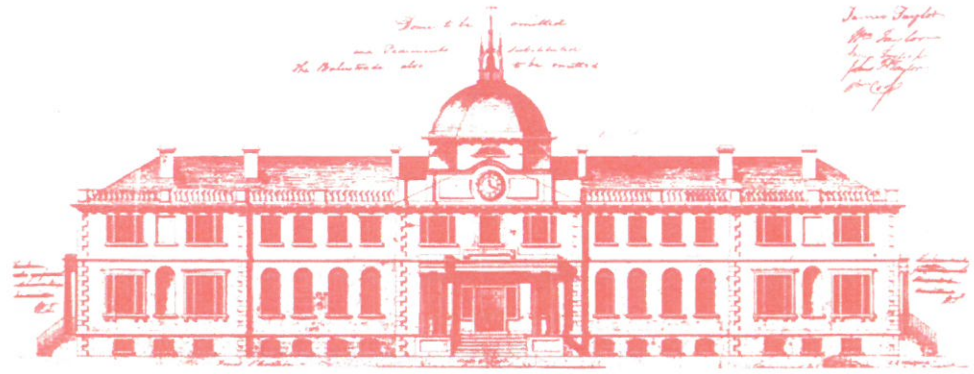
Line Simplification Under Spatial Constraints

Abstract

A linear feature is a chain of discrete positions or an abstraction of an areal feature(e.g., road centreline, river) or the outline of a boundary(e.g., coastline, administrative boundary). Spatiotemporal positions of a moving object - a person(with a cellphone, hand held GPS), tagged animal(e.g., study of movement and migratory patterns), moving vehicle(e.g., vessel, car, or plane with GPS navigation), robot(e.g., self-driving car or drone) can be represented as an ordered series of discrete positions(trajectory). A polyline L defined by n line segments is an ordered connected chain of $n + 1$ positions(coordinates). L can be simple(with no self-crossings) or complex - with planar or non-planar intersections with itself or other polylines to be simpli- fied. The spatial characteristics of L can also be constrained by other objects(point, lines, or polygons) in an embedding planar space.

Given a polyline L with n segments, the line simplification problem seeks to approximate L as L with m vertices, where $m < n + 1$. The goal is to find vertices of L that represent L 'well". In computational graphics, data storage, network transmission, and spatial analysis, it is very bene- ficial to replace complex geometric objects with simpler ones that capture the relevant features of the original. Out of context simplification of L can lead to topological errors. In this dissertation, given $\varepsilon > 0$ (ε - error of approximating L as L), we restrict the vertices of L to be a subset of L with the following optional constraints: (i) L should preserve planar self-intersection and avoid introducing new self-intersections with itself or other polylines, (ii) consecutive segment of L should not invert the topological relation in L, (iii) L should preserve disjoint, intersect, minimum distance relation with other planar objects, and (iv) L should be homotopic to L in the context of other planar objects.

Simplification of a polyline or group of polylines with these constraints makes finding a poly- nomial solution hard[Guibas et al. 1993; Estkowski, 1998; Estkowski and Mitchell, 2001]. The outcomes of this research are development of novel geometric heuristics for simplification of arbitrary static and spatiotemporal polylines in the context of other planar objects. Experimental evaluation showed a competitive compression ratio in a reasonable processing time compared to unconstrained simplification. We also develop geometric tools to make practical our algorithms in industry and data processing.



Home of the School of Graduate Studies, Sir Howard Douglas Hall was designed by J.E. Woolford in 1825 and is the oldest university building in Canada still in use.

UNIVERSITY OF NEW BRUNSWICK

SCHOOL OF GRADUATE STUDIES

ORAL EXAMINATION

Titus Tienaah

IN PARTIAL FULFILMENT
OF THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

Ph.D. Candidate

Titus Tienaah

Graduate Academic Unit

Geodesy & Geomatics Engineering

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June 11, 2018

2:00 p.m.

Head Hall
Room E-11

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Examining Board:

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Dr. David Coleman (Geodesy & Geomatics Eng.) Co-Supervisor
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2008-2011	**MScE**, GGE, University of New Brunswick, Fredericton, Canada.
2003-2007	**BSc**, Geomatics Engineering, Kwame Nkrumah University of Science and Technology

Publications:

Tienaah, T., Stefanakis, E., & Coleman, D.(2018). Line Simplification While Keeping it Simple or Complex ... *In Review*

Tienaah, T., Stefanakis, E., & Coleman, D.(2018). Topologically Consistent Online Tra- jectory Simplification ... *In Review*

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