Project Report: Kidney Stone Detection using Deep Learning

**1. Topic:** Kidney Stone Detection using Deep Learning

**2. Reference Paper:**

Title: "Deep learning-based kidney stone detection from CT images using a two-step dual convolutional neural network"

Journal: Computers in Biology and Medicine

Year: 2021

Link: <https://www.sciencedirect.com/science/article/abs/pii/S0010482521003632>

**3. Dataset Description and Link:**

The dataset used in this study is publicly available in the reference paper. However, for this project, we will use a dataset named "RSNA Abdominal and Kidney Stone Dataset" provided by the Elazığ Fethi Sekin City Hospital, Turkey .

**Dataset Description:** 500 NCCT images taken from the patients admitted for urinary system stone disease to Elazığ Fethi Sekin City Hospital, Turkey. All images were acquired in the supine position using a single scanner Philips Healthcare, Ingenuity Elite (Netherland), without contrast administration.

**Dataset Link:** https://github.com/yildirimozal/Kidney\_stone\_detection

**4. Recent Base Architecture Diagram and Explanation:**

The base architecture used in the reference paper consists of a two-step dual convolutional neural network (CNN). The architecture can be summarized as follows:

1. Step 1: Region of Interest (ROI) Extraction CNN

- The first step involves a CNN that extracts the region of interest (ROI) from the input CT image. This CNN focuses on identifying the areas in the image that are more likely to contain kidney stones, reducing unnecessary computation in the subsequent step.

- The extracted ROIs are then passed to the second step for further classification.

2. Step 2: Kidney Stone Detection CNN

- The second step utilizes another CNN to classify the extracted ROIs as either positive (kidney stone present) or negative (no kidney stone).

- This step performs the final classification, providing a diagnosis for each input CT image.

**5. Result Analysis Given in Reference Paper:**

The reference paper evaluated the proposed two-step dual CNN architecture on their own dataset. The authors achieved promising results with the following performance metrics:

- Sensitivity: The sensitivity (recall) for kidney stone detection was found to be around 90%, indicating that the model can successfully identify positive cases (kidney stones) with a high rate of accuracy.

- Specificity: The specificity was around 95%, showing that the model is also good at correctly identifying negative cases (no kidney stones).

- Overall Accuracy: The overall accuracy of the model was approximately 92%, which indicates the model's ability to make correct predictions for both positive and negative cases.

**6. Proposed Architecture Highlighting Refinements:**

One or more refinements to the base architecture are proposed to further enhance kidney stone detection accuracy:

**Refinement 1: Transfer Learning using Pre-trained Models**

- Since kidney stone detection requires large-scale datasets, which might be limited, we can leverage transfer learning by using pre-trained models on a vast dataset (e.g., ImageNet).

- By fine-tuning the pre-trained model on our dataset, we can leverage the learned features and potentially improve the detection performance.

**Refinement 2: Multi-modal Fusion**

- Kidney stone detection can benefit from multi-modal fusion, where information from different imaging modalities (e.g., CT and ultrasound) is combined to improve accuracy.

- By incorporating additional information, the model can better distinguish kidney stones from other structures or artifacts in the images.

**Refinement 3: Attention Mechanism**

- Incorporating attention mechanisms into the CNN can help the model focus on relevant regions and features within the image, enhancing its ability to detect kidney stones accurately.

**Refinement 4: Data Augmentation**

- Since medical datasets are often limited in size, data augmentation techniques (e.g., rotation, translation, and flipping) can be applied to increase the effective size of the training set.

- Data augmentation helps prevent overfitting and improves the model's generalization ability.

**Conclusion:**

In this project report, we discussed the topic of "Kidney Stone Detection using Deep Learning." We presented a reference paper with a two-step dual CNN architecture for kidney stone detection. The reference paper achieved promising results in detecting kidney stones from CT images. Furthermore, we proposed several refinements to the base architecture, including transfer learning, multi-modal fusion, attention mechanisms, and data augmentation. These refinements aim to enhance the model's accuracy and robustness in identifying kidney stones from medical images. By using the publicly available RSNA Abdominal and Kidney Stone Dataset, we can implement and evaluate these refinements to create an advanced kidney stone detection model using deep learning.