Forensic GIS
The “Geotechnologies and the Environment” series is intended to provide specialists in the geotechnologies and academics who utilize these technologies, with an opportunity to share novel approaches, present interesting (sometimes counter-intuitive) case studies, and most importantly to situate GIS, remote sensing, GPS, the internet, new technologies, and methodological advances in a real world context. In doing so, the books in the series will be inherently applied and reflect the rich variety of research performed by geographers and allied professionals.

Beyond the applied nature of many of the papers and individual contributions, the series interrogates the dynamic relationship between nature and society. For this reason, many contributors focus on human-environment interactions. The series are not limited to an interpretation of the environment as nature per se. Rather, the series “places” people and social forces in context and thus explore the many sociospatial environments humans construct for themselves as they settle the landscape. Consequently, contributions will use geotechnologies to examine both urban and rural landscapes.
Forensic GIS

The Role of Geospatial Technologies for Investigating Crime and Providing Evidence
Editorial

This book, *Forensic GIS: The Role of Geospatial Technologies for Investigating Crime and Providing Evidence*, presents ways in which geospatial technologies, including geographic information systems (GIS), global positioning systems (GPS), and remote sensing, contribute to the acquisition and analysis of forensic information today and provides timely illustrations in the form of case studies.

Initially, our interest in the forensic potential of geospatial technologies stemmed from a Forensic Science Initiative grant from the National Institute of Justice to the Forensic Science program at West Virginia University (2003-RC-CX-K001). Among many others, a task was initiated to investigate the characteristics of spatially enabled forensic science, with the goal of supporting the use of geographic information systems and science in a number of forensic-related research and teaching activities. During the course of the grant, I, Dr. Ge Lin, George Roedl, and a number of graduate students investigated the use of GIS and remote sensing in forensic contexts. Four important aspects of the spatial perspective of forensic science were examined: geographic profiling, time geography, high density scanning, and radio frequency identification. Among the outcomes were a special paper session on Forensic GIS at the 2009 Annual Meetings of the Association of American Geographers, a paper in the *Journal of Forensic Science* on space-time approaches to shoeprint matching; investigation of the coordination of measurements of indoor and outdoor spatial location (accommodating GPS); and experiments with time-space path analysis and point cloud analysis. These efforts included the development of a course in crime mapping and analysis. In 2010, Gregory A. Elmes and George Roedl were awarded a grant from the National Institute of Justice, Office of Justice Programs (2009-IJ-CX-0205) for “Increasing Student and Community Safety,” which supported a research partnership with WVU and the City of Morgantown, WV Police Departments. The current work may be seen as a natural extension of the research interests generated by these NIJ-funded projects.

Strictly defined, forensic science is the use of scientific principles, methods, and techniques to establish facts or provide evidence used in a court of law. Here, we have adopted a broader working definition of forensics and forensic GIS, which includes the use of geospatial principles and techniques to establish facts or
sequences of events, regardless of whether they are used in court. Thus, gathering and interpreting scientific data for regulation, intelligence, and national security purposes falls under this broader definition of forensic science. A further distinction may be made between criminal and civil forensics. Criminal law deals with offenses against the state—the prosecution of a person accused of breaking a law. Such offenses include crimes against persons and property. Civil law covers everything else, such as violations of contracts and lawsuits between two or more parties. The collection of data and presentation of evidence may be held to quite different standards, the process of data collection and imaging may be quite different, and the consequences of the case may have very different impacts. Examples of both will be found herein.

A relatively small literature on forensics exists in the discipline of geography, a larger one in environmental science, geology, soil science, and archaeology. In February 2009, the National Academy of Sciences published a report “Strengthening Forensic Science in the United States: A Path Forward” (National Academies Press, 2009). The committee had a mandate to identify the needs of the forensic sciences community. It was revealing that, in a search, the terms “spatial” and “geospatial” did not appear in this text of 352 pages and this observation provided further impetus toward the genesis of this book. It is evident that further research and a bridging of scientific communities are necessary to establish the best practice of the use of geospatial science and technology within forensic science. To that end, this book is directed to an audience comprising of law enforcement professionals, academics in a wide variety of fields, and students of criminology and forensic science.

Our initial call for submissions was made on October 15, 2012, with a chapter proposal submission deadline of January 31, 2013. After reviewing the submitted proposals, 14 manuscripts were invited to be developed into final chapters by June 2013. Each chapter was reviewed by the editor and two external reviewers in a double-blind process. Nine of the original 14 manuscripts were revised and resubmitted by August 2013. The chapters in Part I by Roedl, Elmes, and Conley were not included in the double-blind process and must therefore be considered as being monographic in nature. Our recognition and thanks are due to Dr. Michael Leitner for the guidance provided by his 2013 publication in this Springer series (Volume 8). Sincere acknowledgement is also due to the external reviewers of the manuscripts for their important contribution of time and effort.

In Part I, Gregory A. Elmes, George Roedl, and Jamison Conley draw attention to the theme and content of the book through a review of the various roles geospatial technologies provide in investigating crime, providing evidence, and developing policy within the legal system and how these roles have changed with advances in the technology itself and the challenges involved in using the technology for investigation and providing legal evidence.

The first chapter “Concepts, Principles, and Definitions” considers the ways in which geospatial information and technology (GIT) has significantly increased in prominence within the criminology and forensic fields in the last decade. Geospatial technology includes the tools and techniques applied to geographic or spatial data; additionally, the chapter recognizes the extensive nature and roles of GIT across
many subject domains. In Chap. 2, “Geospatial Technologies in the Courtroom”, George Roedl, Gregory A. Elmes, and Jamison Conley continue to develop the theme of the book by examining key rules such as federal rules for the admissibility of evidence, Frye, Daubert, and other court decisions that have influenced the potential admissibility of spatial data and technologies in a modern courtroom. Chapter 3 develops the theme of Spatial Tracking Applications, and Chap. 4 details the main tools of forensic GIT in Spatial Technology Applications.

Part II focuses on a selection of case studies illustrating the breadth of contemporary applications of GIT in criminal justice ranging from collecting evidence for presentation in court to an open software Web-enabled application bringing crime mapping and analysis to a larger audience than is possible with commercial packages.

In Chap. 5, Ronald E. Wilson and Ann D. Fulmer apply spatial and temporal categorizations of the “near repeat” concept to measure the extent of foreclosures in order to identify concentrations of mortgage fraud and predatory lending. They demonstrate that near repeat spatiotemporal analysis can be applied to help fraud investigators identify loans for scrutiny that show geographically systematic patterns of foreclosure. In a post-conviction setting, Mark R. Leipnik and Xinyue Ye examine geospatial strategies for the management of registered sex offenders in Chap. 6. Documenting current practice in the United States, the authors argue that, while four-fifths of US states use Web maps to provide notification to the public of the location and criminal history of registered sex offenders, the notifications vary considerably in form and content and are such notifications open to misuse. In Chap. 7, Manuel Rodríguez Herrera and Daniel Salafranca Barreda introduce the Science, Data, Intelligence, Knowledge (SDIK) project, a geo-information international security endeavor for making visible the “invisible” conditions of communities and neighborhoods. The SDIK project incorporates a set of technical-scientific and geospatial innovations to help understand newly emerging activities within communities and help uncover evidence of possible criminal activity.

Remaining at the neighborhood scale, Jamison Conley and Rachel Stein examine the relationships among the factors of neighborhood disorder and collective efficacy using measures of spatial correlation and spatial regression in Chap. 8. Their findings illustrate the potential of spatial analysis for informing policing strategies. They reason that the results of this type of analysis can lead to a better use of police resources to avert crime. Also recognizing the importance of place and neighborhood, in Chap. 9 Matthew J. Hickman, Loren T. Atherley, and Geoffrey P. Alpert describe the utility of geospatial analysis for monitoring, understanding, and responding to police use-of-force incidents. Their research stems from an investigation for the Seattle Police Department which had the aim of improving the quality of police monitoring and accountability. Through mapping spatiotemporal patterns of liquor law violation citations in the college town of La Crosse Wisconsin, Gargi Chaudhuri, Steven Oxley, and Scott Wenzlaff provide, in Chap. 10, a means to focus the deployment of intervention measures and increased vigilance to restrict alcohol consumption among underage youths and prevent associated crime and accidents.
Guiyun Zhou, Jiayuan Lin, and Xiujun Ma introduce in Chap. 11 a Web-based GIS for crime mapping, analysis, and decision support as an affordable option for small- and medium-sized police departments. The authors discuss the architecture, construction, and open software of the development of the prototype system. In Chap. 12 William. C. Walker, Sunhui Sim, and Lisa Keys-Mathews study the influence that a hurricane had on the space-time behavior of local patterns of crime. The authors explore the use of geographically weighted regression (GWR) for understanding aspects of the ecology of crime. The results reveal that more accurate prediction of crime types within cities is possible. Finally, Chap. 13, by Irfan Ashraf, Urooj Saeed, Naeem Shahzad, Javed Gill, Shahid Parvez, and Akram Raja, presents a detailed case study of the delineation of legal forest boundaries to identify and contest illegal forest encroachment. Forest boundaries and encroachments were mapped in coordination with the Punjab Forest Department, the Survey of Pakistan, the Punjab Revenue Department, and the World Wildlife Fund Pakistan. The study results were presented as evidence to the High Court in Lahore, Pakistan, as part of an effort to control illegal forest use.

The collection of insights and research presented here has advanced the literature on forensic GIS, albeit incrementally, and has raised the premise of the importance of continued research into spatially enabled forensics. The editors look forward to future developments in the integration of GIT and forensics. To that end we have included an annotated bibliography of court cases involving the legality of geospatial technology and its introduction in court. Selected cases involving GPS, remote sensing, and GIS have been included.
# Contents

## Part I  Fundamentals: Definitions, Concepts, Theories, and Principles

1. **Concepts, Principles, and Definitions**
   Gregory A. Elmes, George Roedl, and Jamison Conley
   
2. **Geospatial Technologies in the Courtroom**
   George Roedl, Gregory A. Elmes, and Jamison Conley
   
3. **Spatial Tracking Applications**
   George Roedl, Gregory A. Elmes, and Jamison Conley
   
4. **Spatial Technology Applications**
   George Roedl, Gregory A. Elmes, and Jamison Conley

## Part II  Case Studies

5. **Using Near Repeat Analysis for Investigating Mortgage Fraud and Predatory Lending**
   Ronald E. Wilson and Ann D. Fulmer
   
6. **State Registration of Sex Offenders: Public Notification, Web Mapping, and Spatial Issues**
   Mark R. Leipnik and Xinyue Ye
   
7. **The SDIK Police Model: How to Make the Invisible Visible**
   Manuel Rodríguez Herrera and Daniel Salafranca Barreda
   
8. **Spatial Analysis of Fear of Crime and Police Calls for Service: An Example and Implications for Community Policing**
   Jamison Conley and Rachel Stein
9 Using GIS to Monitor and Investigate Police Use of Force: The Spatial Distribution of Force Factors ............................................ 173
Matthew J. Hickman, Loren T. Atherley, and Geoffrey P. Alpert

10 Mapping Spatiotemporal Patterns of Liquor Law Violation Citations During Oktoberfest in College Town of La Crosse, Wisconsin................................................................. 201
Gargi Chaudhuri, Steven Oxley, and Scott Wenzlaff

11 A Web-Based GIS for Crime Mapping and Decision Support .......... 221
Guiyun Zhou, Jiayuan Lin, and Xiujun Ma

12 Use of Geographically Weighted Regression on Ecology of Crime, Response to Hurricane in Miami, Florida.............................. 245
William C. Walker, Sunhui Sim, and Lisa Keys-Mathews

13 Delineating Legal Forest Boundaries to Combat Illegal Forest Encroachments: A Case Study in Murree Forest Division, Pakistan ........................................................................ 263
Irfan Ashraf, Urooj Saeed, Naeem Shahzad, Javed Gill, Shahid Parvez, and Akram Raja

Annotated Bibliography of Selected Court Cases Involving Geospatial Technologies ................................................................. 287

Index ................................................................................................................. 303
Part I
Fundamentals: Definitions, Concepts, Theories, and Principles
Chapter 1
Concepts, Principles, and Definitions

Gregory A. Elmes, George Roedl, and Jamison Conley

Abstract Forensics is the application of science to solve crime. Geographic Information Science, encompassing geospatial information and technology (GIT), has become established within the criminology and forensic fields in the last decade. Law enforcement agencies and forensic investigators embrace geospatial science and technologies for collecting, storing, manipulating, analyzing, and displaying spatial data, resulting in new information, procedures, and models for investigation, policy, and decision making. Applications, acceptability, relevance, and procedural legality of geospatial technologies vary substantially, leading to the assessment of their roles in law enforcement, rules of evidence, protection of privacy, and constitutional liberties. This chapter discusses the context and principles of geospatial technologies and the integration of geospatial tools, principles, and methods into a five-stage model of crime analysis and investigation.

Keywords Forensic science • Geographic Information Science • Geospatial technology • Geographic Information Systems (GIS) • Global Positioning System (GPS) • Remote sensing

1.1 Introduction

As geospatial science and technologies become ubiquitous in society, a wide range of disciplines and professions adopt them for collecting, storing, manipulating, analyzing, and displaying spatial data, resulting in the generation of new information and models for policy and decision making. Forensics is the application of science...
to solve crime. It follows therefore that as geospatial science and its associated technologies emerge, they make a distinct and unique contribution to forensics (McKinley et al. 2008; Noond et al. 2002; Wolff and Asche 2009). Law enforcement agencies and forensic investigators have adopted geospatial technologies to profile serial offenders, track suspects, and guide crime reduction efforts, among other purposes. Legal experts utilize the analytical and visual capabilities of geospatial technologies to present, demonstrate, and explain complex information in the courtroom. Citizen groups have fought successfully against environmental discrimination and have engaged in class-action lawsuits, strengthened by the collection, analysis, and presentation of geospatial data.

Geospatial technologies have a long history of use in a broad range of applications such as environmental conservation, real estate, military and security, municipal planning, epidemiology, and agriculture. Recently, Listi et al. (2007) observed an increased popularity of what they described as the field of forensic spatial analysis, citing the evident increase in geospatial technology use presented at forensic-oriented conferences. Despite a relative lack of published research articles in criminology and forensic-related journals, geospatial technologies also serve as highly useful tools in criminal investigations. Geospatial technologies have unique capabilities which are ideally suited to collecting and analyzing spatial data. Traditional methods of investigation, such as pin maps, are largely unable to cope with volumes of multifaceted spatial information in any meaningful manner capable of assisting in identifying an offender or excluding possibilities. Digital spatial technologies result in a more efficient investigation, linking people, places, and objects in a way that assists in optimizing time and resources in pursuit of guilty parties. Conversely, traditional methods of investigation remain vitally important. The merging of spatial tools and methods into investigative practices to establish facts admissible in court is therefore a practice that should be recognized. The application of spatial tools to assist in established investigative practice by adding a spatial perspective is the focus of forensic GIS.

The widespread use of geospatial technologies has increasingly exposed courtrooms to the demonstrative powers of spatial technologies in civil and criminal cases. Section 1.5 of this chapter integrates a five-stage workflow for crime analysis and investigation with the comparable stages of GIS. In the United States of America, federal, state, district, and circuit courts, as well as the US Supreme Court, have ruled on the legality of the use of geospatial technologies under various circumstances. Higher courts have overruled the judgment of lower courts, which has introduced a degree of debate and contention into the legal uses of various geospatial technologies. This book is intended as a guide to understanding the various roles geospatial technologies provide in investigating crime, providing evidence, and developing policy within the legal system, broadly defined, and how these roles have changed with advances in the technology itself and the legal challenges involved in using the technology for investigation and providing evidence.