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Selecting Robotic Power Solutions: A Case Study of Stochastic Value Modeling

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Abstract: Value modeling is a powerful tool that allows system engineers to ensure that a design will meet the operator's needs. The process involves developing value measures, the criteria that is valued by the user, for a design and using these measures to derive a score that allows for an easy comparison between different alternatives. These value scores can be plotted with the cost of a design alternative to create a cost-value diagram. An inherent issue with value modeling is that it requires precise knowledge of each design alternative. However, early in the design process, precise data is typically not readily available to inform the value model or cost approximations. As such, approximations must be made, introducing uncertainty and risk into the model. This uncertainty and risk can be captured through the use of stochastic value modeling, which allows for uncertainty in the raw data to propagate through the model, creating a distribution of value scores and costs.

In this paper, a case study of stochastic value modeling is presented through the selection of a power source for a robotic application. The selection of the power source is a critical design decision, since failure to select an adequate power source can result in a failed development effort. However, selection of a power system is made difficult by the number of different options and the unpredictable advancement in the technology. As such, the selection of an appropriate power system is an ideal application for a stochastic value model. This paper presents a stochastic value model for selecting a power source for a robotic application comparing different solutions, including: batteries, fuel cells, internal combustion engines, photovoltaics, and thermoelectric generators. The analysis includes value measures associated with power output, weight, noise, and thermal signature. The value model facilitates development of a cost-benefit graph that captures the uncertainty in each design alternative with respect to value and cost. The outputs of the model are then used to demonstrate a technique for risk management throughout the development of the system.

Keywords: Value Modeling, Uncertainty, Risk, Pareto Dominance, Lifecycle Cost