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# Cervical Cancer Segmentation and Classification from Pap Smear Images using Deep Neural Networks

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**Abstract** – Cervical cancer is a significant worldwide cause of mortality, despite its preventability and treatability with early removal of affected tissues. Cervical screening programs must be universally accessible and efficiently implemented, a challenging endeavor that requires, among other factors, the identification of the most susceptible segments of the population. This paper introduces an efficient deep-learning approach for the classification of multi-class cervical cancer using Pap smear pictures. The enhanced SE-ResNet152 model, based on transfer learning, is used for efficient multi-class categorization of Pap smear images.

The suggested network model accurately extracts trustworthy and relevant picture characteristics. The network's hyperparameters are tuned with the Deer Hunting Optimization (DHO) technique. Eleven classifications for cervical cancer illnesses include five categories from the SIPaKMeD dataset and six categories from the CRIC dataset. A dataset of Pap smear pictures including 8,838 images with diverse class distributions is used to assess the suggested methodology. The use of the cost-sensitive loss function during the classifier's training addresses the dataset's imbalance. The suggested technique achieves 99.68% accuracy, 98.82% precision, 97.86% recall, and 98.64% F1-Score on the test set, surpassing previous methods in multi-class Pap smear picture classification. The suggested technique yields superior identification outcomes for the automated preliminary diagnosis of cervical cancer in hospitals and clinics, attributable to its favourable categorization findings.

***Keywords****: Cervical, preventability, trustworthy, surpassing, favourable.*

## INTRODUCTION

Cervical cancer is the fourth most frequent cancer among women globally and the seventh most common cancer overall. Cervical cancer is mostly caused by early sexual activity, inadequate menstrual hygiene, the use of oral contraceptives, tobacco use, immunosuppression, early pregnancy, and sexual relations with many partners [2, 3]. Cervical cancer diagnosis often employs cytopathology screening [4]. The physician use brushes to obtain cells from a patient's cervix during a cervical cytopathological assessment, and the exfoliated cells are then positioned on a glass slide [5]. Cytopathologists analyze malignant tumors under a microscope to determine their nature [6]. Each slide has thousands of cells. Consequently, manual examination is intricate, and experts are prone to errors. A more effective solution is necessary for this problem [7, 8].

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This problem is addressed via the development of automated computer-aided diagnostic (CAD) systems. Swift and dependable examination of pap smears is achievable using CAD [9]. The foundation of early CAD included conventional machine learning and image processing methods; the manually generated features may provide suboptimal classification outcomes [10, 11]. Recent developments in deep learning technology have occurred across several sectors, including natural language processing (NLP), medical imaging, and computer vision, among others. Deep learning is an advanced kind of machine learning that autonomously acquires features for categorization purposes.

Numerous labeled datasets are required to train a deep learning model [13, 14]. A widely used deep learning architecture is the Convolutional Neural Network (CNN), often used in image identification, classification, and segmentation.

The study delineated herein is confined to diverse cervical cancer patients, which provide more categorization challenges than previous methodologies [17]. The optimal CNN model is selected based on a comprehensive experiment [18]. Ultimately, it evaluates the amalgamation of performance improvements, including optimizer selection and image enhancement [19, 20]. The suggested technique integrates the generalization and excellent performance of deep learning algorithms for classification. It is recommended to use transfer learning to categorize Pap smear pictures into several categories of cervical cancer illnesses via a deep learning-based hybrid network model.

The primary contributions of the research are as follows:

• picture pre-processing is used to improve the quality of picture data by eliminating undesirable distortions. Mathematical morphological techniques are used for picture improvement to augment classification efficacy.

Upon concluding a pre-processing phase, the improved SE-ResNet152 model, based on transfer learning, is used for efficient classification. The proposed approach accurately categorizes Pap smear pictures into 11 groups using the CRIC and SIPaKMeD datasets.

The suggested network model effectively extracts accurate disease picture characteristics for effective classification outcomes. The hyperparameters of the CNN are adjusted by DHO optimization techniques, yielding enhanced accuracy in the diagnosis of various illnesses.

The suggested technique is evaluated using publicly accessible datasets. The tests are conducted using the Python platform.

The suggested method surpasses the efficiency of all existing techniques, as shown by the experimental results.

The structure of the piece is as follows. Part 2 of the article examines advanced techniques for the classification of Pap smear pictures. Section 3 delineates the deep learning-based models suggested for the classification of Pap smear images. We also address the databases used for the experimental evaluation of the efficacy and performance of the suggested methodology. Section 4 delineates the assessment criteria and results.

The study concludes in Section 5.

## LITERATURE SURVEY

This section examines available deep learning algorithms for the classification of cervical cancer using Pap smear pictures. Desiani et al. [21] introduced the Bi-path architecture, which integrates picture segmentation and categorization. This work proposes many image processing phases, including enhancement, segmentation, and classification, for the recognition and identification of cervical cancer features in Pap smear pictures. Image quality is enhanced by techniques such as Normalization, CLAHE, and Adaptive Gamma Correction prior to segmentation. Segmentation using the CNN architecture constitutes the first phase. The use of KNN and ANN algorithms for data segmentation results in a secondary pathway, namely a classification step.

Yaman et al. [22] proposed a method for the early detection of cervical cancer with an example pyramid construction. This framework is mostly used for feature extraction. The study seeks to classify cervical cells in pap-smear pictures for the identification of cancer.

The model pyramid deep feature generator was developed using the SIPaKMeD and Mendeley Liquid-Based Cytology (LBC) datasets. The proposed feature generator produces 21,000 features by transfer learning-based feature extraction from DarkNet19 or DarkNet53 networks inside an illustrative pyramid structure.

Employing Neighborhood Component Analysis (NCA), the Support Vector Machine (SVM) technique classifies the 1000 characteristics selected by NCA.

Diniz et al. [23] present a simple but effective ensemble strategy to enhance the categorization problem. A data augmentation approach is implemented to rectify the dataset imbalance. This study offers categorization analyses for two, three, and six categories. Multiple pap smear picture classification tasks are performed with the deep learning-based EfficientNet model.

In their proposal [24], Alquran et al. used the distinctive Cervical Net and Shuffle Net to create a computer-assisted cervical cancer diagnostic system. Five hundred forty-four resultant features are automatically extracted using a pre-trained convolutional neural network integrated with an innovative Cervical Net architecture. PCA is used to reduce dimensionality and choose the most essential characteristics.

Win et al. [25] developed an innovative computer-assisted cervical cancer screening method. The cervical cancer screening method relies on the examination of Pap smear pictures.

The cervical cancer screening procedure comprises four essential stages. Nuclei were identified in cell segmentation by an iterative shape-based method. During the feature extraction phase, three notable characteristics were derived from the areas of segmented nuclei and cytoplasm. The feature selection method used was Random Forest (RF). Bagging ensemble classifiers, including bagged trees, boosted trees, KNN, SVM, and LD, were used to amalgamate the outputs of five classifiers in classification tasks.

Hussain et al. [26] created a segmentation and classification algorithm for Pap smear pictures. The Unet model is recommended for this categorization. This model integrates a fully convolutional layer, densely linked blocks, and residual blocks inside the U-Net architecture.

To ensure feature reusability, the standard U-Net's convolutional layers have been substituted with densely linked blocks. Residual blocks have been included to enhance the pace of network convergence. A stacked auto-encoder model for form representation learning precedes the proposed method to enhance the dependability of the overall network.

Bhatt et al. [27] presented multi-class categorization of cervical cells via Whole Slide Imaging (WSI) with optimum feature extraction. The Conv-Net with a Transfer Learning technique demonstrates substantial efficacy in diagnosing major metamorphic pre- and post-neoplastic lesions. The Conv-Net with a Transfer Learning technique has substantial efficacy in diagnosing metamorphic pre- and post-neoplastic lesions.

The extracted morphological cell characteristics may be recursively transmitted by the model to subsequent Neural Network layers for enhanced learning.

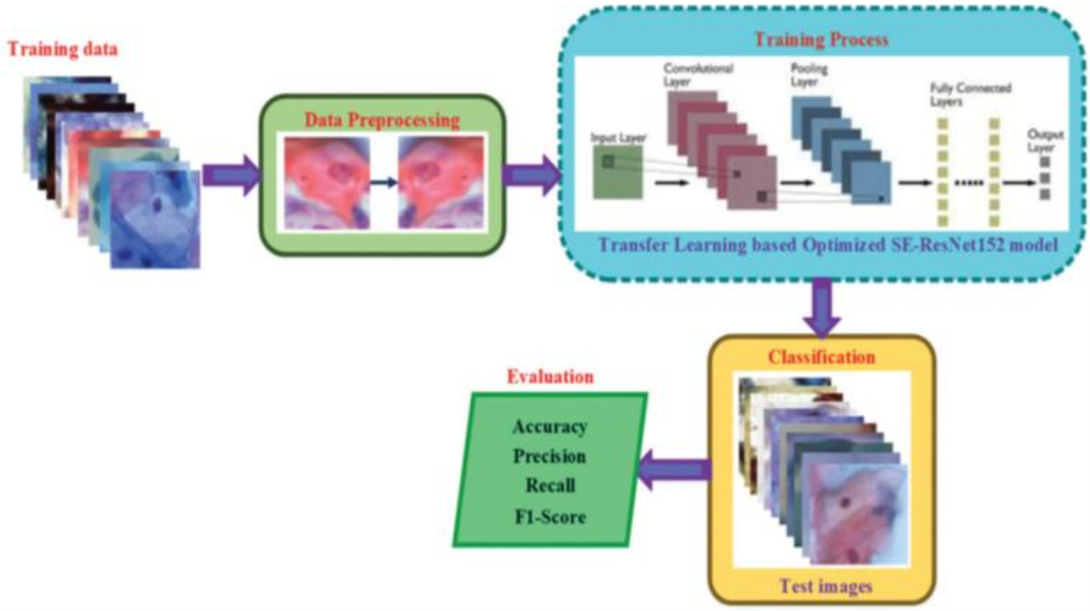
## PROPOSED METHODOLOGY

The primary objective of the proposed model is to assess several ways for enhancing classification using an experimental approach aimed at improving the efficacy of automated multi-class cervical cancer classification and detection. This study classifies the 11 categories of cervical cancer disorders (multi-class classification) as ASC-H, ASC-US, SCC, HSIL, LSIL, NILM, Dyskeratotic, Koilocytotic, Metaplastic, Parabasal, and Superficial-Intermediate. The integration of CRIC and SIPaKMeD dataset pictures is used to evaluate the suggested model using Pap smear images. The data were acquired from publically accessible free sources.

Contrast enhancement in image pre-processing is achieved by the use of mathematical morphological techniques on Pap smear pictures. An improved SE-ResNet152 model based on transfer learning for the classification of various cervical cancer conditions was suggested.

The hyperparameters are tuned using the DHO optimizer.

The schematic representation of the suggested methodology is provided.



## Image Pre-processing

Mathematical morphology has been used to improve contrast in Pap smear pictures. The structural properties of objects underpin the functioning of mathematical morphology approaches. These strategies use interactions among classes and fundamental mathematical principles to discern picture components and elucidate spatial connections. Two distinct data sets serve as input for morphological operators. Equations 1 and 2 delineate the erosion and dilation operators in morphological operations. This procedure denotes the gray-level image matrix identifier and specifies the structural element.

This section analyzes several performance metrics used to evaluate the method, contrasts the suggested approach with contemporary state-of-the-art techniques, and conducts comparisons. The experimental evaluation is conducted using Python. The input needs of each model are met by standardization.
Dimensions and resolution of the photos. Multiple cervical cancer conditions are categorized using the transfer learning-optimized SE-ResNet152.

## Datasets

### CRIC

400 standard Pap smear pictures from the CRIC collection, with 11,534 cells identified manually. There are six distinct categories of images: negative for intraepithelial lesion or malignancy (NILM); low-grade squamous intraepithelial lesion (LSIL); high-grade squamous intraepithelial lesion (HSIL); squamous cell carcinoma (SCC); atypical squamous cells of undetermined significance (ASC-US); and atypical squamous cells that cannot exclude a high-grade lesion (ASC-H). This article only utilizes cropped photos, including 4789 images of isolated cervical cells. Figure 3 presents many instances of photographs from the CRIC dataset.

### SIPaKMeD

The SIPaKMeD dataset enables cervical cell image classification tasks. The photos captured by the webcam and then cropped into 4049 cervical cell images assist in augmenting this dataset. The pictures are classified into five categories: superficial intermediate, parabasal, metaplastic, koilocytotic, and dyskeratotic. Figure 4 presents many sample photos from the SIPaKMeD dataset.

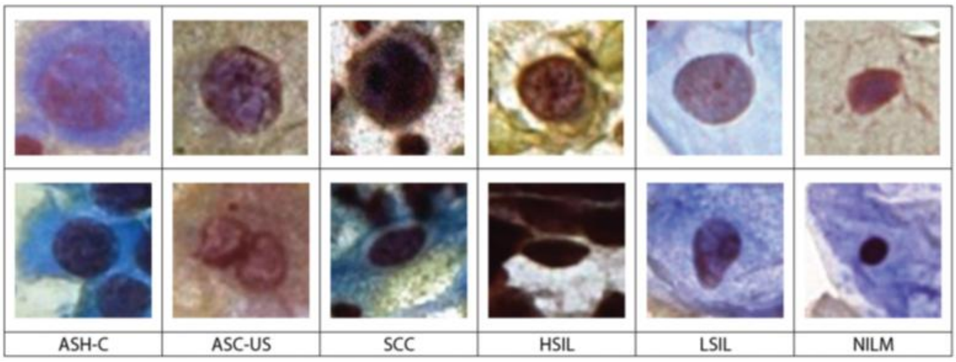



**Fig. 3. Sample images of a CRIC dataset**

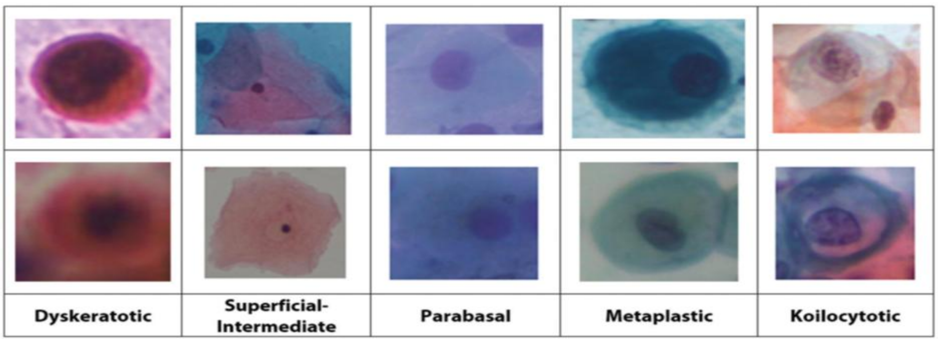
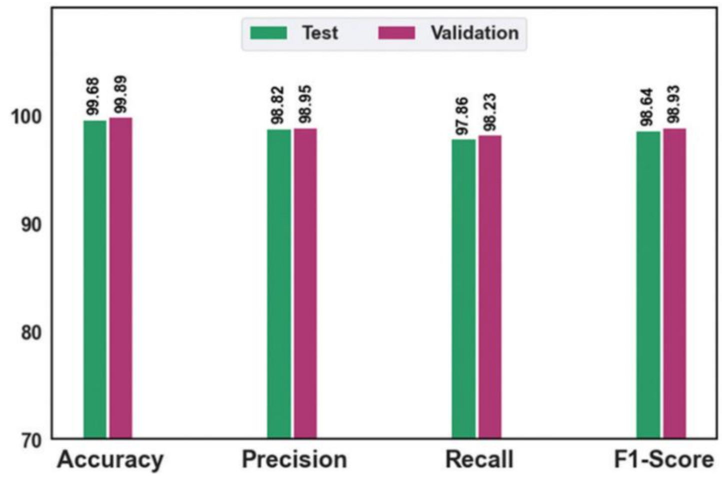



**Fig. 4. SIPaKMeD dataset images**




**Advantages of the proposed approach**

The proposed model effectively extrapolates features that delineate the inter-scale variability of the illnesses, hence improving classification performance.

The suggested technique for identifying Pap smear pictures outperforms current methods, with an accuracy of 99.68%, precision of 98.82%, recall of 97.86%, and an F1-Score of 98.64%. The suggested model's remarkable classification accuracy enables the automated detection and pre-screening of cervical cancer diseases.

**Disadvantages of the proposed approach**

The experimental findings demonstrate that the suggested method is capable of classifying various cervical cancer types.

This area requires more investigation. The suggested method demonstrated superior accuracy relative to the other models. Several constraints are outlined here.

The limitation of the suggested strategy is that the dimensions of concatenated features are larger. In the future, it may be feasible to reduce this collection of characteristics using a feature reduction technique. Transfer learning models are often complex, including several layers and parameters. We will use hybrid hyperparameter optimization for efficient parameter adjustment and reduction.

## CONCLUSION

This research proposes a transfer learning-optimized SE-ResNet152 model as a deep learning framework for cervical cell classification tasks. The suggested model was trained and evaluated using a substantial dataset of photographs. Initially, these photos undergo pre-processing for noise reduction and contrast enhancement. The SE-ResNet152 model, using transfer learning and a DHO optimizer, is used to evaluate this picture dataset for the classification and identification of various cervical cancer illnesses (11 classes). The differentiation of Pap smear pictures exhibits exceptional accuracy and sensitivity, accompanied by a significant reduction in detection time and epochs, as shown by the suggested model's findings. The proposed transfer learning-optimized SE-ResNet152 model accurately detects Pap smear pictures with an overall accuracy of 99.68%. The experimental findings on segmentation benchmarks indicated that the proposed model significantly surpassed most current deep learning network models and achieved performance equivalent to other standard cervical cancer classification methods.

To improve the efficacy of the suggested method, we shall endeavor to use several novel model configurations in the future. In conjunction with revising the module structure, enhancing the ability to extract characteristics is feasible. In the future, various data pre-processing techniques, such as random cropping and color jittering, will be used to improve the model's generalization capabilities.

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