The book series AI-SSE publishes new developments and advances on all aspects of Artificial Intelligence-enhanced Software and Systems Engineering—quickly and with a high quality. The series provides a concise coverage of the particular topics from both the vantage point of a newcomer and that of a highly specialized researcher in these scientific disciplines, which results in a significant cross-fertilization and research dissemination. To maximize dissemination of research results and knowledge in these disciplines, the series will publish edited books, monographs, handbooks, textbooks and conference proceedings. Of particular value to both the contributors and the readership are the short publication timeframe and the world-wide distribution, which enable both wide and rapid dissemination of research output.
Handbook on Artificial Intelligence-Empowered Applied Software Engineering

VOL. 2: Smart Software Applications in Cyber-Physical Systems
Foreword

Artificial Intelligence is defining a new era in human civilization, shaping a new, human-centred society (“Society 5.0”) in which cyberspace (virtual space) and physical space (real space) are highly integrated [1, 2]. The main characteristic of this era is that huge amounts of data, collected from a variety of sensors, are stored and automatically analysed without human intervention and via intelligent algorithms and software which far exceed human capabilities. The consequence is a strong interconnection between humans, devices and services in literally all aspects of professional, social and everyday life, which was never previously seen and is continuously becoming ever more complex.

Certainly, this interconnection between humans and artificial intelligence comes with significant risks. In [3], a warning is issued that “… …Artificial Intelligence (AI) is not an ongoing or imminent global catastrophic risk. Nor is it as uncontroversially a serious cause for concern. However, from a long term perspective, the development of general artificial intelligence, exceeding that of the human brain, can be seen as one of the main challenges to the future of humanity (arguably, even as the main challenge).”

Despite the risks associated with the rapid development of Artificial Intelligence, almost every aspect of society is expected to benefit from it, including economic development, combatting famine, poverty and inequality, improved healthcare, advanced assistive technologies for people in need, efficient energy production and distribution, disaster prevention and intelligent applications in manufacturing and industry.

These advances come from the pressure imposed on researchers worldwide to insert Artificial Intelligence enhancements into software and/or empower software with Artificial Intelligence as a result of technological advancements, such as the Internet of Things, big data collected with a variety of sensors or smartphone and mobile software applications. Thus, a new multi-disciplinary research area has been emerging over the recent past, which is expected to have a significant impact on society.

Professors Maria Virvou, George A. Tsihrintzis, Nikolaos G. Bourbakis and Lakhmi C. Jain have identified the lacuna in an appropriate, high-impact forum
to publish related research and disseminate corresponding knowledge as it accumulates. Thus, they initiated a new Springer series under the title ARTIFICIAL INTELLIGENCE-ENHANCED SOFTWARE AND SYSTEMS ENGINEERING. As they state, “The book series AI-SSE publishes new developments and advances on all aspects of Artificial Intelligence-enhanced Software and Systems Engineering—quickly and with a high quality. The series provides a concise coverage of the particular topics from both the vantage point of a newcomer and that of a highly specialized researcher in these scientific disciplines, which results in a significant cross-fertilization and research dissemination. To maximize dissemination of research results and knowledge in these disciplines, the series will publish edited books, monographs, handbooks, textbooks and conference proceedings. Of particular value to both the contributors and the readership are the short publication timeframe and the world-wide distribution, which enable both wide and rapid dissemination of research output” [4].

In more specificity, the new series will focus on the following:

1. Incorporating Artificial Intelligence enhancements into the software.
2. Developing Artificial Intelligence tools for Software Engineering.
4. Software Engineering for developing Artificial Intelligence and Machine Learning systems.
5. Innovative applications of Artificial Intelligence-empowered Software Engineering.


Specifically, the first volume consists of an introductory/editorial chapter and eleven (11) additional chapters. In the introductory chapter, the editors guide the reader, especially the newcomer to the area of Artificial Intelligence-empowered Applied Software Engineering and focus on Novel Methodologies to Engineering Smart Software Systems. They introduce the corresponding major concepts and topics, the approaches and some of the open challenges of this fascinating discipline. The remaining 11 chapters have been authored by world-renowned researchers who are recognized for their significant contributions to their corresponding fields. The book is organized into three parts, namely: (i) Survey of Recent Relevant Literature (1 chapter), (ii) Artificial Intelligence-Assisted Software Development (5 chapters) and (iii) Software Engineering Tools to develop Artificial Intelligence Applications (5 chapters).

On the other hand, the second volume consists of an introductory/editorial chapter and ten (10) additional chapters. In the introductory chapter, the editors again guide the reader, especially the newcomer to the area of Artificial Intelligence-empowered Applied Software Engineering and now focus on Smart Software Applications in
Cyber-Physical Systems. They introduce the corresponding major concepts and topics, the approaches and some of the open challenges of this fascinating discipline. The remaining 10 chapters have been authored by world-renowned researchers who are recognized for their significant contributions to their corresponding fields. The book is organized into five parts, namely: (i) *Smart Software Applications in Scientific Document Processing* (2 chapters), (ii) *Smart Software Applications in Enterprise Modeling* (3 chapters), (iii) *Smart Software Applications in Education* (2 chapters), (iv) *Smart Software Applications in Healthcare and Medicine* (2 chapters) and (v) *Smart Software Applications in Infrastructure Monitoring* (1 chapter).

Editing a two-volume Handbook in this exciting new research area is a challenging task, especially as this discipline is multi-disciplinary and researchers come from a wide variety of interests and expertise. The editors are required to grasp this breadth and be deeply versed in the corresponding state-of-the-art developments in the field. Profs. Virvou, Tsihrintzis, Bourbakis and Jain have managed to impress us with the breadth of the topics covered in their two-volume Handbook. Their Handbook not only covers an impressively wide variety of topics within this multi-disciplinary area, but also the depth in which each topic is covered is dazzling. Moreover, while the first volume is devoted to general methodologies in empowering software with artificial intelligence, the second volume is devoted to specific application areas and case studies. Thus, I am confident that the readers of the Handbook—either newcomers to this area seeking to know more about it or specialized researchers seeking to be versed in the most recent advances in specific sub-areas—will benefit greatly from this two-volume work and, moreover, will be able to make use of and apply their readings in practice.

I find the editors’ work superb and I warmly congratulate them. I have enjoyed reading this two-volume Handbook and, without any reservation, I recommend it to both specialists in Artificial Intelligence-empowered Applied Software Engineering and general readers who wish to learn more about this emerging and fascinating discipline.

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Further Reading

1. From Industry 4.0 to Society 5.0: the big societal transformation plan of Japan. https://www.i-scoop.eu/industry-4-0/society-5-0/
2. Society 5.0 https://www8.cao.go.jp/cstp/english/society5_0/index.html
The use of Artificial Intelligence is being extended far beyond the related technology of Expert Systems and the respective more traditional procedures of Knowledge Engineering, Knowledge Acquisition or Knowledge Representation and needs to be embodied in other forms of software. The driving conditions behind related efforts in research and development arise from pressure exercised by important and evolving new technological advancements in big data, smartphone and mobile software applications, the Internet of Things, as well as a vast range of application areas in all sorts of human activities and professions. As such, current related research includes efforts towards the efficient incorporation of Artificial Intelligence enhancements into software and the empowerment of software with Artificial Intelligence. The goal is dual: (i) to develop algorithms, mechanisms, methodologies and procedures that allow the software to learn and evolve (i.e., to become better, user-friendlier and more efficient at performing specific tasks), either on its own or with the help of a supervisor/instructor, and (ii) to enhance the whole Software Engineering process, including the use of Artificial Intelligence to (at least partially) automate software development, and to reflect the incorporation of knowledge engineering and knowledge acquisition, prototyping and rapid application development of intelligent software modules.

The book at hand constitutes the second volume of a two-volume Handbook on Artificial Intelligence-Empowered Applied Software Engineering and is devoted to Smart Software Applications in Cyber-Physical Systems. In the book, we present some very significant advances in Smart Software Applications in (i) Scientific Document Processing, (ii) Enterprise Modeling, (iii) Education, (iv) Healthcare and Medicine and (v) Infrastructure Monitoring. The editorial note is followed by 10 chapters, each of which is authored by world-known experts and complemented with additional bibliography for the reader to probe deeper into the chapter topic.

The book is directed towards professors, researchers, scientists, engineers and students in Artificial Intelligence, Software Engineering and Computer Science-related disciplines. It is also directed towards readers who come from other disciplines and are interested in becoming versed in some of the most recent advances in the field of Artificial Intelligence-empowered Applied Software Engineering. Finally, as
societal demand continues to pose new and challenging problems and emerging tech-
nologies press for ever more advanced theories and ever more efficient methodolo-
gies, tools and systems to be devised to address them, it is our hope that the *Handbook
on Artificial Intelligence-empowered Applied Software Engineering* will also attract
the interest of researchers in authoring/editing related volumes to be published in the
new Springer series on ARTIFICIAL INTELLIGENCE-ENHANCED SOFTWARE
AND SYSTEMS ENGINEERING ([https://www.springer.com/series/16891](https://www.springer.com/series/16891)).

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Chapter 1
Introduction to Handbook on Artificial Intelligence-Empowered Applied Software Engineering—Vol. 2: Smart Software Applications in Cyber-Physical Systems

Maria Virvou, George A. Tsihrintzis, Nikolaos G. Bourbakis, and Lakhmi C. Jain

Abstract Significant current research efforts are devoted to the efficient incorporation of Artificial Intelligence enhancements into software and the empowerment of software with Artificial Intelligence. The goal of this research is dual: (i) to develop algorithms, mechanisms, methodologies, and procedures that allow software to learn and evolve (i.e., to become better, user-friendlier and more efficient at performing specific tasks), either on its own or with the help of a supervisor/instructor, and (ii) to enhance the whole Software Engineering process, including the use of Artificial Intelligence to (at least partially) automate software development and reflect the incorporation of knowledge engineering and knowledge acquisition, prototyping and rapid application development of intelligent software modules. The book at hand constitutes the second volume of a two-volume Handbook on Artificial Intelligence-empowered Applied Software Engineering and is devoted to Smart Software Applications in Cyber-Physical Systems. In the book, we present some very significant advances in Smart Software Applications in (i) Scientific Document Processing, (ii) Enterprise Modeling, (iii) Education, (iv) Healthcare and Medicine, and (v) Infrastructure Monitoring. The editorial note is followed by 10 chapters, each of which is

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authored by world-known experts and complemented with additional bibliography for the reader to probe deeper into the chapter topic.

1.1 Editorial Note

For several decades, *Artificial Intelligence* has been a field of very active and intense research worldwide. Recently, the whole field of Artificial Intelligence is being revisited to provide critical functionality and significant enhancements in reasoning, decision making, filtering, software personalization and adaptivity, natural language understanding, deep learning, machine learning and data mining. This broad activity comes under the research and development pressure of the important and evolving new technological advancements in big data, smartphone and mobile software applications, the Internet of Things as well as a vast range of application areas in all sorts of human activities and professions.

In view of the previous, the use of Artificial Intelligence has been extended beyond the related technology of Expert Systems and the respective more traditional procedures of Knowledge Engineering, Knowledge Acquisition or Knowledge Representation and needs to be embodied in other forms of software. As such, current related research includes efforts towards the efficient incorporation of Artificial Intelligence enhancements into software and the empowerment of software with Artificial Intelligence. The goal is dual: (i) to develop algorithms, mechanisms, methodologies, and procedures that allow software to learn and evolve (i.e., to become better, user-friendlier and more efficient at performing specific tasks), either on its own or with the help of a supervisor/instructor, and (ii) to enhance the whole Software Engineering process, including the use of Artificial Intelligence to (at least partially) automate software development, so as to reflect the incorporation of knowledge engineering and knowledge acquisition, prototyping and rapid application development of intelligent software modules.

Within the umbrella of *Artificial Intelligence-empowered Software Engineering*, a number of intelligence paradigms are used, which include Expert Systems, Fuzzy Logic, Machine Learning (and its sub-field of Deep Learning), Artificial Immune Systems, Swarm Intelligence, and Genetic Algorithms.

As a result of its enormous pace of growth (both theoretically and in the breadth of application areas) and its high rates of success, *Artificial Intelligence-empowered Software Engineering* promises a major impact in science, technology and the society itself. However, such an impact also includes threats, among others in security, privacy, safety, democracy, fundamental rights, transparency, business, competition or the job market.

In order to make efficient development and use of *Artificial Intelligence-empowered Software*, further research is required and all aspects and applications of the Software Engineering discipline need to be re-considered within the Artificial Intelligence-empowered framework. Specifically, significant research needs to be conducted along the following broad avenues:
1. Incorporating Artificial Intelligence enhancements into software
2. Developing Artificial Intelligence tools for Software Engineering
3. Merging Software Engineering with Knowledge Engineering
4. Software Engineering for developing Artificial Intelligence and Machine Learning systems
5. Innovative applications of Artificial Intelligence-empowered Software Engineering

The two-volume *Handbook on Artificial Intelligence-empowered Applied Software Engineering* aims at updating both the relevant research communities—including professors, researchers, and students—and the general reader on the most recent related advances, including, but not limited to the following topics:

- Architecture of AI-empowered systems, intelligent agents and softbots
- Architectures for AI-empowered shells
- Automating AI-empowered software design and synthesis
- Decision support methods for AI-empowered software engineering
- Development of AI-empowered multi-modal interfaces
- Development of AI-empowered user models
- Development processes for AI-empowered applications
- Empirical and/or evaluation studies for AI-empowered applications
- AI-empowered user interfaces and human–machine interaction
- AI-empowered Internet-based interactive applications
- Knowledge acquisition for AI-empowered software
- AI-empowered process management and project management
- Knowledge management for AI-empowered business processes, workflows and enterprise modeling
- AI-empowered technologies for semantic web
- AI-empowered technologies for service-oriented systems, Internet of services and Internet of things
- AI-empowered technologies for web services
- AI-empowered methods and tools for software engineering education
- AI-empowered methods and tools for testing, verification and validation, maintenance and evolution
- AI-empowered methods for software metrics
- AI-empowered requirements engineering, domain analysis and modeling
- Methodology and tools for knowledge discovery and data mining
- Ontologies and patterns in UML modeling
- Ontology engineering
- AI-empowered program understanding, programming knowledge, modeling programs and programmers
- AI-empowered software engineering methods for Intelligent Tutoring Systems
- Software life cycle of AI-empowered interactive systems
- AI-empowered software tools assisting system development
- AI-empowered personalized software engineering
As the intention of the Handbook is to provide a concise coverage to the particular topic from the vantage point of a newcomer, each chapter is complete within itself and includes an abstract and a bibliography of references to further reading. Because of the breadth of the topics covered and the extensive response by researchers worldwide, the Handbook was divided into two separate volumes. Additionally, each volume is further organized into various parts, with each part grouping together several related chapters.

While the first volume of the Handbook focused on Novel Methodologies to Engineering Smart Software Systems, the current (second) volume at hand is devoted to Smart Software Applications in Cyber-Physical Systems. Specifically, this second volume consists of the current editorial note (Chap. 1) and an additional ten (10) chapters. All chapters in the book were authored by researchers who work in the corresponding chapter theme and are recognized for their significant research contributions.

In more detail, the chapters in the book are organized into three parts, as follows:

The first part of the book consists of two chapters devoted to Smart Software Applications in Scientific Document Processing. Specifically, Chap. 2, by Elisavet Elli Kostalia and Nikolaos G. Bourbakis, is titled: “Detection, Extraction and SPN Representation of Pseudo-Algorithms in Scientific Documents.” The authors present a short overview on pseudo-algorithm detection and extraction from technical documents. They also present a learning scheme to identify these pseudo-algorithms and a SPN scheme for the analysis of a pseudo-algorithm into its main sections.

Chapter 3, by Shantanu Kumar Rahut, Md. Hasib Ullah, Tanzila Binte Hafiz and Shamim Akhter, is titled: “A Recommender Engine for Scientific Paper Peer-Reviewing System.” The authors propose a hybrid recommender system for selecting reviewers to evaluate research proposals or articles. They analyse their system and evaluate it with encouraging results.

The second part of the book consists of three chapters devoted to Smart Software Applications in Enterprise Modeling. Specifically, Chap. 4, by Shuichiro Yamamoto, is titled: “Visualization of Digital-Enhanced Enterprise Modeling.” The author introduces a meta model for describing value analysis, business models and business processes. He also presents an application example as well as evaluation results.

Chapter 5, by Elamin Abderrahim, Nada Matta, and Hassan Ati, is titled: “Know-linking: when Machine Learning meets Organizational Tools Analysis to generate Shared Knowledge in Large Companies.” Towards knowledge sharing in large companies, the authors propose a Knowledge Management approach based on profiling techniques. Specifically, they present an algorithm of multi-labeled classification.

Chapter 6, by Emine Kambur, Tulay Yildirim, is titled: “Changes in Human Resources Management with Artificial Intelligence.” The authors attempt to outline and explain the change that has occurred with the inclusion of artificial intelligence in human resources management. Specifically, they address recruitment, training,
performance assessment, talent management and salary management in the Artificial Intelligence era.

The third part of the book consists of two chapters devoted to **Smart Software Applications in Education**.

Specifically, Chap. 7, by Joey Sherrill and Yiu-Kai Ng, is titled: “Promoting Reading Among Teens: Analyzing the Emotional Preferences of Teenage Readers.” The authors propose a novel technique of analyzing the emotional contents of a book and using them to compare the similarity of books and predict the likelihood a user will enjoy it based on their age. They also present significant conclusions from their investigations.

Chapter 8, by Vijayalakshmi Ramasamy, Mourya Reddy Narasareddygari, Gurumaran S. Walia, Andrew A. Allen, Debra M. Duke, James D. Kiper and Debra Lee Davis, is titled: “A Multi-Institutional Analysis of CS1 Students’ Common Misconceptions of Key Programming Concepts.” The authors analyze possible misconceptions that the students confront in various CS1 course concepts, which have been identified through a corresponding multi-institutional analysis. They provide insights on the root cause of misconceptions and make inferences which can help instructors develop better pedagogical approaches.

The fourth part of the book consists of two chapters devoted to **Smart Software Applications in Healthcare and Medicine**.

Specifically, Chap. 9, by Mika Sato-Ilic, is titled: “Clustering-based Scaling for Healthcare Data.” The author describes a fuzzy cluster-scaled regression analysis and applications by using mobile health dataset. She evaluates her proposed methodology with encouraging results.

Chapter 10, by Aspasia Daskalopulu, Lefteri H. Tsoukalas and Dimitrios Bargiotas, is titled: “Normative and Fuzzy Components of Medical AI Applications.” The authors discuss quantum-assisted artificial intelligence applications and highlight their motivations as well as their challenges.

Finally, the fifth part of the book consists of one chapter devoted to **Smart Software Applications in Infrastructure Monitoring**.

Specifically, Chap. 11, by Shin Kamada and Takumi Ichimura, is titled: “Adaptive Structural Learning of Deep Belief Network and its Application to Real Time Crack Detection of Concrete Structure using Drone.” The authors propose an adaptive structural learning method based on Restricted Boltzmann Machine (RBM) and Deep Belief Network (DBN) models. They show experimentally that a corresponding system embedded on drones can detect all cracks in a concrete structure.

### 1.2 Book Summary and Future Volumes

The book at hand constitutes the second volume of a two-volume *Handbook on Artificial Intelligence-empowered Applied Software Engineering* and is devoted to **Smart Software Applications in Cyber-Physical Systems**. In it, we present some very significant advances in **Smart Software Applications in (i) Scientific Document**

The book is directed towards professors, researchers, scientists, engineers and students in Artificial Intelligence, Software Engineering and Computer Science-related disciplines. It is also directed towards readers who come from other disciplines and are interested in becoming versed in some of the most recent advances in the field of Artificial Intelligence-empowered Applied Software Engineering. We hope that all of them will find it useful and inspiring in their works and researches.

On the other hand, societal demand continues to pose new and challenging problems and emerging technologies press for ever more advanced theories and ever more efficient methodologies, tools and systems to be devised to address them. As this volume completes the Handbook on Artificial Intelligence-empowered Applied Software Engineering, we also hope to attract the interest of researchers in authoring/editing related volumes to be published in the new Springer series on ARTIFICIAL INTELLIGENCE–ENHANCED SOFTWARE AND SYSTEMS ENGINEERING https://www.springer.com/series/16891).

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