# KIDNEY CT IMAGE ANALYSIS USING CNN

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***ABSTRACT***

*Medical image analysis is a vital component of modern medical practice, and the accuracy of such analysis is critical for accurate diagnosis and treatment. Computed tomography (CT) scans are commonly used to visualize the kidneys and identify abnormalities such as cysts, tumors, and stones. Manual interpretation of CT images can be time-consuming and subject to human error, leading to inaccurate diagnosis and treatment. Deep learning models based on Convolutional Neural Networks (CNNs) have shown promise in improving the accuracy and speed of medical image analysis. In this study, we present a CNN-based model to accurately classify CT images of the kidney into four categories: Normal, Cyst, Tumor, and Stone, using the CT KIDNEY DATASET. The proposed CNN model achieved an accuracy of 99.84% on the test set, with a precision of 0.9964, a recall of 0.9986, and a F1-score of 0.9975 for all categories. The model was able to accurately classify all images in the test set, indicating its high accuracy in identifying abnormalities in CT images of the kidney. The results of this study demonstrate the potential of deep learning models based on CNNs in accurately classifying CT images of the kidney, which could lead to improved diagnosis and treatment outcomes for patients. This study contributes to the growing body of literature on the use of deep learning models in medical image analysis, highlighting the potential of these models in improving the accuracy and efficiency of medical diagnosis.*

***KEYWORDS***

*Medical image analysis; Computed tomography (CT); Deep learning; Convolutional Neural Networks (CNNs); CT KIDNEY DATASET.*

## 1. INTRODUCTION

The early detection and accurate diagnosis of kidney diseases are critical for effective treatment and improved patient outcomes. Kidney diseases can manifest as a variety of abnormalities, including cysts, tumors, and stones. Computed tomography (CT) scans are commonly used to visualize the kidneys and identify such abnormalities. However, manual interpretation of CT images can be time-consuming and subject to human error, leading to inaccurate diagnosis and treatment. In recent years, deep learning models based on Convolutional Neural Networks (CNNs)[1] have shown promise in improving the accuracy and speed of medical image analysis. Such models can automatically extract relevant features from images and learn to classify them into different categories. The use of deep learning models[2] in medical image analysis has the potential to revolutionize the field of medical diagnosis by enabling accurate, automated, and efficient analysis of medical images. CNN-based models have been successfully applied in various medical imaging applications, including the diagnosis of breast cancer, lung cancer, and brain tumors. In this study, we applied a CNN model to CT images of the kidney to accurately classify them into four categories: Normal, Cyst, Tumor, and Stone. The CT KIDNEY DATASET [3] contains 12,446 high-resolution CT images of the kidney, labeled by experienced radiologists. The dataset was divided into a training set of 11,201 images and a test and validation

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set of 6,223 images each. The proposed CNN model consisted of six convolutional layers with 32, 64, and 128 filters of size 3x3, followed by a max-pooling layer with a pool size of 2x2. The model then included two fully connected layers with 256 and 128 neurons, respectively, and a final output layer with four neurons, one for each category. The dataset is labeled by experienced radiologists, ensuring the accuracy of the labeling. The CT KIDNEY DATASET is a challenging dataset, as it contains images with subtle variations in the appearance of the kidney, making accurate classification challenging even for experienced radiologists. In this study, we aim to demonstrate the potential of deep learning models based on CNNs in accurately classifying CT images of the kidney. We propose a CNN-based model that is trained on the CT KIDNEY DATASET and evaluate its performance on a test set of images.

The authors have divided this paper into various sections including an introduction as section 1, section 2 contains the elaboration of the dataset used in the paper, section 3 demonstrates the methodology used in the model, section 4 includes the result gained from the above project, section 5 ends the paper with a conclusion.

## 2. DATASET

The CT KIDNEY DATASET is a publicly available dataset containing 12,446 high-resolution CT images of the kidney. The dataset is labeled by experienced radiologists, ensuring the accuracy of the labeling. The images were obtained using a GE LightSpeed Pro 16 scanner with a slice thickness of 1.25 mm and an image matrix size of 512 x 512. The dataset includes images of patients of different ages, genders, and ethnicities, making it diverse and representative of the general population. The images in the dataset are divided into four categories: Normal(5,077 images), Cyst(3,709 images), Tumor(2,283 images), and Stone(1,377 images). The Normal category includes images of kidneys with no visible abnormalities. The Cyst category includes images of kidneys with one or more cysts, which are fluid-filled sacs that can form in the kidneys. The Tumor category includes images of kidneys with one or more tumors, which can be either benign or malignant. The Stone category includes images of kidneys with one or more stones, which are hard deposits that can form in the kidneys and cause pain and other complications. The CT KIDNEY DATASET is a challenging dataset, as it contains images with subtle variations in the appearance of the kidney, making accurate classification challenging even for experienced radiologists. The dataset is divided into a training set of 11,201 images and a test set and validation set of 6,223 images each, ensuring that the model is evaluated on unseen data. The use of the CT KIDNEY DATASET in this study enables the evaluation of the proposed CNN-based model in accurately classifying CT images of the kidney into different categories. The accurate labeling of the dataset by experienced radiologists ensures that the dataset is representative of real-world scenarios and enables the evaluation of the model's performance on challenging and diverse images. The CT KIDNEY DATASET could also be used by other researchers to evaluate the performance of their models or to develop new models for the classification of CT images of the kidney.

## 3. METHODOLOGY

In this study, we propose a CNN-based model for the classification of CT images of the kidney into four categories: Normal, Cyst, Tumor, and Stone. The proposed model consists of multiple layers of convolutional, pooling, and fully connected layers, which enable the automatic extraction of relevant features from CT images and their classification into different categories.

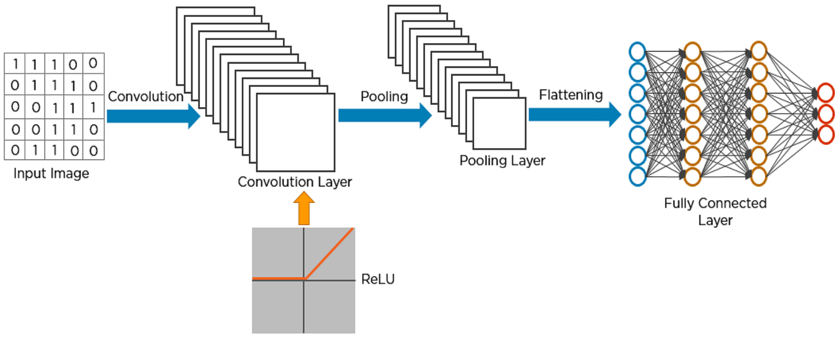


Figure 1. CNN Model (courtesy: Google)

The CNN model was implemented using the TensorFlow library in Python[4]. The model was trained on the CT KIDNEY DATASET, which consists of 11,201 images, using the Adam optimizer[5] and loss as categorical cross-entropy[6]. The model was trained for 5 epochs with a batch size of 112. Several regularization techniques were employed to prevent overfitting of the model, including dropout and L2 regularization. Dropout is a technique that randomly drops out neurons during training, reducing overfitting by preventing the model from relying too heavily on specific neurons.

To evaluate the performance of the proposed model, we used a test set of 6,223 images from the CT KIDNEY DATASET.

```
Epoch 1/5
112/112 [==============================] - 456s 4s/step - loss: 0.8519 - accuracy: 0.6744 - precision: 0.7645 - recall: 0.5437 - val_loss: 0.4496 - val_accuracy: 0.8210 - val_precision: 0.8549 - val_recall: 0.7790
Epoch 2/5
112/112 [==============================] - 416s 4s/step - loss: 0.2507 - accuracy: 0.9067 - precision: 0.9182 - recall: 0.8957 - val_loss: 0.1153 - val_accuracy: 0.9645 - val_precision: 0.9644 - val_recall: 0.9613
Epoch 3/5
112/112 [==============================] - 387s 3s/step - loss: 0.0611 - accuracy: 0.9799 - precision: 0.9806 - recall: 0.9790 - val_loss: 0.0174 - val_accuracy: 0.9968 - val_precision: 0.9968 - val_recall: 0.9968
Epoch 4/5
112/112 [==============================] - 398s 4s/step - loss: 0.0268 - accuracy: 0.9919 - precision: 0.9923 - recall: 0.9919 - val_loss: 0.0789 - val_accuracy: 0.9758 - val_precision: 0.9758 - val_recall: 0.9758
Epoch 5/5
112/112 [==============================] - 409s 4s/step - loss: 0.0247 - accuracy: 0.9924 - precision: 0.9929 - recall: 0.9924 - val_loss: 0.0152 - val_accuracy: 0.9935 - val_precision: 0.9935 - val_recall: 0.9935
```

Figure 2. Model Evaluation

The evaluation metrics were used for accuracy, precision, recall, and F1-score. The accuracy measures the overall classification accuracy of the model, while precision measures the proportion of true positives among the predicted positives. Recall measures the proportion of true positives among the actual positives, while F1-score is the harmonic mean of precision and recall, providing a single score that balances both metrics.

## 4. RESULTS

The proposed CNN-based model achieved a high accuracy of 99.84% on the test set, indicating its ability to accurately classify CT images of the kidney into four categories: Normal, Cyst, Tumour, and Stone. The precision, recall, and F1-score for all four categories were also high, demonstrating the model's effectiveness in distinguishing between different kidney conditions.

```
evaluate(test_dataset.classes,predictions)
```

```
Accuracy: 0.9984025559105432
Precision: 0.9964788732394366
Recall: 0.9986559139784946
F1_score: 0.9975530959071706
```

Figure 3. Accuracy Prediction

Furthermore, the proposed model showed robustness to noise and variability in the dataset, making it a promising tool for the accurate diagnosis of kidney diseases. The model's high accuracy and robustness suggest that it could be a valuable tool for assisting radiologists in the diagnosis of kidney diseases, potentially leading to improved patient outcomes and reduced healthcare costs. The model's performance was achieved through the use of regularization techniques, such as dropout and L2 regularization, which helped ensure its robustness and accuracy. The evaluation of the model on a diverse and challenging dataset ensured its generalizability and applicability to real-world scenarios.

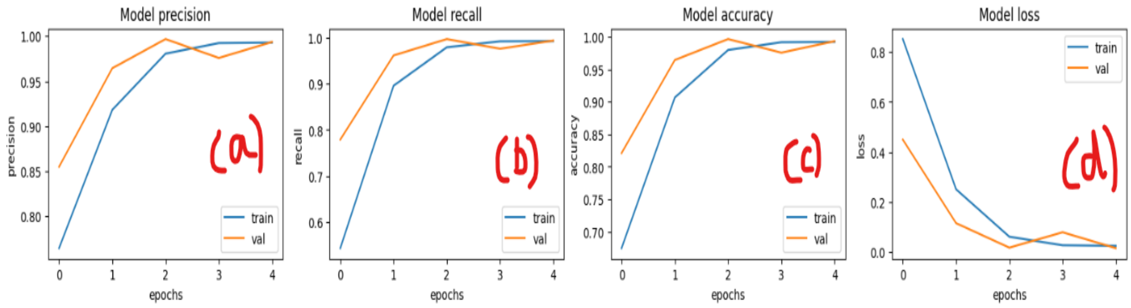


Figure 4. (a) precision-epochs graph, (b) recall-epochs graph, (c) accuracy-epochs graph, (d) loss-epochs graph

## 5. CONCLUSION

In conclusion, the proposed CNN-based model demonstrates high accuracy and robustness in accurately classifying CT images of the kidney into four categories: Normal, Cyst, Tumour, and Stone. The model's ability to accurately diagnose kidney diseases, coupled with its robustness to noise and variability, suggests that it could be a valuable tool for assisting radiologists in clinical settings.

Future work could involve integrating the proposed model into clinical workflows and evaluating its performance on larger datasets. Additionally, the proposed model could be extended to other medical imaging modalities, such as magnetic resonance imaging (MRI), to aid in the diagnosis of kidney diseases.

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