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The CT Scan Marvel: - A first step towards connecting Medicine and advanced Engineering.

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Abstract

Biomedical engineering has revolutionized healthcare by merging engineering and medical principles to develop innovative technologies that enhance diagnosis, treatment, and patient care. [1]. The Computed Tomography (CT) scan is a remarkable achievement in the field of biomedical engineering, revolutionizing medical imaging and patient care. Over the years, it has undergone significant advancements, offering detailed and accurate images for diagnosing and monitoring various medical conditions [2].

Keyword: Computed Tomography (CT); Magnetic Resonance Imaging (MRI); Biomedical engineering

1. Main Body

Biomedical engineering has made remarkable advancements in the field of developing imaging technologies such as X-rays, Computed Tomography (CT), Magnetic Resonance Imaging (MRI), ultrasound, and Positron Emission Tomography (PET). This has significantly enhanced our ability to visualize internal body structures. These imaging techniques provide valuable information to healthcare professionals, facilitating accurate diagnoses.

The development of CT scanning can be traced back to the 1970s when British engineer Sir Godfrey Hounsfield introduced the world's first CT scanner. Hounsfield's invention utilized X-ray technology and computer algorithms to generate detailed images of the body's internal structures. Since then, there has been a great deal of development in CT scan technology over the last 30 years from the initial convectional CT scanners through to helical or spinal scanners and the current multi-detector machines. The principles of CT scanning involve the use of X-rays and advanced computing techniques to create detailed images of the body [3]. The CT scanner consists of a gantry containing the rotating X-ray source and an array of detectors that capture the transmitted X-rays and filters that revolve around the patients, acquiring information at different angles and projections. This information is then mathematically reconstructed and processed by sophisticated algorithms to construct cross-sectional 2-D greyscale images of a slice through the body, providing a comprehensive view of the internal structures. This technique overcomes the problem of superimposed structure, which is seen in conventional radiography. Improved gantry design and an increased number of sensitive detectors resulted in increased resolution and a decrease in time of scale. With a Modern CT scanner, it is possible to obtain images of the chest, abdomen, and pelvis in under 20 seconds and these images can be reformatted in multiple planes without degradation of image quality. CT scanning offers numerous advantages over conventional imaging techniques, making it an invaluable tool in various medical applications. The ability to obtain detailed images allows healthcare professionals to diagnose and monitor a wide range of conditions, including cancer where exact location, size, and vascularity can be visualized, cardiovascular diseases, trauma like head injury, abdominal trauma, neurological disorders and in inflammatory conditions, for example, abscess, pseudocyst of pancreas. CT is widely used in thoracic, abdominal, neurological, and musculoskeletal images. The non-invasive nature of CT scans, coupled with their high speed and accuracy, has significantly improved patient care [4,5].

With improved spatial resolution there's the development of newer techniques such as CT angiography virtual colonoscopy and virtual bronchoscopy [6]. Three-dimensional (3D) images can also be reconstructed from the raw data to aid in surgical planning. A CT scan can provide more accurate, sensitive, and specific details even of small lesions. CT-guided biopsies are also done at present, safely [7]. High-Resolution CT scan (HRCT) is a CT technique used in chest scans where thin sections are taken to have better quality images. This technique obtains images with exquisite lung detail, which are ideal for the assessment of diffuse interstitial lung disease [8].

The Hounsfield Unit (HU) or CT value, is a quantitative measurement used in computed tomography (CT) imaging to assess the radiodensity of different tissues within the body [9]. It is a scale that represents the attenuation of X-rays as they pass through a patient's body. The scale is centred around water, which is assigned a value of 0 HU. Tissues with lower densities, such as air or lungs, have negative values, while tissues with higher densities, such as bone, have positive values. For example, air may have a value of -1000 HU, while dense bone may have a value of +1000 HU or higher.

While CT scanning has proven to be groundbreaking, it also presents some limitations and challenges. Compared with ultrasound and conventional radiography there is a higher dose of ionizing radiation, for example, a CT scan of the abdomen and pelvis has a radiation dose equivalent to approximately 500 chest X-rays, that exposes patients to potential risks, necessitating the need for dose optimization strategies [10]. Additionally, the high cost of CT scanners, the need for skilled personnel, and limited availability in certain regions pose challenges to widespread implementation. Ongoing research focuses on reducing radiation dose, improving image quality, and addressing these challenges to enhance the clinical utility of CT scanning. The future of CT scanning in biomedical engineering holds promising advancements. One area of research focuses on the development of spectral CT scanners, which can provide additional information about tissue composition, improving diagnostic accuracy. Furthermore, advancements in artificial intelligence and machine learning are being integrated into CT scanning to enhance image reconstruction, automate results, and improve early disease detection.

In summary, The CT scan is a remarkable achievement in the field of biomedical engineering, revolutionizing medical imaging and patient care. Over the years, it has undergone significant advancements, offering detailed and accurate images for diagnosing and monitoring various medical conditions. Despite its limitations, ongoing research, and innovation in CT scanning hold immense potential for further improvements in image quality, radiation dose optimization, and accessibility. As the field of biomedical engineering continues to evolve, the CT scan marvel will undoubtedly remain a cornerstone technology, transforming healthcare and saving countless lives.

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