

Activity Detection Systems Using Infrared Array Sensors With Deep Learning

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Thesis Abstract

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<u>Thesis Summary</u> In assistive care technologies, activity detection is one of the vital tasks to assist people by preventing or at least detecting any accident that might occur. Activity detection has conventionally relied on two leading families of devices: wearable and non-wearable ones. As their name suggests, wearable devices are devices that require the person being monitored to wear them or at least carry them with him/her anywhere (s)he goes, such as smartphones, smartwatches, accelerometers, kinetic sensors, etc. It is a burden to the person to carry the device. Non-wearable devices, on the other hand, do not have such limiting constraints. A device (typically a sensor) is placed in a specific location in the area under monitoring, with no need for the monitored person to worry about its functioning. In recent years, many non-contact activity detection techniques have been proposed using Wireless Fidelity (Wi-Fi), Light Detection and Ranging (LiDAR), radar etc. These approaches have limitations like coverage issues, and deployment issues related to computational resources. The recent introduction of the wide-angle low-resolution infrared (IR) array sensor helped develop device-free monitoring systems to solve most of the issues. Many IR-based activity detection systems have been proposed in recent years. The limitations of the existing works include but are not limited to the difficulty to detect the activity, the non-robustness to the environment, and the computational resource constraints in deployment. To address the aforementioned issues, this thesis proposes activity detection systems using a hybrid deep learning model, which could classify blurriness and noisy images produced by the two wide-angle IR array sensors. One is placed on the wall, and another one is placed on the ceiling. Activity detection technique involves two stages. First, we classify the individual frames collected by the wall sensor and the ceiling sensor separately using a Convolution Neural Network (CNN). In the second stage, the output of the CNN is passed through a Long Short-Term Memory (LSTM) with a window size equal to 5 frames to classify the sequence of activities. Afterwards, we combine the ceiling data and wall data and classify each pair of frames using hybrid deep learning model. Furthermore, we propose an activity detection systems using one IR array sensor on the ceiling allowing for performance comparable to that when using dual sensors. By applying advance deep learning based computer vision techniques, we remove the noise and blurriness in data, which help to improve the IR image quality. The IR images/image sequences are then classified using a hybrid DL model that combines a CNN and an LSTM. By incorporating a wider variety of samples, we use data augmentation to improve the training of			

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neural networks and make the model robust to the environment. A Conditional Generative Adversarial Network (CGAN) performs the data augmentation process. By enhancing the images with Super-Resolution (SR), removing the noise, and augmenting the training data with more samples, the classification accuracy of activity detection can be improved. We used quantization to optimize the neural network so that it could run on low-powered devices.

The contribution of the thesis as follows:

We propose a lightweight Deep Learning model for activity classification that is robust to environmental changes. Being lightweight, such a model can run on devices with very low computation capabilities, making it a base for a cheap solution for activity detection.

The blurriness and noise present in the IR captured frames, due to the sensor characteristics the imprecision in the sensor lead to a noticeable drop in performance in conventional methods. Our proposed neural network architecture manages to address this issue by exploiting the temporal changes in the frames to identify the activities accurately.

We identify the activity using a time window of less than 1 second. Despite the smaller time window, we have remarkably enhanced the classification accuracy in comparison to conventional works, which require a larger time window.

Low Resolution (LR) sensors are always preferred over High Resolution (HR) ones if they provide similar performance. It preserve the privacy of the person and have much lower cost. We demonstrate that it is possible, by using deep learning techniques such as Super-resolution, denoising, and CGAN, to achieve classification performance on the LR data that is nearly identical to that of the classification of the HR data, namely 24×32.