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A Recent Systematic Review of Cervical Cancer Diagnosis: Detection and Classification

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ABSTRACT

Women around the world are frequently diagnosed with cervical cancer. In the beginning, there are no symptoms for the fourth most common cause of fatality in women. Cells of cervical cancer develop gradually at the cervix. Several studies have mentioned that early detection of cervical tumor is very important for the cancer to be properly treated and to make sure the cancer can be successfully treated while minimizing deaths due to cervical cancer. The diagnosis of such cancer before it spread fast is currently a pressing issue for healthcare professionals. The systematic analysis has many benefits above conventional literature reviews. These evaluations can be improved by having a more defined review procedure, a more important topic of study, and fundamental priorities that can control research bias. This also provides a comprehensive understanding of the physical characteristics of the healthy and unhealthy cervix and aids in early treatment planning by giving detailed information about one another. Utilizing image segmentation, a number of techniques are employed to find malignancy. The dataset contains four distinct pathological pictures, including normal, malignancy, and high-grade squamous intraepithelial lesions (HSIL). While pap tests are the most popular way to diagnose cervical cancer, their accuracy depends a lot on how well cytotechnicians can use brightfield microscopy to spot abnormal cells on smears.

Keywords:

Cervical, cancer, detection and classification

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1. Introduction

The most common cancer and severe disease that currently endangers the women's health is cervical cancer. The cancer cell grows in women's cervixes. Due to the relatively low survival rate, cervical cancer is often seen as the biggest curse on women's societies around the world. This takes decades to develop, but if detected early enough, it may be preventable.

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There are three different types of cervixes. Type I, II, or III The correct cervix type must be identified in order for the treatment to be effective. The three categories differ by a very small margin. Thus, it becomes challenging for medical professionals to identify the appropriate type of cervix. However, regular screening was found to improve the prognosis of cervical cancer at an early stage to improve the rate of survival for patients around the world.

The fatality rate of cervical cancer patients can be reduced if the disease is detected early and accurately (CC). Pap smear image analysis could be used to prevent cervical cancer. The most popular screening procedure for the cervical lesion is a Pap smear test and visual inspection with acetic acid to classify the cervical cells as normal, precancerous, or cancerous. This test detects pre-neoplastic alterations in cervical epithelial cells; proper screening can prevent disease-related fatalities. A cytopathologist does Pap smear test analysis visually, which is tough and repeated job. Existing models lack significant feature extraction and representation skills, as well as pathological classification. Developed techniques had a variety of limitations, such as lower performance accuracy, high computational complexity, larger feature dimensionality, lack of reliability, and more time consumption due to insufficient hyperparameter optimization. Manual analysis took longer in the case of cervical cancer detection. Missed diagnoses and misdiagnoses are common as a result of the great similarity in pathological cervical images, the vast number of readings, the long reading time, and pathologists' insufficient experience levels.

Early detection and diagnosis are critical in the treatment of cervical cancer. The pap-smear test is the gold standard for detecting cervical cancer. Machine learning is one of a developed approach for autonomously diagnosing cervical cancer, and various computer vision/deep learning-based models have been studied in from previous works. Cervical cancer has fewer symptoms in the early stages. Cancer research is critical because cancer prognosis allows for clinical applications for patients. Cervical cancer automated screening technology is essential for reducing the incidence of cervical cancer. However, the existing technique has flaws: it is inefficient, inaccurate, and has poor generalization ability, especially in complicated situations. A number of cervical cancer research have highlighted artificial intelligence models. Despite recent scientific improvements, there is no completely successful treatment, particularly when diagnosed at an advanced stage. Cervical cancer cases have been significantly reduced as a result of screening procedures such as cytology and colposcopy. Cervical cancer screening using Pap smear is a very useful cell imaging-based detection technique in which cells must be recognized as belonging to one of a plethora of ordinal groups ranging from abnormal to normal.

2. Material and Methods

Around the globe, one of the most important present debates about systematic evaluations is occurring. Unfortunately, only a limited number of studies were carried out in Malaysia as part of the cervical cancer overview [1–3]. The approach adopted to obtain solutions to the research questions asked by the existing research, on the other hand, is described in the next section. The goals of this paper are to investigate and thoroughly explore the cervical cancer in two approaches: (1) detection and (2) classification. A sub-objective is also to investigate the in-depth occurrence rate and how it is handled. Following that, this section reviews and synthesizes scientific literature in an attempt to identify, select, and assess significant cervical cancer studies. Lastly, we aimed to suggest further research in response to the stated challenges in this article. The pre-recording systematic reviews and meta-analysis (PRISMA) technique, which is an accepted standard for performing a systematic literature review, is used in this research. In essence, publication rules were created to assist authors in determining the precision of a review by providing important and required facts. The randomized

investigations assessments survey that may be a significant aspect in systematic analysis reports for various types of research is also highlighted by PRISMA [4]. Given their robustness, three databases were utilized to examine the methodology of this research: Web of Science and Scopus. However, no database is thorough and full, including Scopus and WoS. The four primary sub-sections, namely identification, screening, eligibility, and data abstraction, are also discussed in this section.

2.1 Identification

The systematic review approach comprises three major phases in selecting various eligible publications for this review. The initial stage was to recognize keywords and search for related, comparable terms using the dictionaries, thesaurus, encyclopedia, and past studies. As a result, after deciding on all relevant terms, search strings for Web of Science and Scopus databases were produced (see Table 1). Thus, we effectively collected 3400 papers from databases during the first step of the systematic review process.

Table 1

The search strings

| | |
|-----------------------|---|
| Scopus | TITLE (cervi* AND cancer AND (detect* OR classi*)) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (PUBYEAR , 2022) OR LIMIT-TO (PUBYEAR , 2021)) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (SRCTYPE , "j")) AND (EXCLUDE (SUBJAREA , "MEDI") OR EXCLUDE (SUBJAREA , "BIOC")) |
| Web of Science | TI=((cervi* AND cancer AND (detect* OR classi*)) |

2.2 Screening

During the initial round of screening, duplicate papers were eliminated. The first stage of the study rejected 3345 papers, whereas the second stage screened 17 papers based on the scholars' various exclusion and inclusion criteria. As literature (research articles) is the major source of practical advice, it was the first criterion used. It also covers systematic reviews, reviews, meta-synthesis, meta-analysis, books, book series, chapters, and conference proceedings excluded from the latest research. Furthermore, the review was limited to English-language publications. It is important to keep in mind that the plan was established for the past two-year period (2021-2022). In order to meet the analysis objective, only research executed within Malaysian jurisdiction was chosen. In all, 30 publications were eliminated predicated on particular criteria.

2.3 Eligibility

A total of 38 articles are included in the third level, called eligibility. At this stage, all article titles and important text were carefully scrutinized to confirm that the inclusion criteria were satisfied and that the articles were appropriate for the current study's research objectives. As a result, 8 papers were removed since their title and abstract were not significantly relevant to the study's objective based on empirical data. Finally, 30 articles have been made available for review (see Table 2).

Table 2

The selection criterion is searching

| Criterion | Inclusion | Exclusion |
|---------------|----------------------------------|--|
| Language | English | Non-English |
| Timeline | Between 2021 – 2022 | < 2021 |
| Sources type | Journal (only research articles) | Conference proceeding |
| Document Type | Article | Letter, Review, Conference, Note |
| Research Area | Computer Science and Engineering | Besides Computer Science and Engineering |

2.4 Data Abstraction and Analysis

In this study, an integrative analysis was employed as one of the assessment strategies to examine and synthesize numerous research designs (quantitative, qualitative, and mixed methods). The goal of the expert study was to identify relevant topics and subtopics. The data collecting stage was the initial step in the theme’s development. As depicted in Figure 1, the authors meticulously analyzed a compilation of 30 publications for assertions or material relevant to the present study’s topics. The authors next assess cervical cancer’s impact throughout the identifying and establishing significant groupings in the second stage. The detection and classification impact are the two key topics that evolved from the method. The authors then continued each established subject, along with any themes, notions, or ideas, from this point forward. The writer cooperated with other co-authors to create themes depending on the evidence in the context of this research. Throughout the data analysis process, a log was kept to record any analyses, views, riddles, or other thoughts pertinent to the data interpretation. Finally, the authors contrasted the results to see any inconsistencies in the theme design process. It is worth mentioning that if there are any discrepancies amongst the concepts, the authors discuss them between themselves. Eventually, the produced themes were tweaked to ensure that they were consistent. Experts carried out the analysis, one specializing in public health and the other in medical science, to establish the validity of the problems. By establishing domain validity, the expert review phase helps assure the clarity, importance, and suitability of each sub-theme. On the basis of comments and professional judgments, the writer makes amendments to his or her judgment.

3. Results

As public health concerns the region's expansion and success, the disease has grown in importance. Thirty (30) articles were extracted and analysed using the search technique. All papers were classified into two categories: detection and classification.

3.1 Detection

Cervical intraepithelial neoplasia (CIN) and cervical cancer are important health concerns for women all over the world. By evaluating swab images, the traditional Papanicolaou (Pap) smear study is an efficient approach for diagnosing cervical pre-malignant and malignant diseases. Besides evaluating the Pap smear image, several computer vision approaches can be explored to identify potential precancerous and cancerous tumours. The majority of present research focuses on binary

classification systems that employ various classifiers and Convolutional Neural Networks. However, algorithms have inherent challenges with minute feature extraction and correct classification.

A cervical cancer screening can provide information about the presence of cervical cancer Pap-smear by detecting the cell shape pattern on the Pap-smear image. The manual screening method for classifying cells is a difficult and error-prone task. Several research have been conducted on the classification of cervical cell pictures that are not always segmented first. Segmentation is critical for obtaining the features contained in the image of cervical cells, such as the cell nucleus and cytoplasm. However, the quality of the images affects the segmentation results.

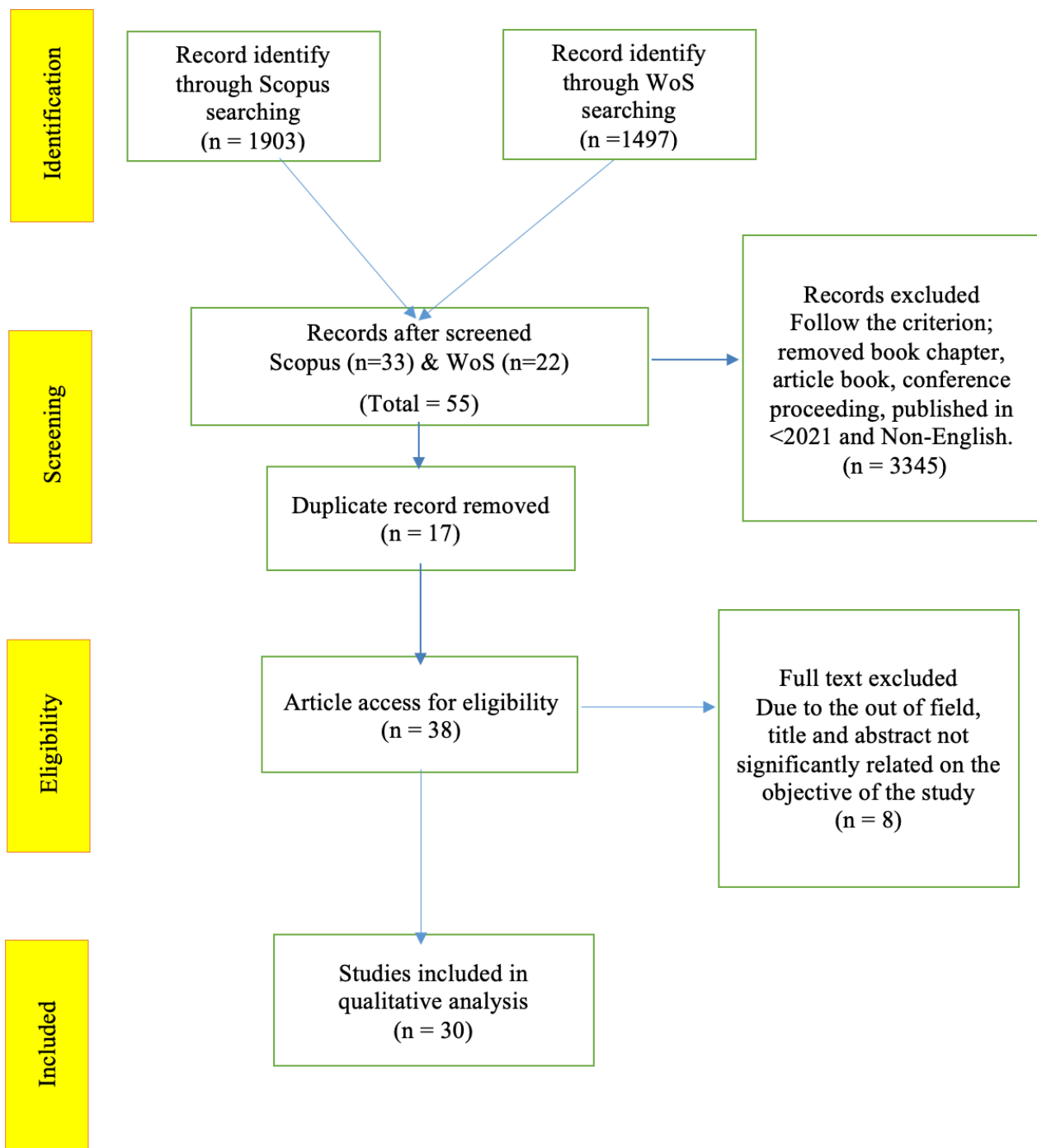


Fig. 1. Flow diagram of the proposed searching study

The paper's optimization approach enhances network sensitivity and overall accuracy, particularly in complicated backgrounds. The findings in this work will be useful in the development of an automatic cervical cancer diagnosis system in the future. Random Tree (RT) algorithms achieved the highest classification accuracy for biopsy (98.33%) and cytology (98.65%) data, while Random Forest (RF) and Instance-Based K-nearest neighbour (IBk) algorithms delivered the best performance for Hinselmann (99.16%) and Schiller (98.58%) data, respectively. Among the feature transformation approaches, logarithmic performed best for biopsy datasets, whereas sine function performed best for cytology. For the Hinselmann dataset, the logarithmic and sine functions worked best, whereas the Z-score performed best for the Schiller dataset. To identify and prioritise relevant risk variables, various Feature Selection Techniques (FST) approaches were applied to the converted datasets. The findings of previous research demonstrate that employing clinical data, appropriate system architecture and tuning, machine learning approaches, and classification may identify Cervical Cancer effectively and efficiently in during its early stages.

Table 3
 Summary of detection method

| Authors | Title | Journal | Methodology | Result and Advantages |
|---|--|--|--|--|
| Jia D., He Z., Zhang C., Yin W., Wu N., Li Z. [10] | Detection of cervical cancer cells in complex situation based on improved YOLOv3 network | Multimedia Tools and Applications 2022 | YOLO algorithm by improving the algorithm k-means++ is used to restore the clustering algorithm k-means in the original yolov3 to cluster the target frame. Segmentation of the cell using | MAP of 78.87% 8.02%, 8.22% and 4.83% higher than SSD (Single Shot Multi-Box Detector), YOLOv3 (You Only Look Once) and ResNet50. |
| Anousouya Devi M., Sheeba J.I., Joseph K.S. [14] | Neutrosophic graph cut-based segmentation scheme for efficient cervical cancer detection | Journal of King Saud University - Computer and Information Sciences 2022 | Neutrosophic Graph Cut-based Segmentation (NGCS) | Average of 13% increment comparing to the traditional graph cut oriented cancer detection approaches. Increment of values: - Accuracy 5.24% Sensitivity 4.25% Specificity 4.65% Precision 5.21% Recall 4.76% |
| Ali M.M., Ahmed K., Bui F.M., Paul B.K., Ibrahim S.M., Quinn J.M.W., Moni M.A. [15] | Machine learning-based statistical analysis for early-stage detection of cervical cancer | Computers in Biology and Medicine 2021 | Application of three feature transformation methods, including log, sine function, and Z-score. | A Random Tree (RT) accuracy biopsy (98.33%) cytology (98.65%) Random Forest (RF) and Instance-Based K-nearest neighbor (IBk) provided the best performance for Hinselmann (99.16%), and Schiller (98.58%) respectively. |
| Zhang C.W., Jia D.Y., Wu N.K., Guo Z.G., Ge H.R. [16] | Quantitative detection of cervical cancer based on time series information from smear images | Applied Soft Computing 2021 | Combination of the fine-tuned Long Short-Term Memory Fully Convolutional Network and Fuzzy Nonlinear Regression. | Accuracy 98.3% Sensitivity 98.1% Specificity 97.9%. |

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| Chitra B., Kumar S.S. [25] | An optimized deep learning model using Mutation-based Atom Search Optimization algorithm for cervical cancer detection | Soft Computing 2021 | The Mutation-based Atom Search Optimization (MASO) algorithm is developed to optimize the hyperparameters in DenseNet 121 architecture. | Accuracy 98.38% Sensitivity 98.83% Specificity 98.5% Precision 98.58% Recall 99.3% F-score 98.25% |
| Cao L., Yang J., Rong Z., Li L., Xia B., You C., Lou G., Jiang L., Du C., Meng H., Wang W., Wang M., Li K., Hou Y. [17] | A novel attention-guided convolutional network for the detection of abnormal cervical cells in cervical cancer screening | Medical Image Analysis 2021 | Attention feature pyramid network (AttFPN) with multi-scale region-based feature fusion network | Online Database Sensitivity = 95.83% Specificity = 94.81% Accuracy = 95.08% AUC = 0.991 External Dataset (110 cases and 35,013 images) Sensitivity = 91.30% Specificity = 90.62% Accuracy = 90.91% AUC = 0.934 Diagnostic time is 0.04s/image compare to average time of pathologist 14.83s/image. |
| Devi, N. Lavanya; Thirumurugan, P. [40] | Cervical Cancer Classification from Pap Smear Images Using Modified Fuzzy C Means, PCA, and KNN | IETE Journal of Research 2021 | Modified fuzzy C-means The geometrical and texture features is extracted using Principal Component Analysis (PCA), and classification. | Minimum accuracy 94.15%, Maximum accuracy 96.28%, Average accuracy 94.86%, Sensitivity 97.96%, Specificity 83.65% F1-score 96.87%, Precision 96.31% |
| Balaji G.N., Suryanarayana S.V., Sengathir J. [19] | Enhanced boykov's graph cuts-based segmentation for cervical cancer detection | EAI Endorsed Transactions on Pervasive Health and Technology 2021 | Boykov-Kolmogorov Graph Cuts and Cloud Model-based Synergy Integrated Segmentation (BKGC-CMSIS) Technique for assisting in the diagnosis of prevalent cervical cancer from pap smear images being used for prognosis. The BKGC-CMSIS approach offers an effective image partitioning method based on Boykov-Kolmogorov Graph Cuts that estimates image data using a synergy cloud model for generating goal functions. | Data items are identified by using an X-condition cloud generator to determine and define the precise borders of cytoplasm and nuclei obtained from pap smear cells. This suggested BKGC-CMSIS approach makes use of the benefits of membership degree by using the smooth term to estimate the degree of similarity between surrounding areas of cervical pap smear cells. The experimental findings of this suggested BKGC-CMSIS scheme are also powerful in improving classification accuracy by 14% when compared to the benchmarked cervical cancer detection techniques under consideration. |
| Bhatt A.R., Ganatra A., Kotecha K. [20] | Cervical cancer detection in pap smear whole slide images | PeerJ Computer Science 2021 | Multiclass classification of cervical cells from Whole Slide Images (WSI). | Accuracy (99.70%) Precision (99.70%) Recall (99.72%) F-Beta (99.63%) |

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| | using convNet with transfer learning and progressive resizing | | Conv Net with Transfer Learning technique. | Kappa scores (99.31%) |
| Ponnusamy S., Samikannu R., Venkatachar y S.K., Sukumar S., Ravi R. [28] | Computer aided innovation method for detection and classification of cervical cancer using ANFIS classifier | Journal of Ambient Intelligence and Humanized Computing 2021 | Artificial Neural Network Fuzzy Inference system (ANFIS) Watershed segmentation techniques for A comprehensive set of fuzzy | The experiment demonstrates that the proposed approach is viable and boosts cancer type detection accuracy. |
| Sun W.-L., Shen Y., Yuan Y., Zhou X.-J., Li W.-P. [21] | The Value and Clinical Significance of Tumor Marker Detection in Cervical Cancer | Scientific Programming 2021 | The binding sites of the two genes were discovered using Cytoscape, and luciferase reporter assays confirmed the direct regulation of miRNA-9-5p and CXCR4; the CCK-8 assay detected its regulation on cell proliferation, and RT-PCR and western blot detected the expression of miRNA-9-5p, CXCR4, PCNA, Ki67 mRNA, and proteins. In the model group, miRNA-9-5p expression was reduced while CA125, CA199, and CEA levels were elevated. CXCR4 is predicted to be a gene controlled by miRNA-9-5p, according to the database. | The results of the luciferase reporter gene suggested that miRNA-9-5p may directly influence CXCR4 expression, and miRNAs are identified by intracellular transfer inhibitors. Overall, MiRNA-9-5p can be used as a biological marker for cervical cancer since it inhibits cancer cell proliferation by reducing CXCR4 gene and protein expression. |
| Desiani A., Member, IAENG, Erwin M., IAENG, Suprihatin B., Yahdin S., Putri A.I., Husein F.R. [33] | Bi-path Architecture of CNN Segmentation and Classification Method for Cervical Cancer Disorders Based on Pap-smear Images | IAENG International Journal of Computer Science 2021 | Normalization, CLAHE and Adaptive Gamma Correction. Then apply CNN and KNN | Accuracy = 90% Sensitivity (SN) Specificity (SP) F1-score |

3.2 Classification

Cervical cancer is one of the treatable tumours if detected early. The most frequent screening procedure for a cervical lesion is a Pap smear test and visual inspection with acetic acid to classify the cervical cells as normal, precancerous, or cancerous. However, the effectiveness of most classification systems is depended on accurate spotting and segmenting of cervical region. These obstacles pave the way for sixty years of cervical cancer research, but proper spotting of the cervical cell remains a hurdle.

A comparative study of the suggested model was done to demonstrate the usefulness of feature selection and class imbalance based on the classifier's accuracy, sensitivity, and specificity. The goals of this study were to increase the efficiency and accuracy of early clinical diagnosis of cervical cancer

and to investigate the use of a tissue classification algorithm paired with multispectral imaging in cervical cancer screening.

Table 4
 Summary of classification techniques

| Authors | Title | Journal | Methodology | Result and Advantages |
|---|--|---|--|--|
| Yaman O., Tuncer T. [22] | Exemplar pyramid deep feature extraction based cervical cancer image classification model using pap-smear images | Biomedical Signal Processing and Control 2022 | DarkNet19 or DarkNet53 networks in an exemplar pyramid structure to extract features. The suggested feature generator generates 21,000 features. | Accuracies = 99.47%, |
| Sellamuthu Palanisamy V., Athiappan R.K., Nagalingam T.[11] | Pap smear based cervical cancer detection using residual neural networks deep learning architecture | Concurrency and Computation: Practice and Experience 2022 | Dual Tree Complex Wavelet Transform (DTCWT) Consists of data augmentation module, DTCWT module and convolutional neural networks (CNN) module. | The average Pap smear detection index (PDI) = 99%. |
| Wang P., Wang S., Zhang Y., Duan X. [12] | Multispectral Image under Tissue Classification Algorithm in Screening of Cervical Cancer | Journal of Healthcare Engineering 2022 | Fusion techniques based on color waveband. | Average gradient =2.0765 SD = 65.2579 Entropy = 4.974 Sensitivity = 85.3% Specificity = 70.8% |
| Tanimu J.J., Hamada M., Hassan M., Kakudi H.A., Abiodun J.O. [24] | A Machine Learning Method for Classification of Cervical Cancer | Electronics (Switzerland) 2022 | Classification algorithm Decision Tree (DT). Feature selection techniques of Recursive feature elimination (RFE) and least absolute shrinkage and selection operator (LASSO). | Accuracy 98.72% Sensitivity 100%. This has been demonstrated that the DT classifier performs better when the number of features is decreased and the high-class imbalance issue is taken into consideration. |
| Elakkiya R., Teja K.S.S., Jegatha Deborah L., Bisogni C., Medaglia C. [13] | Imaging based cervical cancer diagnostics using small object detection - generative adversarial networks | Multimedia Tools and Applications 2022 | Hybrid deep learning technique using Small-Object Detection-Generative Adversarial Networks (SOD-GAN) with Fine-tuned Stacked Autoencoder (F-SAE) | Accuracy 97% Loss of less than 1%. Average time taken to classify the cervical lesion is 0.2 s for 852 images. |
| Jahan S., Islam M.D.S., Islam L., | Automated invasive cervical cancer disease detection at | SN Applied Sciences 2021 | Multilayer Perceptron (MLP), Random Forest and k-Nearest Neighbor, Decision Tree, | Other classification models weren't as effective as MLP. On the other hand, the majority of classification models assert that t |

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| Rashme T.Y., Prova A.A., Paul B.K., Islam M.D.M., Mosharof M.K. [26] | early stage through suitable machine learning model | | Logistic Regression, SVC, Gradient Boosting, AdaBoost. Combination of feature selection techniques such as Chi-square, SelectBest and Random Forest. | their top 25 features in terms of data splitting ratio have the highest accuracy (70:30). |
| Khamparia A., Gupta D., Rodrigues J.J.P.C., de Albuquerque V.H.C. [27] | DCAVN: Cervical cancer prediction and classification using deep convolutional and variational autoencoder network | Multimedia Tools and Applications 2021 | Combination of convolutional network with variational autoencoder for data classification and SoftMax layer for training. | Accuracy 99.2% with 2*2 filter size Accuracy 99.4% with 3*3 filter size. |
| Pirovano A., Almeida L.G., Ladjal S., Bloch I., Berlemont S. [18] | Computer-aided diagnosis tool for cervical cancer screening with weakly supervised localization and detection of abnormalities using adaptable and explainable classifier | Medical Image Analysis 2021 | Explainable region classifier | Accuracy on severity classification 66.8% Accuracy on normal/abnormal classification 95.2% KAPPA score 0.870. |
| Diniz D.N., Rezende M.T., Bianchi A.G.C., Carneiro C.M., Ushizima D.M., de Medeiros F.N.S., Souza M.J.F. [29] | A hierarchical feature-based methodology to perform cervical cancer classification | Applied Sciences (Switzerland) 2021 | Eight traditional machine learning methods to perform a hierarchical classification. | The results show that hierarchical classification performed best when Random Forest was used as the key classifier, especially when compared to decision trees, k-NN, and the Ridge techniques. |
| Tian X., Wang X., Cui Z., Liu J., Huang X., Shi C., Zhang M., Liu T., Du X., Li R., Huang L., Gong D., Tian R., Cao C., Jin P., Zeng Z., Pan G., Xia M., Zhang H., | A Fifteen-Gene Classifier to Predict Neoadjuvant Chemotherapy Responses in Patients with Stage IB to IIB Squamous Cervical Cancer | Advanced Science 2021 | Generalized linear regression analysis integrated with the logistic regression model to generate a 15-gene classifier. | The classifier had strong predictive power, with an area under the curve of 0.80 (95% confidence interval (CI), 0.69-0.91). |

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| Luo B., Xie Y., Li X., Li T., Wu J., Zhang Q., Chen G., Hu Z. [30] | | | | |
| Albuquerque T., Cruz R., Cardoso J.S. [31] | Ordinal losses for classification of cervical cancer risk | PeerJ Computer Science 2021 | A non-parametric ordinal loss for neural networks is developed, which encourages output probabilities to follow a unimodal distribution. | The proposed loss is contrasted against other methods from the literature by using a plethora of deep architectures. Additionally, the proposed loss is found to be the top-performer in several cases. Accuracy 75.6% for seven classes Accuracy 81.3% for four classes. |
| Nikookar E., Naderi E., Rahnavard A. [32] | Cervical cancer prediction by merging features of different colposcopic images and using ensemble classifier | Journal of Medical Signals and Sensors 2021 | Incorporation of different classification algorithm and ensemble classifier. The method combines characteristics from many colposcopy images of a patient. Each image's feature vector comprises semantic medical information, subjective judgements, and a consensus. Each sample's class label is determined using an aggregation method based on expert assessments and consensuses. | Sensitivity 96% Specificity 94% |
| Aurelia J.E., Rustam Z., Wirasati I. [34] | Cervical cancer classification using convolutional neural network-support vector machine | Telkomnika (Telecommunication Computing Electronics and Control) 2021 | Convolutional neural network (CNN) A support vector machine (SVM) with several kernel functions | CNN-SVM Linear 100% 93.67%. CNN-SVM Polynomial 100% 92.72%. CNN-SVM RBF 100% 92.91% |
| Senthilkumar G., Ramakrishnan J., Frnda J., Ramachandran M., Gupta D., Tiwari P., Shorfuzzaman M., Mohammed M.A. [35] | Incorporating Artificial Fish Swarm in Ensemble Classification Framework for Recurrence Prediction of Cervical Cancer | IEEE Access 2021 | Least Absolute Shrinkage and Selection Operator (LASSO) classifier The recurrent gene expression of lncRNA is acquired from Geo Datasets in the early phase. Second, data imputation is performed using the Mode and Mean Missing technique (MMM-DI). Third, the Hilbert-Schmidt independence criteria is combined with the Diversity-based Artificial Fish Swarm (HSDAFS). The diversity parameter is added to the HSDAFS method based on the | The prognostic factor is calculated using a risk score of nine lncRNA signatures from 300 GSE44001 samples. The Chi-Square approach was employed to achieve statistical data. The suggested model depicts the survival of a patient with recurrent cervical cancer. Accuracy 92.69% for ENCSF. Accuracy 84.47% for Kaplan Meier Accuracy 79.90% for LASSO Cox regression. The suggested ENSCF model has a lower error rate of 7.30%, whereas the Kaplan Meier and LASSO Cox regression methods have larger |

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| | | | gene value, and the risk score of the lncRNAs is determined using the Artificial intelligence (AI) technique. Finally, an ENsemble Classification Framework (ENSCF) based on recurrent neural networks is developed for recurrence prediction. | error rates of 15.52% and 20.09%, respectively. |
| Dhawan S., Singh K., Arora M. [36] | Cervix image classification for prognosis of cervical cancer using deep neural network with transfer learning | EAI Transactions on Pervasive Health and Technology 2021 | Deep learning and Transfer Learning. The three pertained models namely InceptionV3, ResNet50, and VGG19 are used for creating ConvNet that will classify the cervix images. | The experiment results show that the Inception v3 model outperforms Vgg19 and ResNet50 on the cervical cancer dataset, with an accuracy of 96.1%. |
| Huang P., Tan X., Chen C., Lv X., Li Y. [37] | AF-SENet: Classification of cancer in cervical tissue pathological images based on fusing deep convolution features | Sensors (Switzerland) 2021 | Image processing algorithm for data augmentation. Second, the deep convolutional features are extracted by fine-tuning pre-trained deep network models, including ResNet50 v2, DenseNet121, Inception v3, VGGNet19, and Inception ResNet. Traditional image characteristics are extracted using local binary patterns and a histogram of the oriented gradient. The fine-tuned models' extracted features are serially fused based on the feature representation ability parameters and the accuracy of many experiments suggested in this research, and spectral embedding is utilized to reduce dimension. Finally, the fused features are inputted into the Analysis of Variance-F Value-Spectral Embedding Net (AF-SENet) for classification. | The dataset is divided into a training set (90%) and a test set (10%). The serial fusion effect of the deep features extracted by Resnet50v2 and DenseNet121 (C5) is the best. Accuracy 95.33%, which is 1.07% higher than ResNet50 v2 and 1.05% higher than DenseNet121. The recognition ability is significantly improved, especially in LSIL, reaching 90.89%, which is 2.88% higher than ResNet50 v2 and 2.1% higher than DenseNet121. |
| Gupta, Surbhi; Gupta, Manoj K. [38] | Computational Prediction of Cervical Cancer Diagnosis Using Ensemble-Based Classification Algorithm | Computer Journal 2021 | Irvine database repository. Missing values are first imputed (k-nearest neighbours), and then the data are balanced (oversampled). To extract the most important characteristics, two feature | Time elapse = 5.6 s Curve score = 99.7% |

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| | | | selection procedures are utilized. | |
| Yu, Yao; Ma, Jie; Zhao, Weidong; Li, Zhenmin; Ding, Shuai. [39] | MSCI: A multistate dataset for colposcopy image classification of cervical cancer screening | International Journal of Medical Informatics 2021 | Deep learning and handcrafted feature extraction techniques. Colposcopy image processing using a gated recurrent convolutional neural network (C-GCNN) that takes into account time series and merged multistate cervical images for CIN grading. | Accuracy = 96.87% sensitivity = 95.68% specificity = 98.72 %. |

4. Conclusions

Cervical cancer is the second most frequent female cancer worldwide, and it is critical to diagnose cervical cancer at an early stage utilising low-cost, high-accuracy automated screening approaches, particularly in countries with limited medical resources. This cancer is the second leading cause of death among women in poor nations, after breast cancer. Cervical intraepithelial neoplasia (CIN) can be efficiently prevented with automatic detection. The only method to avoid morbidity is to notice the problem early. Since the typical Pap smear test draws the assessment about the abnormality of the cell by hand, the clinical test used to identify cervical cancer is more prone to false-negative and false-positive instances.

Detecting and classifying Pap smear cell images is a critical challenge in the detection of cervical cancer. Patients benefit from earlier medical treatment when cancer is detected, diagnosed, and classified early. The purpose of the study is to utilize deep learning techniques to automate cancer detection and classification in order to ensure that patients' health conditions improve on time.

Research proved that a multispectral image aided by a tissue classification algorithm may successfully screen for cervical cancer and can swiftly, efficiently, and safely segment cervical tissue into lesion and non-lesion areas. The segmentation result matched the doctor's illness assessment, showing that it had good clinical application value. This served as a useful reference for the clinical use of multispectral imaging technology, aided by a tissue classification system, in the early detection and diagnosis of cervical cancer. Medical practitioners will be able to use the proposed technique to conduct cervical cancer research.

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