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Diabetes Detection using Foot Thermography with Deep Learning

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ABSTRACT: The study investigates the detection of diabetes mellitus using deep learning and data augmentation methods applied to foot thermography. With the rising prevalence of diabetes-related complications, early detection is crucial for effective management. Leveraging deep learning models, particularly convolutional neural networks (CNNs), and augmenting the dataset through various techniques, this research aims to enhance the accuracy of diagnosing diabetes through foot thermography. By utilizing a diverse set of data augmentation methods, such as image rotation, flipping, and scaling, the study aims to improve the robustness of the model against variations in foot thermography images. The proposed approach seeks to identify specific thermal patterns associated with diabetic conditions. The integration of deep learning and data augmentation techniques showcases a promising direction for accurate and reliable detection of diabetes mellitus from foot thermography, potentially offering a non-invasive and efficient diagnostic tool for early intervention and treatment.

KEYWORDS: Artificial intelligence, biomedical imaging, computational and artificial intelligence, diabetes, foot thermography, medical diagnostic imaging.

I. INTRODUCTION

The Detection of Diabetes Mellitus with Deep Learning using thermal images represents a cutting-edge approach to diabetes diagnosis and monitoring. Diabetes Mellitus is a prevalent and chronic medical condition that affects millions worldwide, and early detection is crucial for effective management. In recent years, deep learning, a subset of artificial intelligence, has demonstrated remarkable capabilities in analysing thermal images to identify patterns and anomalies related to various health conditions. This innovative application harnesses the power of thermal imaging technology to detect subtle temperature variations and thermal signatures associated with diabetes. By utilizing deep learning algorithms, it promises a non-invasive, cost-effective, and efficient means of screening for diabetes, offering the potential to revolutionize how we approach this disease's early identification and management. This development holds great promise for improving healthcare outcomes and enhancing the quality of life for individuals living with or at risk of diabetes.

II. LITERATURE SURVEY

Paper 1

The study proposes a new method based on deep learning for the early detection of diabetes. Like many other medical data, the PIMA dataset used in the study contains only numerical values. In this sense, the application of popular convolutional neural network (CNN) models to such data are limited. This study converts numerical data into images based on the feature importance to use the robust representation of CNN models in early diabetes diagnosis.

Paper 2

Diabetes foot ulceration (DFU) and amputation are a cause of significant morbidity. The prevention of DFU may be achieved by the identification of patients at risk of DFU and the institution of preventative measures through education

and offloading. The studies have reported that thermogram images may help to detect an increase in plantar temperature prior to DFU. 95% comparison of the inference time for the best-performing networks confirmed that the proposed algorithm can be deployed as a smartphone application to allow the user to monitor the progression of the DFU in a home setting.

Paper 3

In this investigation we use deep convolutional neural networks, using 12 distinct data augmentation approaches, to identify DM patients based on foot thermography alone. For the purpose of synthesizing thermal images of the foot, we use the usage of categorization indices such as the Thermal Change Index (TCI).

Paper 4

The study combines the classification result from a parallel classifier. The use of convolutional neural network (CNN) model of ShuffleNet and MobileNetV2 as the baseline classifier. In developing the classifier model, firstly, the MobileNetV2 and ShuffleNet were trained using plantar thermogram datasets. The framework achieved 100% binary classes of positive and negative cases.

Paper 5

The studies reports that thermogram images may help to detect an increase in plantar temperature prior to DFU. However, the distribution of plantar temperature may be heterogeneous, making it difficult to quantify and utilize to predict outcomes. We have compared a machine learning-based scoring technique with feature selection and optimization techniques and learning classifiers to several state-of-the-art Convolutional Neural Networks (CNNs) on foot thermogram images and propose a robust solution to identify the diabetic foot.

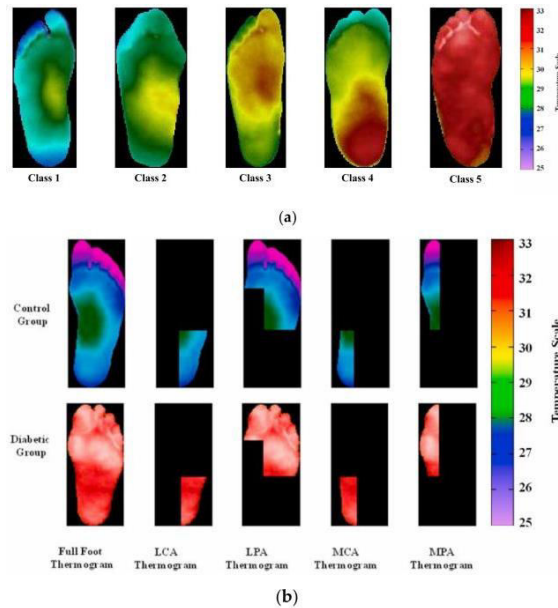
OBJECTIVE

1. To identify diabetes at its earliest stages, allowing for prompt intervention and treatment.
2. To provide a non-invasive and convenient method for diabetes screening, reducing the need for traditional blood tests.
3. To continuously monitor diabetic patients' health by analysing thermal images for variations that indicate changes in their condition.
4. To make diabetes screening more accessible to a wider population, especially in regions with limited healthcare resources.
5. To contribute to more effective and personalized diabetes management, leading to better health outcomes for patients.

III. RELATED WORK

Deep learning, particularly convolutional neural networks (CNNs), has shown great potential for the early detection of diabetic foot ulcers (DFUs) using thermal images. CNNs are able to learn spatial features from images, which can be used to classify pixels as belonging to different classes, such as normal tissue and DFU-affected tissue.

CNN implementation for diabetic foot thermography is as follows[1]. Data pre-processing is the first step to pre-process the thermal images to remove any noise or artifacts. This can be done using various techniques, such as median filtering, contrast enhancement, and image normalization[2]. Once the images have been pre-processed, they can be fed into the CNN model. The model architecture should be designed specifically for the task of DFU detection[3]. Some common CNN architectures that have been used for DFU detection include VGGNet, ResNet, DenseNet, and MobileNet[4]. The CNN model is then trained on a dataset of thermal images of diabetic feet, labelled with the corresponding ground truth labels (DFU or no DFU). The model is trained to minimize the loss function, which is a measure of the difference between the predicted labels and the ground truth labels[5]. Once the model has been trained, it is evaluated on a held-out test set of thermal images. This is done to assess the model's performance on unseen data[6]. Once the model has been evaluated and deemed to be performing well, it can be deployed to a production environment[7]. This means that the model can be used to classify new thermal images of diabetic feet and predict whether or not they are affected by DFU

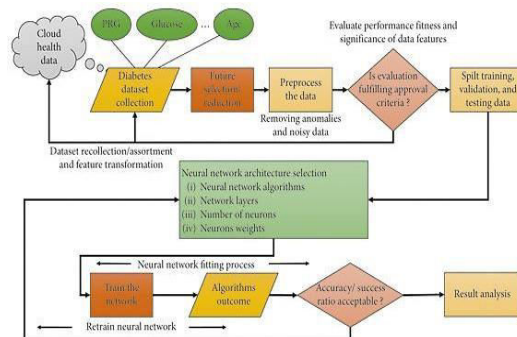


ALGORITHM: Convolutional Neural Network

1. **Convolution layer:** An essential part of the CNN design, the convolution layer extracts features by a combination of linear and nonlinear processes, such as the activation function and convolution operation.
 2. **Nonlinear activation function:** A nonlinear activation function is applied after the outputs of a linear operation, such as convolution. The rectified linear unit (ReLU) is currently the most widely used nonlinear activation function.
 3. **Pooling layer:** This type of down sampling technique lowers the feature maps' in-plane dimensionality, introducing translation invariance to slight shifts and distortions and reducing the number of subsequently learnable parameters.
- 1) **Fully connected layer:** After the final convolution or pooling layer, the output feature maps are usually flattened, or converted into a one-dimensional (1D) array of numbers (or vectors), and linked to one or more fully connected layers, sometimes referred to as dense layers, where each input and each output are connected by a learnable weight. A subset of fully connected layers maps the features recovered by the convolution layers and down sampled by the pooling layers to the final outputs of the network, which in classification tasks are probabilities for each class. The number of output nodes in the last fully linked layer is usually equal to the number of classes.
 - 2) **Activation function:** The last fully connected layer: Typically, this activation function is distinct from the others. A softmax function is used as an activation function in the multiclass classification task to normalize the output real values from the last fully connected layer to the target class probabilities, where all values add up to one and each value ranges from 0 to 1.

IV. PROPOSED SYSTEM

Utilizing deep learning, particularly Convolutional Neural Networks (CNNs), and data augmentation, this system aims to detect Diabetes Mellitus through foot thermography. It involves collecting and pre-processing thermography images, employing augmentation to enhance dataset diversity, training CNN models, and validating predictions. Challenges include data balance and model interpretability, while ethical considerations involve patient privacy and medical validation. The system's success relies on accurate predictions validated by medical professionals, ensuring it meets regulatory standards. This innovative approach amalgamates medical imaging, machine learning, and healthcare expertise for a potentially impactful diagnostic tool in diabetes detection.



V. FUTURE SCOPE

The future scope of Detection of Diabetes Mellitus with Deep Learning using thermal images is highly promising. Further advancements in deep learning models and the continuous expansion of thermal imaging technology are expected to significantly enhance the accuracy and reliability of diabetes detection. Personalized medicine will become more attainable, enabling tailored treatment plans based on individual patient data and thermal imaging results.

VI. CONCLUSION

In conclusion, the application of Deep Learning with thermal images for the detection of Diabetes Mellitus represents a significant step forward in healthcare. This innovative approach offers early diagnosis, non-invasive screening, and continuous monitoring, enhancing the overall management of diabetes. While it has immense potential, it is essential to address limitations and regulatory concerns, ensuring its ethical and accurate use. With ongoing research and development, this technology holds promise in revolutionizing diabetes care by making it more accessible, cost-effective, and efficient, ultimately improving the quality of life for individuals affected by this chronic condition.

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