

## Design of Convolutional Neural Networks for Detection of Liver Disease

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### Abstract

Liver disease is a significant medical condition that affects millions of people worldwide. Early and accurate diagnosis is crucial for the treatment and management of liver disease. In recent years, Convolution Neural Networks (CNNs) have excelled in several medical image-processing applications, including disease diagnosis. The design and development of a convolution neural network for use in identifying liver disease from medical imaging data are the major subjects of this study. The proposed CNN architecture is designed to analyze medical images, especially liver images obtained using imaging methods like computed tomography (CT) scans or magnetic resonance imaging (MRI). The architecture uses input images to teach it hierarchical features through the use of several convolution layers. Additionally, pooling layers are employed for classification while fully linked layers are used to reduce computational complexity and spatial dimensions. To train and evaluate the CNN, a sizable liver imaging dataset comprised of both healthy and ill patients is used. To enhance image quality and ensure uniformity in terms of size and orientation, the dataset has been preprocessed. The network's parameters are tuned during the training process using the appropriate optimization techniques and loss functions. Testing and validation are carried out to assess the network's performance with unobserved data. The findings of the research demonstrate how effective the proposed CNN architecture is at detecting liver disease. As a result of the model's high accuracy rate, it may prove to be a valuable tool for assisting medical practitioners in spotting liver disorders. The study adds to the growing body of information on the application of deep learning algorithms in medical picture analysis and emphasizes the significance of early and precise disease identification.

Keywords: Convolution Neural Networks (CNNs), Magnetic Resonance Imaging (MRI).

### I. Introduction

Liver disease is a major global health problem that affects millions of people. Effective medical intervention and patient treatment depend on the prompt and precise identification of liver disease. Convolution Neural Networks (CNNs) have become potent tools for assessing medical images and diagnosing numerous diseases, including liver ailments, with the advent of deep learning techniques. The purpose of this project is to develop and apply a convolution neural network for detecting liver disease using medical imaging data.

The liver is an essential organ that is important for many physiological functions, including metabolism, detoxification, and nutrition storage. Liver dysfunction can result from several situations, such as infections, alcohol use, genetic predisposition, and other underlying illnesses. Due to liver disease's asymptomatic character in its early stages, early identification is difficult. CT scans and MRIs are examples of medical imaging technologies that offer useful information about the health of the liver and help doctors spot abnormalities.

Convolutional Neural Networks have achieved outstanding results in image analysis and recognition tasks, including medical picture analysis. Their capacity to automatically learn and extract hierarchical information from images makes them well-suited for spotting complex patterns and anomalies present in medical imaging. CNNs can develop the ability to distinguish between healthy and unhealthy states by training on a huge dataset of annotated medical images, which helps in diagnosis.

In this paper, we suggest an architecture for a CNN that is specifically designed to interpret liver pictures received from several imaging modalities. Convolutions, pooling, and fully connected operations are performed by layers in the architecture. The data is downsampled by pooling layers, which also reduces computational complexity, while convolutional layers capture local information. The network can use fully linked layers to make judgments based on learned features.

An extensive liver imaging dataset is selected and preprocessed to train and test the proposed CNN. The dataset contains a variety of instances, both those with healthy livers and those with various liver disorders. By modifying its parameters via gradient descent and backpropagation during training, the network learns to minimize a predetermined loss function. After training, the CNN is validated and put to the test on new data to determine how well it performs.

It is anticipated that the study's findings will show how well the CNN architecture was developed for identifying liver illness. CNN has the potential to be an invaluable tool for medical professionals to use when making accurate diagnostic judgments because of its great sensitivity and accuracy. The necessity of utilizing cutting-edge technologies to improve healthcare procedures is underlined by this research, which advances the field of medical image analysis.

In the parts that follow, we'll go in-depth on the experimental findings, methodology, architecture, dataset, training procedure, and convolutional neural network used to identify liver illness. This study fills the gap between deep learning and medical diagnostics, providing a promising route to bettering patient outcomes and developing the area of detecting liver disease.

## **II. Materials and Methods**

### **1. Gathering and Preprocessing Datasets:**

Pictures from several imaging modalities, including CT scans and MRIs, are collected to create a comprehensive library of liver pictures. The collection includes both photos of a healthy liver and photographs showing various stages of liver disorders. Medical experts anonymize and classify the photos to specify the diseases they represent. To improve the uniformity and quality of the images, preprocessing entails normalizing pixel values, standardizing image sizes, and using noise reduction techniques.

2. CNN Architecture: The CNN architecture was created to capture the unique patterns and features found in liver pictures. It is made up of several convolutional layers, followed by activation techniques (like ReLU) to add non-linearity. To cut down on spatial dimensions and manage overfitting, the architecture might use pooling layers like MaxPooling. Classification is made possible by the network's final fully connected tiers.

3. Data Augmentation: To reduce overfitting and enhance model generalization, strategies for artificially boosting the variety of the training dataset are used. To produce variations of the original photographs, tricks like rotation, flipping, and zooming are used.

4. Training and Optimization: Using the curated and preprocessed dataset, the designed CNN is trained. The difference between anticipated and actual labels is measured during training using a suitable loss function (such as categorical cross-entropy). To reduce the loss function, iterative weight, and bias adjustments are made to the network using optimization methods like Adam or RMSProp.

5. Hyperparameter Tuning: Hyperparameters are modified to get the best model performance, including learning rate, batch size, and dropout rates. To balance underfitting and overfitting, this tuning method uses experimentation and validation.

6. Validation and Testing: A subset of the dataset is held back for validation to track the model's effectiveness throughout training and choose the version that performs the best. The model's generalizability and efficiency in identifying liver illness are evaluated after training on a different, untrained test dataset.

7. Evaluation measures: The accuracy, precision, recall, F1-score, and ROC curves are some of the measures used to assess how well the CNN performs. These measures shed light on the model's capability to distinguish between photos of a healthy and sick liver.

8. Comparative Analysis: The performance of the CNN may be validated by comparison to currently used techniques or conventional diagnostic methods. The benefits and drawbacks of the proposed CNN in detecting liver illness are brought out by this comparison.

9. Ethical Considerations: Potential biases in the dataset, data privacy, patient consent, and other ethical issues are considered and addressed. The study complies with all applicable rules and recommendations.

10. Specifics of the CNN architecture's implementation: A deep learning framework like TensorFlow or PyTorch is used to carry out the CNN architecture. To speed up the training process, hardware resources like GPUs are used.

### **III. Related Work**

Convolutional Neural Networks (CNNs) have drawn a lot of interest in the study of medical image processing for the diagnosis of liver disease. Researchers have looked into several strategies to use deep learning for accurate diagnosis and early liver problem detection. An overview of pertinent papers and methodologies in the field of employing CNNs to identify liver disease is provided in this section.

1. Liver Disease Classification: To categorize images of the liver into various diseases, researchers have created CNN architectures. Studies have concentrated on categorizing liver disorders like cirrhosis, hepatocellular carcinoma, and fatty liver disease. These studies often use annotated datasets of liver images obtained using various imaging modalities to perform multi-class classification.

2. Lesion Detection and Segmentation: Finding lesions or anomalies in liver pictures and segmenting them is another part of detecting liver illness. CNNs have been employed to find tumors, cysts, and other aberrant liver structures. Specialized architectures, like U-Net, which integrate convolutional and deconvolutional layers for precise localization of lesions, are frequently needed for segmentation tasks.

3. Transfer Learning: Transfer learning, which fine-tunes pre-trained CNN models (such as VGG, ResNet) for detecting liver illness, has been extensively researched. With little information, these pre-trained models, which were developed using extensive picture datasets like ImageNet, can be used for medical imaging tasks. This method expedites training and improves model functionality.

4. Ensemble Methods: To increase the reliability and accuracy of liver disease detection, ensemble methods mix numerous CNN models. Ensemble approaches reduce the danger of overfitting and improve generalization by combining the predictions from different models.

5. Domain Adaptation: To improve CNN's ability to generalize across various datasets, domain adaptation approaches have been used because medical images frequently come from various sources and have diverse properties. Models work well on a variety of patient groups when they are adjusted to the imaging methods of certain medical facilities.

6. Explainability and Interpretability: In medical diagnosis, it is essential to be able to explain the conclusions made by CNN models. Researchers have looked into methods for producing heatmaps or saliency maps that highlight the areas of a picture that are most important to the model's conclusion. Medical experts are more likely to believe the model's diagnoses as a result.

7. Limitations and Challenges: Despite the advances, problems including dataset scarcity, class imbalance, and the necessity for a lot of labeled data still exist. Critical factors to take into account also include ethical issues like data privacy and potential biases in training data.

In conclusion, the topic of using convolutional neural networks to identify liver illness is fast developing. To increase accuracy and robustness, researchers have used a variety of CNN architectures, transfer learning techniques, and ensemble methods. Establishing trust and practicality for real-world medical applications requires integrating explainability methodologies and addressing ethical issues. The details of the planned CNN design and how well it detects liver illness will be covered in the section that follows.

## V. Database of Liver CT Images

The creation of a database of liver images with data on both healthy and sick livers is an important contribution of the proposed paper. The literature has reported on a very small number of micro datasets for the machine learning categorization of liver diseases. Data on CT imaging that has been clinically confirmed was gathered for this study from the Bahawal Victoria Hospital in Bahawalpur, Pakistan. Both spiral and sequential image acquisition techniques were employed by the CT scanner to gather images. By using axial reconstruction, the averaging of

Due to the availability of the aforementioned data types, the inclusion criteria required the collection of data from infected individuals with hepatitis B and C, a metastatic tumor (secondary tumor), tumor necrosis, or vascular problem. The current investigation eliminated patients who had renal function testing, were on ventilators, or were children. Patients were unable to undergo a biopsy to corroborate clinical data due to the area's poor socioeconomic position. Serum alpha-fetoprotein and triphasic multidetector computed tomography of the liver, which used non-ionic intravenous ultrafast contrast to enhance the pathological pattern, served as the gold standard for the final diagnosis. The demographic information for the patients chosen for the study is shown in Table 1. Several photos from our compiled database are shown in Figures 1 and 2. Images with various anomalies at various stages are shown in Figure 1. Images from a healthy case are compared to contaminated data in Figure 2.

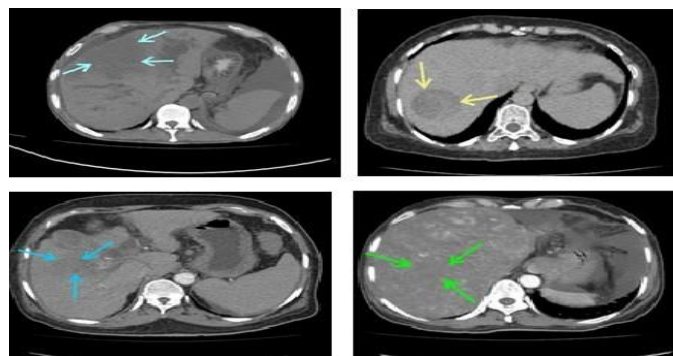


Fig 1. Abnormalities of Liver

| Number of Patients | Existing Disease Process/Lesion                                                         |
|--------------------|-----------------------------------------------------------------------------------------|
| 19                 | Abscess infection, hepatitis B, C                                                       |
| 15                 | Metastatic CA colon, gall bladder, prostate, ovary, and breast                          |
| 23                 | Metastatic, necrotic tumor                                                              |
| 26                 | Metastatic, vascular disorder, AV malformation (arteriovenous malformation), hemangioma |
| 16                 | normal                                                                                  |

Table 1. Data of Patients

## VI. Suggested Proposed Approach

We investigated both traditional machine learning techniques and deep learning-based

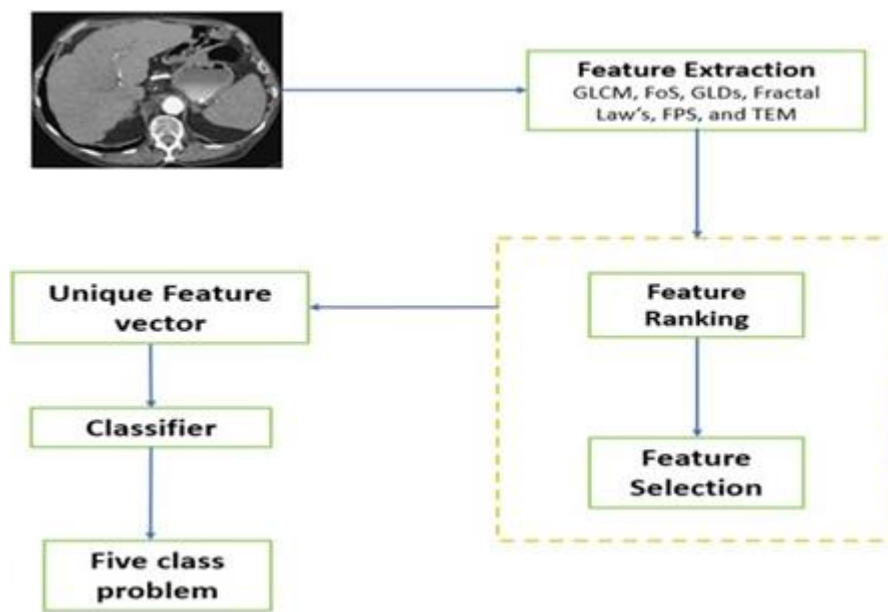


Fig 2. Proposed CNN Classification

In our suggested effort, we employ two methodologies. In Figure 3, the traditional machine learning approach is outlined. An ROI is a portion of an image that has information to help with a particular liver diagnosis. To accurately diagnose advanced diseases, an ROI is a crucial visual representation, hence choosing such image regions is a crucial task. We selected a polygonal ROI with adequate area to gather texture model features. We applied the advised technique Any machine learning approach must include the feature extraction stage since it identifies key information about an image's contents. Different liver lesions exhibit varied distinctive texture features or patterns; for instance, photographs taken under abnormal and normal settings display varying patterns and values of gray-level intensity. In the literature, various models for acquiring texture features have been documented [31–33]. These models offer several different visualizations of an image's content. The spatial distribution of pixel values and derivations from brightness level are a couple of these methods [19]. We enhanced our framework with a feature rating to eliminate unnecessary data. Before classification, there was this stage. Feature ranking prevents collinearity, reduces the dimensionality of feature vectors, and in some way minimizes noise because the majority of the features used to diagnose a certain disease are connected [42]. We used a filter-based approach for feature ranking with dimensionality power. We used gain (ratio and information), knowledge-based feature ranking, and relief feature ranking [43]. The works included in [44,45] examined these characteristics. Figure 4 depicts the network that we have suggested. To extract the features of both healthy and damaged livers, we used a feature extraction framework (FEF). The fundamental building elements of the feature-learning part are depicted in Figure 5's various stages. Stage 1 in Figure 5 deals with the variances in the features. Because of the surroundings, there are scale discrepancies in CT scans. All of these variations are overcome by these receptive fields. Each field includes 16 filters, as shown in Figure 5. Stage 2, an FCL, receives the output from stage 1 after that. We employ a 2 2 MPL to extract features in step 2. Each CovL is then followed by the RLU. We positioned a Spatial Pyramid (SPd) between the CovL and FCL. In stage 3, the FCL receives an output from the SPd. The feature extraction is handled by stages 3 and 4, which are depicted in Figure 5. The final stage, stage 4, an FCL, then transfers the extracted final characteristics to the following module for SS.

## VII. Findings and Discussion

This section describes the experimental setup in detail and summarizes the findings. Additionally, the outcomes of the studies and the selection of various attributes are well explained in this part. We put the suggested technique to the test using 3000 CT scans from 71 patients. The next paragraphs provide a summary of some issues raised by the tests.

- An Intel I-7 with 16 GB of RAM was used for our studies. We made use of an 840 graphics card and an NVIDIA graphical processing unit. TensorFlow and Keras were used for all of our tests. Convolutional and maximum pooling layers were employed. Tables 4 and 5 as well as Figure 4 provide an overview of these layers' specifics.

- We used the Precision (PR), Recall (RC), F1 measure (FM), and Accuracy (AC) metrics to assess our suggested model. The FM is widely used to assess how well a strategy performs in classification situations. The weighted mean of the terms PR and RC is provided by the FM. A classifier's capacity to classify every image in a dataset is gauged using AC. The classifier performs well when the AC value is high, and poorly when the value is low. A machine learning model's entire performance is reported by a single statistic called AC. Mathematically• In the proposed work, we carried out 5-fold and 10-fold validation studies. The 10-fold cross-validation studies yielded noticeably better results; hence, only the 10-fold cross-validation experiments' results are presented in this study. Tables 6 and 7 display the findings of the 10-fold cross-validation experiments. Tables 6 and 7 are the only ones that provide a summary of the F1 measure and Accuracy results.

- We found that the feature selected and its accompanying parameter choices were quite important. We experimented with several combinations and found that the best and worst outcomes differed significantly. Tables 4 and 5 make it evident that the LibSVM classifier produced superior results. It is evident from both tables that LibSVM in version 1 performed better in terms of the F1 measure and Accuracy. Version 1 of LibSVM employed a radial basis function kernel with a fixed gamma value of 1.25 and a 1.5 value for c.

- In the part on the suggested method, we went over numerous feature-ranking techniques based on statistical knowledge and similarity, and we explained them. The information gain, gain ratio, and relief algorithm were some of these ranking techniques. It should be observed that by utilizing the ranking criteria, these algorithms yield the same feature set. We conducted two different types of tests. We conducted trials using the feature-ranking technique covered in the methodology section after using the 37-point extracted feature vector as a starting point. Instead of employing texture characteristics directly, we saw superior results using the feature-ranking approach.

- Various classifiers were used to categorize liver pictures. The major goal was to determine which of the five classes a feature vector Z, which had an unknown label, belonged to. We created two feature vectors to test each classifier's performance. All 37 features that were extracted during the feature extraction stage were included in the feature vector F1. The highest-ranked features, chosen using similarity statistics and a knowledge-based ranking system, made up the second feature vector, or F2. Entropy, skewness, radial sum, information measure with correlation 1 and 2, and angular sum were some of these characteristics.

## VIII. Conclusion

These methods have shown the differences between the textural patterns of healthy and diseased livers. These findings proved that there is heterogeneity in liver texture between diseases and even between mild and severe cases within a single condition. These techniques are simpler to use and manage. We cannot claim that a particular approach is flawless. The analysis can change depending on the ailment. However, when differentiating between various tissue textures, the combination of various approaches can offer encouraging results. Future studies should make use of many forms of analytical software to standardize and corroborate clinical results. For the creation of reliable diagnostic reports and the application of these strategies, appropriate training is required. We were able to demonstrate that texture analysis of CT images is a practically independent method that may aid in differentiating between normal and pathological liver stages. This research demonstrates that irregularities that manifest in the human liver can be

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