Detection of Ovarian Tumor Using Machine Learning Approaches: A Review

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Abstract - The important part of female reproductive system is ovaries. The importance of these tiny glands is derived from the production of female sex hormones and female gametes. The place of these ductless almond shaped tiny glandular organs is on just opposite sides of uterus attached with ovarian ligament. There are several reasons due to which ovarian cancer can arise but it can be classified by using different number of techniques. Early prediction of ovarian cancer will decrease its progress rate and may possibly save countless lives. CAD systems (Computer-aided diagnosis) is a noninvasive routine for finding ovarian tumor. In this survey effort we have also deliberate about the comparison of different machine learning algorithms like K-Nearest Neighbor, Support Vector Machine and deep learning techniques used in classification process of ovarian cancer. Later comparing the different techniques for this type of cancer detection, it gives the impression that Deep Learning Technique has provided good results and come out with good accuracy and other performance metrics.

Keywords - Machine Learning, Deep Learning, Ovarian Cancer, CNN

1. Introduction

In past few decades, a great progression has been done in the field of medical science specially in cancer research. Females related cancers like Breast Cancer and Ovarian Cancer rate is rapidly increasing day by day and lots of researchers and scientists are working in this field by using different techniques [1]. Various techniques like image processing, machine learning, and screening just to recognize the particular stage of the defined cancer in a patient in advance the symptom arrives. This type of cancer symptoms in many instance is not noticeable until the infection/cancer spreads to advanced stages when the mortality rate of the patient become less and treatment turn out to be more problematic. Researchers are developing new techniques for the early stage classification and prediction for ovarian cancer treatments. With the overview of new classification methods, the perfect prediction of a cancer is one of the most challenging tasks for researchers.

Ovarian cancer occurs when ovaries grow, change and develop abnormally without control which may form lump or mass of extra tissues and became tumors- can be cancerous / non-cancerous [2].

Cancerous cells are of two types malignant and benign, malignant cells are cancerous cells and benign are non-cancerous. There are in excess of 30 distinct sorts of ovarian malignant growth, which are grouped by the kind of cell from which they start. Dangerous ovarian tumors start from three normal cell types: (1) Surface Epithelium - cells covering the external coating of the ovaries. (2) Germ Cells - cells that are bound to shape eggs. (3) Stromal Cells - Cells that discharge hormones and interface the various structures of the ovaries. Once one or both ovaries are found with cancer cells spilling out from the ovaries.

If the cancerous cells/tumors couldn’t be detected early; the cancer cells can spread throughout the ovary and pelvic area and continue to spread into abdominal area and into other organs. Deciding the phase of ovarian malignant growth is significant in building up a treatment plan. It is different stages. At stage 1, cancer is limited to one or both of the ovaries [3]. At stage 2, ovarian cancer extends to the pelvic area [4]. At stage 3, it has spread to the abdominal region [5]. At stage 4, ovarian cancer extends into liver or to locations beyond the abdominal area [6] the survival rate of these four stages is 5 years as shown in Figure 1 and Figure 2.

At stage- there is 82-92% chance of surviving the cancer. In this particular stage the tumor is restricted to one or few chances in both ovaries, it initiates from ovarian surface. At stage 2- there is 51-69% survival rate. In this the tumor invades one or both the ovaries in extension to the pelvic region and also to fallopian tubes and uterus but without spreading to the abdomen. At stage 3- the survival chance is 17-39% as tumor extends beyond the pelvic into the abdominal organs. The visible tumor found in upper abdomen less than 2cm in size. Stage 4, only 11.5% chances of life because of distant metastasis to the lung, liver or lymph nodes in the neck [7].

![Stage 1](image1.png) ![Stage 2](image2.png)

Fig. 1: Shows the Stage 1 and stage 2 of ovarian cancer

@ IJAICT India Publications 2020
M.G. Sumithra et al.(eds.). Advances in Computing, Communication, Automation and Biomedical Technology,
https://doi.org/10.46532/978-81-950008-1-4_103
**Fig. 2:** Stage 3 and stage 4 of ovarian cancer.

**Ovarian Tumours**

There are two classes of tumor -

**Benign Tumors**

Some invents from surface ovarian epithelium, for example serous cystadenomas, which are often bilateral and occupied with a watery fluid, and mucinous cystadenomas, which results in multicolor and contains a mucus-like fluid. And few of them are originate from ovarian germ tissues, such as mature cystic teratomas, also known as desmoids cysts [8]. These are few of the common ovarian tumors particularly found in young women.

**Malignant Tumors**

They are similar to serous or mucinous cystadenocarcinomas, which cultivates from the surface of ovarian epithelium, just like their benign counterparts.

**Ovarian Cancer Various Symptoms**

The symptoms of this ovarian cancer can be diagnosed with the help of Computer Aided diagnostic systems. They consist of a dull aching in lower abdominal or may be pain nearby the site of the cyst, dyspareunia, or pain throughout sexual contact, and a sensation of heaviness in the lower abdomen which can also cause repeated urination and bowel movements. If the cysts are the result of Poly Cystic Ovarian Syndrome [PCOS] [9], the person might see amenorrhea and hirsutism, or excessive hair growth on the chin and upper lips, chest and back.

- Endometriosis can also be a reason for sore dysmenorrhea, or sore menstruation and are related with fertility problems.
- Ovarian twisting can cause nausea, vomiting and a mild elevation of the temperature.
- A bloating full feeling in the tummy.
- Irregular periods or unwanted vaginal bleeding during menopause.

Machine learning has enormous usage in medical domains and it is increasing quickly because of its effective methods and approaches in prediction and classification tasks. In Table 1 the whole summary of machine learning techniques and their associated solutions in ovarian cancer detection are given.

### Table 1: A literature survey on the use of machine learning techniques in ovarian cancer detection and prognosis.

| S. No. | Techniques                      | Solutions                          |
|--------|--------------------------------|-----------------------------------|
| 1.     | Support Vector Machine [9]     | Ovarian Cancer prognosis          |
| 2.     | K-Nearest Neighbor [12]        | Ovarian cancer risk classification |
| 3.     | K-mean [26]                    | Predict ovarian cancer susceptibility and recurrences. |
| 4.     | Neural network [5]             | Medical diagnosis                 |
| 5.     | Artificial Neural Network [4]  | Ovarian cancer risk estimation    |
| 6.     | Decision tree [12]             | Prediction of Ovarian cancer      |
| 7.     | Logistic regression [1]         | Ovarian cancer recurrence prediction |
| 8.     | Random forest [11]             | Non-linear feature extraction for ovarian cancer |

**2. Literature survey**

The [10] deliberated roughly the two common techniques for tumor detection and classification. Mass Detection like biopsy is the ordinary method to classify any type of tumor either malignant or benign. Another procedure to determine cancer via liquid-based biopsies- Blood is taken for trial from which different findings are identified for any sign of tumor. Although the old-style technique is quite better than the used process right now.

[11] offered a machine learning dependent framework for the classification of ovarian cancer by clicking their picture content for detection task by implementing CNN i.e., convolutional neural network technique. Basically, they have proposed only a single methodology categorization (classification) procedure. They verified the performance of the proposed model as they had named their model as ML-CNN-LR classifier which abstracts obstetric tumor images, on the basis of two factors: - precision ratio-96.5% and recall rate-99.1%.

[12] deliberated that ML (Machine Learning) methods were able to correctly identify BOT and OC. Our main objective is to originate an easy predictive framework which also gives out a very good performance metrics. Their model consists of two different biomarkers i.e. HE4 and CEA. The model is very simple to understand as well as have a good outperforms the present OC prediction techniques. It reveals that the machine learning method has good enough in predictive modeling for the complex diseases.

[14] there study revealed that the HE 4 has a benefit above the USG score, ROMA score and the CA 125 for the calculation of OC in females with ovarian mass extracts.
HE 4 classification and CAD diagnosis systems are not yet a globally available. In short resource situations, in which HE 4 classifications is more complex imaging approaches do not occur, the USG score is an unpretentious and trustworthy option for the difference classifications and triage of ladies with ovarian masses.

[15] proposed a fine-tuned model using traditional VGG-16 deep neural network trained on ImageNet dataset comprised of images from ultrasound of various ovaries of different females to detect whether they have cysts or not. The proposed algorithm gave 92.11% accuracy. Future works includes classification of different types of cysts including functional, HOC (hemorrhagic ovarian cyst), PCOS (polycystic ovarian syndrome) and dermoid.

[16] have deliberated roughly the sonographic characteristics of kinds of masses originate in or out the ovary boundary in the form of cysts. Typically, there are 7 kinds of ovarian cysts be present. Generally, image processing is used for discovery of ovarian tumors. The accurateness of classification can be enhanced by using genetic algorithms or with fuzzy set algorithms, it will require an active contour technique.

[17] the authors built up a mechanized methodology that permits generation of discrete-esteem pseudo-CT examinations (delicate tissue, bone, and air) from a single high-spatial-goals symptomatic quality three-dimensional MR picture and assessed it in mind PET/ MR imaging. This deep learning approach for MR imaging–based AC gave decreased PET recreation mistake comparative with a CT-based standard inside the mind contrasted and current MR imaging–based AC draws near.

[18] develop a framework and name it as Multi-task deep learning network (MTLN) with multi-scale images and constructed on Link-Net configuration for division and analysis of fetal-head perimeter of 2D ultrasound pictures. Trained the network by using 999 images of dataset. Their proposed technique combined an Ellipse Tuner based on completely associated systems.

[19] a multi-level area segmentation and classification of EOVC test set where the value is n = 26 and coordinated normal value of n = 15. Value changes, mutational marks and duplicate numeral varieties (CNVs) educated a multi-dimensional relapse classifier taking into account correlation with endometrial carcinoma (UCEC) and high-evaluation serous ovarian carcinoma (HGSC). They acknowledged that EOVC are a molecularly heterogeneous gathering of epithelial ovarian malignant growths with particular mutational marks.

[20] they implemented a classification of ovarian tumors using ANN (Artificial Neural Network). The output of the proposed work 80% accuracy while classification for dermoid cyst and around 70% accuracy for follicular cysts of 20 images. Their parameter design was grounded on BPA (Back Propagation Algorithm). MATLAB 13 was used for the classification process and for plotting the graphs.

[21] they propose hybrid strategy by using ReliefF and stacked auto-encoder approaches for recognition measure and utilized help vector machines (SVM) and convolutional neural frameworks (CNN) for course of action. The 3-microarray datasets of Ovarian, Leukemia and Central Nervous System (CNS) were worked. Ovarian malignant growth dataset contains 253 models, 2 classes and 15154 characteristics. Among the methodologies applied and the strategies applied to the 3-microarray data, the best yield of exactness was seen with SVM as 96.14% for ovarian dataset, 94.83% for leukemia dataset and 65% for CNS dataset. The proposed cross breed strategy Relief + CNN procedure defeats a wide range of systems. It gave 98.6%, 99.86% and 83.95% accuracies individually for the datasets of ovarian, leukemia, and CNS datasets, independently.

[22] they proposed the mass spectrometry to design computer-aided system. They offered the comparative performance study of machine learning classifiers that works on ovarian cancer dataset. After doing a comprehensive analysis MLP (Multi Level Perceptron) was the most well-matched classifier for the classification and detection of ovarian cancer for obtaining evaluation parameters such as Sensitivity, Specificity, Errors and Accuracy.

[23] they implemented a classification of ovarian mass spectrometry to design machine learning classifiers that works on ovarian cancer dataset. After doing a comprehensive analysis MLP (Multi Level Perceptron) was the most well-matched classifier for the classification and detection of ovarian cancer for obtaining evaluation parameters such as Sensitivity, Specificity, Errors and Accuracy.

[24] proposed a method and named it as ABC-CNN which detects cancer at every single stage with the help of MRI images. Features are mined out using kernel PCA (Principal Component Analysis) algorithm and then classification is done by using training and testing of convolutional neural network (CNN) technique of each cancer stage. Their dataset contained 250 images which are cancerous and normal images i.e. non-cancerous images. Highest accuracy achieved by implementing the proposed method is 98.9%.

[25] proposed an arbitrary transformation of non-linear features method in which CAD (Computer Aided Diagnosis) System was implemented for early detection of suspicious and non-suspicious ovarian cancer. ReliefF was implemented to make reduction of features selection from different images which was obtained and then ensemble by the classifier based on fuzzy-forest. They worked on total 469 parameters which was able to attained an accuracy of 80.60%, specificity of 76.30% and sensitivity of 81.40% respectively.

[26] they reviewed about the challenges and opportunities of AI (Artificial Intelligence) methods in cancer/tumor diagnosis and prognosis. Clinical imaging data can't be utilized as information straightforwardly. It is crucial to distinct features from the imaging datasets and procedure them for classification process. In advancement and raise of improvement in the loads coefficient in the neural system models are tried, determined, and the
certainty interim is sensible, so clinical understanding need further research.

[27] they have used two ML (Machine Learning) techniques: - KNN (K-Nearest Neighbor) and Decision Tree classifier for upgrading the specificity and reproducibility in the context of SERS-based fluid biopsy. They have collected the samples which contains the serums of ovarian cancer, pancreatic cancer and healthy patients for cancer diagnosis process for the analysis of 5 protein biomarkers expression change in their levels which are MUC4, CA19-9, MMP7, HE4 and mesohaline. Sensitivity of 86%, Specificity of 93% and accuracy of 91% was achieved with value of k=5 and dataset of 200 vectors both of test and train employs total spectrum of all biomarkers.

[28] they used many approaches in their research mainly SVM (Support Vector Machine), C5.0, ELM, MARS and RF (Random Forest). These 5 classifiers are involved in the proposed method for the detection of ovarian cancer. They have given the name to proposed approach as E-C5.0 and this E-C5.0 is able to give the maximum accuracy. After Evaluating all the possible factors in the proposed scheme encourages that FIGO, Pathologic M, age, and Pathologic T were fundamentally recognized with the recurrence of ovarian malignant growth.

[29] they have implemented a Deep Convolutional Neural Networks (DCNN) in context of AlexNet to naturally or usually manually characterize the various different kinds of ovarian diseases in females from cytological pictures. The Deep CNN comprises of five convolutional layers, two full reconnect layers and three max pooling layers. They have prepared the model by using two different input information independently, one was unique image data and the other one was enlarged image data including picture improvement and picture rotation. The testing results are acquired by the technique for 10-overlap cross-approval, indicating that the accuracy of the proposed models has been improved from 72.76 to 78.20% by utilizing enlarged images as dataset.

[30] they have used the 26-gene panel as an up-and-comer biomarker set for preparing AI prescient models and the chosen feature set for characterizing a coordinated articulation information of 530 ovarian tissues. After analysis of multiple classification methods, the resulting solution is given by random forest and support vector machine for cancer tissues prediction. Estimated performance matrices are: accuracy-89%, sensitivity-96% and specificity- 83%.

Fig. 3: Analysis of Machine Learning as well as Deep Learning methods used in different research papers for ovarian cancer detection

As Figure 3 and Figure 4, shows that different algorithms are used for ovarian cancer detection according to this graph which is concluded by using forty research papers shows that KNN is mostly used algorithm for detection process out of SVM, KNN, CNN, DT, ANN, and RF.

Fig. 4: Pie chart showing different machine learning techniques percentage used in Literature Review

3. Methodology
Ovarian cancer is effectively diagnosed with the help of medical images. Many different imaging approaches are available and are popularly used for such diagnosis process: DM (Digital Mammograms), US (Ultra-Sound), MRI (Magnetic Resonance Imaging), Histological images (Microscopic images) and IRT (Infrared Thermography).

Many linked research work was explored those which satisfies the criteria were elaborate in this review inclusion criteria: (1) papers that only consider ovarian cancer. (2) Uses only machine learning as well as deep learning technique. (3) Medical related data were used as dataset for testing procedure. (4) Work should be published in last 10 years.
Machine learning techniques used in this review: Specificity (Sp), Sensitivity (Sn). A brief definition of SVM classifier: way through performance measure called Accuracy, Neural Network) For valuation of CAD, is done all the classifications. It uses binary classes for so it uses labelled training dataset to train the system for classification. This is a supervised machine learning technique, such as the convolutional neural network (CNN), that can remove hierarchical characteristics from image data exclusive of the manual selection, which is also known as objective characteristics, that has been successfully used with a maximum increment on accuracies in numerous applications, such as, speech recognition, natural language processing and image recognition.

Convolutional Neural Network: Most widely used machine learning technique now days is this CNN. Deep learning technique, such as the convolutional neural network (CNN), that can remove hierarchical characteristics from image data exclusive of the manual selection, which is also known as objective characteristics, that has been successfully used with a maximum increment on accuracies in numerous applications, such as, speech recognition, natural language processing and image recognition.

KNN classifier: it is supervised machine learning technique; the initial step of this classifier is to calculate distance of the input test sample with all the dataset entries of training samples.

Random forest: Random Forest combines DT for calculation, and they are structured by getting a few classification trees self-possessed. Every single individual tree is non-dependent one. At the point when information is disturbed the Random Forest offers problematic outcomes. Random Forest can be applied effectively and it accomplish predictions for enormous number of input feature with maximum efficiency.

Decision Tree: A DT classifier is made of single root node, a number of internal and terminal nodes. The internal nodes and root incorporate the test condition for the attributes to discriminate between data that dataset contain having different properties. Every terminal node is assigned with a class label. To construct a DT, the algorithm practices entropy to analyze how similar the input data is? If the outcome value totally fulfills the condition, then the entropy would be zero (0) and on the other side if the input is equal then it has entropy of one (1). The information gain depends on the reduction of entropy after the dividing a data samples that are influenced by positive attribute.

4. Conclusion and Future Scope

The detection of ovarian cancer tumor should be done at an early stage to reduce maternal and perinatal mortality rate. Once a female is caused with ovarian cancer her survival chances decreases and it is difficult to cope up as normal beings. If this happens in early Stage, then it can be cured by removing the ovary so that with time their body will regenerate a new one. There are two methods to be taken as precaution for the detection of ovarian tumor is biopsy procedures: - Liquid and mass. There are many factors on the basis of which anyone can have ovarian cancer but if someone has family history then they should get check-ups on time to avoid the tumor and to be safe. With the use of convolutional neural network for detection of malignancy of ovarian cancer in research for classification and there are many models to detect features from images for that, now a days most reliable models are ResNet-50 and DenseNet-201. With the help of these models it can be classified as whether the image is benign or malignant, also predicting the labels by using performance evaluations like - precision, recall, AUC-ROC and F1-score. For early detection of cancer all types of images such as focused, non-focused, cloudy, or blurred will be used in future for classification purposes.

In future works on the basis of this review, we will design a method for the classification of ovarian cancer with the help of H. E. stained images of PLCO (Prostate, Lung, Colorectal and Ovarian) dataset. In order to obtain best results, we will use deep convolutional neural networking which uses frameworks like DenseNet and ResNet to build a model with real-time images also. The main aim of the research is to detect the malignancy of Ovarian Tumor on cloudy as well as blurred images.

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