Streszczenie rozprawy w języku angielskim

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Tytuł: Multi-scale mathematical modeling of vegetation, soil and weather

Modeling realistic ecosystems of vegetation under variable climatic conditions is an open and a very complex problem, demanding an approach able to capture the enormous amount of detail and various interactions between the vegetation, soil and weather. Previous methods process trees and other plants by coarse geometrical approximations to reduce the computational complexity at the cost of decreased accuracy. On the other hand, there exist methods which are able to model the vegetation at a very detailed level. These, however, are unsuitable for large ecosystem simulations without an enormous computational power. Furthermore, the interplay between plants and weather has received increased attention recently, because of the observation that vegetation contributes substantially to local climatic variations. In this dissertation, we introduce a multi-scale representation of plant ecosystems, which allows for realistic modeling of individual plants, capturing biological features such as growth, seeding, tropism and competition for resources. Our method leverages self-similarities of branching structures to efficiently handle the complexity of modeling and rendering. We also model the feedback between vegetation, soil and weather, including local variations of climate. In particular, we aim at simulating hydrological cycle. For this purpose, we develop a cloud dynamics model, which handles evaporation of plants and soil, cloud formation and precipitation. We also model water propagation in the soil based on soil properties and gravity. Our approach provides the means to run interactive simulations of hundreds of thousands of plants, with a great amount of detail, and capture interactions with local variations of climate at the same time. Our results adhere to biological priors known in forestry, botany and ecology research. Consequently, our method advances the state-of-the-art of generating highly realistic outdoor landscapes of vegetation and weather. Furthermore, it may potentially serve as the means for validation of biological hypotheses.