Application of Delaunay triangulation and shortest path algorithms for wildfire propagation modeling

Alexander Stepanov[1] J. MacGregor Smith[2]

[1] Department of Mechanical and Industrial Engineering, University of Massachusetts, Amherst, MA 01003,
Tel. (413) 546-2749, astepano@ecs.umass.edu

[2] Department of Mechanical and Industrial Engineering, University of Massachusetts, Amherst, MA 01003,
Tel. (413) 545-4542, jmsmith@ecs.umass.edu

Abstract

We present a methodology to model surface fire propagation over a complex heterogeneous landscape. This problem is an intricate one as a fire propagation velocity and direction depend on diverse dynamic factors (weather conditions, wind speed, fuel conditions) and static factors (terrain, fuel distribution and types). Accurate modeling of fire spread as a continuous phenomenon has to take these numerous factors into consideration which can be expensive in time and computation. As we intend to apply this methodology as a part of emergency evacuation planning, we are interested in efficient, effective and fast ways of evaluating fire spread within a region. For evaluating surface wildfire propagation through a complex heterogeneous landscape, we introduce a polynomial time algorithm based upon a Delaunay triangulation, shortest path algorithms and mesh refinement. The presented approach utilizes Delaunay triangulation, as a special data structure, to compute the minimum travel time path for a fire event and serves as a first approximation to evaluate wildfire propagation time. As fire growth depends greatly on the non-linear direction of fire perimeter expansion, the Delaunay triangulation refinement is utilized to capture fire expansion in the direction of fastest spread. We will demonstrate that the proposed technique for fire propagation modeling is scalable, adaptive, and effective, as it benefits from the special computational and algorithmic properties of Delaunay triangulation. We provide a concise formulation of this research problem as a network optimization model on the Delaunay graph. In addition, we present the framework, used to design and test the algorithm, which integrates computational geometry, optimization and fire modeling facets of the problem. The framework is implemented as C++ application with the use of Computational Geometry Algorithms Library (*CGAL*), Boost Graph Library (*BGL*) and a fire growth library (*fireLib*). Extensive experimental results are included.

Keywords: Delaunay triangulation, shortest path algorithms, minimum travel time, wildfire modeling