Cervical Cancer Detection and Classification in Pap smear Images using Enhanced Deep Learning Models

ABSTRACT

Cervical cancer (CC) is the most significant contagious disease possessing women's health by infecting Human PapillomaVirus (HPV) in cervix. Considering, the life daring outcomes of cervical cancer in later stage, early detection is considered crucial. However, past studies employed manual methods like Manual Liquid-based Cytology (MLBC) and Visual Inspection with Acetic acid (VIA) to identify cancerous cells. Meanwhile, the promising limitations including a high error rate, labor-intensive processes, and the need for specialized expertise have been witnessed in existing studies. Furthermore, Artificial Intelligence (AI)-based solutions are explored in this study to overcome the above mentioned shortcomings. Since, AI models are capable of analyzing huge volume of datasets to achieve precise results, it showcase more accurate detection and classification of cervical cancer cells. At present, the AI-based solution for cervical cancer detection and classification has reported suboptimal accuracy in their models. The major aim of this research is to enhance the accuracy of AI-based solution for CC detection using enhanced Deep Learning (DL) models. Three DL models have been enhanced using dissimilar pre-processing and segmentation technique with three distinct mechanisms for accurate classification of cervical cancer cells. These models are evaluated using two datasets: the Herlev dataset used for classification of single-cell images and SIPaKMeD for multi-cell classification in cervical cancer. The methodology encompasses four key stages in three models for detection and classification of cervical cancer: pre-processing, segmentation, feature extraction, and classification.

The three models for CC detection and classification are described below. In Model-1, pre-processing based on diffusion stop function using Contrast Limited Adaptive Histogram Equalization (CLAHE) is utilized along with Topographic Weibull bounding-based segmentation, and segmented image is trained using radiance and variance enabled Deep Learning Neural Network for detection and classification. Model-2 pre-processes by employing the combination of Anisotropic Diffusion Filter (ADF) – histogram-based pre-processing and improved-Weighted Fuzzy C-Means (i-WFCM) - based segmentation; the CC is detected and classified using Restricted

Boltzmann machine –Deep Belief Network (RBM-DBN). Model-3 performs ADF-Dragon Fly Optimization-based pre-processing along i-WFCM with Grasshopper Optimization Algorithm (GOA) -based segmentation techniques; Further, Deep Convolutional Neural Network with Rectified Linear Unit (DCNN with ReLU) is incorporated for classification. These models classify the single cell images from Herlev dataset into 7 classes; superficial, intermediate, columnar, light, moderate, severe, and carcinoma. Whereas multi-cell images from SiPaKMed dataset into 5 classes; superficial, koliocytotic, parabasal, dyskeratotic, and metaplastic. In addition, the proposed three models are evaluated using different performance measures namely accuracy, precision, recall and F1-measure. Out of the three models Model-3 achieves better performance than other models with 97.2% accuracy, 91.3 % precison, 96.9 % recall, and 94.02 % F-measue for multi-cell Classification; in contrast, model-3 achieved 96.7% accuracy, 85.1 % precision, 95.2 % recall, and 89.8 % F-measure for single cell classification in cervical cancer detection. However, evaluating the present research work using real images in a software application could aid the medical professionals in real-time for identifying the cancerous cells with the aim of saving patients' lives lynching in cervical cancer disease.