Quantifying Uncertainty in Materials Strength

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Abstract
A Bayesian approach is used to calibrate a strength model to Taylor impact data.

Introduction
Quantifying uncertainty in model predictions is a motivating factor. Many experiments depend on simulations to estimate variables that cannot be measured directly, thus prompting the need to determine the uncertainty in their predictions.

Taylor Impact Test
Strength data at higher strain rates generally does not measure the stress-strain response directly.

Strength Models
Predict the stress-strain response of a material, range in complexity from simple such as Johnson-Cook to relatively complex such as MTS.

\[
\sigma_{\text{flow}} = f(x_i, \theta)
\]

\[
\theta_{JC} = \{A, R, C, m, n\}
\]

\[
\theta_{MTS} = \{q_i, P_i, \sigma_0, \sigma_u, \sigma_s \ldots \}
\]

\[
x_i = \{\text{velocity}\}
\]

Bayesian Approach With Surrogate
Select Strength model
FE model for Dist
Create surrogate model
Quantify prediction uncertainty
Bayesian calibration via MCMC

Posterior Distribution

\[ A = 0.00380 \pm 0.00010 \]

\[ q_i = 1.82528 \pm 0.10815 \]

Propagation of Uncertainty
Posterior distribution sampled and propagated through the surrogate for an uncertainty estimate.

Conclusions
- Greater variability in MTS model than JC, likely due to increased complexity in the MTS model relative to JC.
- Project combines knowledge base of materials science, statistics, and HPC.
- Future work: will focus on combining disparate data sets into the calibration routine.
- Future work: calibration using cylinder profiles at constant impact velocity.

GP based surrogate models useful tool in estimating uncertainty in materials strength