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Systematic literature review in cervical cancer staging using neural networks

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Abstract

Cervical cancer is the number two killer for women and the Pap smear method is commonly used in the detection of the disease at an early stage. Cervical cancer is one of the biggest killers for many women globally. Several methods have been used to detect cancer during its early stages so that death figures can be reduced. The detection of cancer in women has been a challenge and using the Pap smear test because of its slow and accuracy levels. Scientifically neural networks are strong and reliable tools commonly used for building cancer prediction models for microarray data. Yearly, more than half a million women have been diagnosed with cervical cancer with 300 000 deaths worldwide. The deadly risk of more than a half million women with cervical cancer is the cause of the disease in most cases. Detection of cancer in developing and developed nations must invest a lot of funds in the detection of cancer to reduce mortalities worldwide. Cancer can be cured as long as it has been screened and detected at an early stage. This assists in giving ample time in the treatment of cancer. The exact location of cancerous cells in thousands of cervical squamous epithelial cells can reduce doctors' workloads of doctors and improve the accuracy of a cervical cancer diagnosis. Treatment of cancer depends on the disease extent at diagnosis and the availability of resources and might involve chemoradiation or hysterectomy. Conservatively, fertility-preserving surgical procedures are now standard for ladies with low risk at an early stage. Radiotherapy advancements like intensity-modulated radiotherapy have led to less treatment toxicity for ladies with locally advanced diseases. The study aims to review a systematic review of cervical cancer staging using neural networks. The study objectives are to analyse the effects of neural networks in the detection of cervical cancer, evaluation of the limitations in neural networking, assessment of other literature on neural networks and cervical cancer and the implementation of an outstanding method. The manual systematic review search was chosen for this study. The final review literature was 32 after the inclusion and exclusion criteria. The limitations of this study were the use of the manual search technique hence it is recommended that future studies adopted automatic and manual search methods. A systematic review is a very important aspect in the structuring of research studies as well as the gathering of relevant evidence and research findings.

Keywords: *Adenocarcinoma, Cell Carcinomas, Cervical Cancer Squamous, Deep learning, Neural Network, Transfer Learning.*

Introduction

Neural networks are powerful machine learning methods used commonly in the learning of data features at multiple abstractions. The representations are important for numerous applications like reconstruction, recognition and clustering. Predictive models like cancer prediction use these features for clustering on chosen samples (Daoud and Mayo, 2019). Neural networks can be categorized according to their functionality into filtering, predicting and clustering methods. The methods of neural networking filtering methods are used for the extraction of representations that describes gene expression with no consideration for the prediction goal (Ung et al., 2018; Fakoor et al., 2018). The predicting and clustering methods maximize the prediction forecasting (Chaudhary et al., 2018; Danaee, 2016; Garcia et al., 2018), dividing the sample genes concerning their mutual similarities into groups (Wang, 2018; Yu et al., 2018; Borkowska, 2018).

Cervical cancer many years has been a major carcinogenic disease mostly common among women. It is one of the deadliest cancer types due to its inability to direct symptoms at the onset of the growth of the tumour (Siegel et al., 2018). The diagnosis of cancer involves the collection of cervical cells in the uterus through the Pap smear test method (Anousouya et al., 2018). The cells will then be sent to the laboratory for abnormal cell detection. The challenge however of this problem is fluctuations, errors and poor accuracy test of results is very high. The diagnostic way is very slow and highly expensive for it to be carried out.
The artificial neural network has been effectively realized and recommended by experts as a better way to detect and dragonise cervical cancer in women. The ANN detection method used in cancer is fast, precise and accurate and it's not difficult to carry out (Pegah et al., 2018). ANN has three layers which are the input nodes hidden nodes and output nodes. The number of a specific layer is based on the input from the neurons as shown in Figure 1. The input node is determined by the images imputed and then connects to the hidden node which undergoes processing based on the data set by the input layer. Artificial intelligence has been regarded as a breakthrough to differentiate fields of study mainly medicine. The introduction of ANN opened ways to diversify possibilities. ANN is effective and potent in the assessment of patterns as well as the comprehension of complex information during the diagnosis of complex cases in patients (Zhang et al., 2018). The neural network performs diagnostic functions by camouflaging nerve cells. Neural networks function via a series of mathematical and analogue systems which share information through various interconnected layers and nodes. The adoption of neural networks in the process of staging cervical cancer is a trusted way by which diagnosis can be evaluated and analysed (Anousouya et al., 2018). Because of various research done by different scholars in Artificial Intelligence (AI), neural networks have promises of great magnitude for cervical cancer staging in the future.

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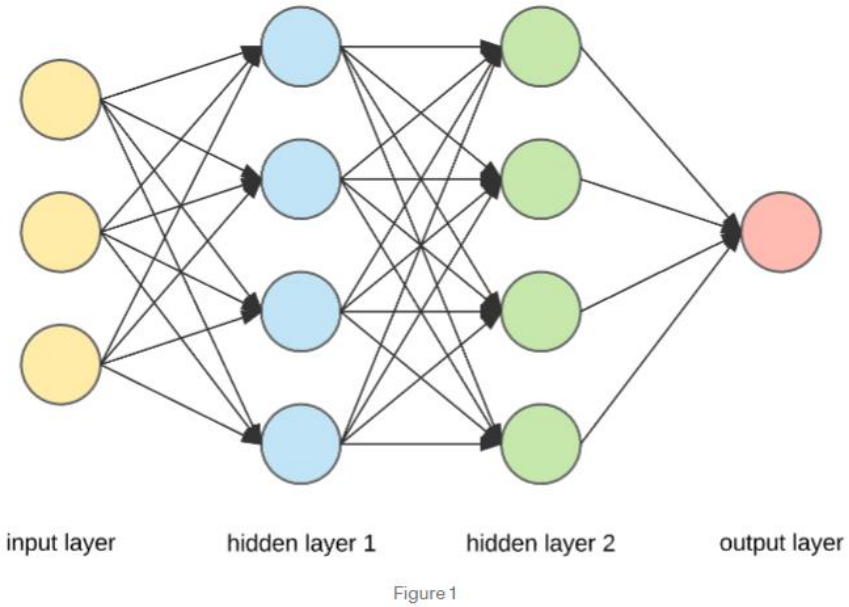


Figure 1

Artificial neural networks are multi-layer as indicated above. They have an input layer, multiple hidden layers and the last part the output player. All nodes are linked to other nodes in the next layer. The network is made deeper by increasing the number of hidden layers (Koutsoukas et al., 2018). Numerous specialists have applied artificial neural networks for various kinds of diseases. Distinctive calculations of artificial neural networks have also been utilized for breast cancer disease identification (Araujo et al., 2018, Mohebian et al., 2018). If we zoom in on one of the hidden or output nodes, what we will encounter is depicted in the figure below.

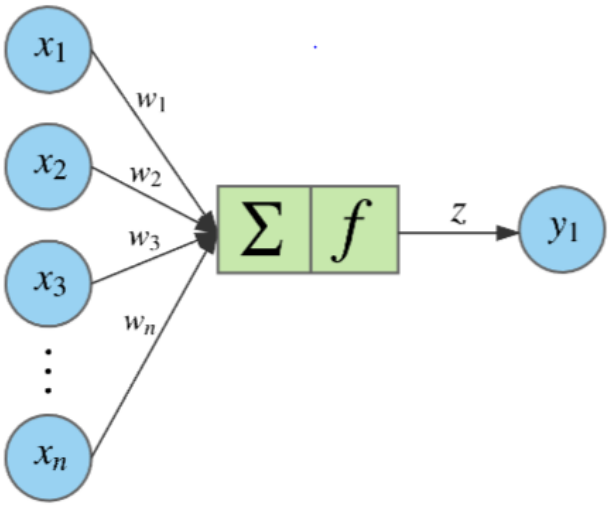


Figure 2

A node assumes the weighted sum of its inputs and exchanges it via a nonlinear activation mode. This will be regarded as the output of the node which will turn out to be the input of another node. The wave of the flow flows from left to right and the final result is measured by repeating the same procedure for all nodes. Deep learning training means learning the weights linked with all of the edges (Koutsoukas et al., 2018).

Purpose and objectives of the study

The study aims to conduct a study on staging cervical cancer using a neural network. Various systematic reviews relating to the utilization of neural network in cervical staging was evaluated by different authors and scholars who researched more on the subject. For successful results of the aim of the study to be achieved segmentation of the study into objectives gives information on neural network use in cervical cancer detection. These objectives are summarized below,

- To analyze the impact of artificial neural networks in cervical cancer detection
- To investigate limitations associated with artificial neural networks in cervical cancer staging
- To assess the records on cervical cancer for artificial neural networking
- To evaluate the best way the use ANN in cervical cancer staging

The initial stage of the research involved analysis which is the systematic review of prior research on ANN use in the diagnosis of cervical cancer as well as the adopted method, results obtained and limitations observed.

Methods

A systematic review is going to be used in this study on the staging of cervical cancer using neural networks. The documentation of steps taken to achieve the aim of the systematic literature review is documented below.

Research Questions

Various questions were raised during the research

Research Question 1: What are the operational mechanisms needed for the exact detection of cervical cancer using a neural network?

Research Question 2: Do previous studies on the subject have made a positive impact on the subject

Research Question 3: Are there limitations in using neural networks in comparison to the laboratory technique?

Search Process

For the inclusion of literature in this study the originality of the study was evaluated based on the Joanna Briggs Institution method (2018). In April 2019 three data sets of the Science Direct, Pubmed and Web of Science were carried out for 5 years (Period between 2014 to

2019). The search used the keywords of ("cervical cancer" "Neural Network" "Deep learning" "transfer learning" "squamous cell carcinomas" or "Adenocarcinoma" in the three sets of data search.

In total 530 records were discovered in the three databases. Duplicates amounting to 43 were removed with 375 records removed from the screened title (n=487) and 88 records taken out from the screened abstract (n=112). The whole test was screened using the inclusion-exclusion technique. For the screening test (n=24) 5 records were taken out, therefore, leaving a quality assessment record of 19. Following a further quality assessment, a sum of n = 7 was taken away from the records (Figure 1). Therefore, using articles with concrete information on the study were utilized in the systematic review of this research.

Table 1. Data Search

Database	Search
Science Direct	("cervical cancer" OR "squamos cell carcinoms" OR "Adenocarcinoma") AND ("neural network" OR "deep learning" OR "transfer learning")
PubMed	("cervical cancer" OR "squamos cell carcinoms" OR "Adenocarcinoma") AND ("neural network" OR "deep learning" OR "transfer learning")

Table 2

Database	Search
Science Direct	271
PubMed	122
Web of Science	137

The exclusion and inclusion criteria

- Articles in this study met the search criteria of more than three search keywords
- The data from articles in this research were taken from 2014 to 2019 which are
- Records only with a defined topic with a methodology that is clear
- Sources of literature with a defined research question, data analysis, and data extraction
- Data excluded from this study were based on duplicate records of the same research from the different databases used in this study
- Records with no defined research questions, data extraction and search process
- Data sources without experimental procedure and methodology
- After the inclusion and exclusion of the assessment reference list, the total quality assessment figure was 19 and 12 for the final review as per information in Figure 2.

Quality Appraisal

An assessment method from York University's Center For reviews and Dissemination (CDR) Database of Abstracts of Reviews of Effects (DARE) criteria 3 was adopted in the quality appraisal of this research.

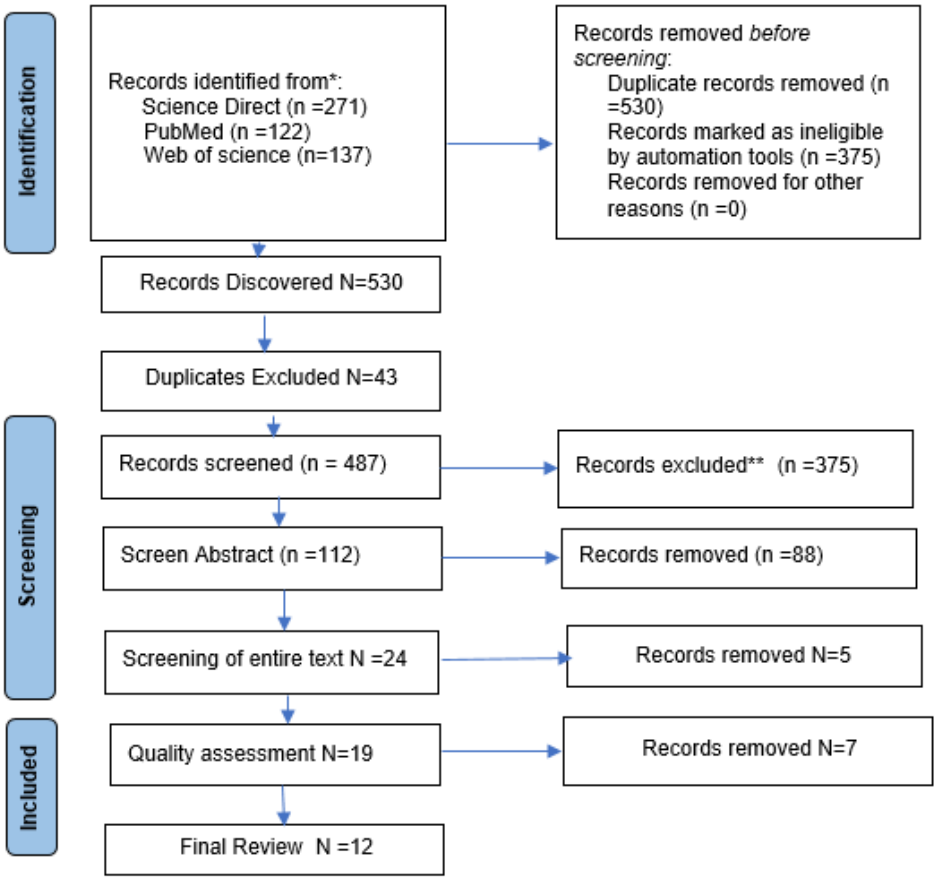
QA1. Are the inclusion-exclusion criteria properly described in the literature?

QA2. Does the keyword search involve all important areas of the study?

QA3. Was the quality of the searched literature analyzed?

QA4. Were the literature sources of data properly explained?

During the appraisal of the quality of this research, point scores were used to differentiate quality items from poor-quality items. For mentioned items, a 1-point score was attached and items not mentioned or with less quality information were regarded as 0, with items having good and contributing information allocated a 0.5 score. The items selected finally for review had more than 3 points of Y =1 and P =0.5 as per information in figure 2. The scoring was based on a scoring system (Yes Y=1)), (no (N=O)); and (pass (P=0.5)).



Background and related studies

A convolutional neural-based localized classification of uterine cervical cancer digital histology images a study was carried out by Haidar et al., (2017). Various steps were used which include segmenting the images into 10 groups, and further subdividing of clusters into 3 clusters which were the top, middle, and bottom parts with an average of 0.51,0.53, and 0.38. Chunk extraction and the segmentation of various groups of images were then followed. The experiment data in total was 65 images. 32 images were regarded from the data as normal (32 images) CIN1 cells (7 images), CIN cells (17 images), and CIN13 cells (10 images). The results however showed that the algorithm used in the study possessed a better result of 77.3% as compared to a prior chosen method of 75.75% though using the same data set. Another research was carried out by Wasswa et al., (2019) about cervical cancer categorization from Pap smears using an enhanced fuzzy c-means algorithm.

The research aimed at combating low accurateness' precision in the Pap Smear method via an automated technique. Image enhancement was done through the contrast adaptive histogram and the classification of cells was carried out using the Trainable Weka Segmentation classifier. Three varying datasets were used in evaluating the classifier and it consisted of single and multiple-cell images and images from Pap smears. The specificity, precision, and accuracy from the analysed data sets were 98.88%, 07.57% for single cell images, "97.64%,98.08% as well as 97.16% for numerous cell images, and "96.8%,98.4% as well as 97.16%". for numerous cell images and "96.8%,98.4% and 95.2% for pap images. The results obtained from the research clearly show better accuracy and precision as opposed to other algorithms based on untruthful results on positivity (2.53%), false results on negativity (0.72%), and errors observed when the data classification of cancer analysis was done. Research on deep convolutional neural networks enabling discrimination of different digital pathology I, ages was assessed by Pegah et al., (2018). The research focussed on differentiating two lung cancer kinds, bladder cancer, varying four kinds of bio makers and five breast cancer biomarkers. The deep learning approach was used in the evaluation and identification of varying subgroups of cancer. The accuracy of the results from the evaluation was 69%,95%,92%, and 100%for the subgroup of cancer identification and bio makers. A deep learning analysis was carried out by Henning et al., (2018) who discovered that a simple approach can deliver good results. A combination of varying PMap techniques was used in the identification of parameters. The image quality, training, and identification were evaluated in the research. Post-processing of pap was observed from the report to have the best quality during detection. Hematoxylin and Eosin (H &E) had the best performance (f1 measure -0.816) of "colorectal adenocarcinomas "as well as Ki67 measure (0.819) in the imaging of breast cancer. Processing and detection were evaluated at 4.15 megapixels and the technique of identification proved to be of high precision and best quality. Siti et al., (2018) analysed the improvement of the features extraction process and classification of cancer of the cervix for the neural Pap system. The Neural Pap in detection evaluates various

limitations but, in this research, several studies were used to remove the eliminations. The proposed algorithm for this research is Adaptive Fuzzy-k-Means and it was observed to be more efficient than the Neural Pap algorithm and has been found to increase the detection and imaging of cervical cancer by 76.35% as compared to Neural -Pap (73.4%). The application of deep learning algorithm in the cancer of the cervix MRI image classification based on wireless sensors was researched by Peng et al., (2019). The study focussed on cervical cancer classification via wireless network use and deep learning algorithm evaluation. During the research, two different types of deep learning analysis were done on 5 different test groups. The results however from the groups indicated that the traditional algorithm is not an ideal test associated with low accuracy and data not going above 90%. Accurate results of the MRI analysis of cervical cancer (Peng et al., 2019) the optimized algorithm and wireless network gave a result with 98% accuracy. This technique, therefore, is deemed highly effective in cervical cancer detection.

Noha et al., (2019) researched early oesophageal adenocarcinoma identification making use of the deep learning technique. The study aimed at carrying out adaptation measures of varying learning techniques in esophageal adenocarcinoma identification. The convolutional neural networks were used in the identification of high-definition white light endoscopy areas of the oesophagus using varying detection techniques. The varying techniques which were used in the detection were fast R-CNN, Faster R-CNN, regional-based convolutional neural network, R-CNN, and the single shot multi-box detector. During the evaluation 100 images were taken from 39 patients. The result from the research showed that SSD and Faster R-CNN (accuracy-0.83) had the best imaging quality comprising of sensitivity, specificity, and F measure of 0.96,0.92, and 0.94 for SSD respectively. The technique revealed how efficient it is in the detection of abnormal regions of oesophageal adenocarcinoma.

Another study was analysed by Nguyen et al., (2018) on a systematic assessment of cervical cancer initiation and progression uncovers genetic panels for deep learning-based early diagnosis, and made some propositions on novel diagnostic and prognostic biomarkers. The data sets were 8 in total comprising 202 cancer, 115 cervical intraepithelial neoplasia, and 105 normal samples. The deep learning method was used in the evaluation of the sets of data and assessment of cell viability. Records from the study revealed 97.96 % accuracy, 99.01% sensitivity, and a specificity reading of 95.65%. However, this evaluation will assist in opening new avenues with effective reading for cancer cell staging.

Another study on gynaecology on the artificial neural network using image-guided adaptive brachytherapy treatment planning was carried out by Ramin and Zara, (2018). The researcher used the correction of intra-fractional organs at risk dose variation. The results revealed high accuracy and efficiency as well as correct maintenance of dosage.

Another study was carried out by Matsuo et al., (2019) on survival outcome prediction in cervical cancer: Cox models against deep learning. The major focus of the research was to compare the cox model and the neural network model in cancer diagnosis. Forty demo graphs of cancer were grouped into 3 segments. The deep learning results and cox method were 0.695 and 0.787 for the concordance index and showed that the deep learning technique is suitable for cervical cancer diagnosis.

Liyuan et al., (2019) carried out a study on 'automatic PET cervical tumor segmentation by combining deep learning and anatomic prior. Machine learning in the study was integrated with a convolutional neural networking system and this was done by fabricating a spatial convolutional neural system which assisted to map the PET image at (-1,0 and 1) pixels. In the 50 samples taken for cervical tumour patients, a diced coefficient of 0.84 was attained. However, it was noted that the technique was accurate in the diagnosis of cervical tumours.
Miao et al, (2018) studied the automatic classification of cervical cancer from cytology through the convolutional neural network. The researcher used two data sets in the research with original image 3012 and augmented image 108432. The research used the three-folding cross-validation technique. The results indicated an overall accuracy of 93.33 % for the original image group and 89.48% for the augmented image group. An improvement of 3.85% was attained using augmented images. The technical diagnosis was found to be very effective in cervical cancer staging. Detection of early prevents cancer therefor reducing the burden of cervical cancer (Mehmood et al.,2021).

Results, Discussion and Search Results

The table indicates the results from the article search. 22 articles were used in this search from different databases (Science Direct, PubMed, and Web of Science) as shown in the table. The studies comprise journals and conference proceeding articles. Table 4 shows the average quality and the search period of the searched articles. No topic was chosen in the years 2014 and 2016 when the inclusion and exclusion criteria were done. From table 4 it can be observed that it has an increasing average score with 0.6 recorded as the average quality score from the Spearman correlation coefficient ($p<0.023$).
Evaluation of Quality.

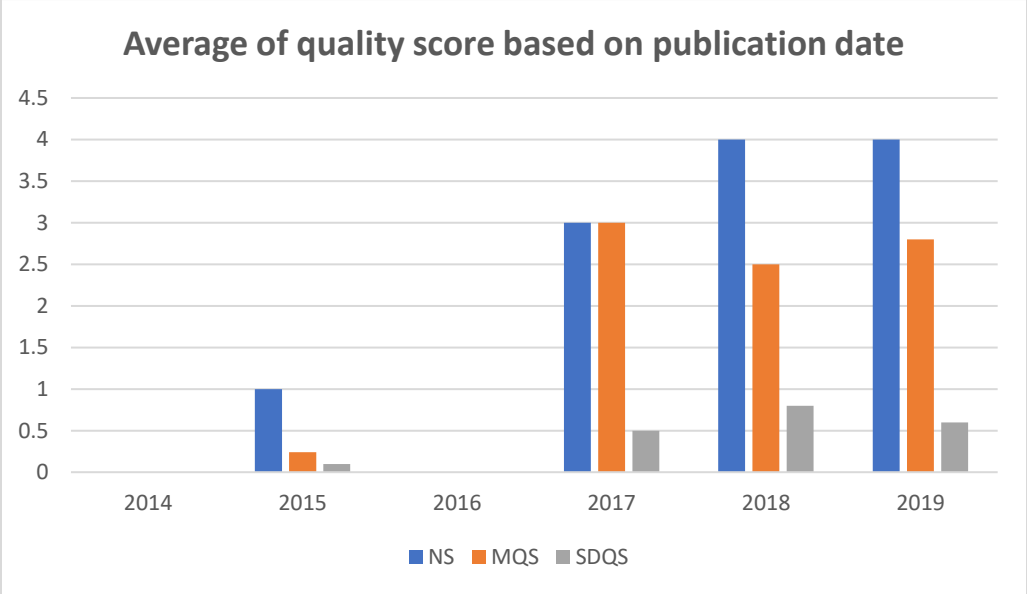
The quality assessment was based on the date of publication (last 5 years) and quality appraisal as shown in Fig 1. Research questions were also taken into consideration to fall in line with the study the focus.

Table 3 Systematic review of studies

ID	Author	AT	Database
S1	Haidar et al. (2017)	RA	Science Direct
S2	Wasswa et al. (2018)	RA	Science Direct
S3	Pegah et al. (2018)	RA	Science Direct
S4	Henning et al. (2018)	RA	Science Direct
S5	Siti et al. (2015)	RA	Science Direct
S6	Peng et al. (2019)	RA	PubMed
S7	Noha et al. (2019)	RA	PubMed
S8	Nguyen et al. (2017)	RA	PubMed
S9	Ramin & Zahra (2017)	RA	PubMed
S10	Matsuo et al., (2019)	RA	Web of Science
S11	Liyuan et al., (2019)	RA	Web of Science
S12	Miao et al., (2018)	RA	Web of Science

S (Study); AT (Article type); RA (Research Article).

Table 4 Average of quality score based on publication date



NS - Number of studies
MQS – Mean quality service
SDQS- Standard deviation of the quality

Impact of Neural Network on Cervical Cancer Staging

Illuminative opinions observed from related research indicated the effects of neural networks in cervical cancer staging. The Pap smear test has not been scoring accurate and reliable results on the diagnosis of cervical cancer coupled with the low accuracy in images. The

artificial neural network has been important as seen in the imaging study (Haidar et al., 2017). Results were observed to have an accuracy of 77.37 % and this accuracy rate is very high in cervical cancer staging. Pegah et al., (2019) indicate the accuracy result was (69, 85, 92 and 100) % for different experiment processes during evaluation. With the utilization of neural networking in cancer staging, cervical cancer identification can be done fast and with high accuracy.

Moreover, comparing with related methods and other cancer types can be correlated with his research. Correlations between the convolutional neural network technique and deep learning nuclei done by Henning et al., (2018) indicated that the convolutional neural network method had a better accuracy of 77.37% as opposed to 73.40%.

It must be mentioned however that the deep learning algorithm technique has been observed from the research as an efficient imaging technique with an accuracy rate of 98% (Peng et al., 2019). In cervical cancer staging, the neural network was discovered to be efficient in cancer detection analysis but better techniques in detection and cancer diagnosis should be birthed using the combination of both. This was clear in a proposal technique by Liyuan et al., (2019). The research used a combination of deep learning and machine learning methods of 84% accuracy was obtained from the research which indicated a high image accuracy as compared to a single technique. Good accuracy results came from transfer learning, deep learning and artificial neural network artificial neural network has the upper hand in simplicity as opposed to deep learning. Neural network, however, as a cervical cancer staging technique is effective and needs to be adopted in ontological fields for high accuracy during cancer detection.

Limitations of Study

Numerous study limitations were observed in this research, and this was mainly the staging of cervical cancer with the neural network as one of the main challenges. However, many of the articles in this research were based on study populations that are limited to only those with surgical cases. Therefore, there is superiority in the imaging technique used in neural network algorithms that cannot be given comparisons to cervical cancer cases which are not surgical. The other study limitation which needs to be mentioned concerns the use of deep learning techniques. This approach of deep learning in cervical cancer staging training requires a lot of money hence it is very expensive. This, therefore, means that it requires experts to interpret the predictions from this approach. As a result, the implementation of this approach, which is an objective of this research will be challenging for oncological researchers with less research experience in the predictions and interpretations of the technique. A recognition however has been made of the use of the neural network in its identification and will gain more traction among medical practitioners and other students of cancer. The use of neural networks has been commended because of their accuracy and simplicity as per the revelations of this stud.

Conclusions

Systematic research is all about identification, selection of thesis, and assessment of different methods used in the studies of a period of 5 years of the selected articles for the systematic review. Instructions by Kitchenham et al., (2018) and the Joann Briggs Institute (2018) were used in this study. The instructions are made up of the research as well as the searching technique adopted during the period of the research. The account of the systematic review was revealed using various methods and ways that can be carried out in cancer staging. Numerous types of research revealed various ways and their effectiveness in detection considering the accuracy and precision of image viewing. The research used three databases which are Science direct, Pubmed, and Web of Science from the period of 2014 to 2019 adding current and technical approaches into this research. Various limitations were recorded during this research. The literature chosen was limited to those taken from reputable international journal papers. One of the recommendations which were made after this study s that there is a need for wider books and conference literature to be carried out in future studies using the same time frame. The variations of the manual search criteria and automated search criteria must be assessed in the forthcoming research to evaluate the best search form in systematic review research

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