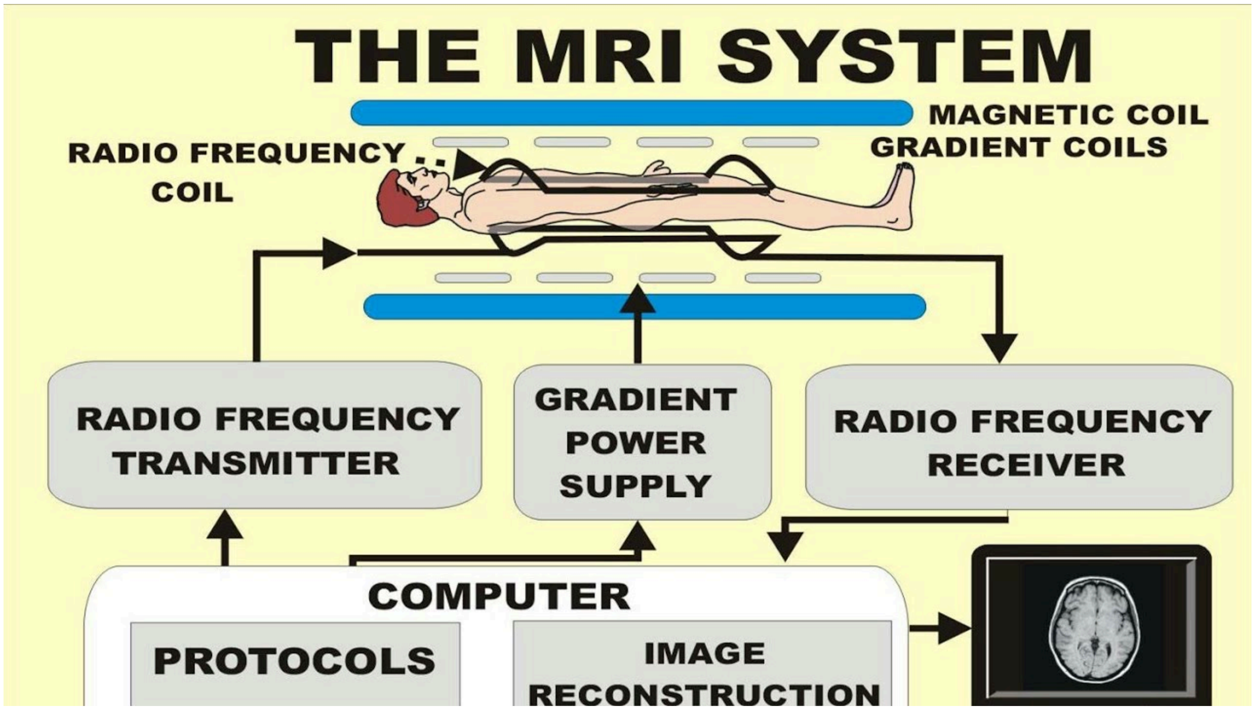
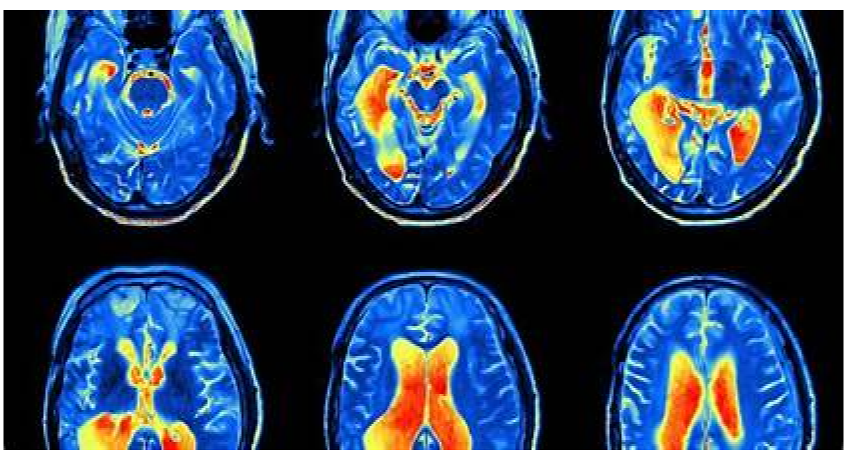

THE MRI SYSTEM
MAGNETIC COIL
GRADIENT COILS
RADIO FREQUENCY COIL
RADIO FREQUENCY TRANSMITTER
GRADIENT POWER SUPPLY
RADIO FREQUENCY RECEIVER
COMPUTER
PROTOCOLS
IMAGE RECONSTRUCTION



1. An introduction to the topic

Magnetic Resonance Imaging (MRI) is a powerful medical imaging technique that provides detailed images of the internal structures of the human body such as organs and soft tissues without using ionizing radiation unlike X-rays and Computerized Tomography (CT) scans. The machine is a tube that is able to fit the entire body and depending on what needs to be examined you are put inside the machine either head first or feet first.

Generated images are based on the behavior of hydrogen atoms in the body when exposed to strong magnetic fields and radiofrequency pulses (Whitlock, 2022).Radio waves (radiofrequency pulses or B1 field) transmitted by the machine aid in creating 3D images. MRI scanner is a magnet and the strength of the magnet is measured in units called Tesla (T). The MRI scanner used in hospitals and clinics is around 1.5T or 3T. Fun Fact!! According to Broadhouse(2019) an MRI scanner is around 60,000 stronger than the Earth's magnetic field. The magnetic field within the scanner is called the B0 field which is the main magnetic field.

MRI tends to be loud so during an operation patients are required to wear headphones and be very still or the images that are to be depicted will become blurry and the process would have to restart. There are two types of scanners: Open and Close MRI. Open MRI scanner has magnets on opposite sides of the machine inside and the machine is open to prevent the feeling of claustrophobia. The closed MRI is only open on one end and rings of magnets that go around the entire body.

2. Identification of the Physics principles involved in the operation of the tool/technology.

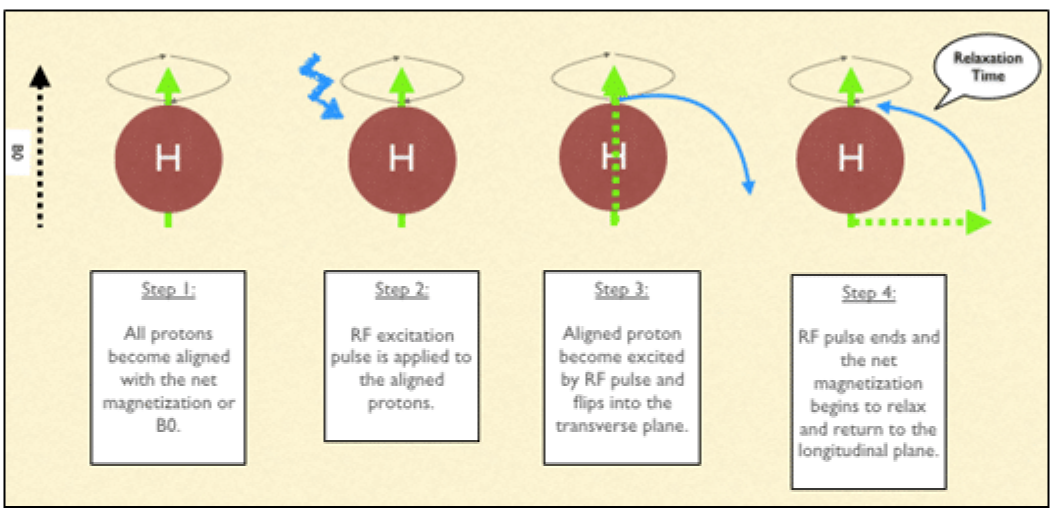
The physics principle behind MRI is the nuclear magnetic resonance (NMR). This refers to the alignment and stimulation of atomic nuclei with magnetic fields.

An organ or tissue in your body can be seen in great detail with magnetic resonance imaging (MRI), a medical imaging technology that combines computer-generated radio waves and a magnetic field (*Mayo Clinic*, 2023).

Because magnetic resonance imaging (MRI) can provide high-resolution images of soft tissues, organs, and even the brain, it has become an essential tool in modern medicine for precise diagnosis, treatment planning, and condition monitoring.

The peculiar makeup of the human body makes MRI scans useful as a diagnostic tool. All of our cells, which are primarily composed of hydrogen ions (H2O), contain water. The hydrogen molecules in our body are like poles that spin on their axes and when they do so

These positively charged hydrogen ions (H+ ions) can be affected by the magnet incorporated in the MRI scanner, which will cause them to "spin" in the same way. Hydrogen protons are like tiny magnets and align with the stronger magnetic field. We can add levels of complexity by adjusting the direction and strength of this magnetic field, which will modify the protons' "spin." The spinning motion of the hydrogen atom is called precession and how fast they spin is called the precessional frequency.



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3. Explanation of the overall operation of the tool/technology including the equipment used.

MRI technology, a non-invasive diagnostic tool, utilizes robust magnetic fields, radio waves, and computer systems to generate detailed images of internal structures (Norquay et al., 2022; Patel et al., 2017). The main elements of an MRI machine comprise a magnet, gradient coils, radiofrequency coils, and a computer system (Norquay et al., 2022; Patel et al., 2017).

The central component of an MRI machine is the magnet, typically superconducting, which produces a strong magnetic field. This field aligns nuclei of hydrogen atoms, (protons) within the body, inducing them to rotate in a particular orientation (Norquay et al., 2022). The magnet is cooled using a solid cryogen like liquid helium or liquid nitrogen to sustain the necessary temperature and magnetic field potency (Patel et al., 2017).

Alongside the main magnet are gradient coils which produce a magnetic field gradient, facilitating the spatial encoding of proton signals. They generate linear magnetic field gradients along the x, y, and z axes, ensuring accurate localization of proton signals within the body (Norquay et al., 2022; Patel et al., 2017).

In conjunction with the main magnet and gradient coils, radiofrequency coils are employed to both transmit and receive radiofrequency (RF) pulses throughout the MRI procedure. These coils are specifically crafted to resonate at the same frequency as the hydrogen nuclei (protons) within the body. Positioned around the region of interest, they collaborate with gradient coils to stimulate the protons and capture the ensuing signals. Subsequently, the computer system processes these signals to produce the conclusive images (Norquay et al., 2022; Patel et al., 2017).

The computer system is integral to MRI technology, as it handles the raw data acquired by the RF coils and transforms it into intricate images. Composing various components such as a data acquisition system, a reconstruction algorithm, and a user interface, the computer system ensures seamless processing of information. The data acquisition system captures raw data from the RF coils, while the reconstruction algorithm interprets and transforms this data into the final images (Norquay et al., 2022; Patel et al., 2017).

These elements collaborate to generate intricate images of internal structures. Throughout an MRI scan, the magnet aligns the protons within the body, whereas the gradient coils establish a magnetic field gradient to facilitate spatial encoding. The RF coils both emit and receive RF pulses, stimulating the protons and capturing the ensuing signals. Subsequently, the computer system processes the raw data, transforming it into detailed images, which offer valuable insights for both diagnostic and research objectives (Norquay et al., 2022; Patel et al., 2017).

1. The patient is placed inside the tube and radio waves are transmitted and received.
2. The radiofrequency pulses applied tips the aligned H2 nuclei out of its magnetic field and when it is turned off, the nuclei return to their original alignment, releasing energy in the process which helps to create the image.
3. Even though we say they are images, they really aren't, they are just magnetic field and radiowaves mapped onto a computer.

4. Applications of the tool /technology in medicine and other fields.

The human body can be captured in extremely complex and detailed images using magnetic resonance imaging. In general, MRI scanning works quite well for observing soft tissue, which is why tumors, strokes, ligament injuries and bleeding are frequently found with this technique. With the use of IV gadolinium-based drugs, it can also be utilized to visualize the functionality of suspected masses and tumors(Jones & Huber, 2018).

Factor	CT (CT abdo used as example)	MRI	X-ray (CXR used as example)	Ultrasound
Duration	3-7 minutes	30-45 min	2-3 min	5-10 minutes
Cost	Cheaper	Expensive	Cheap	Cheap
Dimensions	3	3	2	2
Soft tissue	Poor detail	Excellent detail	Poor detail	Poor detail
Bone	Excellent detail	Poor detail	Excellent detail	Poor detail
Radiation	10mSv	None	0.15mSv	None

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5. The current use of Artificial Intelligence (AI) in the technology or the research that is being done to incorporate its use in the technology.

The integration of Artificial Intelligence (AI) with Magnetic Resonance Imaging (MRI) technology has seen a notable rise, aiming to improve image processing, interpretation, and diagnostic precision. AI algorithms, especially deep learning models, demonstrate significant efficacy in identifying and diagnosing diverse medical conditions through MRI images (Duamwan et al., 2023; Mukherjee et al., 2023; Rahman et al., 2020).

For instance, in the realm of Alzheimer's disease detection, AI algorithms have demonstrated an impressive classification accuracy of 94.96% when analyzing MRI scans (Rahman et al., 2020). The research also utilized interpretable AI methods, including Local Interpretable Model Agnostic Explanations (LIME) and Felzenszwalb's segmentation algorithm, to offer medical practitioners clear and comprehensible insights, aiding in efficient, uniform, and convenient diagnostic processes.

Likewise, AI-driven tools have demonstrated high accuracy in identifying autism spectrum disorder (ASD) through the analysis of facial features and MRI scans (Mukherjee et al., 2023). The research provided an extensive examination of AI methodologies, encompassing machine learning, image processing, and deep learning, and their efficacy when applied to facial and MRI images of children with Autism Spectrum Disorder (ASD) compared to typically developing children.

AI-driven image processing methods have been employed to enhance the automated detection of breast tumors from MRI scans (Duamwan et al., 2023). The suggested approach utilized Otsu's thresholding segmentation in combination with various image processing techniques to detect the desired regions of interest in MRI images. This method achieved a higher accuracy rate when compared to alternative existing methods.

Moreover, the application of fuzzy system-based medical image processing has been utilized to enhance the accuracy of predicting brain diseases using MRI images of the brain (Hu et al., 2021). The research developed a model for brain image processing and predicting brain disease diagnosis, utilizing enhanced fuzzy clustering and HPU-Net to enhance the model's safety performance.

Additionally, AI algorithms have been applied in image watermarking tasks to improve the fidelity of the extracted watermark and withstand different types of geometric and signal processing assaults (Singh et al., 2020). The research introduced a new approach for computing image moments by combining analytical and numerical methods. This method enhances watermark extraction robustness and resistance against diverse attacks.

In summary, the integration of AI algorithms with MRI technology has seen a notable rise, aiming to refine image processing, interpretation, and diagnostic precision. Utilizing AI methodologies like deep learning, machine learning, image processing, and fuzzy clustering has demonstrated enhancements in detecting and diagnosing diverse medical conditions, such as Alzheimer's disease, Autism Spectrum Disorder (ASD), and breast tumors. Furthermore, AI algorithms have found applications in image watermarking to bolster the fidelity of extracted watermarks and withstand different types of attacks.

Future advancements in AI integration with MRI for enhanced patient care may involve the refinement of more sophisticated and precise AI algorithms. Furthermore, there's potential for AI to merge with other medical imaging techniques, expanding its utility across diagnostic platforms. Additionally, the creation of AI-driven decision support systems could aid healthcare professionals in diagnosing and managing medical conditions. Moreover, AI algorithms might forecast patient prognoses and tailor treatment strategies accordingly, ultimately enhancing patient care and overall outcomes.

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