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Analysis of Imaging Artifacts in MR Brain Images

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ABSTRACT

MRI brain images are widely used in medical applications for research, diagnosis, treatment, surgical planning and image guided surgeries. These MR brain images are often corrupted with various imaging artifacts and may affect the performance of brain image processing techniques. In this paper, we listed and identified the causes of the common imaging artifacts in MR brain images.

Keywords: MR brain image, imaging artifacts, magnetic resonance imaging.

INTRODUCTION

The rapid progress in computerized medical image analysis and computer-aided diagnosis has propelled medical imaging into one of the most important sub-fields in scientific imaging[1]. Magnetic resonance imaging (MRI) is most widely used imaging technique in the medical field. It is a noninvasive, flexible imaging tool and does not require ionizing radiation such as x-rays. It reveals information about human soft tissue anatomy that are not externally visible[2]. In clinical practice, MRI is used to distinguish pathologic tissue from normal tissue.

A Brain MRI also called as MR brain scan or head scan a neurological test which produces a high-resolution image of the human head. A MRI scan of the head is a safe and painless test that uses a magnetic field and radio waves to produce detailed images of the brain and the surrounding tissues. MRI is more versatile and shows better resolution of subtle details than a CT scan, so it is used commonly to study and evaluate the patients with neurological complaints to investigate for brain diseases.

There are primarily three types of MR brain images, T1, T2 and PD, which focus on different contrast characteristics of the brain tissues. A Sample of the same slice on the three types are shown in Fig. 1. These image types can also be taken in three orientations, axial, corona and sagittal (see Fig. 2). The axial orientation of the MR head image is viewed from neck to head. The coronal orientation begins at the tip of the nose and ends at the back of the head. The sagittal orientation extends from ear to ear. By interpreting

these various types and contrast that are produced, a radiologist or other physicians can help to make diagnoses of medical conditions.

MR brain images have a high spatial resolution and provide much information on the brain anatomical structure, allowing quantitative pathological or clinical studies. However, the presence of image artifacts may introduce undesired distortions to the brain images.

In this paper we make a study to identify the brain image artifacts and it causes. The remaining part of the paper is organized as follows: In section 2, the artifacts in brain images and its causes are explained and tabulated and the conclusions is given in section 3.

Artifacts in MR Brain Images

An artifact is a feature appearing in an image that is not present in the original object. Artifacts may be very noticeable or just a few pixels out of balance but can give confusing artifactual appearances with pathology that may be misdiagnosed. There are many kinds of artifacts that affect the brain MRI. Many different artifacts may occur during brain imaging, some affecting the diagnostic quality, while others may be confused with pathology[3,4]. Artifacts in brain MRI are typically classified as Hardware Issues (calibration, power stability), Software problems (programming errors), Physiological phenomena (motion, blood flow) and Physics limitations (Gibbs and susceptibility, chemical shift, metal)[3].

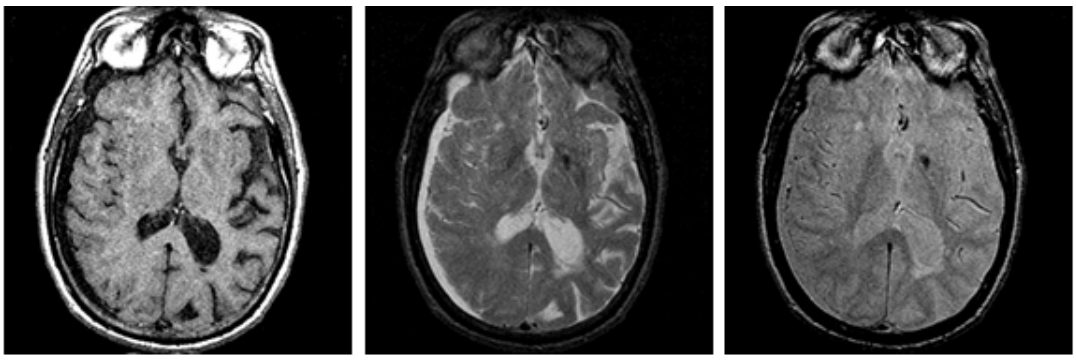

Fig. 1: Types of MRI axial scan (a) T1 scan (b) T2 scan (c) PD scan of the same subject

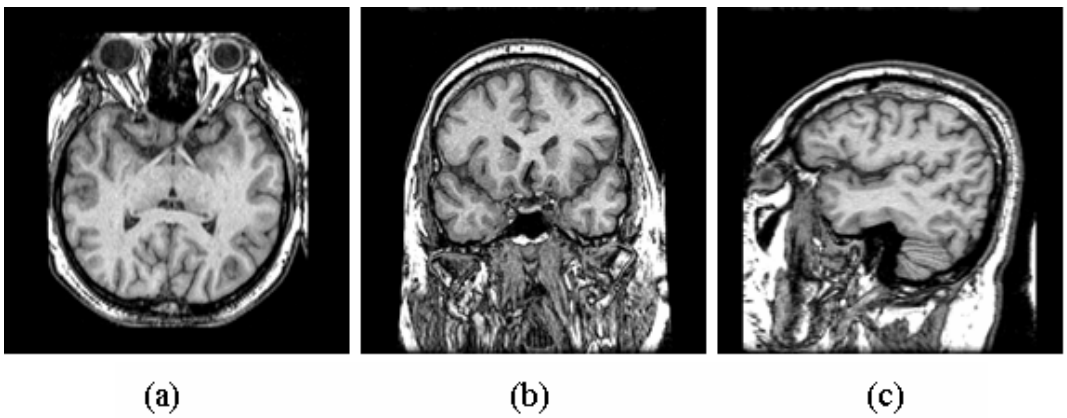

Fig. 2: Types of MRI orientation on T1 –weighted images (a)axial (b)coronal (c)sagittal

Table 1. List of common artifacts in brain MR images

S.No	Artifacts	Cause
1.	Chemical Shift Artifact	This artifact arises due to the inherent differences in the resonant frequency of the two main components of an MR image: fat and water. (see Figure 3(a)).
2.	Aliasing / Wrap Around Artifact	Occurs when the field of view (FOV) is smaller than the body part being imaged causing the region beyond to project on the other side of the image. (see Figure 3(b)).
3.	Black Boundary / Black Line Artifacts	The Black Boundary Artifact is an artificially created black line located at fat-water interfaces such as muscle-fat interfaces. (see Figure 3(c)).
4.	Gibbs Ringing / Gibbs Phenomenon / Transaction Artifact	The bright or dark lines that are seen parallel and adjacent to borders of abrupt intensity change, as when going from bright CSF to dark spinal cord on a T2-weighted image. (see Figure 3(d)).
5.	Zipper Artifact	Most of this type are related to hardware or software problems beyond the radiologist control. This may occur in either frequency or phase direction. (see Figure 3(e)).
6.	Motion Artifact	Patient motion such as respiration, cardiac motion, eye movements, swallowing and minor subject movement is the largest physiological effect that causes artifacts. Movement of the object being imaged during the sequence results in inconsistencies in phase and amplitude, which lead to blurring and ghosting. The nature of the motion artifact depends on the timing of the motion with respect to the acquisition. (see Figure 3(f)).
7.	Entry Slice (inflow) Phenomenon Artifact	Entry slice phenomenon occurs when unsaturated spins in blood first enter into a slice or slices. It is characterized by a bright signal in a blood vessel at the first slice that the vessel enters.
8.	Field (B_0) Inhomogeneity Paramagnetic / Ferromagnetic Implants Artifacts	Image distortion and signal loss, because of presents of magnetic material (inside or outside the patient) and technical problems or scanning at the edge of the field. (see Figure 3(g)).
9.	Slice-overlap / Cross-slice Artifact	Loss of signal seen in an image from a multi-angle and multi-slice acquisition. (see Fig. 3 (h)).

Table 1. List of common artifacts in brain MR images (*Continued* …)

10.	Moire Fringes Artifact	Moire fringes are an interference pattern most commonly seen in gradient echo images. Because of lack of perfect homogeneity of the main magnetic field from one side of the body to the other results in superimposition of signals of different phases that alternately add and cancel. This causes the banding appearance and is similar to the effect of looking though two screen windows.
11.	RF Overflow / Clipping Artifact	Occurs when the signal received from the amplifier exceeds the dynamic range of the analog-to-digital converter causing clipping and produces non-uniform washed-out appearance in an image. (see Figure 3 (i)).
12.	Central Point Artifact	This is caused buy a constant offset of the DC voltage in the amplifiers and produce a focal dot of increased or decreased signal in the center of an image. (see Figure. 3 (j)).
13.	Quadrature Ghost Artifact	An amplifier artifact caused by unbalanced gain in the two channels of a quadrature coil. Combining two signals of different intensity causes some frequencies to become less then zero causing 180 degree ghost. (see Figure 3. (k)).
14.	Susceptibility Artifact	Susceptibility artifacts occur as the result of microscopic gradients or variations in the magnetic field strength that occurs near the interfaces of substance of different magnetic susceptibility. (see Figure 3 (l))
15.	Eddy Current Artifact	Varying magnetic field from gradients can induce electrical currents in conductors such as the cryostat causing distortion of the gradient waveforms, particularly a problem with echo-planar imaging that uses strong and rapidly changing gradients. (see Figure 3 (m)).
16.	RF inhomogeniy Artifact	Failure of RF coil. MR images contain unwanted intensity variation due to non- uniformity in RF coils used to measure the FID response signal and non-uniform loading of the coils by the patient. Brain MR images corrupted by RF inhomogeneity (bias artefact) exhibit brightness variations across the image. (see Figure 3 (n)).
17.	Gradient failure (B1 inhomogenity) Artifact	Failure of the magnetic field gradient.

Table 1. List of common artifacts in brain MR images (*Continued* …)

18.	Partial Volume Artifact	The partial volume artifact is caused by imaging voxel containing two different tissues and therefore possessing a signal average of both tissues. (see Figure 3 (o)).
19.	Flow Artifact	Movement of the body fluid during the sequence. Flow artefacts is one type of motion artefacts caused by motion of liquids within the human body, usually blood or cerebrospinal fluid (CSF). (see Figure 3 (p)).
20.	RF noise Artifact	RF noise, which often appears as static on the image, can be caused by a medical device located anywhere in the MR procedure room. RF noise is a result of excessive electromagnetic emissions from the device that interfere with the normal operation of the MR scanner. The interference is attenuated and aliased in the frequency direction**.**

The limitations and malfunction in the hardware or software of the MRI device may cause undesired image distortions, which can lead to misinterpretation of MR brain data. Physiological phenomena artifacts in brain scans are caused by a variety of factors such as respiration, heartbeat, twitching, tremor which affect the quality of MR brain images. Motion artifacts in brain scanning are a chronic problem causing either ghost images or diffuse image noise in the phase-encoding direction[4].

Physics limitation artifacts caused by metallic objects, such as dental crowns, dental implants and metallic orthodontic appliances, are a common problem in head and neck MRI. The presence of metallic sources may reduce image quality in the maxillofacial region of MRI[5,6], causing large magnetic field distortion and signal loss. The list of common artifacts in MR brain images[3,7-10] are summarized in Table. 1 and are illustrated in Fig. 3.

CONCLUSIONS

The knowledge of artifacts in MRI brain and factors producing noise are important for maintenance of high image quality. In this paper, we analyzed some of the important artifacts in MRI of brain and their common causes. All imaging artifacts listed may degrade the brain image quality and increase the difficulties in brain image processing techniques. All the brain image processing techniques need to incorporate these artifacts to correctly recognize and diagnose the brain related diseases.

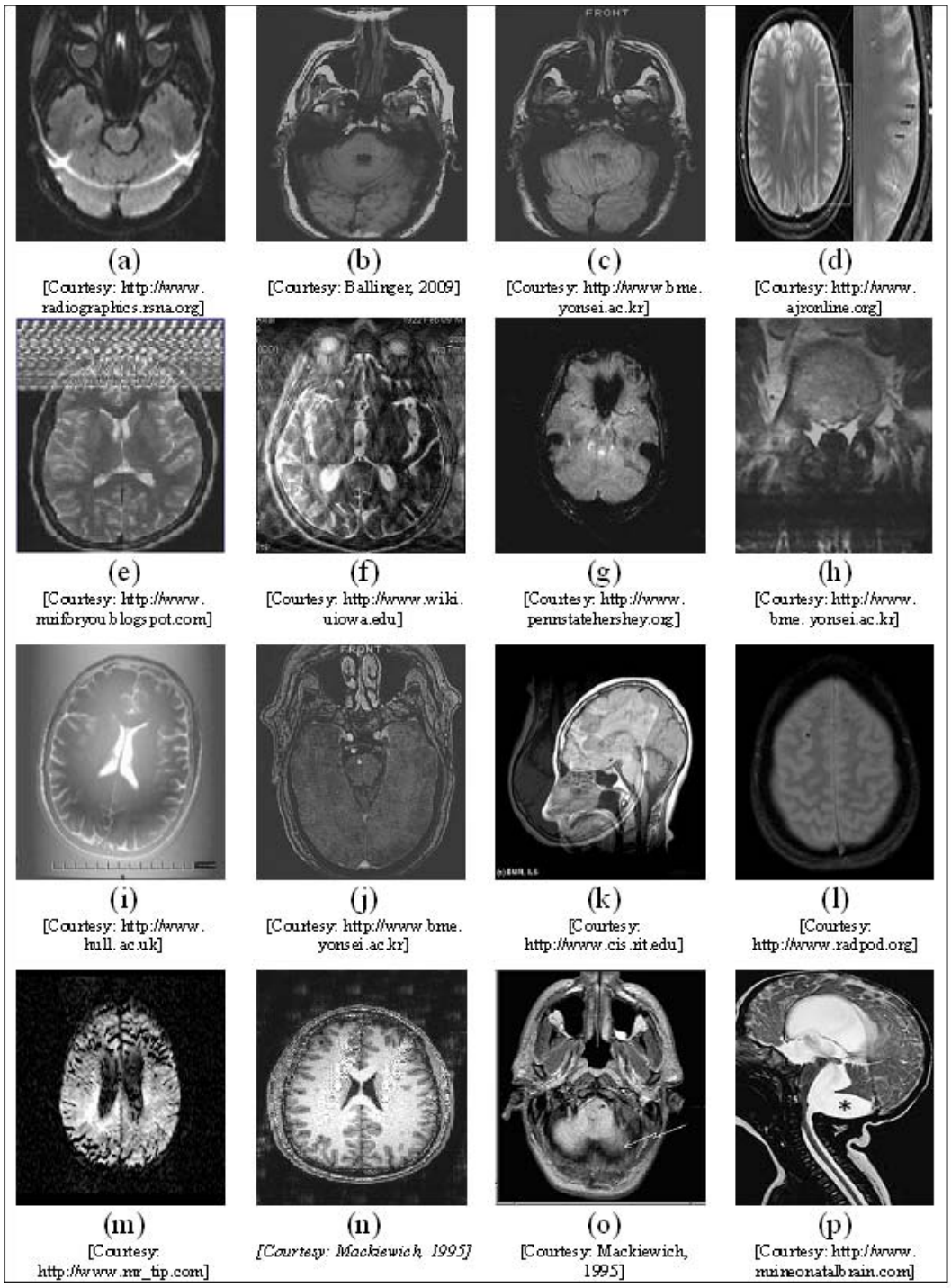

Fig. 3: Different types of artifacts in brain MRI (a) Chemical Shift (b) Aliasing (c) Black Boundary (d) Gibbs Ringing (e) Zipper (f) Motion (g) Field (B0) inhomogeneity (h) Slice-overlap (i) RF Overflow (j) Central Point (k) Quadrature Ghost (l) Susceptibility (m) Eddy Current (n) RF inhomogeniy (o) Partial Volume (p) Flow

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