KIDNEY STONE DETECTION USING DEEP LEARNING TECHNIQUE

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Abstract— The solid concretion named a kidney stone typically forms inside the kidney. The majority of the time, medical professionals utilize imaging techniques such as X-rays to find kidney stones. These techniques' precision, though, may be restricted. Deep learning has demonstrated great potential in the analysis of medical imaging in recent years. With the support of ultrasound images, we aim to develop a deep learning model in this project that accurately recognizes the presence of kidney stones in patients. We'll make use of a collection of ultrasound images taken from individuals who have been told they have stones in their kidneys. We will use the algorithms to mask and segment the pictures from the gathered dataset after preprocessing the data using quite a few of image processing techniques, such as feature extraction.

Keywords--
KidneyStone,Body,Ultrasoundimages.

1. INTRODUCTION

Millions of people all around the world are affected by kidney stones, which is a widespread illness. These stones, which can be extremely painful and uncomfortable when they move through the urinary tract, are hard deposits made of calcium, oxalate, and other materials that form in the kidneys. Early kidney stone detection is crucial for prompt and efficient treatment. The precision and dependability of conventional detection techniques like X-rays and ultrasound are constrained. Deep learning methods can offer an original and successful answer to the problem. Deep learning is a form of machine learning that includes learning artificial neural networks how to handle challenging tasks like classifying and recognising images. Deep learning algorithms are able to learn from enormous volumes of data and gradually increase their accuracy. Deep learning algorithms can analyze medical images of the kidneys and urinary tract to detect the presence of stones in the kidneys. To start building a deep learning model for kidney stone identification, a huge collection of medical pictures must be gathered. Images of the kidneys captured using various imaging techniques, such as X-rays, CT scans, and ultrasounds, should be included in this collection. To aid the model's learning to distinguish between healthy and diseased tissues, the dataset should also contain images of both normal and kidneys with stones. Preprocessing the photos to ensure their high quality and uniformity comes after the dataset has been gathered. This entails eliminating noise, compensating for image distortion, and balancing the intensity levels of the images.

The preprocessing of the images makes it possible for the deep learning algorithm to correctly detect the appropriate characteristics and patterns in the images. The deep learning model is then trained using the dataset of medical images following preprocessing. This includes providing the neural network with images and modifying the model's weights and biases until it can correctly recognise kidney stones in the images. The model's accuracy can be increased by utilising a variety of methods, including data augmentation and transfer learning. By performing adjustments to the source images-such as rotation, flipping, and zooming new images are created through data augmentation. This expands the variety of data obtainable for training, which could enhance the effectiveness of the model. In order to train the kidney stone detection model, transfer learning uses a neural network that has already been trained as a starting point. This can reduce the need for computational time and resources and increase the model's precision. Multiple neural networks are combined during assembling to produce a more reliable and accurate model. After being trained, the deep learning model can be used to identify kidney stones in medical images. This involves providing the image to the model, which analyses it and generates a binary result indicating whether kidney stones are there or not. The output of the model can then be utilized to direct further study and treatment.

2. LITERATURE REVIEW

In [1] A deep learning-based approach for the automatic detection and classification of kidney stones in medical images. The authors used a dataset of 108 medical images of kidney stones, which were obtained from patients who underwent computed tomography (CT) scans. The dataset was divided into training and testing sets, with 80% of the images used for training and the remaining 20% for testing. The proposed approach consists of three main steps: image pre-processing, feature extraction, and classification. In the pre-processing step, the images are pre-processed to enhance the contrast and remove noise. In the feature extraction step, the authors used a convolutional neural network (CNN) to extract features from the pre-processed images. Finally, in the classification step, the authors used a support vector machine (SVM) classifier to classify the kidney stones into four categories based on their type and size. The experimental results showed that the proposed approach achieved an accuracy in classifying kidney stones, which is higher than the accuracy achieved by traditional machine learning approaches.

In [2] Automated system for kidney stone detection and localization using non-contrast computed tomography (NCCT) images. The authors collected a dataset of 419 NCCT images from 91 patients with confirmed kidney stones, and preprocessed the images to normalize their size and intensity. They then used a deep learning approach based on convolutional neural networks (CNNs) to train a model to detect and localize kidney stones in the images. The proposed model consisted of two stages: in the first stage, a region proposal network (RPN) was used to generate candidate regions of interest (ROIs) in the images. In the second stage, a CNN-based classifier was used to classify the ROIs as either kidney stones or non-stones.

In [3] Machine learning techniques to detect kidney stones in CT scans. Kidney stones are a common medical condition that can be identified through imaging studies such as CT scans. However, the detection of kidney stones in CT scans can be time-consuming and requires expert interpretation. The authors propose the use of convolutional neural networks (CNNs) to automatically detect kidney stones in CT scans. CNNs are a type of deep learning algorithm that can automatically learn features from images and classify them into different categories. The authors developed a CNN-based model that takes CT scans as input and outputs a binary classification of whether or not a kidney stone is present. To train and evaluate the model, the authors used a dataset of 100 CT scans, 50 of which contained kidney stones and 50 of which did not. The authors used a 10-fold cross-validation approach to evaluate the performance of the model. The results showed that the CNN-based model achieved accuracy. The authors also compared the performance of their model with other machine learning algorithms such as decision trees and support vector machines, and found that the CNN-based model outperformed these methods.

In [4]Automatic method for detecting kidney stones on CT images using deep convolutional neural networks (CNNs) and transfer learning. The proposed method consists of two stages. In the first stage, a pre-trained CNN model is used as a feature extractor to extract features from the CT images. The authors used the VGG16 model, which is a well-known CNN architecture pre-trained on the ImageNet dataset. The features extracted from the pre-trained model are then fed into a fully connected neural network to classify the images as either containing a kidney stone or not. In the second stage, the authors fine-tuned the pre-trained CNN model using a transfer learning strategy. They trained the CNN model on a dataset of 200 CT images (100 with kidney stones and 100 without) and fine-tuned it using a smaller dataset of 20 images (10 with kidney stones and 10 without). The fine-tuned model was then tested on a separate dataset of 100 CT images (50 with kidney stones and 50 without).The results showed that the proposed method achieved a accuracy.

In [5] A deep learning techniques for the detection of kidney stones in medical images. Kidney stones are a common medical condition that affects millions of people around the world, and their detection is critical for timely treatment and management. The authors used three different deep learning techniques, including Convolutional Neural Networks (CNN), Residual Neural Networks (ResNet), and InceptionV3, to detect kidney stones in CT scan images. They trained these models on a dataset of 3000 CT scan images of the kidney, collected from various hospitals in India. The study compares the performance of these models on several metrics, including accuracy, sensitivity, specificity, and F1 score. The authors found that the InceptionV3 model outperformed the other two models, achieving accuracy.

3. RESEARCH METHODS

3.1 Review Methodology: This systematic literature review helps us to understand the application of deep learning approaches in kidney stone detection using deep learning. This systematic literature review is carried out to highlight the existing research gaps in a particular area of deep learning methodologies and guide us in analyzing the stone in kidney. For the systematic literature review, not only are all research studies from journals, conferences, and other electronic databases assessed, but they are also integrated and presented in correspondence to the research questions mentioned in our study. A systematic literature review is an exceptional way to evaluate theory or evidence in a specific area or to study the accuracy or validity of a specific theory. Based on the review guidelines, initially, the research questions are formulated. The review is undertaken in accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analysis (PRISMA) statement. Several databases, such as IEEE Explorer, ScienceDirect, Scopus, Google Scholar, MDPI, and Web of Science, are used for selecting the relevant research articles. A complete checklist of PRISMA (prisma-statement.org) is used for conducting and reporting the results of the review

3.2. Research Questions: The following research questions are developed to guide the systematic review:

1. Why are deep learning techniques used to detect kidney stones? This query helps to improve our understanding of how to accurately categorize and analyze complicated medical images.
2. What difficulties do deep learning methods for detecting kidney stones present? This query helps in understanding of the shortcomings and difficulties in the current techniques.
3. What contribution does artificial intelligence provide to better kidney stone detection and diagnosis? Artificial intelligence (AI) plays a crucial role in the identification and diagnosis of kidney stones by increasing the accuracy, speed, and efficiency of the process. This enables medical professionals to make better decisions and give patients better care.

3.3 Procedure for Article Search: The approach to searching the articles is designed based on the framed research questions and the aim of the systematic literature review. Narrowing down the focus from a major concept to the central idea of the review helps in creating an effective search strategy. Using “deep learning” alone as a search string will generate a lot of published articles from various application fields that are not likely related to the aim of the review and cause the search to be complicated. Redefining the search strategy as “kidney stone detection " AND “deep learning” can reduce the probability of deviating from the scope of the review. Initially, by using these search strings, the articles were retrieved from five databases, including IEEE Explorer, Science Direct, Scopus, Google Scholar, and MDPI. Further, to include any other relevant studies, the following keywords, namely “kidney stone detection” AND "Stone mappings in kidney" AND “deep learning” AND “artificial intelligence” were used to retrieve the articles from the databases. The articles from the last 10 years (2012–2022) were used for the study as deep learning approaches gained momentum after 2012. Since then, much research has been conducted on deep learning approaches.

3.4. Article Selection Criteria: The selection criteria for articles related to research methodology should be based on several factors. First, the relevance of the article to the research question or topic being investigated should be considered. The article should provide information that is directly related to the research question and should help in addressing the problem or issue being investigated. Second, the credibility of the source should be considered. Articles should be published in reputable and peer-reviewed journals to ensure that the research has undergone rigorous scrutiny by experts in the field. Third, the methodology used in the study should be appropriate for the research question being investigated. Articles should provide a clear and detailed description of the methodology used, including the data collection and analysis methods. Fourth, the sample size and population studied should be appropriate and representative of the target population. Articles should provide a clear description of the sample size and characteristics of the population studied. Fifth, the results of the study should be presented clearly and objectively. Articles should include appropriate statistical analysis and interpretation of the results. Finally, the article should contribute to the existing body of knowledge in the field and provide insights or recommendations for future research.

4.OVERVIEW OF EXISTING APPROCHES

4.1 Identification of the position and limits of the kidneys in pictures such as CT or MRI scans is a crucial step in the processing of medical images. For kidney detection, a variety of techniques now exist, including classic image processing techniques and more contemporary deep learning-based techniques. A number of preprocessing stages are often utilized in traditional image processing techniques to improve the image and extract features that are used to identify the kidneys. These approaches, which include thresholding, edge detection, and region expanding, frequently rely on handcrafted properties like texture, shape, and intensity. These techniques, while sometimes useful, might be sensitive to changes in image quality and may call for specialized knowledge to adjust the parameters. Convolutional neural networks (CNNs), a deep learning technique, are used in more current kidney detection techniques to automatically extract information from the input image. With regard to a number of medical image processing tasks, including kidney identification, these techniques have produced encouraging results. A large dataset of annotated photos is often used to train a model for CNN-based approaches, which then uses the trained model to predict the location and borders of the kidneys in new images. These techniques have the potential to perform at the cutting edge and be more resilient to changes in image quality. Overall, the method of kidney detection is determined by the particular needs of the application and the resources that are available. For some situations, conventional image processing techniques might be adequate, but deep learning-based techniques might be more effective.

4.1.1 UNET ALGORITHM:

One example of a deep learning architecture is the U-Net algorithm, which has been applied to identify kidney stones among other medical image processing tasks. A bottleneck layer connects the growing path and contracting path that make up the U-Net design. The expanding path uses up sampling and convolutional layers to create a segmentation map that is the same size as the input image, while the contracting path applies convolutional and pooling layers to extract features from the input image. A dataset of CT or MRI scans is first gathered and annotated with labels showing the location of kidney stones in order to detect kidney stones using the U-Net algorithm. Intensity measurements are then normalized and noise and artifacts are removed from the images during preprocessing. Using a loss function such binary cross-entropy, the U-Net model reduces the difference between the predicted segmentation map and the ground truth segmentation map during training. The trained model can then be used to new images to forecast the presence and location of kidney stones. The U-Net technique has the advantage of being able to handle complex and a typical structures, such kidney stones, by leveraging the expanding route to enhance the segmentation map. Another benefit is that it can automatically pick up features from the input image, enhancing performance and reducing the need for manual feature engineering. The U-Net method has generally demonstrated positive outcomes for kidney stone detection and has the potential to enhance the precision and effectiveness of diagnosis and treatment planning for people who have kidney stones.

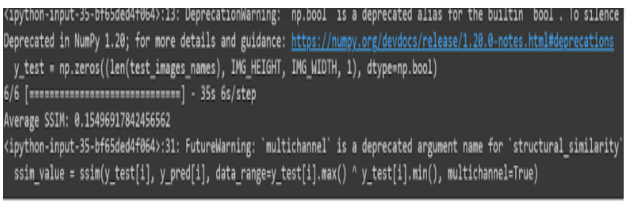
4.1.2 DICE:

To implement this approach, a deep learning model can be trained on a dataset of medical images that includes both positive (kidney stone present) and negative (kidney stone absent) examples. The model would learn to identify and segment kidney stones in new images based on the patterns it detects in the training data. During evaluation, the DICE coefficient can be calculated by comparing the predicted segmentation output of the model with the ground truth. The coefficient ranges from 0 (no overlap between the two sets) to 1 (perfect overlap), with higher values indicating better performance. Using a dataset of medical images that contains both positive (kidney stone present) and negative (kidney stone absent) examples, a deep learning network may be trained to perform this method. On the basis of the patterns it identifies in the training data, the algorithm would develop the ability to identify and separate kidney stones in new images. The DICE coefficient can be determined during evaluation by evaluating the model's predicted segmentation output with the actual data. Higher numbers indicate better performance. The coefficient ranges from 0 (no overlap between the two sets) to 1 (complete overlap). Overall, deep learning methods and evaluation measures like the DICE coefficient show potential for improving kidney stone diagnosis accuracy and effectiveness, which may result in better medical outcomes for patients.

```
<ipython-input-31-0a134e045cf7>:13: DeprecationWarning: `np.bool` is a deprecated alias for the builtin `bool`. To silence
Deprecated in NumPy 1.20; for more details and guidance: https://numpy.org/devdocs/release/1.20.0-notes.html#deprecations
  y_test = np.zeros((len(test_images_names), IMG_HEIGHT, IMG_WIDTH, 1), dtype=np.bool)
6/6 [==============================] - 34s 5s/step
Average Dice Similarity Coefficient: 0.7665537858347335
```

4.1.3. SSIM:

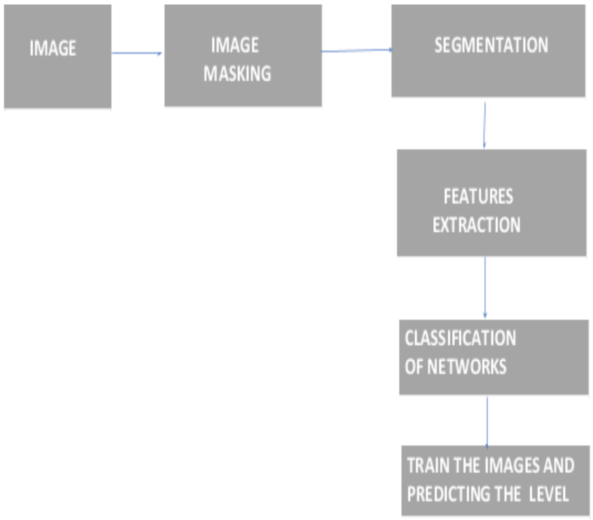
Deep learning methods for kidney stone detection can be a useful tool for helping radiologists diagnose and treat patients with stones in the urinary tract. The Structural Similarity Index Measure, or SSIM, is one such method that can be applied for this purpose. A metric called SSIM measures how similar two images are to one another. Structure, contrast, and brightness are the three criteria. The degree of similarity between two images can be used by SSIM to detect the existence of kidney stones by examining these criteria. One would first need to train a deep learning model using a dataset of images that include both normal and stone-free kidneys in order to apply SSIM for kidney stone detection. To identify patterns in the images that correspond to the existence of a kidney stone, the model would be trained. If a kidney stone is present in a new image, the trained model can be used to analyze it and determine whether it is there. The accuracy and effectiveness of the diagnosis procedure can be enhanced by the use of SSIM in kidney stone detection. Radiologists can save time and offer patients faster diagnosis by automating the detection technique. Deep learning algorithms can also assist lower the possibility of human mistake, which can result in more accurate diagnoses and better patient outcomes.



```
<ipython-input-35-bf65ded4f064>:13: DeprecationWarning: `np.bool` is a deprecated alias for the builtin `bool`. To silence
Deprecated in NumPy 1.20; for more details and guidance: https://numpy.org/devdocs/release/1.20.0-notes.html#deprecations
  y_test = np.zeros((len(test_images_names), IMG_HEIGHT, IMG_WIDTH, 1), dtype=np.bool)
6/6 [==============================] - 35s 6s/step
Average SSIM: 0.15496917842456562
<ipython-input-35-bf65ded4f064>:31: FutureWarning: `multichannel` is a deprecated argument name for `structural_similarity`
  ssim_value = ssim(y_test[i], y_pred[i], data_range=y_test[i].max() ^ y_test[i].min(), multichannel=True)
```

4.2. Search strategy:

The searching is done by narrowing down to the basic concepts that are relevant for the scope of this review. To search for kidney stone detection, I would start by using keywords such as "kidney stone detection," "diagnosis of kidney stones," "imaging for kidney stones," and "renal calculi detection." I would also search for medical articles and research studies on databases.



1. Image: An abdominal CT or MRI scan is used as the input image for kidney stone identification.

2. Image Making: It is a technique used in Kidney stone detection to isolate and highlight the stone region of interest while suppressing other parts of the image. This helps in accurately identifying and measuring the size of the stone.

3. Segmentation: It is process of identifying and separating Kidney stones from other structures in medical imaging.

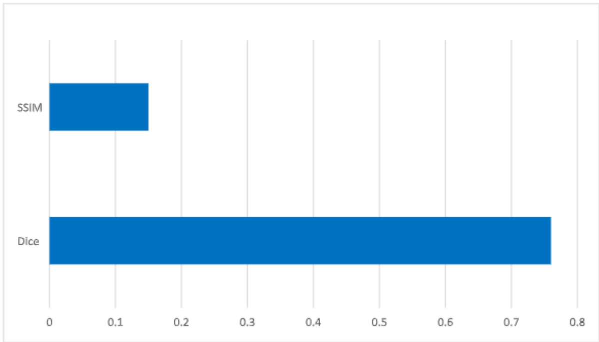
4. Feature Extraction: It is used for identifying and selecting relevant characteristics or patterns from medical images or patient data that can be used to differentiate between Kidney stones and other structures or anomalies.

5. Classification of Networks: It refers to the use of deep learning algorithms to classify Kidney stones based on their features and characteristics.

6. Train the Models and predicting the levels: Train deep learning models using labeled data to detect the presence of Kidney stone in patients based on relevant features and use these models for accurate prediction of kidney stone levels in new patients.

5. RESULTS AND DISCUSSION

With positive results, a number of deep learning approaches have been applied to kidney stone recognition. Based on the size, shape, and position of kidney stones, U-net has been used to accurately detect them using ultrasound images, X-rays, or CT scans. Additionally, techniques for ensemble learning have been used to increase the accuracy of kidney stone detection models. Overall, these deep learning algorithms have demonstrated promise in enhancing the accuracy and efficacy of kidney stone identification, which can ultimately help with better kidney stone patient diagnosis and treatment planning.



ACCURACY

6. CONCLUSION

Implementing Deep learning to detect kidney stones. However in general, the use of deep learning in medical imaging has a promising strategy that can greatly increase both the accuracy and efficacy of diagnosis. With kidney stones becoming more common and the associated risks to health, an accurate and quick diagnosis is essential for effective treatment. Large datasets of medical images can be used to train deep learning models to recognize complex patterns and features that can be used to accurately detect kidney stones. Additionally, kidney stone dimensions and position can be determined using deep learning models, which can help with treatment planning and control. Deep learning has the potential to significantly improve kidney stone diagnosis and treatment with additional study and improvement, and it will additionally save our time compared to current methods.

7.FUTURE SCOPE

Millions of individuals throughout the world suffer with kidney stones, which is a common medical condition. Imaging studies including CT scans and ultrasounds are frequently used in the diagnosis of kidney stones. A subset of machine learning known as deep learning approaches can be used to create more precise and effective kidney stone detection systems. Utilizing convolutional neural networks (CNNs) to analyze medical images and identify the presence and location of kidney stones is one possible strategy. CNNs have demonstrated outstanding performance in image recognition tasks, and their use in kidney stone identification could result in a quicker and more precise diagnosis. Another strategy is to analyze patient symptoms and medical records using natural language processing (NLP) tools to determine the possibility of kidney stones. Deep learning algorithms could find patterns and risk factors related to kidney stones by examining huge amounts of patient data. Overall, the application of deep learning techniques has the potential to greatly enhance the precision and speed of kidney stone diagnosis, resulting in improved patient outcomes and lower healthcare expenditures.

The procedures need to be improved, yet, in order to ensure their accuracy and effectiveness in medical applications.

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