**NUCLEAR MAGNETIC RESONANCE PHENOMENON**

The nuclei of certain atoms with odd atomic number, and/or odd mass behave as spinning charges. The nucleus is the center of positive charge, and this spinning charge generates a tiny magnetic field, indicated as a vector with a magnitude and direction. [1] If a chemical sample containing such atoms is placed inside a magnetic field, the nuclear magnetic moment can only acquire a finite number of orientations, according to the principles of quantum mechanics. Nuclear Magnetic Resonance (NMR) is a spectroscopic technique to study molecules with nuclei in magnetic field that absorb and re-emit electromagnetic radiation.

Nuclei possessing non-zero nuclear spin have nuclear magnetic moment which produces magnetic interactions with external magnetic field. The principle behind NMR is that many nuclei have spin and all nuclei are electrically charged. If an external magnetic field is applied, an energy transfer is possible between the base energy to a higher energy level. The energy transfer takes place at a wavelength that corresponds to radio frequencies and when the spin returns to its base level, energy is emitted at the same frequency. NMR relies on the magnetic properties of the atomic nucleus. When placed in a strong magnetic field, certain nuclei resonate at a characteristic frequency in the radio frequency range of the electromagnetic spectrum.

**RELATIONSHIP BETWEEN FREQUENCY AND MAGNETIC FIELD**

The external magnetic field and the frequency are directly proportional. If the external field is larger, the frequency needed to induce the alpha to beta transition is larger. It follows then that in a larger field, higher frequency radio waves would be needed to induce the transition. The splitting of energy levels proportional to an external magnetic field is called the Zeeman Effect. This effect causes magnetic resonances which are classified under radio frequency spectroscopy. In these resonances, the transitions between two branches of a single energy level split in an external magnetic.

**DRIFT IN MEDICAL IMAGING AND APPLICATION TO MRI**

[2] Drift is usually referred to as the physiological noise or the disturbance due to the movement of the subject. It is due to the thermal motion of electrons either in the material. With the increase of the temperature the atoms move faster and transfer their energy to neighboring atoms creating more collisions and causing more loss of energy. F-MRI data may be due to long-term physiological shifts, movement related noise remaining after realignment. [3] Localization errors can also be happen due to spectrally and spatially selective pulses. In single-voxel MRI Systems, field drift leads to line broadening which can affect spectral resolution and quantification. In phase-encoded chemical shift imaging (CSI) it can lead to localization errors. Long acquisition times increase the risk of sample drift during imaging. Without correction of the drift, the image will be smeared and the resolution shall be degenerated.

**VOXEL EXPLANATION AND ADVANTAGE OF VOXELS OVER PIXELS**

A voxel is a unit of graphic information that defines a point in 3D space. Voxels themselves do not typically have their position (their [coordinates](https://en.wikipedia.org/wiki/Coordinate)) in the space but there is a rendering system that infers the position of a voxel based upon its position relative to other voxels. [4] A [pixel](http://searchcio-midmarket.techtarget.com/definition/pixel) (picture element) defines a point in two dimensional space with its [x and y coordinates](http://searchcio-midmarket.techtarget.com/definition/x-and-y-coordinates) , a third [z coordinate](http://whatis.techtarget.com/definition/z-coordinate) is needed. In 3D space, each of the coordinates is defined in terms of its position, color, and density. A voxel represents a single sample, or data point, on a regularly spaced, 3D grid.

A voxel represents only a single point on this grid, not a volume; the space between each voxel is not represented in a voxel-based dataset. Texture analysis is a powerful image analysis method that quantitates voxel intensities and their patterns and interrelationships. [5] Texture analysis can identify intensity patterns including those that cannot easily be detected by the unaided human eye. Voxel-based morphometry (VBM) is a [neuroimaging](https://en.wikipedia.org/wiki/Neuroimaging) analysis technique that allows investigation of focal differences in [brain](https://en.wikipedia.org/wiki/Brain) [anatomy](https://en.wikipedia.org/wiki/Anatomy) using the statistical approach of  [parametric mapping](https://en.wikipedia.org/wiki/Statistical_parametric_mapping). In traditional [morphometry](https://en.wikipedia.org/wiki/Morphometry), volume of the whole brain or [its subparts](https://en.wikipedia.org/wiki/List_of_regions_in_the_human_brain) is measured by drawing regions of interest (ROIs) on images from [brain scanning](https://en.wikipedia.org/wiki/Brain_scanning) and calculating the [volume](https://en.wikipedia.org/wiki/Volume) enclosed. Then the brain images are smoothed so that each [voxel](https://en.wikipedia.org/wiki/Voxel) represents the average of itself and its neighbors. Finally, the image volume is compared across brains at every voxel.

A voxel represents a value on a regular grid in 3D space. As with pixels in a bitmap, voxels themselves do not typically have their position (their coordinates) explicitly encoded along with their values. Some volumetric displays use voxels to describe their resolution.

**ARTIFACTS OBSERVED IN MR IMAGES AND ITS REASON**

[6] Artifacts in magnetic resonance imaging (MRI) may be caused by the MR scanner hardware itself or by the interaction of the patient with the hardware. Various artifacts observed in MRI are Motion, Chemical Shift, Truncation, Aliasing, etc. Aliasing artifacts occur when the anatomical structures located outside the field of view are mapped at the opposite end of the image. Truncation artifacts occur near sharp high-contrast boundaries and are also known as the Gibbs phenomenon. Chemical-shift artifacts occur during the frequency encoding of the MRI process. Fat and water molecules oscillate differently within the magnetic field, causing them to show up differently during the encoding. Increasing the bandwidth, reducing the matrix size, or suppressing the fat-frequency signal can all minimize this artifact.

**Motion artifact** is one of many [MRI artifacts](https://radiopaedia.org/articles/mri-artifacts-1) occurring as a result of tissue/fluid moving during the scan. Motion artifacts caused by breathing, cardiac movement, CSF pulsation/blood flow create a ghost artifact which can be reduced by patient immobilization, or cardiac/respiratory gating. It manifests as ghosting in the direction of phase-encoding. These artifacts may be seen from arterial pulsations, swallowing, breathing, peristalsis, and physical movement of a patient. Periodic motion, such as respiratory or cardiac/vascular pulsation, produces discrete, well-defined ghosts.

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