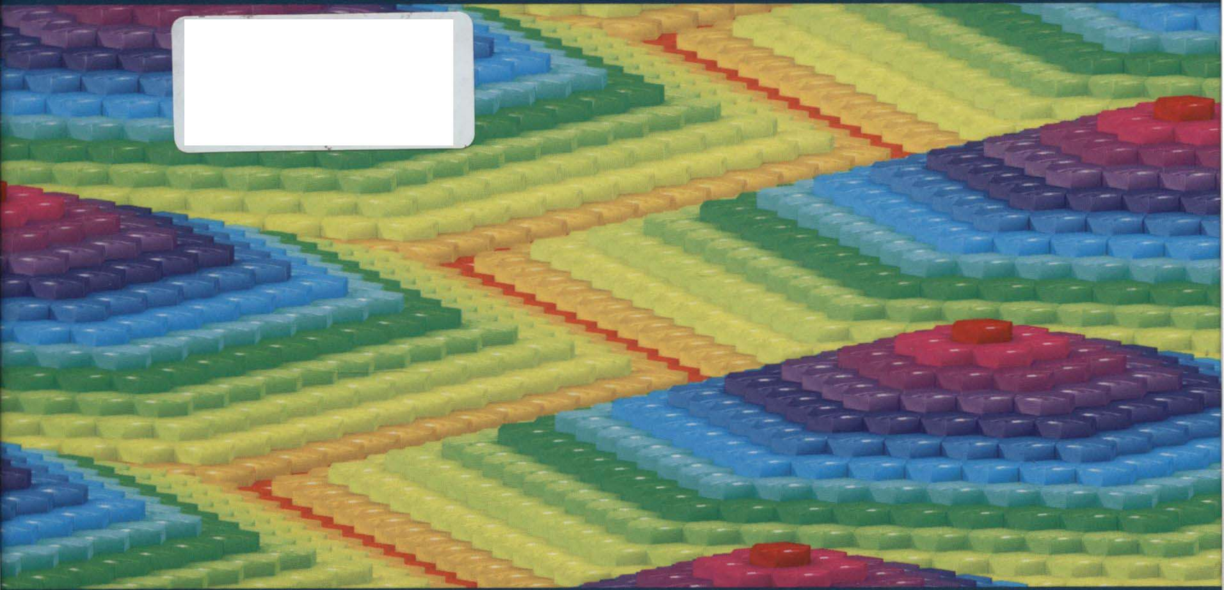
NUMERICAL METHODS IN ENGINEERING SERIES

DISCRETE ELEMENT MODEL AND SIMULATION
OF CONTINUOUS MATERIALS BEHAVIOR SET



Volume 1

Discrete Element Method to Model 3D Continuous Materials

Mohamed Jebahi, Damien Andre
Inigo Terreros and Ivan Iordanoff

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coordinated by
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Preface

Bridging the scales for material multiphysical studies.

Smart materials, Added Value Manufacturing, and factories for the future are key technological subjects for the future product developments and innovation. One of the key challenges is to play with the microstructure of the material to not only improve its properties but also to find new properties. Another key challenge is to define micro- or nano-composites in order to mix physical properties. This allows enlarging the field of possible innovative material design. The other key challenge is to define new manufacturing processes to realize these materials and new factory organization to produce the commercial product. From the material to the product, the numerical design tools must follow all these evolutions from the nanoscopic scale to the macroscopic scale (simulation and optimization of the factory). If we analyze the great amount of numerical tool development in the world, we find a great amount of development at the nanoscopic to the microscopic scales, typically linked to *ab initio* calculations and molecular dynamics. We also find a great amount of numerical approaches used at the millimeter to the meter scales. The most famous in the field of engineering is the finite element method (FEM). But there is a numerical death valley to pass though, from micrometers to several centimeters. This scale corresponds to the need for taking into account discontinuity or microstructures in the material behavior at the sample scale or component scale (several centimeters). Since the 2000's, some attempts have been carried out to apply the discrete element method (DEM) for simulation of continuous materials. This method has been developed historically for true granular materials, like sand, civil engineering grains or pharmaceutical powders. Some recent developments give new and simple tools to simulate quantitatively continuous materials and to pass from microscopic interactions at the material scale to the classical macroscopic properties at the component scale (stress and strain, thermal conductivity, cracks, damages, electrical resistivity, etc.).

In this set of books on descrete element model and simulation of continuous materials, we propose to present and explain the main advances in this field since 2010. This first book primarily explains in a clear and simple manner the numerical way to build a DEM simulation that gives the right (same) macroscopic material properties, e.g. Young Modulus, Poisson Ratio, thermal conductivity, etc. Then, it shows how this numerical tool offers a new and powerful method for analysis and modeling of cracks, damages and finally failure of a component. The second book [JEB 15] presents the coupling (bridging) between DEM method and continuum numerical methods, like the FEM. This allows us to focus DEM on the parts where the microscopic properties and discontinuities conduce the behavior and allow FEM calculation where the material can be considered as continuous and homogeneous. The last book [CHA 15] presents the object oriented numerical code developed under the free License GPL: GranOO (www.granoo.org). All the presented developments are implemented in a simple way on this platform. This allows scientists and engineers to test and contribute to improving the presented methods in a simple and open way.

Now, dear reader let us open this book and welcome in the DEM community for the material of future development ...

Ivan IORDANOFF
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