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Finding Bilateral Symmetry of the Human Brain from MRI

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***Abstract*:** Various subjects that are paired usually are not identically the same, asymmetry is perfectly normal but sometimes asymmetry can be noticeable too much. Structural and functional asymmetry in the human brain and nervous system is reviewed in a historical perspective. Brain asymmetry is one of such examples, which is a difference in size or shape, or both. Asymmetry analysis of brain has great importance because it is not only indicator for brain cancer but also predict future potential risk for the same. In our work, we have concentrated to segment the anatomical regions of brain, isolate the two halves of brain and to investigate each half for the presence of asymmetry of anatomical regions in MRI.

***Keywords*:** MRI, Asymmetry Relation, Region of Interest

INTRODUCTION

Medical images are usually obtained by X-rays and recent years by Magnetic Resonance (MR) imaging. Magnetic Resonance Imaging (MRI) is used as a valuable tool in the clinical and surgical environment because of its characteristics like superior soft tissue differentiation, high spatial resolution and contrast. The field of medical imaging gains its importance with increase in the need of automated and efficient diagnosis in a short period of time. Computer and Information Technology are very much useful in medical image processing, medical analysis and classification.

Recognition of brain tumors by MR imaging is based primarily on mass effect and signal alteration. Most tumors have prolonged T1 and T2 relaxation times and thus appear hyperintense to normal brain on T2-weighted images (T2WI) but hypointense on T1-weighted images (T1WI); on proton-density-weighted images (PDWI) most tumors are slightly hyperintense. The infrequent fat-containing tumors appear hyperintense on T1WI and have relatively low signal on T2WI. Some tumors, generally extra-axial ones, appear more or less isointense with brain tissue in all sequences. To detect them, focal mass effect, effects on adjacent bone, and perifocal soft tissue changes must be determined. Some small tumors may go unnoticed, however, if paramagnetic contrast material enhancement is not used to highlight them. Secondary tumor effects, such as necrosis, hemorrhage, or cyst formation, modulate the MR appearance of brain tumors, generally by making them more conspicuous but at the same time more likely to be mistaken for a non-neoplastic lesion. If standard imaging sequences are used along with intravenous contrast enhancement, brain tumor detection is almost 100%.

The most common tumors of intra-axial location are gliomas and metastases. Gliomas derive from brain cells and are thus true brain tumors, whereas metastases are deposits of extradural malignancies; the former tend to be poorly demarcated from the normal brain parenchyma, whereas the latter are generally sharply demarcated. In cerebral hemispheric lesions, imaging in the axial or coronal plane is usually best, whereas in lesions at or near the midline, sagittal imaging is often most informative. Most MR radiologists prefer imaging in the axial plane as the first component of the standard tumor protocol.

MR imaging may gain importance in both development and application of novel nonsurgical brain tumor therapies. Prediction of tumor type and grading may become more reliable with more sophisticated imaging techniques and better data analysis.

Various subjects that are paired usually are not identically the same, asymmetry is perfectly normal but sometimes asymmetry can be noticeable too much. A major argument is that the human brain shows a substantial interaction between structurally, or ‘bottom-up’ asymmetry and cognitively, or ‘top-down’ modulation, through a focus of attention to the right or left side in auditory space. These results open up a more dynamic and interactive view of functional brain asymmetry than the traditional static view that the brain is lateralized, or asymmetric, only for specific stimuli and stimulus properties.

Structural and functional asymmetry in the human brain and nervous system is reviewed in a historical perspective. Brain asymmetry is one of such examples, which is a difference in size or shape, or both. Asymmetry analysis of brain has great importance because it is not only indicator for brain cancer but also predict future potential risk for the same. In our work, we have concentrated to segment the anatomical regions of brain, isolate the border line of each to investigate the presence of asymmetry of anatomical regions in MRI. We used three techniques i.e. contrast enhancement, binary homogeneity enhancement with uniform colour reduction and seeded region growing algorithm for the same.

The term asymmetry is often substituted for the term laterality when it comes to left–right differences in psychology and the neurosciences.3 However, while the term asymmetry can mean both structural and functional left–right dissimilarities, laterality is typically only used in relation to functional asymmetry.

Although symmetry is a fundamental organizing principle of the universe in both abstract conceptual sense and the explicit form of mirror symmetry in organisms, visual symmetry is not much in evidence in the natural world. A view of any purely natural scene shows few exactly symmetric objects, and those that are approximately symmetric are usually life forms of some sort. Thus, at the level of our perception, symmetry is something that is imposed on the world by animate organisms, either by virtue of their biological make-up or by the constructions of human civilization. This view is paradoxical in relation to artistic depictions, in which the background and compositional structure is often symmetrical, while the figures representing the action are usually asymmetrical. Similarly, symmetries of various kinds play a huge role in the composition of music, and may be regarded as the key factor that distinguishes this artificial auditory environment from undifferentiated noise. Thus, symmetry is a largely human concoction that weaves an interesting perceptual counterpoint through our understanding of, and interactions with, the world on the human scale of visual and auditory perception.

In a neuroscience perspective, the concepts of symmetry and asymmetry are closely tied to the two hemispheres of the human brain as shown in Figure 1, and the mirror symmetrical organization of the body along the vertical body axis, producing two mirror body halves. The two hands are also almost anatomically perfect mirror images of each other, but are clearly symmetrical with regard to function or physiology. A clear majority of the population (90%) prefers the right hand for manual activities, with superior fine motor control and motor strength. Thus, the example with left-and right-handedness poses an important conceptual distinction between structural, or object, symmetry and functional, or activity-related, asymmetry. Two objects may show mirror symmetry with regard to shape and structure, although the functions of the two are clearly asymmetrical. A similar distinction applies to the two cerebral hemispheres, which at least on the surface seems to be symmetrical mirror images, making up the left and right halves of the brain.

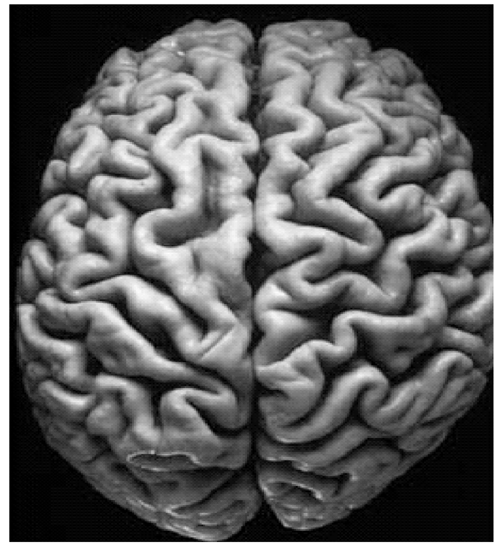

Figure 1 The human brain divides the brain into two halves, the right and left hemisphere, which are approximate mirror images of each other.

In 1864, the French neurologist Paul Broca made the observation that a patient with a vascular lesion that affected brain tissue in the middle frontal gyrus in the left hemisphere lost the ability to produce speech. This clinical syndrome later became known as Broca's, or expressive aphasia, indicating an inability to produce speech, while being able to understand when spoken to. Towards the end of 19th century another functional asymmetry was discovered, when the German neurologist Carl Wernicke made a similar observation, although in his case the patient, after a lesion to the left upper posterior part of the temporal lobe was unable to understand speech. This syndrome is known as Wernicke's, or impressive aphasia, i.e. the inability to understand when spoken to, although able to produce spontaneous speech.

It has been known for almost 150 years that the left hemispheres subserve language functions, while more recent research has pointed towards the right hemisphere as being specialized for processing of spatial relations and for emotional control. Although asymmetry is the norm when it comes to functions of the brain and nervous system, the mind also strives for symmetry, and sometimes 'symmetry breaking' is an aversive state of mind, to be avoided. This can be exemplified in compulsive-obsessive disorders where breaking a symmetrical behavioural pattern produces anxiety and is a clinical syndrome that seriously handicaps the patient. An obsessive-compulsive patient constructs a symmetrical inner world that should not be broken, and also shows stereotyped behaviour, e.g. only walking on left-right squares on the pavement. Thus, the distinction between structural and functional asymmetry is a key distinction when discussing symmetry and asymmetry in the brain and the nervous system.

To increase the utility of computerized tools, it would be intuitive to incorporate anatomical and pathological knowledge and heuristics to help the system draw diagnostic inferences. In neuro-imaging applications, for example, one way to perform this knowledge integration is to uncover symmetry/asymmetry information from the corresponding regions of the head and to explore its implication to positive clinical findings. To correctly quantify asymmetric patterns in brain images, however, the symmetry axis, or the symmetry plane, needs to be appropriately oriented in space; i.e., the symmetry plane needs to be correctly identified either manually or using computerized methods.

REVIEW WORKS

The human left and right cerebral hemispheres perform different functions is widely accepted. There is little evidence of whether or not similar functional asymmetries exist in non-human vertebrates. Rodents, cats, at least one species of marsupial, and macaque monkeys have consistent hand preferences for food reaching. These may result from constitutional factors, but in every species studied the distribution of preferences is unskewed. Canaries appear to have left-hemisphere dominance of vocal production, and there is limited support for the conjecture that macaque monkeys have left-hemisphere dominance for reception of species-specific cries and/or for short-term auditory memory. Left and right unilateral hemispheric damage may have appreciably different effects on emotionality in rats, sound localization in cats, and tactile discrimination in monkeys, although the available evidence is equivocal. It seems possible that asymmetries of cerebral function are widespread in vertebrates. In particular, left hemisphere dominance of species-specific communication might be common in birds and primates: left-hemisphere dominance of human speech may be an example of a general vertebrate tendency towards unilateral control of vocalization.

The assignment of different functions to the right and left hemisphere of the human brain is a crucial element of current neuropsychology [1-3]. The left hemisphere contains mechanisms responsible for speech, and is said to operate in a manner suitable for mental arithmetic and logical thought. These are important characteristics, and the left hemisphere was formerly held to be ‘dominant’ over the ‘minor’ right hemisphere. But more emphasis is now given to the minor hemisphere’s own specializations — perception and expression of emotion; knowledge of spatial relations, especially in connection with visual input; and generally, operations that take place in a wholistic, global, or Gestalt fashion.

The purpose of this review is not to examine in detail the nature of these asymmetries in human brain functions but to consider the extent to which differences between the left and right hemisphere mark off man from all other vertebrates. There are various ways in which lateralization of function could be related to uniquely human capacities of the brain. For instance, lateralization would be secondary to language, if it could be shown that possession of language induces cerebral asymmetry, rather than vice versa. Any other asymmetrically represented process could conceivably be the driving force behind lateralization, but linguistic competence is clearly a strong candidate. Possible alternatives are right-handedness [4-5] and the existence of a conscious self which communicates directly with only the left hemisphere[6-9]. In each of these cases we might suppose that human brains become lateralized only as a Consequence of the development of language, handedness or a perceiving self, and would therefore be surprised to find evidence of lateralization in non-human species which lack these characteristics.

As overwhelming advantages of cerebral asymmetry are not easily established by the study of individual differences in man, it is all the more important to investigate other sources of evidence as to its origin. Implicit in most theories is the view that lateralization is inextricably linked with especially human intellectual characteristics — if this is the case, the absence of lateralization of brain function in animals needs to be convincingly demonstrated.

On the other hand, if anatomical and functional precursors to human cerebral asymmetry can be found in species other than *Homo sapiens,* we might be provided with new clues concerning its existence in ourselves. I will discuss, first, some relevant aspects of comparative neuro-anatomy; second, what may be taken as firm features of human cerebral dominances; and third, evidence concerning the occurrence of these features in other animals.

Despite this degree of contralateral advantage, it must be stressed that, in terms of hemispheric specialization, audition offers a rather different set of possibilities than vision. A single hemisphere receives information from both ears, and may therefore operate on all auditory input, and make comparisons between right and left auditory fields, without the intervention of the other hemisphere. For instance, a single hemisphere could in theory localize a sound source at any point in the horizontal plane, or decode speech entering either ear, even in the absence of cerebral commissures. By comparison, for visual stimuli, a single hemisphere acting alone is restricted to its own half of the visual field. A mammalian hemisphere and to a limited extent, that of some other vertebrates[9] has the advantage of being able to compare inputs from the two eyes, arising from one point in the visual field, thus deriving stereoscopic depth. But the nature of the mammalian chiasma tends to retain the left-visual-fie1d-to-the-right-hemisphere system which occurs in lower vertebrates with side-facing eyes.

It is safe to say that interest in functional asymmetries has preceded the emphasis of human neuro-anatomical imbalance. But since [4-5] suggested that disparities between the surface area of the left and right planum temporale on the dorsal horizontal extension of the temporal lobe was related to left-sided localization of speech perception, considerably more data have become available. The planum temporale is a triangle of secondary auditory cortex, and is in the vicinity of the neurologically identified Wernicke’s area which, when damaged, impairs speech comprehension. Researchers found that out of 100 brains, 65 had a significantly larger planum temporale in the left hemisphere, compared to the right. Of the remaining 35 brains, 11 had a larger area on the right, and 14 were classified as symmetrical. The human brain thus appears to be typically, if not universally, asymmetrical in the region of the temporal/parietal boundary. Moreover; the primacy of the left planum temporale is already evident in foetal and neonatal brains. It is found that primary auditory cortex, immediately in front of the planum temporale, tends to be more extensive on the right, although there were enormous individual variations in their sample. A more general demonstration of the nature of hemispheric size differences has been obtained by a radiological brain scan technique. This does not at present allow for measurement of bounded areas such as the planum temporale, but provides a coarse-grained picture of living brains *in situ.* Since fixed brains may suffer up to 40 per cent shrinkage, and mechanical distortion, this is valuable additional evidence.

The results may be summarized as follows: the front of the human brain is wider on the right; the back of the human brain is wider on the left. This applied to individuals categorized as right-handed. For the left-handers, the frontal lobe still tended to be larger on the right, but was more often equal, and the right occipital lobe was also often the larger of the two.

PROPOSED APPROACH

The paper is based on the image segmentation method, which refers to the major step in image processing, the inputs are images and, outputs are the attributes extracted from those images. It will help to find out symmetric extraction of the brain image. The goal of segmentation is to isolate the regions of interest depending on the problem and its characters. A gray level image consists of two main features, namely region and edge. Segmentation algorithms for gray images are generally based on of two basic properties of image intensity values, discontinuity and similarity. The method is employed to segment an image into two symmetric regions based on finding pixels that are of similar in nature. The method has the advantage that it is fairly robust, quick, and parameter free except for its dependency on the order of pixel processing. The output is shown in figure 2.

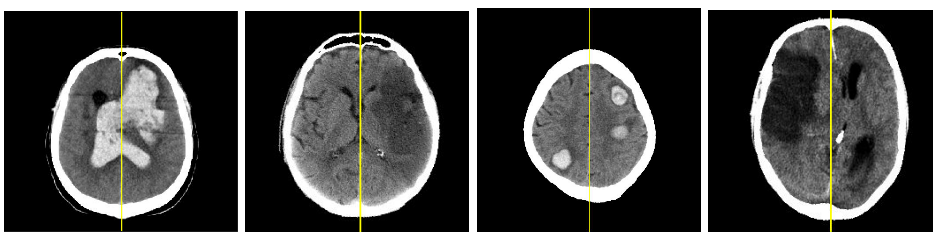

Figure 2 Ideal symmetry axis is extracted as the intersection of two halves brain image

Algorithm

Input: Digitized brain image stored in a two dimensional array

Step 1 Read the next Row of image (initially the first row) to a single dimensional array i.e. Row

Step 2 Determine the Mid Pixel position of the Row and Read the Intensity of Mid Pixel of Row

Step 3 Check the Mid Pixel Intensity with all the pixels stating from First to Last position of Row

Step 4 If any Pixel Intensity of the Row is greater than Maximum Threshold (MT) then divide the Row into two equal parts. If the total positions of Row are odd, then take floor value of Middle position assign to Mid

Step 5 Push (First and Mid) and (Mid+1 and Last) to stack respectively

Step 6 If any Pixel Intensity of the Row is not greater than MT then intensity of Mid pixel will be moved to all the pixels after modifying intensity value using uniform colour quantization technique in colour space breaking in eight level scales.

Step 7 if the stack is not empty then pop first and last position of Row and go to Step 2

Step 8 if it is not Last Row go to step 1

The findings of experimental result, using the algorithm, shows that the anatomical asymmetry very clearly indicated in brain image pair.

CONCLUSIONS

In the proposed method, we have processed brain image by proposed algorithm to produce the final result. The proposed method has been implemented by C language and outputs are given. The proposed technique, we have obtained 90% of near accurate result including accurate results and has the potential for further development.

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