Scientific Report

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Period of the fellowship	01/02/2021 to 31/01/2022

I – SCIENTIFIC ACTIVITY DURING YOUR FELLOWSHIP

Different research activities were carried out during the tenure of my postdoctoral fellowship. The research activities were mainly focused on data/video analytics using machine learning (ML) and deep learning (DL) models. Along with data/video analytics, a brief research work was also conducted on augmented reality (AR), IoT-enabled edge-computing and on massive open online courses (MOOCs) recommender system. In data/video analytics using DL: **(1)** human action recognition (HAR) was evaluated over publicly available datasets such as UCF sports, UCF11 and J-HMDB using variety of DL models. The challenges with the existing state-of-the-arts were covered by proposing a bi-directional long short-term memory (BiLSTM) based attention mechanism with a dilated convolutional neural network (DCNN) that selectively focuses on effective features in the input frame to recognize the different human actions in the videos, **(2)** Wireless visual sensor networks (WVSNs) typically consist of numerous visual nodes, each of which continuously generates a massive amount of video data. The efficient monitoring and streaming of such huge amounts of data is very challenging due to the limited availability of computational resources. To overcome the drawbacks of traditional surveillance systems, the strength, and capabilities of a 3DCNN was investigated for intelligent camera prioritization in large-scale WVSNs based on violent activity recognition. Experimental analysis confirmed that 3DCNN is capable of learning not only spatial but also temporal information, showing 98%–99% accuracy, **(3)** In industry 4.0, streaming of immersive video over the network consumes a tremendous amount of bandwidth, where the users are only interested in specific regions of the videos. Furthermore, for delivering full excitement videos and minimizing the bandwidth consumption, the automatic selection of the user's region of interest (RoI) in a 360° video is very challenging because of subjectivity and difference in contentment. To tackle these challenges, two efficient convolutional neural networks for salient object detection and memorability computation were employed in a unified framework to find the most prominent portion of a 360° video, **(4)** The advent of smart cameras, Nx-IoT, and efficient learning algorithms for sports video analytics have enhanced the performance of players as well as facilitate the live spectators inside the stadium. The smart cameras in Nx-IoT soccer environment are interconnected through wireless networks, that

capture and transmit the data to an AI-assisted computing platform. Majority of the spectators are very enthusiastic to watch and celebrate the better performance of their favorite teams. The IoT-enabled soccer environment provides the spectators with live information (visual, and textual) related to the important events of the match and allows them to share and discuss the match situation in real-time, which can be provided to the spectators as a FinTech service. Therefore, an efficient deep learning-based framework for multi-person salient soccer events recognition in Nx-IoT-enabled environments was proposed to recognizes the salient events in soccer video, including goal, substitute, penalty save, penalty goal, red card, and head goal. Different CNN architectures with multi-layer LSTM were evaluated to proposes an efficient CNN+LSTM approach for soccer events learning and recognition in Nx-IoT enabled environments, **(5)** Due to the rapid development of artificial intelligence technology, industrial sectors are monitored by AI assisted visual sensor networks capturing different surrounding environment images. However, during tempestuous weather conditions, the visual quality of the images is reduced due to contaminated suspended atmospheric particles that affect the overall surveillance systems. To tackle these challenges, a computationally efficient lightweight convolutional neural network referred to as Light DehazNet(LD-Net) was evaluated to reconstruct hazy images. Unlike other learning-based approaches, LD-Net jointly estimates both the transmission map and the atmospheric light using a transformed atmospheric scattering model, **(6)** A review on traditional ML and DL techniques for white blood cells (WBCs) in blood smear images were conducted, providing an in-depth analysis of available ML and DL methods for medical image analysis (MIA) with a significant focus on leukocytes classification in blood smear images and other medical imaging domains, i.e., magnetic resonance imaging (MRI), CT images, X-ray, and ultrasounds. The impact of this review was to find the most suitable ML and DL techniques in MIA, especially for leukocyte classification in blood smear images.

Augmented reality (AR) techniques are used extensively in various real-world applications for education, training, entertainment, tourism, and cultural heritage. Research work in AR was conducted in two directions: **(1)** AR techniques make the learning process easy, and fun as compared to traditional methods. Overlaying virtual content into the real world makes learning methods attractive and entertaining for students while performing activities. To make the learning process more effective, a handheld marker-based AR technology was proposed to be used for primary school students. A set of four applications based on primary school level course were developed to augment virtually the learning of the English alphabet, decimal numbers, animals and birds, and an AR Globe for knowing about different countries around the world. These applications can be played wherever and whenever a user wants without Internet connectivity, subject to the availability of a tablet or mobile device and the required target images, **(2)** Virtual reality (VR) has been widely used as a tool to assist people by letting them learn and simulate situations that are too dangerous and risky to practice in real life, and one of these is road safety training for children. Traditional video- and presentation-based road safety training has average output results as it lacks physical practice and the involvement of children during training, without any practical testing examination to check the learned abilities of a child before their exposure to real-world environments. Therefore, a 3D realistic open-ended VR and Kinect sensor-based training setup using the Unity game engine was developed, wherein children are educated and involved in road safety exercises. The proposed system applies the concepts of VR in a game-like setting to let the children learn about traffic rules and practice them in their homes without any risk of being exposed to the outside environment.

Smart home applications are ubiquitous and have gained popularity due to the overwhelming use of Internet of Things (IoT)-based technology. The revolution in technologies has made homes more convenient, efficient, and even more secure. The need for advancement in smart home technology is necessary due to the scarcity of intelligent home applications that cater to several aspects of the home simultaneously, i.e., automation, security, safety, and reducing energy consumption using less bandwidth, computation, and cost. Our research work provides a solution to these problems by deploying a smart home automation system with the applications mentioned above over a resource-

constrained Raspberry Pi (RPI) device. The RPI is used as a central controlling unit, which provides a cost-effective platform for interconnecting a variety of devices and various sensors in a home via the Internet. A cost-effective integrated system for smart home based on IoT and Edge-Computing paradigm was developed, providing remote and automatic control to home appliances, ensuring security and safety. Additionally, the proposed solution uses the edge-computing paradigm to store sensitive data in a local cloud to preserve the customer's privacy. Moreover, visual and scalar sensor-generated data are processed and held over edge device (RPI) to reduce bandwidth, computation, and storage cost.

Online learning environments (OLE) including learning management systems (LMS) and massive open online courses (MOOCs) are gaining popularity as the best modern alternate solutions available for education in the current era. At the start of 2020, the global pandemic enforced social distance practice worldwide, changing the work environment dynamics, leaving options like online trading, work from home, and online education. Online learning environments gained particular attention in the educational sector, where users could access the online learning resources to fulfil their academic requirements during the lockdown. From massively available content such as MOOC, learners are overwhelmed with the available choices. In this scenario, recommender systems (RS) come to the rescue to help the learner make appropriate choices for completing the enrolled course. There is tremendous scope and a multitude of opportunities available for researchers to focus on this domain. A systematic mapping review on MOOC recommender systems (MOOCRS) was performed to highlight solutions in multiple areas of the MOOCRS such as course recommendation, learner peer recommendation, resource recommendations.

II – PUBLICATION(S) DURING YOUR FELLOWSHIP

S.No	Title/link	Name of Journal	Date of Publication	Author Status	Impact Factor
1	Human action recognition using attention-based LSTM network with dilated CNN features	Future Generation Computer Systems	2021	Corresponding Author	7.187
2	Deepview: Deep Learning based Users Field of View Selection in 360° Videos for Industrial Environments	IEEE Internet of Things Journal	2021	Corresponding Author	9.515
3	Light-DehazeNet: A Novel Lightweight CNN Architecture for Single Image Dehazing	IEEE Transactions on Image Processing	2021	Corresponding Author	10.856
4	AI-Driven Salient Soccer Events Recognition Framework for Next Generation IoT-Enabled Environments	IEEE Internet of Things Journal	2021	Corresponding Author	9.515
5	A Systematic Mapping Review on MOOC Recommender Systems	IEEE Access	2021	Corresponding Author	3.367
6	Anomaly based camera prioritization in large scale surveillance networks	Computers, Materials & Continua	2022	Corresponding Author	3.772
7	School of the Future: A Comprehensive Study on the Effectiveness of Augmented Reality as a Tool for Primary School Children's Education	Applied Sciences	2021	Corresponding Author	2.679
8	An Adaptive Game-Based Learning Strategy for Children Road Safety	Sensors	2021	Corresponding Author	3.576

	Education and Practice in Virtual Space				
9	A Review on Traditional Machine Learning and Deep Learning Models for WBCs Classification in Blood Smear Images	IEEE Access	2020	Corresponding	3.367
10	Cross-Modal Guidance Assisted Hierarchical Learning Based Siamese Network for MR Image Denoising	Electronics	2021	Co-author	2.397
11	Towards Smart Home Automation Using IoT-Enabled Edge-Computing Paradigm	Sensors	2021	Co-author	3.576

III – ATTENDED SEMINARS, WORKHOPS, CONFERENCES

Conferences

- **Keynote Lecture** Title, "*Efficient Deep Learning Methods, IoT Applications, Current Trends/Challenges and Future Directions*", 5th EAI International Conference on Advanced Hybrid Information Processing (EAI ADHIP 2021), 22-24 October 2021.
- **Keynote Lecture** Title, "Efficient Deep Learning Methods for IoT Applications: Current Challenges and Future Directions", 18th International Conference on Wireless Networks and Mobile Systems (WINSYS 2021), 7-9 July, 2021
- *Deep learning-based wheat ears count in robot images for wheat phenotyping*, Ehsan Ullah, Mohib Ullah, Muhammad Sajjad, and Faouzi Alaya Cheikh*, Intelligent Robotics and Industrial Applications using Computer Vision (IRIACV), Electronic IMAGING, San Francisco 2022.*
- *An automated approach for analysing students feedback using sentiment analysis techniques*, Shpetim Sadriu, Krenare Pireva Nuci, Ali Shariq Imran, Imran Uddin and Muhammad Sajjad, *5th Mediterranean Conference on Pattern Recognition and Artificial Intelligence (MedPRAI 2021) 2021, Istanbul, Turkey*

Projects

- I contributed to two tasks of ALAMEDA project (Horizon 2020): 1) Facial expression analysis using DL models, 2) Wearable sensors data analysis using ML/DL algorithms
- AgriTech Project: I contributed to proposal writing.
- Wild Animal Classification: I contributed to proposal writing.

IV – RESEARCH EXCHANGE PROGRAMME (REP)

I visited Inria Strasbourg France dated 7th to 14th November 2021, where I worked with Stephane Cotin (Research Director and Head of the MIMESIS team at Inria). I performed the following activities at Inria.

- Talk: I presented my research work at Inria, where PhD students, researchers and professors participated. The duration of the talk was scheduled for one hour, but due to keen interests of the audience, the questions/answers sessions exceeded to half hour more.
- Scientific Exchange: We had numerous meetings on different ongoing projects at Inria while sharing scientific experiences and ideas.