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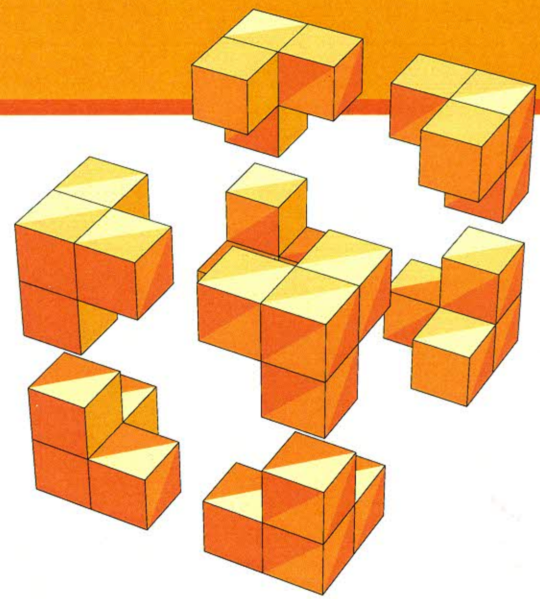

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Certificate of Completion

2012 Wolfram Science Summer School

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WOLFRAM SCIENCE
SUMMER SCHOOL 2012

Modeling complex patterns of crack propagation: branching and merging mechanisms

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Project description

The development of accurate models and simulations is becoming increasingly important in fault detection and prevention techniques applied to a wide variety of engineered systems. The recent advances in measurement devices technology has provided the designer an incredible amount of data related to acoustic, thermal and optic behaviour of the material subject to crack generation and propagation mechanisms. The lack of a reliable model prevents a correct interpretation of these data and makes predictions of future evolution difficult to be performed. In this project, a different approach is considered: the kinematic behaviour is addressed under the assumption that the crack shape can be reconstructed through the application of a suitable and known set of deterministic rules. The aim is to propose an alternative approach to the development of a model for crack propagation by applying the NKS method. The problem firstly addressed is the simulation of mechanisms of crack branching and merging in 2D using a set of simple rules; the features of the resulting pattern is then considered and boundaries shapes, crack diffusion properties, frequencies of branching and merging are studied.

Summary of results and conclusions

The backbone of the model is a set of rules based on which the characteristics of the crack can be determined at every step in a *deterministic* fashion; an enumeration scheme has been set up in order to allow a rigorous analysis of the rule space found, which is in total made up by *2^48 = 281 474 976 710 656* different rules.
Analyzing the behaviour of large samples of the rule space, characteristics common to real systems are recognizable: the presence of mechanisms of branching, merging and dying; the generation of complex patterns, with both random and nested behaviours; the strong dependence on the initial position of the crack; the dominant dependence on the pattern adopted to model the microstructure.
Dynamic simulations show that the reconstructed behaviour is significantly close to the real one.
Summarizing, the work presented unveils the possibility of using computational models based on simple rules to accurately simulate the kinematics of crack propagation phenomena.

Future directions

New problems and questions arise from the results presented in order to improve the accuracy of the computational model developed.
1. *Modeling the interaction between the propagating crack and the microstructure.*
2. *Application of the computational model to microstructure patterns obtained from experimental measurements.*
3. *Engineering the computational model: assessing the relation between the simulation and the experimental observation of crack propagation.*