CHAPTER 3

TEXTURE ANALYSIS AND BWM TEXTURE

3.1 TEXTURE

One of the fundamental and one of the major issues in image processing and computer vision is texture. It may be regarded as a macroscopic region, whose structure is simply attributed to the repetitive patterns in which elements are arranged to some rule. The textures of some objects can be particularly challenging due to movement (water), fine detail (skin surface and hair, grass, leaves) or their ethereal quality (cloud, glass). In digital images, texture is defined as a function of the spatial variation in pixel intensities (gray values). It is useful in a variety of applications and has been a subject of intense study by many researchers.

Texture analysis is one of the fundamental aspects of human vision by which we discriminate between surfaces and objects. An image is not just a random collection of pixels; it is a meaningful arrangement of regions and objects. A region in an image has a constant texture if a set of local statistics or other local properties of the picture function are constant, slowly varying, or approximately periodic. Image texture, defined as a function of the spatial variation in pixel intensities (gray values), is useful in a variety of applications and has been a subject of intense study by many researchers. One immediate application of image texture is the recognition of image regions using texture properties which is something that repeats with variation.
3.2 TEXTURE ANALYSIS

Images containing repeating patterns are said to be “textured”. Texture analysis of such images mainly concerns with feature extraction and image coding. An application of image texture analysis, for example, is the recognition of image regions in terms of texture properties. By representing a complex texture with a small number of measurable features or parameters, significant dimension reduction is feasible enabling automated texture processing. Texture analysis implies formulating a set of statistical measures on the image section being analyzed.

The analysis of texture parameters is a useful way of increasing the information obtainable from medical images with applications ranging from the segmentation of specific anatomical structures to detection of a lesion. Since there is no strict mathematical definition for texture, many different methods for computing texture features have been proposed over the years. There are four major issues in texture analysis as defined by Materka and Strzelecki (1998):

1. Feature extraction: to compute the characteristics of a digital image that could numerically describe its textural properties;

2. Texture discrimination: to partition a textured image into regions, each corresponding to a perceptually homogeneous texture (leads to image segmentation);

3. Texture classification: to determine to which of a finite number of physically defined classes (such as normal and abnormal tissue) a homogeneous texture region belongs;

4. Shape from texture: to reconstruct 3D surface geometry from texture information.
Texture analysis can be approached by some of the methods like geometrical, statistical, model-based and signal processing (transform) based and eigen-decomposition based methods.

### 3.2.1 Geometrical Method

This approach represents texture by well-defined primitives (*microtexture*) and a hierarchy of spatial arrangements (*macrotexture*) of those primitives. Materka and Strzelecki (1998) states that the advantage of the structural approach is that it provides a good symbolic description of the image; however, this feature is more useful for synthesis than analysis tasks.

### 3.2.2 Model Based Method

Syntactic models analyse the geometric structure of textures via spatial analytical techniques. Fractal analysis and structural approach are two main methods used to create syntactic models for textures. Fractals measure geometric complexity which could be used to describe many spatial patterns of texture. Structural approaches attempt to derive geometrical representations based on the concept that texture might be viewed as a spatial organisation of texture elements.

Probability Models generalise the feature based descriptive approach by deriving a probability model from the joint distribution of selected image features. It assumes each texture is generated by a particular underlying stochastic process and describes the texture by a model of the generative process. Typically, a probability model is specified by a joint probability distribution of texture features in which textures are characterised by model parameters.
3.2.3 Transform Based Method

Tianhorng and Jay Kuo (1993) has pointed out that spatial/frequency analysis could be performed using the methods such as Gabor transform, Wigner distribution and wavelet transform which provide good multiresolution analytical tools. A large class of natural textures can be modeled as a quasi-periodic pattern and detected by highly concentrated spatial frequencies and orientations.

3.2.4 Statistical Method

In contrast to other methods (above mentioned), this approach does not attempt to understand explicitly the hierarchical structure of the texture. Instead, they analyse the spatial distribution of gray-levels of the image in terms of its textural properties. Depending on the complexity of the image and amount of information to be extracted from the image, statistical method is divided into first order, second order and higher order statistics. First order statistics estimates mean, variance, skewness and flatness.

Methods based on second-order and higher order statistics (i.e. statistics given by pairs of pixels) have been shown to achieve higher discrimination rates than the power spectrum (transform-based) and structural methods says Materka and Strzelecki (1998). Srinivasan and Shobha (2008) have said statistical methods analyze the spatial distribution of gray values, by computing local features at each point in the image, and deriving a set of statistics from the distributions of the local features. The reason behind this is the fact that the spatial distribution of gray values is one of the defining qualities of texture. Jianguo and Tieniu (2002) says that in statistical methods, texture is described by a collection of statistics of selected features. The spatial dependence relationship can be incorporated by considering the distribution of intensities as well as the position of pixels with equal or nearly
equal intensity values. The technique involves statistically sampling the way certain graylevels occur in relation to other graylevels.

3.3 NEURONAL COMMUNICATION THROUGH WHITE MATTER

The brain is a very large network of different communication centers that can flash on and off and send messages to one another through electrical impulses. The human brain can be divided into major functional regions, each responsible for different kinds of applications, such as memory, sensory input and processing, executive function or even one’s own internal musing. The functional regions of the brain are linked by a network of white matter conduits. These communication channels help the brain coordinate and share information from the brain’s different regions. White matter is the tissue through which messages pass from different regions of the brain. Performing any cognitive task relies on coordinated processing in multiple, often distant brain regions. In the specific case of reading, the brain integrates signals from cortical regions specialized for processing visual, phonological and linguistic information. These regions are separated by many centimeters and thus depend on the accurate formation of specific white matter connections during development. Michal et al (2007) claims that skilled reading requires proficient processing in gray matter areas, as well as appropriate connection topology and efficient signal transmission within the white matter pathways.

3.4 BWM TEXTURE: DESCRIPTION AND CHARACTERIZATION

The texture characteristics of the BWM can be summarised as follows: Sarah-Jayne and Uta (2003) have said that there are various types of motion in the natural environment, of which motion of biological forms is essential to detect in order to predict the actions of other individuals.
Biological motion in living-systems refers to the way in which the neural signal travels from the brain to other parts of the body and vice versa. This transfer of information takes place through the channel called nerve fibres in the brain. When the message is transferred through the carriers like blood, oxygen, water etc., a particular pattern is followed for a given task. When the tissues are imaged under magnetic field in DTMRI technique, different types of tissues resonate distinctly giving rise to different extents of graylevel variations. Such gray-level variations depict the textural attributes of the white matter of the brain.

In general, the analytical description of the texture of an object is as follows: The features of a texture are decided by the spatial statistics of local gray value variations. (Normally, under Laplacian assumption of unknown statistics, the graylevels can be assumed to be uniformly distributed). The associated stochastical parameters can be specified by collecting image-signal statistics from the spatial domain of interest and can be used as feature descriptors of the image.

3.5 DTMRI IN WHITE MATTER TEXTURE MEASUREMENT

Magnetic resonance imaging is a very versatile imaging modality which is used to acquire structural or functional aspects of images from different organs. This being the state-of-the-art in the area of brain imaging that is used to identify diseases, effect of external stimulus on brain functions, segmentation of specific section in brain to study brain activities and to localize infected/affected area in the brain. It also images microscopic information that may not be assessed visually. Therefore texture analysis technique provides the means for obtaining this information.

The messages are sent down the axons through a process of electrical conduction. It is filled with a fluid containing a high concentration
of ions such as sodium, potassium, and chloride. When the electrical impulse flowing down the axon reaches its end, it spreads out in hundreds of nerve terminals that communicate with the dendrites and cell bodies of many other neurons. This transfer of messages results in a property called texture of brain white matter. This is in turn associated with movement of water molecules in tissues and is known as the diffusion (i.e. random motion). Diffusion is larger in directions along structures in tissues (e.g. white matter in brain or muscles) than in directions perpendicular to it and hence it is anisotropic.

However, a relatively new technique known as diffusion tensor magnetic resonance imaging, which enables visualization of the intrinsic directionality within the brain by detecting small movements in water molecules (Brownian motion) caused by their intrinsic kinetic energy dissipation. By measuring the diffusion of water from several (usually 6) different planes, one can reconstruct the directionality of structures, particularly large white matter fiber bundles, by using a tensor (3 x 3 matrix); this process is known as diffusion tensor imaging. The addition of other scan pulses sensitized to different direction of diffusion enables the calculation of a vector for each voxel that describes the primary direction of water movement in that area. Color mapping of this data produces brilliant images detailing white matter pathway trajectories. This gives promise as a new way of further understanding the anatomy of the brain, as well as a tool for diagnosing several common pathological conditions.

3.6 CHANGES IN MORPHOLOGY OF BRAIN WHITE MATTER

Lars et al (2010) describes that the fast and efficient information processing between different brain areas is a prerequisite of higher cognitive abilities. White matter pathways connecting brain networks provide a foundation for such abilities. White matter integrity and speed of information
processing are especially prone to ageing effects, and thus age-related cognitive decline may occur as a result of cortical disconnection. Age-related decline in the performance of these tasks might reflect changes in functional integration rather than dysfunction of specific gray matter areas. A plausible anatomic substrate for functional disconnection is disruption of the white matter tracts that link the components of distributed neurocognitive networks, or “structural disconnection”. A postmortem study has provided evidence that normal ageing is accompanied by a loss of white matter fibers, particularly small, myelinated fibers says O’Sullivan et al (2001).

Knowledge about these white matter connections should enhance the understanding of normal brain function. Such knowledge should also help for diagnosing certain pathological disorders in patients. For example, recent research has found white matter pathway syndromes related to language. Furthermore, an understanding of white matter structure could help surgeons to avoid damaging important pathways.