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Original Article

A Comparative Analysis and Prediction of Ovarian Cancer using AI Approach

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Abstract

The aim of this paper is to analyze and predict ovarian cancer in women using Artificial Intelligence. The program in logic and the decision tree of machine learning are being created to presume Ovarian Cancer. Ovarian malignancy is a significant infection among ladies, even at a very early age. The side effects of ovarian diseases are taken as the factors to settle on the choice tree to foresee the conceivable outcomes. The fundamental side effects would be the foundations of the sickness to settle on the choice tree furthermore than all the yes and no of the tree would have a determination or an outcome. This will assist the women to aware of the type of the ovarian cancer with symptoms and to take necessary steps to avoid this deadly disease. As per the research outcome, it is quite helpful for women all over the world to be aware of the disease. Analysis and prediction provide a major outcome of this research. Advanced technology helps move the health system in a new direction. It gives attention to ladies about ovarian malignancy from one side of the planet to the other. There are numerous country regions all around the world exists where the specialist and the patient proportion are poor, there it can furnish attention to ovarian malignancy alongside the expectation if any patient has ovarian disease or not. Any little or big indications of ovarian disease, they will become more acquainted with what sort of ovarian malignant growth they have through the product. It will decrease the mortality rate.

***Keyword:** Artificial Intelligence (AI); Ovarian Cancer; Decision Tree; ID3 Algorithm; Prolog*

Introduction

Ovarian cancer is the seventh most common disease among women and the 18th most common disease, accounting for approximately 300,000 new cases and 200,000 deaths in 2018 (Ashfaque, 2021).The strength of this paper is that it can provide awareness to women about ovarian cancer all over the world. Many rural areas around the world have a low doctor-patient ratio; in these areas, it can be used to raise awareness of ovarian cancer and predict whether or not a given patient has the disease. If any patient has symptoms of ovarian cancer, they will learn what type of ovarian cancer they have through the software. It will reduce the deaths. Ovarian malignancy mortality has diminished by more than 30% since the mid-1970s due to decreases in rate and upgrades in treatment over many years. All things considered, less than one-half of ladies get by the past 5 years after a determination as a result of the power of forceful high-grade serous carcinomas and the shortfall of explicit early indications and compelling early recognition techniques.

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Computer science is heading towards a revolutionary future in the history of medical science. Using technology, tomorrow's medical science will be much more convenient, effective, and easily accessible. Artificial intelligence (AI) can reduce detection errors to diagnose any disease compared to human expertise. Here in this paper, it is being developed to predict Ovarian Cancer. Ovarian cancer is a major disease among women, and there are no such symptoms at the early stages. Here, the symptoms of ovarian cancer are taken as variables in the decision tree to predict the possibilities. The main symptoms would be the roots of the disease to make the decision tree furthermore than all the yes and no of the tree would have a conclusion or a result. Through this decision tree, the possibilities of the disease in women's bodies will be predicted. This prediction will help women take precautions and will lead them towards advanced technology and medical treatment.

In the literature review section, authors wrote a literature survey corresponding to the paper with references after thoroughly reviewing the papers. In the methodologies, the types of ovarian cancer are briefly described, and the symptoms of the different types of ovarian cancer are listed in a table. With the symptoms, prolog programming is implemented to predict the types of the ovarian cancer. Decision tree and Entropy are also described in the methodology. In experiment and simulation, the dataset and the decision tree created by the ML programming with the dataset are described. In result and discussion, the accuracy of the programming is shown with discussion of the results.

Review of Literature:

The review proposes that a top-notch hazard expectation model is direly required for the clinical administration of ovarian malignant growth. This review shows a danger expectation model by utilizing both clinicopathological and atomic variables for epithelial ovarian disease. the occasion of an excellent danger expectation model for ovarian disease to direct customized treatment could be an essential examination centre inside the field (Zhang *et al*., 2015). In the 21st Century Ovarian Cancer is one of the most common and deadly diseases in women. It is increasing day by day due to a lack of consciousness and social awareness. Most of the women diagnosed with this disease are at stage III or IV. It's time to take the necessary steps to prevent screening and the early symptoms of this disease. So, this paper focuses on preventing, screening, and how to take the necessary steps for this disease (Chien & Poole, 2017). Ovarian cancer, a deadly disease, is increasing the mortality rate for women. It is the world's seventh leading cause of death in women. The existing screening processes are not very helpful. As a result, women are diagnosed with this disease at the last stage. The traditional treatment process is expensive and painful also. So, it's necessary to find out good detection strategies and new ideas for preventing the disease. In this paper, the reason, problems, solutions, and new strategies are written to find out a better way to prevent the disease (Arora, Mullangi & Lekkala, 2021).

Ovarian cancer has lots of subdivisions and subtypes. It's not a single disease. It has lots of reasons and symptoms. This cancer has different risk factors, compositions of the molecules, origins of cells, clinical features, and treatments. Epithelial ovarian carcinomas are the most popular ovarian cancer among women. Surgery and platinum-based chemotherapy are the most common cancer treatments at the beginning, and ovarian cancer is very responsive to chemotherapy. Sub-divisional progress has been made to identify the genes associated with a high risk of ovarian cancer. In this way, ovarian cancer treatment and other things are changing (Matulonis *et al*., 2016). Ovarian cancer, a major and deadly disease among women, is increasing day by day. Here the spread and stages are discussed. It primarily affects women after menopause.220 consecutive dangerous ovarian carcinomas, including peritoneal carcinomas and carcinosarcomas, were reviewed. (Seidman *et al*., 2004). Epithelial ovarian cancer (EOC) is classified into a minimum of five different histotypes: high-grade serous carcinoma (HGSC), endometrioid carcinoma, clear cell carcinoma, mucinous carcinoma, and low-grade serous carcinoma (LGSC). These histotypes display different morphology, etiology, and biological behavior. According to the World-Health Organization (WHO) classification of tumors of the ovary (2014), histotypes are distinguished and supported (Kawakami *et al*., 2019).

Optimal cytoreductive surgery for an EOC is crucial for improving overall existence and disease-free survival. Developing methods to predict the respectability of the disease will identify those who will enjoy maximal cytoreductive effort during a primary or interval surgical setting. Numerous composite models, including several aspects of preoperative workout and, sometimes, laparoscopy, are proposed to reinforce the accuracy of the predictive process (Laios *et al*., 2020). Since Hippocrates' time over 2000 years ago, weather has been thought to influence symptoms in chronic disease patients. Studies have not reached consensus partly because of their small sample sizes or short durations; by considering a limited range of weather conditions, and heterogeneity in study design. Resolving this question requires the gathering of high-quality symptoms and weather data from large numbers of people. Other factors that may be related to daily pain variation and weather, such as mood and amount of physical activity, must be included in such data. Collecting this sort of multi-faceted data in large populations over long periods of time (Dixon *et al*., 2019).

The study suggests this research implements decision tree classifiers and artificial neural networks to predict whether the patient will survive ovarian cancer or not. Dataset was obtained from the Danish Cancer Register and contains five Input parameters. The dataset contains some missing values and a lucid improvement in accuracy was detected after removing them. Three features of the initial dataset were shown to be the most significant: the mobility of cancer, the surface of cancer, and the consistency of cancer. The addition of the opposite two features (Size of cancer and age of the patient) failed to improve the results significantly. it absolutely was noticed that the patients with cystic, but fixed, and even cancer have always died from ovary cancer. In contrast, the patients with uneven, but fixed and solid cancer have always survived cancer. it's recommended to incorporate more information about either cancer or the patient to extend the possibility of predicting the output of such patients (Osmanovi *et al*., 2017).

The traditional techniques, mainly Computer Tomography (CT) and magnetic resonance imaging (MRI), are costly, time-consuming, and tedious. During the literature survey, it had been learned that Deep Learning outclassed traditional CNN algorithms among various image processing algorithms. Within the present work, a Deep Convolutional Neural Network (DCNN) is implemented for predicting ovarian cancer and classifying its subtypes with histopathological images as input. For achieving higher accuracy, a replacement architecture is intended and implemented from scratch inspired by the pre-Trained AlexNet Model (Kasture & Al, 2021). Uncontrolled growth of malignant cells causes cancer that contains mutations in an exceedingly person's normal DNA. A remarkable source of difficulty in influencing malignancy as a disease is its confusing assortment. Even once they occur on the identical site, there don't seem to be two manifestations of cancer alike. Of the likelihood that the treatment is to kill all dominant mutant cells, other transformations will eventually evolve. this could be the explanation why, in most cases, cancer therapy seems to figure, the tumor decreases or may even become undetectable after a time. Most patients with ovarian cancer have undetectable diseases and are thought to be in clinical abatement. Most of those women will suffer a recurrence and eventually succumb to the disease. The dimensionality diminishment by given dataset and second, utilization of assessed choosing new features which are a subset of the old one's conditions to anticipate new yields of the framework. is thought as feature selection (Elavarasu, Vinod & Elangovan, 2017).

Ovarian cancer is the fifth leading cause of cancer-related death in women. As at the earlier stage it is asymptomatic so the chances to survive is only 20% overall in 5 years. Chemotherapies are quite helpful for the patients. Molecular pathogenesis is a better understanding to detect ovarian cancer early and novel therapeutics (Barton *et al*., 2008). In the 1980s, platinum-based chemotherapy was established, which is quite helpful for ovarian cancer treatment. But still, 90% of patients who are in an advanced stage of ovarian cancer are there due to the clinical failure of chemotherapy. Here, drugs play quite a helpful role. Drugs are increasing the survival role from 20% to 30-40%. But more improvement and advancement are necessary (Tan, Ang & Kaye, 2008). With BRCA1 and BRCA2 gene identification, a woman can recognise an inherited predisposition to ovarian cancer. Any woman who has identified any of the genes has a high risk of developing ovarian cancer. BRCA1 and BRCA2 gene testing are now accepted with a strong history of ovarian cancer, but for that, an advanced clinical system is necessary. It will help reduce ovarian cancer mortality by about 10% (Berchuck *et al*., 2008). Artificial Intelligence (AI)(Das *et al*., 2018a; Das, Sanyal, & Datta, 2018a; Das *et al*., 2018b; Das & Sanyal, 2020a, 2020b), Soft Computing(Das, Sanyal & Datta, 2019a, 2019b), and Machine Learning (ML)(Das, Sanyal & Kumar Upadhyay, 2020; Das, Sanyal & Datta, 2021; Das *et al*., 2021) in this advance digital era are playing crucial role in the field of medical diagnosis as well as healthcare management.

Methodology:

A Decision Tree is a hierarchically well-thought-out structure, with each node divide the data space into segment based on value of the attribute. Three things are significant that is the structure of the tree, the threshold values and the values (α) for the leaf nodes (A, B, C, and D, E) as shown in figure 1.

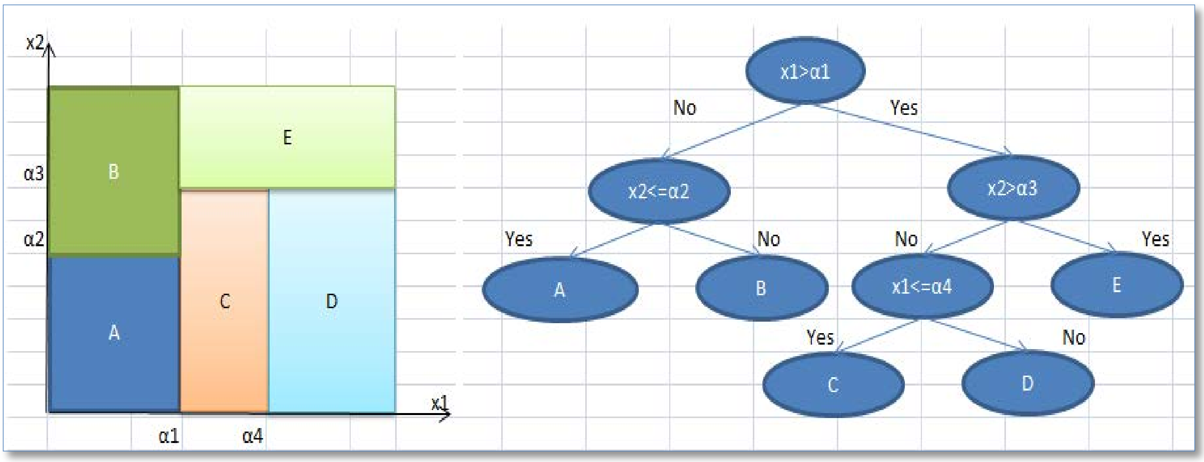

Figure 1: Feature space (left) and Decision Tree (right)

Types of Decision Trees

a) Categorical-Variable Decision Tree: Decision Tree which contains a categorical target variable then it is termed as categorical variable decision tree.
Example: Supposed to predict job offer is accepted or declined based on the categorical data (Yes/No).
b) Continuous-Variable Decision Tree: Decision Tree contains a continuous target variable then it is termed as Continuous Variable Decision Tree.
Example: Customer income depends on age, occupation and others various variable. These variables are continuous variable needed to build decision tree for predicting customer income label.

The ID3 is one of the most popular decision tree algorithms. This algorithm iteratively dichotomizes (divide) the attributes into two completely opposite groups. Then, it computes the entropy and information gain of each attribute. These can help to find out the most common dominant attribute. The most dominant node is considered as the decision node. Similarly, the entropy and information gain would be computed again for the other attributes. These procedures continue until reach a decision for that branch.

ID3 Algorithm

Step 1: Compute the entropy E (S) of the data set S.
Step 2: For every attribute or features:
    a) Compute entropy E(A) for all other attribute values.

b) Compute average Information entropy I(A) for the current attributes.
c) Compute Information Gain G(A) for the current attributes.

Step 3: Pick the highest Gain attribute and set as decision Node (i.e., in first iteration Root Node, next iteration it becomes the next decision Node and so on).

Step 4: Repeat it for remaining attributes until the desired decision tree is realized.

Entropy

The entropy is the measure of uncertainty in a data set S. The following notation E(S) represents it. Consider p is the positive response (YES) and n is the negative response (NO) of the outcome attribute for data set S.

$$E(S) = -\{\frac{p}{(p+n)}\log_2\frac{p}{(p+n)} + \frac{n}{(p+n)}\log_2\frac{n}{(p+n)}\} \quad (1)$$

Information Gain (IG)

The information gain is the quantity of information acquired through random variable by observing another random variable. Information gain represented by the following equation.

$IG(S, A_i)$ = E(S) - I(A_i) (2)

Where, I(A_i) is the Average Information and it is computed as follows:

$$I(A_i) = \sum \frac{p_i+n_i}{p+n} E(A_i) \quad (3)$$

Where $E(A_i)$ is the entropy of attribute A_i.

Ovarian cancers types are categorized on the basis of different question abilities such as the most common, less common, or rare, tumors ' types, etc? But there are 4 types of ovarian cancers that are generalized in basic(OCRA, 2021) :

a. *Epithelial-ovarian cancer:* This type is the most common. It includes several subtypes and serous carcinoma and mucinous carcinoma.
b. *Stromal-tumors:* These rare tumors are diagnosed at an earlier stage than other ovarian cancers. It represents about 1 percent of all ovarian cancers, according to the ACS.
c. *Germ-cell tumors:* These rare ovarian cancers and it tends to occur at a younger age.
d. *Small-cell carcinoma:* It is an extremely rare ovarian cancer and it is not certain whether the cells in SCCO are from ovarian epithelial cells, sex-cord stromal cells, or germ cells. Small-cell carcinoma of the ovary, hypercalcemic type (SCCOHT) is a rare but highly undifferentiated, aggressive malignancy that primarily affects young women.

Each of the types has subtypes but they are symptomatically the same. The only way to diagnose the subtypes is the detailed clinical examination procedures. The disease type which need to be diagnosed and symptoms which need to be verified are shown in table 1.

Table 1: Hypothesis or disease and Symptoms

Hypothesis or disease Types	Symptoms to be verified
Epithelial ovarian cancer(Mayo Clinic, 2021a)	a. Abdominal bloating or swelling. b. Quickly feeling full when eating. c. Discomfort in the pelvic area. d. Fatigue e. Weight loss
Stromal tumors (CTCA, 2018)	a. Unexpected Vaginal bleeding is one the most common symptoms. b. Hormonal symptoms. c. abdominal pain and palpable mass. d. Weight loss. e. A frequent need to urinate.

Germ cell tumors (Cleveland Clinic, 2021)	a. Pelvic pain or tenderness. b. Swollen belly (abdomen). c. Nausea or difficulty eating. d. Changes in bowel habits (constipation). e. Irregular vaginal bleeding.
Small cell carcinoma (SCCO) (Stewart *et al*., 2016)	a. Increasing abdominal distension. b. Aggressively spreading. c. weight loss. d. generalized malaise. e. Fatigue. f. Back pain.
Ovarian cysts (Mayo Clinic, 2021b)	a. Sudden, severe abdominal or pelvic pain b. Pain with fever or vomiting c. Fullness or heaviness abdomen d. a dull or sharp ache in the lower abdomen on the side of the cyst

The symptoms of each disease are ranked based the decision tree algorithm, The ID3 algorithm is applied, where, entropy(E) represent in equation 1, and information gain (IG) represent in equation 2, are the mathematical basis to the same.

Implementation

The first order predicate logic (FOPL) is used for formulating the hypothesis (disease) to be tested as well as the symptoms to be verified. The above table is formulated by FOPL and the same is programmed by Programming in Logic (PROLOG), which acquired the artificial intelligence (AI) capability. The results are shown in the figure 2 and 3.

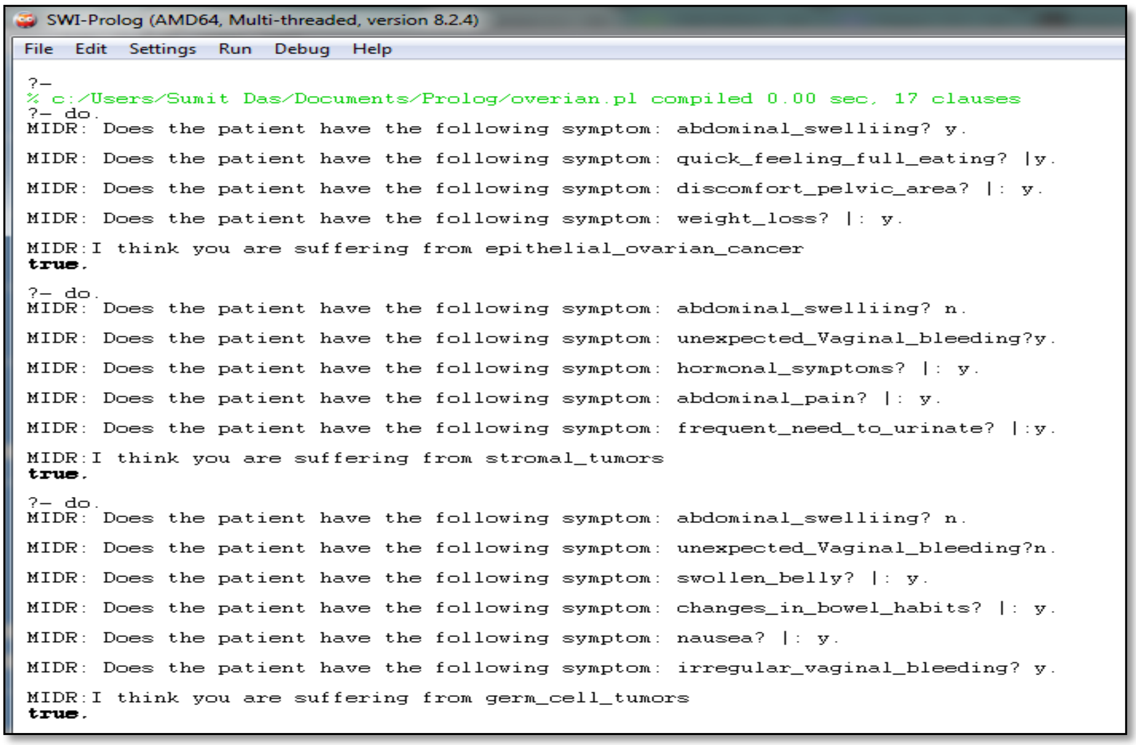

Figure 2: The MIDR performed diagnosis of Ovarian Cancer: Epithelial, Stromal Tumours and Germ Cell Tumours

```
SWI-Prolog (AMD64, Multi-threaded, version 8.2.4)
File  Edit  Settings  Run  Debug  Help

?-
% c:/Users/Sumit Das/Documents/Prolog/overian.pl compiled 0.00 sec, -2 clauses
?- do_diagnosis.
MIDR: Does patient have following symptom(Y/N): abdominal_swelliing? n.

MIDR: Does patient have following symptom(Y/N): unexpected_Vaginal_bleeding? |:n.

MIDR: Does patient have following symptom(Y/N): swollen_belly? |: n.

MIDR: Does patient have following symptom(Y/N): rasing_Abdominal_distension? |:n.

MIDR: Does patient have following symptom(Y/N): sudden_severe_abdominal? |: y.

MIDR: Does patient have following symptom(Y/N): pain_with_fever? |: y.

MIDR: Does patient have following symptom(Y/N): sharp_ache_in_lower_abdomen? |:y.

MIDR: Does patient have following symptom(Y/N): weakness? |: y.

MIDR: Does patient have following symptom(Y/N): heaviness_abdomen? |: y.

MIDR:I think you are suffering from ovarian_cysts
true.

?- do_diagnosis.
MIDR: Does patient have following symptom(Y/N): abdominal_swelliing? n.

MIDR: Does patient have following symptom(Y/N): unexpected_Vaginal_bleeding? |:n.

MIDR: Does patient have following symptom(Y/N): swollen_belly? |: n.

MIDR: Does patient have following symptom(Y/N): rasing_Abdominal_distension? |:y.

MIDR: Does patient have following symptom(Y/N): generalized_malaise? |: y.

MIDR: Does patient have following symptom(Y/N): fatigue? |: y.

MIDR: Does patient have following symptom(Y/N): back_pain? |: y.

MIDR:I think you are suffering from small_cell_carcinoma
true.
```

Figure 3: The MIDR performed diagnosis of Ovarian Cancer: Ovarian Cysts and Small cell carcinoma.

Results and Discussion:

The experiment is performed using the ovarian cancer dataset (Ashfaque, 2021), and the missing fields are replaced by mean as shown in figure 4 and fields value are replaced by 1 for high value and 0 for low as shown in figure 5.

	AFP	Age	ALP	Ca	CA125	CA19-9	CL
0	3.58	47	56.0	2.48	15.36	36.48	107.4
1	34.24	61	95.0	2.62	2444.00	19.98	100.1
2	1.50	39	77.0	2.57	56.08	12.18	102.6
3	2.75	45	26.0	2.35	2555.00	18.41	103.2
4	2.36	45	47.0	2.48	1391.00	11.15	99.6

Figure 4: Sample data

	AFP	Age	ALP	Ca	CA125	CA19-9	CL
0	0	47	0	1	0	0	1
1	1	61	1	1	1	0	0
2	0	39	1	1	0	0	1
3	0	45	0	0	1	0	1
4	0	45	0	1	1	0	0

Figure 5: Processed data

The ID3, decision tree algorithm is used to compute the variable of importance of the attributes(symptoms), through which the order of the symptoms is ranked for Prolog programming. The ovarian cancer data set is used to implement decision tree by ID3 algorithms.

The decision tree for the filtered dataset is programmed and simulated as shown in the following figure 6.

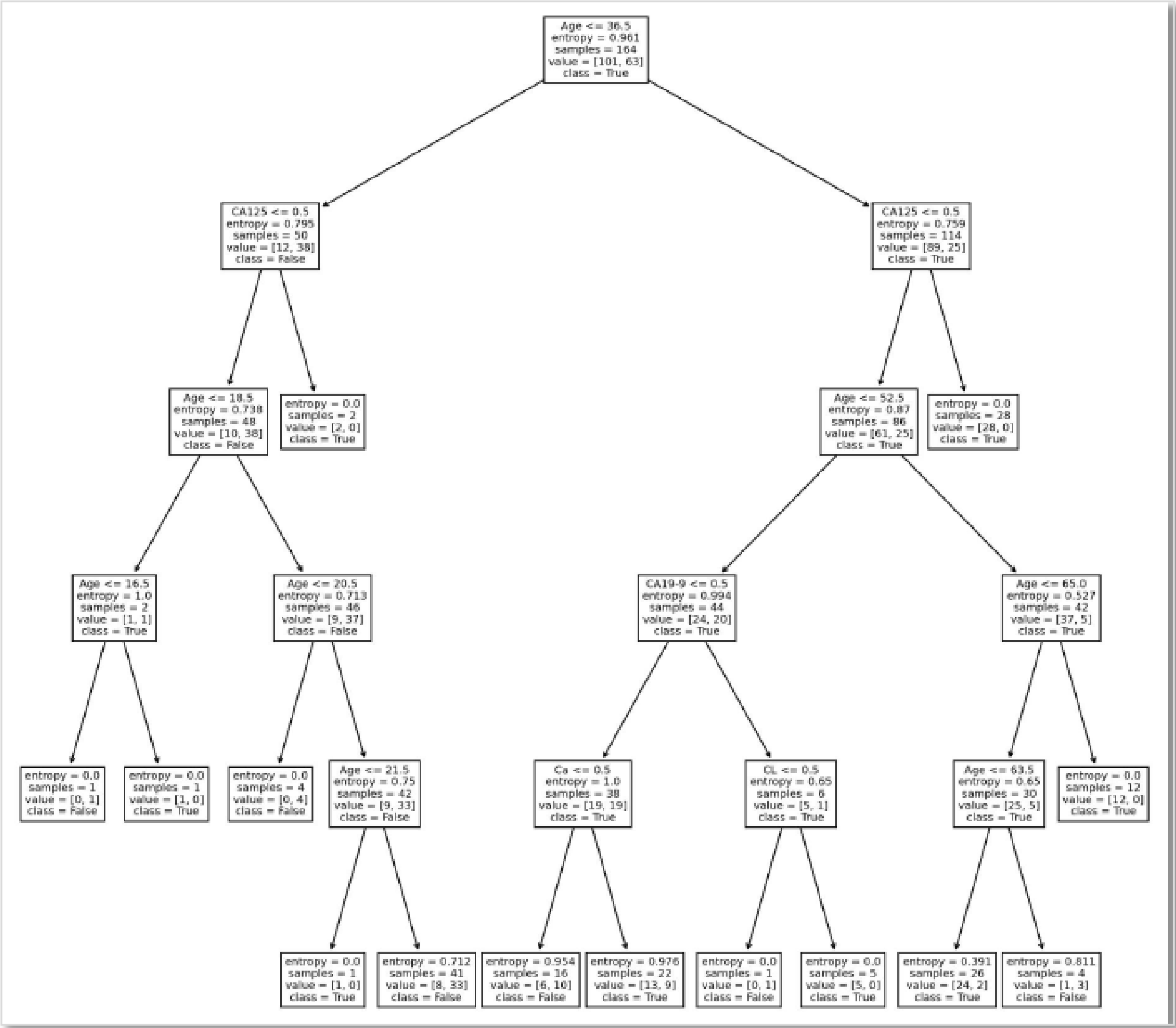

Figure 6: Decision Tree of Ovarian Cancer

To implement the diagnosis of ovarian cancer, declarative language programming in logic is used. The Decision Tree training accuracy and Decision Tree validation accuracy have been received, which are 0.8414634146341463 and 0.6901408450704225 respectively. One more result Naïve Bayes training accuracy and Naïve Bayes validation accuracy has received which are 0.774390243902439 and 0.704225352112676 respectively. The outcome of the results speculates that the artificial intelligence (AI) approach is very significant for medical diagnosis and, to some extent, for personalised medical diagnosis.

The limitation of the work is that it is not possible to detect that anyone has ovarian cancer or not for real because one must do the tests (USG, CA-125) that are required to get assure if it is ovarian cancer or not for further treatment. It cannot inform 100% accuracy about the types of ovarian cancer. It will create an opportunity for people to provide awareness along with the prediction if someone is affected by it or not without any doctor. In the future, it can be modified to predict more accurately. Deaths that are caused by ovarian cancer can be reduced. While researching the paper there were some obstacles such as the symptoms of the different types of the ovarian cancer are quite similar, there is no major differences. People have to go through the different tests to get assure about the disease. There were very less datasets of ovarian cancer available in the internet which are reliable.

Conclusion:

This paper concludes that machine learning approaches were able to accurately classify Ovarian Cancer. The goal of this paper is to develop a simple predictive model with an accurate performance. It got the accuracy high for the Decision Tree training than the accuracy of Naïve Bayes training. In this approach, it obtained a model(MIDR-machine intelligent doctor) which reduces the time to predict ovarian cancer and is more usable for the common people who are not able to touch all the time with medical care and is much helpful for doctors in a short time. The model is simple to interpret and outperforms the existing Ovarian Cancer prediction methods. It demonstrates that the ID3 algorithm approach using AI has good potential in predictive modelling for complex diseases.

Future Work: To get more and more accurate results, the work on this ovarian cancer will continue. More advanced technologies will be used to find more solutions and ways to detect and cure this deadly disease, as well as reduce its prevalence.

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Conflicts of Interest:

The authors declare that the research review was conducted in the absence of any commercial or economic associations that could be construed as a potential conflict of interest.

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