A Novel Machine Learning Approach for Severity Classification of Diabetic Foot Complications Using Thermogram Images

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INTRODUCTION

Diabetes mellitus can result in severe health complications, including foot ulcers that can lead to lower limb amputations. Early detection of foot ulcers is crucial to prevent further complications, and a temperature monitoring system at home has been found to be effective in identifying diabetic foot ulcers in advance. Thermography is also a non-invasive technique used to examine thermal changes in diabetic feet, and machine learning techniques are being developed to assist medical experts in early diagnosis.

SCAN ME

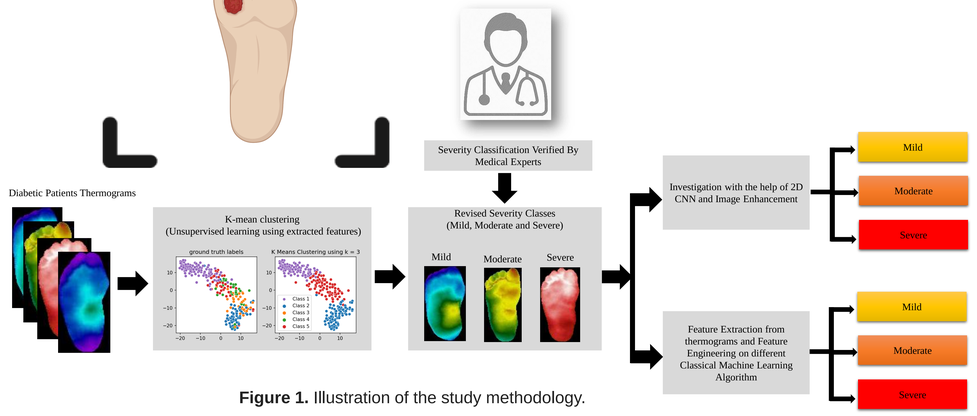

Figure 1. Illustration of the study methodology.

METHODOLOGY

The study applied a methodology involving a pre-trained CNN model, principal component analysis (PCA), and k-mean clustering algorithm to revise classes of thermogram images. The revised classes were then tested using different image enhancement techniques and classical machine learning algorithms, with performance indicators used to select the best algorithm. This study utilized 167 foot-pair thermograms from diabetic and control subjects obtained from various medical centers in Puebla, Mexico. The dataset included demographic information and segmented thermograms of different plantar arteries and feet to compute local temperature distribution and assess ulceration risk.

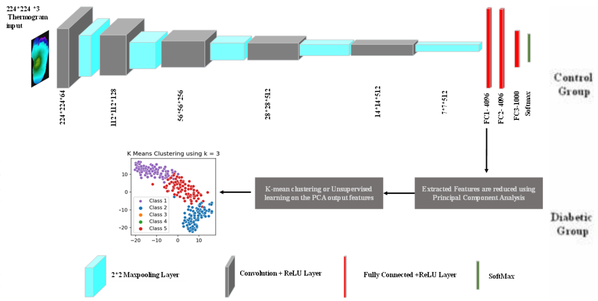

Figure 3. Detailed framework of thermogram image clustering.

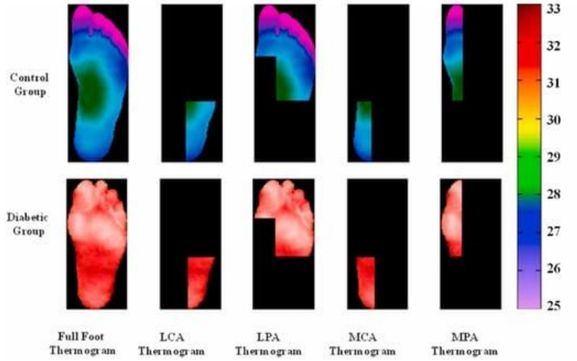

Figure 2. Sample of MPA, LPA, MCA, and LCA angiosomes of the foot for control and diabetic groups

CONCLUSION

The paper proposes a framework to cluster diabetic thermograms based on severity using machine learning, which could aid in early detection and prevention of foot complications. The proposed system could be easily deployed as a web application, allowing patients to benefit from remote healthcare using just an infrared camera and a mobile application. The study successfully proposed a novel framework for clustering diabetic thermograms based on severity, which was verified by medical experts. The machine learning classifiers demonstrated comparable performance to the 2D CNN approach using image enhancement, indicating the potential for the future deployment of the proposed system as a web application for remote healthcare.

DISCUSSION

The authors developed a trained AdaBoost classifier achieving an F1-score of 97% in classifying diabetic and healthy patients using thermogram images. They also proposed a deep learning technique called the diabetic foot thermogram network (DFTNet) for non-convenient classification of plantar thermogram images, which involved taking two classes at a time and then averaging the results after ten folds of different combination of set classes, and found that image enhancement techniques improved classification performance.

Khandakar A, Chowdhury MEH, Reaz MBI, Ali SHM, Kiranyaz S, Rahman T, Chowdhury MH, Ayari MA, Alfkey R, Bakar AAA, Malik RA, Hasan A. A Novel Machine Learning Approach for Severity Classification of Diabetic Foot Complications Using Thermogram Images. Sensors. 2022; 22(11):4249. https://doi.org/10.3390/s22114249

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