JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue

JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)

An International Scholarly Open Access, Peer-reviewed, Refereed Journal

# AUTOMATED SYSTEM FOR KIDNEY STONE DETECTION USING DEEP LEARNING MODELS

**[1] Lalitha Bhagya Prathyusha K, [2]Pavithra K, [3]Harshitha Reddy B, [4]Ashida Sk,[5] Kiran Lal V, [6]Sahithi P**

[1]UGScholar, [2]UGScholar, [3]UGScholar, [4]UGScholar, [5]Assistant Professor, [6]Assistant Professor

[1 23456]Department of Electronics and Communication Engineering (ECE),

[123456]Narayana Engineering College, Nellore, India

***Abstract:*** Kidney stone problem (nephrolithiasis) is a common type of urological disease with a high recurrence rate. This disease is a progressive disease that damage the kidneys leading to be permanent and undone problem. Therefore, it is vital to identify kidney stone disease before the permanent damage is done. If the stone problem is caught in the early stage, kidney disease can be treated very effectively. So, stone diagnosis is vital not only for treatment of kidney disease but also in management of recurrent stone formation. Hence early detection of kidney stone is essential Ultrasound imaging is one of the available imaging techniques used for diagnosis of kidney abnormalities, which may be like change in shape and position and swelling of limb. During surgical processes it is vital to recognize the true and precise location of kidney stone. The detection of kidney stones using ultrasound imaging is a highly challenging task as they are of low contrast and contain speckle noise. This challenge is overcome by employing suitable image processing techniques. The ultrasound image is first preprocessed to get rid of speckle noise using the image restoration process. The restored image is smoothened using Gabor filter and the subsequent image is enhanced by histogram equalization. The preprocessed image is achieved with level set segmentation to detect the stone region. Segmentation process is employed twice for getting better results; first to segment kidney portion and then to segment the stone portion, respectively. The results are analyzed using MLP-BP ANN algorithms for classification and its type of stone.

***Keywords*- Ultrasound image, Image processing, Image segmentation, Artificial neural networks**

## I. INTRODUCTION

Due to lifestyle changes, primarily due to modern food habits, people suffer from new lifestyle and life-threatening diseases. One such lifestyle disease common nowadays is the formation of stones in the kidney. Kidney stones are formed due to the undiluted solution that is not diluted out from the human body. The study of medical image analysis has undergone a revolution in recent years thanks to the development of deep learning algorithms. A subset of artificial intelligence (AI) called deep learning has achieved outstanding results in a number of medical applications, including the segmentation, classification, and illness detection of images. Deep learning algorithms are ideally suited for challenging medical image processing jobs because they can automatically learn sophisticated patterns and characteristics from large-scale datasets. This paper proposes a novel deep learning-based strategy to tackle the difficulties associated with kidney stone identification. We want to create an autonomous kidney stone detection system that can precisely recognize and classify kidney stones in 3 medical imaging data by utilizing the capability of convolutional neural networks (CNNs).

## II. RELATED WORK

Several works have been proposed for kidney stone detection using various imaging techniques. Here the system is proposed using Deep learning concept.

i) **Deep Learning:** Deep learning has made significant breakthroughs in computer vision, with applications ranging from image classification and object detection to image segmentation and generative modeling. In natural language processing, deep learning has enabled the development of advanced models for tasks such as language translation, sentiment analysis, and text generation.

ii) **Deep Learning in kidney stone detection:** Deep learning has emerged as a transformative technology in kidney stone detection, particularly in the realm of medical imaging. By harnessing the power of deep neural networks, healthcare professionals can now analyze various imaging modalities, including ultrasound, CT scans, and X-rays, with unprecedented accuracy and efficiency. These models are trained to recognize intricate patterns and features indicative of kidney stones, enabling them to swiftly identify, localize, and classify stones within the urinary tract. Deep earning models involves various steps begin by gathering and annotating a large dataset of medical images, such as CT scans. Normalize, resize, and augment these images to ensure consistency and diversity. Design an ANN with multiple layers suitable for image analysis, or adapt existing simple neural network structures for the task. Split the data into training, validation, and test sets. Train the model using appropriate loss functions and optimizers, and

finetune hyperparameters for optimal performance. Kidney image information base comprises of almost US (ultra sound) kidney images gathered from various people of different emergency clinics. The preprocessing of ultrasound image, involves

(1) Image restoration

(2) Smoothing and sharpening

(3) Contrast enhancement

It also comprises of

1. Watershed Algorithm
2. Lifting Schemes wavelet Processing
3. ANN classification.

## III. PROPOSED METHODOLOGY

In this work, the classification of normal and kidney stone images is done automatically using deep learning models and identified the areas of interest. In our proposed work, the Computed Tomography (CT) scan is fed to the model and gives the desired classification output. The block diagram of the proposed methodology is given in Fig 1 and the process flow is described in detail.

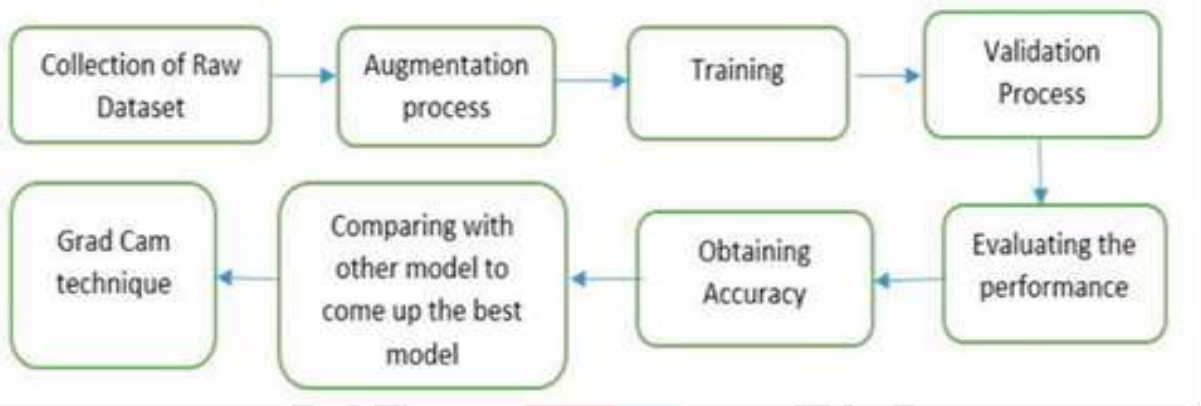


Fig 1. Block Diagram of Proposed Methodology

i) **Collection of Raw Dataset:** This is the initial step where you gather the raw data needed for your machine learning project. It involves identifying sources, acquiring data, and ensuring that the dataset is relevant and representative of the problem you're trying to solve.

ii) **Augmentation Process:** In this step, you enhance the dataset by applying various augmentation techniques. Augmentation helps in increasing the diversity of the dataset, which can improve the model's generalization ability and robustness. Common augmentation techniques include flipping, rotating, cropping, scaling, and adding noise to the images or data.

iii) **Training :**This is where you feed the augmented dataset into your machine learning model to train it. During training, the model learns to map input data to the correct output labels by adjusting its internal parameters through optimization algorithms like gradient descent. The goal is to minimize the difference between the predicted outputs and the actual targets.

iv) **Validation Process :**During training, it's important to monitor the performance of the model on data that it hasn't seen before, which is where validation comes in. A portion of the dataset (usually separate from the training set) is set aside for validation. The model's performance is evaluated on this validation set at regular intervals during training to prevent overfitting and to tune hyperparameters.

v) **Evaluating the Performance:** Once training is complete, the model's performance needs to be evaluated on a separate test dataset. This block involves using the trained model to make predictions on the test dataset and then evaluating its performance using various metrics such as accuracy, precision, recall, F1 score, etc. We get confusion matrix to understand the models behavior in classifying true positives, true negatives, etc.

vi) **Obtaining Accuracy:** Accuracy is a commonly used metric to evaluate the performance of a classification model. It measures the proportion of correct predictions out of the total predictions made by the model. However, depending on the nature of the problem, other metrics like sensitivity, specificity, or mean squared error might also be used to assess performance.

vii) **Comparing with Other Models to Come Up with the Best Model:** In many cases, multiple models are trained and evaluated on the same dataset to find the best performing model. This block involves comparing the performance metrics of different models to select the one that performs the best according to predefined criteria (e.g., highest accuracy, lowest error).

viii) **Grad CAM Technique**: Grad-CAM (Gradient-weighted Class Activation Mapping) is a technique used for visualizing and understanding the decision-making process of deep learning models, particularly convolutional neural networks (CNNs), in image classification tasks. It generates heatmap visualizations highlighting the regions of an image that the model focuses on when making predictions. This technique helps to interpret and explain the model's decisions, providing insights into its behavior and improving model transparency.

ix) **Dataset Description**: Datasets for kidney stone detection encompass a broad range of details, crucial for algorithm development and research endeavors. These datasets typically include various imaging modalities, with ultrasound and CT scans being the most prevalent. Ultrasound datasets often contain images of kidneys affected by stones,

showcasing different stone sizes, shapes, and positions within the kidneys. Moreover, annotations or labels indicating the presence and characteristics of stones are provided, facilitating supervised learning tasks. In contrast, CT scan datasets offer a more detailed perspective, with high resolution images capturing intricate stone morphology and spatial relationships within the renal system Researchers often preprocess these datasets to standardize imaging parameters, enhance image quality, and ensure compatibility across different platforms and algorithms. The detail within kidney stone detection datasets extends beyond raw images, encompassing metadata, annotations, preprocessing steps, and ethical safeguards, all of which are essential for robust algorithmic development and clinical applicability.

Fig 1: Examples of CT scan images with kidney stones and without stones

## IV. IMAGE PROCESSING TECHNIQUES

Image processing involves the manipulation and analysis of digital images using computer algorithms. It encompasses techniques to enhance, transform, or extract information from images for diverse applications. These methods include filtering, segmentation, and feature extraction, among others. Image processing plays a crucial role in fields like medical imaging, remote sensing, and computer vision. It aims to improve image quality, extract relevant features, and facilitate automated analysis..

i) **Data Augmentation:** Data augmentation plays a crucial role in increasing the diversity of the training dataset by applying various transformations to the images. In this project, several augmentation techniques are employed, including rotation, translation, scaling, shearing, and flipping. Rotation involves rotating the image by a specified angle, while translation shifts the image horizontally or vertically. Scaling changes the size of the image, making it larger or smaller, while shearing distorts the shape of the image by shifting one part of the image relative to another. By applying these augmentation techniques, we generate additional training samples, which help improve the model's generalization and robustness.

ii) **Image Enhancement:** Image enhancement techniques are used to improve the quality of medical images and highlight relevant features for kidney stone detection. These techniques include contrast enhancement, histogram equalization, and noise reduction. Contrast enhancement increases the difference in brightness between different parts of the image, making it easier to distinguish between structures. Histogram equalization adjusts the intensity distribution of the image to improve its contrast and visibility. Noise reduction techniques, such as Gaussian blurring or median filtering, help remove unwanted noise from the images, improving their clarity and reducing the impact of artifacts on the model's performance.

iii) **Image Normalization:** Image normalization is essential for standardizing the pixel values of the images to a common scale. In this project, normalization is 26 performed to rescale the pixel values to the range [0, 1] or [-1, 1]. Normalizing the pixel values helps ensure that the model learns more effectively by preventing the gradients from becoming too large or too small during training. It also helps improve the model's convergence and stability, making it less sensitive to changes in the input data.

iv) **Preprocessing for Feature Extraction:** Preprocessing techniques are applied to extract relevant features from the medical images, which are essential for detecting kidney stones. These techniques include edge detection, region of interest (ROI) extraction, and feature extraction. Edge detection algorithms, such as Canny edge detection, are used to identify boundaries and contours within the images. ROI extraction focuses on isolating specific regions of interest within the images that are likely to contain kidney stones. Feature extraction algorithms extract quantitative features from the images, such as texture, shape, and intensity, which are used as input features for training the deep learning model.

v) **Image Segmentation**: Image segmentation techniques are used to partition medical images into meaningful regions or segments. In the context of kidney stone detection, segmentation is employed to isolate the kidney stones from the surrounding tissues and structures. Various segmentation algorithms, such as thresholding, region growing, and active contours (snakes), are applied to accurately delineate the boundaries of the kidney stones. Segmentation plays a crucial role in improving the accuracy of the detection algorithm by focusing the analysis on the relevant regions of the images.

vi) **Image Registration**: Image registration techniques are utilized to align and match corresponding features between different medical images. In the context of kidney stone detection, image registration is used to align images acquired from different modalities or at different time points, enabling the comparison and analysis of images from multiple sources. Registration algorithms, such as rigid, affine, and non-rigid transformations, are applied to ensure spatial alignment and consistency across the images. Image registration facilitates the integration of information from diverse imaging modalities and enhances the accuracy of the detection algorithm by providing a comprehensive view of the patient's condition. Overall these enables the effective interpretation of data across various domains

## V. RESULTS AND DISCUSSION

There are several images from the database. It comprises of both normal and abnormal images. Between them, one is selected and subjected to stone detection procedure. Here we read image text using command unread. It stores pixels in memory and read those pixels. To reduce the unwanted disturbances, we will perform image preprocessing. Without this preprocessing the quality will be not good for examining. During surgeries it is very important to predict the correct location of the kidney stone correctly. Generally ultrasound image consists of speckle noise. So we can overcome that noise by performing image preprocessing. Next, image is sent to segmented block where segmentation is performed. In this, level set function is used to remove curves. It is good in accuracy, speed and performance. Now segmentation is done for stone portion. Segmented image is sent to discrete wavelet transforms block. It consists of two filters namely Daubechies and Symlette filters. Finally, if single object is detected it will display stone is detected or else no stone is detected.

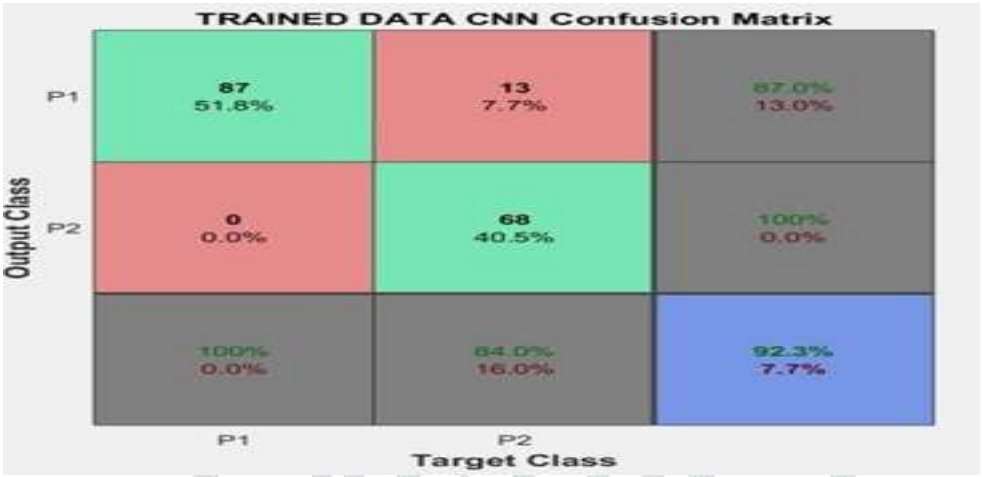


Fig 2: Trained Data Confusion matrix


Fig 3: CNN Confusion matrix

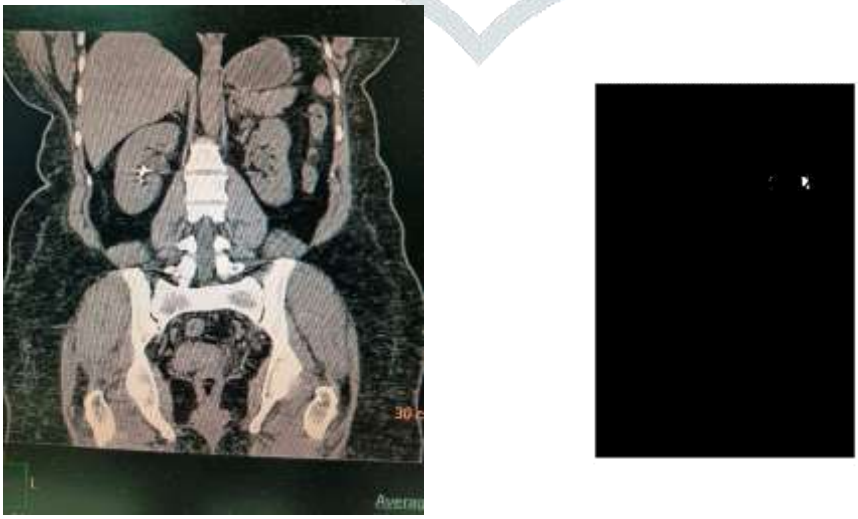

Fig 4: CT scan image with kidney stones

Fig 5: CT scan image with no kidney stones

## VI. CONCLUSION

The number of patients diagnosed with kidney stone disease gradually increases every year. Thus there is always a need for highly accurate systems for stone detection and identification. This paper proposes an automated system for the accurate detection of kidney stone using deep learning models. This study successfully classified the computed tomography images into normal and kidney stones and identified the stone area in the kidney using the Grad-CAM technique. It helps the experts work easily, making them less or no work. Experiments with a large set of datasets and new models is devoted as a future scope for this work.

## REFERENCES

[1] Vb Lakshmi, Kb Sivachandra, S Abhishek, T Anjali, "Nephrolithiasis Taxonomy: A Multifaceted Exploration of Renal Calculi", 2023 2nd International Conference on Automation, Computing and Renewable Systems (ICACRS), pp.655-660, 2023

[2] Sohaib Asif, Qurrat-ul-Ain, Muhammad Awais, Saif Ur Rehman Khan, "IR-CNN: Inception residual network for detecting kidney abnormalities from CT images", Network Modeling Analysis in Health Informatics and Bioinformatics, vol.12, no.1, 2023.

[3] Ferentinos, K. P.. (2018). Deep learning models for plant disease detection and diagnosis. Comput. Electron. Agric. , 145 , 311-318 . http://doi.org/10.1016/j.compag.2018.01.009

[4] Gulshan, Varun., Peng, L.., Coram, Marc., Stumpe, Martin C.., Wu, Derek J.., Narayanaswamy, Arunachalam., Venugopalan, Subhashini., Widner, Kasumi., Madams, T.., Cuadros, Jorge A., Kim, R.., Raman, R.., Nelson, Philip., Mega, J.., & Webster, D.. (2016). Development and Validation of a Deep Learning Algorithm for Detection of Diabetic Retinopathy in Retinal Fundus Photographs.. JAMA , 316 22 , 2402-2410 . http://doi.org/10.1001/jama.2016.17216

[5] Zaidi, Syed Sahil Abbas., Ansari, M. S.., Aslam, Asra., Kanwal, N.., Asghar, M.., & Lee, Brian. (2021). A Survey of Modern Deep Learning based Object Detection Models. Digit. Signal Process. , 126 , 103514 . http://doi.org/10.1016/j.dsp.2022.103514

[6] Asnaoui, Khalid El., & Chawki, Youness. (2020). Using X-ray images and deep learning for automated detection of coronavirus disease. Journal of BiomolecularStructure&Dynamics,1-12. http://doi.org/10.1080/07391102.2020.1767212

[7] S Sachin Kumar, M Anand Kumar, and KP Soman. Sentiment analysis of tweets in malayalam using long short-term memory units and convo-lutional neural nets. In International Conference on Mining Intelligence and Knowledge Exploration, pages 320–334. Springer, 2017.

detection using coronal ct images. Computers in biology and medicine, 135:104569, 2021.

[9] A Lalith Vikas. Kidney stone detection using image processing and neural networks. Annals of RSCB, 25(6):13112–13119, 2021.

[10] Waliu Olalekan Apena and Orobosa Libert Joseph. Convolutional neural network model layers improvement for segmentation and classification on kidney stone images using keras and tensorflowDeep learning model for automated kidney stone

[11] Yingpu Cui, Zhaonan Sun, Shuai Ma, Weipeng Liu, Xiangpeng Wang, Xiaodong Zhang, and Xiaoying Wang. Automatic detection and scoring of kidney stones on noncontrast ct images using stone nephrolithometry: combined deep learning and thresholding methods. Molecular Imaging and Biology, 23(3):436–445, 2021.

[12] Johan Jendeberg, Per Thunberg, and Mats Liden. Differentiation of distal ureteral stones and pelvic phleboliths using a convolutional neural network. Urolithiasis, 49(1):41–49, 2021.

[13] Kalannagari Viswanath and Ramalingam Gunasundari. Design and analysis performance of kidney stone detection from ultrasound image by level set segmentation and ann classification. In 2014 International Conference on Advances in Computing, Communications and Informatics (ICACCI), pages 407–414. IEEE, 2014.

[14] Joan Serrat, Felipe Lumbreras, Francisco Blanco, Manuel Valiente, and Montserrat Lopez-Mesas. mystone: A system for automatic kidney stone ´classification. Expert Systems with Applications, 89:41–51, 2017.

[15] Is¸ıl AKSAKALLI, Sibel KAC¸ DIOGLU, and Y Sinan HANAY. Kidney x-ray images classification using machine learning and deep learning methods. Balkan Journal of Electrical and Computer Engineering, 9(2):144–151, 2021.

[16] Jyoti Verma, Madhwendra Nath, Priyanshu Tripathi, and KK Saini.Analysis and identification of kidney stone using kth nearest neighbour (knn) and support vector machine (svm) classification techniques.

[17] M. B, N. Mohan, S. K. S and S. K. P, "Automated Detection of Kidney Stone Using Deep Learning Models," 2022 2nd International Conference on Intelligent Technologies (CONIT), Hubli, India, 2022, pp. 1-5, doi: 10.1109/CONIT55038.2022.9847894
[18] G. G, P. Sai G B and J. J. Hilda, "Automated Kidney Stone Detection using Deep Learning Technique," 2024 Second International Conference on Emerging Trends in Information Technology and Engineering (ICETITE), Vellore, India, 2024, pp. 1-6, doi: 10.1109/ic-ETITE58242.2024.10493536.
[19] V. N, B. S, D. p, D. L and H. P, "Deep Learning Model for Automated Kidney Stone Detection using VGG16," 2023 Second International Conference on Electronics and Renewable Systems (ICEARS), Tuticorin, India, 2023, pp. 1158-1164, doi: 10.1109/ICEARS56392.2023.10085509