Evaluating the Impact of Thoracic Pressure on Intracranial Pressure Under Epistemic Uncertainty

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Epistemic Uncertainty

• Uncertainty caused by a lack of knowledge of a system.
• In principle, could be reduced by additional measurements.
• Dempster-Shafer Evidence Theory
  • Combine multiple (possibly overlapping) regions for parameters
  • Outputs a belief function (lower bound on probability) and a plausibility function (upper bound on probability)
• Computed using Sandia National Laboratory’s DAKOTA tool
GRC Head Model

• Extension of the Stevens, et al., model to include additional head drainage pathways

• Presented at 2020 IWS
Experiment

• Forcing fluid flow out of the CSF space (simulating additional drainage or reabsorption) reduces CSF pressure.

• Goal: What level of flow is needed to reproduce an observed 2 mmHg drop?

• Uncertain parameters:
  • Jugular Compliance
  • Extrajugular Volume
  • Cardiac Output Rate
  • Heartrate
Results

• For this choice of uncertain parameter ranges, the GRC Head Model supports a flow rate in the interval [0.415, 0.472] mL/min.

• Shape of the belief function offers few constraints to distributions.

• As with all epistemic uncertainty, improvements can be made by incorporating additional data on the uncertain parameters.
Conclusions

• Epistemic UQ allows for the incorporation of multiple data sources for parameter data and to capture the uncertainty that results.

• Uncertainty analyses are easily performed with DAKOTA.

• Inspection of the resulting belief and plausibility functions can offer insight into which parameters result in larger uncertainties.

• The GRC Head Model is consistent with a 2 mmHg drop in CSF pressure being equivalent to an additional [0.415, 0.472] mL/min of additional drainage/reabsorption of CSF.