



Machine vision theory and applications for cyber-physical systems

Manish Khare¹ · Ashish Khare² · Moongu Jeon³ · Ishwar K. Sethi⁴

Published online: 23 May 2022

© The Author(s), under exclusive licence to Springer Science+Business Media, LLC, part of Springer Nature 2022

Different types of Cyber-Physical Systems will affect every aspect of our life soon. Semiconductors and the internet revolutionized technologies have transformed our lives and interactions with information and communication technology. Now we will live with a new paradigm of a cyber-physical system that would transform how we interact with and manipulate the physical systems. Cyber-physical systems are the new generation of systems that integrates computing and communication capabilities with the dynamics of physical and engineered systems. Society has realized how cyber-physical systems will impact the economy and social structure. Therefore vast investments are being made worldwide to develop this technology. The physical world, however, is not entirely predictable. So we have a wide and open area of research to explore and exploit the challenges and immense research opportunities in cyber-physical systems that communicate with other machines and interact with people. Cyber-Physical Systems (CPS) are a natural consequence of an increasingly connected physical world.

The significant applications of cyber-physical systems include intelligent electric grids, smart buildings, smart transportation, next-generation air traffic management, advanced manufacturing, innovative medical technologies, automatic pilot avionics, autonomous

✉ Manish Khare
manish_khare@daiict.ac.in

Ashish Khare
khare@allduniv.ac.in

Moongu Jeon
mgjeon@gist.ac.kr

Ishwar K. Sethi
isethi@oakland.edu

¹ Dhirubhai Ambani Institute of Information and Communication Technology (DA-IICT), Gandhinagar, Gujarat, India

² University of Allahabad, Prayagraj, Uttar Pradesh, India

³ Gwangju Institute of Science and Technology (GIST), Gwangju, Republic of Korea

⁴ Oakland University, Rochester, MI, USA

vehicle, etc. Hence, CPS should run dependably, safely, securely, and efficiently in real-world applications. CPS users connect, transfer data directly, and perform asynchronously based on underlying cyber-infrastructure. Over the past two decades, the number of cyber components has grown gradually. CPSs are now becoming software-intensive systems with more integrated computing hardware and computational algorithms. In today's scenario of CPS, software dominates all aspects of connecting the physical and cyber worlds by orchestrating the computation, communications, and control (CCC) technologies.

Consequently, the engineering of high-confidence CPSs has also evolved with the help of different new emerging technologies. Some of these other interactions are due to advanced machine vision algorithms. Nowadays, tremendous progress has been made in advancing machine vision algorithms for CPS technology over the last five years. More advanced machine vision algorithms in CPS have solved many challenges in real-time interaction between physical systems and dynamic environments, the efficiency issues in smart homes, buildings, communities, connected vehicle systems, and their reliability.

Machine Vision-based CPS refers to computer vision-based systems where assumptions like controlled surroundings do not hold. Furthermore, exploring the domain of computer vision algorithms provides dozens of new opportunities. Machine vision-based CPS raises the need for applied research that focuses on the technology transfer from academics to practitioners, yielding several challenges like top-notch accuracy, real-time processing, minimal training data, minimal manual input, user-friendly interfaces, etc. Machine vision Technologies in Cyber-Physical Systems aim to achieve a close integration of cyber systems and physical systems and detect and control physical systems in a real-time, secure, reliable, efficient, and adaptive manner with the help of different machine vision technologies.

This special issue brings together recent state-of-the-art advances in immersive experiences. We received 56 submissions, out of which we accepted 26 research papers for this special issue by considering the technical quality, the originality, and the innovation of the proposed ideas, solutions, and systems. The authors of accepted papers are from different countries: India, China, Austria, Iran, Canada, Australia, Republic of Korea, Turkey, France, Iran, and Italy. Below we briefly describe the accepted papers.

Laxmanika and Pradeep Kumar Singh present their work title “Robust and imperceptible image watermarking technique based on SVD, DCT, BEMD, and PSO in wavelet domain” (<https://doi.org/10.1007/s11042-021-11246-8>). This paper uses SVD, DCT, DWT, PSO, and BEMD to improve the image watermarking technique's robustness, imperceptibility, and security.

Manish and Nitin Kumar present their work title “CBRC: a novel approach for cancelable biometric template generation using random permutation and Chinese Remainder Theorem” (<https://doi.org/10.1007/s11042-021-11284-2>). This paper proposes a novel method based on Random Permutation and the Chinese Remainder Theorem, which performs well on gray and color images. Random Permutation provides security against the visual appearance, while the Chinese Remainder Theorem provides security against the intensity values after the random permutation step.

D. Sangeetha, S.S.Chakkaravarthy, S.C. Satapathy, V. Vaidehi, and M.V. Cruz present their work title “Multi keyword searchable attribute-based encryption for efficient retrieval of health Records in Cloud” (<https://doi.org/10.1007/s11042-021-10817-z>). This paper proposes Conjunctive Multi keywords Searchable Attribute-Based Encryption and Location-Based Encryption to maintain the privacy of the Public Health Record data while searching and sharing data over a network in the cloud.

Shouxin Liu, Wei Long, Yanyan Li, and Hong Cheng present their work titled “Low-light image enhancement based on membership function and gamma correction” (<https://doi.org/10.1007/s11042-021-11505-8>). In this paper, the author successfully overcomes the defect of the traditional fuzzy set membership function in that parameters must be manually set. Then they creatively combine the gamma function and fuzzy set membership function and avoid over-or under enhancement. The authors redesign the objective exposure measure method (OEM) for the HSV color space according to the different images.

Yunyi Yan, Wenyi Yu, and Lingxia Zhang present their work title “A method of band selection of remote sensing image based on clustering and intra-class index” (<https://doi.org/10.1007/s11042-021-11865-1>). In this paper, the author proposes a method of hyperspectral image feature perception based on clustering and intra-class frequency band index to avoid the problem of being over-dependent on the similarity to select the band but ignoring the amount of information and the correlation of the band.

Deepika Sharma and Arvind Selwal present their work title, “An intelligent approach for fingerprint presentation attack detection using ensemble learning with improved local image features” (<https://doi.org/10.1007/s11042-021-11254-8>). This paper presents a novel IFPAD approach to counter the spoofing attacks in the typical CPS-based infrastructures. The LABP descriptor is proposed for the hybrid IFPAD technique that generates a robust feature set with improved discrimination capabilities compared to the other versions of LBP.

Saurav Kumar, Himanshu Gupta, Dristi Yadav, Irshad Ahmad Ansari, and Om Prakash Verma present their work title “YOLOv4 algorithm for the real-time detection of fire personal protective equipment at construction sites” (<https://doi.org/10.1007/s11042-021-11280-6>). The author worked towards the real-time detection of fire, PPE, and persons at construction sites for effective monitoring and assisting in evacuation tasks. This work utilizes the YOLOv4 and YOLOv4-tiny algorithms based on deep learning for carrying out the detection task.

Amirhossein Peyvandi, Babak Majidi, Soodeh Peyvandi, Jagdish C. Patra, and Behzad Moshiri present their work title “Location-aware hazardous litter management for smart emergency governance in urban eco-cyber-physical systems” (<https://doi.org/10.1007/s11042-021-11654-w>). This research collects a novel dataset of littered face masks in various conditions and environments. Then, a new deep neural network architecture for rapidly detecting discarded face masks on the video surveillance edge nodes is proposed. Furthermore, a location intelligence model for predicting the areas with a higher probability of hazardous litter in the smart city is presented.

Krishna Kumar Nirala, Nikhil Kumar Singh, and Vinay Shivshanker Purani present their work title “A survey on providing customer and public administration based services using AI: chatbot” (<https://doi.org/10.1007/s11042-021-11458-y>). This paper discusses artificial intelligence-based chatbots, including their applications, challenges, architecture, and models. It also talks about the evolution of chatbots from Turing Test and Rule-based chatbots to advanced Artificial Intelligence-based Chatbots (AI-Chatbots). AI-Chatbots provide many kinds of services, and this paper outlines two main aspects: customer-based and public administration-based services. This survey aims to understand and explore the possibility of customer & public administration services-based chatbots.

Kirtana Sunil Phatnani and Hemant A. Patil present their work title, “Music footprint recognition via sentiment, identity, and setting identification” (<https://doi.org/10.1007/s11042-021-11430-w>). This paper explores the identification and quantification of emotional contagion produced by music in human beings.

Shashwat Sanket, M. Vergin Raja Sarobin, L. Jani Anbarasi, Jayraj Thakor, Urmila Singh, and Sathiya Narayanan present their work titled “Detection of a novel coronavirus from chest X-rays using deep convolutional neural networks” (<https://doi.org/10.1007/s11042-021-11257-5>). The paper’s main objective is experimentation with a fast diagnostic method, i.e., chest X-ray classification for COVID-19 infected patients. Here authors propose a convolutional neural network (CNN) based model for analysis/detection of COVID-19, dubbed CovCNN in the remainder of this paper.

Divya Singh and Rajeev Srivastava present their work title, “Channel spatial attention based single-shot object detector for autonomous vehicles” (<https://doi.org/10.1007/s11042-021-11267-3>). In this paper, the single-shot object detection is provided faster results, and the attention module helps to provide more accurate detection. The proposed model sequentially incorporates these two attention mechanisms, such as channel (RGB-wise) and spatial attention for single-shot object detection (CSA-SS).

Neeraj Varshney, Brijesh Bakariya, and Alok Kumar Singh Kushwaha present their work title “Human activity recognition using deep transfer learning of cross position sensor based on the vertical distribution of data” (<https://doi.org/10.1007/s11042-021-11131-4>). A model based on the transfer learning for the vertical distribution of cross position sensor data is proposed in this paper. This work is significant because it reduced the need to reprocess extensive data repeatedly.

Sundaresan Raman, Manan Soni, Rohit Ramaprasad, and Vinay Chamola present their work title “LWCNN: a lightweight convolutional neural network for agricultural crop protection” (<https://doi.org/10.1007/s11042-021-11866-0>). In this paper, the author proposed a Lightweight Convolutional Neural Network (LWCNN) for the classification task of detecting the presence of downy mildew disease in pearl millets (leaves and ears).

Yang Zhou, Kai Liu, Qingyu Dou, Zitao Liu, Gwanggil Jeon, and Xiaomin Yang present their work title “LNMF: lightweight network for multi-focus image fusion” (<https://doi.org/10.1007/s11042-021-11659-5>). The authors first convert the fusion problem into a classification problem in this paper. Then, using a lightweight network to classify focus and defocus areas of source images. Finally, focus areas are fused to obtain an all-in-focus image. The proposed lightweight network reduces operation complexity and memory consumption while achieving sound fusion effects.

Jaeyong Kang, and Jeonghwan Gwak, present their work title, “Ensemble of multi-task deep convolutional neural networks using transfer learning for fruit freshness classification” (<https://doi.org/10.1007/s11042-021-11282-4>). In this work, the authors designed and implemented a transfer learning-based ensemble method that combines the bottleneck features of two pre-trained CNN models with different architectures (ResNet-50 and ResNet-101) for the task of fruit freshness classification. Authors also designed and implemented a multi-task learning framework that uses information on the kind of fruit to enhance the performance of fruit freshness classification.

Krishna Dev, Zubair Ashraf, Pranab K. Muhuri, and Sandeep Kumar present their “Deep autoencoder based domain adaptation for transfer learning” (<https://doi.org/10.1007/s11042-022-12226-2>). In this work, the authors proposed two different variants of the transfer learning techniques for classification, which are termed (i) Domain adapted transfer learning with deep autoencoder-1 (D-TLDA-1) using the linear regression and (ii) Domain adapted transfer learning with deep autoencoder-2 (D-TLDA-2) using softmax regression.

Selen Ayas, and Mustafa Sinasi Ayas, present their work title, “A novel bearing fault diagnosis method using deep residual learning network” (<https://doi.org/10.1007/s11042-021->

11617-1). In this paper, a novel DL-based model is presented for fault detection and classification of motor bearing. First, this work converts time-domain signals to images by a proposed signal-to-image conversion approach. Then, the converted gray-scale images are fed into a novel deep residual learning (DRL) network structured to learn an end-to-end mapping between images and the health condition of the motor bearing.

Aritro Sengupta, Amit Singh, Pankaj Kumar, and Tapobrata Dhar present their work titled “A secure and improved two-factor authentication scheme using elliptic curve and bilinear pairing for cyber-physical systems” (<https://doi.org/10.1007/s11042-022-12227-1>). In this article, the authors have explained how the different two-factor authentication schemes proposed in the previous papers are susceptible to various security attacks. Later on, an effective and user-friendly two-factor authentication scheme is proposed in this article to be implemented on CPS. The proposed scheme works on the principles of bilinear pairing and can overcome the loopholes of the previously proposed schemes.

Youssef Bouaziz, Eric Royer, Guillaume Bresson, and Michel Dhome present their work title “Map management for robust long-term visual localization of an autonomous shuttle in changing conditions” (<https://doi.org/10.1007/s11042-021-11870-4>). This paper introduces a solution to build and use multi-session maps incorporating sequences recorded in different conditions (day, night, fog, snow, rain, change of season, etc.). Authors exploit a ranking function during visual localization to extract the most relevant keyframes from the map. This ranking function is designed to consider the vehicle’s pose and the current environmental condition.

Shiwangi Mishra, Iman Beheshti, M. Tanveer, and Pritee Khanna present their work title “3D Supervoxel based features for early detection of AD: A microscopic view to the brain MRI” (<https://doi.org/10.1007/s11042-021-11871-3>). This work segmented whole-brain structural magnetic resonance imaging (MRI) into 116 regions using atlas-based segmentation. Important atrophic regions are used for further analysis based on a region ranking procedure from these segmented regions. This study aims to perform super voxel-based partitioning to attain features prominent for Alzheimer’s disease detection.

Mohd. Aquib Ansari, and Dushyant Kumar Singh, present their work title, “An expert video surveillance system to identify and mitigate shoplifting in megastores” (<https://doi.org/10.1007/s11042-021-11438-2>). This article proposes a deep neural network-based solution to identify these shoplifting activities. The proposed model uses a dual-stream fusion-based network that effectively binds appearance and motion dynamics in the temporal domain to identify shoplifting actions efficiently. This article introduces a shoplifting dataset synthesized in the author’s lab, which contains standard human and object stealing actions.

Soma Debnath, Ratnakirti Roy, and Suvamoy Changder present their work title, “Photo classification based on the presence of diagonal line using pre-trained DCNN VGG16” (<https://doi.org/10.1007/s11042-021-11557-w>). The proposed approach of this paper classifies digital photographs into two categories: photographs containing diagonal lines or not by the application of transfer learning. The proposed model is implemented on the ground truth dataset of 5683 images, and satisfactory results have been achieved. The paper’s contribution is significant because the existence of a similar classifier for digital photographs is zero in the literature.

Zahra Mortezaie, Hamid Hassanpour, and Azeddine Beghdadi present their work title “People re-identification under occlusion and crowded background” (<https://doi.org/10.1007/s11042-021-11868-y>). In this paper, a technique is proposed to improve the performance of re-identification approaches using (a) a pre-processing step; and (b) a proposed weighing

mechanism. The input image is first segmented into the person's body, background, and possibly carried objects in this approach. Then, considering the image's segments, the occluded parts of the body are retrieved using their neighboring pixels.

Selen Ayas, and Mustafa Sinasi Ayas, present their work title, "A modified densenet approach with near miss for anomaly detection in industrial control systems" (<https://doi.org/10.1007/s11042-021-11618-0>). This paper presents a modified DenseNet approach with NearMiss (NM) undersampling technique to detect anomalies in a small-scale ICS commonly used to test anomaly detection approaches. The utilized small-scale ICS is the Secure Water Treatment (SWaT) testbed.

Soumendra Goala, Deo Prakash, Palash Dutta, Pranjal Talukdar, K. D. Verma, and G. Palai present their work title "A decision support system for surveillance of smart cities via a novel aggregation operator on intuitionistic fuzzy sets" (<https://doi.org/10.1007/s11042-021-11522-7>). In this paper, a fuzzy multi-criteria decision support system is utilized to prioritize the parts of a smart city which may lie under the potential threat of terror attacks. For this purpose, a new aggregation operation on Intuitionistic fuzzy sets has been proposed. In addition, a case study on a smart city has been carried out, which showcases the applicability of the proposed methodology.

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.