

Lecture Notes in Networks and Systems 613

Sandeep Kumar · Harish Sharma ·  
K. Balachandran · Joong Hoon Kim ·  
Jagdish Chand Bansal *Editors*

# Third Congress on Intelligent Systems

Proceedings of CIS 2022, Volume 2

 Springer

# Lecture Notes in Networks and Systems

Volume 613

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*Editors*

Sandeep Kumar  
Department of Computer Science  
and Engineering  
CHRIST (Deemed to be University)  
Bengaluru, Karnataka, India

Harish Sharma  
Department of Computer Science  
and Engineering  
Rajasthan Technical University  
Kota, Rajasthan, India

K. Balachandran  
Department of Computer Science  
and Engineering  
CHRIST (Deemed to be University)  
Bengaluru, Karnataka, India

Joong Hoon Kim  
School of Civil, Environmental  
and Architectural Engineering  
Korea University  
Seoul, Korea (Republic of)

Jagdish Chand Bansal  
South Asian University  
New Delhi, Delhi, India

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# Preface

This book contains outstanding research papers as the proceedings of the 3rd Congress on Intelligent Systems (CIS 2022), held on September 05–06, 2022, at CHRIST (Deemed to be University), Bangalore, India, under the technical sponsorship of the Soft Computing Research Society, India. The conference is conceived as a platform for disseminating and exchanging ideas, concepts, and results of researchers from academia and industry to develop a comprehensive understanding of the challenges of the advancements of intelligence in computational viewpoints. This book will help in strengthening congenial networking between academia and industry. We have tried our best to enrich the quality of the CIS 2022 through the stringent and careful peer-review process. This book presents novel contributions to Intelligent Systems and serves as reference material for advanced research.

We have tried our best to enrich the quality of the CIS 2022 through a stringent and careful peer-review process. CIS 2022 received many technical contributed articles from distinguished participants from home and abroad. CIS 2022 received 729 research submissions from 45 different countries, viz., Algeria, Australia, Bangladesh, Belgium, Brazil, Bulgaria, Colombia, Cote d’Ivoire, Czechia, Egypt, Ethiopia, Fiji, Finland, Germany, Greece, India, Indonesia, Iran, Iraq, Ireland, Italy, Japan, Kenya, Latvia, Malaysia, Mexico, Morocco, Nigeria, Oman, Peru, Philippines, Poland, Romania, Russia, Saudi Arabia, Serbia, Slovakia, South Africa, Spain, Turkmenistan, Ukraine, United Kingdom, United States, Uzbekistan, and Vietnam. After a very stringent peer-reviewing process, only 120 high-quality papers were finally accepted for presentation and the final proceedings.

This book presents second volume of 60 research papers data science and applications and serves as reference material for advanced research.

Bengaluru, India

Kota, India

Bengaluru, India

Seoul, Korea (Republic of)

New Delhi, India

Sandeep Kumar

Harish Sharma

K. Balachandran

Joong Hoon Kim

Jagdish Chand Bansal

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# Editors and Contributors

## About the Editors

**Dr. Sandeep Kumar** is currently a professor at CHRIST (Deemed to be University), Bangalore. Before joining CHRIST, he worked with ACEIT Jaipur, Jagannath University, Jaipur, and Amity University, Rajasthan. He is an associate editor for Springer's *Human-centric Computing and Information Sciences (HCIS)* journal. He has published more than 80 research papers in various international journals/conferences and attended several national and international conferences and workshops. He has authored/edited six books in the area of computer science. Also, he has been serving as General Chair of the International Conference on Communication and Computational Technologies (ICCCT 2021, 2022, and 2023) and the Congress on Intelligent Systems (CIS 2022). His research interests include nature-inspired algorithms, swarm intelligence, soft computing, and computational intelligence.

**Dr. Harish Sharma** is an associate professor at Rajasthan Technical University, Kota, in the Computer Science and Engineering Department. He has worked at Vardhaman Mahaveer Open University, Kota, and Government Engineering College, Jhalawar. He received his B.Tech. and M.Tech. degrees in Computer Engineering from Government Engineering College, Kota, and Rajasthan Technical University, Kota, in 2003 and 2009, respectively. He obtained his Ph.D. from ABV—Indian Institute of Information Technology and Management Gwalior, India. He is a secretary and one of the founder members of the Soft Computing Research Society of India. He is a lifetime member of the Cryptology Research Society of India, ISI, Kolkata. He is an associate editor of *The International Journal of Swarm Intelligence (IJSI)* published by Inderscience. He has also edited special issues of the many reputed journals like *Memetic Computing Journal of Experimental and Theoretical Artificial Intelligence Evolutionary Intelligence* etc. His primary area of interest is nature-inspired optimization techniques. He has contributed to more than 105 papers published in various international journals and conferences.

**Dr. K. Balachandran** is currently a professor and head of CSE at CHRIST (Deemed to be University), Bengaluru, India. He has 38 years of experience in research, academia, and industry. He served as a senior scientific officer in the Research and Development Unit of the Department of Atomic Energy for 20 years. His research interest includes data mining, artificial neural networks, soft computing, and artificial intelligence. He has published more than 50 articles in well-known SCI-/SCOPUS-indexed international journals and conferences and attended several national and international conferences and workshops. He has authored/edited four books in the area of computer science.

**Prof. Joong Hoon Kim** a faculty of Korea University in the School of Civil, Environmental and Architectural Engineering, obtained his Ph.D. from the University of Texas at Austin in 1992 with the thesis “Optimal replacement/rehabilitation model for water distribution systems.” His major areas of interest include optimal design and management of water distribution systems, application of optimization techniques to various engineering problems, and development and application of evolutionary algorithms. His publication includes *A New Heuristic Optimization Algorithm: Harmony Search Simulation*, February 2001, Vol. 76, pp 60–68, which has been cited over 6,700 times by other journals of diverse research areas. His keynote speeches include “Optimization Algorithms as Tools for Hydrological Science” in the Annual Meeting of Asia Oceania Geosciences Society held in Brisbane, Australia, in June of 2013, *Recent Advances in Harmony Search Algorithm* in the 4th Global Congress on Intelligent Systems (GCIS 2013) held in Hong Kong, China, in December of 2013, and “Improving the convergence of Harmony Search Algorithm and its variants” in the 4th International Conference on Soft Computing For Problem Solving (SOCPROS 2014) held in Silchar India, in December of 2014. He hosted the 1st, 2nd, and 6th Conference of International Conference on Harmony Search Algorithm (ICHSA) in 2013, 2014, and 2022. He also hosted the 12th International Conference on Hydroinformatics (HIC 2016). Also, he has been serving as an Honorary Chair of Congress on Intelligent Systems (CIS 2020, 2021, and 2022).

**Dr. Jagdish Chand Bansal** is an associate professor at South Asian University, New Delhi, and visiting faculty at Maths and Computer Science, Liverpool Hope University, UK. He obtained his Ph.D. in Mathematics from IIT Roorkee. Before joining SAU, New Delhi, he worked as an assistant professor at ABV—Indian Institute of Information Technology and Management Gwalior and BITS Pilani. His primary area of interest is swarm intelligence and nature-inspired optimization techniques. Recently, he proposed a fission-fusion social structure-based optimization algorithm, spider monkey optimization (SMO), which is being applied to various problems from the engineering domain. He has published more than 70 research papers in various international journals/conferences. He is the editor-in-chief of the *journal MethodsX* published by Elsevier. He is the series editor of the book series *Algorithms for Intelligent Systems (AIS)* and *Studies in Autonomic, Data-Driven and Industrial Computing (SADIC)* published by Springer. He is the editor-in-chief of the *International Journal of Swarm Intelligence (IJSI)* published by Inderscience. He is also

the associate editor of *Engineering Applications of Artificial Intelligence (EAAI)* and *ARRAY* published by Elsevier. He is the general secretary of the Soft Computing Research Society (SCRS). He has also received gold medals at UG and PG levels.

## Contributors

**Devendra Agarwal** Artificial Intelligence Research Center, Department of CSE, School of Engineering, Babu Banarasi Das University, Lucknow, India

**Neha Ahlawat** Department of Computer Science and Engineering, Faculty of Engineering and Technology, SRM Institute of Science and Technology, Modinagar, Ghaziabad, UP, India

**A. Alfred Kirubaraj** Karunya Institute of Technology and Sciences, Coimbatore, Tamil Nadu, India

**P. R. Ancy** Computer Science and Engineering Department, School of Engineering and Technology, CHRIST (Deemed to be University), Bangalore, India

**Milos Antonijevic** Singidunum University, Belgrade, Serbia

**José E. C. Arroyo** Department of Computer Science, Universidade Federal de Viçosa, Viçosa, MG, Brazil

**Cyril Joe Baby** Fupro Innovation Private Limited, Mohali, India

**Cysil Tom Baby** CHRIST (Deemed to be University), Bangalore, India

**Nebojsa Bacanin** Singidunum University, Belgrade, Serbia

**Indu Bala** The University of Adelaide, Adelaide, SA, Australia

**A. Balasubramanian** Department of Automobile Engineering, Sri Venkateswara College of Engineering, Sriperumbudur, India

**Kirti Beniwal** Department of Applied Mathematics, Delhi Technological University, Delhi, India

**Ahmed Benjelloun** National School of Business and Management, University Mohammed Ben Abdellah, Fez, Morocco

**Dip Bhakta** Bangladesh University of Professionals (BUP), Dhaka, Bangladesh

**Devershi Pallavi Bhatt** Manipal University Jaipur, Jaipur, Rajasthan, India

**Lokita Bhoge** MKSSS's Cummins College of Engineering for Women, Pune, India

**Kisalaya Chakrabarti** Haldia Institute of Technology, Haldia, India

**P. S. R. Charan** Department of ECE, Vishnu Institute of Technology, Bhimavaram, India

**Indranath Chatterjee** Department of Computing and Data Science, FLAME University, Pune, India

**Rajdeep Chauhan** Department of CSE, BNMIT, Bengaluru, Karnataka, India

**Nupur Choudhury** Guwahati University, Guwahati, Assam, India

**Matheus de Freitas** Department of Computer Science, Universidade Federal de Viçosa, Viçosa, MG, Brazil

**Binet Rose Devassy** Department of Electronics and Communication Engineering, Sahrdaya College of Engineering and Technology, Kodakara, India

**Dipankar Dutta** University Institute of Technology, The University of Burdwan, Burdwan, West Bengal, India

**Roxana Flores-Quispe** School of Computer Science, Universidad Nacional de San Agustín de Arequipa, Arequipa, Peru

**D. Franklin Vinod** Department of Computer Science and Engineering, Faculty of Engineering and Technology, SRM Institute of Science and Technology, Modinagar, Ghaziabad, UP, India

**Gabriel P. Félix** Department of Computer Science, Universidade Federal de Viçosa, Viçosa, MG, Brazil

**P. C. Gagan Machaiah** ECE Department, Dayananda Sagar College of Engineering, Bangalore, Karnataka, India

**Pranshav Gajjar** Institute of Technology, Nirma University, Gujarat, India; Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University, Kyoto, Japan

**R. Gandhiraj** Department of Electronics and Communication Engineering, Amrita School of Engineering, Amrita Vishwa Vidyapeetham, Coimbatore, India

**Debasish Ghose** Indian Institute of Science, Bangalore, India

**Dibyendu Ghosh** Indian Institute of Technology, Kharagpur, Kharagpur, India

**Radhakrishnan Gopalapillai** Department of Computer Science and Engineering, CMR Institute of Technology, Bengaluru, India

**Dewang Goplani** Department of CSE, BNMIT, Bengaluru, Karnataka, India

**P. Jai Govind** CHRIST (Deemed to be University), Bangalore, India

**Ankit Gupta** Intel Labs, Intel Technology, Bangalore, India

**Bhavana Gupta** SOIT, RGPV Bhopal, Bhopal, India

**Zlatko Hajdarevic** Singidunum University, Belgrade, Serbia

**H. Hannah Inbarani** Department of Computer Science, Periyar University, Salem, India



**Banushruti Haveri** ECE Department, Dayananda Sagar College of Engineering, Bangalore, Karnataka, India

**Hendry** Faculty of Information Technology, Satya Wacana Christian University, Salatiga, Central Java, Indonesia

**Jaciel David Hernandez-Resendiz** Multidisciplinary Academic Unit Reynosa-Rodhe, Autonomous University of Tamaulipas, Reynosa, Mexico

**Vladimir Hlavac** Faculty of Mechanical Engineering, Czech Technical University in Prague, Prague, Czech Republic

**Vinayak Honkote** Intel Labs, Intel Technology, Bangalore, India

**Bayzid Ashik Hossain** Charles Sturt University, Bathurst, Australia

**Archana Ingle** TSEC, University of Mumbai, Mumbai, India

**Md. Adnanul Islam** Monash University, Melbourne, Australia

**Y. Jani** Department of Computer Science, Muslim Arts College (Affiliated to Manonmaniam Sundaranar University, Abishekapatti, Tirunelveli-627012), Thiruvithancode, Tamil Nadu, India

**Hothefa Shaker Jassim** Modern College of Business and Science, Muscat, Oman

**R. Prarthna Grace Jemima** Loyola-ICAM College of Engineering and Technology, Chennai, India

**Binita Jiby** MKSSS's Cummins College of Engineering for Women, Pune, India

**Deepa V. Jose** CHRIST (Deemed to be University), Bangalore, India

**Daniel Bennett Joseph** Department of Automobile Engineering, Sri Venkateswara College of Engineering, Sriperumbudur, India

**Jeffin Joseph** Karunya Institute of Technology and Sciences, Coimbatore, Tamil Nadu, India

**Dijana Jovanovic** College of Academic Studies "Dositej", Belgrade, Serbia

**Luka Jovanovic** Singidunum University, Belgrade, Serbia

**Saad Kabak** National School of Business and Management, University Mohammed Ben Abdellah, Fez, Morocco

**Srirangan Kannan** Department of Computer Science and Engineering, Sri Venkateswara College of Engineering, Sriperumbudur, India

**Shashi Kant** Artificial Intelligence Research Center, Department of CSE, School of Engineering, Babu Banarasi Das University, Lucknow, India

**Sanjeet Kanungo** Tolani Maritime Institute, Induri, Maharashtra, India

**S. Karthikeyan** Department of Computer Science, Institute of Science, Banaras Hindu University, Varanasi, India

**Amritpal Kaur** Manipal University Jaipur, Jaipur, Rajasthan, India

**Gnana King** Department of Electronics and Communication Engineering, Sahrdaya College of Engineering and Technology, Kodakara, India

**B. N. S. S. Kiranmai** Symbiosis Institute of Business Management, A Constituent of Symbiosis International (Deemed) University, Bengaluru, India

**Addapalli V. N. Krishna** Computer Science and Engineering Department, School of Engineering and Technology, CHRIST (Deemed to be University), Bangalore, India

**Vyom Kulshreshtha** Computer Science and Engineering, Amity University Madhya Pradesh, Gwalior, India

**Deepak Kumar** University Institute of Technology, The University of Burdwan, Burdwan, West Bengal, India

**Naveen Kumar** CHRIST (Deemed to be University), Bangalore, India

**Prince Kumar** University Institute of Technology, The University of Burdwan, Burdwan, West Bengal, India

**Vivek Kumar** Department of Applied Mathematics, Delhi Technological University, Delhi, India

**Ashish Kumar Lal** Department of Computer Science, Institute of Science, Banaras Hindu University, Varanasi, India

**Madhusudan G. Lanjewar** School of Physical and Applied Sciences, Goa University, Taleigao, Goa, India

**Ann Mariya Lazar** Department of Electronics and Communication Engineering, Sahrdaya College of Engineering and Technology, Kodakara, India

**Yanghepu Li** Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University, Kyoto, Japan

**Bárbara A. Macías-Hernández** Faculty of Engineering and Science, Autonomous University of Tamaulipas, Victoria, Mexico

**Eleni G. Makri** Unicaf, Larnaca, Cyprus

**S. H. Malave** Lokmanya Tilak College of Engineering, Navi Mumbai, India

**Daniel H. F. Manongga** Faculty of Information Technology, Satya Wacana Christian University, Salatiga, Central Java, Indonesia

**M. Meena** Department of Electronics and Communication Engineering, Vels Institute of Science, Technology and Advanced Studies (VISTAS), Chennai, India

**Merin Meleet** R V College of Engineering, Bengaluru, Karnataka, India

**Nishchol Mishra** SOIT, RGPV Bhopal, Bhopal, India

**Tanya Mital** Department of CSE, BNMIT, Bengaluru, Karnataka, India

**W. Mohammed Abdul Razak** R V College of Engineering, Bengaluru, Karnataka, India

**H. S. Mohana** Navkis College of Engineering, Hassan, Karnataka, India

**Rashmi Mothkur** Department of CSE, Dayananda Sagar University, Bangalore, India

**Deepak Motwani** Computer Science and Engineering, Amity University Madhya Pradesh, Gwalior, India

**James Mountstephens** Faculty of Computing and Informatics, Universiti Malaysia Sabah, Kota Kinabalu, Sabah, Malaysia

**Debarka Mukhopadhyay** Christ (Deemed to be University), Bengaluru, India

**Md. Saddam Hossain Mukta** United International University (UIU), Dhaka, Bangladesh

**Najmusseher** Department of Computer Science, CHRIST (Deemed to be University), Bengaluru, India

**K. Natarajan** CHRIST (Deemed to Be University), Bangalore, India

**S. Nivetha** Department of Computer Science, Periyar University, Salem, India

**Parita Oza** Pandit Deendayal Energy University, Gandhinagar, India;  
Nirma University, Ahmedabad, India

**Manoj Kumar Panda** Department of Electronics and Communication Engineering, Amrita School of Engineering, Amrita Vishwa Vidyapeetham, Bengaluru, India

**George A. Papakostas** MLV Research Group, Department of Computer Science, International Hellenic University, Kavala, Greece

**Jivan S. Parab** School of Physical and Applied Sciences, Goa University, Taleigao, Goa, India

**Rajesh K. Parate** Department of Electronics, S. K. Porwal College, Kamptee, Maharashtra, India

**Samir Patel** Pandit Deendayal Energy University, Gandhinagar, India

**A. M. V. Pathi** Department of ECE, Vishnu Institute of Technology, Bhimavaram, India

**Deepak Patkar** Nanavati Hospital, Mumbai, India

- Bikram Paul** Indian Institute of Technology Guwahati, Guwahati, Assam, India
- G. Pavithra** ECE Department, Dayananda Sagar College of Engineering, Bangalore, Karnataka, India
- Prithika Pembarti** MKSSS's Cummins College of Engineering for Women, Pune, India
- Sakshi Phadatare** MKSSS's Cummins College of Engineering for Women, Pune, India
- C. L. Pooja** Bangalore Institute of Technology, Bengaluru, India
- Shreekanth M. Prabhu** Department of Computer Science and Engineering, CMR Institute of Technology, Bengaluru, India
- V. Praveena** Department of ECE, Vishnu Institute of Technology, Bhimavaram, India
- Mathieson Tan Zui Quen** Faculty of Computing and Informatics, Universiti Malaysia Sabah, Kota Kinabalu, Sabah, Malaysia
- P. Raajan** Department of Computer Science, Muslim Arts College (Affiliated to Manonmaniam Sundaranar University, Abishekapatti, Tirunelveli-627012), Thiruvithancode, Tamil Nadu, India
- Linesh Raja** Manipal University Jaipur, Jaipur, Rajasthan, India
- Dipali Ramdasi** MKSSS's Cummins College of Engineering for Women, Pune, India
- Ulises Manuel Ramirez-Alcocer** Multidisciplinary Academic Unit Reynosa-Rodhe, Autonomous University of Tamaulipas, Reynosa, Mexico
- Jino S. R. Ramson** Saveetha School of Engineering, Thandalam, Chennai, Tamil Nadu, India
- Md. Sohel Rana** University of Alabama at Birmingham (UAB), Birmingham, USA
- P. Vanaja Ranjan** Embedded System Technologies, Department of Electrical and Electronics Engineering, College of Engineering - Guindy, Chennai, India
- Rakesh Ranjan** University Institute of Technology, The University of Burdwan, Burdwan, West Bengal, India
- Geetanjali Rathee** CSE Department, NSUT, New Delhi, India
- J. Reena** Loyola-ICAM College of Engineering and Technology, Chennai, India
- R. Rishabh** R V College of Engineering, Bengaluru, Karnataka, India
- Mani Roja** TSEC, University of Mumbai, Mumbai, India
- O. P. Roy** Department of Electrical Engineering, NERIST, Nirjuli, Arunachal Pradesh, India

**Sourabh Prakash Roy** Department of Electrical Engineering, NERIST, Nirjuli, Arunachal Pradesh, India

**Eeshankur Saikia** Guwahati University, Guwahati, Assam, India

**Shailesh S. Sangle** Thadomal Shahani Engineering College, Mumbai, India

**Manoj Sankhe** MPSTME, NMIMS Mumbai, Mumbai, India

**Ch. V. V. Santhosh Kumar** Department of ECE, Vishnu Institute of Technology, Bhimavaram, India

**Barka Satya** Faculty of Information Technology, Satya Wacana Christian University, Salatiga, Central Java, Indonesia;  
Faculty of Computer Science, Universitas Amikom, Yogyakarta, Indonesia

**Raghavendra R. Sedamkar** Computer Engineering Department, Thakur College of Engineering and Technology, Mumbai, India

**M. Sekar** Indian Maritime University, Chennai, Tamil Nadu, India

**Sheba Selvam** Department of CSE, BNMIT, Bengaluru, Karnataka, India

**S. Senith** Karunya Institute of Technology and Sciences, Coimbatore, Tamil Nadu, India

**Monikka Reshmi Sethurajan** CHRIST (Deemed to Be University), Bangalore, India

**B. N. Shankar Gowda** Bangalore Institute of Technology, Bengaluru, India

**Jaya Sharma** Department of Computer Science and Engineering, Faculty of Engineering and Technology, Delhi-NCR Campus, SRM Institute of Science and Technology, NCR Campus, Modinagar, Ghaziabad, UP, India

**Paawan Sharma** Pandit Deendayal Energy University, Gandhinagar, India

**Pankaj Sharma** Computer Science and Engineering, Eshan College of Engineering, Mathura, India

**Paras Sharma** Indraprastha Institute of Information Technology, Delhi, India

**K. Shashi Raj** ECE Department, Dayananda Sagar College of Engineering, Bangalore, Karnataka, India

**S. K. Shinde** Lokmanya Tilak College of Engineering, Navi Mumbai, India

**P. Shreedevi** Malnad College of Engineering, Hassan, Karnataka, India

**Shubham** Department of Electrical Engineering, NERIST, Nirjuli, Arunachal Pradesh, India

**Praveen Kumar Shukla** Artificial Intelligence Research Center, Department of CSE, School of Engineering, Babu Banarasi Das University, Lucknow, India

**V. A. Siddeshwar** Department of Computer Science and Engineering, Sri Venkateswara College of Engineering, Sriperumbudur, India

**Poulami Singha** University Institute of Technology, The University of Burdwan, Burdwan, West Bengal, India

**A. K. Singh** Department of Electrical Engineering, NERIST, Nirjuli, Arunachal Pradesh, India

**Aparna Singh** CSE Department, NSUT, New Delhi, India

**K. Sivasankaran** Department of Automobile Engineering, Sri Venkateswara College of Engineering, Sriperumbudur, India

**J. Snegha** Loyola-ICAM College of Engineering and Technology, Chennai, India

**Ivana Strumberger** Singidunum University, Belgrade, Serbia

**S. Swathi** Department of ECE, Vishnu Institute of Technology, Bhimavaram, India; Department of ECE, SRKR Engineering College, Bhimavaram, India

**V. Tanisha** Department of CSE, BNMIT, Bengaluru, Karnataka, India

**Suparba Tapna** Durgapur Institute of Advanced Technology and Management, Durgapur, India

**S. Tarun Kumar** Indian Maritime University, Chennai, Tamil Nadu, India

**Edgar Tello-Leal** Faculty of Engineering and Science, Autonomous University of Tamaulipas, Victoria, Mexico

**Viswanathan Thangaraj** Symbiosis Institute of Business Management, A Constituent of Symbiosis International (Deemed) University, Bengaluru, India

**Ethiraj Thipakaran** Department of Electronics and Communication Engineering, Amrita School of Engineering, Amrita Vishwa Vidyapeetham, Coimbatore, India

**Priya Thomas** CHRIST (Deemed to be University), Bangalore, India

**Gaurav Trivedi** Indian Institute of Technology Guwahati, Guwahati, Assam, India

**Stefanos Tsimenidis** MLV Research Group, Department of Computer Science, International Hellenic University, Kavala, Greece

**M. Umme Salma** Department of Computer Science, CHRIST (Deemed to be University), Bengaluru, India

**Jayaraman Valadi** Department of Computing and Data Science, FLAME University, Pune, India

**P. G. Varna Kumar Reddy** Department of Electronics and Communication Engineering, Vels Institute of Science, Technology and Advanced Studies (VISTAS), Chennai, India

**B. N. Veerappa** Department of Studies in CSE, University BDT College of Engineering, Davanagere, India

**Yuber Velazco-Paredes** School of Computer Science, Universidad Nacional de San Agustín de Arequipa, Arequipa, Peru

**P. R. Venkat** Department of Computer Science and Engineering, Sri Venkateswara College of Engineering, Sriperumbudur, India

**Ch. Venkateswara Rao** Department of ECE, Vishnu Institute of Technology, Bhimavaram, India

**R. Vidhya** Department of Electronics and Communication Engineering, Loyola-ICAM College of Engineering and Technology, Chennai, India

**R. Vignesh** Loyola-ICAM College of Engineering and Technology, Chennai, India

**D. Franklin Vinod** Department of Computer Science and Engineering, Faculty of Engineering and Technology, Delhi-NCR Campus, SRM Institute of Science and Technology, NCR Campus, Modinagar, Ghaziabad, UP, India

**D. Vinodha** Department of Computer Science and Engineering, Sri Venkateswara College of Engineering, Sriperumbudur, India

**Rupesh Wakodikar** Department of Electronics, Nevjabai Hitkarini College, Bramhapuri, Maharashtra, India

**Anupam Yadav** Dr BR Ambedkar National Institute of Technology, Jalandhar, Punjab, India

**Mohammad Abu Yousuf** Jahangirnagar University, Dhaka, Bangladesh

**Akib Zaman** United International University (UIU), Dhaka, Bangladesh

**Liang Zhao** Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University, Kyoto, Japan

**Miodrag Zivkovic** Singidunum University, Belgrade, Serbia

**Zhenyu Zuo** Graduate School of Advanced Integrated Studies in Human Survivability, Kyoto University, Kyoto, Japan

# Patch Extraction and Classifier for Abnormality Classification in Mammography Imaging



Parita Oza, Paawan Sharma, and Samir Patel

**Abstract** Breast cancer is a fatal disease that affects millions of women worldwide. The number of cases of breast cancer has risen over time. Although it is difficult to prevent this disease, the survival rate can be improved with early detection and proper treatment planning of the disease. Thanks to breakthroughs in deep learning, the progress of computer-assisted diagnosis (CAD) of breast cancer has seen a lot of improvement. Deep neural networks have advanced to the point where their diagnostic capabilities are approaching those of a human specialist. Mammograms are crucial radiological images used to detect breast cancer at its early stage. Mammogram image scaling at the input layer is required for training deep convolutional neural networks (DCNNs) directly on high-resolution images. This could result in the loss of crucial information for discovering medical abnormalities. Instead of developing an image classifier, the idea is to create a patch classifier. The technique for extracting abnormal patches from mammography images is proposed in this research. Patches are extracted from a benchmark and publicly available MIAS dataset. These patches are then used to train deep learning classifiers such as VGG-16, ResNet-50, and EfficientNet-B7. With the patches already included in the CBIS-DDSM dataset, we contrast the results of the MIAS patches. EfficientNet-B7 on CBIS-DDSM patches produced good results (92% accuracy) when compared to other classifiers such as VGG-16 and ResNet-50. We also discovered that ResNet-50 is demonstrated to be quite robust on both datasets.

**Keywords** Mammogram · Deep learning · Patch extraction · Classification

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P. Oza (✉) · P. Sharma · S. Patel  
Pandit Deendayal Energy University, Gandhinagar, India  
e-mail: [parita.ophd@sot.pdpu.ac.in](mailto:parita.ophd@sot.pdpu.ac.in); [parita.prajapati@nirmauni.ac.in](mailto:parita.prajapati@nirmauni.ac.in)

P. Sharma  
e-mail: [Paawan.Sharma@sot.pdpu.ac.in](mailto:Paawan.Sharma@sot.pdpu.ac.in)

S. Patel  
e-mail: [Samir.Patel@sot.pdpu.ac.in](mailto:Samir.Patel@sot.pdpu.ac.in)

P. Oza  
Nirma University, Ahmedabad, India



## 1 Background

Breast cancer is one of the most common abnormal neoplasms in the female population. Mammography is a referral examination for breast cancer screening [1]. Furthermore, it has been established that the breast cancer survival rate is highly influenced by the stage at which the disease is detected [2]. Computer-aided diagnostic (CAD) systems are being developed for automated breast cancer diagnosis. This approach improves finding accuracy and the capacity to recognize irregularities such as breast mass, calcification, focal distortion, asymmetries. Only professional doctors make final decisions; thus, CAD systems can operate as a second reader designed to aid a radiologist.

DCNNs are extensively utilized for cancer detection, classification, and segmentation in medical imaging. Unfortunately, training a network from scratch can take days or weeks and requires a significant amount of computing power [3]. In addition, to avoid overfitting the training dataset, the training procedure for supervised deep CNNs typically necessitates a high number of annotated samples. The most common method for dealing with this issue is transfer learning (TL). The goal is to fine-tune a model that has been pre-trained [4]. In most cases, TL-based convolutional neural networks (CNNs) are utilized to categorize the entire image. Instead, in patch-based classification, we categorize individual patches of an image belonging to a given class before categorizing the whole image based on the patches' categorization. For training DCNNs directly on high-resolution images, image scaling at the input layer is necessary. This might lead to the loss of vital information to detection medical anomalies. Patch-based classification seeks to answer the following question: "What are the prominent traits of a specific patch that indicate that it belongs to one of two classes?". Furthermore, image scarcity is a prevalent problem in medical imaging studies. As a result, making several patches from a single image might significantly expand the training set.

We present a method for extracting patches from mammograms in this paper. For patch extraction, we used the MIAS [5] dataset. We created a patch-based classifier that uses DCNNs to classify breast mammography images into benign and malignant categories. We employed transfer learning with pre-trained models like VGG-16 [6], ResNet-50 [7], and EfficientNet-B7 [8] to classify patches. We utilized CBIS-DDSM [9] mammography patches as a comparison.

The rest of the paper is organized as follows: Sect. 2 presents the literature of the domain. Then, the proposed methodology is showcased in Sect. 3. We discussed the results in Sect. 4. We finally end with the conclusion in Sect. 5.

## 2 Related Work in the Domain

The fields of AI such as machine learning and deep learning have made potential advancements in biotechnology and medical research domain [10]. Despite the fact

that several authors have proposed using traditional machine learning and computer vision techniques to classify breast abnormalities [11], due to the scarcity of publicly available datasets, the use of deep learning approaches has been limited in the field of breast imaging [12–14]. Due to privacy and regulatory concerns, having significant and correctly annotated picture data is the most frequent problem in the medical research arena [15–17]. In the majority of situations, this issue also results in an overfitting scenario. The majority of the time, convolutional neural networks (CNNs) based on transfer learning are used to classify the entire image. To fit the model input size, we must resize the picture when utilizing the transfer learning approach for the whole mammography. The loss of certain significant picture information during image scaling is undesirable for medical image analysis. This issue may be resolved, and the model performance can be enhanced, by extracting accurate ROI patches similar to model's input size from whole mammograms and utilizing them for training. While including additional patch samples in the training set, the accuracy of transfer learning technique may also be improved.

A patch-based method is proposed by authors of [2] to detect and segment micro-calcifications from mammograms. This model comprises two convolutional neural network-based blocks: the detector and the segmentation. The model might be particularly beneficial in the screening situation, where the high number of exams may cause the reader's attention to be diverted to support diagnosis or restrict the differential diagnosis. Another study [1] proposes a patch-based CNN approach for breast mass detection in full-field digital mammograms (FFDM). Authors look into using transfer learning to adapt to a specific area. Transfer learning is an effective way of transferring knowledge from one visual domain to another. The majority of current research is now based on this concept. Issues like ignorance of semantic characteristics, analysis limitations to the present patch of pictures, missing patches in low-contrast mammography images, and segmentation ambiguity are addressed in [18]. An ensemble learning strategy is presented in the work employing machine learning techniques like random forest and boosting to improve the classification performance of breast mass systems while reducing variance and generalization error. To categorize breast cancer images, [19] proposed a CNN model which can do feature extraction, feature reduction, and classification. The model can classify breast cancer images into three categories: malignant, normal, and benign. A recent survey [20] provided the study of publicly available mammographic datasets and dataset-based quantitative comparison of the most modern approaches. Authors of [21] presented an end-to-end model to identify and classify masses inside the whole mammographic image. They expanded on that work by categorizing local image patches using a pre-trained model on a labeled dataset that offers ROI data. ResNet-50 and VGG-16 are used as a pre-trained models in this work. For mammogram classification, a CNN-based patch classifier is proposed in [22]. A curriculum learning technique was applied in the study to attain high levels of accuracy in classifying mammograms. Authors of [23] examined several classification strategies for mammogram classification, divided into four categories based on function, probability, rule, and similarity. Furthermore, the research concentrated on various issues relating to mammography datasets and classification algorithms. Patch-based classifiers

are also used for other imaging modalities such as breast histopathology imaging. For the automatic categorization of histological breast image, authors of [24] suggested a patch-based classifier utilizing convolutional neural network (CNN). One patch in one decision and all patches in one decision are two operating modes used in the proposed classification system. Additionally, on the concealed test dataset of histopathology images, authors achieved an accuracy of 87%.

### 3 Methodology

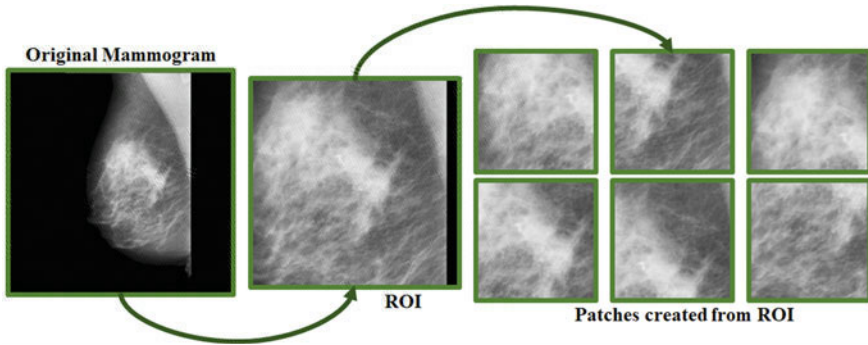
#### 3.1 Dataset

MIAS: MIAS [5] is an ancient and benchmark mammography dataset with 322 images divided into three categories: standard, benign, and malignant. The images in the datasets are all  $1024 \times 1024$  pixels in size. The  $(x, y)$  image coordinates of the anomaly's center and the estimated radius (in pixels) of a circle encompassing the abnormality are supplied as ground truth.

CBIS-DDSM: CBIS-DDSM [9] is a standardized and upgraded version of DDSM mammography [25]. The dataset contains roughly 10,000 images of various abnormalities, including normal, benign, and malignant conditions. The dataset is separated into training and testing sets to compare and contrast different methodologies. Due to a lack of memory during training, we picked 6700 images for our work.

#### 3.2 Patch Extraction

We adopted a patch-based technique to analyze the input mammograms, anticipating that local information would be adequate to categorize such tiny and limited areas. Furthermore, a patch-based method allowed us to significantly expand the training set and do a proper data augmentation simply. The dataset we utilized is supplied with information on the abnormality's approximate radius and center. The region of interest was initially extracted using these parameters, and several patches containing benign or malignant information were then extracted. First, we extracted squared patches with  $N \times N$  dimension and took their annotated labels from the corresponding mammograms. Next, we slide the patch mask over the mammogram with uniform step size and took only those region of interest (ROI) with a certain number of suspicious pixels (see Fig. 1). Then, we used a sliding window algorithm to create multiple patches from the extracted region of interest. We are able to feed models with varied inputs since every patch that is ultimately chosen has a unique visual detail. Algorithm 1 presents the entire process for extracting patches from mammograms.



**Fig. 1** Mammogram with ROI and extracted patches

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**Algorithm 1** Patch extraction from mammograms

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**Require:** Mammogram Images, Annotation file

**Ensure:** Extracted ROI from abnormal mammograms

Data: MIAS mammogram datasets

Initialization: Patch size, width, height,  $(X, Y)$  coordinates of abnormalities,  $R$  (Approximate center of coordinates), cropped ROI

**for** each image detail in annotation file **do** Do

    Read images from Benign and Malignant Folders

    Read width and height of image

    Find new  $(x, y)$  coordinates pairs to generate cropped ROI

$x1 = X + R - \text{Patch Size}$

**if**  $x1 > 0$  **then**  $x1 = x1$  **else**  $x1 = 0$

$y1 = Y + R - \text{Patch Size}$

**if**  $y1 > 0$  **then**  $y1 = y1$  **else**  $y1 = 0$

$x2 = X - R + \text{Patch Size}$

**if**  $x2 \leq \text{width}$  **then**  $x2 = x2$  **else**  $x2 = \text{width}$

$y2 = Y - R + \text{Patch Size}$

**if**  $y2 \leq \text{height}$  **then**  $y2 = y2$  **else**  $y2 = \text{height}$

    ROI = im.crop( $x1, y1, x2, y2$ )

**end for**

    Use sliding window algorithm to create multiple patches from the extracted region of interests

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### 3.3 Transfer Learning (TL)

We adopt transfer learning to develop a patch classifier. We used three pre-trained DCNN models; VGG-16, ResNet-50, and EfficientNet-B7. As shown in Fig. 2, we employed a recent implementation of deep neural networks that features TL to start a new model with specified modifications utilizing parameters from a pre-trained model for a specific purpose. We began by building a foundation model and populating it with weights that had already been trained. The underlying model's layers are then locked. The output of one (or multiple) layer from the base model is then used to build a new model on top of it. Finally, the new model is trained using MIAS and CBIS-DDSM patches, and the results are compared either.

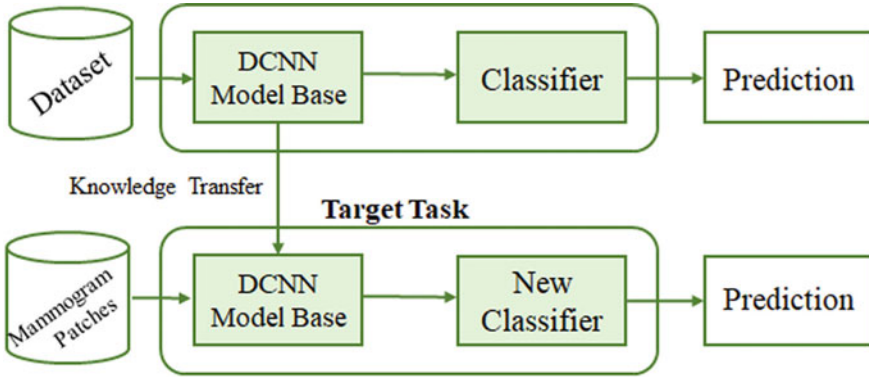


Fig. 2 Patch classifier using transfer learning

### 4 Result Analysis and Discussion

We split the dataset into train and test random splits using the ratio of 70:30. The experiments were run for 100 epochs with a batch size of 128. We considered accuracy and loss as performance parameters for our models. Figures 3 and 4 depict the training and validation performance of all the models, respectively. The graphs show that, in comparison to CBIS patches, none of the three models could perform well with MIAS patches. We also found that the performance of EfficientNet-B7 on CBIS-DDSM

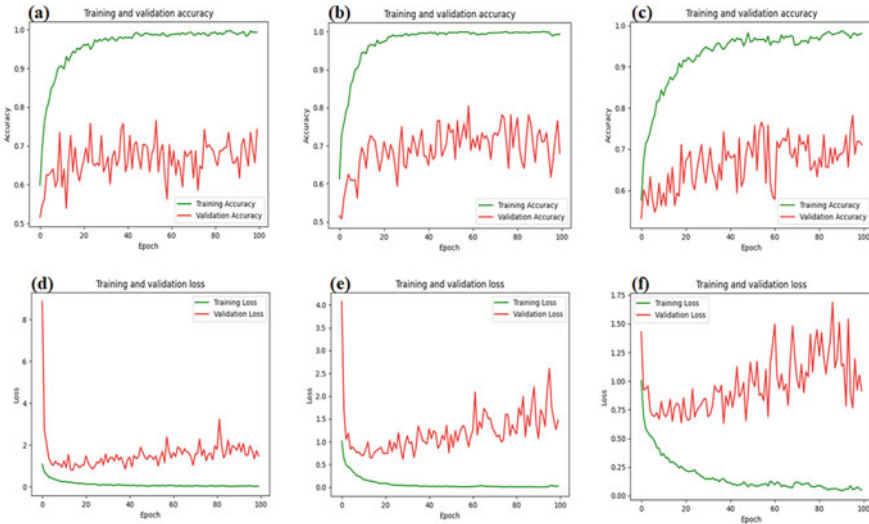
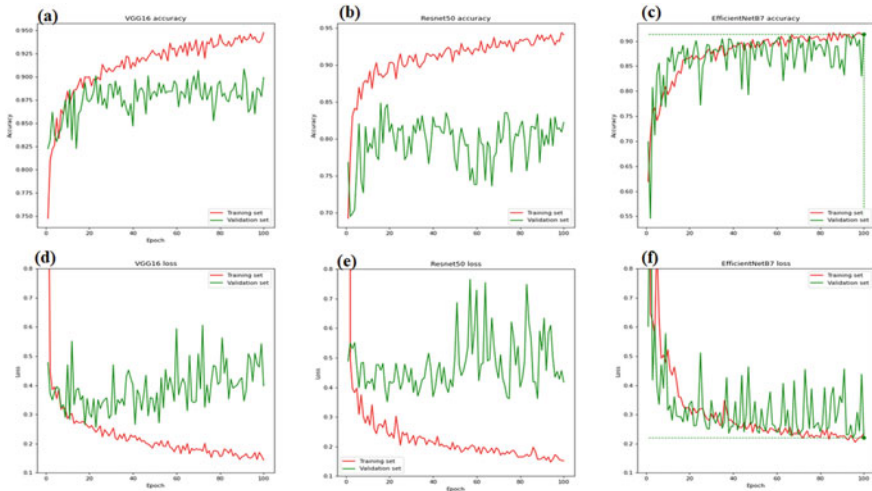


Fig. 3 Model performance on MIAS patches. a, d Accuracy and loss of VGG-16. b, e Accuracy and loss of ResNet-50. c, f Accuracy and loss of EfficientNet-B7



**Fig. 4** Model performance on CBIS-DDSM patches. **a, d** Accuracy and loss of VGG-16. **b, e** Accuracy and loss of ResNet-50. **c, f** Accuracy and loss of EfficientNet-B7

patches is quite good compared to other models used in this study. The models were built up to have the best accuracy and loss. To keep track of the validation loss, early stopping was used. As a result, EfficientNet-B7 has the best accuracy and loss at almost the final epoch on CBIS-DDSM patches (see Fig. 4c, f). Still, the model is suffering from a very classic problem of oscillation, which can be handled by controlling the value of the learning rate. We solely gave further performance characteristics for all the models on CBIS-DDSM and MIAS patches (see Tables 1 and 2). When compared to MIAS patches, the comparison reveals that all models performed better on CBIS-DDSM patches.

**Table 1** Performance measures of various models on CBIS-DDSM patches

	Sensitivity	Specificity	Precision	Recall	Test accuracy	Test loss
VGG-16	0.86	0.89	0.88	0.86	0.88	0.44
ResNet-50	0.69	0.93	0.90	0.69	0.82	0.44
EfficientNet-B7	0.90	0.92	0.91	0.90	0.91	0.38

**Table 2** Performance measures of various models on MIAS patches

	Sensitivity	Specificity	Precision	Recall	Test accuracy	Test loss
VGG-16	0.82	0.79	0.79	0.82	0.84	0.52
ResNet-50	0.61	0.84	0.77	0.61	0.76	0.69
EfficientNet-B7	0.84	0.77	0.78	0.84	0.83	0.50