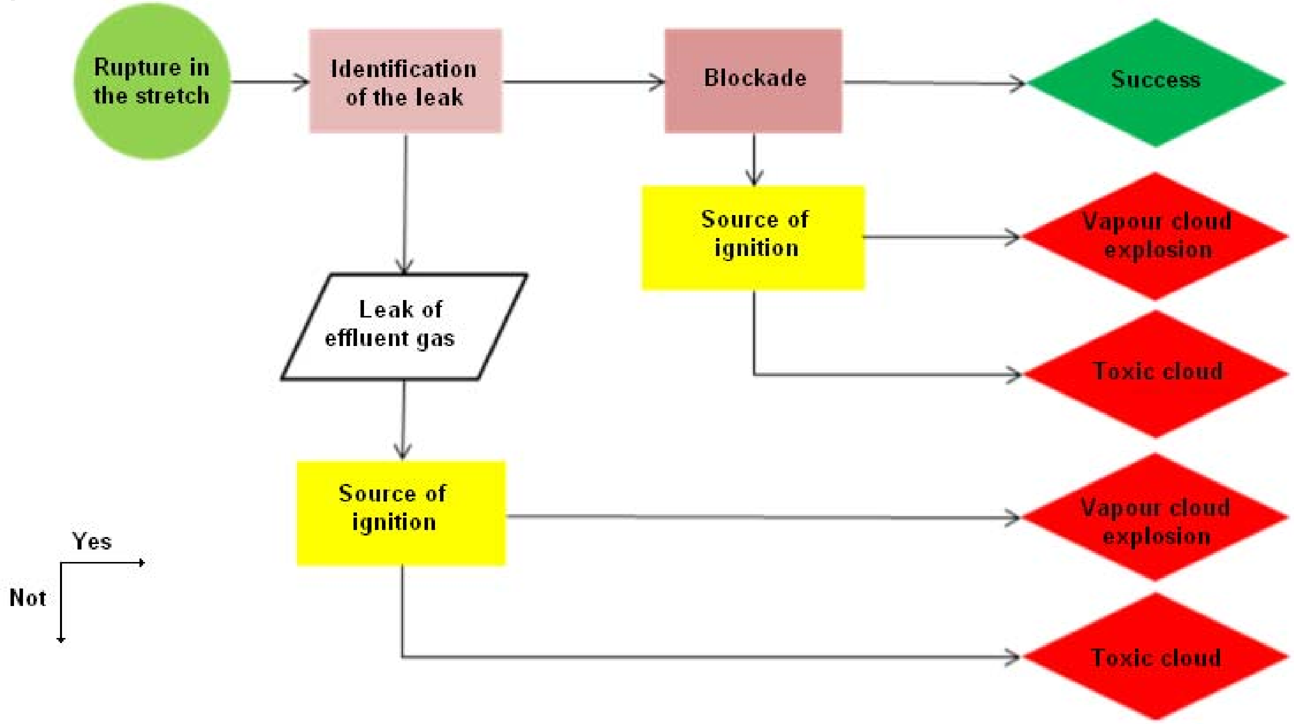
Example: Oil Refinery

- *The method proposed in this work was used to quantify opinions of a group of experts with the objective of performing a PRA for an oil refinery project at Northeast of Brazil;*

- *It was considered situations involving operations of refining oil process that were classified by the experts as being moderated, critical or very critical risky to the people outside refinery:*
  - *PHA was adopted in this stage;*
  - *12 out 133 situations analyzed in the PHA were classified as very critical risky;*
    - *Such situations were modeled by Event Sequence Diagrams;*
    - *The proposed method was adopted in order to quantify the probability of occurrence of related events.*

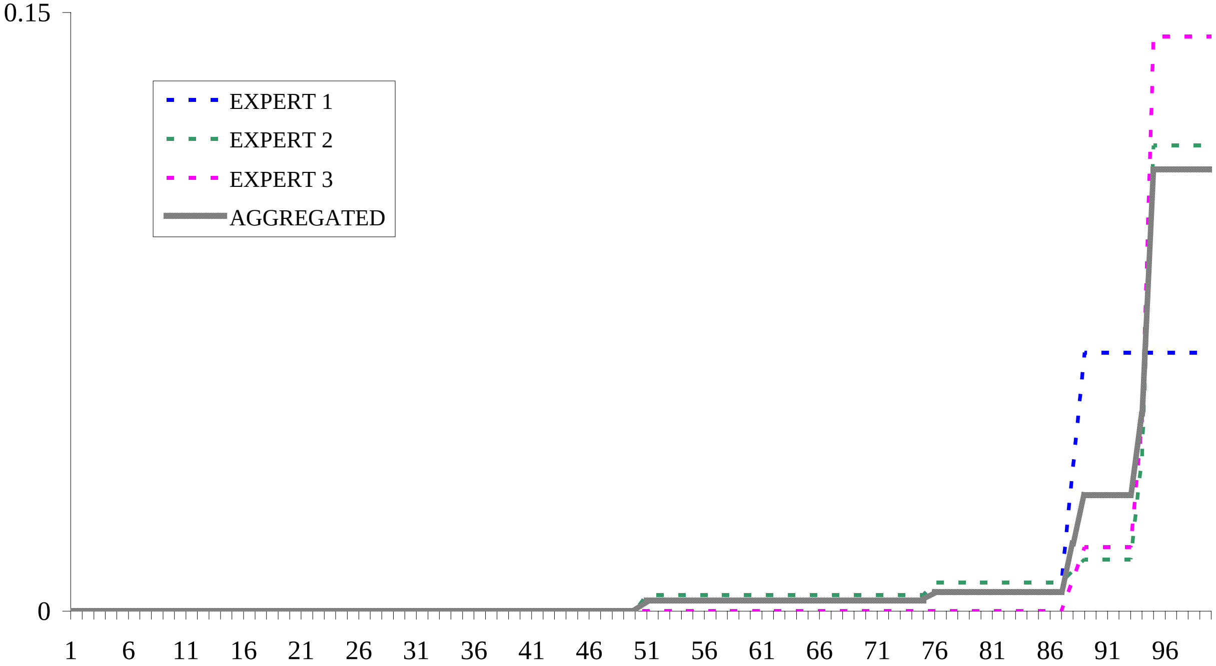
Example: Oil Refinery

- *Illustration: Coke Unit*
  - *Specifically in the stretch that runs from the system top of the tower until the entry of MDEA Unit;*
  - *The experts have identified as a hazard a big release of hydrocarbon gas and H_2S, which can be caused by a rupture in the stretch (the initiator event);*
  - *The possible effects from the release of these substances are vapour cloud explosion and toxic cloud;*



Example: Oil Refinery

- *Illustration: P(blockade | the identification of the leak)*
  - *The experts answered individually about such an event;*



	Expert 1	Expert 2	Expert 3
Mean	0.90	0.92	0.96
Median	0.92	0.96	0.97
Mode	0.93	0.97	0.97
Standard Deviation	0.11	0.11	0.03

Conclusions

- *Many of the elicitation methods are robust and sophisticated;*
- *However, some of them are not feasible to be applied in PRA problems due to the inherently large amount of parameters to be elicited and consequently to the long time required;*
- *Perhaps the main characteristic of the method is its efficiency, due to the computational searching;*
- *Although the binary searching method has been adopted here, other procedures such as the Fibonacci algorithm are also possible;*

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