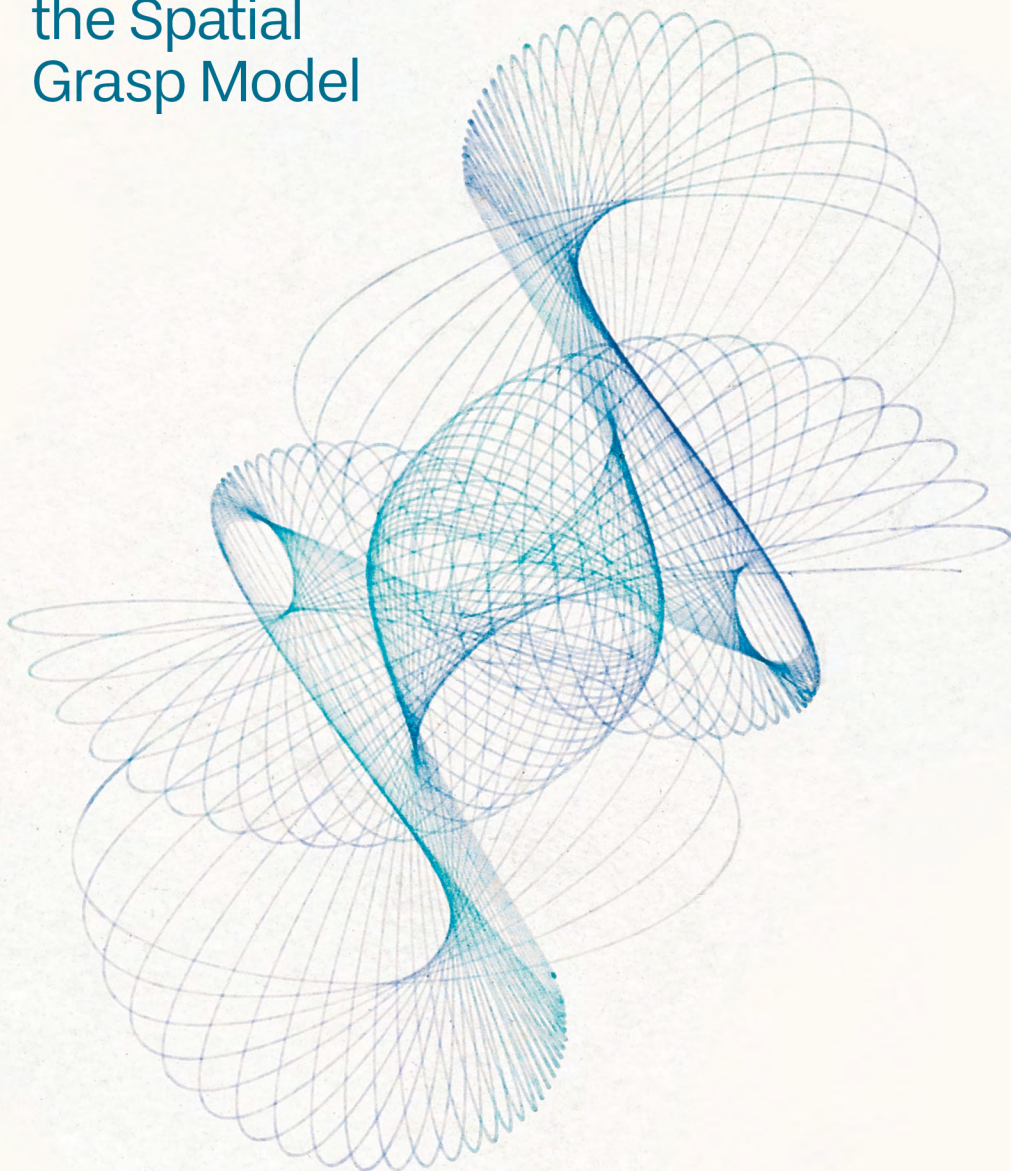


Self-Healing and
Self-Recovering
Systems under
the Spatial
Grasp Model



Peter Simon Sapaty

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BY

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United Kingdom – North America – Japan – India – Malaysia – China

Emerald Publishing Limited
Emerald Publishing, Floor 5, Northspring, 21-23 Wellington Street, Leeds LS1 4DL.

First edition 2025

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British Library Cataloguing in Publication Data

A catalogue record for this book is available from the British Library

ISBN: 978-1-83662-897-2 (Print)

ISBN: 978-1-83662-896-5 (Online)

ISBN: 978-1-83662-898-9 (Epub)



INVESTOR IN PEOPLE

To complete this book in wartime extremely helpful were my wife Lilia as psychologist, doctor, and talented cook, also strong cat Tom as healer and security guard.

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About the Authors

Peter Simon Sapaty, Chief Research Scientist, Institute of Mathematical Machines and Systems, Ukrainian Academy of Sciences, has worked with networked systems for more than five decades. Outside of Ukraine, he worked in the Slovak Republic, Germany, the UK, Canada, and Japan as a group leader, Alexander von Humboldt researcher, and invited or visiting professor. He chaired SIG on Mobile Cooperative Technologies within Distributed Interactive Simulation Project in the USA. He developed distributed management and control technology resulting in European patent and about 300 publications including 10 Wiley, Springer, Emerald, and Taylor & Francis books. He is in Marquis *Who's Who in the World*, *Cambridge Outstanding Intellectuals of the 21st Century*, and also with boards of six international scientific journals.

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Preface

In our dynamic and extremely complex world, we urgently need advanced philosophical, psychological, organizational, and technological measures to cope with emergencies, destructions, conflicts, and crises which often appear in very different types of organizations and systems. The main goal of this book is to offer related measures and practical solutions which could provide improvement, healing, and recovery in very complex situations, and especially with the use of internal system resources.

To follow this, we have chosen the developed and patented Spatial Grasp Technology (SGT) based on parallel coverage and management of distributed dynamic systems, which proved efficient for solving problems in different physical and virtual worlds and also resulted in 10 other books. SGT evolved from the WAVE approach which allowed us more than half a century ago to practically implement citywide heterogeneous computer networks and solve problems on them in a flexible and mobile way, well before the internet. The approach was very unusual at that time as operated like a self-spreading spatial virus which was penetrating through and gluing very different pieces of software and hardware to operate together as a system. This heterogeneous self-penetrating and self-gluing feature of WAVE, subsequently inherited and strengthened by SGT and its basic Spatial Grasp Language (SGL), encouraged us to investigate and offer effective self-analysis, self-healing, and self-recovery measures for large distributed systems using internal resources rather than external management and control.

After reviewing and classifying numerous publication sources and describing basics of SGT and SGL, the book will be offering different self-improving, self-healing, and self-recovery examples, methods, and solutions by which distributed dynamic systems can become more stable in important areas, including industry, economy, education, biology, psychology, psychiatry, finance, security, defense, conquest of space, and many others.

Kiev, Ukraine
December 2024
Peter Simon Sapaty

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Acknowledgments

With special thanks to good colleagues, friends, and their organizations for the lasting support and active discussions of the ideas of this book:

John Page, University of New South Wales, Australia

Steve Lambacher, Aoyama Gakuin University, Japan

Kohei Arai, Saga University, Saga Prefecture, Japan

Thomas Ditzinger, Springer Books, Germany

Gabriella Williams, Taylor & Francis Books, UK

Melian Lee, *International Relations and Diplomacy Journal*, David Publishing, USA

Judith Reveal, **Victor Welzant**, and **George S. Everly**, *International Journal of Crisis, Stress, and Human Resilience*, International Critical Incident Stress Foundation, USA

Svitlana Tymchyk, **Nataliia Karevina**, and **Yevheniia Petruk**, *Journal of Mathematical Machines and Systems*, National Academy of Sciences of Ukraine

Nadya Aronova, Institute of Mathematical Machines and Systems, Ukraine

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Chapter 1

Introduction

Abstract

In our dynamic and extremely complex world, we urgently need advanced philosophical, psychological, organizational, and technological measures to cope with regular emergencies, destructions, and crises, which appear almost every day and in different types of organizations and systems. The main goal of this book is to offer such measures and practical solutions, especially those which can provide efficient improvement, healing, and recovery in very complex situations in a self-healing and self-recovery mode, using mostly internal system resources. To accomplish this goal, we have chosen the patented and developed Spatial Grasp Technology (SGT) with its basic Spatial Grasp Language (SGL) based on spatial coverage and management of distributed systems, which already proved efficient for solving numerous problems in very different physical and virtual areas.

1.1. Introduction

We begin with an explanation of the words in the book title with brief reviews of the related publications and then provide a summary of the rest of the chapter's material.

- *Meanings of the Words in the Book Title:*

Healing is discussed in [1]. With physical trauma or disease suffered by an organism, healing involves the repairing of damaged tissues, organs, and the biological system as a whole and the resumption of (normal) functioning. Medicine includes the process by which the cells in the body regenerate and repair to reduce the size of a damaged or necrotic area and replace it with new living tissue.

Self-healing [2] refers to the process of recovery (generally from psychological disturbances, trauma, etc.), motivated by and directed by the patient, guided

2 *Self-healing and Self-recovering Systems Under the Spatial Grasp Model*

often only by instinct. Such a process encounters mixed fortunes due to its amateur nature, although self-motivation is a major asset. The value of self-healing lies in its ability to be tailored to the unique experience and requirements of the individual.

Self-healing Systems are discussed in [3]. In the field of technology, ensuring system reliability and resilience is critical. With increasing system complexities and user expectations for uninterrupted services, traditional manual intervention methods are no longer sufficient. Self-healing systems, an advanced concept in system design, offer a promising solution to maintain continuous operation and recover from failures automatically. These systems are designed to detect, diagnose, and rectify issues autonomously, thus minimizing downtime and enhancing overall system performance.

Recovery [4] can be defined as: possibility of regaining something lost or taken away, restoration or return to health from sickness, restoration or return to any former and better state or condition, something that is gained in recovering, an improvement in the economy marking the end of a recession or decline, and the regaining of substances in usable form as from refuse material or waste products.

Self-recovery channel [5] is made of several collections that provide knowledge on self-recovery after disasters and conflicts all around the world. The aim of a self-recovery approach is to ensure an efficient humanitarian response to affected populations. Main themes: conflict, disaster management, disaster risk reduction, early recovery, early warning, humanitarian access, humanitarian assistance, humanitarian financing, information management, natural disasters, and resilience.

Self-recovery system, like the one on board [6], provides vehicle's own power by transforming the drive wheels into winches without requiring any conveniently located anchor point. This means that the system is effective in areas where there is nothing available to anchor a cable to and there is no risk of damage or injury from a cable snapping under load and whipping back toward the vehicle.

Spatial Grasp Model is the basis of distributed processing and management SGT [7–17], where a high-level scenario in recursive SGL propagates and matches distributed environments in parallel wavelike mode. Such propagation can result in returning and analyzing the reached states and data which can be arbitrarily remote, as well as in further waves from the initial and new points.

- *Organization of the Rest of the Chapter:*

Section 1.2 reviews existing word problems, current book goals, and the chosen approach, as Spatial Grasp Model and Technology, for solving complex world problems. Section 1.3 reviews other books in the related areas which are analyzed, compared with, and stimulated this book project. Section 1.4 reviews the latest author's publications which influenced this book project mostly. Section 1.5 mentions history and previous publications of the developed approach, which were used throughout the book too. Section 1.6 provides a summary of other book chapters, and References point at numerous literature sources discussed throughout the book.

1.2. World Problems, Book Goals, and the Approach Used

- *Existing World Problems:*

Global Risks Report 2024 [18] describes the current world as plagued by dangerous crises: climate and conflict. Underlying geopolitical tensions combined with the eruption of active hostilities in multiple regions are contributing to an unstable global order characterized by polarizing narratives, eroding trust, and insecurity. Countries are grappling with the impacts of extreme weather, and cost-of-living pressures continue to bite, amidst elevated inflation and interest rates under continued economic uncertainty.

WTW Natural Catastrophe Review January – June 2024 [19] presents insights and lessons which are learned from major natural disasters in the first half of 2024, explores key themes of the year so far, and offers an outlook for the second half of 2024. Offering a smarter way to risk, this report goes beyond the numbers to help navigate the complex landscape of natural catastrophe and climate risk management.

The urgency of *Healing the World* is discussed in [20]. In an age of unprecedented challenges, healing the world has become an urgent necessity. This work delves into the multifaceted aspects of healing the world, exploring how individuals, communities, and nations can contribute to global wellness. Healing the world begins with self-awareness and personal growth, with self-care and resilience being critical aspects in this way.

- *Book Goals:*

The main goal of this book is to *enrich large distributed systems, the whole world including, with higher-level organizational and technological features* that can improve their performance, especially in complex situations. These should guarantee effective, up to universal, *self-healing and self-recovering capabilities* due to the internal systems resources, with a minimum of outside management and control.

- *The Approach Used:*

Toward accomplishing these goals, the book will be investigating the application of the patented, developed, and tested Spatial Grasp Technology (SGT) in different countries [7–17] for effective management, healing, and recovery of large distributed dynamic systems in important areas, and the book is also a sequel to previous SGT-related books on distributed management and control [8–17]. Within SGT, a high-level scenario in recursive SGL propagates and matches distributed environments in parallel wavelike mode, as symbolically in Fig. 1.1.

SGL top-level organization can be expressed just in a single string-formula mode:

$$\mathit{grasp} \rightarrow \mathit{constant} \mid \mathit{variable} \mid \mathit{rule} (\{\mathit{grasp},\})$$

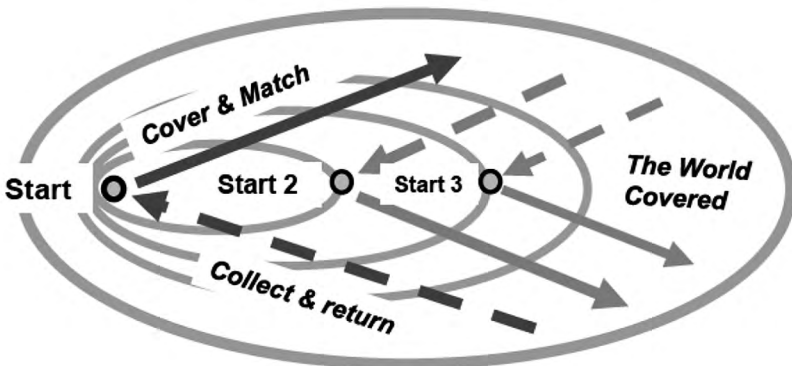


Fig. 1.1 Parallel Recursive Wavelike World Coverage with SGT.

An SGL scenario, or *grasp*, initially applied in some point (or points) of distributed spaces can be a *constant* directly providing the result or a *variable* in which content was or will be obtained from this or other space points. It can also be a *rule* expressing certain ordering, action, control, description, or context over parenthesized operands, generally as grasps too. SGL can express effective, integral, and distributed solutions in large networked systems in a simple and compact way. Communicating SGL interpreters can be of arbitrary numbers (up to thousands and millions) integrated with other systems and communications, altogether representing powerful spatial engines operating without central resources or control.

1.3. Other Books in the Areas Considered

Self-healing Control Technology for Distribution Networks is discussed in [21], providing a comprehensive introduction to self-healing control for distribution networks. It details the construction of self-healing control systems with simulations and applications, provides key principles for new generation protective relay and network protection, and demonstrates how to monitor and manage system performance. Also, it highlights the practical implementation of self-healing control technologies backed by rigorous research data and simulations.

Self-organizing Networks: Self-planning, Self-optimization and Self-healing are discussed in [22]. With the current explosion in network traffic and mounting pressure on operators' business cases, self-organizing networks play a crucial role. They are conceived to minimize human intervention in engineering processes and at the same time improve system performance to maximize return-on-investment and secure customer loyalty.

Advances in Self-healing Systems Monitoring and Data Processing are discussed in [23]. This book presents the systematized research, development and improvement of methods in self-healing communication and control systems, and also new models and methods of data processing focused on the specifics of self-healing systems. The goal is to equip the reader with the necessary knowledge

about trends in monitoring and detecting failures and modeling processes and methods of data processing in self-healing communication and control systems.

Transcendental Medication: The Evolution of Mind, Culture, and Healing is discussed in [24]. Transcendental Medication considers why human brains evolved to have consciousness, yet we spend much of our time trying to reduce our awareness. It outlines how limiting consciousness, rather than expanding it, is more functional and satisfying for most people, most of the time. The suggestion is that our brains evolved mechanisms to deal with the stress of awareness in concert with awareness itself, otherwise it is too costly to handle this.

Developing a Cybersecurity Immune System for Industry is discussed in [25]. Cyber immune systems try to mimic the adaptive immune system of humans and animals because of their capability to detect and fend off new, unseen pathogens. Today's current cyber security systems provide an effective defense mechanism against known cyber-attacks but are not so good when it comes to defending against unknown attacks. This book describes the possible development and organization of self-healing computing based on cyber immunity techniques and aims at working in the new realm of Industry 4.0.

The Recovery of the Self in Psychosis [26] details specific therapeutic approaches as well as considers how treatments can be individually tailored and adapted to help persons whose mental health challenges may be either mild or more severe. By focusing on basic elements of the experiences of persons diagnosed with psychosis and exploring the broader meanings these experiences have, each of these treatments offers distinctive ways to help persons define and manage their own recovery.

Space Systems for Disaster Warning, Response, and Recovery is discussed in [27]. This Springer Brief provides a general overview of the role of satellite applications for disaster mitigation, warning, planning, recovery, and response. It covers both the overall role and perspective of the emergency management community as well as the various space applications that support their work. Key insights are provided as to how satellite telecommunications, remote sensing, navigation systems, GIS, and the emerging domain of social media are utilized in the context of emergency management needs and requirements.

Global Networks: Engineering, Operations and Design are discussed in [28]. The telecommunications industry has advanced in rapid, significant, and unpredictable ways into the 21st century. The book guides the global industry and academia even further by providing an in-depth look at the current and developing trends, as well as examining the complex issues of developing, introducing, and managing cutting-edge telecommunications technologies.

Global Networks, Linked Cities are discussed in [29]. In the author's pioneering book *The Global City*, it is argued that certain cities in the postindustrial world have become central nodes in the new service economy, strategic sites for the acceleration of capital and information flows as well as spaces of increasing socio-economic polarization. One effect has been that such cities have gained importance and power relative to nation-states.

Network Origins of the Global Economy: East vs. West in a Complex Systems Perspective is discussed in [30]. The upheavals of recent decades show us that

traditional models of understanding processes of social and economic change are failing to capture real-world risk and volatility. This has resulted in a flawed policy that seeks to capture change in terms of the rise or decline of regimes or regions. In order to comprehend current events, understand future risks, and decide how to prepare for them, we need to consider economies and social orders as open, complex networks.

The current book offers a universal distributed control and management technology which can effectively cover and solve different problems expressed in the books mentioned.

1.4. Latest Publications Which Especially Influenced This Book

These publications contain draft solutions which proved useful for the book or being close to them.

Simulating Distributed and Global Consciousness is discussed in [31]. The paper investigates the possibility of using the developed Spatial Grasp Model and Technology for simulating global awareness and consciousness in distributed dynamic systems, with potential applications in intelligent system management, industrial development, space research, security, and defense. The key technology component, SGL, allows us to obtain powerful and compact spatial solutions to different problems by directly expressing their top semantics.

Spatial Management of Air and Missile Defence Operations is discussed in [32]. It describes applications of the SGT and its SGL for integrated air and missile defense. Based on holistic space navigation and processing by recursive mobile code self-spreading in distributed words, SGT differs radically from the traditional management of large distributed systems. The paper shows SGL solutions for discovery, tracking, and destroying ballistic missiles and hypersonic gliders with the use of collectively behaving constellations of LEO satellites.

Distributed System Integrity is discussed [33]. We have witnessed an exploding growth of different kinds of sophisticated distributed systems with financial, industrial, ecological, security, military, and other applications. Providing high integrity of such systems is becoming a key point of their development, evolution, and usage, especially in crisis situations and under disastrous and adversarial conditions. It demonstrates how to organize distributed systems in such a way so that they can self-recover in any circumstance by supplying their nodes with genetic-like capabilities by which any self-repairs can be organized.

Global Awareness in Distributed Dynamic Systems is discussed in [34]. The paper investigates the applicability of the developed high-level model and technology for the solution of diverse problems in large distributed dynamic systems which can provide sufficient awareness of their structures, organization, and functionalities. After the review of meanings of awareness and existing approaches for its expression and support, the paper shows the application of the Spatial Grasp Model and Technology and its basic SGL for practical awareness solutions in large distributed dynamic systems.

Managing Distributed Systems with Spatial Grasp Patterns is discussed in [35]. The pattern can represent the world's regularity, a human-made design, a model, plan, diagram, a standard way of modeling, acting and thinking, a distinctive style or form, etc. The paper reviews existing works on patterns, briefs the developed SGT and its basic SGL, and shows how practical patterns can be expressed in SGL. It also provides network examples of distributed pattern recognition and matching with the use of self-propagating network templates reflecting images to be found.

Global and International Security is discussed in [36]. Such security cannot be provided from a single point or a set of separate points whatever powerful these might be. It should be deeply embedded and integrated with bodies of real systems. Based on the developed Spatial Grasp Model and Technology, the paper investigates practical security solutions for finding and tracing the distribution of forbidden items, world roaming criminals, recovery from natural and human-made disasters, tracing and elimination of moving dangerous objects in terrestrial and celestial spaces, and restoration of damaged transport networks.

Networking Solutions in Combined Distributed Worlds are discussed in [37]. The paper analyzes the rapidly growing importance of graph and network models and tools in such areas as transport, communications, social and military systems, goods production and distribution, education, economy, biology, psychology, criminology, climate change, and many others. Based on the developed SGT, it provides practical examples of combined networking solutions for finding the strongest production centers in their networks and powerful user communities, with orientation on their optimal distributed delivery infrastructures.

Self-recovering Infrastructures and Networks are discussed in [38]. Self-recovery, often mentioned as self-healing and remediation, is an extremely important superpower-like feature of large systems on national, international, and global levels. It may relate to critical infrastructures covering different human activity areas including prosperity, integrity, economy, evolution, and especially security. The paper investigates and shows how the developed SGT can organize distributed infrastructures with any volumes and topologies to behave in a self-healing and self-repairing manner.

Spatial Networks as Models for Organoid Cultures and Brain Research is investigated in [39]. It relates to the concept of organoids as simplified versions of organs produced artificially. It investigates potential capabilities of the creation, evolution, and analysis of organoid models with the developed Spatial Grasp Model and Technology (SGT) and shows compact expression of growing organoid models under SGT which includes cell growth, division and replication, cell worm creation and movement, and killer cell operation.

1.5. History and Previous Publications of the Approach Developed

The Spatial Grasp Model and Technology with its basic SGL, described in the book, has a history spanning more than half a century. Starting in 1969 and originally known as WAVE, it was practically implemented in the distributed academic

city network in Kiev, Ukraine, well before the internet, and then used, in other countries too, for solving different problems, fighting network intrusions including [40–96]. Many of the mentioned publications contain original ideas with their trial implementations which proved useful for the current book.

1.6. Summary of Other Book Chapters

1.6.1. Chapter 2: Spatial Grasp Technology Basics

The chapter first reviews existing parallel and distributed processing models and technologies for comparison with the one chosen for this book SGT, which is based on distributed and parallel processing, management, and control too. Then describes the general issues of SGT and explains the main features of SGL which include its recursive structure, constants, variables, rules, SGL top summary, how SGL scenarios evolve, and SGL control states. The chapter provides details of the networked SGL implementation which include general features, SGL interpreter organization, main data structures of the interpreter, and its spatial tracking system.

1.6.2. Chapter 3: Spatial Grasp Language

The chapter first reviews existing distributed programming languages for comparison with SGL of the chosen SGT for this book, as SGL is fundamentally oriented on distributed programming too. It repeats main SGT features, shows full SGL syntax, then describes its main components which include the following: SGL constants representing information, physical matter, special constants, and custom constants; SGL variables like global variables, heritable variables, frontal variables, nodal variables, and environmental variables; and SGL rules named as type, usage, movement, creation, echoing, verification, assignment, advancement, branching, transference, exchange, timing, and qualification.

1.6.3. Chapter 4: Networks Representation and Processing Basics

The chapter reviews existing publications on networks and graphs which proved useful for the book, reminds main features of SGT and SGL, then describes elementary network operations in SGL which include network creation, counting its elements, finding node with maximum number of links, ordering network nodes by the number of their links, and finding names of direct neighbors of a node. It also shows how to find and collect different paths between nodes and how to build breadth-first spanning tree and shortest path tree from a node to all other nodes. Special attention is paid to finding particular components like strongest sub-networks or cliques and weakest or articulation points. Different pattern matching techniques are described too which are based on a path through all pattern nodes and also through all its links. All network algorithms and solutions are presented in SGL.