EU-MATHS-IN
Success story

COMPANY
Bekaert

RESEARCH CENTRE
KU Leuven. Department of Computer Science

PRODUCTIVE SECTOR
Materials

Digital Twin

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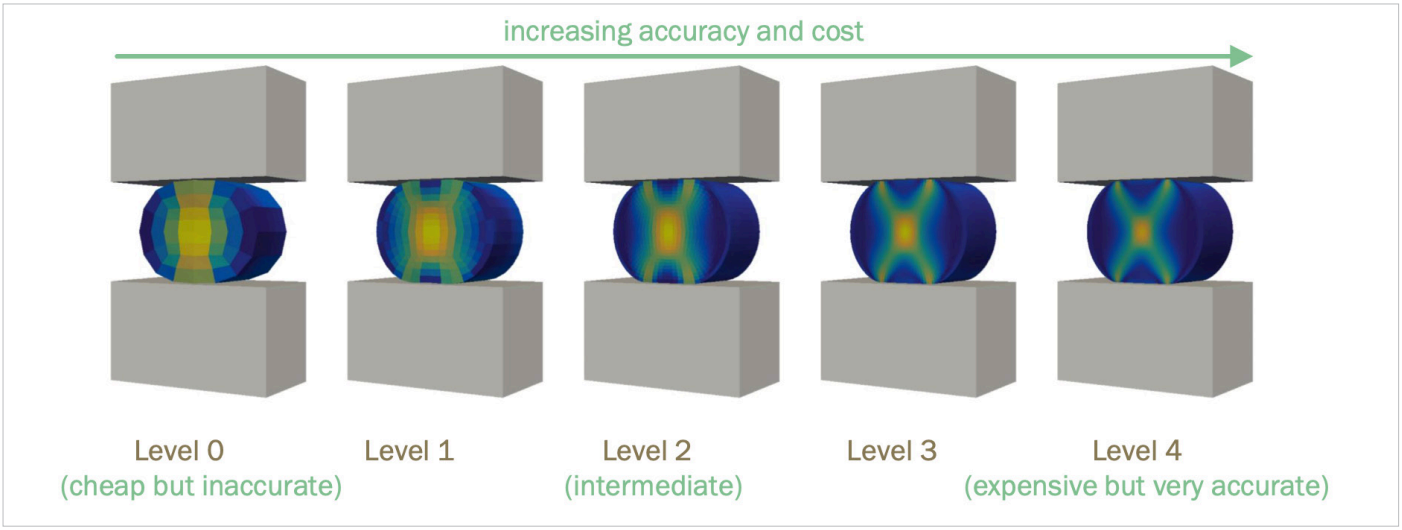
SS_028_2020

EUFORIA

Catching uncertainties in steel wire drawing. Multilevel Monte Carlo to the rescue.



PROBLEM DESCRIPTION

Bekaert is a world market and technology leader in steel wire transformation and coating technologies processing about 3 million tons of steel wire each year. To further increase the steel wire quality, Bekaert wants to reduce the various uncertainties in the wire drawing process using novel methodologies from uncertainty quantification (UQ).

CHALLENGES AND GOALS

- ✔ High dimensional: the presence of many uncertain parameters render classical UQ techniques impractical.
- ✔ Expensive simulations: a single simulation with fixed parameters takes several hours to even days.
- ✔ Industrial test case: not every parameter combination is feasible for the deterministic solver.

MATHEMATICAL AND COMPUTATIONAL METHODS

Wire drawing reduces the cross section of a steel wire by pulling it through a single (or a series of) drawing die(s). A mathematical model describes the non linear plastic deformation of the wire In this model, many uncertainties are present geometrical (wire diameter, wire shape), physical (wire strength, yield) and process related (approach angle, drawing speed).

Sampling techniques, such as Monte Carlo repeatedly pick random values for the uncertain parameters and evaluate the associated model output However, such techniques are too expensive to analyze the impact of uncertainties, since many model evaluations are needed.

Instead, a multilevel sampling strategy is used if the model is accessible on different levels of accuracy (e g by using different finite element grids), samples on different levels can be combined, such that many computationally cheap samples are taken on the coarse grid, and only few expensive samples are required on the finest grid.

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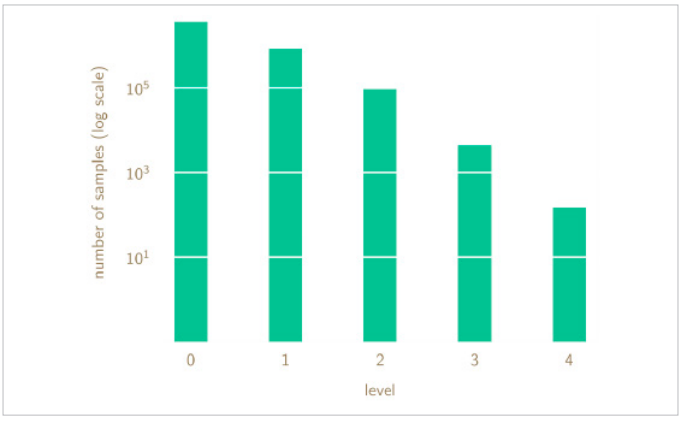
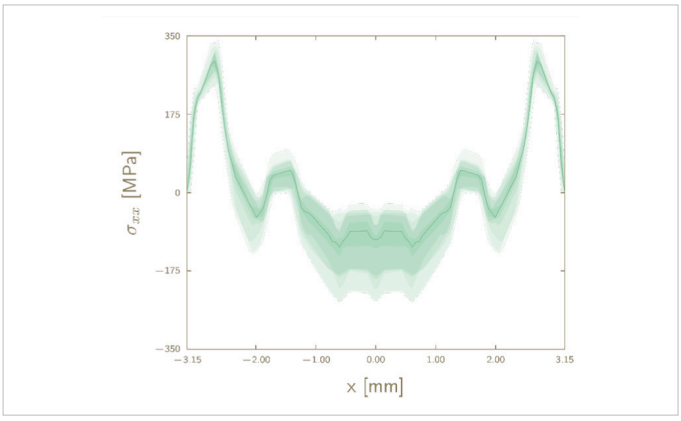


Distribution of the number of samples across the levels



Example outcome: uncertainty on the tensile stress in a cross-section of the wire

RESULTS AND BENEFITS

Using the multilevel sampling approach, statistics of a quantity of interest can be computed much faster compared to previous UQ methods.

- ✔ Our Multilevel Monte Carlo method takes 12 days to compute the expected value of the drawing force (relative error of 1%).
- ✔ Our Multilevel Quasi-Monte Carlo method takes only 4 days.
- ✔ On the same hardware, classic Monte Carlo approach would take 1.5 years!

Using novel multilevel sampling techniques from uncertainty quantification that dramatically reduce the cost of a numerical simulation, the steel wire company Bekaert can produce steel wire with more reliable properties.

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KU Leuven, Department of Computer Science, NUMA Section.