EFFICIENT TRAFFIC CRASH AND SNOW COMPLAINT GIS SYSTEM

by

ANTHONY B. NGO

A THESIS

Presented to the Faculty of

The Graduate College at the University of Nebraska

In Partial Fulfillment of Requirements

For the Degree of Master of Science

Major: Computer Science

Under the Supervision of Professor Peter Revesz

Lincoln, Nebraska

November, 2011

EFFICIENT TRAFFIC CRASH AND SNOW COMPLAINT GIS SYSTEM

Anthony B. Ngo, M.S.

University of Nebraska, 2011

Adviser: Peter Revesz

We describe the design and implementation of a traffic crash and snow complaint GIS

system developed for the Lincoln Public Works department. We also describe a novel

geocoding algorithm that was used to move data from the older Criminal Justice

Information System, which is a relational database, to the new GIS system. In addition,

we describe the implementation of several indexing algorithms that enable the system to

efficiently answer rectangular range queries and queries about the relative locations of

moving objects. Finally, in many applications (on-line analysis or mobile GIS), we need

to execute spatial query efficiently (fast and small), and to scan through all the existing

complex objects (non-zero extent) might be very slow. Thus, we introduce an

approximated indexing method, called ApproximatedR-Tree, for improving performance

and space over complex objects.

Acknowledgements

I would like to express my sincere gratitude to my thesis advisor Professor Peter Revesz, who first introduced me to spatial databases and GIS. Without his expertise and generous guidance I would not have been able to complete this thesis. He has provided me numerous ideas for carrying out the research involved in this work.

Also, I would like to thank Dr. Jitender Deogun, and Dr. Ashok Samal for serving on my thesis committee. I appreciate their feedback on my research and their valuable comments on my thesis.

In addition, I would like to thank Alicea McCluskey, Shane Dostal, Scott Opfer, Al McCracken, and Angela Chesnut of the Lincoln Public Works Department for providing information and suggestion about street maintenance operations and traffic crash analysis; Mark Wieting of Lincoln Information System Department for providing traffic crash data from Criminal Justice Information Systems; Frank Larson, Tracy Schuppan, and Tan Pham of Lincoln Comprehensive Engineering Information Services (CEIS) Department for providing GIS technical advice; James Anderson of Lincoln Information Systems Department for supporting the ArcGIS Server; Virendra Singh of Lincoln Public Works Department for expert advice regarding traffic crash analysis; Tim Pratt of Lincoln CEIS Department for managing and overseeing software development, and Roger Figard for allowing and encouraging me to publish these results.

Moreover, I would like to thank Michael Boscarino, HP CoSD Applications Technical Lead, Harish Raju, HP CoSD Applications Portfolio Manager, Ross Martin, County of San Diego GIS Manager, and Jason Batchelor, County of San Diego GIS Coordinator, for encouraging and allowing me to work from home in Lincoln, NE in order to complete my Master thesis.

Finally, this thesis is for my beloved wife, Thuloan Pham, my daughters, Mary Ngo, Kristy Ngo, and Julie Ngo, and my parents. Without their day-to-day support, love, and encouragement, this thesis could not have been completed.

TABLE OF CONTENTS

List of Tables	vi
List of Figures	vii
Chapter 1	1
Introduction	
1.1 Motivation for traffic crash database	
1.2 Motivation for snow complaint database	
1.3 Outline of the thesis	
1.4 The major contributions of the thesis	
Chapter 2	
Related Work	
1.1 Crash Data Analysis	5
2.2. Geocoding	
1.3 R-trees	
Chapter 3	10
The Geocoding Problem	10
Chapter 4	
Rectangular Range Queries	
Chapter 5	
The Snow Complaint Database	
Chapter 6	
Efficient Moving Points Estimation	23
6.1 The Point Estimation Algorithm	23
6.2 Implementation Results	
Chapter 7	31
Approximated R-Tree	31
7.1 Virtual point approximation of spatial objects	31
7.2 The Damage Assessment Mobile Application	
7.3 Implementation Results	
Chapter 8	
Future Work	
References	38

List of Tables

1.	Example CJIS traffic crash street information	10
2.	Run times using indexing versus no indexing	15
	Running time results for point dominance queries	

List of Figures

1. R-Tree Bounding Boxes	6
2. R-Tree Index Structure	
3. Street center line and one-node intersection	
4. Searching street segment on ONST between ATST and BTST	10
5. Traffic crashes in the red rectangular area	
6. Traffic crashes dominated by point Q for January 2010	14
7. Run time using indexing versus no indexing	15
8. Street Maintenance Manager Software architecture	17
9. Snow complaint data entry form	18
10. Search snow complaints from 12/01/2010 to 03/29/2011	19
11. Range queries	20
12. The moving point P starting at b_P and moving with speed a_P	21
13. The dual representation of point P(a _P ,b _P)	22
14. Approximating points below query line L	23
15. 10,000 moving points and query lines in dual plane	25
16. Time vs. m graph with $n = 10,0000$ moving points	28
17. GIS Parcel Polygons' Virtual and GPS Points	30
18. Damage Assessment GIS Mobile Application Architecture	32
19. Polygon vs. Virtual Point Parcel Query Times	