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A Web-Based Tool For Eliciting Probability Distribution From Experts

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Abstract

Abstract

- The Tool is designed to help elicit probability distributions about uncertain model parameters from experts.
- A key feature of the Tool is that users can log in from different sites and view and interact with the same graphical displays, so that expert elicitation sessions can be conducted remotely.
- This will make probability elicitation easier in situations where it is difficult to interview experts in person.

Introduction

Introduction

- The Tool is named after the UK Research Council funded MATCH (Multidisciplinary Assessment of Technology for Healthcare) project.
- The development of the Tool was motivated by the need to elicit user opinions about medical devices.
- An advantage of eliciting a probability distribution, rather than asking an expert for a single point estimate, is that it allows an expert to express his or her uncertainty about the parameter.

Approaches

There are two main approaches: Frequentist method and Bayesian method.
In Frequentist Approach: Probabilities are interpreted as long run frequencies.

- never uses or gives the probability of a hypothesis (no prior or posterior).
- does not require a prior.

In Bayesian Approach: The Bayesian treats probability as beliefs, not frequencies.

- The unknown parameter θ is given a prior distribution $\pi(\theta)$ representing his subjective beliefs about θ.
- depends on the prior and likelihood of observed data.
- requires one to know or construct a 'subjective prior'.

Bayes theorem

Bayes theorem- It describes the probability of occurrence of an event related to any condition.

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)}$$

where,

- P(A) = Prior
- P(B | A) = Likelihood
- P(A | B) = Posterior
- P(B) = evidence

Bayes theorem

- **Likelihood:** The likelihood function is the probability density of the data, viewed as a function of the parameters.
  It is denoted as $L(\theta \mid \underline{x})$
- **Prior:** Prior is a Probability calculated to express one's beliefs about this quantity before some evidence is considered.
  $\pi(\theta)$, which tells us what is known about θ without knowledge of the data.
- **Posterior:** The posterior distribution summarizes what you know after the data has been observed.

$$\text{Posterior} \propto \text{Likelihood} \times \text{Prior}$$

Types of priors

- Conjugate prior: For some likelihood functions, if you choose a certain prior, the posterior ends up being in the same distribution as the prior.
- Non-informative priors: Non informative priors are formal representation of ignorance
  - Uniform prior: This can be interpreted as that all possible values are equally likely to a prior, or you have no prior information and you can't distinguish between possible values.
  - Vague prior: Vague prior is presented by using a prior distribution which has "Infinite Variance".
  - Jeffery's prior: Approximately non- informative if it's taken proportional to the square root of Fisher's information measure

Prior Elicitation

Prior elicitation is the process by which we attempt to construct the most suitable prior distribution for .

Steps for Elicitation

- Data
- Likelihood function
- Determining a prior distribution
- When uniform is your prior distribution, you don't need prior elicitation, uniform gives equal probabilities.
- Other distribution needs prior Elicitation i.e find the value of hyper parameter of prior distribution

Applications

Application

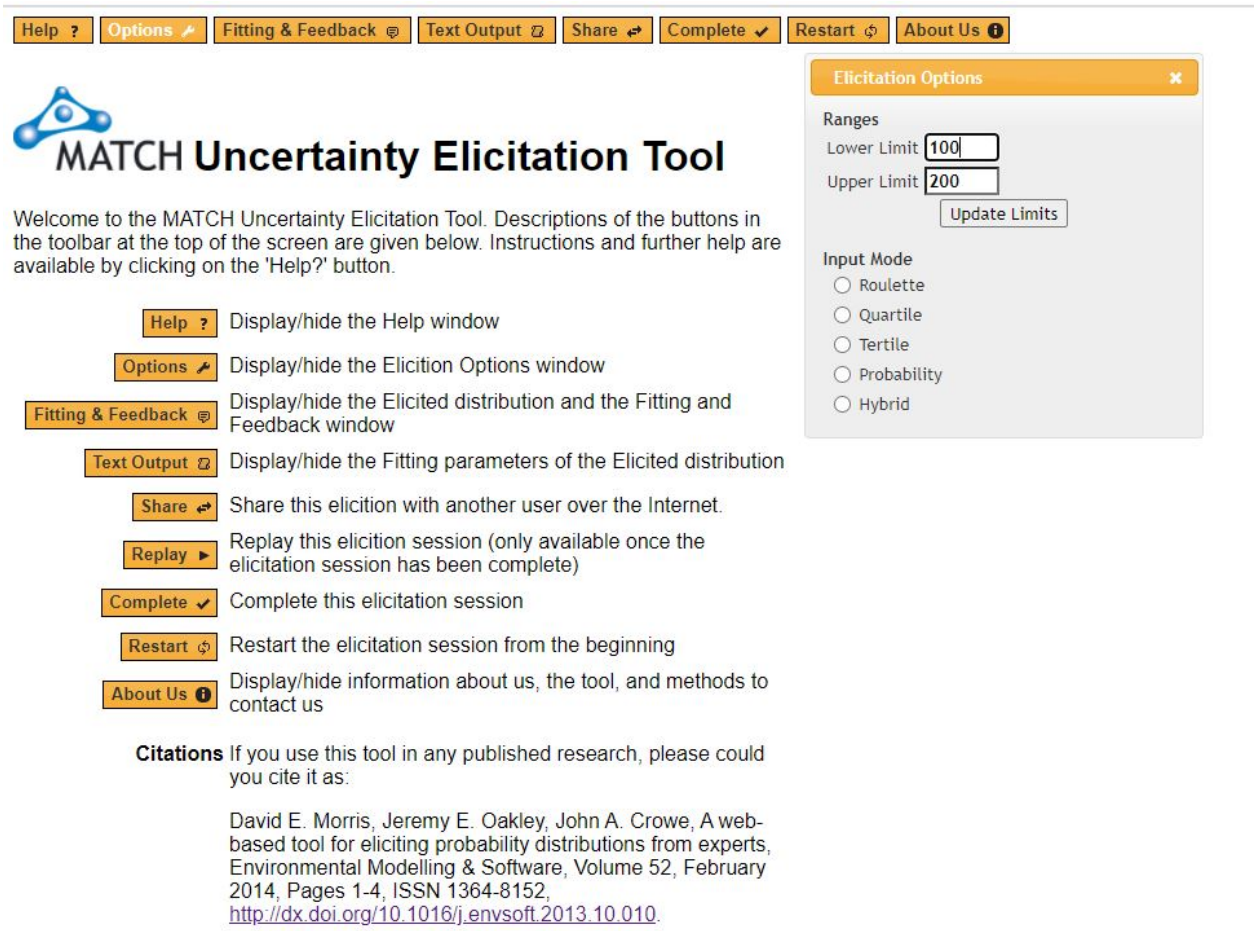
- Used in Clinical trial design and analysis.
- Better decision making in drug development through adoption of formal prior elicitation.
- Elicitation of treatment response rate for a trial of a rare disease.

Match Elicitation tool

Eliciting a univariate

Eliciting a univariate probability distribution -In most elicitation schemes the expert usually makes a small number of probability judgements about X, and the facilitator fits a probability distribution to these judgements.

Tool Representation



http://optics.eee.nottingham.ac.uk/match/uncertainty.php

Tool Representation

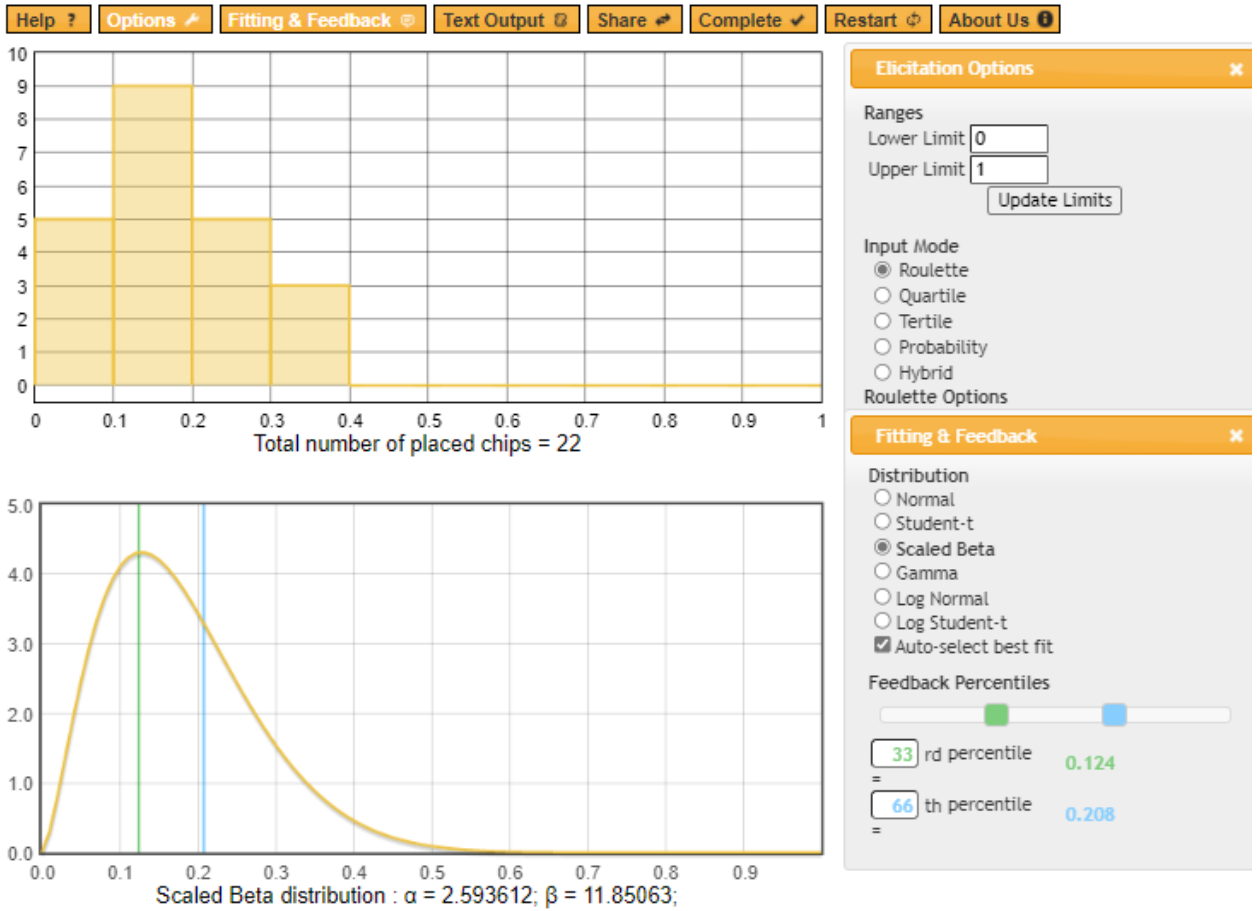
- Probability density function
- Lower limit
- Upper limit
- Median
- Lower tertile
- Upper tertile
- Lower quartile
- Upper quartile
- Roulette method

Roulette method

- The expert is provided with a grid of m equally sized bins which cover the range of X, and is asked to allocated a total of n chips between the bins.
- **Question:** Riya, a movie pirate, is trying to identify the proportion of potential customers who might be interested in buying K.G.F 2 next month. Based on the proportion of customers who have bought similarly kind of movies from her in the past, she wants to elicit her prior distribution of . For each month over the last 18 months. Riya knows the proportion of his customers who have bought similar movies; these proportions are shown below

0.32	0.25	0.28	0.15	0.33	0.12	0.14	0.18	0.12	0.05	0.25
0.08	0.07	0.16	0.24	0.38	0.18	0.15	0.22	0.05	0.01	0.19

Elicit a prior for θ. Riya asks five potential customers if they would buy movie from him, and four say they would. Using this information, what is Riya's posterior distribution for ?

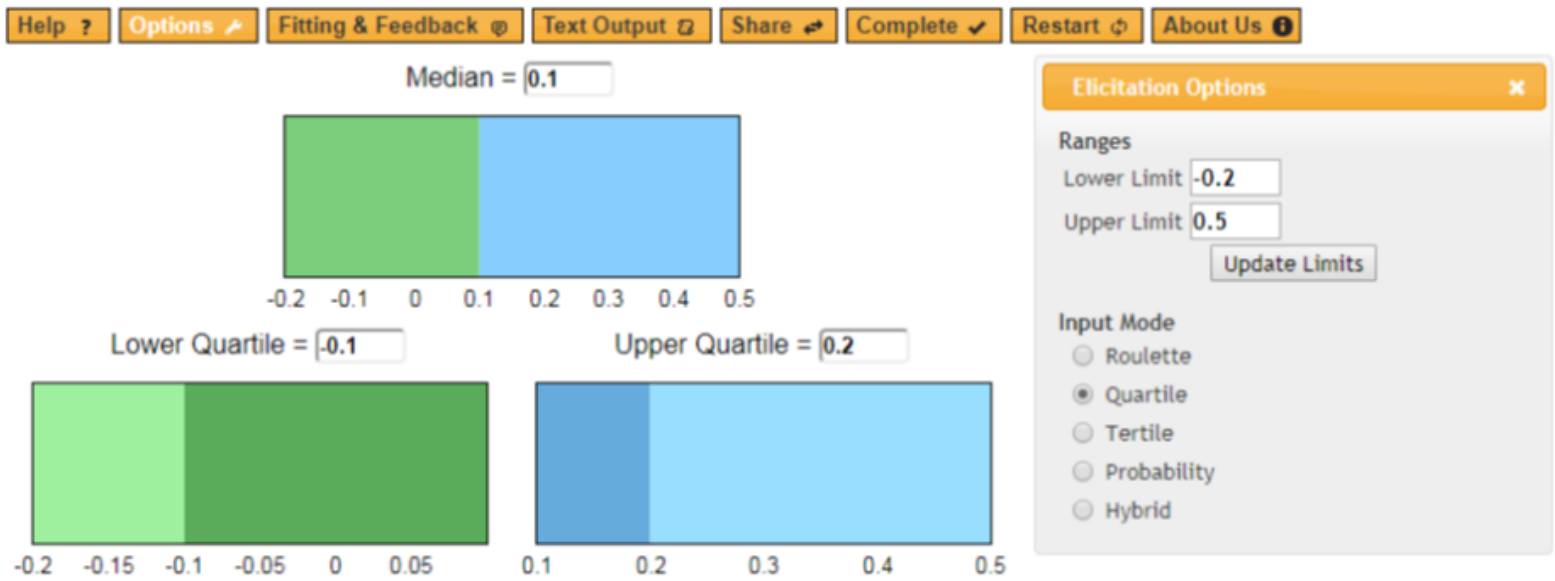

Help ?
Options
Fitting & Feedback
Text Output
Share
Complete
Restart
About Us
Total number of placed chips = 22
Scaled Beta distribution : α = 2.593612; β = 11.85063;
Elicitation Options
Ranges
Lower Limit 0
Upper Limit 1
Update Limits
Input Mode
Roulette
Quartile
Tertile
Probability
Hybrid
Roulette Options
Fitting & Feedback
Distribution
Normal
Student-t
Scaled Beta
Gamma
Log Normal
Log Student-t
Auto-select best fit
Feedback Percentiles
33 rd percentile = 0.124
66 th percentile = 0.208

Quartile method

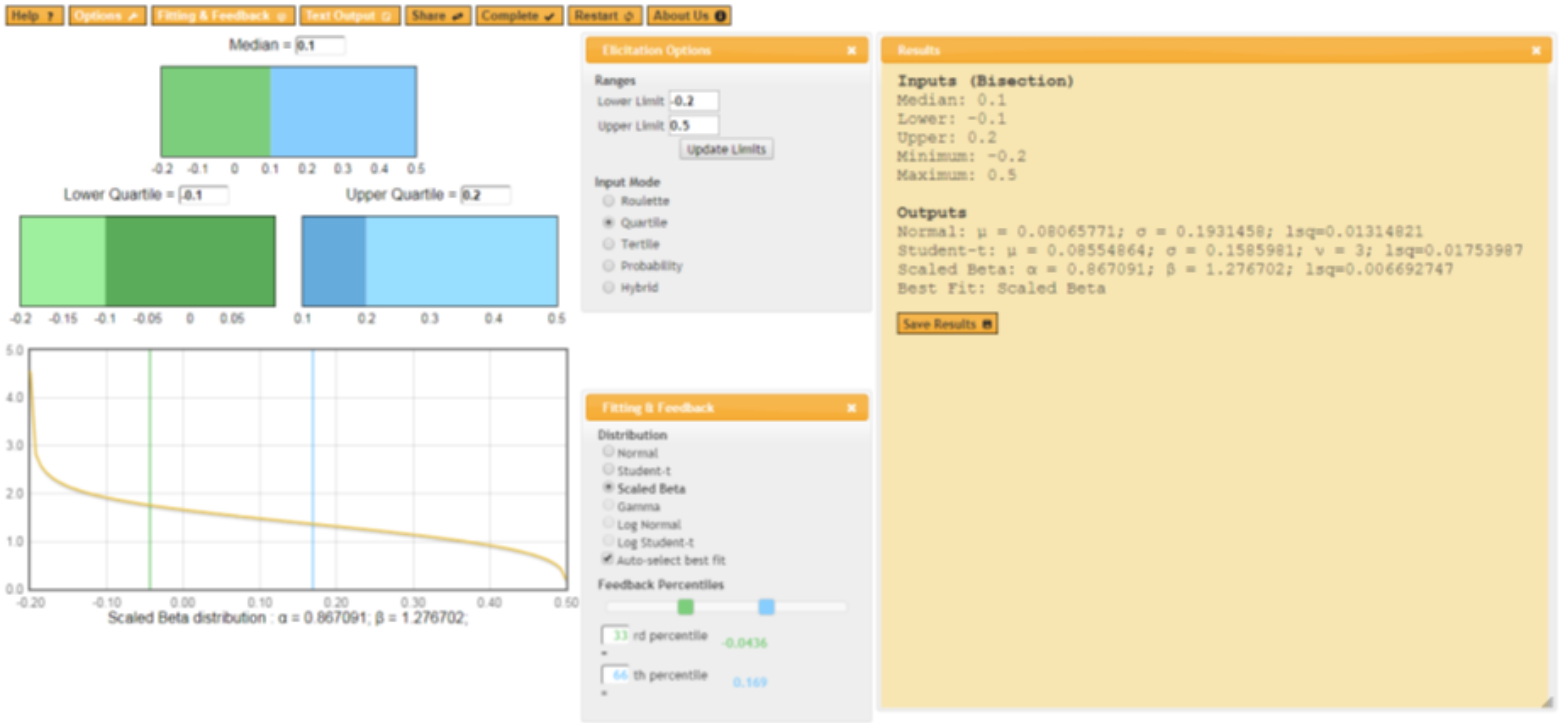
- This method is also referred to as the bisection method. The expert specifies the median, lower quartile and upper quartile of X.
- **Question:** In this worked example, the Median is 0.1, the Lower Quartile is -0.1 and the Upper Quartile is 0.2:

min	1st quartile	median	3rd quartile	max
-0.2	-0.1	0.1	0.2	0.5

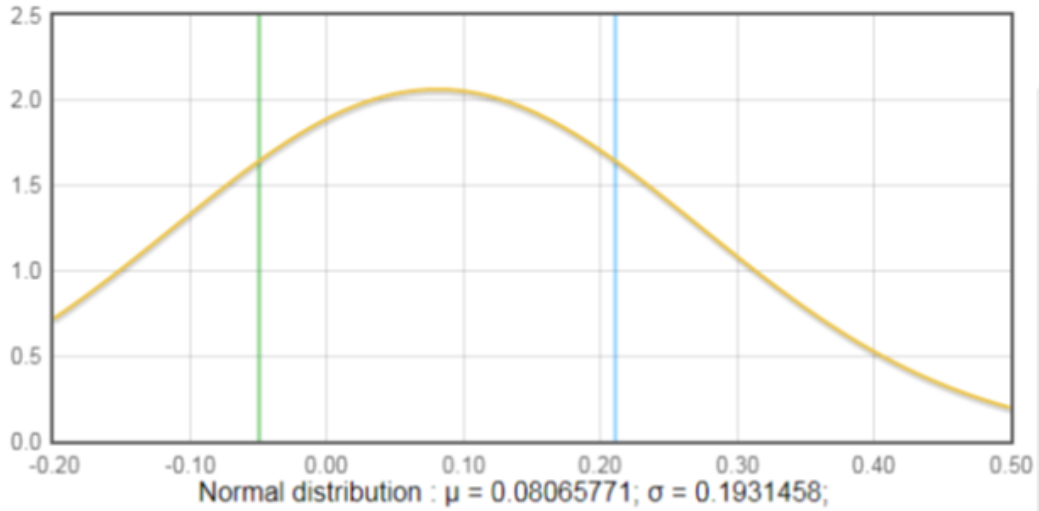
Quartile method

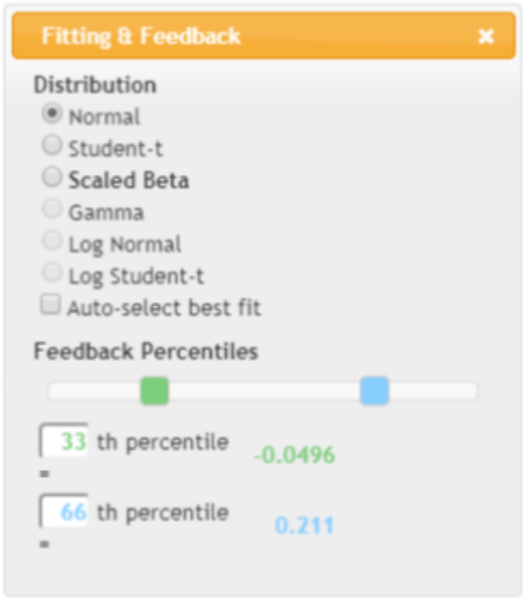


Quartile method



Quartile method





Tertile method

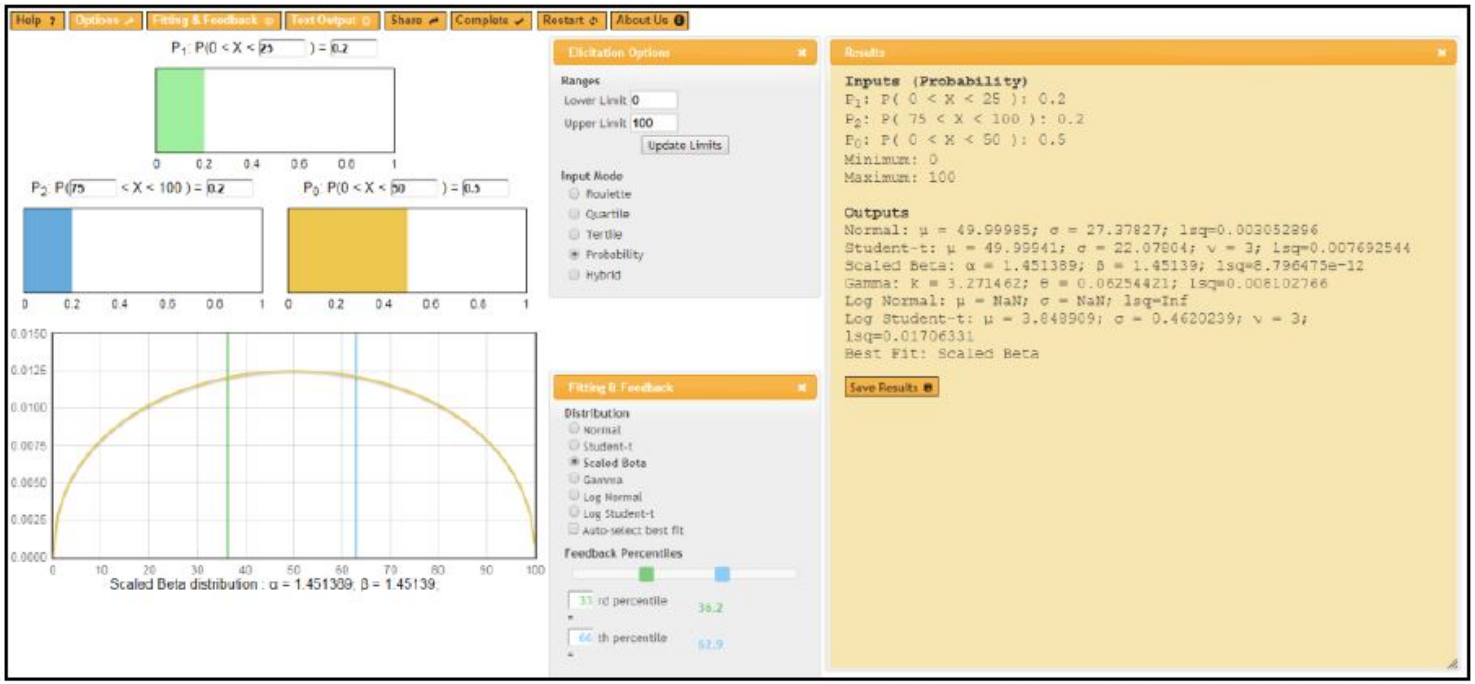
- The expert specifies the median, the 33rd percentile and the 66th percentile.
- In this worked example, Median is 16, the Lower Tertile is 14 and the Upper Tertile is 18.5:

Tertile method

Tertile method

Probability method

The expert specifies three probabilities. If the range of X is [0,1], then the default probabilities asked for are P(0 ¡ X ¡ 0.25), P(0.75 ¡ X ¡ 1) and P(0 ¡ X ¡ 0.5), but the numbers in these inequalities can be changed.



Hybrid method

The expert specified the median and two probabilities, for example P(0 ¡ X ¡ 1/3) and P(2/3 ¡ X ¡ 1). Again, these judgements can be specified by manipulating sliding bars.

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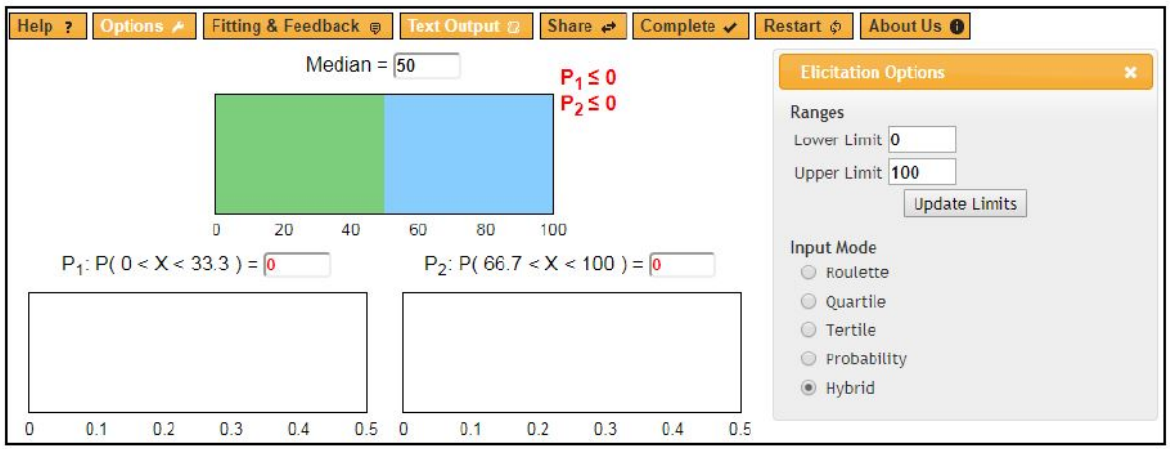
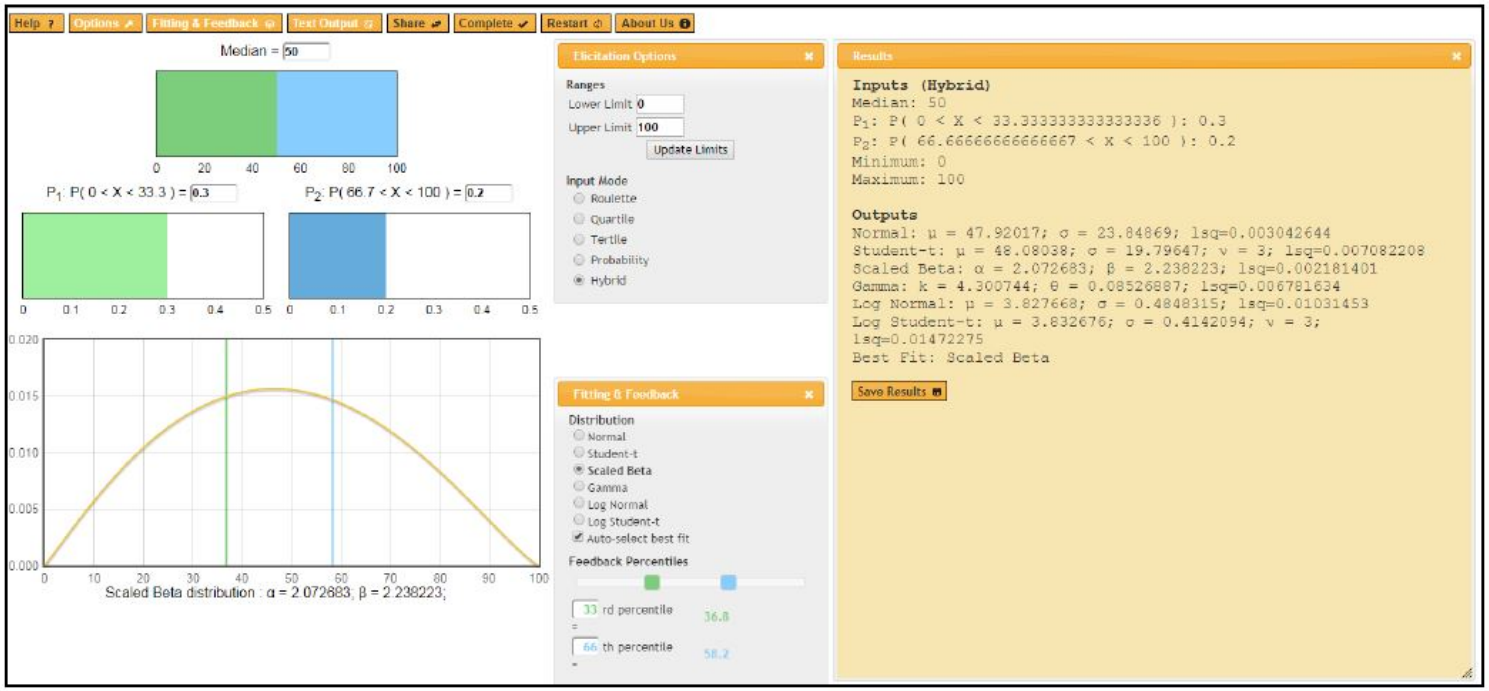
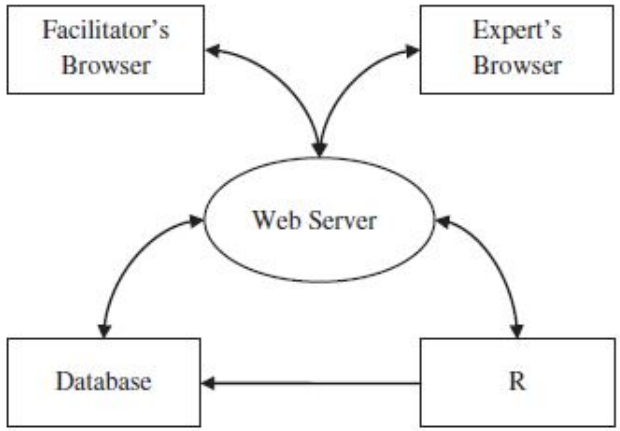


Hybrid method



playback mode

- Clicking the Share button on the Tool provides a web link, and anyone viewing this web link can then view and interact with the same graphics.
- The MATCH Tool is based on the SHELF elicitation package.
- The browser behaves as though it is receiving data that has been inputted by another expert or facilitator, and displays them as if it is an inactive party present in the actual elicitation session.



Limitations

Limitations

- It does not tell you how to select a prior.
- If the prior information is wrong.
- It can produce posterior distributions that are heavily influenced by the priors.
- It often comes with a high computational cost, especially in models with a large number of parameters.

Conclusion

The Tool is a significant advance in making expert elicitation easier and more practical, particularly in cases when it is difficult to bring the experts and facilitator together to the same location.

"Today's posterior is tomorrow's prior"

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