

SEMPID

Software for the Extraction of Material Properties from Indentation Data

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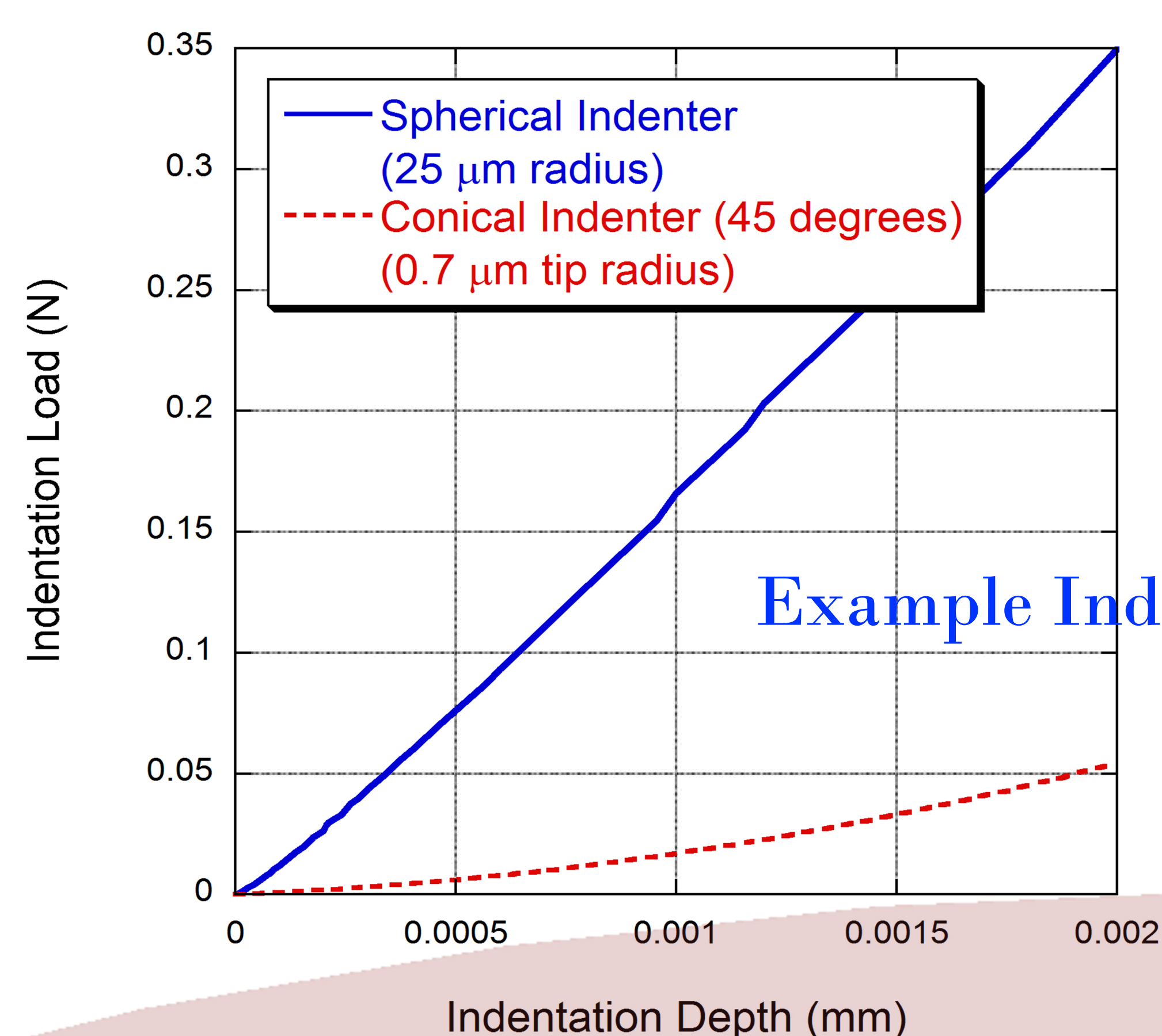
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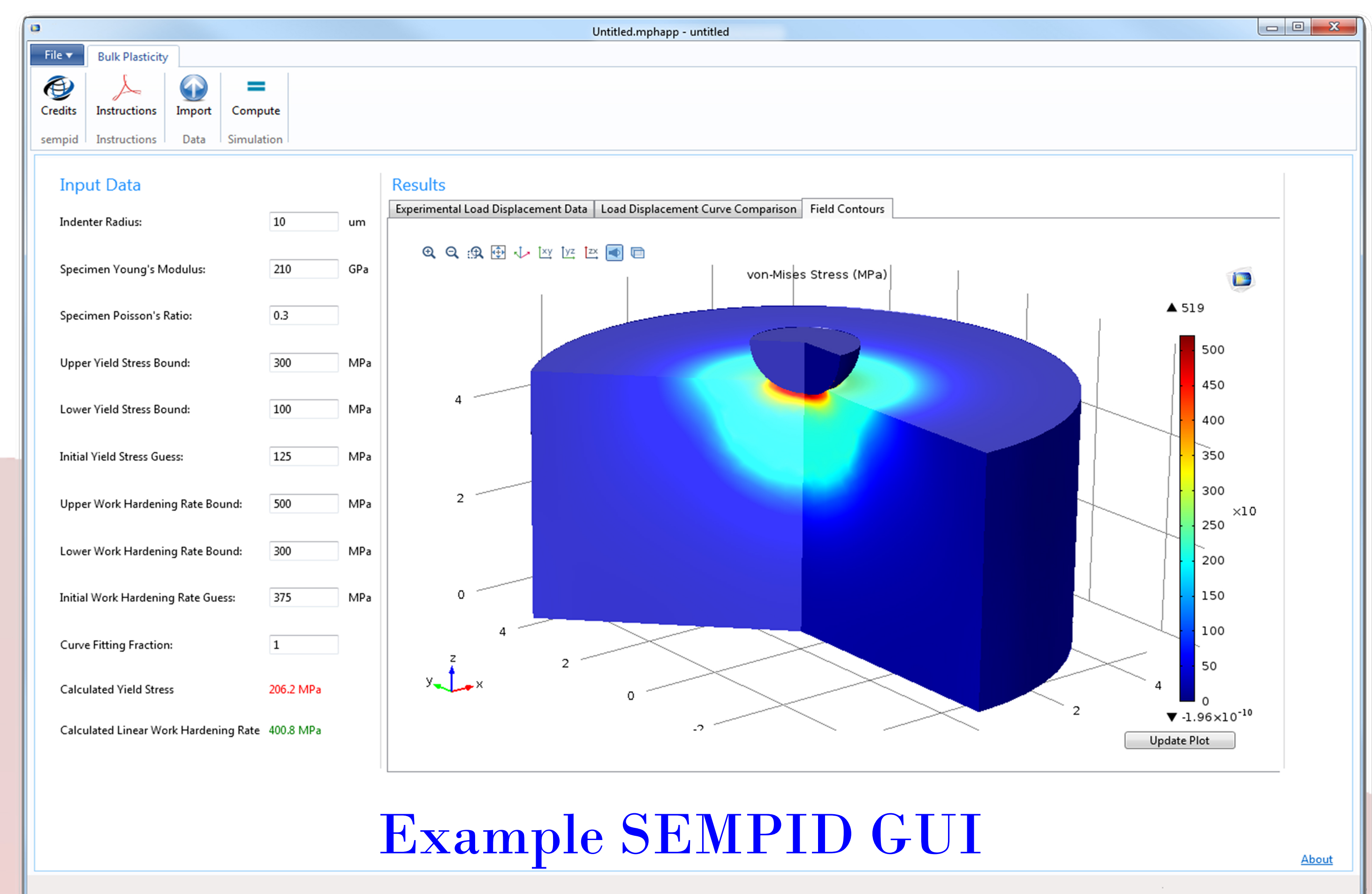
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Methodologies for inferring mechanical properties from indentation experiments (load-displacement-time data) have recently been developed [1,2,3]. The properties concerned include *metal plasticity parameters* such as the *yield stress* and *work hardening rate* (i.e. strain coefficients and strain exponents), and *creep parameters*, such as the *steady-state creep stress exponent* and the *steady-state creep activation energy*. The approach is conceptually very simple, being based on iterative comparisons between (selected) experimental data and corresponding (finite element) model outcomes. The FEM input parameters (constitutive relations and material parameters) are varied until measured and predicted data converge. The SEMPID software tools handle this procedure automatically using built-in optimisation algorithms.

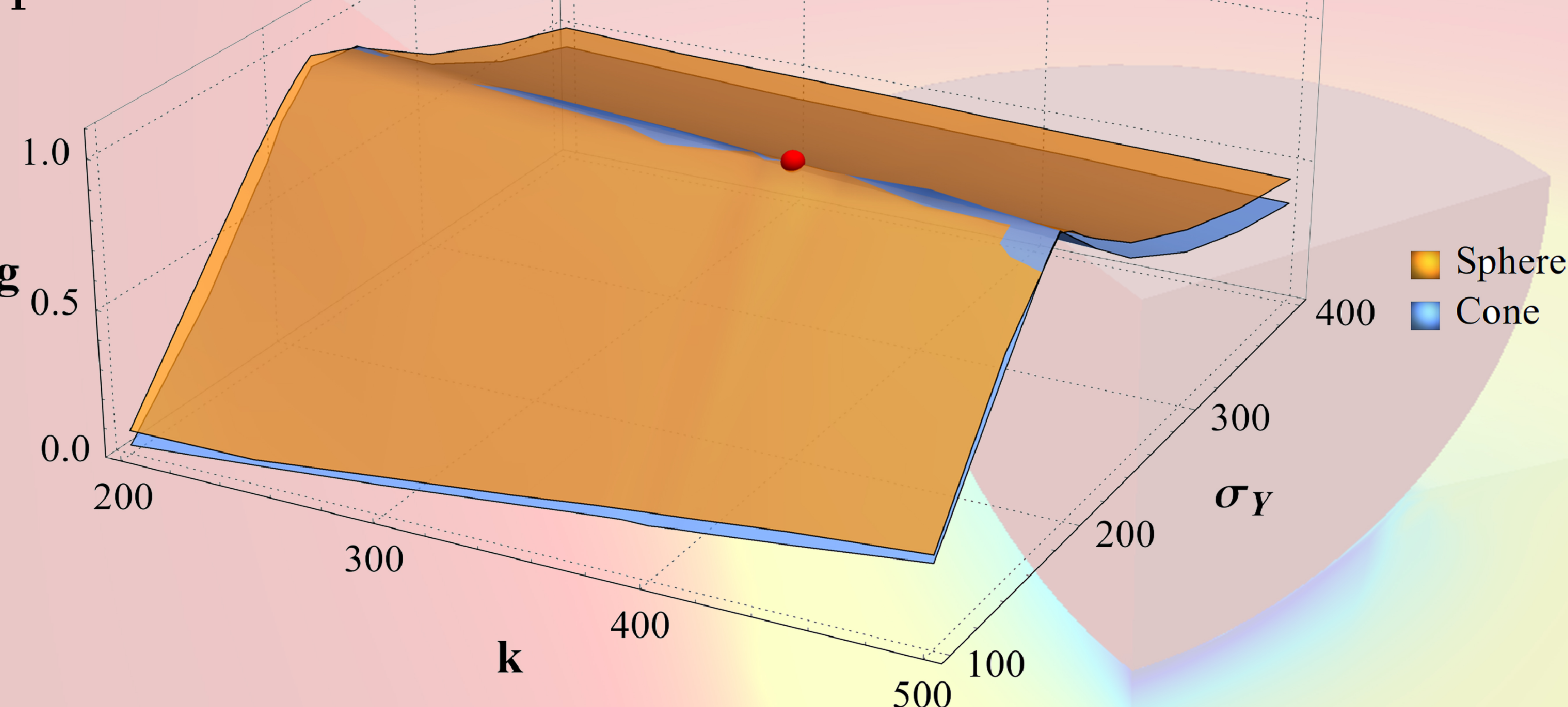
SEMPID Operating Procedures



Obtain experimental indentation data (*2 different tip shapes*) and import into relevant SEMPID software application (*hosted remotely*). The SEMPID applications can accommodate tests that are done on any scale, and there is no need for prior experience with finite element analysis.



Specify *search bounds* on the relevant, unknown material properties and SOLVE. Indentation models are then run “behind-the-scenes”, where a “*goodness-of-fit*” parameter, between experimental and model data “*g*”, is *maximised*, via automated, iterative alteration of the model input parameters.



The figure on the left shows surface contour plots of “*g*”, the “goodness-of-fit” parameter as a function of two “unknown” material property variables - in this instance the yield stress (σ_Y) and a (linear) work hardening rate (*k*), obtained via an automated sweep of these parameters, using spherical and cone indenters. The maximum value of “*g*” occurs where the red dot is shown in the graph - i.e. $\sigma_Y = 200$ MPa and *k* = 400 MPa. Two indenters are used to ensure that the converged solution is “*unique*”.

SEMPID Benefits

Small samples, thin coatings, low cost, fast turn-around times, reliable data, intuitive user interfaces, no prior FEA modelling experience needed, built-in optimisation tools

Potential Applications

Material property determination, material property mapping, monitoring of material property degradation, quality control, thin coating material properties

References

- [1] Use of Quasi-static Nanoindentation Data to Obtain Stress-Strain Characteristics for Metallic Materials, Acta Materialia, 58 (2010) 3613-3623
- [2] A Procedure for Extracting Primary and Secondary Creep Parameters from Nanoindentation Data, Mechanics of Materials, 65 (2013) 124-134
- [3] A Critical Assessment of the “Stable Indenter Velocity” Method for Obtaining the Creep Stress Exponent from Indentation Data, Acta Materialia, 80 (2014) 56-66