EchoStone: Time Reversal Imaging for Accurate Kidney Stone Diagnosis

Abstract:

The diagnosis of kidney stones was accomplished using the time reversal algorithm. The K-wave MATLAB toolbox was utilised to simulate acoustic waves for detecting kidney stones. The toolbox facilitated the focusing of waves, allowing for precise detection. A heterogeneous density medium example from the K-wave toolbox was employed, and the time reversal algorithm was integrated with it to accurately detect the position of the kidney stones.

Aim: The aim of this project was to diagnose the presence of stones in the kidney using time reversal imaging techniques.

Methodology:

The diagnosis of kidney stones followed the proposed methodology, leveraging the capabilities of the K-wave toolbox, which is designed for the time-domain simulation of propagating acoustic waves in 1D, 2D, or 3D environments.

From the toolbox, the heterogeneous medium helped define and locate any stone present. Different medium densities were applied to simulate variations in tissue properties, allowing for better differentiation between healthy tissue and the presence of stones. The medium densities were kept distinct from the overall medium density to reflect real-life conditions more accurately.

Following the simulation of varying medium densities, the time reversal imaging technique was employed to locate the stone. This was achieved with the help of transducer wave simulations from the K-wave toolbox. Time reversal imaging extracted key features from the simulations, and based on the eigenvalues and transfer matrix, it accurately identified the presence and location of kidney stones within the medium. The methodology provided a precise, non-invasive approach to diagnosing kidney stones using advanced acoustic wave simulations.

Scope:

The scope of this project in healthcare is significant, as it offers a non-invasive, precise diagnostic tool for detecting kidney stones. By using acoustic wave simulations and time reversal imaging, this technique could improve early diagnosis, reduce the need for more invasive methods like CT scans, and offer real-time imaging solutions. With further development, it could be applied to other areas of medical imaging, enhancing the detection of various conditions that require accurate localisation of abnormalities, thereby improving patient outcomes.