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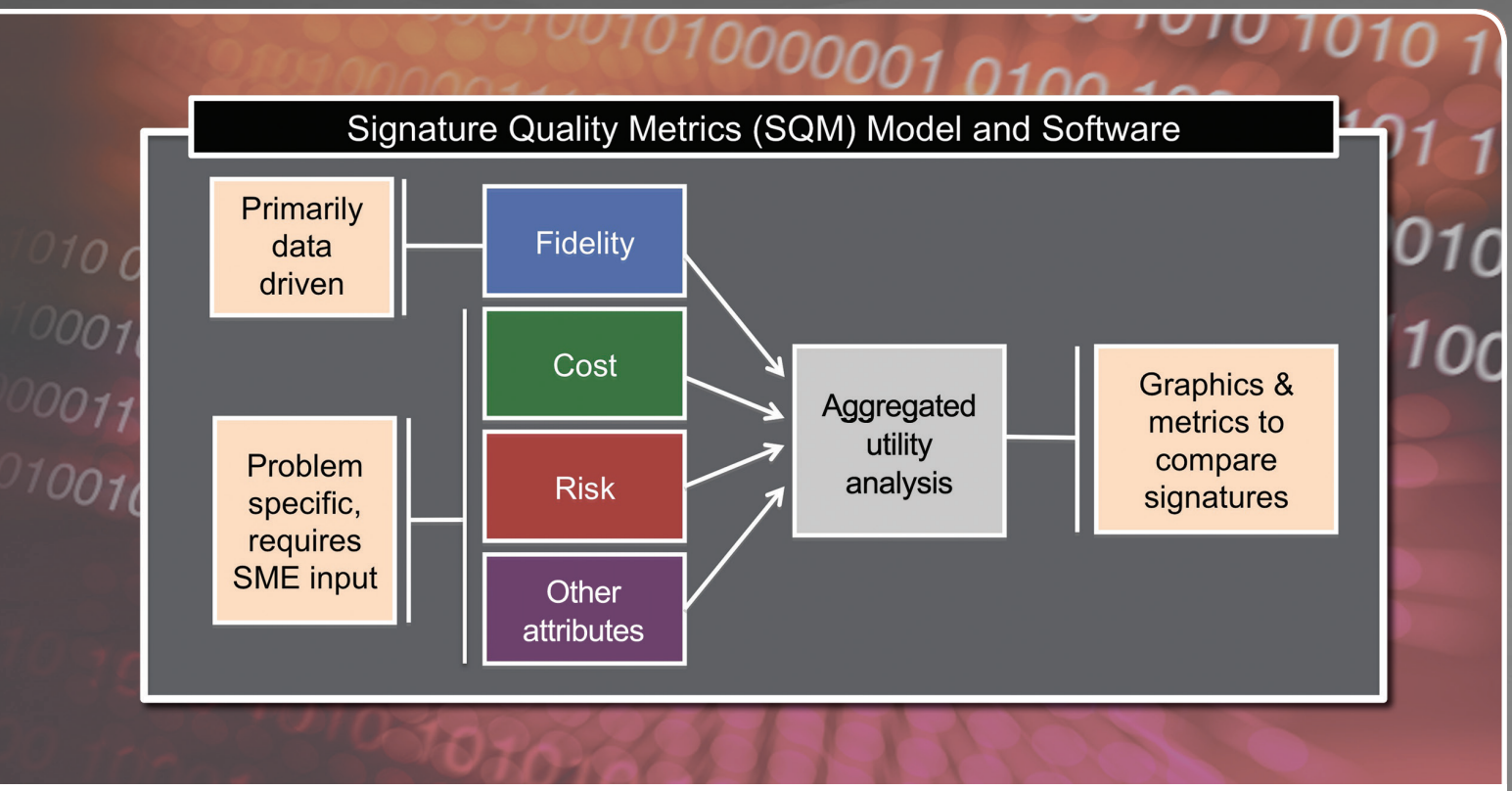


Signature Quality Metrics

Every signature discovery effort needs a transparent approach for evaluating the quality of the resultant signature system.

CHALLENGE

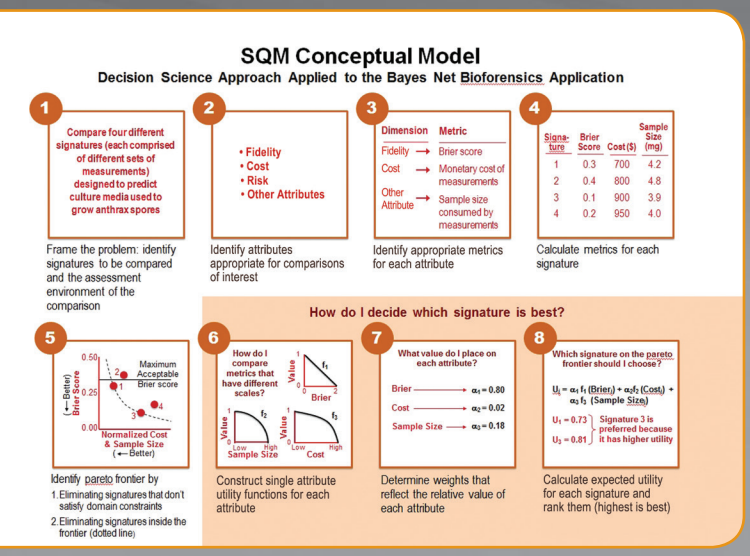
Developers and stakeholders of signature systems need a holistic approach for assessing the quality of signature systems as they move through the stages of research and development, construction and evaluation of prototypes, and eventual deployment in an operational environment. In order for signature quality metrics (SQM) to be useful and effective, they should be quantitative, robust, comparable, and interpretable. SQM empowers investigators to identify weaknesses and opportunities for improvement, making it possible to examine the cost/benefit trade-offs associated with incremental or fundamental changes to their signature systems.

APPROACH/METHODS

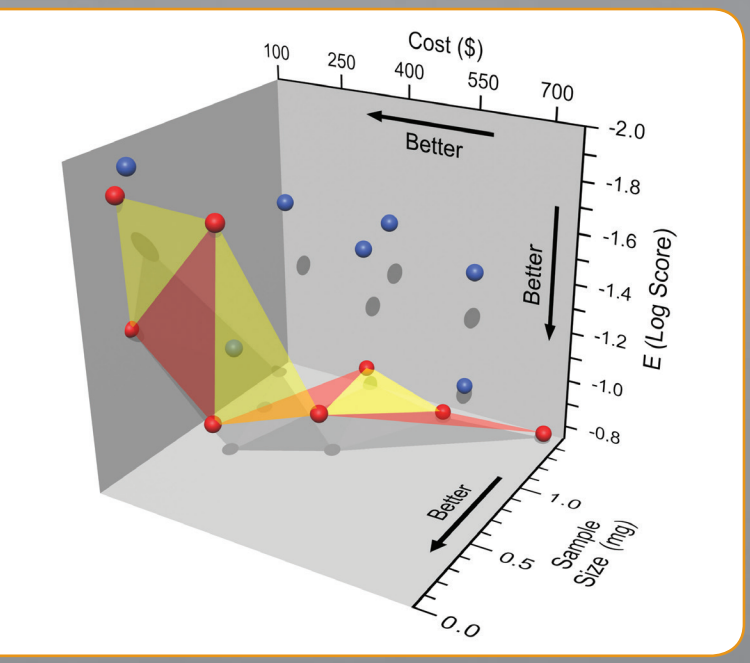
SQM is an application of decision theory and multi-attribute decision science. The SQM methodology includes the assessment of fidelity, risk, cost, and other attributes. These four components of signature quality provide a basis for guiding investigators in their assessment of signature systems. Not all of them may be relevant for a particular assessment; only the attributes that are most appropriate should be selected to evaluate a given system (or set of systems). The attributes of choice can then be aggregated into an overall utility function that reflects the relative value evaluators ascribe to each of the attributes. The expected utility can be used to compare one system to another or to compare flavors of the same system. Systems that demonstrate the highest expected utility are preferred to those with lower expected utility.

SQM Components in More Detail

Fidelity refers to how well the signature system detects, predicts, or characterizes the phenomenon of interest. It includes metrics such as sensitivity, specificity, and positive



A Detailed View of the SQM Process Applied to the Evaluate Variations of the Bacillus Anthracis Signature System



Three-dimensional Scatter Plot Illustrating the Pareto Frontier of the Bacillus Anthracis Signature System. The red points indicate systems on the Pareto frontier. The red and yellow interpolating surfaces estimate the frontier itself.

predictive value. Risk refers to the assessment of likelihoods and consequences associated with decision errors and the use of the signature system. Cost refers to the resources expended to develop, deploy, and/or utilize the signature system. Any other factors that may distinguish one signature system from another that are not already accounted for by fidelity, cost, or risk are grouped in the other catagory. Examples include human safety, ease of use, system portability, policy considerations, and danger associated with employing the signature system.

The assessment of signature quality begins by measuring (or calculating) the attributes of interest for each system, followed by a comparison of the systems in terms of each attribute. Signature systems may be formally compared using multi-attribute utility analysis. The value we ascribe over the range of each attribute is reflected in the single attribute utility functions. These single attribute utility values are then aggregated in a linear or multiplicative fashion into an overall utility function, using a set of weights that reflect the relative value of each attribute. Systems that maximize the expected utility are preferred.

IMPACT/BENEFIT

SQM provides a rigorous approach for measuring the quality of signature systems in any domain. We define system quality as the extent to which a system achieves its intended purpose—which includes satisfying operational constraints. SQM provides a common yardstick whereby investigators, program managers, and stakeholders can gauge performance of systems. It provides assurance to all interested parties that a well-defined notion of system quality was integrated into the development process from beginning to end.

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