SALT : Software for Adversarial Life Testing

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This report describes software that has been developed for calculations appearing in Lindley & Singpurwalla (1990). It will begin with a brief description of the paper and then outline the program and what it does.

The paper by Lindley & Singpurwalla concerns itself with adversarial life testing. In particular it considered the situation where a manufacturer must decide whether to offer a sample of his product for testing in order to convince a consumer of the reliability of that product. If testing is to be done then it considers how many of the product should be tested. This is a decision problem and so first a probability model and set of utilities need to be developed. Then a simple criterion for whether testing should begin is given, and how many products should be tested if testing is to occur; the latter is done by picking the number of products to be tested that maximize expected utility.

SALT is a program that calculates these expected utility values. These values are a function of many parameters, related to both the utility function and the probability model, which need to be specified before the program can be run. A list of the parameters needed, and a brief description of their meaning, is given below.

\( a_1, a_2, a_3 \) and \( p \) : these specify the consumer’s utility. The consumer’s utility of accepting a product with observed lifelength \( x \) is \( a_1 x^p - a_2 \) (so \(-a_2\) is the utility to the consumer of accepting an item that does not work). The utility of rejecting a product is a constant \( a_3 \). SALT automatically sets \( p \) to 1.

\( b_1, b_2, b_3 \) and \( q \) : these specify the manufacturer’s utility. The manufacturer’s utility is a mirror image of the consumer’s; the utility to the manufacturer of product acceptance with an observed lifelength \( x \) is \( b_1 x^p - b_2 \), whilst the utility of rejection is \( b_3 \). Unlike \( p \), SALT allows \( q \) to be specified by the user.

\( b_4 \) : the fixed cost to the manufacturer of putting an item on test.
\( b_5 \) : the fixed cost to the manufacturer of an item failing on test.
\( b_6 \) : the cost of running the test is assumed proportional to the total time on test. The constant of proportionality is \( b_6 \); so the cost of running the test for 1 unit of time is \( b_6 \).

\( \alpha_1 \) and \( \beta_1 \) : the consumer is assumed to express his opinion about the mean lifelength of the product
that is being tested before the test is done by an inverse prior distribution, with scale parameter $\alpha_1$ and shape parameter $\beta_1$.

$\alpha_2$ and $\beta_2$: the manufacturer also expresses his (possibly different) prior opinion about the mean lifelength of the product on test by an inverse gamma distribution with scale $\alpha_2$ and shape $\beta_2$.

$N$: the size of the batch from which products may be drawn for testing; obviously the most products that can be tested is $N$.

$n$: this is a SALT parameter. SALT will calculate utilities for testing upto $n$ items, where $n \leq N$. The user will find that calculations for $n>15$ become very time consuming.

SALT is designed to be user-friendly, and is menu-driven. The first task for the user is to specify a valid set of the parameters that have just been described; this is done by selecting the input parameters option. For each parameter a brief description of what it represents will be given, and the user is also free to select the default value which has been derived from MIL STD 781C, a standard testing plan used by the US Government. To prevent overflow it is recommended that the values of the parameters $\alpha_1$, $\beta_1$, $\alpha_2$, $\beta_2$ and $q$ be not too large, and in particular that $\alpha_2$, $\beta_2$ and $q$ are less than about 70. Elicitation of the prior parameters $\alpha_1$, $\beta_1$, $\alpha_2$ and $\beta_2$ may not only be done by direct specification, but by through the prior elicitation option. This option relates them to the standard MIL STD 781C testing plan, which requires specification of a minimum acceptable mean time between failure, specified mean time between failure, manufacturer's and consumer's risks and so on; using this information the program fits an appropriate inverse gamma prior; see Lindley and Singpurwalla for more details.

Once the parameters have been entered, the user can then proceed with the solving of the decision problem or return to alter parameter values. Whilst the computer is finding utility values, it displays the current status of its calculations. To calculate utility values up to about $n=12$ takes very little time, but calculations for $n=13$ and higher become progressively slower. Beyond $n=15$ they can be prohibitively slow. Once calculations have been completed then the user can display the results in a table or as a graph, or alternatively send the output to a printer.

Reference