CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Cervical cancer (CC) is recognized as the third most common disease among all women. It is a global health concern that often goes unnoticed in its initial stages. However, the screening process for CC can be hindered by various social and behavioral factors. At present, restricted research focusing on Machine Learning (ML) and Deep Learning (DL) techniques are available in the field of gynecology and computer science to detect CC (Laboni Akter etal. 2021). As a consequence, several lives have been lost to this deadly disease, in particular due to a lack of awareness. CC can be cured with corresponding ease when diagnosed at the initial stage (Bogdanova et al. 2022, S. Zhang et al. 2020). A deficiency in medical facilities is the second reason for untreated CC deaths in underdeveloped countries.

Q. Wu et al. (2020) suggest that the incorporation of computers in the medical field enormously rehabilitated the way for performing medical procedures, along with further integration using ML and DL. Some ML models including Decision Tree (DT), Random Forest (RF), and Extreme Gradient Boosting (XGBoost), were utilized to precisely predict CC on the basis of performance metrics. Results have shown significant improvement compared to existing methods by achieving 93.33% accuracy (K. Kaushik et al. 2022). Additionally, one of the most influential factors in the dataset is identified by providing insights into their impact on the development of the categorization model.

Furthermore, different types of preventive measures are implemented that solely depends on screening test are insufficient to prevent cervical cancer (Jahan et al. 2021).Early detection of this cancer at its initial stage is effective in controlling deaths caused by highly spreading CC. Recently, Artificial intelligence (AI), ML, computer vision, and DL have been commonly utilized tools for identifying several diseases. Compared to others, ML models with best-performing algorithms have gained significant attention for recognizing targeted diseases (Park et al. 2021).

By applying various pre-processing mechanisms like dimensionality reduction, data cleansing, and feature selection, available ML techniques enhance the quality of datasets of specific diseases (Priya et al. 2023).The obtained preprocessed data is analyzed by receiving

the assistance from clinical professionals in rapidly testing diseases and giving the most effective medical procedures to assist the treatment of diseases. In recent times, cervical cancer is considered as a fatal disease for women, irrespective of age. Screening for cervical cancer is highly recommended for women belonging to a certain age category. Since cervical cancer is asymptomatic until the final stage, it is a tedious task to have recurrent scanning for cervical cancer in developing countries. The application of data mining and ML algorithms detects the root causes of cervical cancer.

There is a cumulative demand for the usage of machine learning algorithms in medical diagnosis which are particularly beneficial in the early stages of medical conditions (N. Al Mudawiet al. 2022). It influences many individuals and organizations to integrate ML and DL models for analyzing huge amounts of data to get valuable results. ML models were utilized to predict CC. Improved results were obtained by removing some data from the data set before training the model and used the removed data for validation. Cervical cancer is one of the most commonly seen gynecological cancers globally. Detection and prevention is highly effective to drop down the global illness count due to cervical cancer. In some extreme cases, cervical cancer leads to death. Current testing methods were not available in most of the underdeveloped countries.

In a study by Drokow et al. (2021a) novel ensemble methods for cervical cancer predictions were implemented using multiple ML algorithms. The mortality rate of cervical cancer is increasing globally. It is a lethal disease and should be prevented by vaccination and could be cured if detected at the initial stage. Many individuals have been involved in finding techniques for screening tests for pre-diagnosis of CC. The stages of CC can be found using Pap smear images of the cervix dataset. However, there are some difficulties for women in underdeveloped countries with regular Pap smear tests (Priya et al. 2020). In contrast, the relevant data available for cervical cancer prediction is inadequate. So, the data is oversampled using SMOTE to adjust the data inadequacy.

2.2. Review of Cervical Cancer Detection

2.2.1. Pap smear Test

CC is a very common variant of malignancy occurring in females and considered as a leading cause of mortality, especially among the underdeveloped nations. The only way to effectually treat it is to perceive the disease at an initial stage.Ali, Ahmed, Bui, Paul, Ibrahim, Quinn, & Moni (2021) explored machine learning-based classification models for

initial stage CC detection utilizing medical data. The dataset contains many missing values which can be handled using statistical techniques. Then the dataset is split into four parts with four dependent variables. Different feature transformation methods were employed to transform the given dataset into the proper form to achieve enhanced efficacy. Various types of classifiers were used with the processed data, and it was found that the machine-learning approach worked well. The outcomes of data transformation on classifier were explored. The cervical cancer dataset from the Kaggle repository contains four different classes of features including Cytology, a biopsy, schiller, and Hinselmann. Among all other machine learning algorithms, random trees obtained higher accuracy for biopsy and cytology. Random forest and IBK gave better accuracy for Hinselmann and Schiller. Several studies have been focused on developing a technique for accurately predicting and identifying cervical cancer at its initial stages using clinical data. Although this approach has achieved prominent enhancement, there is a persistent necessity for substantial improvement to ensure the models' accuracy and efficiency that satisfies the requirements for clinical application and acceptance.

Malignant growth in the cervix is recognized as the fourth most common reason for death due to cancer in females globally (M. Mehmood et al. 2021a). The increase in CC is linked to human papillomavirus contamination. CC can be efficiently proscribed through readily accessible screening and early recognition compared to various other types of cancers, emphasize the eminence of employing risk assessments. Cervical cancer is characterized by the abnormal growth and replication of cervical tissue cells, leading to uncontrolled cell proliferation and mortality. Once the abnormality becomes malignant, it can affect other body parts. CC can be prevented by early screening, which minimizes the global suffering of CC. In most of the developing nations, women usually prefer not to undergo appropriate testing programs because of regular check-ups requiring extravagant procedures, they are illiterate, and they are not permitted in health center. As a consequence, the diagnosis of particular patients' risk is very high. Several risk factors facilitate the cervical malignancy. However, the significant features could be extracted by using CervDetect which uses Random Forest as a feature selection tool. In addition, the hybrid method that combines shallow and RF neural networks was utilized for detecting cervical cancer. The proposed system detects cervical cancer with a maximum achieved accuracy of 93.6% which is better than most other models.

2.2.2. Pap smear test image classification techniques

Yang T et. al.(2024)introduced a novel Deep Learning method to improve the cervical cancer detection accuracy. The proposed systemcontains a combination of different models that is used to extract and purify features from Pap-smear images, integrating comprehensive information along with the removal of repeated data. This method improves classification performance, showing superior accuracy and robustness compared to existing techniques. The enhanced detection capability of this network helps pathologists in diagnosing cervical cancer more effectively.

A novel method for the classification of Pap smear images is presented by Khansara P. et. al (2024) to detect cervical cancer. An ensemble method is proposed with deep learning model which integrates multiple classifiers that can improve the accuracy and reliability of cervical cell classification. This approach supports techniques such as maximum occurrence and maximum probability scoring to enhance the detection of cervical cancer cells. The results demonstrate that this ensemble method significantly outperforms traditional single-model approaches, providing a robust tool for supporting cytologists in cervical cancer screening

Moreover Tan S. et.al. (2024)discussed the use of deep learning models, especially pre-trained CNN models, for automated cervical cancer detection. It emphasizes the use of transfer learning to handle limited amount of data and the performance of 13 pre-trained models are compared here. The result shows that DenseNet-201 performed the best in terms of accuracy and computational efficiency.

In a study by Wubineh B. et.al.(2024) they proposed a novel residual Deep Convolutional Generative Adversarial Network (RES_DCGAN) for data augmentation and a ResNet50V2 self-attention method to classify cervical cells. The method improves data flow and generates higher-quality images, obtaining better performance with an accuracy of 98% using Xception and 96.4% with ResNet50V22.

The potential technique involving multi-level classification of a dataset with Support Vector Machine (SVM) and Perception learning method(Priya et al. 2023).Classification algorithms are utilized for binary data categorization. In addition, a Gradient boosting machine is implemented to enhance accuracy and performed well in accurately determining the risks for CC. The accuracy for the base model ranges between 82.29% and 90.95%. After

using MLP-OVA along with gradient boosting, accuracy was increased to 93.48%, and sometimes even better accuracy can be observed.

There is an increasing demand for the use of machine learning algorithms in medical diagnosis, especially in the early stages of medical conditions. This stimulates many individuals and organizations to start using ML and DL models for analyzing large amounts of data to extract valuable information. ML algorithms were utilized for the prediction of CC. Enhanced results were attained by removing some data from the data set before training the model and used the removed data for validation.

There are four stages of analysis including Pseudo-code, dataset, data pre-processing, and Predictive Method Selection (N. Al Mudawiet al. 2022). In PMS, ML models comprise of DT, SVM, LR, KNN, XGBoost, and Adaptive boosting is implemented. The highest accuracy has been observed in RF, adaptive boosting, DT, and XGBoost. The SVM algorithm has also given greater accuracy only varying by a small degree.

Cervical cancer is one of the most commonly seen gynecological cancers globally. Detection and prevention are the most efficient methods to drop the global illness count in cervical cancer. In some extreme cases, cervical cancer leads to death. Current testing methods were not available in most of the underdeveloped countries. A novel ensemble methods for cervical cancer predictions was implemented using multiple ML algorithms, including XGBoost, KNN, LR, DT, and MLP (Drokow et al. 2021a). The average accuracy of 96.6% is achieved using these multiple machine learning models. The proposed algorithm achieved a better F1 score proving the enactment of the model. The conclusions show that the chances of getting affected by cervical cancer can be precisely detected using the proposed method.

In this case, using only oversampling and under-sampling cannot fulfill the requirement. So, the novel resampling method to get the desired data balance between classes is presented (A. Newaz et al. 2022a). It is balanced by applying the SMOTE algorithm which generates artificial samples. The model efficacy was increased by applying a Genetic Algorithm to detect the important factors for cervical cancer tests. Using eight optimized features from 32 features by RF and GA algorithms enhanced the accuracy by 94% which is better than most existing models. By combining two or more models the best possible efficacy for diagnosing cervical cancer can be achieved.

Regular Screening is a crucial step to prevent cervical cancer through pre-cancer detection for further treatment. Pap is one of the screening tests that observe any precancerous or abnormal changes in the cervix cells. The criteria are poorly reproduced in manual Pap screening. Screening systems assisted by computers must be developed for the digital processing of Pap smear images to prevent cervical cancer.

Firstly, Logistic Regression and Genetic algorithms were used in Chaudhuri et al. (2021) model to select the features, and usually select twelve features that are more related to the class and not among one another. The next five features will be selected using the same model (LR and GA). LR and Naïve Bayes (NB), Extra Trees (ET), SVM, and Gradient Boosting (GDB), RF were used for categorization. The accuracy achieved greater performance than most other conventional models.

Human papilloma Virus and other prognostic factors cause CC which requires prior prognosis and identification to prevent this disease. It is potentially a dangerous virus capable of transferring cervical cancer to any age group. The human papillomavirus vaccine was being procured for young people between the age group of fifteen to twenty-six to prevent incidence in the young population. However, prevention is still underway in many parts of the world. The goal is to identify and investigate forecasters of CC and to study the difficulties of imbalanced datasets with different ML algorithm-based models.

A multi-level sampling approach was applied to get 501 image samples for the study (S. Devi et al. 2023a). Although some of the patients were absent, it is balanced by Random Forest (RF), DT, NB, MLP, and LR algorithms. Pap smear screening was taken by all patients, the images were collected, and abnormal results were sent for biopsy. LR model showed a sensitivity range of 88% -94% and an accuracy of 84% - 89%. DT model showed a sensitivity range of 83% -84% with an accuracy of 84%-88%. The NB and LR algorithms showed better efficacy for the given dataset.

CC is one of the major cancers women are facing at present. Especially in developing countries where medical facilities are inadequate for screening, detecting, and treatment of cervical cancer. In addition, this type of cancer can spread through sexual contact with HPV. Pap smear image analysis is the most commonly used diagnosis method. An advanced hybrid system for the detection of CC is being proposed in this study, utilizing ML and DL methods.

The division of AI has gained significant prominence in the field of cancer diagnosis. However, the experts are limited for examining and producing accurate results. A combined data is prepared using fused feature extraction for merged images and other data (Mukku et al. 2023). The afore-mentioned combined characteristics are fed into three cutting-edge ML algorithms: SVM, KNN, and RF. ML classification involves forecasting the class or category of a given data point, such as the binary classification of cancer. The model achieved better accuracy than most conventional models.

Cervical cell screening using traditional means is mostly dependent on the experience of pathologists and is associated with low efficiency and accuracy. Deep learning and machine learning combined with medical image processing demonstrate its advantage in cell categorization. A novel system with profound CNN and SVM algorithm was put forward to classify the cervical cells accurately (A. D. Jia et al. 2020). GLCM and Gabor combine the strong features with abstract features. This fused input is fed into SVM for categorization. An efficient technique for amplification of datasets was devised to enhance the resilience of the model. Two separate datasets were tested using the proposed methods. The accuracy, sensitivity as well as specificity of the proposed model are much greater than most other conventional models. Overall capability outperforms the other traditional methods.

Globally, CC is the most often cause of cancer death in women. This gynecological disease is likely to be asymptomatic at the early stage making it very difficult to diagnose, especially in developing countries that face the problem of screening. In CC diagnosis, ML techniques can be applied to identify the malignant cells at the starting level to prevent them from progressing into further stages and curing them with less medical assistance when compared to more complex medical procedures followed in critical stages of cervical cancer. The first problem in cervical cancer diagnosis using ML is the data balancing and non-uniform data scaling. A model in which Synthetic minority oversampling is applied together with fivefold cross-testing to solve these issues was developed (N. K. Chauhan et al. 2022). Powerful ML algorithms like MLP, DT, KNN, NB, RF, SVM, Logistic Regression, and Linear Discriminant analysis were compared. SVM, RF, and DT came out as the top three suitable models for cervical cancer diagnosis using scaled and unscaled data produced through min-max scaling. Universal-variant feature selection and recursive feature elimination (RFE) were used for the optimization of the diagnosis process. Random forest with RFE shows much greater performance than other implemented models.

The consequences of study demonstrated the potential usage of following algorithms for prediction of the overall survival (OS) among cervical cancer patients (Ling et al. 2022).On testing, all the incorporated models achieved the accuracies of above 90%. i.e., SVM and DT gave an accuracy of 92%, LR achieved 90%, and XGBoost and light GBM resulted in better accuracy than other models. Hence, the prediction of OS and PFS were effectively determined in proposed study. Subsequently, the findings were validated using the Cox proportional hazards model. These outcomes demonstrate the capabilities of machine learning techniques for précised detection of overall survival (OS) among cervical cancer patients. Furthermore, these techniques observe the relationship between clinical markers and OS or PFS, assisting healthcare professionals in making precise decisions on clinical environment.

In addition, the study develops the predictive model for predicting the prognosis of patients diagnosed with CC. The accurate predictions are made by trained model through analyzing the risk pattern extracted from individual medical records and preliminary screening. To analyze the factors of risks linked with CC, a DT classification algorithm is employed. To identify the most significant attributes for CC prediction, two feature selection techniques, namely Recursive Feature Elimination (RFE) and Least Absolute Shrinkage and Selection Operator (LASSO), are thoroughly explored. The study utilizes a dataset containing missing values and demonstrates a significant level of disparity. To tackle these obstacles, researchers suggested the employment of a hybrid approach called SMOTETomek, which combines under and oversampling techniques.

A comparative analysis is carried out comprehensively to illustrate the effectiveness of the suggested model in terms of the feature selection and handling class imbalance on basis of classifier performance such as accuracy, sensitivity, and specificity (Tanimu et al. 2022). The results indicate that the DT classifier, utilizing the chosen characteristics derived from RFE and the SMOTETomek technique, achieves superior performance with higher accuracy. This highlights the DT classifier's ability to handle classification problems more effectively when the number of features is reduced, and the issue of class imbalance is properly addressed.

Considering cervical tissue for analysis, Raman spectroscopy is widely utilized to analyze inflammation in the cervix and detect precancerous tissues for the identification of

CC(H. Zhang et al. 2021). This research lays the groundwork for the application of Raman spectroscopy for examining the cervical precancerous lesions. It encompasses on acquiring real Raman spectrum signals from cervical tissue which shows the signs of precancer. These signals were then analyzed using PLS and Relief methods to identify the unique characteristics of the spectrum. Following this, KNN and ELM classification models were developed and compared, resulting in the effective detection of CC at an early stage. An innovative approach of integrating features while feature extraction was suggested in this research, incorporating both the derivative features that provide better-detailed peak information from the original spectrum. The accuracy rate of KNN without feature fusion was 88.17%, which increased to 93.55% after fusion. Similarly, the accuracy rate of ELM without feature fusion was 90.81%, rising to 93.51% after fusion. These findings indicate that feature fusion has enhanced accuracy to a certain degree, suggesting the potential of this method as a new approach for spectral data fusion.

Efficient machine-learning-based classification models were developed for the early detection of CC using clinical data (Ali et al. 2021). The dataset utilized in this study was obtained from the Kaggle data repository that consists of four categories of attributes: biopsy, cytology, Hinselmann, and Schiller. The dataset was categorized based on these attributes into four distinct groups. Three different feature transformation techniques, namely log, sine function, and Z-score, were applied to these datasets. Various supervised ML algorithms were evaluated for their classification performance. The RT algorithm demonstrated the highest classification accuracy for the biopsy (98.33%) and cytology (98.65%) data, while RF and Instance-Based KNN (IBk) yielded the best results for Hinselmann (99.16%) and Schiller (98.58%) datasets, respectively. The findings of this research suggest that through suitable system design, tuning, and the application of ML approaches, accurate and efficient detection of CC in its early stages can be achieved using clinical data.

Three different ML algorithms, namely KNN, SVM, and RF, were employed and analyzed to predict CC and hyper parameter optimization is accomplished through exhaustive grid search. Furthermore, the reliability of the results was further enhanced by utilizing k-fold cross-validation (Degirmenci 2022). Among the evaluated methods, the SVM method with the sigmoid kernel demonstrated the highest performance, achieving an

accuracy of 0.9274, precision of 0.9093, recall of 0.8410, and F1-score of 0.8565. This study highlights the potential ML-based approach in the early diagnosis of CC that offers promising prospects for improving women's health outcomes.

Moreover, a study on the basis of on adequacy test was conducted by Salau-Ibrahim & Rilwan (2021) using various ML algorithms for the detection of CC in behavioral risk dataset. This study diverges from the norm of utilizing datasets containing gene expression or histological images to classify the presence of cervical disease in patients instead utilizing a behavioral dataset to construct two predictive models. The research also delves into the impact of feature scaling and selection on the predictive capabilities of the classification models. The analysis focused on evaluating the performance of supervised algorithms using the selected CC behavioral risk dataset. The choice of the behavioral risk dataset was made to propel advancements in CC research and explore the potential of its features in training and testing learning classifiers for CC detection. The study employed NB and LR algorithms to develop the predictive models. The Logistic Regression-based model achieved an exactness of 0.90, precision of 0.87, recall of 0.86, as well as an f-measure of 0.83. Consequently, the experimental findings demonstrated that the GNB-based model surpassed its logistic regression counterpart.

The ML-based mathematical model has been developed to analyze the various possibilities of CC, the researchers have examined the prediction using eight different body factors (Lilhore et al. 2022). The researchers employed SVM, RF, decision tree, and Boruta examination to generate several classification models. The researchers conducted a comprehensive examination of the capabilities of these modeling techniques for both development and performance evaluation. The performance of these models is accessed based on precision and effectiveness of these methodologies. Overall, the statistical Boruta analysis and RF methods performed well in terms of accuracy, precision, and other parameters for identifying the risk and type of CC. The SVM model shows similar outcomes, achieving a precision of 0.8456, recall of 0.812, F1 score of 0.684, and support of 0.717. In contrast, the Boruta analysis unveiled similar findings, with a precision of 0.912, recall of 0.891, F1 score of 0.798, and support of 0.768. When associated with alternative ML algorithms, the experimental consequences indicate that the Boruta analysis surpassed them in performance.

However, three ML methods, namely DT, RF, and XGB, are highly explored for accurately detecting CC based on behavioral variables (L Akter et al. 2021). Remarkably, all models have yielded significant results, achieving an accuracy of 93.33%, surpassing the effectiveness of current methods. Additionally, it has been acknowledged that analyzing the most influential features from the dataset based on feature importance scores, influences the performance of classification model.

The proposed research to anticipate CC by utilizing ML algorithms technique consists of four phases: research dataset, data pre-processing, predictive model selection (PMS), and pseudo-code (N. Al Mudawi et al. 2022). The PMS section incorporates experiments with various traditional ML methods, such as DT, LR, SVM, KNN, adaptive boosting, GB, RF, and XGB. In case of CC prediction, the highest classification score is attained by the RF, DT, adaptive boosting, and GB algorithms. On the other hand, SVM achieves an accuracy that is a little less than other algorithms.

Research carried out by Arora et al. (2020) concentrates on utilizing class balancing and ML methods for Data-Driven prediction of CC. The research presented in this paper enhances the field of ML in the context of CC diagnosis. The study employs various ML algorithms such as KNN, SVM, and RF. The comparative analysis based on evaluation metrics such as accuracy, sensitivity, specificity, negative predicted accuracy, and positive predictive accuracy is accomplished. The findings indicate that the RF algorithm combined with the SMOTE method outperformed SVM and KNN in predicting the four target variables Schiller, Biopsy, Hinselmann, and Cytology.

Drokow et al. (2021b) study introduces an innovative ensemble method to forecast the risk of CC. In particular, researchers propose a voting classifier that integrates prediction probabilities from various ML models: LR, KNN, decision tree, XGBoost, and multilayer perceptron. The performance of voting classifier in terms of mean accuracy, precision, recall, and f1-score were exceeded than past research. Additionally, the voting algorithm achieves high average scores for all performance measures.

Su et al. (2022) utilizes deep learning techniques for the analysis of whole slide cervical images (WSCI) to develop an automated and efficient approach for diagnosing CC. The integration of CNN along RF classifier is employed for the classification of whole slide

cervical images. A novel multilevel ensemble-based feature fusion method is utilized to extract features from the CNN-extracted features. The ensemble combines features from different convolutional layers with varying depths, enabling the capture of comprehensive features that describe patches at various levels. PCA is applied to reduce the dimensionality of multilevel features. The experiments are conducted on a WSCI dataset comprising 163 WSCIs from 27 patients. Two models, CNN + PCA + RF and CNN + RF, are combined with four feature extraction strategies to perform eight comparative analyses on 163 WSCIs. The result indicates that the classification accuracy of the CNN + PCA + RF model using the multilevel feature fusion strategy achieves the highest performance. Furthermore, the CNN + PCA + RF model with the multilevel feature fusion strategy outperforms models utilizing single-level feature extraction methods.

In Kudva et al. (2018) study, categorization of the cervical images through visual inspection via acetic acid is considered as a significant step in the automated image-oriented detection of the CC. Numerous algorithms have been established for classifying cervical images, which relies on mathematical features and image classification. It is a complicated task to decide the appropriate feature and algorithm learning. Alternatively, CNN is a suitable hierarchical system for processing the raw image. The adopted study demonstrates the viability of the image patches classification utilizing the CNN shallow layer in cancer detection. The cervical images are assimilated after the employment of 3 to 5% acetic acid. It is performed with the support of an Android device among 102 women. 42 images were categorized as VIA-positive and the remaining 60 were termed as VIA-negative. 275 image patches, which encompasses 15 × 15 pixels images that are extracted manually from the VIA-positive. It is considered an example of positive images. Subsequently, 409 patches were fetched from the VIA-negative fields and it is termed as VIA-negative. The mage patches were categorized by the utilization of the CNN shallow layer which is composed of the convolutional, linear unit, pooling as well as two connected layers. An accuracy of 100% has been achieved through the employment of a shallow CNN technique.

Similarly, the conventional study by Gautam et al. (2018) reported a Pap smear image investigation structure for CC screening for both single as well as multi cellular images. The framework had three steps that were, recognition of nuclei, dissection, and grouping of segmented and also detected nuclei through DL approaches. In the detection phase, the

image quality was increased by removing the noise from the image by applying median filtering, then CLAHE was applied to improve the contrast and accentuate the differences between the nucleus and background, and finally, a global threshold was applied, which localizes the nuclei. Next, for the segmentation of nuclei, two steps were considered: cell separation and patch-based CNN. Finally, the classification was done by the classifier, which classifies the cell as either a normal or abnormal cell. From the results, the effectiveness of the algorithms is shown individually, and it proved the sufficiency of cell-nuclei detection for classification at the same time.

Song et al. (2016) adopted a learning-based method comprise of robust shape features that deliberates the segmentation of individual cells in Pap smear images for monitoring the automatic changes in cells. This was considered a vital prerequisite for early detection of CC. The approach for segmenting the individual cervical cells had three main processes: cell component segmentation, multiple cell labeling, and cell boundary refinement and inference. Multi-scale deep convolutional networks were adopted to learn the diverse cell appearance features. The two different datasets were evaluated and it is demonstrated that proposed method is superior to the state-of-the-art methods in terms of segmentation accuracy. Furthermore, the approach was effective in segmented abnormal cells, even for images that had a large number of overlapped cells and high degrees of overlapping. This task was more challenging in the splitting of overlapped objects because the splitting procedure was based on the pixel.

Sompawong et al. (2019) intended to apply a Mask-Regional Convolutional Neural Network (Mask R-CNN) to CC screening by histological slides in his contemporary study. Additionally, images from the slides were pre-processed before they were used in the model. The images were resized while retaining the horizontal and vertical resolution ratio by changing the horizontal resolution to 1,024 pixels and padding the vertical resolution with black to obtain 1,024 pixels. Then, the Mask R-CNN model was used to perform feature segmentation and identify the different objects in an image. The method was compared with the other state-of-the-art methods in terms of mean average precision (mAP), accuracy, sensitivity, and specificity. The approach attained better results than the existing methods.

Elayaraja et al. (2022) states that the treatment of the CC has been effective when screening is done at the initial stage. The existing work proposes a productive technique for

the exposure and segmentation of the cancer portion in the cervical images utilizing the transform as well as windowing method. The image processing is performed in the following steps such as pre-processing, modification, extraction, optimization, categorization, and segmentation in the proposed methodology. Gabor transforms the test image to alter the pixels related to the domain of spatial into multi-resolution. The multi-level parameters were extracted from the modified image. The extracted features are optimized through the Genetic Algorithm (GA). The prominent part is categorized using CNN. Finite Segmentation Algorithm (FSA) is utilized to detect as well as segment the affected region in the images. The suggested GA-oriented CNN method demonstrates the effectual detection and categorization of the CC through the parameters such as accuracy, specificity, and sensitivity. The experimental results of the sensitivity, specificity, and accuracy were reported to be 99.37%, 98.9%, and 99.21% respectively.

As reported by Alyafeai et al. (2020), CC affects females with almost 528000 cases reported every year. 85% of the cases exist in the developing nations. The fatality rate is highly attributed because of inadequate medical staff and pre-screening techniques. The centigrams are termed as the image captured in the cervical region. It is a standard technique for the assessment of cancer's existence. It has a high variability amongst the unskilled practitioners. The proposed framework encompasses two main DL models for detection as well as tumor classification. The initial model diagnoses the cervix region a thousand times more rapid than the driven models. It detects an accuracy rate of 0.68 for the IoU measurement. The extracted features are utilized by the second model for the categorization of cervix tumors.

Soni et al. (2021) suggests the utilization of CNN to measure the features among lightweight models. The suggested DL classifier outperforms the existing models based on accuracy as well as the speed of classification. The classifier is evaluated through the Area under Curve (AUC) score and the value is 0.82. It classifies the cervix region twenty times faster than the conventional models. The accuracy, lightweight framework, and speed enhance the mobile phone deployment. The deployment promotes the earlier detection of the CC in the earlier phase for the less developed nations.

The Pap smear is a technique utilized for cancer detection at the earlier stage. The developing nations, namely India, confront hurdles in the management of the patient's

frequency every day. The online as well as offline ML techniques are utilized for benchmarking the datasets for diagnosing CC. The significance of ML is seen in diverse fields as it provides the beneficiaries with task completion. The medical image analysis is performed for diagnosing and generating pictures of the structures as well as activities in the body. The utilization of ML exhibits the various beneficiaries during the disease diagnosis of the patients. CNN-CRF delivers the applications for the evaluation of the structure and capturing the images of the human body structure. The incorporation of ML is beneficial for evaluation of the diverse types of medical images likely CT scans and neural networks. ML benefits the medical image analysis field in the health care system.

2.2.3 Datasets used in Pap smear image classification

Chi-square is incorporated for feature selection based on their similarities that eradicates inappropriate features from the dataset (Priya et al. 2020). The data set consists of 858 patient records, each with 32 features and 4 selected classes for computational analysis using ML and DL models. The linear SVM classifier is trained and tested using the selected attribute from the genetic algorithm, achieving an accuracy of 93.82%. Back propagation further enhanced the accuracy of the model to a considerable extent.

In the proposed model, initially, nuclei of the cells were selected by shape iterative technique (Win et al. 2020). The cytoplasm is removed from the image by marker control watershed method. For feature selection, RF algorithm was used. Bagging ensemble classifiers including linear regression (LD), SVM, KNN, bagged trees, and boosted trees were utilized for classification. The effectiveness is tested using SIPaKMeD and Herlev datasets were used. The accuracy achieved was greater in two-class categorization. In five-class categorization, 94.09% accuracy was achieved utilizing the SIPaKMeD dataset.

Pap smear technique-based screening of cervical cancer is developed that involves classification and detection using Pap smear images (Alquran et al. 2022). Hence, this imaging technique is utilized for designing computerized systems for classifying abnormalities in the cervical cells images. The dataset included 917 Pap smear images from the Herlev dataset each having one nucleus. These images are collected and manually labeled into seven categories or classes. ResNet101 extracts the automated features which are then employed in discriminating the seven classes of images in SVM. The propagated method was a built-in cascading type with five models of SVM (polynomial) classifier. The

overall accuracy for seven classes is 92% in the testing phase and much greater compared to others.

CC is undoubtedly a dangerous disease that has been stigmatized by health professionals. Delayed diagnosis and treatment, which are quite difficult, endanger valuable lives. In both developing and developed countries, the usual screening of the disease faces difficulties due to clinical costs, inadequate clinical services, social practices, and a delayed onset of symptoms. AI is computationally inexpensive, and prior detection of various health implications such as CC. Diseased individuals need not undergo complicated clinical guidelines and prior identification of CC is quite convenient with the use of ML solutions. In a suggested model the dataset includes 858 patients each with 36 features (Q. M. Ilyas et al. 2021). The missing information is balanced by pre-processing which improves the classifier performance. ML models such as SVM, KNN, DT, NB, J48 Trees, RF, LR, and MLP classifiers are used for experiments. An enhanced accuracy of 94% was achieved, which is better than the single classification models and most other conventional models.

Cervical cancer stands as the fourth most often seen cancer in the female population around the world, claiming 341,831 lives and 604,127 additional cases worldwide in 2020. Prior identification of the disease is crucial to reduce such a high death rate. A fast, accurate, and interpretable machine learning model is the goal of the study. Optimized functions reduce computation and improve rendering. A three-step hybrid selection method and a stacked categorization model are tested on a CC dataset from the UCI ML Repository, along with 35 characters and one final variable.

Numerous diseases affect women worldwide, and among those illnesses, there are frequent mentions of cervical cancer. Worldwide, a huge number of cancer patients are reported every year. The WHO ranks CC fourth among all other prevalent malignancies. Early detection of this malignancy may allow for treatment, reducing the fatality rate. Due to the lack of symptoms, this particular kind of cancer is less well-known. Regular screening test performance helps malignant cells to be identified in their initial stages, lowering the annual mortality rate. Numerous medical methods, including Pap smear tests, colposcopies, biopsies, HPV DNA tests, and other screening techniques, are used to forecast this malignancy.

In a suggested model, the database includes images from the Herlev database, which consists of seven different classes and twenty different features, all collected from the cervix of women patients by Pap smear test (Priyanka 2021). Pap smear tests can identify cancer at the initial stages. The proposed model achieves 74.04% accuracy in the prediction of cells. The texture patterns are predetermined in the decision system with SVM. The test results are compared with ANN and KNN which proves SVM is a better classifier. This proposed method helps the doctor to make a faster decision about the further treatment of the patient because the cell classification is done accurately.

Cervical biopsy plays an important role in detecting cervical cancer. The process of automatically classifying biopsy images to detect cervical cancer is time-consuming and relies on the expertise of the clinical technologist. The classification accuracy of cervical tissue images with comparable lesions is low, and the issue of incomplete samples must be addressed. In Huang et al. (2020) the dataset includes 468 biopsy images of the cervix. The biopsy images of the cervix are classified by the proposed model based on ensemble learning SVM and least absolute shrinkage and selection operator (LASSO). The LASSO technology is used for feature selection, which reduces the operation time by a significant amount at the same time ensuring accuracy followed by serial fusion. EL-SVM is used for classifying the biopsy images and generalizability was tested using ROC curve and error curve. The usual classification of datasets using the proposed model shows greater accuracy than other models. LSIL and HSIL were separately analyzed and showed varying accuracy of 91.88% for LSIL and 81.54% for HSIL.

Cervical cancer was recognized as the leading reason of death globally, with the majority of deaths occurring in developing nations. The mortality rate of CC is estimated to be around 60% in underdeveloped countries, and the rates could be even higher due to inadequate screening, insufficient sensitization, and many other factors. The purpose of this study is to leverage the powerful capabilities of ML for preceding recognition of CC. Identification of the most important feature is a crucial step in diagnosing diseases using a Machine Learning algorithm (Al-Batah et al. 2022). Generally, there are three feature selection and ranking techniques, and there are eighteen classifier algorithms, which groups under six learning models that were trained and tested with the primary dataset. The dataset contains 500 images. LWNB classifier had the highest overall performance compared to the other five strategies. Random Forest had the second-highest performance. However, the

learning strategy had the best overall performance compared to others. Logistic classifiers and LWNB classifiers are the best solutions to the issue of imbalance class distribution, which is a common issue in medical diagnostic datasets.

Computer vision plays a crucial role in Medical image analysis and classification by assisting healthcare professionals in predicting diseases (Kalbhor et al. 2023). Various deep-learning models have been developed to analyze several clinical image features and make accurate diagnoses for numerous variations of cancer such as cervical cancer. In general, the Pap smear examination is mostly utilized for prior detection of CC, this often produces False-positive errors because of human intervention. To address this issue, further research is needed to develop a computer-assisted prognosis technique on DL that can accurately classify Pap smear images. The dataset consists of Herlev and SIPAKMED are benchmark datasets for this study. One promising approach is Fuzzy min-max, which offers several advantages, such as efficient training with minimal passes and the ability to handle overlapping class classification. A combination of Fuzzy min-max and ML classifiers was used in this model for feature extraction and Pap smear image classification. DL models such as GoogleNet, ResNet-18, and Alexnet were applied. Significant performance has been attained by the model and the accuracy was better than most conventional models.

Cervical cancer is the second most common cancer among all women at the global level. It arises when abnormal cells develop in the cervix and proliferate uncontrollably. During the initial stages, symptoms of cervical cancer may not be apparent. However, it can be easily identified utilizing various ML techniques such as CNN which is widely recognized for its exceptional accuracy and functional to diverse fields. Additionally, the SVM is a commonly employed classification tool for diseases, renowned for its high accuracy. Hence, the combination of CNN-SVM, utilizing multiple linear kernel functions, serves as an effective classifier for classifying cervical cancer. The dataset consists of 652 images from cervical cancer patient in which 607 are from major and 45 from minor.

The model accuracy achieved was 93.67% for the test data and improved with the count of epochs (Aurelia et al. 2021). The results of the experiment indicated that the techniques utilized accurately and appropriately forecasted the data. The results confirm that CNN-SVM having a linear kernel was noted as the suitable model for the classification of

cervical cancer data. Further research will aim to enhance this method to achieve greater accuracy by utilizing a larger database, to provide improved results.

Among Gynecological cancers, CC stands as the third highest prevailing primary lethal disease among women in world countries. This unfortunate context is influenced by a range of factors, including smoking, immune deficiencies, inadequate nutritional status long-term contraceptive use, and many others. In addition, HPV also spreads the disease through sexual means. Due to these rapid spreading, cervical cancer stands as a great threat to women communities, especially in underdeveloped and developing countries. An experiment was set to detect CC and to find the key factors by utilizing the ML classification algorithm (Asadi et al. 2020). The dataset consists of information about 145 patients each with 23 attributes. The machine learning algorithms such as SVM, C and R tree, QUEST, MLP, and RBF were utilized. The accuracy of this algorithm varied during the first, second, and third trials but all were above 90%.The verification obtained from this investigation affirms that ML can enhance the detection of cervical cancer. The study's results indicate that the DT algorithm can be used accurately to detect the most important factors.

Considering the complexities in causal elements, exact prognosis of cervical cancer in the clinical environment is problematic. Many new approaches based on machine learning have identified for better prognostic prediction on the basis of shortcomings in commonly utilized Cox proportional hazards model, with the inability to fully utilize information and the potential failure to get the optimum match. Nevertheless, because these efforts frequently rely on open datasets, they are pertinence for frequent restriction. Thus, it is necessary to examine the well-performing ML algorithms for accurately detecting cervical cancer. To identify patient survival, the recent pathological data from 216 patients collected from Chengdu's Fifth People's Hospital is utilized. Several ML techniques, such as LR, KNN, DT, SVM, XGBoost, RF, extreme gradient boosting, and light gradient boosting machine (LightGBM), were explored in this study.

Machine learning provides a cost-effective and computationally efficient solution for early diagnosis of various diseases, particularly CC. By utilizing ML-based solutions, patients can deflect traditional and cumbersome medical procedures, making early detection of CC more appropriate. Nevertheless, the existing difficulties in machine learning techniques for disease detection impacts the precision of a sole classifier. Considering the

single classification method encounters suboptimal predictions owing to biases, over fitting, misapplication of noisy data, and anomalies. To tackle this challenge, the current research suggests an Ensemble classification technique utilizing majority voting to enhance the precision of diagnosis through the incorporation of the patient's medical history and symptoms.

Numerous classifiers including DT, SVM, RF, KNN, NB, Multiple Perceptron (MP), J48 Trees, and Logistic Regression (LR) classifiers were evaluated (Q. M. Ilyas et al. 2021). This research utilizes two publicly accessible CC datasets to diagnose CC. The initial dataset, known as the "CC Behaviour Risk Dataset," consists of 20 attributes, including the class attribute. On the other hand, the second dataset, referred to as the "CC (Risk Factors) Dataset," has been subjected to experimentation by multiple researchers. This dataset comprises 36 attributes and encompasses a total of 858 subjects. The results demonstrate a significant improvement in accurate prediction, attaining 94%, that surpasses the accuracy of various classification techniques evaluated using similar datasets. Therefore, the proposed model offers valuable insights to healthcare professionals for the identification of diseases and early treatment.

Web Framework for CC Detection System (WFC2DS), is a cutting-edge expert web system tailored to revolutionize the detection of CC (Qathrady et al. 2024). WFC2DS incorporates the advanced KNN classification algorithm for analyzing a vast dataset containing information from 858 patients with 36 attributes. The main goal is the early detection of CC, using the Biopsy attribute as the target variable. The assessment criteria include accuracy, specificity, sensitivity, and the F1 score. KNN achieves an accuracy of 90.6% with an F1 score of 91%. This research plays a significant role in reducing the global burden of CC, showcasing ground breaking progress in women's healthcare. WFC2DS is compared with state-of-the-art ML techniques enhances the accuracy of CC diagnosis along overall healthcare landscape for women worldwide.

An early prediction of CC using ML algorithms is achieved using Data mining methodologies, specifically tree-based algorithms, have been employed to provide precise forecasts for individuals with CC(Mugad et al. 2021). The SMOTE was implemented to address the problems of imbalanced data sets, where the number of cancerous patients was significantly lower than noncancerous patients. The decision tree model retained superior

predictions compared to decision forest and decision jungle models, in terms of AUROC curve value. The performances of decision forest and decision jungle models were suppressed due to their lower AUROC curve values. Since, the increasing volume of data on CC patients and rapid advancements in data analysis tools, it is anticipated that an optimal screening approach for CC patients can be noticed to enhance patient care. This study may serve as a blueprint for establishing a healthcare framework tailored to CC patients in the future. Accuracy for various algorithms are as follows: KNN gave the best accuracy than Decision Tree Classifier and RF at 85.11% and 87.90%, respectively.

A novel approach utilizing an ensemble algorithmic model is demonstrated for the computerized diagnosis of CC (Gupta et al. 2022). The researchers utilized the dataset available at the University of California Irvine database repository as benchmark dataset for their study. To ensure the accuracy of their findings, the researchers first addressed the missing values in the dataset through a KNN imputation technique. Subsequently, they balanced the data by oversampling. Two feature selection methods were employed to identify the most significant features within the dataset. The researchers introduced a stacking architecture, which had not been previously analyzed CC dataset. These results surpassed the performance of the previous methods used in similar studies. The main goal of this research was to introduce a computerized model capable of accurately detecting CC. Additionally, the scientists evaluated their suggested learning framework against different ensemble methods like RF, GB, voting ensemble, and weighted voting ensemble to gauge its efficiency and room for enhancement.

The application of the RF algorithm in the diagnosis of CC was studied (D. Jia et al. 2020). The accuracy of these diagnoses hinges on three key factors: cell divisions, extracting the selected features, and classification. The RF algorithm, incorporating Artificial Fish Swarms Algorithm (AFSA), is utilized to identify and categorize cervical epithelial cells. The efficacy of these methods was evaluated using 200 cervical Pap smear images. The findings of the experiments demonstrated successful segmentation of cervical cells, with an accuracy of 81.31% achieved through the proposed feature selection method using the minimum number of features. Furthermore, the enhanced RF algorithm, employing 2 and 7 classifications under fivefold cross-validation, attained the best accuracy. These findings indicate that the proposed method offers significant advantages in cell recognition, thereby establishing a practical framework for the accurate diagnosis of CC.

A study on the prognostic of CC using an ML algorithm integrated model based on CC risk prediction score that is both timely and cost-effective through the utilization of supervised ML methods combined with dimensionality reduction techniques (Arora et al. 2021). These techniques aid in delivering predictions with a reduced number of features. The CC (Risk Factors) Data Set has been utilized by researchers available from UCI ML repository. The empirical analysis of CC risk factors demonstrates that the RF classifier, when employing recursive feature elimination using a cross-validation technique, achieves an accuracy of 93%.

The prediction of CC using photonic combined with ML, data was gathered from test liquids is analyzed using ML algorithm that includes RF and NB (Kruczkowski et al. 2022). Interferograms that depict the optical characteristics of the substances being measured, along with meta-data from the measurements, are converted into multidimensional datasets. A crucial phase in the ML process involved devising an innovative method for the initial processing and enhancement of the datasets. A portion of the data was employed to train the algorithm, while the remainder was used to validate its correct functioning. The conventional classifiers that were tested exhibits high accuracy exceeding 95%, precision exceeding 95%, recall exceeding 95%, and F1 score exceeding 95% for the training datasets. For the validation datasets, the accuracy, precision, recall and F1 scores were above 89%, 90%, 90%, and 89% respectively. This approach could be highly beneficial for medical professionals in the early diagnosis of CC.

The application of optical devices that can be integrated with smartphone platforms were explored (Shukla et al. 2023). These devices offer several advantages, including cost-effectiveness, durability, and portability that showed promising results compared to existing commercial devices. In this particular study, the focus is on a 3D-printed smartphone-based spectroscopic device (3D-SSD) and its applicability in the detection of CC. The device is capable of evaluating intrinsic fluorescence (IF) by analyzing polarized fluorescence (PF) and the elastic-scattering (ES) spectra obtained from cervical tissue samples of varying grades. The researchers analyzed IF spectra from 30 cervical tissues samples and employed a combination of principal component analysis (PCA) and RF-based multi-class classification algorithms to classify the samples. The overall accuracy of this classification algorithm was found to be above 90%. The use of a smartphone for image collection, spectral data analysis,

and display makes this device a promising for regular screening in clinical settings. It is potential for being cost-effective and portable screening tool holds great promise in the early detection and management of CC.

Research on the prediction of CC utilizing a stacked ensemble algorithm incorporating SMOTE and RF algorithms was conducted (Bhavani et al. 2023). In this research, they have suggested an ensemble method that utilizes heterogeneous individual models and an ensemble model to predict CC based on multiple factors of risk. To address the issue of imbalanced data, Synthetic Minority Over-sampling Technique (SMOTE) has been used for data balancing. Additionally, Recursive Feature Elimination (RFE) with RF for feature extraction has been utilized, resulting in improved accuracy compared to existing methods. The UCI provided the dataset used in this study which consists of 858 instances with 32 features. The dataset includes four target variables, namely Hinselmann, Schiller, Cytology, and Biopsy, each representing a different type of CC examination. Through pertaining multiple classification and ensemble techniques, it is suggested that the ensemble method outperforms other methods.

An advanced decision-making system designed for the detection of CC by utilizing risk factors identified in an accessible dataset (A. Newaz et al. 2022b). The dataset exhibits a significant contradiction between good and bad instances. While sampling techniques can be employed to tackle this issue, oversampling or under-sampling alone is inadequate in achieving a proper balance between the classes due to the substantial level of imbalance. Therefore, a new resampling approach that combines oversampling and under sampling to establish an appropriate equilibrium between the two classes has been recommended. To enhance the efficiency of the classifiers, GA is utilized to pinpoint the key risk factors for CC detection. By utilizing the optimized feature from GA, the RF classifier achieved the highest G-mean score of 94.47%, as well as a sensitivity and specificity of 94.25% and 94.69%, respectively. As a result, the proposed resampling method adeptly combats class disparity, while GA effectively recognizes the key features to improve class differentiation and the amalgamation of these methods yields the optimal performance for CC diagnosis.

An approach of analyzing features of nuclei in Pap smear images in the area of CC detection was suggested to reduce workload (Diniz et al. 2021). The study explores eight conventional ML techniques for a step-by-step classification process. A novel hierarchical

classification approach is suggested for computer-aided screening of cell abnormalities, which suggests specific areas of interest in microscopy images based on the identification of cervical cell nuclei. The datasets utilized in this research can be accessed from the CRIC Searchable Image Database and the Herlev Database. The performance of various algorithms is analyzed using Herlev and CRIC databases, with different numbers of classes considered for image classification. The findings reveal that the hierarchical classification method achieved optimal results when employing RF as the primary classifier, outperforming decision trees, k-NN, and Ridge methods, especially.

A study on ML and Class Balancing methods for the Diagnosing CC utilized a dataset from 859 women patients, containing 36 attributes per sampling and 4 usual distinct outputs (Glučina et al. 2023). Multiple AI and ML methods were proposed to obtain the targeted outputs. Algorithms such as LR, MLP, KNN, and various NB methods were employed. The research indicates that the fusion of MLP and KNN alongside oversampling methods enhances overall performance. The incorporation of AI, ML, and class rebalancing leads to a substantial enhancement in screening accuracy. The authors intended for preliminary screening through questionnaire and AI model for underscoring the potential of AI and ML in advancing CC screening.

An ML-based algorithm namely CervDetect is employed to assess the causative factors associated with malicious cervical growth (M. Mehmood et al. 2021b). CervDetect utilizes Pearson correlation to preprocess the data by examining the relationships between incoming and outgoing parameters. Additionally, CervDetect employs the RF feature selection method to identify important features. The dataset utilized in this research is publicly available in the UCI database, containing information on patient history, practices, procedures, and demographic statistics for 858 instances with 32 features each. Furthermore, CervDetect utilizes a mixed approach that combines RF and shallow neural networks for the detection of CC. The results demonstrate that CervDetect attained an outstanding accuracy of 93.6%. This underscores the importance of early screening for CC and suggests a hybrid methodology that integrates RF and shallow neural networks.

Meanwhile, multiple RF techniques could be trained using distinct rotations of identical images that aim to enhance the cell data by rotating each cell sample within the training dataset for effective CC detection (Kuko et al. 2020). The ensemble learning strategy

employed in conjunction with RF models has resulted in an accuracy rate of 90.37%, along with a sensitivity of 96.33% and a specificity of 83.59% when categorizing abnormal and normal cervical cells into binary classes during a 5-fold cross-validation process.

The Synthetic Minority Oversampling Technique (SMOTE) is a prevalent oversampling approach integrated with fivefold cross-validation addresses the aforementioned issues (N. K. Chauhan et al. 2022). The study conducts a comprehensive comparison of the performance of various ML classifiers, including NB, LR, KNN, SVM, Linear Discriminant Analysis, MLP, DT, and RF, on both measured and unmeasured data. The data is scaled using Min-Max scaling, Standard scaling, and Normalization techniques. The results reveal that DT, RF, and SVM are the top three ML algorithms for CC diagnosis. The general outcome of the RF predictor with RFE (RF-RFE) surpasses other classifiers explored in this study.

The main objective of the Prediction and Detection of Cervical Malignancy Using ML Models is to identify and examine the indicators of CC and address the challenges posed by demented datasets using various ML algorithms (S. Devi et.al. 2023 b). To conduct the study, a multi-step sampling strategy was employed, resulting in the recruitment of 501 samples. ML classification methods, including DT, RF, LR, MLP, and NB, were utilized to assess the demented input and desired datasets. Among the participants, 26 women with unusual pap tests were found to have atypical malignant cells on their cervix. These women underwent further tests, such as cervical biopsies, and 7 of them were diagnosed with CC. In models 1, 2, and 4, LR demonstrated a sensitivity ranging from 88% to 94% and an accuracy ranging from 84% to 89% for predicting CC. On the other hand, DT algorithms in approaches 3, 5, and 6 displayed a sensitivity of 83% to 84% and an accuracy of 84% to 88%. The NB and LR algorithms achieved the highest AUROC curve on the testing dataset, whereas all models showed comparable performance on the training data.

However, the detection of cervix cancer using Pap smear images could be improved by computer-based decision system that can recognizes in its early stages (Akyol et al. 2020). The cervix images obtained from the Pap smear test contain both normal and abnormal cells, with the abnormal cells being highlighted in the images. These images were analyzed by pathologists, and a dataset was constructed by extracting relevant features. 917 images in the Herlev dataset had their features extracted and stored in a separate dataset.

To analyze the system efficiency, various ML algorithms, including SVM, NB, RF, MLP, LR, and KNN, were applied to the dataset. Moreover, the accuracy obtained ranged from 83% to 92%.

ML approach was utilized in predicting the variants of cytokine genes and socio-demographic characteristics about CC (M. Kaushik et al. 2021). The study encompassed a dataset of both individuals without any health issues and individuals diagnosed with CC. Various ML approaches were employed to assess various risk factors, such as demographic characteristics and variations in cytokine genes. The proposed method was evaluated using various statistical parameters. The dataset underwent multi-stage random splitting before applying ML methods. The effectiveness of the proposed approaches was evaluated by various performance metrics. Among all the methods, LR attained the highest accuracy of 82.25% and the uppermost F1-score of 82.58%. The NB classifier exhibited the highest sensitivity at 85%. Notably, the ridge classifier outperformed most ML classifiers with an accuracy of 84.78% and a sensitivity of 97.83%. The findings highlight the successful use of ML-aided detection of cytokine gene variations and socio-demographic factors to forecast the likelihood of CC development.

A study on the usage of the Refractive index in predicting the CC with ML showcases the use of optical sensors and predictive algorithms in assessing CC(Kruczkowski et al. 2021). By measuring the refractive index of tissues and detecting changes, valuable information about the tissue's condition can be obtained. The optical dimensions generated datasets for training as well as validating analysis software. It discusses data pre-processing and ML outcomes using three algorithms (RF, eXtreme GB, NB) and evaluates their performance in classifying healthy and diseased tissues. All three algorithms demonstrated high accuracy rates (>89%) in their respective measures. This innovative solution enables swift sample measurements and automated result classification, serving as a potential tool to aid healthcare professionals.

The proposed approach on Pap smear images for diagnosing CC through the utilization of fractional coefficients and ML classifiers utilizes two different types of features: the discrete coefficient transform (DCT) coefficient and the hash transform coeffecients (Kalbhor et al. 2022). These features are then used as input for seven different ML algorithms, namely simple logistics, Bayesnet, NB, RT, RF, decision table, and part. To

optimize the feature size, fractional coefficients are employed to form five different sizes of feature vectors. The results indicate that the DCT transform attains the highest classification accuracy of 81.11%. Furthermore, when comparing the performance of the different ML algorithms, it is observed that the RF classifier demonstrates the best overall performance.

CC is an influential cause for the mortality of women. The cancer complications can be restricted if it is detected and managed at an earlier phase. The conventional study by Ghoneim et al. (2020) discusses the detection of CC cells and classifies them using CNN. The images of the cell are provided as input to the CNN model by extracting the DL features. Extreme Learning Machine (ELM) categorizes provided input images. The model is utilized through transfer learning as well as fine-tuning. Alternatively, Multi-layer perception (MLP) and AutoEncoder (AE) classifiers have been analyzed. Herlev database is utilized for experimental analysis. The suggested CNN-ELM system aids in achieving an accuracy of 99.5% in CC detection. Moreover, 91.2% of accuracy attained in the classification issues.

The conventional screening of cervical cells mainly relies on the pathologist's experience inducing the issues of poor efficiency and low accuracy. The processing of medical images through the integration of DL and ML gains its preeminence in the cell classification system. A novel framework of the CNN+SVM model has been proposed by A. D. Jia et al. (2020) for the accurate detection of cancer cells. Gray-Level Co-occurrence Matrix (GLCM) is utilized to extract the strong features of the method. Subsequently, Gabor encompasses the abstract features of the hidden layers in CNN. The fused data were provided as input to SVM for the categorization. The effectual dataset intensification technique was constructed to enhance the model's robustness. The proposed technique has been analyzed for two independent datasets and evaluated using specificity, sensitivity, and accuracy. The values are 99.4%, 99.3%, and 98.9% respectively. The outcomes reveal that the CNN+SVM model has been employed in the cell categorization at the earlier phase.

Gorantla et al. (2019) states that almost 570,000 women are affected by the CC Worldwide. It is a significant cause of cancer-associated death. Moreover, it is caused by HPV that increases excessive cell growth in the region of the cervix. The death rate in developing nations has been minimized through the regular assessment of women for HPV. Even though, developing nations are struggling to provide low-cost testing due to the absence of affordable medical techniques. There are also issues raised to the skewed ratio

among the oncologists and patients. The novel methodology CervixNet has been proposed in the DL technique in the field of biomedical imaging. It enhances the images in the centigrams through segmentation process. The segmentation of the Region of Interest (ROI) is to identify the appropriate treatment. The task classification has been performed via a novel algorithm of Hierarchical Convolutional Mixture of Experts (HCME). It has the potential for the handling overfitting since the smaller datasets are an immense issue in the biomedical Imaging field. The proposed framework outperformed the prevailing methodologies in the Intel as well as the Mobile-ODT Kaggle dataset, which provides 96.77% accuracy. It has a kappa score of 0.951. Therefore, from the implications it has been evident that the proposed method is considered to be the first low-cost screening of the CC.

In a study by Tan et al. (2021) indicates that the developing nation possesses an elevated incidence rate of CC due to a scarcity of medical sources for detection, prevention as well as management. DL methods aid in achieving high scanning accuracy in the cancer screening process. These methods are utilized for early detection and effectual treatment, thereby attaining CC prevention in the successful pathway. The adopted work demonstrates the construction of DCNN that guides the pathologists in the CC screening process. ThinPrep Cytologic test (TCT) images are collected in diverse hospitals by pathologists. The images are classified into the test (408,030 images), validation (2301 images), and training (13,775 images) datasets. It is trained and evaluated in the Faster R-CNN. The outcome of the analysis reveals that the specificity and sensitivity of the proposed model are 34.8% and 99.4%, respectively. AUC is estimated to be 0.67. The model differentiates between the positive and negative cells. The sensitivity values of High-grade Squamous Intraepithelial Lesions (HSIL), Low-grade Squamous – Intraepithelial Lesions (LSIL) and Atypical Squamous Cells of Underdetermined Significance (ASCUS)were 73.9%, 71.5%, and 89.3% respectively. The system can categorize the images rapidly. Additionally, it generates a report in three minutes. Therefore, the system minimizes the pathologist's burden and saves valuable time to evaluate complicated cases. The study concludes that the CNN-oriented TCT screening model has been achieved via retrospective research on the multicenter images. The proposed model exhibits speed and accuracy in the CC screening process. It aids in overcoming the scarcity of medical facilities for diagnosing CC.

In research carried out by Kavitha et al. (2023) suggest that Excessive cell growth and propagation are the diagnostic indicators of cancerous disease. When the cancer-affected cells enter the organ, they damage the adjacent cells and, finally, other organs. The cervix is located at the bottom of the uterus and CC manifests itself in the uterine cervix. The growth, as well as the death of the cervical cells, are the significant features of the condition. The implications of the false-negative results exhibit a moral dilemma that incorrect diagnosis leads to premature death in women due to the disease. Alternatively, the false positive results do not lead to ethical concerns. It requires patients to perform expensive and time-consuming techniques. It also provides unnecessary stress and anxiety to the patients. A pap test is conducted for detection of the CC at the earlier phase. The adopted work demonstrates a method for the improvisation of the images utilizing the Brightness Preserving Dynamic Fuzzy Histogram Equalization. The fuzzy c-means is applicable for the detection of the individual components. The images are categorized to determine the right area. ACO algorithm is utilized for the feature selection. The categorization is conducted by ANN, MLP, and CNN algorithms.

CC is a significant gynecologic malignancy, and the incident rate, as well as mortality, is substantially high in distant areas and inadequate medical conditions in China. CNN method in a simple architecture was proposed by M. Wu et al. (2018) to enhance the diagnostic accuracy of the CC in the regions and thereby improve current situations. The model has been trained and validated with the support of the two groups of images in the datasets. They are an original group with 3012 datasets and an augmented group with 108432 data sets. The group has a fixed number of RGB images for performing three-fold validation in the model. The classification accuracy is 93.33% for the real image group. Moreover, the augmented group exhibits 89.48% accuracy. An improvisation of 3.85% accuracy has been established through the augmented images in the model. The outcome fetched from the paired t-test reveals that the two models were classified accurately with significantly different P-values less than 0.05. The proposed scheme has been utilized for the classification of the cytological images and to improve the diagnostic accuracy of the pathologists, which is potentially applicable to China. It is influenced by the inadequate medical facilities in remote areas.

Waly et al. (2022) states that biomedical imaging is a significant way for investigating the internal organs and its complications. The Pap smear image is widely

utilized for diagnostic purposes. CC is a chief reason for the elevated mortality rate of women. Pap smear image screening is important for the assistance of earlier detection and diagnostic purposes for the CC. It achieves cancerous cell identification through the computer-aided system utilizing DL approaches such as CNN and proposed the model IDCNN-CDC. It involves four major processes, which are likely pre-processing, separation, extraction, and classification. GF technique is incorporated to improvise the data with the noise removal system in the image. Tsallis entropy technique with the dragonfly optimization (TE-DFO) demonstrates the image segmentation for the identification of the affected portion appropriately. The cell images are provided as input in the DL-oriented SqueezeNet system for the extraction of DL features. The extracted features of the SqueezeNet are incorporated into the ELM for detection as well as categorization of the cervix cells. Herlev database is employed for experimental analysis. The database has been generated from the Herlev University Hospital. The outcome of the experiment reveals the high performance in terms of the F-score, accuracy, and specificity.

Rehman et al. (2020) states that CC is the fourth most frequently occurring cancer and it is the chief causative of mortality in the World. The numerous types of screening examinations are performed for diagnosing and the most significant is the Papanicolaou smear examination. The cell cytology is conducted in the tests. Hence, it is considered to be a real tool for the earlier identification of the CC. There is a possibility of the CC misdiagnosis. Hence, the conventional study proposes an auto-assisted screening system and it utilizes the CNN techniques for analyzing cervical cell dataset. The training is accomplished via transfer learning. ImageNet datasets are utilized to initialize the weights through the training process. On further tuning of the database, the extraction of the feature vector in the whole connected layer of CNN takes place. Three diverse classifiers are recommended including SVM, GentleBoost – ensemble of Decision Trees (GEDT), and Softmax regression (SR). The enactment of the screening system is analyzed through two different protocols such as 2-class as well as 7-class problematic from the Herlev database. 2-class problems exhibit the accuracies of SVM, SR, and GEDT to be 99.5%, 98.8%, and 96.6%, respectively. While in the case of 7-class problems are 98.12%, 97.21% and 98.85% correspondingly. The outcome reveals that the proposed system delivers better performance compared to the existing counterparts in differential testing conditions.

Pap smear tests are a labor-intensive and tedious process that results in a high level of variability due to numerous inter-operators. An algorithm of computer-based classifications is proposed for the classification. The existing study demonstrates the utilization of CNN for image classification. Arifianto et al. (2021) employs a productive model to minimize the computational cost significantly. The pre-trained SqueezeNet architecture is utilized to train the image dataset in the Caffe. The fine-tuning process has begun with the model feature initialization in the broader spectrum. Hence, the last layer of the output number has been altered to fit the label number in the CC. It has been concluded that the performance of the SqueezeNet is three times faster than the MobileNet and six times greater than the SeNet.

The specific location of the cancerous cells in the cervical cells has minimized the doctors' workload and elevated the diagnostic accuracy. Xia et al. (2020) proposed a novel network architecture for the detection of cancer cells namely Series-parallel fusion network (SPFNet). It is compared with the traditional framework that utilizes the classification networks for the extraction of the image feature and it acts as a backbone. It utilizes the differential integration strategies and train five differential models to detect the most appropriate network for task detection. The proposed system compares with the detection and a similar data set is tested with the detection algorithm. The experimental outcome reveals that the detection framework creates optimal performance compared to others. It shows an average precision of 78.4% in the detection tasks.

In a study by Chandran et al. (2021) state that the conventional screening of CC relies on pathologists' experience and has less accuracy. The chief component of preventing CC is colposcopy. In integrating the screening as well as treatment, the colposcopy played an indispensable role in the minimization of the incidence rate as well as mortality over the last fifty years. Due to the progressive workload, vision screening led to misdiagnosis and resulted in the low efficiency of diagnosis. The image processing utilizing CNN observed the superiority of the CC classification in the DL field and proposes two main CNN architectures for the detection of CC utilizing colposcopy images. They are CYENET and VGG19 model. The model is developed for the classification of the CCs from the colposcopy images. The sensitivity, specificity, and accuracy have been calculated for the developed model. The accuracy of VGG19 is 73.3%. A satisfactory outcome has been achieved from the VGG19. The kappa value of the model VGG19 reveals that the model relies on moderate classification. Additionally, the experimental consequences show that the anticipated

CYENET model exhibits high kappa, sensitivity as well as specificity are estimated to be 88%, 96.2%, and 92.4% respectively. The accuracy is enhanced by 92.3%, which is 19% greater than the model VGG19.

Rhee et al. (2020) developed an automatic contouring tool for the estimation of the clinical treatment volume (CTV) and tissues to plan the treatment for CC affected patients. Auto-contouring tools based on CNN are developed to demarcate the three CTVs and 11 real structures for cancer treatment. It is a web-based plan system. 2254 retrospective CT scans are extracted from the solitary cancer unit along 210 CT scans from the dissection are utilized to train and to validate the CNN-oriented auto-contouring tools. Sørensen-dice similarity coefficient (DSC) is utilized to estimate the tool's accuracy. The mean surface and distances among the contours that are generated automatically and contours drawn by the physician in the CT scans. Moreover, the scoring of the generated contours is performed by the radiation oncologists. 30 such contours are examined from the South African hospitals. 80% of CTV and 98% of the bony contours in the dataset are clinically satisfactory based on the physician review. CNN-oriented contouring tools are well-performed on both the external as well as internal datasets. It had an elevated rate of adequacy.

Cheng et al. (2021) says that the diagnosis in terms of computer assistance is a key for scaling up the screening process. The prevailing algorithm performs poorly in the WSI analysis. It failed for the generalization of the staining and imaging. It observes the sub-optimal level in the clinical verification. The integration of the high and low-resolution WSI paves the way to develop a new lesion cell detection technique. Recurrent Neural Network (RNN) evaluates the degree of lesion in the WSI. The training and validation of the WSI analysis for 3,545 patients with annotations of 79,911 from the imaging instruments and multiple hospitals were done. In almost 1170 patients WSI attains a specificity of 93.5% and a sensitivity of 95.1%. The average performance of the cytopathologists acquires 88.5% true positive highlights of 10 lesion cells for 447 positive slides. Finally, the system has the potential to recognize one gigapixel in 1.5 minutes.

The earlier identification of intraepithelial neoplastic is significantly elevating the patient's survival rate. The adopted study by Li et al. (2020) utilizes DL for the precise identification of cancerous cells with the aid of colposcopy images. It encompasses two main

components a key-frame and a feature combination network. In addition, the features of the real image, as well as colposcopy images, are captured at 60, 90, 120, and 150 s in the tests of acetic acid, which are prearranged using the feature networks. Numerous tactics are equated and all of them outperform the prevailing diagnosis system utilizing one time slot. The graph convolution network with edge feature is the most appropriate fusion in research due to the reliability in clinical practice. A dataset comprising the colposcopy image with a time-lapse of 7668 is gathered from the patients of the collaborative hospital for training and validating the DL framework. Colposcopists are compared with the computer-assisted diagnosing systems. The proposed DL framework attains an accuracy of 78.33% compared to that of colonoscopists' diagnostic procedures.

CC has been screened through colposcopy. It identifies CIN and cancerous cells but exhibits misdiagnosis. The prevailing algorithms for evaluating cervical cancer have neglected sequential colposcopy, which is unfavorable for clinical applications.Yue et al. (2019) constructs a cervigram-oriented RCNN (C-RCNN) for the classification of differential CIN grades as well as CC. The spatial features are extracted using CNN. The progression of the sequential encoding for the temporal features and the Convolutional layer integrates the differential stages of cervical images. The dataset encompasses 4,753 original images for the training and validation of the performance. The specificity, sensitivity, and accuracy are estimated to be 98.22%, 95.09%, and 96.13%, respectively. The operating characteristics are found to be 0.94 and it reveals that the visual representation and dynamics are integrated in the training phase. The comparative analysis discusses the effectual performance of the C-RCNN with the competing environment. It shows substantial enhancement as it concentrates on the single frame. The architecture has been extended for the applications of diagnosing medical images.

Sellamuthu Palanisamy, Athiappan, & Nagalingam (2022) noticed that detection as well as classification of the smear images is a significant task for the documentation of the CC. The conventional study demonstrates the DTCWT-oriented DL algorithm for the categorization of the images to four differential conditions likely in situ, normal, superficial, and dysplastic. The proposed work encompasses the data augmentation, DTCWT as well as a CNN module for the categorization of the cell images. The high classification value has been achieved with the aid of several cell images. Therefore, the flipping and shearing functions

have been utilized for the data augmentation to enhance the sample dataset for the further categorization module. The behavior of the data-augmented images is conveyed into the pixels using the DTCWT that generates the coefficients of the subband in the matrix format. ResNet 18 is utilized to train and classify the datasets that categorize the provided image into four classes. Moreover, the developed technique is validated on the images in the dataset. In addition, the average PDI (Pap smear Detection Index) is estimated to be 99%.

Youneszade, Marjani, & Pei (2023) indicated several challenges in integrating DL techniques that are tedious for the AI to resolve. CC ranks second with 700 or more mortalities per day. The number is assessed to be 400,000 in the year 2030. It is curable when detecting and treating at the earlier stage. Colposcopy and Pap smear are generally used screening methods for cancer detection. The manual screening is subjected to an increased false rate due to numerous errors. To resolve the issue, ML and DL techniques are utilized for expanding the automatic segment and classifying the cervical cytology as well as colposcopy images. In addition, these techniques elevate the accuracy in detecting the differential stages of CC. Almost 50 surgical images from the Guanacaste dataset are classified into malignant and benign cases. However, CNN is exhibiting outstanding performance. The dissection and classification aid the patient with earlier recognition, treatment, and the diagnosis of CC.

Attallah (2023) states that the CAD system requires the initial segmentation procedure for the cervical cell extraction from the slide Pap smear which is a tedious task. The model utilizes a manual extraction process that does not require the classification phase adequacy. Moreover, fewer data samples in the cervical datasets and the utilization of DL are uncomplimentary for cancer detection. The prevailing CAD system acquires the attributes from the individual domain. The combination of the features in the multiple domains generally has elevated performance. Because, CAD model performs well for the extraction of multiple domains, not a single domain. It does not necessitate the pre-segmentation procedure and is less complicated than the prevailing techniques. It hires three DL models for acquiring the spatial features at a greater level compared to the huge parameters in the individual DL. The layers are utilized in CADs. It recovers the textual and statistical descriptors of the multiple domains involving the time-frequency and spatial domain as an alternative to achieve clearer visibility of cancer features and not the case of prevailing

CADs. It analyses the impact of the manual attributes on the diagnostic accuracy of hybrid and independent models. Then, it investigates the outcomes of integration of DL with each CNN of integrated manual features.

It utilizes PCA to merge DL features with cohesive manual features for analyses of the merging DL features with differential features on the categorization outcome. The accuracy is 100% for 35 principal components in the quadratic SVM. The integration of several DL features along with the descriptors of the multiple domains can improve diagnostic accuracy. The comparative performance evaluation observes the competing capacity of the suggested framework.

The table below (Table 2.1) illustrates the comparative analysis of the various ML and DL algorithms.

Table 2.1 Comparative Analysis of Various ML and DL algorithms for detection of CC

Author	Approach used	Purpose	Outcome	Limitation
M. A. Qathrady *et al.*,Qathrady et al. (2024)	WFC2DS with the integration of the ML classification algorithm KNN	Detection of CC using a web framework system	KNN attains an accuracy of 90.6% with an F1 score of 0.91. This study contributes to lessening the burden of CC detection and indicating the advanced transformation in women's healthcare.	Data used are within the UCI dataset. The research was performed in default settings.

Author	Approach used	Purpose	Outcome	Limitation
H. Zhang *et al.*,H. Zhang et al. (2021)	The study involved collecting real Raman spectrum signals from precancerous tissue, followed by utilizing PLS and Relief techniques to extract signal features in the spectrum.	Utilizing Feature Fusion Alongside Raman Spectroscopy for Timely Detection of CC.	KNN's accuracy without feature fusion was 88.17%, which increased to 93.55% after fusion. Similarly, the ELM's accuracy without feature fusion was 90.81%, rising to 93.51% after fusion.	The research model utilized an insufficient sample size.
N. Al Mudawi and A. AlazebN. Al Mudawi& A. J. S. Alazeb (2022)	This research used various ML techniques, such as DT, LR, SVM, KNN, adaptive boosting, GB, random forest, and XGB.	Development of a Framework for Forecasting CC Utilizing ML Models.	The highest classification score is attained by the RF, DT, adaptive boosting, and GB algorithms.	The DT algorithm exhibits a high degree of instability, resulting in a substantial alteration of the optimal decision tree layout with even a minor modification in the data. Consequently, its reliability is inadequate.

Author	Approach used	Purpose	Outcome	Limitation
S. Gautam, N. Jith, A. K. Sao, A. Bhavsar, and A. NatarajanGautam et al. (2018)	This research suggested utilizing a CNN-based patch approach for the division in single cell images.	Factors to Consider for an Image Analysis System for PAP Smear with CNN Features	The experimental findings showcase the efficacy of the suggested algorithms when used independently while also establishing the adequacy of cell-nuclei detection (as opposed to precise segmentation) for classification purposes.	The drawback of the approach concentrated only on a limited number of features needed to train the model using more number of features
X. Tan *et al.*,Tan et al. (2021)	The Faster R-CNN is utilized in the analysis pipeline for detecting CC from the TCT smear.	An automated system for screening CC utilizing convolutional neural network technology: a comprehensive study across multiple cohorts and centers.	This model has demonstrated enhanced efficiency and precision in CC screening, addressing the issue of limited medical resources for such screenings.	The presence of numerous overlapping and adhering cells made it challenging to differentiate between diseased cells and normal cells. Consequently, the system struggled to accurately identify cell characteristics, resulting in a relatively low level of accuracy.

Author	Approach used	Purpose	Outcome	Limitation
A.-u. -Rehman, N. Ali, I. A. Taj, M. Sajid, and K. S. Karimov-Rehman et al. (2020)	The ConvNets-based automatic mass screening system for detecting CC is proposed. The process consists of four stages: (1) gathering data, (2) pre-processing, (3) acquiring features, and (4) classifying cervical cells. Detailed explanations of each step are provided in the subsequent sections.	A CNN-Based Automated Mass Screening System for Detecting CC.	The method under consideration demonstrates superior performance in relationships of arrangement accuracy, sensitivity, specificity, and area under the curve compared to previous cutting-edge techniques. It is estimated based on the Herlev Pap smear dataset.	DL approaches require the exploration of high-precision diagnosis. Specific classifiers are necessitated for resolving issues.

2.3 Research Gap

- The DT algorithm is highly imbalanced while processing Pap smear dataset for CC detection that influences the best decision tree layout with even a slight data adjustment. It is consequence of extensive enumeration and interpretation of data during the pre-processing stage N. Al Mudawi & A. Alazeb (2022).

- Considering the Pap smear dataset, the data disparity between negative and positive classes arose class imbalanced problem that results in misclassification in detection of cervical cancer with very poor performance and bias towards the majority class Newaz et al. (2022a).

- The accuracy of the system should be improved by using different datasets while reducing computational loads. The system needs a high-performance CPU to deal with huge datasets Alquran et al. (2022).
- A small sample dataset would affect the efficiency of a machine learning model. Although ML algorithm approaches are beneficial in cervical cancer prediction, a large sample size is suggested to solve the class imbalance problem Devi et al. (2023a).
- The system uses pre-trained models, which are usually trained on diverse and large datasets, often from different domains results in suboptimal performance. The proposed model's accuracy is much lower than other models Priyanka (2021).
- Lack of sequential model such as recursive deep neural network depreciates the performance of CC detection. However, data pre-processing can still improve the accuracy of the model Mehmood et al. (2021a).
- Ensemble models such as LWNB, Random Forest, and logistic classifier are adopted in an existing study for the prediction of cervical cancer. It encounters the problem of class imbalance in data distribution, which affects the overall performance Al-Batah et al. (2022).
- A modified version of the fuzzy min–max neural network can improve classification accuracy. The multiclass classification performance must be evaluated by experimenting with seven-class, five-class problems Kalbhor et al. (2023).
- The accuracy could be improved using a large dataset for classifying and predicting diseases Aurelia et al. (2021). In future, additional samples could be validated based on reliability and efficacy of the model H. Zhang et al. (2021).
- To enhance the study, future research needs to expand dataset size beyond UCI and thoroughly analyze potentially important features. It is also crucial to collaborate with medical experts to ensure rigorous clinical validation. In addition, hyperparameter tuning would be considered as an alternative data balancing techniques that greatly contribute to the study's advancement Qathrady et al. (2024).
- About the constraints of this research, it is important to note that the cancer dataset is restricted in size, necessitating a substantial number of malignant cases for optimal training. Furthermore, a thorough examination of various class balancing techniques such as oversampling the minority class can lead to a higher risk of overfitting.

Therefore, an ensemble and novel data balancing technique is essential for this significantly imbalanced dataset Gupta & Gupta (2022).

- However, it is important to note that experiments were conducted, allowing for only one target construct, Biopsy. In terms of future direction, it is recommended that more advanced techniques be used for imputing missing values, as this study employed a simple imputation technique Bhavani & Govardhan (2023).
- The different data balancing techniques is explored to focus on reducing type II errors, moreover, the algorithms are less complex and reduces computational time compared to alternative approaches Newaz et al. (2022b).
- Although this research is confined to certain limitations, utilizing a sequential model on this dataset, like an R-DNN, could prove beneficial for diagnostic purposes Mehmood et al. (2021b).
- The approach needs to concentrate on cell extraction and segmentation as well as to collect more data to attain higher accuracy Kuko &Pourhomayoun (2020), Tan et al. (2021).
- Various constraints have been identified in past studies and they are mentioned below. Initially, the DT algorithm exhibits high instability, resulting in a notable alteration in the optimal decision tree structure with even minor data modifications. This lack of stability renders it unreliable, as other predictors demonstrate superior performance with comparable data. Furthermore, this research encountered significant challenges in handling the dataset due to the extensive enumeration and interpretation of data during the data pre-processing phase N. Al Mudawi& A. J. S. Alazeb (2022).
- The proposed system is evaluated through the other datasets. It also recommends the utilization of hyper parameter tuning in deep neural network architectures, such as Inception, ResNet, and tree-oriented models Ghoneim et al. (2020).
- Since previous studies concentrates only on a limited number of features, it is required to train the model using a larger number of features Gautam et al. (2018).
- Futuristic approaches are aimed at improvising the classification accuracy through the utilization of supplementary DCNN models likely VGG, GoogLeNet, and other novel data augmentations.
- DL approaches require the exploration of high-precision diagnosis, which requires specific classifiers to resolve the issues -Rehman et al. (2020).

This thesis tried to bridge the gaps by implementing a comparative analysis of various deep learning models, evaluating their performance across diverse datasets, and employing a performance metric evaluation approach. The anticipated findings of this study are expected to advance the understanding of automated cervical cancer screening and assist to develop more accurate and robust classification systems.

2.4 Summary

The chapter discussed CC prediction and classification using AI (Artificial Intelligence)-based algorithms, namely Deep Learning (DL) and Machine Learning (ML). In the existing studies, the ML approach used the SVM model extensively, and the DL approach used the CNN model. This chapter elaborated on the prediction and classification of cervical disease using existing research studies.