Convolutional Neural Network Model Based Human Wearable Smart Ring System: Agent Approach

Lokesh B. Bhajantri, Ramesh M. Kagalkar, and Pundalik Ranjolekar

Abstract—**The Internet of Things has a set of smart objects with smart connectivity that assists in monitoring real world environment during emergency situations. It could monitor the various applications of emergency situations such as road accidents, criminal acts including physical assaults, kidnap cases, and other threats to people's way of life. In this work, the proposed work is to afford real time services to users in emergency situations through Convolutional Neural Networks in terms of efficiency and reliable services. Finally, the proposed work has simulated with respect to the performance parameters of the proposed scheme like the probability of accuracy and processing time.**

Keywords—**Internet of Things, Agents, Convolutional Neural Networks, Smart Ring System, Agent Knowledge Base**

I. INTRODUCTION

THE Internet of Things (IoT) consists of intelligent things or devices for sending information to the base station. The recent development of IoT has made our lives easier for accessing information anyplace and anywhere. Over the period of years, the improvement of an intelligent system that might be used to attach the community. Smart objects are used for emergency offerings to users in an environment. Most of the IoT based devices or systems are capable to give services to users or humans in terms of health issues like coronary heart, breast most cancers, diabetes, thyroid, dermatology, liver problem diseases, etc. Also, some of the systems carried out the use of devices for the fitness care tracking system [1].

The IoT associates with sensors for receiving and transmit real time data using digital cameras in emergency situations. The sensors could be object detection sensors, motion sensors, hand gesture sensors, etc. Based on the context information by the sensors and relevant actions are performed accordingly. The IoT is an important part of real world environment. Gradually, the user wants to associate with various things of IoT environment for computing and communication of real time data. The various types of communications with real time data over the IoT that connected by high speed Internet [2]. The IoT comprises various real time applications for computing and communication over the network. Also, it's having a major impact on various public and private organizations for transmitting emergency data over the network to users [3].

Agents are independent programs situated in the real world environment, which are used to act on behalf of the user for fulfilling the preferred task in a predetermined time. Agents are autonomous, self-motivated, decision making, goal oriented, collaborative, and learning, and act upon the environment. There are two types of agents as static and mobile agents to sense the environment and perform the desired tasks. The static agents are situated in the fixed environment and mobile agents are move around the environment i.e., move from one environment to another. The mobile agents have a mobility factor to sense and capture the real time data from the device system or objects or devices or nodes [4]. Therefore agents are used for balancing the load of a system. The multi-agent systems may comprehensively collaborate with each other to achieve their individual goals and also, may interact with users and system resources. A multi-agent system is used to process real time context data from the environment during emergency situations. The context aware computing demonstrates the state of affairs of a user wearable device/system state, surroundings, and adopting its behavior based on real time data [5]. Context awareness emphasizes the most important characteristic in multi-agents that allows for interpreting various contexts such as temporal, emergency, and computational contexts coming from the environment.

Convolutional Neural Network (CNN) has a set of layers such as Convolutional Layer (CL), the Pooling Layer (PL), and Fully Connected Layer (FCL) [6]. In which, the CL is the main part of the CNN that is used to perform feature extraction along with PL. The final layer of CNN is used to perform mapping the output of the network against the features that are extracted by the CL and PL. The CNN is associated with the performance parameters like kernels and weights. CNN is used to provide fast and accurate video analysis for making efficient decisions and classifications of data. In this work, it has been used CNN for detecting whether context data is an emergency or not in the real world environment using multi agent system. CNN involuntarily gains the knowledge of the feature set through the trained emergency data. The operation of the proposed scheme using CNN is as shown in Fig.3. The CNN comprises the various applications in a real world environment such as classification and recognition, computer vision, natural

Lokesh B. Bhajantri is with the Department of Information Science and Engineering, India (email: lokeshcse@yahoo.co.in).

Ramesh M. Kagalkar is with KLE College of Engineering and Technology, Chikodi, Karnataka, India, (rameshvtu10@gmail.com).

Pundalik Ranjolekar is with Department of CSE, KLE Society's Dr. M. S. Sheshgiri College of Engineering and Technology, Karnataka, India (e-mail: pundalikr@rediffmail.com).

language processing, video analysis, health care applications, sentiment analysis, emergency situations, and so on.

The rapid developments of IoT and camera technology as well as video processing techniques are used to process the real time data to users during emergency situations. The proposed agent systems are to track and detect and send the real time emergency context information such as road accidents, kidnap cases, physical attacks, and the person in an emergency due to various conditions of health. The proposed system has the following advantages like cost effective emergency data to users over the network, increases the network lifetime, effectively context aware transmission of data to a Centralized Agency Service (CAS) for taking the insights of data and emergency users can access the services in anytime and anywhere in his/her devices.

The respite of the work is composed as a systematic related work towards the scheme is depicted in Section 2. Section 3 demonstrates the proposed scheme. The results and discussion about the system and prototypes of the device and experimental outcomes are explained in Section 4. Finally, it concludes the proposed work in Section 5.

II. RELATED WORK

The various works are discussed with respect to the proposed work as pursue: the work given in [7] depicts the real time video fire and smoke detection using CNN. This work is to perform the feature extraction and classifications of video fire detection. The IoT approach for monitoring health is described in [8]. This approach is used for detecting the health issues of humans like heart diseases, breast cancer, thyroid, diabetics, etc. This is implemented using a machine learning algorithm. The women's safety system using IoT is presented in [9]. This system is used to get the details of the location and image of the attacker through the Pi-camera. Therefore such information is sent to predefined contact numbers or police station via a Smartphone system. The IoT based women's safety solutions are described in [10]. This system is to transmit the victim location to a nearby police station. Also, track the health issues of women in emergency situations. The work given in [11] presents a review on the machine learning based human safety system. This paper describes the review of human safety devices in real world environment using sensor technology, IoT, and machine learning approach to solve the emergency situation problems of humans.

The works given in [12] depict an operation of ring IoT device which is used to control and monitor the things or devices. The system associates with GSM and GPS network that transmits the data to police stations which are nearby to the emergency situation and track the location of the device during an emergency situation, respectively. The convolutional neural network based video content analysis is presented in [13]. The scheme is to classify the object using video content analysis. The car accident detection based IoT technology is presented in [14]. In which, the proposed system is used to detect the accidents and immediately notify the concerned peoples and agencies like hospital and police service systems through GSM and also, transmit the accident place through GPS. Image detection using CNN is presented in [15]. This work depicts the overview of

CNN layers in terms of issues and challenges towards image recognition.

The emergency service systems using IoT and cloud environments are described in [16]. This work depicts the cloud based emerging services as well as the usage of IoT for data analytics. The design and implementation of safety device for women is presented [17]. This device is to transmit the alert message to the police station as well as nearby surrounding people to save the women. Also, records the audio of emergency situation when the women in trouble. The proposed system was designed with a mobile app for women's safety. The work given in [18] depicts fire detection in surveillance using CNN. This work demonstrates the cost effective CNN model for fire detection videos. The outcome of the proposed work is evaluated towards efficiency and accuracy parameters. Some of the literature surveys are given in [19-21].

The existing system has some constraints for providing emergency services to users. The constraints are in the form of text messages or phone calls. Also, it has based on applications of healthcare and monitoring of users in terms of movement, sound, etc., but these are inefficient during an emergency situation. Therefore, the proposed system is to design and develop an efficient approach for giving a real time services to users during an emergency situation. Also, it captures the emergency real time video and audio data of emergency users efficiently. Apart from these, emergency users can get emergency services in anytime and anywhere. The proposed device is tiny and robust.

III. PROPOSED WORK

This section has been describing the network environment for the proposed system, functioning scheme, and agency service systems. In an emergency situation, the proposed work has considered the CNN model based smart ring system using agents. The proposed architecture has the following modules like smart ring system module, CAS system module, emergency service modules like hospital, police, and insurance modules, and followed by parent mobile service system module. The interaction between Ring Manager (RM) agent and Real Time Data Analyzer (RTDA) agent is as shown in Fig.1.
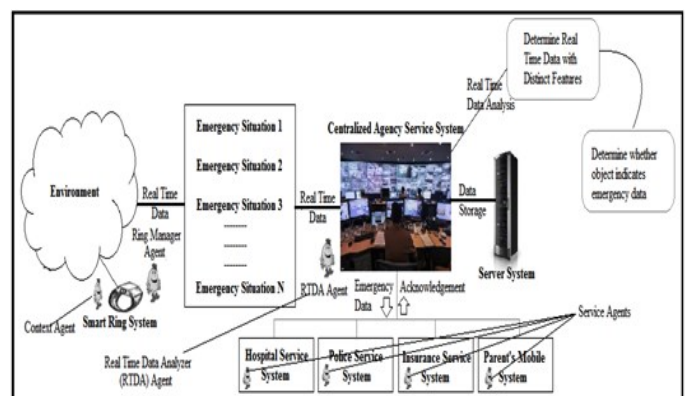

Fig.1. Proposed Network Environment

The proposed smart ring system is an associate with the RM agent i.e., the agent is deployed in each ring system. The RM agent is a static agent that creates the Emergency Context Agent (ECA) and Agent Knowledge Base (AKB) to store the

emergency situation information based on the behavior of emergency users. During emergency situations, the RM agent interprets the context data or real time data by the ECA and the RM agent sends the context aware real time data to the CAS service system through the GSM mode for performing data analytics. ECA generates emergency records using sound, motion, and hand gesture sensors. RM agent read and updates the real time data or video into or from the AKB during emergency situations with data capture time, video, and signal strength for data transmission. Also, the agent monitors the smart ring system in terms of location information and ring_ID. The AKB is read and updated by the proposed agents. The AKB associates with the ring_ID, location, context type, signal strength, centralized agency service system status, etc. The proposed AKB is as shown in Table I.

RTDA agent resides at a centralized agency service system, which is a static agent for real time data analytics and decisions. This agent receives the data from the RM agent for taking whether the data is an emergency or not in a real world environment based on the proposed CNN algorithm. Also, updates the Centralized Agency Knowledge Base (CAKB) with respect to the emergency situations is as shown in Table II. CAKB is updated by RTDA agent in terms of emergency situation information, smart ring_ID, location of emergency users, other agency informations like hospital, police, insurance service systems, acknowledgment status, ring information such as ring owner name, owner address, owner mobile number, etc. The proposed method is used to analyze the video for finding the frame rate and bit rate of real time video or data by using its meta-data in the agent knowledge base. Then extract the keyframes sequence of real time or video content. Finally, the RTDA agent performs the actions on real time data or video of emergency situations. The proposed agent communication is as shown in Fig.2. The proposed algorithm is described as below:

Begin

Step1: The proposed system comprises with sensors during emergency situations periodically.

Step 2: RM agent sends the real time data from the smart ring system and forwards the same to the proposed CAS System.

Step2: The proposed CAS system collects the real time data by RM agent to determine the emergency data with the help of RTDA agent based on the proposed CNN.

Step3: RTDA agent collects and analyses the real time data is as follows:

i) *The Convolutional Layer (CL)* - is used to extract the features from the real time data, i.e., kernel valid padding.

ii) *Pooling Layer (PL)* - which is for reducing the spatial size of the Convolved Feature, i.e., sub-sample their input.

iii) Finally, *Fully Connected Layer (FCLs)* - after number of iterations of CLs and PLs, the sophisticated reasoning is achieved through fully connected layers in the network.

iv) The result or output of fully connected layers towards whether the data is an emergency or not in the environment.

End

Fig.2. Agent Communications

TABLE I
RM AGENT KNOWLEDGE BASE

Ring_ID	Location	Context Type	Status	Signal Strength	Centralized Agency Service Status/Others
BP-611332	Latitude and Longitude	Emergency Context	Active	$\geq 75\%$	Active
⋮	⋮	⋮	⋮	⋮	⋮

TABLE II
RTDA Agent Knowledge Base

Ring_ID	Location	Context Type	Status	Signal Strength	Centralized Agency Service Status/Others	Acknowledgment Status	Smart Ring Owner Information	Real Time Data Rate/ Video Bit rate	Frame Rate
BP-611332	Latitude and Longitude	Emergency Context	Active or Inactive	$\geq 75\%$	Active	Active or Pending	Yes	4,000 - 8,000 kbps	>30fps
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮

Fig.3 shows the operations of the proposed CNN architecture. The CL layer is the main layer of CNN architecture. The various sizes of kernels or filters are applied to the input i.e., emergency situation information (real time video) to generate feature maps. The result of the CL becomes the input of the next layer of CNN that is called as PL where maximum activations are selected from the neighborhood. It is used to extract informations such as human pose estimation, attribute estimation, and object identifications in terms of behavior, sounds, and actions. In which PL is used to minimize the number of parameters when the given real time video is too large. There are various types of PLs as average, sum, and maximum layers for classifications of data. Finally, the proposed CNN architecture has FCLs that are used to take the decisions of the emergency situations by adjusting the weights of the neurons. The proposed work associates with the probabilities for each class for defining each class score using Softmax activation.
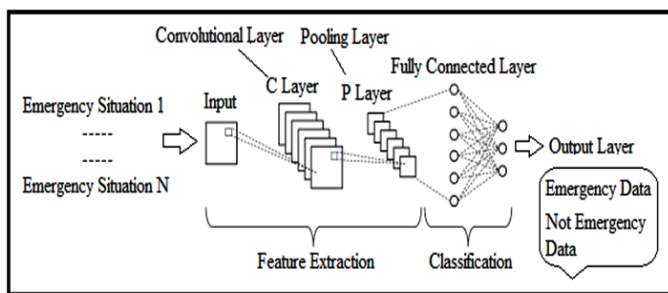
Fig.3. Operations of Proposed Convolutional Neural Networks

A. Smart Ring System

The proposed smart ring system is associates with a static RM agent. Also, this system associates with a digital camera module. This module transmits the real time data of emergency context information using the sensors for detecting the behavior of the users. Once an emergency context or situation is created, the RM agent is automatically activated to start sending the real time data along with the location of an emergency situation to the concerned service systems. Also, the RM agent itself to analyze the emergency situation and sends the information to nearby hospital, police, and CAS emergency service systems. Based on the emergency context data, each emergency system to perform the tasks and acknowledge the same to the proposed CAS system for completion of emergency tasks.

B. Centralized Agency Service System

The proposed RTDA agent is running the background of the CAS system that gets the context data by the RM agent during emergency situations. RTDA agent can examine and affirm the emergency context statistics like type of emergency, location, emergency private details such as name, contact information, and so forth. Once RTDA agent found the real time data as emergency data using the CNN approach, and then notify other service systems for saving the life of emergency users. The proposed CAS has CAKB for storing and maintaining the information about emergency portions of facts. Also, it stores the smart ring system/device details like ring ID, ring owner informations like gender, Aadhar number, cell number, address, acknowledgment status of other service systems, and so on.

C. The Police Service System

The Police Service (PS) agent deployed in the Police Service (PS) systems that collect the emergency data with the help of an RTDA agent. The PS agent verifies the RTDA agent emergency data and performs the actions, finally sends the response to the CAS system. Suppose in case of emergency scenario, the police itself will put the grievance in an emergency situation with aid of the consent of a CAS system. PS agent monitors the police service system in terms of human resources as well as other resources for services. Also, the PS agent updates the information in the PS agent Knowledge Base (PSKB), once the service has been acknowledged to the RTDA agent in terms of user details and acknowledgment details. Fig.4 depicts the flow chart of the proposed PS system.
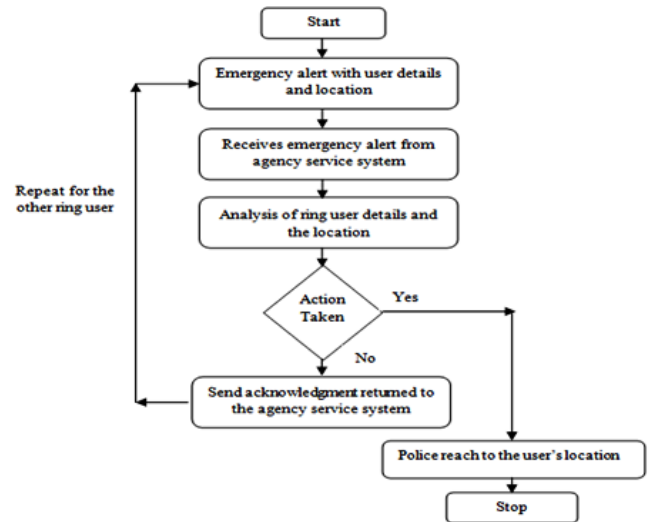

Fig.4. Flow Chart Diagram of Police Service System

D. The Hospital Service System

The hospital provider system associates with Hospital Service (HS) agents that get the vigilant information from the CAS system, as well as RM agent. In case of emergency users, the HS agent can analyze the emergency information like location, insurance coverage, etc., The hospital can assert the statements with the help of the insurance service system. Therefore, the hospital system will transmit the acknowledgment to the CAS. HS agent updates the emergency information's into the HS Knowledge Base (HSKB). Fig.5 shows a flow chart diagram of the proposed hospital service system.
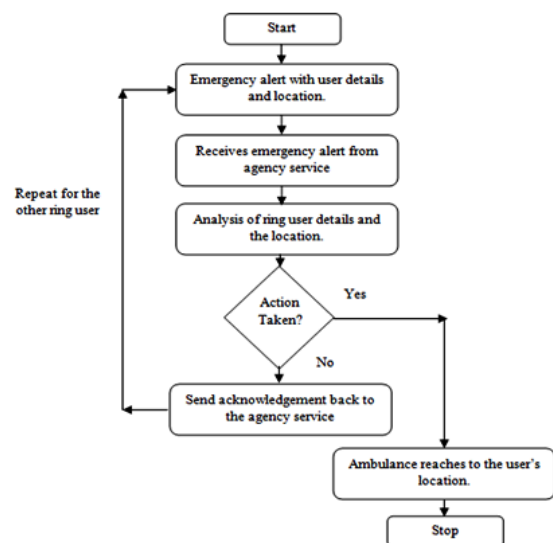

Fig.5. Flow Chart Diagram of the Proposed Hospital Service System

E. An Insurance Service System

The Insurance Service (IS) agent is located at the insurance service systems that collect the emergency alert message from the CAS system during emergency situations. The IS agent examines the policies of emergency users and transmits the status of the acknowledgment to the CAS system for taking better insights. Fig.6 shows a flow chart diagram of the proposed insurance service system.
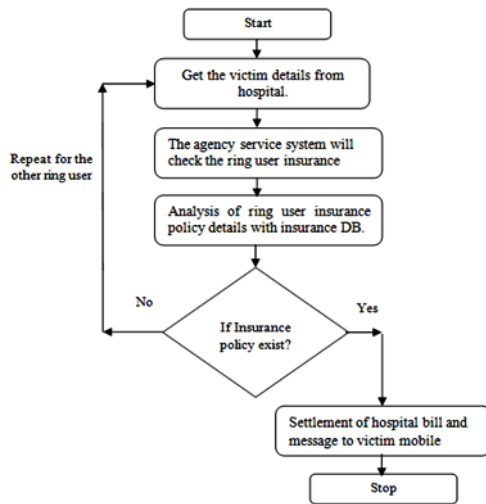

Fig.6. Flow Chart Diagram of the Proposed Insurance Service System

IV. RESULTS AND DISCUSSION

The proposed scheme has been implemented with the following requirements like Arduino Nano Board, sensors, (P2P) IP camera, software, etc. It has considered the functional requirements like registration, CAS system, and other emergency service systems. Also, it associates with non-functional requirements are secure, robust, better network performance. The following Fig.7 shows the prototypes of the proposed system.

The proposed smart ring system sends the real time emergency data to the service systems with the help of an RM agent using GSM. The real time data or video is capturing from the P2P IP camera. The RTDA agent analyzes video or data at a centralized agency system to determine whether the context data is an emergency or not, when the RM agent detects the emergency situations, it sends the video frame of emergency situations along with the time and location for the same.

Proposed Centralized Agency Service System

Arduino Nano Board with LCD Display
(a) The Proposed CAS System

Insurance Service System
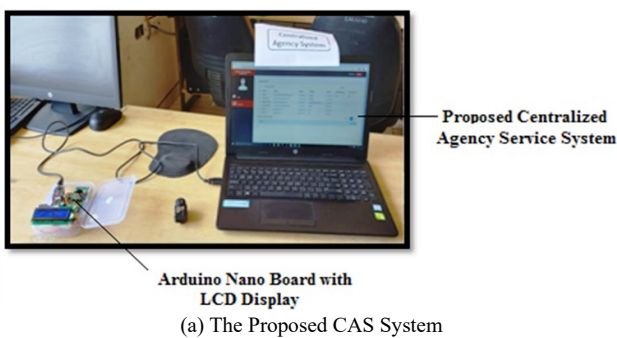
Police Service System
(b) The Proposed Police and Insurance Service Systems

Hospital Service System

(c)The Proposed Hospital Service System
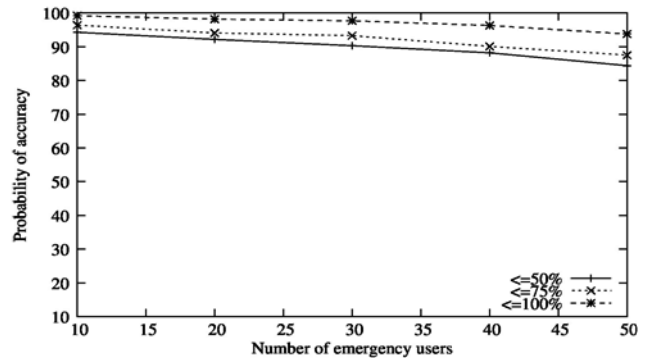
Fig.7. Prototypes of the Proposed System

Fig.8. Probability of Accuracy versus Number of Emergency Users

The proposed system has examined for various categories of users like old age peoples, women, and children's under various scenarios like a person under threat, accident, and unconsciousness and it has given 83% to 98.26% accuracy with minimum processing time. Suppose, in case of good condition of the network, it may get good results as 100%. In other conditions of the network, it may chance to get higher than 50% of results in emergency situations. The number of emergency users versus the probability of accuracy is as shown in Figure8. As increase the number of users in the network, gradually decrease the accuracy of the network. Suppose network conditions increase, the probability of accuracy increases in the network. In this work, it has considered the network conditions in terms of <=50%, <=75%, and <=100%.

The processing time for making decisions is as described in Fig.9. As increase the amount of emergency users, the processing time gradually increases for making decisions whether the context is emergency or not. The proposed system takes less time for processing the real time data or video to take insights into the emergency data.
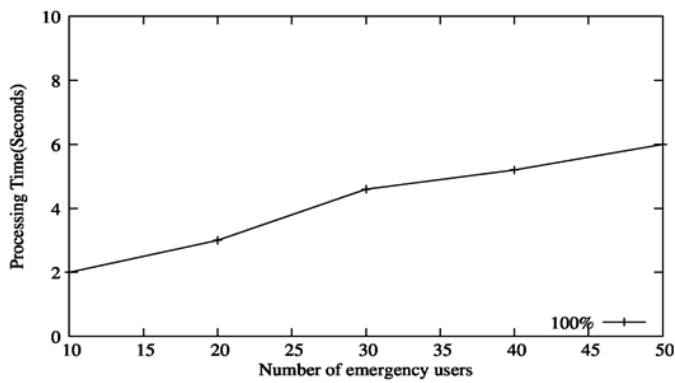
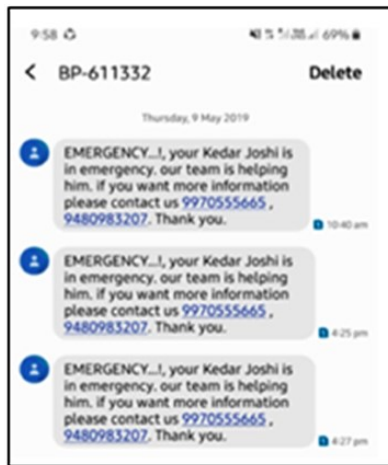Fig.9. Processing Time versus Number of Emergency Users

Fig.10. Emergency Messages at Parent's Mobile System

Fig.10 depicts the emergency information of the user that is sent by the CAS to the parent's mobile system. The proposed CAS system will provide information to the concerned users during an emergency situation.

CONCLUSION

The proposed device is to give emergency offerings to users. The proposed system achieves 83% accuracy and tested the sample cases under the various categories of users like old age peoples, women, and children for different kinds of scenarios like a person under threat, accident, and unconsciousness. This system takes a very minimal processing time under different scenarios, which acts as a "Life-Saving System" for emergency users.

REFERENCES

[1] A P. Pandey, R. Litoriya, "An IoT Assisted System for Generating Emergency Alerts Using Routine Analysis," *Journal of Wireless Personal Communications*, vol.11, no.1, pp.1-22, 2020.

[2] S. S. Sabry, N. A. Qarabash, H. S. Obaid, "The Road to the Internet of Things: A Survey," in *Proceedings of 9th Annual Information Technology, Electromechanical Engineering and Microelectronics Conference (IEMECON)*, IEEE, Jaipur, India, pp. 1-7, 2019.

[3] P. Sethi, S. R. Sarangi, "Internet of Things: Architecture, Protocols, and Applications," *Journal of Electrical and Computer Engineering*, vol.2017, no. 9324035, pp. 1-25, 2017.

[4] N. Sahli, N. Jabeura, M. Badra, "Agent-based Framework for Sensor-to-Sensor Personalization," *Journal of Computer and System Sciences*, vol.81, no.3, pp. 487-495, 2015.

[5] F. Derakhshan, S. Yousefi, "A Review on the Applications of Multiagent Systems in Wireless Sensor Networks," *International Journal of Distributed Sensor Networks*, vol.15, no.5, pp. 1-19, 2019.

[6] S. Albawi, T. A., Mohammed, S. Alzawi, "Understanding of a Convolutional Neural Network," in *Proceedings of the International Conference on Engineering and Technology*, IEEE, Turkey, pp. 1-17, 2017.

[7] S. Frizzi, R. Kaabi, M, Bouchouicha, J.M., Ginoux, E, Moreau, F. Fnaiech, "Convolutional Neural Network for Video Fire and Smoke Detection," in *Proceedings of 42nd Annual Conference of the IEEE Industrial Electronics Society*, Florence, IEEE, Italy, pp. 877- 881, 2016.

[8] M. Manas, A. Sinha, S. Sharma, Md. R. Mahboob, "A Novel Approach for IoT based Wearable Health Monitoring and Messaging System," *Journal of Ambient Intelligence and Humanized Computing*, Vol.10, pp.2817–2828, 2019.

[9] N. R. Sogi, P. Chatterjee, U. Nethra, V. Suma, "SMARISA: A Raspberry Pi based Smart Ring for Women Safety Using IoT," in *Proceedings of International Conference on Inventive Research in Computing Applications (ICIRCA 2018)*, IEEE, Coimbatore, India, pp.451- 454, 2018.

[10] A. Jesudoss, Y. Nikhila, T. Sahithi Reddy, "Smart Solution for Women Safety Using IoT," *International Journal of Pure and Applied Mathematics*, vol.119, no.12, pp. 43-49, 2018.

[11] K. Sharma, D. D. Londhe, "Human Safety Devices Using IoT and Machine Learning: A Review," in *Proceedings of 3rd International Conference for Convergence in Technology (I2CT)*, IEEE, Pune, India, pp.1-7, 2018.

[12] R. Darbar, M. Choudhury, V. Mullick, "Ring IoT: A Smart Ring Controlling Things," in *Physical Spaces*, 2019.
Available From: https://rajkdarbar.github.io/RingIoT.pdf

[13] I. Aljarrah, D. Mohammad, "Video Content Analysis using Convolutional Neural Networks," in *Proceedings of 9th International Conference on Information and Communication Systems (ICICS)*, IEEE, Jordan, pp. 122-126, 2018.

[14] S. Sharma, S. Sebastian, "IoT based car accident detection and notification algorithm for general road accidents," *International Journal of Electrical and Computer Engineering (IJECE)*, vol. 9, no.5, pp. 4020-4026, 2019.

[15] R. Chauhan, K. K. Ghanshala, R.C. Joshi, "Convolutional Neural Network (CNN) for Image Detection and Recognition," in *Proceedings of 2018 First International Conference on Secure Cyber Computing and Communication (ICSCCC)*, IEEE, Jalandhar, India, pp.1-6, 2018

[16] S. Sharma, V. Chang, U. S. Tim, J. Wong, S. Gadia, "Cloud and IoT –based Emerging Services Systems," *Journal on Cluster Computing*, Vol.22, pp.71-91, 2019.

[17] W. Akram, M. Jain, C. S. Hemalatha, "Design of a Smart Safety Device for Women using IoT," in *Proceedings of International Conference on Recent Trends in Advanced Computing*, VIT, Chennai, Elsevier, pp.656-662, 2019.

[18] K. Muhammad, J. Ahmad, I. Mehmood, S. Rho, S. W. Baik, "Convolutional Neural Networks based Fire Detection in Surveillance Videos," *Journal on IEEE Access*, vol.6, pp.18174-18183, 2018.

[19] F. Wu, C. Rüdiger, J. Redoute, M. R. Yuce, "WE-Safe: A Wearable IoT Sensor Node for Safety Applications via LoRa," in *Proceedings of IEEE 4th World Forum on Internet of Things (WF-IoT)*, IEEE, Singapore, pp. 144-148, 2018.

[20] A. Kaur, A. Jasuja, "Health Monitoring based on IoT using Raspberry Pi," in *Proceedings of International Conference on Computer Communication and Automation. (ICCCA)*, IEEE, Greater Noida, India, pp.1335-1340, 2017.

[21] F. Bhatti, M. A. Shah, C. Maple, S.U. Islam, "A Novel Internet of Things-Enabled Accident Detection and Reporting System for Smart City Environments," *Journal on Sensors*, Vol.19, No.9, pp.1-29, 2019.