Transactions on Computational Science
and Computational Intelligence

Hamid R. Arabnia · Leonidas Deligiannidis
Hayaru Shouno · Fernando G. Tinetti
Quoc-Nam Tran *Editors*

Advances in Computer Vision and Computational Biology

Proceedings from IPCV'20, HIMS'20, BIOCOMP'20, and BIOENG'20

Springer

Transactions on Computational Science and Computational Intelligence

Series Editor
Hamid Arabnia
Department of Computer Science
The University of Georgia
Athens, Georgia
USA

Computational Science (CS) and Computational Intelligence (CI) both share the same objective: finding solutions to difficult problems. However, the methods to the solutions are different. The main objective of this book series, "Transactions on Computational Science and Computational Intelligence", is to facilitate increased opportunities for cross-fertilization across CS and CI. This book series will publish monographs, professional books, contributed volumes, and textbooks in Computational Science and Computational Intelligence. Book proposals are solicited for consideration in all topics in CS and CI including, but not limited to, Pattern recognition applications; Machine vision; Brain-machine interface; Embodied robotics; Biometrics; Computational biology; Bioinformatics; Image and signal processing; Information mining and forecasting; Sensor networks; Information processing; Internet and multimedia; DNA computing; Machine learning applications; Multi-agent systems applications; Telecommunications; Transportation systems; Intrusion detection and fault diagnosis; Game technologies; Material sciences; Space, weather, climate systems, and global changes; Computational ocean and earth sciences; Combustion system simulation; Computational chemistry and biochemistry; Computational physics; Medical applications; Transportation systems and simulations; Structural engineering; Computational electro-magnetic; Computer graphics and multimedia; Face recognition; Semiconductor technology, electronic circuits, and system design; Dynamic systems; Computational finance; Information mining and applications; Astrophysics; Biometric modeling; Geology and geophysics; Nuclear physics; Computational journalism; Geographical Information Systems (GIS) and remote sensing; Military and defense related applications; Ubiquitous computing; Virtual reality; Agent-based modeling; Computational psychometrics; Affective computing; Computational economics; Computational statistics; and Emerging applications. For further information, please contact Mary James, Senior Editor, Springer, mary.james@springer.com.

More information about this series at http://www.springer.com/series/11769

Hamid R. Arabnia • Leonidas Deligiannidis
Hayaru Shouno • Fernando G. Tinetti
Quoc-Nam Tran
Editors

Advances in Computer Vision and Computational Biology

Proceedings from IPCV'20, HIMS'20, BIOCOMP'20, and BIOENG'20

Springer

Editors
Hamid R. Arabnia
Department of Computer Science
University of Georgia
Athens, GA, USA

Leonidas Deligiannidis
School of Computing and Data Sciences
Wentworth Institute of Technology
Boston, MA, USA

Hayaru Shouno
Graduate School of Information Science & Engineering
University of Electro-Communications
Chofu, Japan

Fernando G. Tinetti
Facultad de Informática - CIC PBA
Universidad Nacional de La Plata
La Plata, Argentina

Quoc-Nam Tran
Department of Computer Science
Southeastern Louisiana University
Hammond, LA, USA

ISSN 2569-7072 ISSN 2569-7080 (electronic)
Transactions on Computational Science and Computational Intelligence
ISBN 978-3-030-71050-7 ISBN 978-3-030-71051-4 (eBook)
https://doi.org/10.1007/978-3-030-71051-4

© Springer Nature Switzerland AG 2021
This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.
The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.
The publisher, the authors, and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

It gives us great pleasure to introduce this collection of papers that were presented at the following international conferences: Image Processing, Computer Vision, and Pattern Recognition (IPCV 2020); Health Informatics and Medical Systems (HIMS 2020); Bioinformatics and Computational Biology (BIOCOMP 2020); and Biomedical Engineering and Sciences (BIOENG 2020). These four conferences were held simultaneously (same location and dates) at Luxor Hotel (MGM Resorts International), Las Vegas, USA, July 27–30, 2020. This international event was held using a hybrid approach, that is, "in-person" and "virtual/online" presentations and discussions.

This book is composed of seven parts. Parts I through III (composed of 21 chapters) include articles that address various challenges in the areas of Image Processing, Computer Vision, and Pattern Recognition (IPCV). Parts IV and V (composed of 29 chapters) present topics in the areas of Health Informatics and Medical Systems (HIMS). Part VI (composed of 14 chapters) includes articles in the areas of Bioinformatics and Computational Biology (BIOCOMP). Lastly, Part VII (composed of 4 chapters) discusses research topics in the areas of Biomedical Engineering and Sciences (BIOENG).

An important mission of the World Congress in Computer Science, Computer Engineering, and Applied Computing, CSCE (a federated congress to which this event is affiliated with) includes *"Providing a unique platform for a diverse community of constituents composed of scholars, researchers, developers, educators, and practitioners. The Congress makes concerted effort to reach out to participants affiliated with diverse entities (such as: universities, institutions, corporations, government agencies, and research centers/labs) from all over the world. The congress also attempts to connect participants from institutions that have* ***teaching*** *as their main mission with those who are affiliated with institutions that have* ***research*** *as their main mission. The congress uses a quota system to achieve its institution and geography diversity objectives."* By any definition of diversity, this

congress is among the most diverse scientific meetings in the USA. We are proud to report that this federated congress had authors and participants from 54 different nations representing variety of personal and scientific experiences that arise from differences in culture and values.

The program committees (refer to subsequent pages for the list of the members of committees) would like to thank all those who submitted papers for consideration. About 47% of the submissions were from outside the USA. Each submitted paper was peer-reviewed by two experts in the field for originality, significance, clarity, impact, and soundness. In cases of contradictory recommendations, a member of the conference program committee was charged to make the final decision; often, this involved seeking help from additional referees. In addition, papers whose authors included a member of the conference program committee were evaluated using the double-blind review process. One exception to the above evaluation process was for papers that were submitted directly to chairs/organizers of pre-approved sessions/workshops; in these cases, the chairs/organizers were responsible for the evaluation of such submissions. The overall paper acceptance rate for regular papers was 17%; 12% of the remaining papers were accepted as short and/or poster papers.

We are grateful to the many colleagues who offered their services in preparing this book. In particular, we would like to thank the members of the Program Committees of individual research tracks as well as the members of the Steering Committees of IPCV 2020, HIMS 2020, BIOCOMP 2020, and BIOENG 2020; their names appear in the subsequent pages. We would also like to extend our appreciation to over 500 referees.

As Sponsors-at-large, partners, and/or organizers, each of the following (separated by semicolons) provided help for at least one research track: Computer Science Research, Education, and Applications (CSREA); US Chapter of World Academy of Science; American Council on Science and Education & Federated Research Council; and Colorado Engineering Inc. In addition, a number of university faculty members and their staff, several publishers of computer science and computer engineering books and journals, chapters and/or task forces of computer science associations/organizations from 3 regions, and developers of high-performance machines and systems provided significant help in organizing the event as well as providing some resources. We are grateful to them all.

We express our gratitude to all authors of the articles published in this book and the speakers who delivered their research results at the congress. We would also like to thank the following: UCMSS (Universal Conference Management Systems & Support, California, USA) for managing all aspects of the conference; Dr. Tim Field of APC for coordinating and managing the printing of the programs; the staff of Luxor Hotel (MGM Convention) for the professional service they provided; and Ashu M. G. Solo for his help in publicizing the congress. Last but not least, we

would like to thank Ms. Mary James (Springer Senior Editor in New York) and Arun Pandian KJ (Springer Production Editor) for the excellent professional service they provided for this book project.

Athens, USA — Hamid R. Arabnia
Boston USA — Leonidas Deligiannidis
Chofu Japan — Hayaru Shouno
La Plata Argentina — Fernando G. Tinetti
Hammond USA — Quoc-Nam Tran
Savannah, Georgia, USA — Ray Hashemi
Savannah, Georgia, USA — Azita Bahrami

Image Processing, Computer Vision, and Pattern Recognition

IPCV 2020 – Program Committee

- *Prof. Emeritus Nizar Al-Holou (Congress Steering Committee); ECE Department; Vice Chair, IEEE/SEM-Computer Chapter; University of Detroit Mercy, Detroit, Michigan, USA*
- *Dr. Mahmood Al-khassaweneh; University of Detroit Mercy, Detroit, Michigan, USA*
- *Prof. Emeritus Hamid R. Arabnia (Congress Steering Committee); Department of Computer Science, The University of Georgia, USA; Editor-in-Chief, Journal of Supercomputing (Springer); Fellow, Center of Excellence in Terrorism, Resilience, Intelligence & Organized Crime Research (CENTRIC)*
- *Dr. Azita Bahrami (Vice-Chair); President, IT Consult, USA*
- *Prof. Dr. Juan-Vicente Capella-Hernandez; Universitat Politecnica de Valencia (UPV), Department of Computer Engineering (DISCA), Valencia, Spain*
- *Prof. Juan Jose Martinez Castillo; Director, The Acantelys Alan Turing Nikola Tesla Research Group and GIPEB, Universidad Nacional Abierta, Venezuela*
- *Prof. Emeritus Kevin Daimi (Congress Steering Committee); Department of Mathematics, Computer Science and Software Engineering, University of Detroit Mercy, Detroit, Michigan, USA*
- *Prof. Zhangisina Gulnur Davletzhanovna; Vice-rector of the Science, Central-Asian University, Kazakhstan, Almaty, Republic of Kazakhstan; Vice President of International Academy of Informatization, Kazskhstan, Almaty, Republic of Kazakhstan*
- *Prof. Leonidas Deligiannidis (Congress Steering Committee); Department of Computer Information Systems, Wentworth Institute of Technology, Boston, Massachusetts, USA*
- *Dr. Trung Duong; Research Faculty at Center for Advanced Infrastructure and Transportation (CAIT), Rutgers University, the State University of New Jersey, New Jersey, USA*

- *Prof. Mary Mehrnoosh Eshaghian-Wilner (Congress Steering Committee); Professor of Engineering Practice, University of Southern California, California, USA; Adjunct Professor, Electrical Engineering, University of California Los Angeles, Los Angeles (UCLA), California, USA*
- *Prof. Ray Hashemi (Vice-Chair); College of Engineering and Computing, Georgia Southern University, Georgia, USA*
- *Prof. Byung-Gyu Kim (Congress Steering Committee); Multimedia Processing Communications Lab.(MPCL), Department of Computer Science and Engineering, College of Engineering, SunMoon University, South Korea*
- *Prof. Tai-hoon Kim; School of Information and Computing Science, University of Tasmania, Australia*
- *Prof. Dr. Guoming Lai; Computer Science and Technology, Sun Yat-Sen University, Guangzhou, P. R. China*
- *Prof. Hyo Jong Lee; Director, Center for Advanced Image and Information Technology, Division of Computer Science and Engineering, Chonbuk National University, South Korea*
- *Dr. Muhammad Naufal Bin Mansor; Faculty of Engineering Technology, Department of Electrical, Universiti Malaysia Perlis (UniMAP), Perlis, Malaysia*
- *Dr. Andrew Marsh (Congress Steering Committee); CEO, HoIP Telecom Ltd (Healthcare over Internet Protocol), UK; Secretary General of World Academy of BioMedical Sciences and Technologies (WABT) a UNESCO NGO, The United Nations*
- *Prof. Aree Ali Mohammed; Head, Computer Science Department, University of Sulaimani, Kurdistan, Iraq*
- *Prof. Dr., Eng. Robert Ehimen Okonigene (Congress Steering Committee); Department of Electrical & Electronics Engineering, Faculty of Engineering and Technology, Ambrose Alli University, Nigeria*
- *Prof. James J. (Jong Hyuk) Park (Congress Steering Committee); Department of Computer Science and Engineering (DCSE), SeoulTech, Korea; President, FTRA, EiC, HCIS Springer, JoC, IJITCC; Head of DCSE, SeoulTech, Korea*
- *Prof. Dr. R. Ponalagusamy; Department of Mathematics, National Institute of Technology, India*
- *Dr. Akash Singh (Congress Steering Committee); IBM Corporation, Sacramento, California, USA; Chartered Scientist, Science Council, UK; Fellow, British Computer Society; Member, Senior IEEE, AACR, AAAS, and AAAI; IBM Corporation, USA*
- *Prof. Hayaru Shouno; Chair, Technical Committee of Neuro-Computing (NC), Institute of Electronics, Information & Communication Engineers (IEICE), Japan and University of Electro-Communications, Japan*
- *Ashu M. G. Solo (Publicity), Fellow of British Computer Society, Principal/R&D Engineer, Maverick Technologies America Inc.*
- *Prof. Dr. Ir. Sim Kok Swee; Fellow, IEM; Senior Member, IEEE; Faculty of Engineering and Technology, Multimedia University, Melaka, Malaysia*

- *Prof. Fernando G. Tinetti (Congress Steering Committee); School of CS, Universidad Nacional de La Plata, La Plata, Argentina; also at Comision Investigaciones Cientificas de la Prov. de Bs. As., Argentina*
- *Prof. Hahanov Vladimir (Congress Steering Committee); Vice Rector, and Dean of the Computer Engineering Faculty, Kharkov National University of Radio Electronics, Ukraine and Professor of Design Automation Department, Computer Engineering Faculty, Kharkov; IEEE Computer Society Golden Core Member; National University of Radio Electronics, Ukraine*
- *Dr. Haoxiang Harry Wang (CSCE); Cornell University, Ithaca, New York, USA; Founder and Director, GoPerception Laboratory, New York, USA*
- *Prof. Shiuh-Jeng Wang (Congress Steering Committee); Director of Information Cryptology and Construction Laboratory (ICCL) and Director of Chinese Cryptology and Information Security Association (CCISA); Department of Information Management, Central Police University, Taoyuan, Taiwan; Guest Ed., IEEE Journal on Selected Areas in Communications.*
- *Prof. Layne T. Watson (Congress Steering Committee); Fellow of IEEE; Fellow of The National Institute of Aerospace; Professor of Computer Science, Mathematics, and Aerospace and Ocean Engineering, Virginia Polytechnic Institute & State University, Blacksburg, Virginia, USA*
- *Prof. Jane You (Congress Steering Committee); Associate Head, Department of Computing, The Hong Kong Polytechnic University, Kowloon, Hong Kong*

Health Informatics & Medical Systems

HIMS 2020 – Program Committee

- *Prof. Abbas M. Al-Bakry (Congress Steering Committee); University President, University of IT and Communications, Baghdad, Iraq*
- *Prof. Emeritus Nizar Al-Holou (Congress Steering Committee); Electrical & Computer Engineering Department; Vice Chair, IEEE/SEM-Computer Chapter; University of Detroit Mercy, Michigan, USA*
- *Prof. Emeritus Hamid R. Arabnia (Congress Steering Committee); Department of Computer Science, The University of Georgia, USA; Editor-in-Chief, Journal of Supercomputing (Springer); Fellow, Center of Excellence in Terrorism, Resilience, Intelligence & Organized Crime Research (CENTRIC)*
- *Prof. Dr. Juan-Vicente Capella-Hernandez; Universitat Politecnica de Valencia (UPV), Department of Computer Engineering (DISCA), Valencia, Spain*
- *Prof. Juan Jose Martinez Castillo; Director, The Acantelys Alan Turing Nikola Tesla Research Group and GIPEB, Universidad Nacional Abierta, Venezuela*
- *Prof. Emeritus Kevin Daimi (Congress Steering Committee); Department of Mathematics, Computer Science and Software Engineering, University of Detroit Mercy, Detroit, Michigan, USA*
- *Prof. Zhangisina Gulnur Davletzhanovna; Vice-rector of the Science, Central-Asian University, Kazakhstan, Almaty, Republic of Kazakhstan; Vice President of International Academy of Informatization, Kazskhstan, Almaty, Republic of Kazakhstan*
- *Prof. Leonidas Deligiannidis (Congress Steering Committee); Department of Computer Information Systems, Wentworth Institute of Technology, Boston, Massachusetts, USA*
- *Prof. Mary Mehrnoosh Eshaghian-Wilner (Congress Steering Committee); Professor of Engineering Practice, University of Southern California, California, USA; Adjunct Professor, Electrical Engineering, University of California Los Angeles, Los Angeles (UCLA), California, USA*

- *Hindenburgo Elvas Goncalves de Sa; Robertshaw Controls (Multi-National Company), System Analyst, Brazil; Information Technology Coordinator and Manager, Brazil*
- *Prof. Ray Hashemi (Vice-Chair); College of Engineering and Computing, Georgia Southern University, Georgia, USA*
- *Prof. Byung-Gyu Kim (Congress Steering Committee); Multimedia Processing Communications Lab.(MPCL), Department of Computer Science and Engineering, College of Engineering, SunMoon University, South Korea*
- *Prof. Tai-hoon Kim; School of Information and Computing Science, University of Tasmania, Australia*
- *Prof. Louie Lolong Lacatan; Chairperson, Computer Engineerig Department, College of Engineering, Adamson University, Manila, Philippines; Senior Member, International Association of Computer Science and Information Technology (IACSIT), Singapore; Member, International Association of Online Engineering (IAOE), Austria*
- *Prof. Dr. Guoming Lai; Computer Science and Technology, Sun Yat-Sen University, Guangzhou, P. R. China*
- *Prof. Hyo Jong Lee; Director, Center for Advanced Image and Information Technology, Division of Computer Science and Engineering, Chonbuk National University, South Korea*
- *Dr. Muhammad Naufal Bin Mansor; Faculty of Engineering Technology, Department of Electrical, Universiti Malaysia Perlis (UniMAP), Perlis, Malaysia*
- *Dr. Andrew Marsh (Congress Steering Committee); CEO, HoIP Telecom Ltd (Healthcare over Internet Protocol), UK; Secretary General of World Academy of BioMedical Sciences and Technologies (WABT) a UNESCO NGO, The United Nations*
- *Michael B. O'Hara; CEO, KB Computing, LLC, USA; Certified Information System Security Professional (CISSP); Certified Cybersecurity Architect (CCSA); Certified HIPAA Professional (CHP); Certified Security Compliance Specialist (CSCS)*
- *Prof. Dr., Eng. Robert Ehimen Okonigene (Congress Steering Committee); Department of Electrical & Electronics Engineering, Faculty of Engineering and Technology, Ambrose Alli University, Nigeria*
- *Prof. James J. (Jong Hyuk) Park (Congress Steering Committee); Department of Computer Science and Engineering (DCSE), SeoulTech, Korea; President, FTRA, EiC, HCIS Springer, JoC, IJITCC; Head of DCSE, SeoulTech, Korea*
- *Prof. Hayaru Shouno; Chair, Technical Committee of Neuro-Computing (NC), Institute of Electronics, Information & Communication Engineers (IEICE), Japan and University of Electro-Communications, Japan*
- *Ashu M. G. Solo (Publicity), Fellow of British Computer Society, Principal/R&D Engineer, Maverick Technologies America Inc.*
- *Prof. Dr. Ir. Sim Kok Swee; Fellow, IEM; Senior Member, IEEE; Faculty of Engineering and Technology, Multimedia University, Melaka, Malaysia*

- *Prof. Fernando G. Tinetti (Congress Steering Committee); School of Computer Science, Universidad Nacional de La Plata, La Plata, Argentina; also at Comision Investigaciones Cientificas de la Prov. de Bs. As., Argentina*
- *Prof. Quoc-Nam Tran (Congress Steering Committee); Department of Computer Science, Southeastern Louisiana University, Hammond, Louisiana, USA*
- *Prof. Hahanov Vladimir (Congress Steering Committee); Vice Rector, and Dean of the Computer Engineering Faculty, Kharkov National University of Radio Electronics, Ukraine and Professor of Design Automation Department, Computer Engineering Faculty, Kharkov; IEEE Computer Society Golden Core Member; National University of Radio Electronics, Ukraine*
- *Prof. Shiuh-Jeng Wang (Congress Steering Committee); Director of Information Cryptology and Construction Laboratory (ICCL) and Director of Chinese Cryptology and Information Security Association (CCISA); Department of Information Management, Central Police University, Taoyuan, Taiwan; Guest Ed., IEEE Journal on Selected Areas in Communications.*
- *Dr. Yunlong Wang; Advanced Analytics at QuintilesIMS, Pennsylvania, USA*
- *Prof. Layne T. Watson (Congress Steering Committee); Fellow of IEEE; Fellow of The National Institute of Aerospace; Professor of Computer Science, Mathematics, and Aerospace and Ocean Engineering, Virginia Polytechnic Institute & State University, Blacksburg, Virginia, USA*
- *Prof. Jane You (Congress Steering Committee); Associate Head, Department of Computing, The Hong Kong Polytechnic University, Kowloon, Hong Kong*
- *Dr. Farhana H. Zulkernine; Coordinator of the Cognitive Science Program, School of Computing, Queen's University, Kingston, ON, Canada*

Bioinformatics and Computational Biology

BIOCOMP 2020 – Program Committee

- *Prof. Abbas M. Al-Bakry (Congress Steering Committee); University President, University of IT and Communications, Baghdad, Iraq*
- *Prof. Emeritus Nizar Al-Holou (Congress Steering Committee); Electrical and Computer Engineering Department; Vice Chair, IEEE/SEM-Computer Chapter; University of Detroit Mercy, Michigan, USA*
- *Prof. Emeritus Hamid R. Arabnia (Congress Steering Committee); Department of Computer Science, The University of Georgia, USA; Editor-in-Chief, Journal of Supercomputing (Springer); Fellow, Center of Excellence in Terrorism, Resilience, Intelligence & Organized Crime Research (CENTRIC)*
- *Prof. Hikmet Budak; Professor and Winifred-Asbjornson Plant Science Chair Department of Plant Sciences and Plant Pathology Genomics Lab, Montana State University, Bozeman, Montana, USA; Editor-in-Chief, Functional and Integrative Genomics; Associate Editor of BMC Genomics; Academic Editor of PLosONE*
- *Prof. Emeritus Kevin Daimi (Congress Steering Committee); Department of Mathematics, Computer Science and Software Engineering, University of Detroit Mercy, Detroit, Michigan, USA*
- *Prof. Leonidas Deligiannidis (Congress Steering Committee); Department of Computer Information Systems, Wentworth Institute of Technology, Boston, Massachusetts, USA*
- *Prof. Youping Deng (Congress Steering Committee); Professor & Director of Bioinformatics Core, Department of Complementary & Integrative Medicine; Co-Director, Genomics Shared Resource, University of Hawaii Cancer Center, University of Hawaii John A. Burns School of Medicine, Honolulu, Hawaii, USA*
- *Dr. Lamia Atma Djoudi (Chair, Doctoral Colloquium & Demos Sessions); France*
- *Prof. Mary Mehrnoosh Eshaghian-Wilner (Congress Steering Committee); Professor of Engineering Practice, University of Southern California, California,*

USA; Adjunct Professor, Electrical Engineering, University of California Los Angeles, Los Angeles (UCLA), California, USA

- *Prof. Ray Hashemi (Vice-Chair); College of Engineering and Computing, Georgia Southern University, Georgia, USA*
- *Prof. George Jandieri (Congress Steering Committee); Georgian Technical University, Tbilisi, Georgia; Chief Scientist, The Institute of Cybernetics, Georgian Academy of Science, Georgia; Ed. Member, International Journal of Microwaves and Optical Technology, The Open Atmospheric Science Journal, American Journal of Remote Sensing, Georgia*
- *Prof. Dr. Abdeldjalil Khelassi; Computer Science Department, Abou beker Belkaid University of Tlemcen, Algeria; Editor-in-Chief, Medical Technologies Journal; Associate Editor, Electronic Physician Journal (EPJ) - Pub Med Central*
- *Prof. Byung-Gyu Kim (Congress Steering Committee); Multimedia Processing Communications Lab.(MPCL), Department of Computer Science and Engineering, College of Engineering, SunMoon University, South Korea*
- *Prof. Dr. Guoming Lai; Computer Science and Technology, Sun Yat-Sen University, Guangzhou, P. R. China*
- *Dr. Ying Liu; Division of Computer Science, Mathematics and Science, College of Professional Studies, St. John's University, Queens, New York, USA*
- *Dr. Prashanti Manda; Department of Computer Science, University of North Carolina at Greensboro, USA*
- *Dr. Muhammad Naufal Bin Mansor; Faculty of Engineering Technology, Department of Electrical, Universiti Malaysia Perlis (UniMAP), Perlis, Malaysia*
- *Dr. Andrew Marsh (Congress Steering Committee); CEO, HoIP Telecom Ltd (Healthcare over Internet Protocol), UK; Secretary General of World Academy of BioMedical Sciences and Technologies (WABT) a UNESCO NGO, The United Nations*
- *Prof. Dr., Eng. Robert Ehimen Okonigene (Congress Steering Committee); Department of Electrical & Electronics Engineering, Faculty of Eng. and Technology, Ambrose Alli University, Edo State, Nigeria*
- *Prof. James J. (Jong Hyuk) Park (Congress Steering Committee); Department of Computer Science and Engineering (DCSE), SeoulTech, Korea; President, FTRA, EiC, HCIS Springer, JoC, IJITCC; Head of DCSE, SeoulTech, Korea*
- *Prof. Dr. R. Ponalagusamy; Mathematics, National Institute of Technology, Tiruchirappalli, India*
- *Ashu M. G. Solo (Publicity), Fellow of British Computer Society, Principal/R&D Engineer, Maverick Technologies America Inc.*
- *Dr. Tse Guan Tan; Faculty of Creative Technology and Heritage, Universiti Malaysia Kelantan, Malaysia*
- *Prof. Fernando G. Tinetti (Congress Steering Committee); School of Computer Science, Universidad Nacional de La Plata, La Plata, Argentina; also at Comision Investigaciones Cientificas de la Prov. de Bs. As., Argentina*
- *Prof. Quoc-Nam Tran (Congress Steering Committee); Department of Computer Science, Southeastern Louisiana University, Hammond, Louisiana, USA*

- *Prof. Shiuh-Jeng Wang (Congress Steering Committee); Director of Information Cryptology and Construction Laboratory (ICCL) and Director of Chinese Cryptology and Information Security Association (CCISA); Department of Information Management, Central Police University, Taoyuan, Taiwan; Guest Ed., IEEE Journal on Selected Areas in Communications.*
- *Prof. Layne T. Watson (Congress Steering Committee); Fellow of IEEE; Fellow of The National Institute of Aerospace; Professor of Computer Science, Mathematics, and Aerospace and Ocean Engineering, Virginia Polytechnic Institute & State University, Blacksburg, Virginia, USA*
- *Prof. Mary Yang (Steering Committee, BIOCOMP); Director, Mid-South Bioinformatics Center and Joint Bioinformatics Ph.D. Program, Medical Sciences and George W. Donaghey College of Engineering and Information Technology, University of Arkansas, USA*
- *Prof. Jane You (Congress Steering Committee); Associate Head, Department of Computing, The Hong Kong Polytechnic University, Kowloon, Hong Kong*
- *Dr. Wen Zhang; Icahn School of Medicine at Mount Sinai, New York City, Manhattan, New York, USA; Board member, Journal of Bioinformatics and Genomics; Board member, Science Research Association*
- *Dr. Hao Zheng; Novo Vivo, VP of Bioinformatics, California, USA*

Biomedical Engineering and Sciences

BIOENG 2020 – Program Committee

- *Prof. Emeritus Nizar Al-Holou (Congress Steering Committee); ECE Department; Vice Chair, IEEE/SEM-Computer Chapter; University of Detroit Mercy, Detroit, Michigan, USA*
- *Prof. Emeritus Hamid R. Arabnia (Congress Steering Committee); Department of Computer Science, The University of Georgia, USA; Editor-in-Chief, Journal of Supercomputing (Springer); Fellow, Center of Excellence in Terrorism, Resilience, Intelligence & Organized Crime Research (CENTRIC)*
- *Prof. Emeritus Kevin Daimi (Congress Steering Committee); Department of Mathematics, Computer Science and Software Engineering, University of Detroit Mercy, Detroit, Michigan, USA*
- *Prof. Leonidas Deligiannidis (Congress Steering Committee); Department of Computer Information Systems, Wentworth Institute of Technology, Boston, Massachusetts, USA*
- *Prof. Mary Mehrnoosh Eshaghian-Wilner (Congress Steering Committee); Professor of Engineering Practice, University of Southern California, California, USA; Adjunct Professor, Electrical Engineering, University of California Los Angeles, Los Angeles (UCLA), California, USA*
- *Prof. Ray Hashemi (Vice-Chair); College of Engineering and Computing, Georgia Southern University, Georgia, USA*
- *Prof. Byung-Gyu Kim (Congress Steering Committee); Multimedia Processing Communications Lab.(MPCL), Department of Computer Science and Engineering, College of Engineering, SunMoon University, South Korea*
- *Prof. Tai-hoon Kim; School of Information and Computing Science, University of Tasmania, Australia*
- *Prof. Dr. Guoming Lai; Computer Science and Technology, Sun Yat-Sen University, Guangzhou, P. R. China*
- *Dr. Muhammad Naufal Bin Mansor; Faculty of Engineering Technology, Department of Electrical, Universiti Malaysia Perlis (UniMAP), Perlis, Malaysia*

- *Dr. Andrew Marsh (Congress Steering Committee); CEO, HoIP Telecom Ltd (Healthcare over Internet Protocol), UK; Secretary General of World Academy of BioMedical Sciences and Technologies (WABT) a UNESCO NGO, The United Nations*
- *Prof. Dr., Eng. Robert Ehimen Okonigene (Congress Steering Committee); Department of Electrical & Electronics Engineering, Faculty of Eng. and Technology, Ambrose Alli University, Edo State, Nigeria*
- *Prof. James J. (Jong Hyuk) Park (Congress Steering Committee); Department of Computer Science and Engineering (DCSE), SeoulTech, Korea; President, FTRA, EiC, HCIS Springer, JoC, IJITCC; Head of DCSE, SeoulTech, Korea*
- *Ashu M. G. Solo (Publicity), Fellow of British Computer Society, Principal/R&D Engineer, Maverick Technologies America Inc.*
- *Prof. Fernando G. Tinetti (Congress Steering Committee); School of Computer Science, Universidad Nacional de La Plata, La Plata, Argentina; also at Comision Investigaciones Cientificas de la Prov. de Bs. As., Argentina*
- *Prof. Quoc-Nam Tran (Congress Steering Committee); Department of Computer Science, Southeastern Louisiana University, Hammond, Louisiana, USA*
- *Prof. Shiuh-Jeng Wang (Congress Steering Committee); Director of Information Cryptology and Construction Laboratory (ICCL) and Director of Chinese Cryptology and Information Security Association (CCISA); Department of Information Management, Central Police University, Taoyuan, Taiwan; Guest Ed., IEEE Journal on Selected Areas in Communications.*
- *Prof. Layne T. Watson (Congress Steering Committee); Fellow of IEEE; Fellow of The National Institute of Aerospace; Professor of Computer Science, Mathematics, and Aerospace and Ocean Engineering, Virginia Polytechnic Institute & State University, Blacksburg, Virginia, USA*
- *Prof. Jane You (Congress Steering Committee); Associate Head, Department of Computing, The Hong Kong Polytechnic University, Kowloon, Hong Kong*
- *Dr. Wen Zhang; Icahn School of Medicine at Mount Sinai, New York City, Manhattan, New York, USA; Board member, Journal of Bioinformatics and Genomics; Board member, Science Research Association*

Contents

Part I Imaging Science and Applications of Deep Learning and Convolutional Neural Network

Evolution of Convolutional Neural Networks for Lymphoma Classification 3
Christopher D. Walsh and Nicholas K. Taylor

Deep Convolutional Likelihood Particle Filter for Visual Tracking 27
Reza Jalil Mozhdehi and Henry Medeiros

DeepMSRF: A Novel Deep Multimodal Speaker Recognition Framework with Feature Selection 39
Ehsan Asali, Farzan Shenavarmasouleh, Farid Ghareh Mohammadi, Prasanth Sengadu Suresh, and Hamid R. Arabnia

Deep Image Watermarking with Recover Module 57
Naixi Liu, Jingcai Liu, Xingxing Jia, and Daoshun Wang

Deep Learning for Plant Disease Detection 69
Matisse Ghesquiere and Mkhuseli Ngxande

A Deep Learning Framework for Blended Distortion Segmentation in Stitched Images 85
Hayat Ullah, Muhammad Irfan, Kyungjin Han, and Jong Weon Lee

Intraocular Pressure Detection Using CNN from Frontal Eye Images 93
Afrooz Rahmati, Mohammad Aloudat, Abdelshakour Abuzneid, and Miad Faezipour

Apple Leaf Disease Classification Using Superpixel and CNN 99
Manbae Kim

Part II Imaging Science – Detection, Recognition, and Tracking Methods

Similar Multi-Modal Image Detection in Multi-Source Dermatoscopic Images of Cancerous Pigmented Skin Lesions 109
Sarah Hadipour, Siamak Aram, and Roozbeh Sadeghian

Object Detection and Pose Estimation from RGB and Depth Data for Real-Time, Adaptive Robotic Grasping 121
Shuvo Kumar Paul, Muhammed Tawfiq Chowdhury, Mircea Nicolescu, Monica Nicolescu, and David Feil-Seifer

Axial Symmetry Detection Using AF8 Code 143
César Omar Jiménez-Ibarra, Hermilo Sánchez-Cruz, and Miguel Vázquez-Martin del Campo

Superpixel-Based Stereoscopic Video Saliency Detection Using Support Vector Regression Learning 159
Ting-Yu Chou and Jin-Jang Leou

Application of Image Processing Tools for Scene-Based Marine Debris Detection and Characterization 173
Mehrube Mehrubeoglu, Farha Pulukool, DeKwaan Wynn, Lifford McLauchlan, and Hua Zhang

Polyhedral Approximation for 3D Objects by Dominant Point Detection 189
Miguel Vázquez-Martin del Campo, Hermilo Sánchez-Cruz, César Omar Jiménez-Ibarra, and Mario Alberto Rodríguez-Díaz

Multi-Sensor Fusion Based Action Recognition in Ego-Centric Videos with Large Camera Motion 205
Radhakrishna Dasari, Karthik Dantu, and Chang Wen Chen

Part III Image Processing and Computer Vision – Novel Algorithms and Applications

Sensor Scheduling for Airborne Multi-target Tracking with Limited Sensor Resources 211
Simon Koch and Peter Stütz

Superpixel-Based Multi-focus Image Fusion 221
Kuan-Ni Lai and Jin-Jang Leou

Theoretical Applications of Magnetic Fields at Tremendously Low Frequency in Remote Sensing and Electronic Activity Classification 235
Christopher Duncan, Olga Gkountouna, and Ron Mahabir

Clustering Method for Isolate Dynamic Points in Image Sequences 249
Paula Niels Spinoza, Andriamasinoro Rahajaniaina, and Jean-Pierre Jessel

Computer-Aided Industrial Inspection of Vehicle Mirrors Using Computer Vision Technologies 263
Hong-Dar Lin and Hsu-Hung Cheng

Utilizing Quality Measures in Evaluating Image Encryption Methods 271
Abdelfatah A. Tamimi, Ayman M. Abdalla, and Mohammad M. Abdallah

Part IV Novel Medical Applications

Exergames for Systemic Sclerosis Rehabilitation: A Pilot Study 281
Federica Ferraro, Marco Trombini, Matteo Morando, Marica Doveri, Gerolamo Bianchi, and Silvana Dellepiane

Classification of Craniosynostosis Images by Vigilant Feature Extraction 293
Saloni Agarwal, Rami R. Hallac, Ovidiu Daescu, and Alex Kane

DRDr: Automatic Masking of Exudates and Microaneurysms Caused by Diabetic Retinopathy Using Mask R-CNN and Transfer Learning 307
Farzan Shenavarmasouleh and Hamid R. Arabnia

Postoperative Hip Fracture Rehabilitation Model 319
Akash Gupta, Adnan Al-Anbuky, and Peter McNair

ReSmart: Brain Training Games for Enhancing Cognitive Health 331
Raymond Jung, Bonggyn Son, Hyeseong Park, Sngon Kim, and Megawati Wijaya

ActiviX: Noninvasive Solution to Mental Health 339
Morgan Whittemore, Shawn Toubeau, Zach Griffin, and Leonidas Deligiannidis

Part V Health Informatics and Medical Systems – Utilization of Machine Learning and Data Science

Visualizing and Analyzing Polynomial Curve Fitting and Forecasting of Covid Trends 351
Pedro Furtado

Persuasive AI Voice-Assisted Technologies to Motivate and Encourage Physical Activity 363
Benjamin Schooley, Dilek Akgun, Prashant Duhoon, and Neset Hikmet

A Proactive Approach to Combating the Opioid Crisis Using Machine Learning Techniques 385
Ethel A. M. Mensah, Musarath J. Rahmathullah, Pooja Kumar, Roozbeh Sadeghian, and Siamak Aram

Security and Usability Considerations for an mHealth Application for Emergency Medical Services 399
Abdullah Murad, Benjamin Schooley, and Thomas Horan

Semantic Tree Driven Thyroid Ultrasound Report Generation by Voice Input 423
Lihao Liu, Mei Wang, Yijie Dong, Weiliang Zhao, Jian Yang, and Jianwen Su

Internet-of-Things Management of Hospital Beds for Bed-Rest Patients 439
Kyle Yeh, Chelsea Yeh, and Karin Li

Predicting Length of Stay for COPD Patients with Generalized Linear Models and Random Forests 449
Anna Romanova

Predicting Seizure-Like Activity Using Sensors from Smart Glasses 459
Sarah Hadipour, Ala Tokhmpash, Bahram Shafai, and Carey Rappaport

Epileptic iEEG Signal Classification Using Pre-trained Networks 465
Sarah Hadipour, Ala Tokhmpash, Bahram Shafai, and Carey Rappaport

Seizure Prediction and Heart Rate Oscillations Classification in Partial Epilepsy 473
Sarah Hadipour, Ala Tokhmpash, Bahram Shafai, and Carey Rappaport

A Comparative Study of Machine Learning Models for Tabular Data Through Challenge of Monitoring Parkinson's Disease Progression Using Voice Recordings 485
Mohammadreza Iman, Amy Giuntini, Hamid Reza Arabnia, and Khaled Rasheed

ICT and the Environment: Strategies to Tackle Environmental Challenges in Nigeria 497
Tochukwu Ikwunne and Lucy Hederman

Conceptual Design and Prototyping for a Primate Health History Knowledge Model 509
Martin Q. Zhao, ElizabethMaldonado, Terry B. Kensler, Luci A. P. Kohn, Debbie Guatelli-Steinberg, and Qian Wang

Implementation of a Medical Data Warehouse Framework to Support Decisions 521
Nedra Amara, Olfa Lamouchi, and Said Gattoufi

Personalization of Proposed Services in a Sensor-Based Remote Care Application 537
Mirvat Makssoud

A Cross-Blockchain Approach to Emergency Medical Information 549
Shirin Hasavari, Kofi Osei-Tutu, and Yeong-Tae Song

Robotic Process Automation-Based Glaucoma Screening System: A Framework 569
Somying Thainimit, Panaree Chaipayom, Duangrat Gansawat, and Hirohiko Kaneko

Introducing a Conceptual Framework for Architecting Healthcare 4.0 Systems 579
Aleksandar Novakovic, Adele H. Marshall, and Carolyn McGregor

A Machine Learning-Driven Approach to Predict the Outcome of Prostate Biopsy: Identifying Cancer, Clinically Significant Disease, and Unfavorable Pathological Features on Prostate Biopsy 591
John L. Pfail, Dara J. Lundon, Parita Ratnani, Vinayak Wagaskar, Peter Wiklund, and Ashutosh K. Tewari

Using Natural Language Processing to Optimize Engagement of Those with Behavioral Health Conditions that Worsen Chronic Medical Disease 601
Peter Bearse, Atif Farid Mohammad, Intisar Rizwan I. Haque, Susan Kuypers, and Rachel Fournier

Smart Healthcare Monitoring Apps with a Flavor of Systems Engineering 611
Misagh Faezipour and Miad Faezipour

Using Artificial Intelligence for Medical Condition Prediction and Decision-Making for COVID-19 Patients 617
Mohammad Pourhomayoun and Mahdi Shakibi

An Altmetric Study on Dental Informatics 625
Jessica Chen and Qiping Zhang

Part VI Bioinformatics & Computational Biology – Applications and Novel Frameworks

A Novel Method for the Inverse QSAR/QSPR to Monocyclic Chemical Compounds Based on Artificial Neural Networks and Integer Programming 641
Ren Ito, Naveed Ahmed Azam, Chenxi Wang, Aleksandar Shurbevski, Hiroshi Nagamochi, and Tatsuya Akutsu

Predicting Targets for Genome Editing with Long Short Term Memory Networks 657
Neha Bhagwat and Natalia Khuri

MinCNE: Identifying Conserved Noncoding Elements Using Min-Wise Hashing 671
Sairam Behera, Jitender S. Deogun, and Etsuko N. Moriyama

An Investigation in Optimal Encoding of Protein Primary Sequence for Structure Prediction by Artificial Neural Networks 685
Aaron Hein, Casey Cole, and Homayoun Valafar

Rotation-Invariant Palm ROI Extraction for Contactless Recognition 701
Dinh-Trung Vu, Thi-Van Nguyen, and Shi-Jinn Horng

Mathematical Modeling and Computer Simulations of Cancer Chemotherapy 717
Frank Nani and Mingxian Jin

Optimizing the Removal of Fluorescence and Shot Noise in Raman Spectra of Breast Tissue by ANFIS and Moving Averages Filter 731
Reinier Cabrera Cabañas, Francisco Javier Luna Rosas, Julio Cesar Martínez Romo, and Iván Castillo Zúñiga

Re-ranking of Computational Protein–Peptide Docking Solutions with Amino Acid Profiles of Rigid-Body Docking Results 749
Masahito Ohue

Structural Exploration of Rift Valley Fever Virus L Protein Domain in Implicit and Explicit Solvents by Molecular Dynamics 759
Gideon K. Gogovi

Common Motifs in KEGG Cancer Pathways 775
Bini Elsa Paul, Olaa Kasem, Haitao Zhao, and Zhong-Hui Duan

Phenome to Genome – Application of GWAS to Asthmatic Lung Biomarker Gene Variants 787
Adam Cankaya and Ravi Shankar

Cancer Gene Diagnosis of 84 Microarrays Using Rank of 100-Fold Cross-Validation 801
Shuichi Shinmura

A New Literature-Based Discovery (LBD) Application Using the PubMed Database 819
Matthew Schofield, Gabriela Hristescu, and Aurelian Radu

An Agile Pipeline for RNA-Seq Data Analysis 825
Scott Wolf, Dan Li, William Yang, Yifan Zhang, and Mary Qu Yang

Part VII Biomedical Engineering and Applications

Stage Classification of Neuropsychological Tests Based on Decision Fusion 833
Gonzalo Safont, Addisson Salazar, and Luis Vergara

An Investigation of Texture Features Based on Polyp Size for Computer-Aided Diagnosis of Colonic Polyps 847
Yeseul Choi, Alice Wei, David Wang, David Liang, Shu Zhang, and Marc Pomeroy

Electrocardiogram Classification Using Long Short-Term Memory Networks 855
Shijun Tang and Jenny Tang

Cancer Gene Diagnosis of 78 Microarrays Registered on GSE from 2007 to 2017 863
Shuichi Shinmura

Index 881

Part I
Imaging Science and Applications of Deep Learning and Convolutional Neural Network

Evolution of Convolutional Neural Networks for Lymphoma Classification

Christopher D. Walsh and Nicholas K. Taylor

1 Introduction

Lymphoma is a haematological disease that is the tenth most common cause of death in the United Kingdom, with an overall incidence rate of approximately 18.3 cases per 100,000 people [1, p.3]. There are several subgroups of the disease. The two most common are Hodgkin's Lymphoma, which has approximately four known subtypes and Non-Hodgkin's Lymphoma, which has many more. The World Health Organisation revised its report on the classification of Lymphomas in 2016. They currently recognise over 60 subtypes of Non-Hodgkin's Lymphoma [2, p.2376]. Treatment usually involves immunotherapy, chemotherapy or radiotherapy either individually or in combination. Over recent decades, the survival rate of Lymphoma patients has improved dramatically. This improvement has taken place due to a better scientific understanding of the biology of the disease that researchers are rapidly transforming into type-specific and individualised therapies [1, p.4].

However, lymphoma does not easily fit into the standards developed for diagnosing solid cancers and requires a different approach to diagnose and classify. Haematoxylin and Eosin (H&E) stained biopsies are the only starting point for the histological diagnosis of suspected lymphoma [2]. Because of the difficulty in diagnosis and typing of these biopsies, the National Institute for Health and Care Excellence (NICE) and the National Cancer Action Team (NCAT) have laid down strict parameters for the classification of a tissue sample. They specify that sample typing should only be carried out by specialists in haematopathology. They require that a team of these specialists are assembled to serve each geographical region and cross-validation performed to ensure an accurate diagnosis. NICE and NCAT also

C. D. Walsh (✉) · N. K. Taylor
School of Mathematical and Computer Sciences, Heriot-Watt University, Edinburgh, UK
e-mail: c.walsh.1@research.gla.ac.uk; N.K.Taylor@hw.ac.uk

© Springer Nature Switzerland AG 2021

H. R. Arabnia et al. (eds.), *Advances in Computer Vision and Computational Biology*, Transactions on Computational Science and Computational Intelligence,
https://doi.org/10.1007/978-3-030-71051-4_1

specify that no more than 62 days must elapse between the patient presenting with symptoms and the commencement of treatment. Per the standards set by the Royal College of Pathologists, this means that the classification of these biopsies can take no more than 10–14 days from the time the sample taken from the patient.

The original guidance specified that each specialist pathology team covered a region with a population of 500,000. In 2012 due to NHS restructuring, NCAT issued an update that increased the population covered by each group to two million [1, p.5]. Due to the specialist knowledge required, tight deadlines for classification and increasing pressure on the NHS, it is recognised that, at present, not every region can meet the guidelines. Fewer can offer specialist diagnostics for all diseases within the lymphoma spectrum. Therefore, an automated and reproducible methodology could help to meet these standards.

In recent years, artificial neural networks (ANNs) have met and in some cases surpassed human-level accuracy at image recognition tasks. Several new network architectures have emerged that brought about this revolution; in particular, Convolutional Neural Networks. This improvement in accuracy indicates that ANNs have become increasingly relevant for medical image classification. There have already been encouraging successes in diagnosing solid cancer biopsies which merited the investigation into the application of ANNs to Lymphoma diagnosis and inspired this work.

2 Related Work

2.1 Artificial Neural Networks in Medical Diagnosis

Recent developments in deep neural networks along with a general increase in available computing power have presented a significant opportunity for the development of automated medical diagnosis. The following is a brief review of some of the relevant material to this work.

We found no prior work that expressly set out to investigate the effectiveness of lymphoma classification based on histopathological diagnosis using ANNs optimised with evolutionary algorithms. One of the closest pieces of work was a paper titled “Bioimage Classification with Handcrafted and Learned Features” published in March 2018 by L. Nanni et al. [3]. The paper investigated the effectiveness of a general-purpose bioimage classification system. They used and compared several methods of classification, mainly support vector machines, a hybrid convolutional network and support vector machine and purely convolutional approach. The networks were pre-trained on prior image data and repurposed to biological image classification. It is particularly relevant as one of the datasets used to test the classifier is the same as in this work. This allowed us to compare the test accuracy of our work with a human pathologist and another system with a similar goal. L. Nanni et al. tested their bioimage classification system on image

data from source datasets ranging from 120 × 120 to 1600 × 1200 pixels. They pre-processed their data to reduce and standardise the dimensions to 128 × 128 pixels. The purely convolutional approach resulted in a validation accuracy of 71.20% on the lymphoma biopsy dataset [3, p.8].

Artificial Neural Networks have also been used in many other medical imaging tasks recently, one of the papers we reviewed was titled "Combining Convolutional Neural Network With Recursive Neural Network for Blood Cell Image Classification" by Liang et al. published in July 2018. Their work investigated the possibility of using recurrent neural networks to model the long-term dependence between key image features and classification. They combined a convolutional neural network and recurrent neural network to deepen the understanding of image content in sizeable medical image datasets. They pre-processed the data by rotating some of the images to increase the number of training instances. This approach achieved a validation accuracy of 90.79% [4, p.36194].

Another application of ANNs to medical diagnosis was "Applying Artificial Neural Networks to the Classification of Breast Cancer Using Infrared Thermographic Images" by Lessa et al. [5], published in 2016. They used multilayer feedforward networks with a FLIR thermal imaging camera to investigate the possibility of employing ANNs to identify breast cancer from the thermal data alone without using penetrating scans. Image masks were applied to the data to pick out specific regions of interest and remove unnecessary data and also converted the images to grey-scale. This approach achieved an 85% validation accuracy [5, p.1].

The success of Convolutional Networks in the reviewed work warranted further investigation into their application to Lymphoma classification, and to what extent Evolutionary Algorithms could optimise them for that task.

3 Approach

We aimed to test the feasibility of automatic classification of lymphomas using ANNs. Given the necessity for accuracy in classification, we also proposed to use Evolutionary Algorithms to optimise the Neural Networks. Therefore the research questions we sought to answer in this work were:

1. Can Artificial Neural Networks classify the subtype of a non-Hodgkin's lymphoma biopsy at a validation accuracy similar to experienced human pathologists?
2. Can Evolutionary Algorithms improve the network metrics of ANNs designed to classify non-Hodgkin's lymphoma?