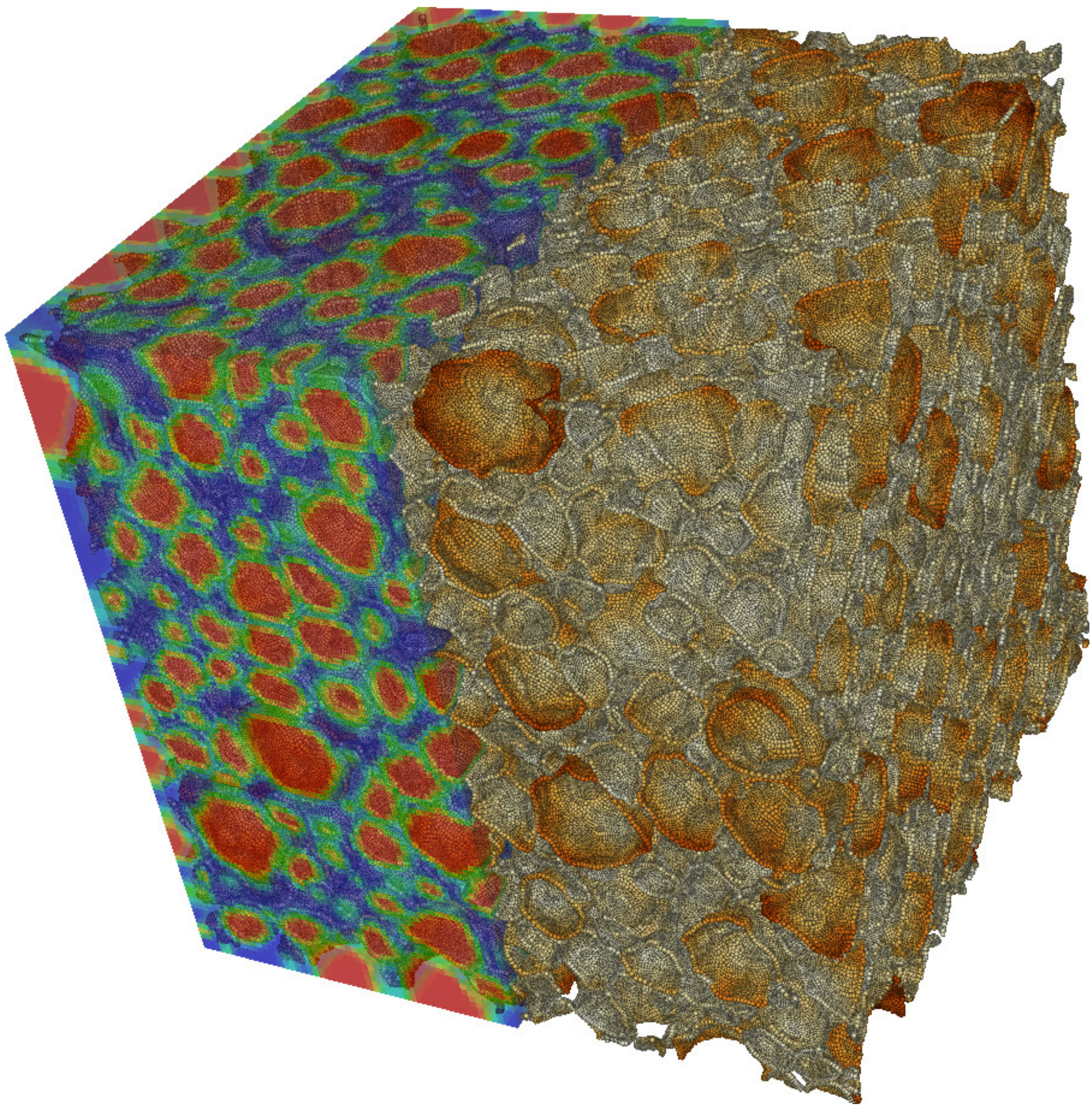
Parresia

SIMULATION • ANALYSIS • INSIGHT

https://bbanerjee.github.io/ParSim/

MULTI-PHYSICS SIMULATIONS AND SENSOR DATA ANALYSIS



The evolution on aluminum foam microstructure due to expanding gases during casting

WHAT WE DO

Multi-physics Engineering Simulations

We create novel techniques for mesh generation and discretization

Finite element meshing technology for geometry captured by sensors

Particle discretization methods for meshless numerical methods

We develop and validate models to simulate complex material behavior

Pure metals and alloys, polymers, foams, elastomers, fiber composites, rocks, soils, concrete, powders.

High pressure and temperature, fully and partially saturated with fluids and gases, various loading rates.

We develop improved techniques for multi-physics simulation

Our flagship internal code is Vaango - a Material Point Method software for massively parallel fluid-structure interaction

We use finite element analysis for small deformations, the material point method for large deformations, peridynamics for fracture, and the discrete element method for particulate flows.

We provide load estimates for engineering designs

Loads on engineered structures include pressure, wind, temperature, earthquake, landslides etc. We compute these loads from multi-physics simulations and provide them to designers.

Sensor Data Analysis and Failure Prediction

We analyze data from sensors to find patterns

Sensors for temperature, pressure, vibrations, and small displacements (laser-based) produce time-varying signals. We use machine learning (Tensorflow) and computational geometry (CGAL) to find patterns in the data.

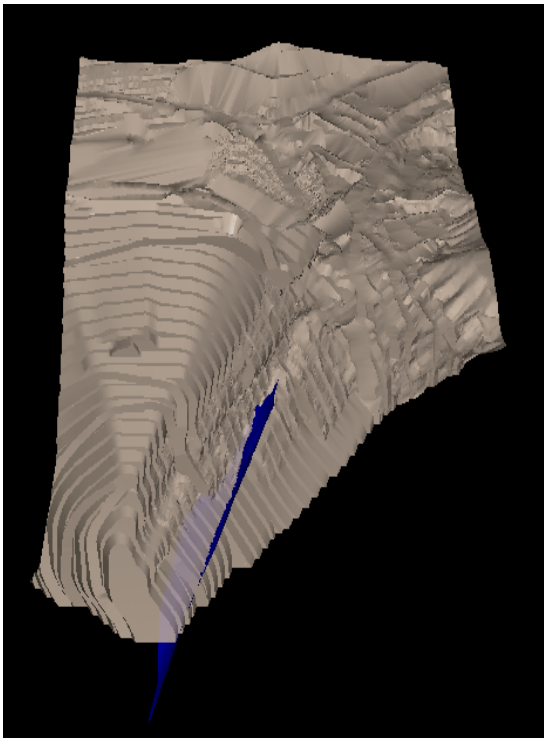
We develop predictive tools based on sensor-data analysis

We predict the failure of components and structures based on large-scale sensor data. We also provide bespoke software that incorporates these predictive tools.

GEOMETRY/DISCRETIZATION

Bench slope and overburden stability of open-pit mines is critical for smooth production operations. Pore pressure increases due to increased rainfall frequently cause slope failures.

A typical mine geometry and fault location (image on right) is complex and takes at least 10 days to mesh using conventional methods before simulations can be performed and risks analyzed.



Benches in an open-pit mine. The blue plane is a fault. Meshing of such geometries is not possible without specialized tools

Parresia Research Limited uses advanced computational geometry techniques developed in the computer graphics world to simplify the mesh generation procedure.

For post-failure simulations needed in risk assessment, we use Vaango and the discrete element method. The mine geometry us discreted using particles for such simulations.

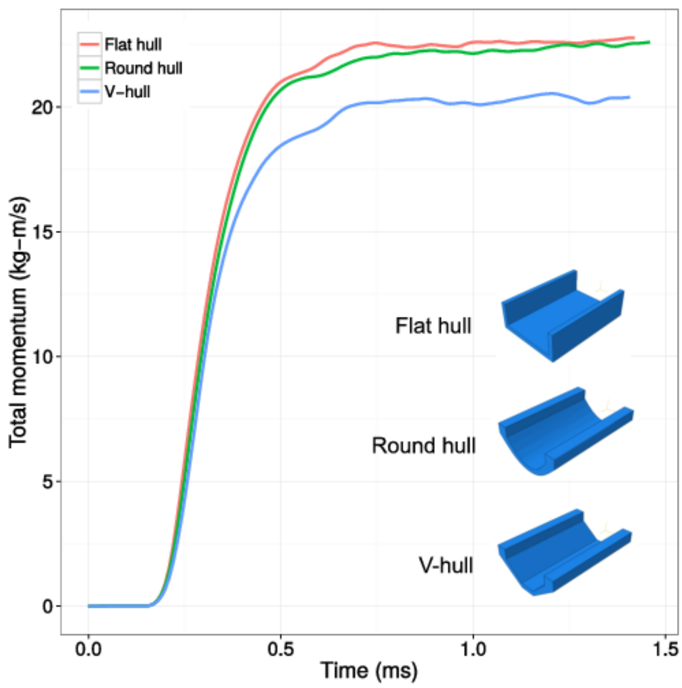
Customers include a leading US-based geotechnical consulting company.

SOILS AND ROCKS

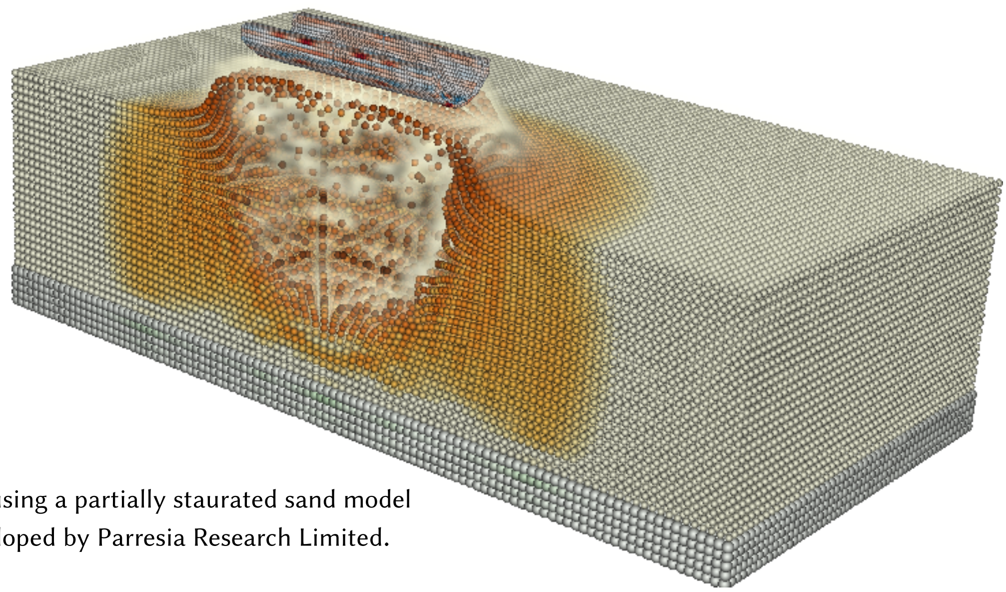
We specialize in the dynamic behavior of soils (earthquake loading, rapid pile driving, explosions) and rocks. We also analyze complex three-dimensional quasistatic problems of slope stability, subsidence, and multi-scale problems such as bolting and caving.

We perform simulations at many different length scales depending on the requirements of the problem. Fully and partially saturated soils and rocks are our current area of focus in this field.

The primary expertise of the team is in large deformation mechanics, plasticity, and fracture under dynamic conditions. We use commercial finite element software or our in-house material point method/peridynamics/discrete element codes depending on the complexity of the deformation and the material model.



The V-shaped hull is the best design for deflecting an explosion due to a IED.



An explosion using a partially staurated sand model (ARENA) developed by Parresia Research Limited.

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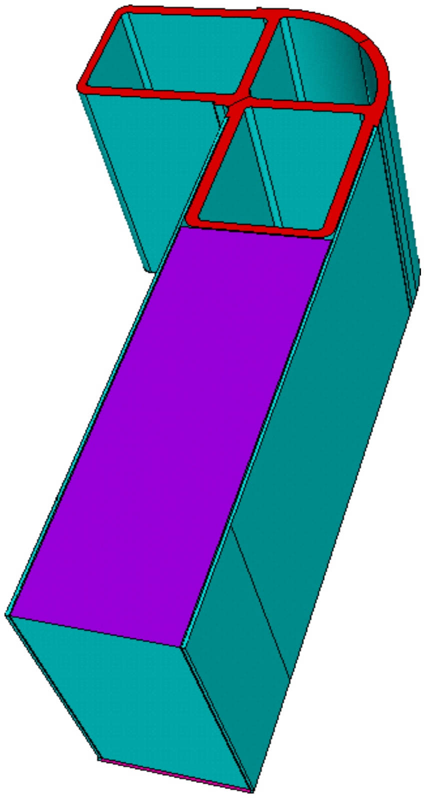
ARCHITECTED COMPOSITES

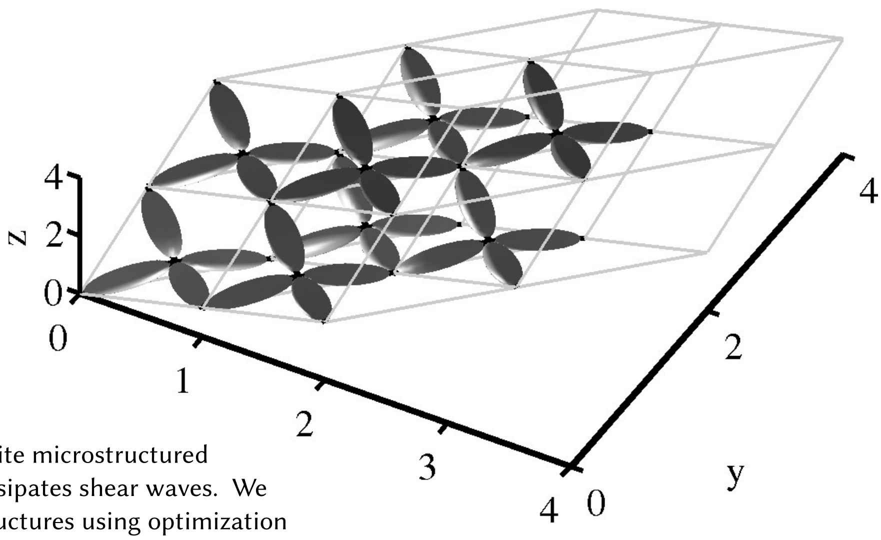
We simulate a large variety of anisotropic composite materials including structural composite (carbon and glass fibre/polymer), filled foams (polymer and metal), and architected materials and metamaterials.

Our commercial customers typically provide industrial composite designs that we analyze for nonlinear buckling, fracture, and plastic deformation.

Our research projects involve the design of new architected materials and metamaterials that have unusual properties such as negative Poisson's ratio and large bulk to shear modulus ratios.



A carbon-fiber and polyurethane foam sandwich composite corner joint for aerospace components. We analyze the buckling and delamination failure of these structures.



A pentamode composite microstructured metamaterial that dissipates shear waves. We design these microstructures using optimization techniques.

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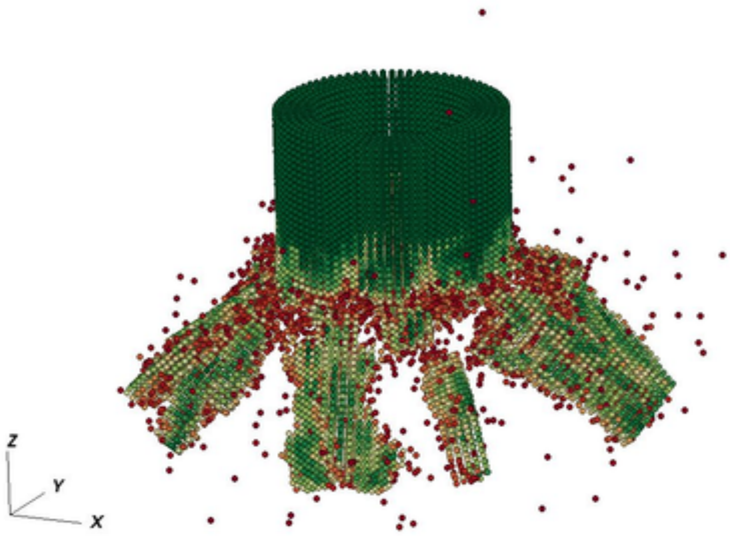
FRACTURE /ADHESION

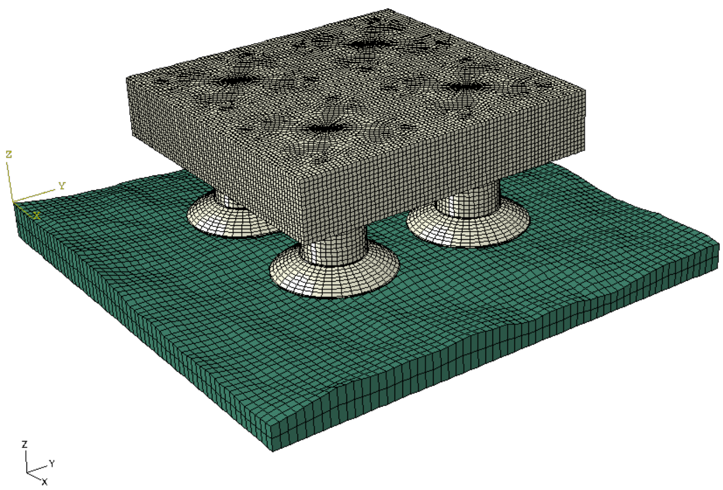
For quasistatic problems we use J-integral based fracture mechanics and extended finite elements (X-FEM) for fracture simulation. Commercial software tools with in-house pre- and post-processing are typically used for our analyses. Adhesion of nonlinear elastomers is modeled using special contact algorithms.

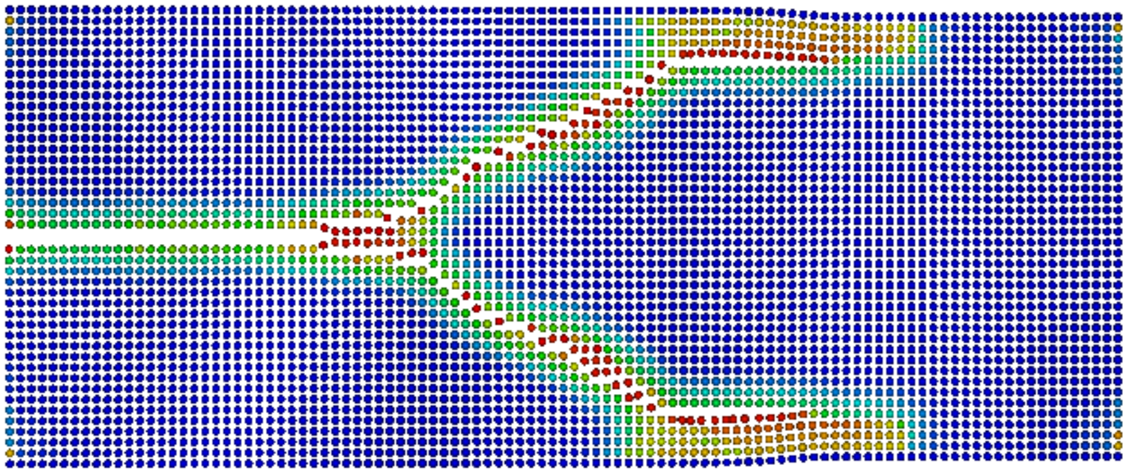
For dynamic problems, we use a combination of the material point method, damage mechanics, loss of hyperblocity conditions, and peridynamics to predict fracture initiation and propagation.

A large component of our in-house research work is geared towards developing improved predictive capabilities for dynamic fracture and long-term fracture effects. We also investigate fracture algorithms for complex visual effects.



Fracture of a pressurized cylinder (above).
Adhesion of a micro-suction device to a rough surface (below).





Crack-splitting simulation with peridynamics.

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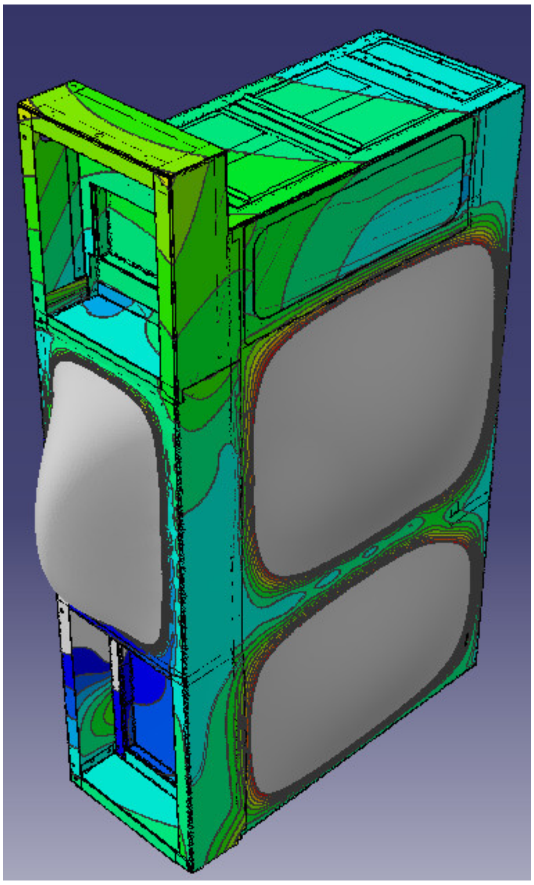
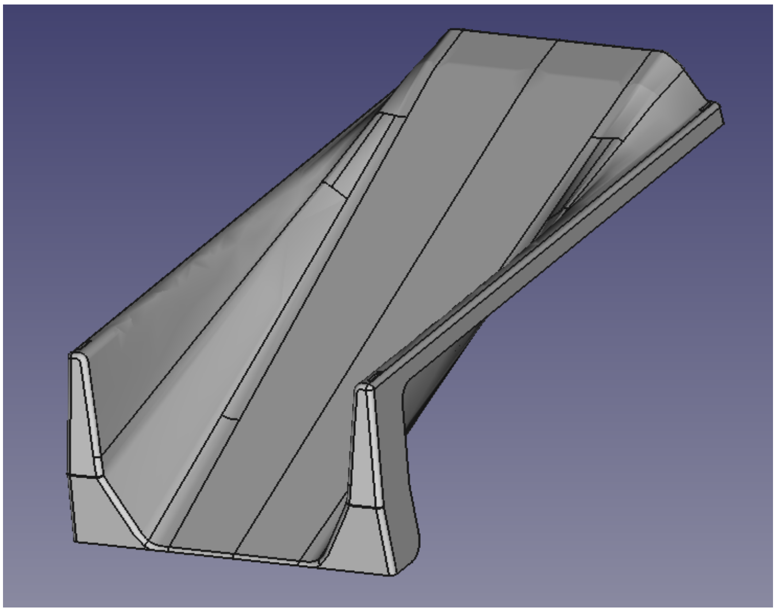
LOAD ESTIMATION

Load estimates are typically inputs to engineering designs. We use finite element analyses, material point method simulations, and discrete element method simulations to estimate loads on structures and their time evolution.



An electrical switchgear box with more than a thousand spot-welds and rivets. Finite element simulations of various high-speed heating events were used to determine the loads experience by the structure, leading to a robust design



A chute for transferring produce from a conveyor belt to another. Material point method and discrete element simulations were used to estimate loads on the structure.

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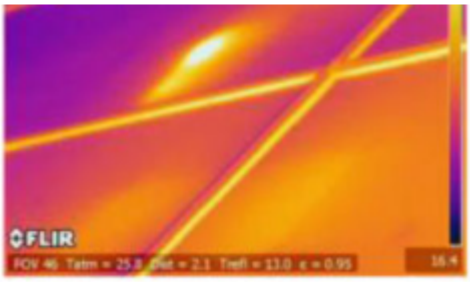
SENSOR DATA ANALYSYS

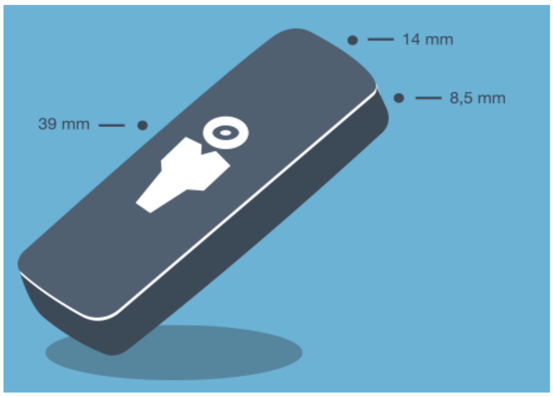
We use a range of machine learning techniques to extract information on changes and anomalies (geometry, displacement, vibration, temperature, etc.) from sensor data.

We also generate synthetic data from simulations, validate the data using actual sensor data, and use the combined data to create predictive models for when a component will be due to fail.

A molten metal ladle that is laser scanned periodically to determine the ablation of the lining over time. The laser displacement data are then used to predict the life of the lining, suggest maintenance schedules, and indicate design changes.



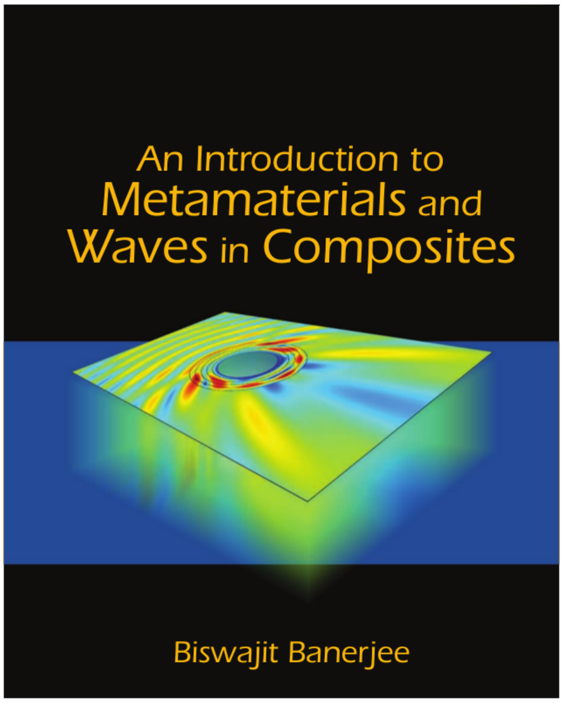
Hot-spots in a solar panel installation can be detected automatically from voltage-current or voltage-capacitance curves or from images captured by infrared cameras.



A fitness device that measures the posture of a person. Sensor data analysis is used to determine the posture of people with unusual physical characteristics who normally cannot use the device.

OUR STORY

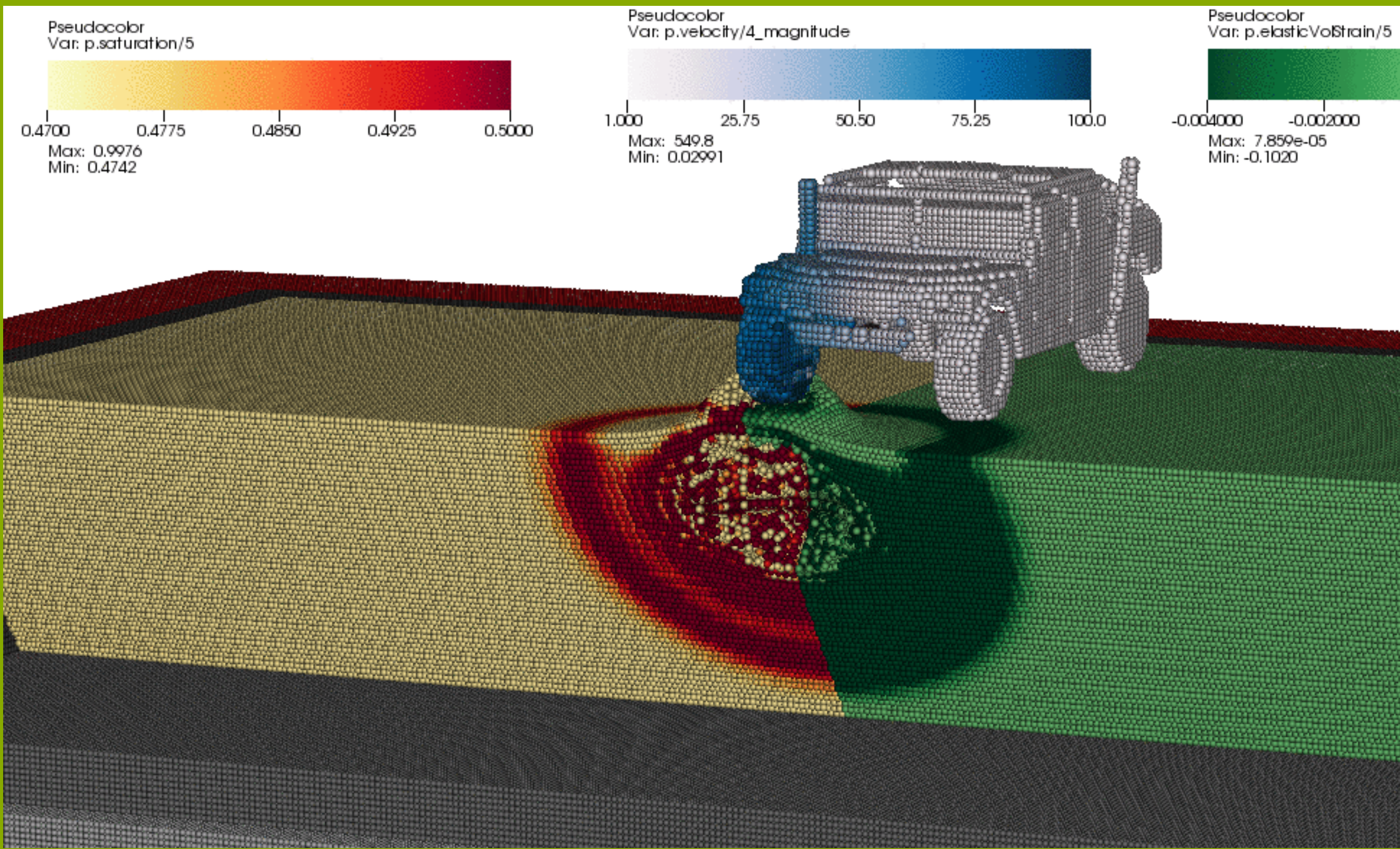
Parresia Research was established in 2014 to provide mechanics research and data analytics services, and to develop new parallel computing software for mechanics.



Since then we have completed successful multi-year projects developing, implementing, and validating new constitutive models for partially saturated soils for explosive loading conditions.

The company was founded by Dr. Biswajit Banerjee who has a BS and MS in Mining Engineering (Rock Mechanics) and a PhD in Mechanical Engineering (Computational Mechanics). Dr. Banerjee has more than 25 years of experience in academia and industry and has authored a popular textbook on Metamaterials and Waves in composite materials.

Our work includes a strong research component and we have ongoing collaborations with research teams at the University of Utah (Mechanical Engineering) and the Unversity of Colorado, Boulder (Civil Engineering).



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to discuss your project

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