1.Nuclear Magnetic Resonance and its basics

Nuclear Magnetic Resonance is an analytical chemistry technique avail in quality control and research for regulating the content and purity of a sample as well as its molecular structure. For known compounds it can quantitatively analyse mixtures. It is based on the fact that when a population of magnetic nuclei is placed in an external magnetic field, the nuclei become aligned in a predictable and finite number of orientations. NMR is used to compare against spectral libraries and to reduce the basic structure directly for unknown compounds. NMR can be used to determine molecular conformation in solution as well as studying physical properties at the molecular level such as conformational exchange, phase changes, solubility, and diffusion. Basics of the phenomenon is that many nuclei have spin and all nuclei are electrically charged. When an external magnetic field is applied, an energy transfer is possible between the base energy to a higher energy level generally a single energy gap. The energy transfer gradually occurs at a wavelength which corresponds to radio frequencies and when these spin returns to its base level, energy is released at the same frequency. The signal that matches this transfer is measured in many ways and processed in order to yield an NMR spectrum for the nucleus concerned.[1]

2.Relationship between frequency and magnetic field in MRI

Magnetic fields generally produce electric current. Magnetic field and frequency are directly proportional to each other. If the magnetic field is large than the frequency is 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. Each nucleus has a characteristic value such that as a constant of proportionality between the nuclear angular and magnetic momentum. This precession process generates an electric field with frequency. If we irradiate the sample with radio waves (MHz) the proton can absorb the energy and results into the less favourable higher energy state. This absorption is called resonance because the frequency of the applied radiation and the precession resonate. If a nucleus experiences a different magnetic field it will process at a different frequency and absorb at a different frequency. For all nuclides, the resonant frequency is proportional to the strength of the magnetic field. By increasing the magnetic field strength increases the tension on the nuclei and increases the resonant frequency. The specific nuclide can be tuned to various radio frequencies by varying the field strength is used in the imaging process. The resonance condition depends on having exactly the right combination of external magnetic field and frequency.[2]

3.The concept of drift in imaging and its applications in MRI

Drift in imaging is undesired characteristics equivalent to extraneous component like noise or disturbances. It 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 which creates more collisions causes the great loss of energy. F-MRI data may be due to long-term physiological shifts, movement related noise remaining after realignment, or instability. Localization errors can also be happen due to spectrally and spatially selective pulses. In single-voxel MRS, field drift leads to line broadening which can affect spectral resolution and quantification.[3] 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. It occurs due to change in frequency in the component. As the atoms move at high pace there is variation in temperature which results in more smashes in electrons which causes loss of energy. It’s applications is that we can figure out the deduction in signal by extending non-diffusion weighted images as well as we can correct it and improve the signal by neglecting such unwanted components before data analysis. Therefore such effects can be eliminated during MRI analysis.[4]

4.Voxel in MRI and its advantages over pixels

A voxel is a unit of graphic information and defines a point in three-dimensional space. It is used in 3-D space where each of the coordinates is defined in terms of its position, colour, and density. Its dimensions are represented by the pixel, together with the thickness of the slice. Slice thicknesses in clinical MRI vary from a maximum near 5 mm, achieved using 2D multi slice imaging, to sub-mm, achieved with 3D scan techniques. For a cube where any point on an outer side is expressed with an x , y coordinate and the third, z coordinate defines a location into the cube from that side, its density, and its colour.[5] MRI spatial resolution, which determines the radiologist’s ability to distinguish structures as separate and distinct from each other is inherently related to the acquired voxel volume. Therefore, voxel is more preferable than pixels and voxel has more advantages because pixels represents the smallest sampled 2D element in an image. Pixel sizes range in clinical MRI from mm to sub-mm. voxels themselves do not typically have their position explicitly encoded along with their values while Some volumetric displays use voxels to describe their resolution. By increasing the resolution more than the acceptable range it will result grains in the image due to low SNR and decreasing it more than the acceptable rang will produce a blurry image due to high SNR. If the voxel has curved fibre paths than by using a smaller voxel size in all 3 dimensions produces more accurate results. By increasing slice thickness will increases voxel size thus SNR for image will become smoother.[6]

5. Aliasing or Wrap-around artefacts in MRI

There are artefacts in MRI such as Chemical shift artefact, Aliasing artefact, Boundary black artefact, truncation artefact, Motion artefact and many more. Lets focus on Aliasing artefact:

Aliasing or Wrap-around artefacts : Aliasing or wrap-around results from a spatial miss mapping caused by an under sampling in the phase-encode direction. As a consequence of the acquired [K-spaces](http://www.mr-tip.com/serv1.php?type=db1&dbs=K-Space) frequencies not being sampled densely enough, whereby portions of the object outside of the desired [FOV](http://www.mr-tip.com/serv1.php?type=db1&dbs=Field%20of%20View) get mapped to an incorrect location inside the [FOV](http://www.mr-tip.com/serv1.php?type=db1&dbs=Field%20of%20View). The cyclical property of the [Fourier transform](http://www.mr-tip.com/serv1.php?type=db1&dbs=Fourier%20Transformation) fills the missing data of the right side with data from behind the [FOV](http://www.mr-tip.com/serv1.php?type=db1&dbs=Field%20of%20View) of the left side and vice versa.[7] This is caused by a too small number of samples acquired in sthe [frequency encoding](http://www.mr-tip.com/serv1.php?type=db1&dbs=Frequency%20Encoding) direction, therefore the spectrums will overlap, resulting in a replication of the object in the x direction. The objects outside of the FOV overlap on the opposite side of the image. when the field of view (FOV) is smaller than the body part being imaged it results in aliasing. The part of the body that lies beyond the edge of the FOV is projected onto the other side of the image. In the continuous MR signal picked by the receiver coil is converted into its digital counterpart for presentation as a grey-scale image. This universal involves sampling of the continuous signal at pre-defined intervals. For greater fidelity in signal conversion, the sampling rate should be at least twice the highest frequency within the signal (Nyquist rate). At lower sampling rates, high-frequency signals become indistinguishable from lower frequency signals than they become aliases. In MRI, spatial localisation within a single image depends on the frequency signature of the MR signal originating from that portion. The higher frequency signals come from the edge of the image and are aliased over the lower frequency central portion of the image within a given bandwidth. Aliasing in MRI can occur in both phase and frequency axis. It can occur in the end slices of 3-D acquisition. [8]

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