Artificial intelligence with wireless Sensor Network for Fire detection.

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Abstract— **Artificial intelligence techniques such as intelligent search and intelligent agent is very appealing research for disaster surveillance such as Fire. A method for fire response is developed using the AI techniques. This is achieved by focusing wireless sensor networks as well as convolutional neural networks with Intelligent agents. The result analysis of this work is quite efficient.**

Keywords—Artificial Intelligence, Wireless Sensor Networks. Convolutional neural Networks

I. Introduction

Since last few years, fire detection is an emerging issue, because its effecting the human lives. Often, such occasions are more damaging when the fire surrounds the living area. There is an immense need of such system where fire can be detected on early basis to reduce losses of human lives and property. When fire is at initial stages it is mandatory to get rid of fiery place. To avoid the fire losses, there must be fire alarm system installed at working places. Fire alarms contains of numerous devices working in organized way such can detect the fire and alert people through alarming the situation. Sometimes alarms can be activated manually, or detection devices identifies the events such as heat, smoke, and gas. Most of the alarms comprises of chimes, horns, or mountable sounders.

Artificial intelligence techniques for search and rescue using intelligent agents are very effective for fire kind of disaster. In this article, we proposed a concept of fire detection and rescuing using AI techniques. This is done by introducing three different intelligent agents. We introduced three different agents i.e. search agent, coordinator agent and final rescue agent. We provide a theoretical concept for rescue agent where as other agent working is based on WSNs and CNNs.

II. The Proposed Method

A theoretical foundation is proposed in this article to setup a collaboration between different agents for the fire management. The idea has three agents i.e. search, coordinator and rescue as shown in Figure 1. Search agent must detect the fire and report it to coordinator agent. Coordinator agent has to receive the information from the search agent and sent it to the rescue agent, where the rescue agent goes at the target location to perform the rescue operations. The detection of fire and its location is done by WSNs and with convolutional neural networks. WSNs are also used for sending the information to coordinator as well as to rescue agent. Rescue agents used some searching algorithms to reach the disaster location. Explanation of each agent is described in the subsections.

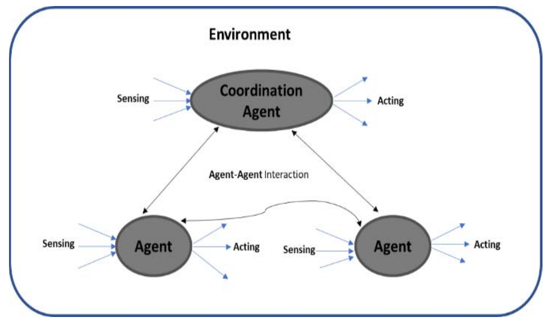

Fig. 1. A multi-agent system, a schematic diagram

A. Search Agent

This section is defining the search agent and its working. The environment of search consists of a wireless sensor network and convolutional neural network. A search agent can detect fire in the smart homes using WSNs and CNN. We used temperature and smoke sensors to detect the fire as well as different cameras to record the videos. Search agent has a trained CNN model to classify the recorded video for fire detection. In the subsections we give detail for formation of WSN and of CNN model.

While setting up the wireless sensor network, various topologies use is possible, conditional on the communication methods and quantity of sensor nodes. The supreme mostly used topologies includes: (i) The star network topologies, (ii) The tree, (iii) The mesh, and (iv) The peer to peer . Relatively, the star topology structure is really proficient related to the other topologies. In this work we used ZigBee protocol. ZigBee protocol is used for communication between the sensor and the home sink. ZigBee is built using standard description of IEEE 802.15.4 and practices protocols with high-level communication to construct private local area networks. It operates on low powered, tiny, digital radio equipment's. ZigBee can also be used for transferring data approximately over a limited distance of 10 to 100 m. This remoteness confides on the conditions related to environment, and it differs for different family units. ZigBee is known to be a low-powered protocol because it requires a negligible quantity of power to transmit and receive data.

Convolutional Neural Networks is a biologically motivated deep neural network. Deep CNNs have very efficient and powerful applications in the field of computer vision like renewal of images, classification, localization, image segmentation and object detection. The fundamental concept behind the CNN is dividing the problem into different subparts, repeatedly, until unless the final solution. A simple CNN model is multi-layer feedforward network consist repeated layers of convolutions and subsampling. The final

978-1-7281-7624-6/20/$31.00 ©2020 IEEE
DOI 10.1109/CSCI51800.2020.00136

layers which are for high reasoning classification of the CNNs. Convolutional layers apply a convolution process on the image (input) and the results are passed to the next layer. At the end it yields features maps. After each convolutional layer, there may be a pooling layer. Pooling layers subsample their input. Finally, after several convolutional and max pooling layers, the high-level reasoning in the neural network is done via fully connected layers.

We used similar design to AlexNet but with little changes according to our problem. We used two neurons as output neuron. Our model consists of three convolutional layers along with 2 max-pooling layers and two fully connected layers.

B. Coordinator Agent

Coordinator agent is for communication between Search and rescue agent. This agent receives the fire detected information and its location from the search agent using the WSN (a network based on ZigBee described in previous section) and send this information to rescue agent. This agent has the ability of conversation between many search and rescue agents. For our work, we specify one coordinator agent for 10 search and 5 rescue agents.

III. Implementation

To estimate the competence and efficiency of our planned work, we implement the search agent components i.e. WSN on Fire Dynamic Simulator, abbreviated as FDS [1] for smart homes as well as the CNN using python. FDS is a simulation software established by NIST for the simulation of fire. It is a computer program which resolves the Navier–Stokes Equations. This SW is written in a computer language called FORTRAN and it has ability to take multiple inputs e.g. Sensors thresholds, Initial values of sensors, Humidity etc. By taking these kinds of inputs, it calculates the Navier–Stokes Equations. Similarly, we used python language to developed the CNN model. Python version 3.6 is used for this purpose.

IV. Results and Discussion

A. Sensors behaviour in terms of energy Consumtion

Energy utilization were calculated during the simulation of fire in FDS for our proposed methodology and we compared it with the 50% and 100% duty cycle. Figure 2 illustrates the results of the comparison. Duty cycles of 50% and 100% specify the active state period of the radio interface. An energy-efficient communication stack possesses less than 1% duty cycle. Each room has a sensor of a pair of 3000mAh AA batteries.

B. Fire detection network results and analysis

To train and test our CNN model, we used Foggia video fire dataset[2], Chino smoke dataset [3], and other datasets. We train our CNN model using 30% of data and remaining 70% data is used for validating and testing. Training done in 80,000 iterations and it used 128 batch size. Initially the learning rate was 0.01 but we used step decay learning process so, every after 1000 iterations it decreases by a factor 0.5. Later, after 40,000 iteration our model learning rate is fixed that is 0.001. We also set momentum value of 0.9

As, to train and test CNN model we used two different datasets. These datasets include fire and smoke images as well as no smoke and no fire images. During the training and testing of both of our model we calculate the training and testing accuracies shown in Figure 3.

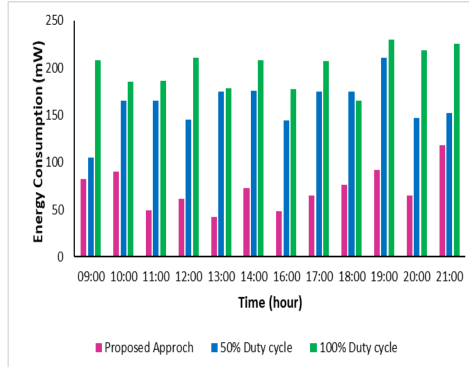

Fig. 2. Comparison of consumption of Energy when the sensors functioned in 50% and 100% duty cycle.

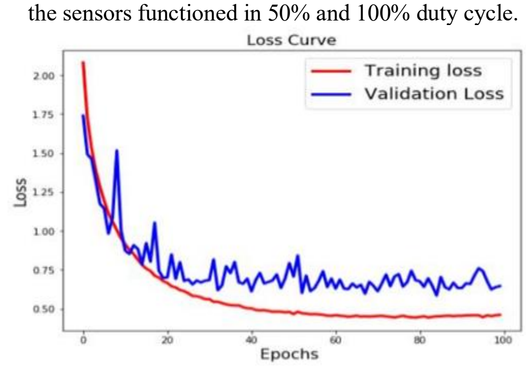

Fig. 3. Training and Validation loss of CNN model

Acknowledgment

This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIT) (No. NRF-2018R1C1B5038818).

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