**Biomedical Signal Processing and Control**

This study aims to establish a robust framework for automating the screening of COVID-19 using deep learning-based techniques applied to chest CT-scan images, with the ultimate objective of enhancing early diagnosis, timely treatment, and effective containment of the virus to mitigate its spread and save lives. The proposed method involves the development of this framework, utilizing deep learning models (DLMs) to detect COVID-19 in CT-scan images. These images are resized to meet the chosen DLMs' requirements, and transfer learning is applied to retrain benchmark models, such as DarkNet19 and MobileNetV2. Additionally, a newly designed, lightweight DLM is introduced to classify CT images as COVID or non-COVID. Performance metrics include accuracy, sensitivity, specificity, F-1 score, precision, negative prediction value, Fowlkes-Mallows index, and area under the curve.

In the field of biomedical signal and image analysis, the absence of standardized DLMs necessitates model selection based on performance, classification accuracy, and training efficiency. Many existing DLMs feature complex architectures with numerous layers, increasing the number of learnable parameters. Adjusting kernel size, stride, and other parameters can fine-tune classification accuracy. The proposed DLM, designed for 227x227 images, comprises four Conv2D layers, two pooling layers (PLs), and two fully connected layers (FCLs). It employs 9x9, 7x7, 5x5, and 3x3 kernels with a stride of 2 and max pooling in the PLs, while the FCLs consist of 512 and 2 neurons with a 0.5 dropout rate, offering an effective framework for biomedical image analysis.

DarkNet19, a pre-trained deep learning model, functions with 256x256 input images and serves as YOLOv2's core. With 19 Conv2D layers and 5 pooling layers, it efficiently employs 3x3 convolutional kernels, excelling in real-time object detection by treating the task as a regression problem. Initially trained on ImageNet data, its final layers, including the FCL, SOFTMAX layer, and classification layer, are tailored for ImageNet, featuring a final FCL with 1000 neurons. MobileNetV2, designed for mobile devices with 224x224 input, incorporates features like inverted residuals and linear bottlenecks, distinguishing it from MobileNetV1. The model optimizes depthwise convolution for downsampling and employs a 1x1 convolutional kernel, linear activation, and an FCL with 1000 neurons after training on ImageNet data.

The evaluation of this system's superiority utilizes eight parameters, including accuracy, sensitivity, specificity, F-1 score, precision, negative prediction value, Fowlkes-Mallows index, and area under the curve. Results reveal that classifying COVID and non-COVID subjects requires 620 iterations, with DarkNet19 taking 238 minutes, MobileNetV2 requiring 177 minutes, and the proposed DLM only needing 94 minutes for training in each fold. DarkNet19 achieves the highest average classification accuracy of 98.91%. Training and validation accuracy graphs illustrate that the proposed DLM reaches maximum accuracy in around 200 iterations, while MobileNetV2 and DarkNet19 require approximately 200 and 180 iterations, respectively. The proposed model boasts minimal loss percentage and training time compared to pre-trained DarkNet19 and MobileNetV2, with DarkNet19 covering the most area. Importantly, this system's versatility extends to potential use in screening for other diseases.

ONE PARAGRAGH:

This study aims to automate COVID-19 screening via deep learning on CT-scan images, enhancing early diagnosis and containment. The method includes resizing images, transfer learning, and a lightweight DLM. In biomedical signal/image analysis, the absence of standardized DLMs prompts careful model selection based on performance and efficiency. DarkNet19, a pre-trained model for real-time object detection, and MobileNetV2, optimized for mobile devices, are utilized. The evaluation involves eight parameters, highlighting DarkNet19's highest average classification accuracy of 98.91%. DarkNet19 achieves this using the least training time (238 minutes) compared to MobileNetV2 (177 minutes) and the proposed DLM (94 minutes). The proposed DLM also exhibits minimal loss percentage, and DarkNet19 covers the largest area. Importantly, this system's adaptability extends to screening other diseases.

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author = {Kapil Gupta and Varun Bajaj},

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abstract = {COVID-19 is the most transmissible disease, caused by the SARS-CoV-2 virus that severely infects the lungs and the upper respiratory tract of the human body. This virus badly affected the lives and wellness of millions of people worldwide and spread widely. Early diagnosis, timely treatment, and proper confinement of the infected patients are some possible ways to control the spreading of coronavirus. Computed tomography (CT) scanning has proven useful in diagnosing several respiratory lung problems, including COVID-19 infections. Automated detection of COVID-19 using chest CT-scan images may reduce the clinician’s load and save the lives of thousands of people. This study proposes a robust framework for the automated screening of COVID-19 using chest CT-scan images and deep learning-based techniques. In this work, a publically accessible CT-scan image dataset (contains the 1252 COVID-19 and 1230 non-COVID chest CT images), two pre-trained deep learning models (DLMs) namely, MobileNetV2 and DarkNet19, and a newly-designed lightweight DLM, are utilized for the automated screening of COVID-19. A repeated ten-fold holdout validation method is utilized for the training, validation, and testing of DLMs. The highest classification accuracy of 98.91% is achieved using transfer-learned DarkNet19. The proposed framework is ready to be tested with more CT images. The simulation results with the publicly available COVID-19 CT scan image dataset are included to show the effectiveness of the presented study.}

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**Nuclear Engineering and Technology**

**Abstract**: This study introduces an innovative diagnostic technology that leverages deep learning and IR thermography for system-scale condition classification using Raspberry Pi and IR sensors. The technology efficiently identifies abnormalities or accidents in an entire system, offering real-time accident type and location identification. The experiment involved thermal image measurements and performance validation of major components under various accident conditions in nuclear power plants using compact infrared sensor modules. These thermal images were used to train a deep learning model, specifically convolutional neural networks (CNN), known for image processing. The outcome is a novel diagnostic system capable of component diagnosis, system-wide assessment, and accident classification based on thermal images. The optimal CNN model enables prompt and precise condition monitoring, making it a valuable tool for comprehensive safety monitoring in nuclear power plants.

**Methods:** In this study, a classification-type Convolutional Neural Network (CNN) architecture is employed to enable rapid and accurate thermal image-based system diagnosis. To identify the optimal architecture, several well-established classification models, including AlexNet, GoogleNet, VGGNet, ResNet, and DenseNet, were compared. The choice of architecture is crucial as it directly impacts classification time. The computational efficiency of the architectures was assessed in terms of Multiply and Accumulate per second (MACs), which is closely linked to classification time. The deep learning model's performance relies on various hyperparameters, so adjustments were made to optimize the training process. The study employed the Adaptive Momentum Estimation (Adam) algorithm as the optimizer with a learning rate of 0.001 and a batch size of 4. Training extended over 100 epochs to ensure effective learning without the use of pretrained weights. PyTorch served as the platform for implementing the deep learning application.

**ONE PARAGRAGH:**

This study presents an innovative diagnostic system utilizing deep learning and IR thermography to classify system conditions, offering real-time detection of abnormalities and accidents. Thermal images captured during thermal-hydraulic tests in nuclear power plants were used to train a Convolutional Neural Network (CNN) for component diagnosis, system-wide assessment, and accident classification. The choice of CNN architecture, including AlexNet, GoogleNet, VGGNet, ResNet, and DenseNet, played a crucial role in determining classification time efficiency, assessed through Multiply and Accumulate per second (MACs). The study optimized hyperparameters with the Adaptive Momentum Estimation (Adam) algorithm, a learning rate of 0.001, a batch size of 4, and 100 training epochs without pretrained weights, using PyTorch as the platform for deep learning application. This approach enables rapid and precise condition monitoring, valuable for enhancing safety in nuclear power plants.

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author = {Ik Jae Jin and Do Yeong Lim and In Cheol Bang},

keywords = {System scale diagnosis, Nuclear power plant, Infrared sensor, Deep learning, Convolutional neural network, Fault detection},

abstract = {Comprehensive condition monitoring of large industry systems such as nuclear power plants (NPPs) is essential for safety and maintenance. In this study, we developed novel system-scale diagnostic technology based on deep-learning and IR thermography that can efficiently and cost-effectively classify system conditions using compact Raspberry Pi and IR sensors. This diagnostic technology can identify the presence of an abnormality or accident in whole system, and when an accident occurs, the type of accident and the location of the abnormality can be identified in real-time. For technology development, the experiment for the thermal image measurement and performance validation of major components at each accident condition of NPPs was conducted using a thermal-hydraulic integral effect test facility with compact infrared sensor modules. These thermal images were used for training of deep-learning model, convolutional neural networks (CNN), which is effective for image processing. As a result, a proposed novel diagnostic was developed that can perform diagnosis of components, whole system and accident classification using thermal images. The optimal model was derived based on the modern CNN model and performed prompt and accurate condition monitoring of component and whole system diagnosis, and accident classification. This diagnostic technology is expected to be applied to comprehensive condition monitoring of nuclear power plants for safety.}

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