Physical representations of the physics based computer models in the CompModels package

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Abstract

The **CompModels** package for R provides a suite of computer model test functions that can be used for computer model prediction/emulation, uncertainty quantification, and calibration, but in particular, the sequential optimization of computer models. The package is a mix of real-world physics problems, known mathematical functions, and black-box functions that have been converted into computer models with the goal of Bayesian (i.e., sequential) optimization in mind. Likewise, the package contains computer models that represent either the constrained or unconstrained optimization case, each with varying levels of difficulty. The following document serves to provide a schematic overview of the physical representations of the physics based computer models.

Keywords: Simulators, computer models, black-box.

1. Pressure Vessel Computer Model

The pressure vessel computer model is designed to minimize the total cost of constructing a pressure vessel considering the cost of material, forming, and welding. The four inputs to the computer model are the thickness of the shell (x_1), the thickness of the head (x_2), the inner radius (x_3), and the length of the cylindrical section of the vessel (x_4) not including the head. Note, the thicknesses of the variables are integer multiples of 0.0625 inches. The cost of the pressure vessel is subject to four constraints. For implementation details in R, please use `?pressure`.

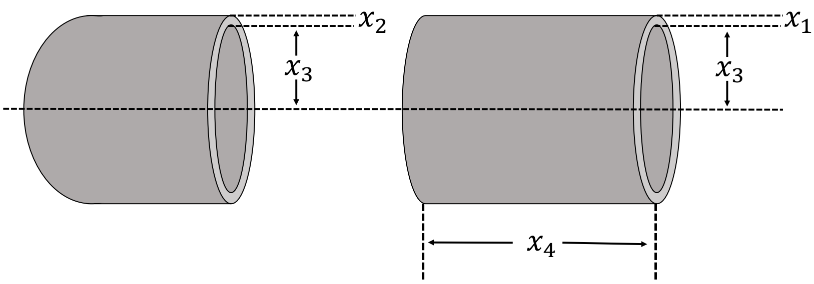

Figure 1: The physical representation of the pressure vessel computer model.

Attribute	Parameter	Domain
Shell thickness	x_1	$[0, 99]$
Head thickness	x_2	$[0, 99]$
Inner Radius	x_3	$[0, 200]$
Length of cylinder	x_4	$[0, 200]$

Table 1: Computer model inputs.

2. Sprinkler Computer Model

The sprinkler computer model is a multiobjective optimization problem adapted from Bebber, Hochkirchen, and Siebertz (2010). The objectives are to minimize the water consumption associated with using a garden sprinkler, while also maximizing the speed and range of the garden sprinkler. The eight inputs to the computer model are the vertical (x_1) and tangential (x_2) nozzle angle, the nozzle profile (x_3), the diameter of the sprinkler head (x_4), the dynamic (x_5) and static (x_6) friction moment, the entrance pressure (x_7), and the diameter flow line (x_8). For implementation details in R, please use `?sprinkler`.

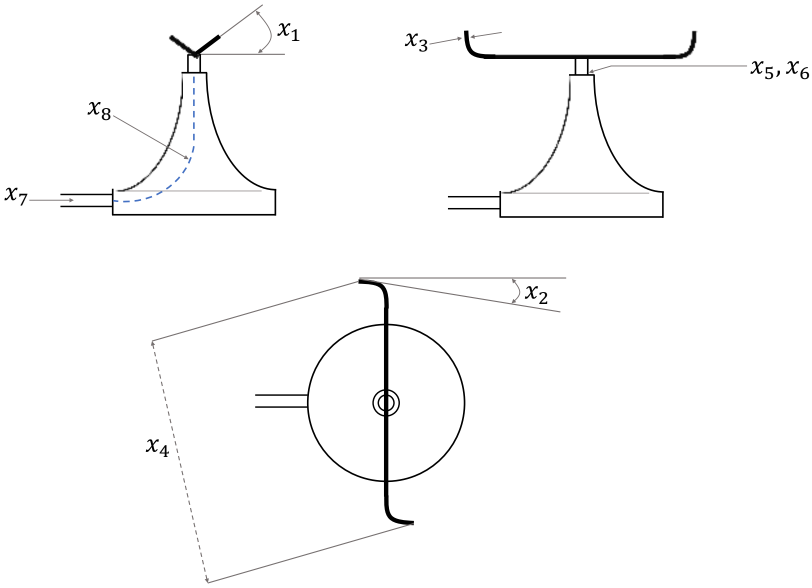

Figure 2: The physical representation of the sprinkler computer model.

Attribute	Parameter	Domain	Units
Vertical nozzle angle	x_1	$[0, 90]$	°
Tangential nozzle angle	x_2	$[0, 90]$	°
Nozzle profile	x_3	[2e-6, 4e-6]	m^2
Diameter of the sprinkler head	x_4	$[0.1, 0.2]$	mm
Dynamic friction moment	x_5	$[0.01, 0.02]$	Nm
Static friction moment	x_6	$[0.01, 0.02]$	Nm/s
Entrance pressure	x_7	$[1, 2]$	bar
Diameter flow line	x_8	$[5, 10]$	mm

Table 2: Computer model inputs.

3. Tension Spring Computer Model

The tension spring computer model is designed to minimize the weight of a tension spring. The three inputs to the computer model are the wire diameter (x_1), mean coil diameter (x_2), and the number of active coils (x_3). The tension spring weight is subject to four constraints on the shear stress, surge frequency, and deflection. For implementation details in R, please use `?tension`.

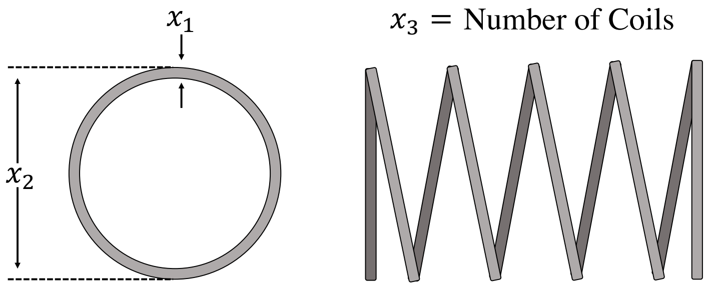

Figure 3: The physical representation of the tension spring computer model.

Attribute	Parameter	Domain
Wire diameter	x_1	$[0.05, 2]$
Mean coil diameter	x_2	$[0.25, 1.3]$
Number of active coils	x_3	$[2, 15]$

Table 3: Computer model inputs.

References

Bebber Dv, Hochkirchen T, Siebertz K (2010). *Statistische Versuchsplanung: Design of Experiments (DoE)*. First edition. Germany: Springer Berlin Heidelberg.

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