Section number: 06. Discrete Mathematics and Computer Science

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Title of the poster: Cellular Automata and Fractal Evolution

Text of the abstract:

It is an old question whether harmony of complex structures, which we so frequently observe in nature, comes from a central plan or from self-organization of the parts. Political and economical organizations of mankind were always built in a hierarchical way, with central forces caring for every detail.

On the other side there is the idea, starting with Adam Smith in economy and Charles Darwin in biology, that a system will develop best when you let all participants act in their own way, according to some general principles. Today, this idea is realized in many fields. On an abstract level, however, there is still little understanding on how large and complex structures develop from distributed local action. The main problem seems that the whole system is practically infinite while the locally available information is bounded. How can these tiny pieces of information be passed and composed in order to give a complete description of the system? An answer to this problem can be done by using cellular automata.

Using the Sierpinski fractal, we show how self-similar hierarchies can develop from local action. The construction is non-deterministic, and the shape of the final pattern is determined by a sequence of decisions made during construction. Non-determinism occurs only at certain moments and only at one place at a time, and corresponds to the choice of the neighbors sequence of a central cell. This construction, based on an extension and filling algorithm by approaching the signal theory, can easily be extended to other self-similar patterns which fit the lattice $\mathbb{Z}^2$. Using the two-dimensional bitmap as a hight field we can also generate three dimensional fractal mountains.

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Key words: cellular automata, signal theory, Sierpinski fractal.