Chapter one
Introduction

Digital imaging technologies have become indispensable components for clinical procedures. Major advances in the field of medical imaging and computer technology have created opportunity for quantitative analyses of medical images and provided powerful techniques to probe the structure, pathology and function of the human body. The availability of many different imaging modalities increased the requirement for significant innovations to obtain accurate and fast results in all aspect of image processing.

A lot of researches in medical imaging are focused on pathology diagnosis of abdominal organs such as spleen, liver, kidney and gallbladder. Texture analysis is an important step for radiological operations such as diagnosis, study of anatomical structures, quantification of volumes of tissues, treatment planning, localization of pathologies and computer aided surgery. Liver imaging can be performed with ultrasonography, CT and MRI. MRIs have higher contrast resolution. MRIs have many advantages for image navigation, such as good soft tissue contrast, free form ionizing radiation and multi-planar capabilities. However, the image analysis is a big challenging because, smaller edge magnitudes in MRIs cause edge-based segmentation algorithms to be more complicated. Also, partial volume effects and artifacts due to motion and pulsation in MRIs lead to more challenges in characterization of liver.

The analysis of texture parameters is a useful way of increasing the information obtainable from medical images. It is an ongoing field of research, with applications ranging from the segmentation of specific anatomical structures and the detection of lesions, to differentiation

between pathological and healthy tissue in different organs. Texture analysis uses radiological images obtained in routine diagnostic practice, but involves an ensemble of mathematical computations performed with the data contained within the images.

The texture of images refers to the appearance, structure and arrangement of the parts of an object within the image. Images used for diagnostic purposes in clinical practice are digital. A two dimensional digital image is composed of little rectangular blocks or pixels (picture elements), and a three-dimensional digital image is composed of little volume blocks called voxels (volume elements); each is represented by a set of coordinates in space, and each has a value, representing the grey-level intensity of that picture or volume element in space. Since most medical images are two-dimensional we will restrict the discussion to pixels, bearing in mind that the extension to voxels and volumetric images is straightforward. We may attribute the texture concept in a digital image to the distribution of grey-level values among the pixels of a given region of interest in the image. Thus, texture analysis is in principle a technique for evaluating the position and intensity of signal features, i.e. pixels, and their grey-level intensity in digital images (Caslellano et al 2004).

Texture features are, in fact, mathematical parameters computed from the distribution of pixels, which characterize the texture type and thus the underlying structure of the objects shown in the image. According to the methods employed to evaluate the inter-relationships of the pixels, the forms of texture analyses are categorized as structural, model-based, statistical and transform methods Medical images possess a vast amount of texture information relevant to clinical practice. (Caslellano et al 2004).

1.1 Segmentation

Segmentation is the process of partitioning a digital image into multiple segments .The goal of segmentation is to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze. Image segmentation is typically used to locate objects and boundaries (lines, curves, etc.) in images (R.C. Gonzalez et al 2002). .More precisely; image segmentation is the process of assigning label to every pixel in an image such that pixels with the same label share certain visual characteristics. The result of image segmentation is a set of segments that collectively cover the entire image (B.Georgescu et al 2003) or a set of contours extracted from the image .Each of the pixels in a region is similar with respect to some characteristic or computed property, such as color, intensity, or texture.

1-2 Anatomy of the Human Abdomen

The abdomen is a roughly cylindrical chamber constitutes the part of the human body between the inferior margin of the thorax at the thoracic diaphragm and the superior margin of the pelvis at the pelvic brim. The inferior thoracic aperture is the superior opening to the human abdomen and it is closed by the diaphragm. The boundaries of the abdominal cavity are the abdominal wall. The human abdominal wall, which is a muscular structure protected by fascia, skin and fat, is continuous with the pelvic wall at the pelvic inlet. Abdominal viscera, which include major elements of the gastrointestinal system, major neurovascular structures, the spleen, kidneys and ureters, are either suspended in the peritoneal cavity by mesenteries or are located between the cavity and the musculoskeletal wall. (Drake et al 2004).

1-1-1 Anatomy f the Liver

The liver is a roughly triangular organ that extends across the entire abdominal cavity just inferior to the diaphragm. Most of the liver's mass is located on the right side of the body where it descends inferiorly toward the right kidney. The liver is made of very soft, pinkish-brown tissues encapsulated by a connective tissue capsule. This capsule is further covered and reinforced by the peritoneum of the abdominal cavity, which protects the liver and holds it in place within the abdomen (Richard Drake.et, al 2004).

The peritoneum connects the liver in 4 locations: the coronary ligament, the left and right triangular ligaments, and the falciform ligament. These connections are not true ligaments in the anatomical sense; rather, they are condensed regions of peritoneal membrane that support the liver.

- The wide *coronary ligament* connects the central superior portion of the liver to the diaphragm.
- Located on the lateral borders of the left and right lobes, respectively, the *left* and *right triangular ligaments* connect the superior ends of the liver to the diaphragm.
- The *falciform ligament* runs inferiorly from the diaphragm across the anterior edge of the liver to its inferior border. At the inferior end of the liver, the falciform ligament forms the round ligament (ligamentum teres) of the liver and connects the liver to the umbilicus. The round ligament is a remnant of the umbilical vein that carries blood into the body during fetal development.

The liver consists of 4 distinct lobes – the left, right, caudate, and quadrate lobes.

- The left and right lobes are the largest lobes and are separated by the falciform ligament. The **right lobe** is about 5 to 6 times larger than the tapered left lobe.
- The small **caudate lobe** extends from the posterior side of the right lobe and wraps around the inferior vena cava.
- The small **quadrate lobe** is inferior to the caudate lobe and extends from the posterior side of the right lobe and wraps around the gallbladder.

Bile Ducts

The tubes that carry bile through the liver and **gallbladder** are known as bile ducts and form a branched structure known as the biliary tree. Bile produced by liver cells drains into microscopic canals known as bile canaliculi. The countless bile canaliculi join together into many larger bile ducts found throughout the liver.

These bile ducts next join to form the larger left and right **hepatic ducts**, which carry bile from the left and right lobes of the liver. Those two hepatic ducts join to form the common hepatic duct that drains all bile away from the liver. The common hepatic duct finally joins with the cystic duct from the gallbladder to form the **common bile duct**, carrying bile to the duodenum of the small intestine. Most of the bile produced by the liver is pushed back up the cystic duct by peristalsis to arrive in the gallbladder for storage, until it is needed for digestion.

Blood Vessels

The blood supply of the liver is unique among all organs of the body due to the hepatic portal vein system. Blood traveling to the **spleen**, **stomach**, **pancreas**, gallbladder, and **intestines** passes through capillaries in these organs and is collected into the **hepatic portal vein**. The hepatic portal vein then delivers this blood to the tissues of the liver where the contents of the blood are divided up into smaller vessels and processed before being passed on to the rest of the body. Blood leaving the tissues of the liver collects into the **hepatic veins** that lead to the **vena cava** and return to the **heart**. The liver also has its own system of arteries and arterioles that provide oxygenated blood to its tissues just like any other organ.

Lobules

The internal structure of the liver is made of around 100,000 small hexagonal functional units known as lobules. Each lobule consists of a central vein surrounded by 6 hepatic portal veins and 6 hepatic arteries. These blood vessels are connected by many capillary-like tubes called **sinusoids**, which extend from the portal veins and arteries to meet the central vein like spokes on a wheel.

Each sinusoid passes through liver tissue containing 2 main cell types: Kupffer cells and hepatocytes.

- *Kupffer cells* are a type of macrophage that capture and break down old, worn out red blood cells passing through the sinusoids.
- *Hepatocytes* are cuboidal epithelial cells that line the sinusoids and make up the majority of cells in the liver. Hepatocytes perform most of the liver's functions – metabolism, storage, digestion, and bile production. Tiny bile collection vessels known as bile

canaliculi run parallel to the sinusoids on the other side of the hepatocytes and drain into the bile ducts of the liver. (Richard Drake.et, al 2004).

1-3 Physiology of the Liver

Digestion

The liver plays an active role in the process of digestion through the production of *bile*. Bile is a mixture of water, bile salts, cholesterol, and the pigment bilirubin. Hepatocytes in the liver produce bile, which then passes through the bile ducts to be stored in the gallbladder. When food containing fats reaches the **duodenum**, the cells of the duodenum release the hormone cholecystokinin to stimulate the gallbladder to release bile. Bile travels through the bile ducts and is released into the duodenum where it emulsifies large masses of fat. The emulsification of **fats** by bile turns the large clumps of fat into smaller pieces that have more surface area and are therefore easier for the body to digest.

Bilirubin present in bile is a product of the liver's digestion of worn out red blood cells. Kupffer cells in the liver catch and destroy old, worn out red blood cells and pass their components on to hepatocytes. Hepatocytes metabolize hemoglobin, the red oxygen-carrying pigment of red blood cells, into the components *heme* and *globin*. Globin protein is further broken down and used as an energy source for the body. The iron-containing heme group cannot be recycled by the body and is converted into the pigment bilirubin and added to bile to be excreted from the body. Bilirubin gives bile its distinctive greenish color. Intestinal bacteria further convert bilirubin into the brown pigment stercobilin, which gives feces their brown color.

Metabolism

The hepatocytes of the liver are tasked with many of the important metabolic jobs that support

the cells of the body. Because all of the blood leaving the digestive system passes through the hepatic portal vein, the liver is responsible for metabolizing carbohydrate, lipids, and proteins into biologically useful materials.

Digestive system breaks down carbohydrates into the monosaccharide glucose, which cells use as a primary energy source. Blood entering the liver through the hepatic portal vein is extremely rich in glucose from digested food. Hepatocytes absorb much of this glucose and store it as the macromolecule glycogen, a branched polysaccharide that allows the hepatocytes to pack away large amounts of glucose and quickly release glucose between meals. The absorption and release of glucose by the hepatocytes helps to maintain homeostasis and protects the rest of the body from dangerous spikes and drops in the blood glucose level. (See more about **glucose in the body**.)

Fatty acids in the blood passing through the liver are absorbed by hepatocytes and metabolized to produce energy in the form of ATP. Glycerol, another lipid component, is converted into glucose by hepatocytes through the process of gluconeogenesis. Hepatocytes can also produce lipids like cholesterol, phospholipids, and lipoproteins that are used by other cells throughout the body. Much of the cholesterol produced by hepatocytes gets excreted from the body as a component of bile.

Dietary proteins are broken down into their component amino acids by the digestive system before being passed on to the hepatic portal vein. Amino acids entering the liver require metabolic processing before they can be used as an energy source. Hepatocytes first remove the amine groups of the amino acids and convert them into ammonia and eventually urea. Urea is less toxic than ammonia and can be excreted in urine as a waste product of digestion. The

remaining parts of the amino acids can be broken down into ATP or converted into new glucose molecules through the process of gluconeogenesis.

Detoxification

As blood from the digestive organs passes through the hepatic portal circulation; the hepatocytes of the liver monitor the contents of the blood and remove many potentially toxic substances before they can reach the rest of the body. Enzymes in hepatocytes metabolize many of these toxins such as alcohol and drugs into their inactive metabolites. And in order to keep hormone levels within homeostatic limits, the liver also metabolizes and removes from circulation hormones produced by the body's own glands.

Storage

The liver provides storage of many essential nutrients, vitamins, and minerals obtained from blood passing through the hepatic portal system. Glucose is transported into hepatocytes under the influence of the hormone insulin and stored as the polysaccharide glycogen. Hepatocytes also absorb and store fatty acids from digested triglycerides. The storage of these nutrients allows the liver to maintain the homeostasis of blood glucose. Our liver also stores **vitamins and minerals** - such as vitamins A, D, E, K, and B12, and the minerals iron and copper - in order to provide a constant supply of these essential substances to the tissues of the body.

Production

The liver is responsible for the production of several vital protein components of blood plasma: prothrombin, fibrinogen, and albumins. Prothrombin and fibrinogen proteins are coagulation factors involved in the formation of blood clots. Albumins are proteins that maintain the isotonic

environment of the blood so that cells of the body do not gain or lose water in the presence of body fluids.

Immunity

The liver functions as an organ of the **immune system** through the function of the Kupffer cells that line the sinusoids. Kupffer cells are a type of fixed macrophage that form part of the mononuclear phagocyte system along with macrophages in the spleen and **lymph nodes**. Kupffer cells play an important role by capturing and digesting bacteria, fungi, parasites, worn-out blood cells, and cellular debris. The large volume of blood passing through the hepatic portal system and the liver allows Kupffer cells to clean large volumes of blood very quickly.

(Richard Drake.et, al 2004).

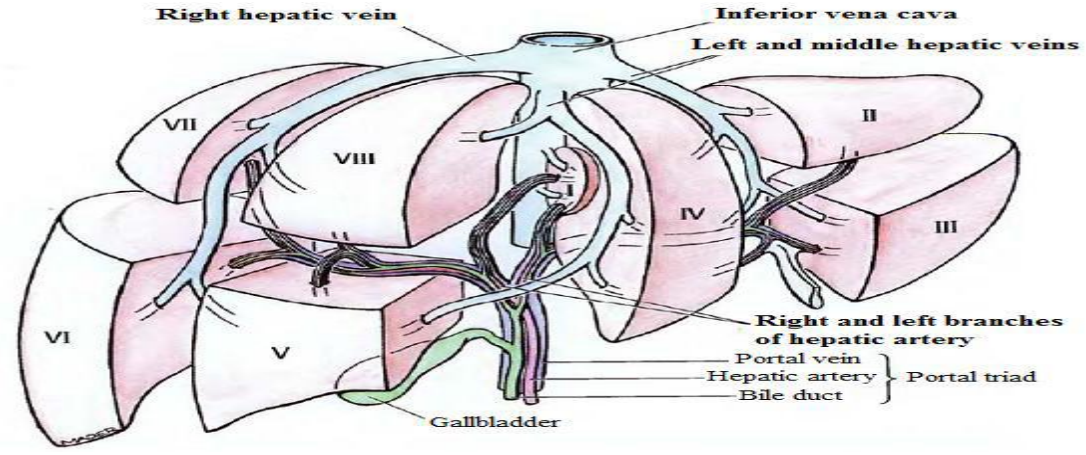

Figure 1.1. Subdivision of the liver into the eight Couinaud segments by the portal vein and the hepatic veins.

1-4 Abdominal Imaging

Abdominal imaging that provides diagnostic imaging and intervention of abdominal and pelvic disorders is an important specialty in diagnostic radiology. Interactions with surgical and medical subspecialties, extensive clinical experience for optimal patient care are provided by this

specialty of the diagnostic radiology. Digital image processing methods are used to extract more detailed information or to obtain measurements that are useful for planning treatments or surgeries (Bidaut et al 2000).

1-4-1 MR Imaging

MR imaging is widespread used for several clinical purposes as a medical imaging technique and will be used in future more intensively. Interpretation of an MR image contrast resolution is based on how the image was acquired. Image quality optimization and improvement, conspicuity of pathologic findings with reduced error can be provided by understanding the fundamental principles of MRI. Therefore, the methods used to obtain the image are extremely important and should be well understood. However, by nature MRI, which is based on observation of the resonance phenomenon through electromagnetic detection at the resonance frequency, is considered a complex modality by many radiologists and clinicians. There are many degrees of freedom in acquisition parameters for MRI when we compare with other imaging techniques. The main difficulty to understand MRI and its different modalities are due to its technique that involves physics, digital signal processing, electronics and mathematics areas. (Evgin et al 2013).

1-5 Problem of the study:

Organ texture analysis from medical images is still an open problem and liver segmentation is much more challenging task among other organ segmentations due to several reasons. One of them is high intra- and inter-patient variability of liver shapes. Another reason is that the artifacts such as beam hardening, reconstruction artifacts and noise cause image quality degradation while movements of patients cause blurred boundaries. Also, varying conditions for

machine setup lead to very high variability's of intensity values both in datasets of different patients and even in each slice of the same dataset of a patient. Moreover, liver has different positions and very similar intensity values with the adjacent organs that are kidney and heart in addition to the variation of the intensity throughout the liver from the right lobe to the left lobe including the other lobes.

1-6 Objectives

The general objective of this study was to characterization and segments the liver in MR images in order to have subjective method to of classification and delineation of liver.

***Specific objective*:**

- To write the Algorithm that read MR image and segment the region of interest (ROI).
- To classify the region into liver tissues, ligaments, portal and hepatic vein stone and other vessels e.g. IVC
- To find a multiple regression equations, which can be used in a routine work to demarcate and recognize the classified region by click button.
- To find the accuracy, of the applied algorithm and the classification power of the applied textural features.

1-7 Important of the study:

This study will provides a means of liver segmentation from an axial MR image which will help in further classify the segmented image looking any abnormality or for stereography which depend on the organ size or dimensions for diagnosis or reconstructing the image in any different orientation for pathological evaluation.

1-8 Overview of the study:

Chapter one was an introduction .chapter two overviewed the available literatures. Whereas chapters three demonstrated the methodology used in the study. Chapter four presented the

obtained result and analysis, and finally chapter five discussed the result and states the conclusions, and recommendation, Appendix and reference.