Healthcare Technologies Serving Cancer Diagnosis and Treatment

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1 Introduction

One of the most common and deadly diseases in the world is cancer. Early prediction of cancer can extend the survival rate of the patient. Early diagnosis and cancer prediction can be achieved by incorporating artificial intelligence in picture. The application of artificial intelligence in cancer research and oncology is vast. These include early prediction, detection, and diagnosis of cancer and its sub-types, treatment optimization, and identification of new therapeutic targets in drug discovery. Data from various imaging modalities are used for training the model. Cancer research involves prevention, causes, and development of cancer and genes involved in it. Cancer is described based on the cell that formed them, which is epithelial or squamous cell. Cancer is divided into many types based on its origin such as carcinoma, sarcoma, leukemia, lymphoma, myeloma, melanoma, brain, and spinal cord tumors. Carcinomas are the most common types of cancer among various cancer types, and they are formed by the epithelial cells which cover the inside and outside surfaces of the body. Carcinoma that forms in different epithelial cells have specific

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C. Ram Kumar, S. Karthik (eds.), *Translating Healthcare Through Intelligent Computational Methods*, EAI/Springer Innovations in Communication and Computing, https://doi.org/10.1007/978-3-031-27700-9_18

names. One such type is adenocarcinoma; this is a cancer in epithelial cells that produce mucus or fluids. Breast cancer is a type of adenocarcinoma. Cancer that forms in squamous cells is known as squamous cell carcinoma; this is a type of epithelial cell which lies just beneath the outer surface of the skin. Lung cancer belongs to this type of carcinoma. In this chapter, cancer research in breast cancer and lung cancer is addressed.

1.1 Breast Cancer

The most common type of cancer among the female population is breast cancer. It can be either benign or malignant. It is a malignant type that starts in the epithelial cell lines of the female breast. Several factors can increase the risk of getting breast cancer, which include lifestyle changes and damage to the genetic material; genetic mutations that led to breast cancer have been experimentally linked to estrogen exposure. Defects in genes like BRCA1, BRCA2, and P53 can also cause breast cancer. Based on the type of spreading nature of cancer, it is classified as in situ and invasive breast cancer.

Cancer which starts growing at milk duct and not grown in the entire organ is termed in situ breast cancer, whereas invasive breast cancer is a type where the cancer cells spread into the entire breast. Preliminary diagnosis of breast cancer includes physical examination of the organ, and radiation methods like mammogram and breast ultrasound. Advanced diagnosis includes tissue biopsy and breast MRI. The treatment includes chemotherapy, radiation therapy, and surgical removal of breast. Chemotherapy uses drugs to destroy cancer-causing cells. Chemotherapy can be given to the breast both before and after the surgery, depending on the individual's symptoms or needs. Radiation therapy uses high-powered beams of X-ray and protons to kill cancer cells. It can be done by passing the radiation from the machine that aims at the cancer cells, i.e., external beam radiation. Radiation therapy can also be done by placing a radioactive element inside the body, i.e., brachytherapy [1]. The various types of breast cancer are shown in Fig. 1.

The malignant growth that begins in the covering of the milk channel and is painless goes under the type ductal carcinoma in situ. It is an early type of bosom disease and it is reparable whenever treated early. On the off chance that it is left untreated, it spreads to the encompassing tissue and is called intrusive ductal carcinoma. This kind of malignant growth is the most well-known sort of bosom disease and records for around 70–80% of the bosom disease analyzed and has a place with this sort of disease. It is normally found in men too [2].

The disease cells which present in the lobules of the bosom go under the kind of lobular carcinoma, which don't spread beyond the lobules that is all there is to it is painless. Lobular carcinoma is exceptionally treatable and when this moves to next stage it becomes intrusive lobular carcinoma. It spreads to the encompassing bosom tissue as well as goes into the circulation system and lymphatic framework and

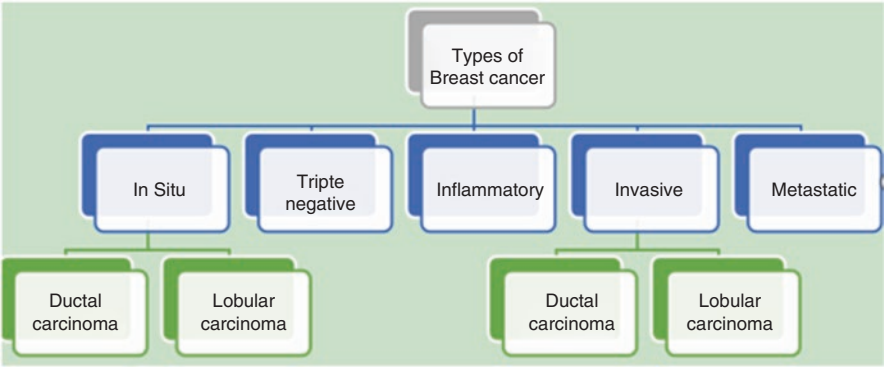

Fig. 1 Breast cancer types

spreads to different organs in the body. Among different sorts of bosom disease, it is the second most considered normal kind of bosom malignant growth on the planet.

The disease cells which tried negative for chemical epidermal development factor receptor 2 (HER 2), estrogen receptors, and progesterone receptor go under triple negative bosom malignant growth. This sort of disease is challenging to treat with hormonal treatment since it misses the mark on normal receptors. Being the most forceful type of bosom cancer, chemotherapy might be a reasonable choice.

One of the forceful and quickly developing malignant growth cells are inflammatory bosom disease. In this malignant growth, the disease cells invade the skin and lymph vessels of the bosom. Whenever the malignant growth cells block the lymph vessels, the bosom becomes red, enlarged, reversal, straightening, and dimpling of areolas might happen.

Metastatic malignant growth is the last phase of disease where the malignant growth cells spread to different parts of the body, particularly to lungs, liver, bones, and cerebrum [2].

1.2 Lung Cancer

The most well-known reason for disease passing in all kinds of people overall is because of cellular breakdown in the lungs. This kind of cancer begins in the parenchyma of the lungs or bronchi. Chain smoking is additionally one of the significant reasons for cellular breakdown in the lungs. Presenting to cancer-causing specialists like asbestos and metals, for example, nickel, arsenic, and chromium has the most noteworthy gamble of getting cellular breakdown in the lungs at a later phase of life. It is the most commonly analyzed disease around the world. Persistent openness of cancer-causing agents and tobacco smoke prompts strange development of lung epithelium. Hereditary changes happen assuming that the openness of such specialists proceeded and lead to harm in protein union. This influences the periods of the cell cycle and advances carcinogenesis.

The most well-known quality changes liable for cellular breakdown in the lungs incorporates MYC, BCL2, p53, EGFR, KRAS, and p16. In view of the presence of the cellular breakdown in the lungs' cells under magnifying instrument, it is extensively grouped into Small Cell Lung Cancer (SCLC) and Non-Small Cell Lung Cancer (NSCLC). SCLC is more normal among smokers and it is described by little cells with no particular core. It has a higher development rate and metastasize to different organs like central nervous system (CNS), liver, and bones. The SCLC and NSCLC can be separated by particular sorts of biomarkers.

Ordinarily seen biomarkers in SCLC are thyroid record factor 1, CD 56, synaptophysin, and chromogranin. NSCLC is a typical term which incorporates numerous different kinds of cellular breakdown in the lungs [3]. The sorts of cellular breakdown in the lungs are displayed in Fig. 2.

Squamous cell carcinoma is primarily connected with smoking. It tends to be available in lungs as pancoast growth and hypercalcemia. The cancer in the prevalent sulcus of lungs is named as pancoast growth. Post-medical procedure repeat spot of pancoast cancer is cerebrum. It is dominatingly found in men to ladies.

Adenocarcinoma is most usually found in ladies and non-smokers. This is because of the openness of cancer-causing specialists. The biomarkers answerable for adenocarcinoma incorporate Napsin A, Cytokeratin-7, and thyroid record factor 1 [3]. Adenosquamous carcinoma has over 10% of blended glandular and squamous parts, while enormous cell carcinoma misses the mark on separation of a little cell and glandular or squamous cells. Carcinoid cancer is additionally partitioned into average and abnormal. Commonplace carcinoid conveys better visualization and is sporadically connected with carcinoid conditions. Cellular breakdown in the lungs can be analyzed by CT filter, PET sweep, bronchoscopy, mediastinoscopy,

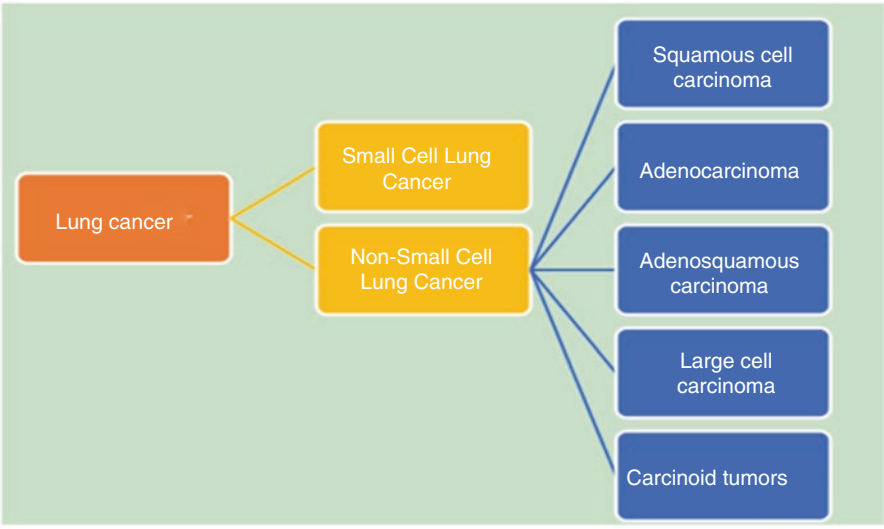

Fig. 2 Types of lung cancer

thoracoscopy, and biopsy. Therapy for cellular breakdown in the lungs incorporates radiation treatment, chemotherapy, immunotherapy, designated drug treatment, and medical procedure. The medical procedure methodology for cellular breakdown in the lungs includes wedge resection, segmental resection, lobectomy, and pneumonectomy [4].

2 Imaging Modalities for Cancer Screening and Detection

2.1 Imaging Modalities

Imaging modalities help in screening and diagnosis of cancer images. The preceding section gives an overview of different imaging based on various regions in electromagnetic spectrum and some impedance, thermal, and elasticity properties of human tissues that are in clinical usage and under research.

X-ray imaging: The human body is allowed to flow the X-ray beam into the body and the non-absorbed beams are recorded by the film or computer screen. The techniques which use X-ray imaging are computed tomography (CT), fluoroscopy, mammograms, digital breast tomosynthesis, and radiography. These non-invasive techniques use ionizing radiation to generate images of the body [5].

Ultrasound imaging: Breast images are obtained by passing high frequency ultrasound waves. Breast ultrasound is required to identify and differentiate solid masses and cysts. But this method may not predict all the early signs of cancer possibilities like micro-calcification, which is a micro calcium deposit. It is suitable for pregnant women and age less than 40 years [5].

Radio wave imaging: The low-frequency range of the EM spectrum are the radio waves. The radiowave imaging gives 3D image of the tissue in which it travels. Acquisition of radio waves are done using multi-static array processing which uses radio waves that is suitable for breast cancer screening and diagnosis [5].

Magnetic resonance imaging (MRI): MRI employs muscular magnetic field and radio waves for the diagnosis of breast cancer. This helps to spot the footage and location of tumor and also to know the status of tumor growth for treatment. A contrast agent named Gadolinium is inoculated into the human body before the test. The agent is washed out through the kidneys [5].

Gamma imaging: Using mammogram, it is difficult to identify lumps in the breast where gamma imaging helps to diagnose it. The radioisotope Technetium (99mTc) is injected into the body which emits gamma rays, and it is captured by the gamma detectors. Positron emission tomography and breast-specific gamma imaging use this imaging technique [13].

Functional magnetic resonance imaging (fMRI): fMRI uses the combined concepts of MRI and blood oxygen. It helps to identify the molecular behavior of breast. Diffusion weighted imaging and dynamic contrast-enhanced MRI belong to the fMRI technique [5].

Breast thermal imaging: The infrared (IR) light emitted by our body surface is the source of thermal imaging. The emitted IR light is captured by an IR camera and records the thermal pattern. The cancer region reflects more IR light than other regions. This technique is radiation-free, contactless, and painless [5].

Nuclear medicine imaging: Radio tracers are infused into bloodstreams where they emit radiations and are captured by a radio detector. Scintimammography, sentinel lymph node scintigraphy, and positron emission tomography work on this imaging principle [14].

Electric impedance imaging: Cancer cell has low electrical impedance. Electrodes are attached to the body, and electrical impedance of the body cells is recorded in electrical impedance tomography [15] and electrical impedance mapping. These recordings from the electrodes are reconstructed as images which are used for further study.

Elasticity imaging: This is a hybrid imaging technique that encloses ultrasound imaging and elasticity imaging software. Cysts and solid lesions in breast can be differentiated in elasticity imaging. Digital image elasto yomography uses elasticity property of tissues and measures the variation in healthy and cancer tissues [12, 16].

Photoacoustic imaging: This is a hybrid technique which works on photo-acoustic effect. Laser pulse of 532 nm from an optical microscope focuses on the sample, and ultrasound is used to record the image [17].

Microwave imaging: Microwave region of electromagnetic spectrum is used for image capturing. Water content of tissues possess dielectric properties like permittivity and conductivity. The dielectric properties vary for malignant and normal tissues, and this variation is recorded and constructed as 2D and 3D images [6]. Figure 3 shows the image modalities under research which are not familiar in clinical usage.

2.2 Cancer Screening and Diagnosis Techniques

Cancer screening refers to abnormalities in human cells. Thermography, electrical impedance tomography, ultrasound, and magnetic resonance Imaging techniques help for cancer screening. Diagnosis refers to locate the cancer cells; how much it has spread and also identify its stage. Mammography, positron emission tomography, tomosynthesis, and electronic palpation imaging techniques support both screening and diagnosis. The preceding section provides the mechanism of operation, sensitivity, specificity, and method of examination of different imaging techniques. Sensitivity in medical diagnosis refers to positive result of a test and specificity tells the negative result of a test.

Mammography: In mammography, low energy X-rays are used to examine human breast, which help in preliminary spotting of breast cancer. This shows a sensitivity of 90%, also in contrast, specificity greater than 94%. It may cause pain in

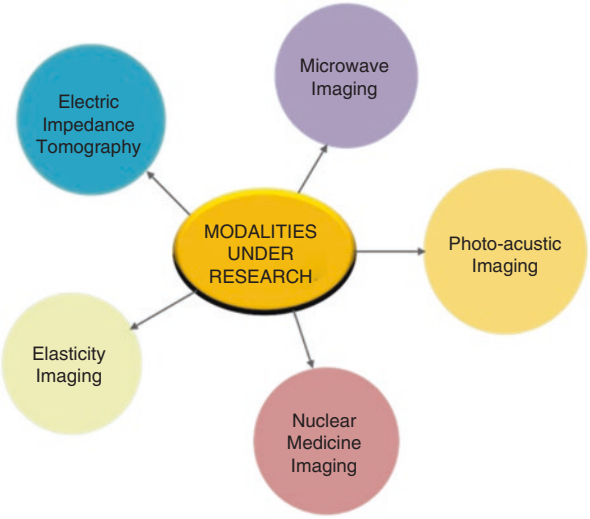

Fig. 3 Breast imaging modalities under research

breast, reaction to contrast reaction and claustrophobia. It is not suitable for women of all age group and pregnant women. Tomosynthesis, the 3D mammography uses low energy X-rays and gives 3D image of the breast with sensitivity of 84% and specificity of 92% [5–7]. Contrast-enhanced mammography (CEM) has sensitivity similar to MRI and shorter than MRI in predicting lesions. Non-ionic low osmolar iodinated dissimilitude material is rendered to the person under examination intravenously before examination. The dosage amount of 1.5 ml/kg is passed at a rate of 3 ml/s. After 120 s of dosage, low-energy and high-energy images are obtained by bilateral craniocaudal and mediolateral oblique imaging [18].

Magnetic resonance imaging: Radio waves, along with muscular magnetic field, is utilized in MRI. Based on the emission of radio waves by the body tissues, the image of organ is obtained. It gives a high resolution image and suitable for breast implants. On the other hand, it suffers from contrast dye reaction and risk of excessive sedation. Its sensitivity is 90%, and its specificity is 50% [5, 6].

Ultrasound scan (US): Ultrasound is a screening technique that has a transducer to produce ultrasound frequency acoustic waves and it is passed into the body and reconstructed as image. This can guide doctors to do biopsies. US supports to scan certain organs, whereas it is not suitable to scan brain, lungs, and pelvis. Its sensitivity is about 82%, and its specificity is about 84% [5, 6].

Positron emission tomography (PET): Radioactive tracers are injected into the body that emit gamma rays from the tracer substances. PET helps to find out the spread of cancer to other regions. It has improved localization and better image contrast. This technique is not suitable for kidney patients and may give allergic reactions

and also it's more expensive than other imaging techniques. Its sensitivity is about 90% and specificity is about 86% [5, 6].

Thermography: Thermography is a screening technique, where temperature sensors are placed on the skin surface and surface temperature is measured. It is free from radiation and can be used as wearable. Its sensitivity and specificity are greater than 90% [5].

2.3 Lung Cancer Detection Using CT Scan Images

Lung cancer is a killer disease seen in a large proportion of the population. Cells in lungs grow abnormally, which is difficult to predict in early stages. Smoking and exposure to toxins are the major causes of lung cancer. This section gives an insight on tumor detection, features, and classification of tumor from CT images [8].

Tumors are classified as benign and malignant based on their size, shape, and appearance. Sizes less than 10 mm are benign and greater than 10 mm are considered as malignant. With respect to shape, malignant is classified as lobulated, speculated, ragged, and halo. Benign has an even appearance whereas malignant has uneven appearance [12].

CT image obtained is subjected to pre-processing to diminish the unnecessary regions. Pre-processing includes smoothing, noise removal, applying filter, histogram equalization, median filter, etc. [11, 12]. Features of tumor can be based on shape intensity and texture. The shape of mass includes area, perimeter, compactness, and circularity. Texture decides the visual smoothness of image in spatial domain. It includes mean, variance, median, standard deviation, and smoothness. Intensity features are based on the statistics of individual pixels. Features include uniformity, contrast, entropy, energy, and homogeneity [9–12].

3 Cancer Prediction and Detection with Data Analysis

Disease is the best reason for death and enduring universally, according to the World Health Organization. Precise and early disease diagnosis will decrease the malignant growth-related wretchedness and mortality. Computer supported disease assessment helps in identifying the high risk nature of malignant cancer. Early discovery limits the gamble of malignant growth spreading to different areas of the body and guarantees legitimate treatment when the illness initially shows up.

In the field of medication, the volume of information created has extended essentially since the computerization era [19]. Simultaneously, there has been an increase in interest in utilizing AI and neural organization advancements to break down clinical information and to create expectations [20]. The preparation strategies for ML and Neural organization insightful instruments for clinical applications by and large need huge volumes of named information, which is a specific test.

Conventional manual naming is a period monotonous procedure that, much of the time, forestalls the age of huge satisfactory examples. Gathering huge homogeneous datasets in the clinical calling is extreme, notwithstanding the naming trouble. The inborn fluctuation of authentic information assembled in regular clinical practice, specifically, presents a compromise between informational index quality and informational collection amount. This strategy utilized AI classifiers, for example, support vector machine (SVM), logistic regression, decision tree (C4.5), random forests, and K-nearest neighbors (KNN) on the breast cancer. Figure 4 shows the Wisconsin Diagnostic informational collection used to foster the best powerful and prescient calculation for bosom malignant growth screening.

It begins with information assortment and afterward continues on to pre-handling, which incorporates four stages: information purging, quality determination, target role setting, and element extraction. The data is then used to foster AI calculations that can foresee bosom malignant growth in view of a particular arrangement of execution pointers. To furnish the new information and allotted marks to assess the calculations and it is executed [21]. This is often achieved by utilizing the train test split capacity to divide the marked information that obtained into two sections. The preparation information or the preparation set accommodates 75% of the information used to foster our AI model. Test information, or test set, is 25% of the information that will be utilized to perceive how well the model performs. In the wake of applying five essential calculations, support vector machine has accomplished great outcomes in breast cancer forecast and analysis, and it provides the best exhibition concerning exactness and accuracy.

3.1 Cancer Analysis Using Neural Networks

Breast cancer is the most common cancer among women, according to statistics. A basic neural network can be used to detect and forecast the possibility of cancer in breast lumps. A Particle Swarm Optimized Wavelet Neural Network (PSOWNN) that uses mammograms as its input set to detect worrisome spots in breast masses is used to detect breast abnormalities in digital mammograms. The goal of WNN optimization is to enhance classification accuracy in breast cancer diagnosis while lowering the rate of mis-classification. The PSOWNN classifier, which was created by applying the PSO algorithm to WNN, is being tested for diagnosing breast cancer in mammograms.

The application of neural networks in breast cancer detection provides a significant advantage over traditional methods in terms of time taken for examination. ANN investigates a massive amount of data after a short training period, whereas traditional approaches need a long time to evaluate one data at a time.

ANNs are simple to implement and estimate outputs with high precision. Predicting outcomes in medicine has traditionally taken years of experience and knowledge in the field. Furthermore, other forms of ANNs can be developed to identify breast cancer, broadening the frontiers for earlier and easier diagnosis of breast cancer.

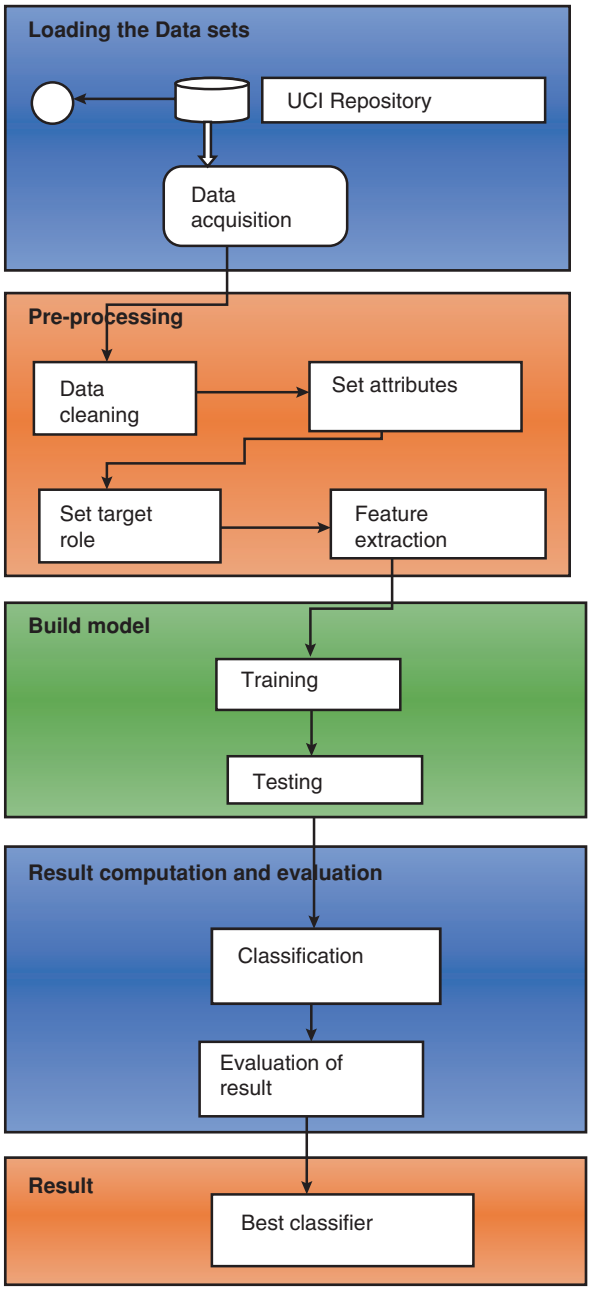

Fig. 4 Process of breast cancer prediction using machine learning algorithm

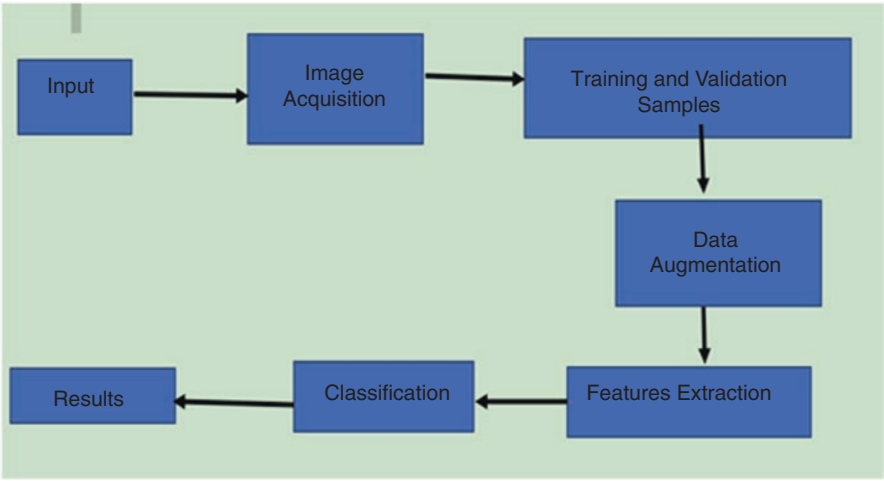

Fig. 5 Block diagram for detecting cancer using neural networks

BreakHis data set of breast tumor data set was used to collect the data [22]. After that, the data was separated into various training and test set ratios. Ten percent of the training set is used as a validation set for cross-validating the model in all trials. Image scaling and data augmentation are examples of image pre-processing, as shown in Fig. 5. To get better results, we used image re-sizing and data augmentation methods like rotation, zooming, random flip, horizontal flip, and vertical flip to pre-process the photographs. Before the training, we scaled the images to 230*230 and 460*460 pixels. The use of these strategies increases the performance of the network by allowing it to generalize more effectively and avoid over-fitting [23].

4 Conclusion

The chapter provides a summary of cancer diagnosis, treatment, biopsy method examination, different imaging techniques used in screening and diagnosis, and finally data analysis in cancer detection. When concerned about imaging techniques, thermography and ultrasound scans are radiation-free, less expensive, and suitable for screening. Mammography and tomosynthesis are based on protocols and give good sensitivity in diagnosis. MRI and PET scans are expensive; on the other hand, they give high resolution images with improved localization. After preliminary diagnosis by the above techniques, to confirm the presence of cancer, biopsy procedure guides us. Through endoscopy, the cancer cells are located and tissues are collected and examined further in biopsy. Being an invasive procedure, this may cause the cancer cells to burst and spread to surrounding cells. Data analysis in cancer detection became a new horizon with machine learning and artificial neural networks. ANN with swarm optimization techniques gives improved results in processing massive data.

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