Ministry of Higher Education and Scientific Research, Al-Andalus Private University for Medical Sciences, College of Biomedical Engineering

Improvement and detection of lumbar disc herniation using MRI images

Spinal disc herniation image enhancement and Detection from MRI

A thesis prepared to meet the requirements of the applied project

Student presentation

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Summary

shinesThe spine is a series of bones that overlap each other like building blocks, separated by pads. They are called discs and help absorb load and pressure. Spinal diseases are one of the most important problems. Health problems that affect the body.

A herniated nucleus pulposus, also known as a slipped disc, is a common and widespread spinal condition. It occurs when the disc between the vertebrae, which cushions the vertebrae along the spine, ruptures. This causes severe back pain, and any delay in treatment can lead to nerve damage. Detecting and demonstrating lumbar disc herniation using image processing is beneficial for increasing diagnostic accuracy and reducing human error resulting from fatigue and visual errors. core

The idea of this project is to process images of lumbar disc herniation captured by MRI by segmenting the herniation area and determining its location more clearly, enabling doctors to take the necessary steps to treat, study, and diagnose this condition better. Through this project, we will use MATLAB to process MRI images using medical image processing algorithms for detection and display.

ABSTRACT

separated by cushions called discs that help absorb load and pressure, and diseases The spine consists of a series of bones that overlap each other like building blocks,
The spine is one of the most important health problems that affect the body.

Considered one of the common and widespread cases of diseases of the spine, and The herniation of the pulpal nucleus or what is known as a herniated disc (disc) is
vertebrae, and leads to the occurrence of Excruciating back pain and any delay distributed along the spine, where the work of the cushion works between the it is a rupture that occurs in the disc located between the vertebrae that is
may lead to nerve damage. The detection and presentation of cases of lumbar
Pulpal herniation by image processing is useful to increase the accuracy of diagnosis, and to reduce human errors resulting from fatigue and visual errors.

hernia area, and determining its location more clearly so that doctors can take the lumbar nucleus pulposus captured by the resonator device (MRI) by dividing the The idea of this project is to process the images of cases of herniation of the
necessary steps for treatment, study and diagnosis of this condition better, and
Through In this project, we will use MATLAB software to process resonator .images using medical image processing algorithms for detection and visualization

Chapter One

Project introduction

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Chapter One

Project introduction

In this chapter, we present an introduction to our project, its importance, and the goals we worked to achieve during

Academic year 2022-2023.

1-1 Introduction:

The spine is a very important organ in the body as it controls movement, nerves and many other functions.

Other organs that depend on the spine, and the spine is functionally responsible on the one hand for keeping the body

In an upright position – it bears the weight of the head, trunk and arms – and on the other hand, the spine protects the spinal cord

The spinal cord. This part is considered one of the most important parts of the human body, or living organisms in general, because it is a focal point.

It is essential for controlling the ability to sit, stand and walk, thanks to its congenital components.

The human spine consists of a series of irregular bones called vertebrae, numbered 33, extending from

From the middle of the base of the skull to the coccyx area to protect the spinal cord.

Spinal problems are considered health problems that greatly affect human life, especially since

These problems result in an inability to move.

The most important of these diseases and problems are the following:

Herniated disc:

It is also known as a “herniated disc between the vertebrae,” and occurs as a result of increased heavy loads on the vertebrae, which

It causes increased pressure on the nerve root, causing severe roughness in the vertebral joints. This causes...

The disease causes severe pain in the lower back, along with sciatica. Despite the difficulty

This condition and the severity of the pain associated with it, but it is treated automatically, after taking doses of medication from

Anti-inflammatories, along with getting enough rest when there are severe cases

Difficulty, which may require surgical intervention, after the patient undergoes some medical examinations, such as:

Perform MRI and CT scans.

Herniated disc is a common disease that occupies a large part of people’s attention because it occurs at all ages.

It is rare under the age of twenty and over the age of sixty, and reaches its peak in the fourth decade of life and is seen at a rate of

It is higher in males, with lumbar disc herniation accounting for 90% of cases and cervical disc herniation accounting for 10% of cases. In the same context,

It is 70% more common in males than 30% in females.

Different methods are used to image the spine, such as magnetic resonance imaging (MRI), which is a method

Good for clearly showing between the vertebrae, and MRI is not invasive and does not use

Ionizing radiation, but more importantlyIt provides good contrast to soft tissues allowing visualization of the internal structure.

For the disc.

2-1 The importance of the project and its objectives:

The importance of the research lies in the fact that it:

- It deals with the topic of disc herniation, which is considered one of the most common diseases of the spine..

- It deals with the detection and presentation of lumbar disc herniation cases by image processing to increase accuracy.

Diagnosis and reduction of human errors.

- The main objective of the project is:Processing of images of lumbar disc herniation cases captured by

MRI can segment the hernia area and determine its location more clearly to enable doctors

To take the necessary steps to treat, study and diagnose this condition better.

Through this project, we will use the MATLAB program to process the MRI images using algorithms.

Medical image processing for detection and display.

3-1 Project Problem:

Automated segmentation methods provide reproducible results, while reducing the need for manual interaction time.

Segmentation methods are crucial elements in medical image analysis, especially in the areas of image-assisted diagnosis.

Computer and image-guided surgery and radiation therapy planning.

Furthermore, fragmentation of degenerated intervertebral discs remains an unresolved problem. Diagnosis

Computer-aided segmentation requires a method capable of accurately identifying the intervertebral discs at different stages of

Disease (from normal to severely deteriorated) in terms of the required segmentation accuracy.

4-1 Chapter Content:

The project consists of several chapters. In the first chapter, we provide: a general introduction to the project and its importance.

Its objectives and the content of the project chapters.

In the second chapter we talk about: the basic theoretical concepts related to the spine and herniated nucleus pulposus, with mention of:

Imaging techniques used to detect this disease.

In the third chapter, we mentioned some previous studies related to our project.

We will leave the fourth chapter to talk about the practical part of the project and its components in general and the techniques used in it.

Image processing and our results are followed by a list of references used in this study.

Chapter Two

Basic concepts

Chapter Two

Basic concepts

In this chapter, we will review the basic concepts and theoretical information related to our project, which

It will be the cornerstone on which the entire project is built.

1-2 Anatomy of the spine:

The spine is a bony structure in the middle of the back that extends from the skull to the pelvis and is usually made up of:

33 vertebrae divided into segments: 7 cervical vertebrae, 12 thoracic vertebrae, 5 lumbar vertebrae, 5 sacral vertebrae and 4

Coccygeal vertebrae, as shown in Figure (2-1), where the sacral and coccygeal vertebrae fuse together to form a continuous bone.

It is called the sacrum and coccyx.

This study is based on the spine in the lumbar vertebrae region in the lower back area and consists of five

Vertebrae called (L1-L5) are connected axially by intervertebral discs that provide stability.

The flexibility of the spine is also stabilized by ligaments, muscles and spinal cord.

The spinal cord and nerve roots pass through a longitudinal cavity called the spinal canal (taken from references 1 and 2).

2) .

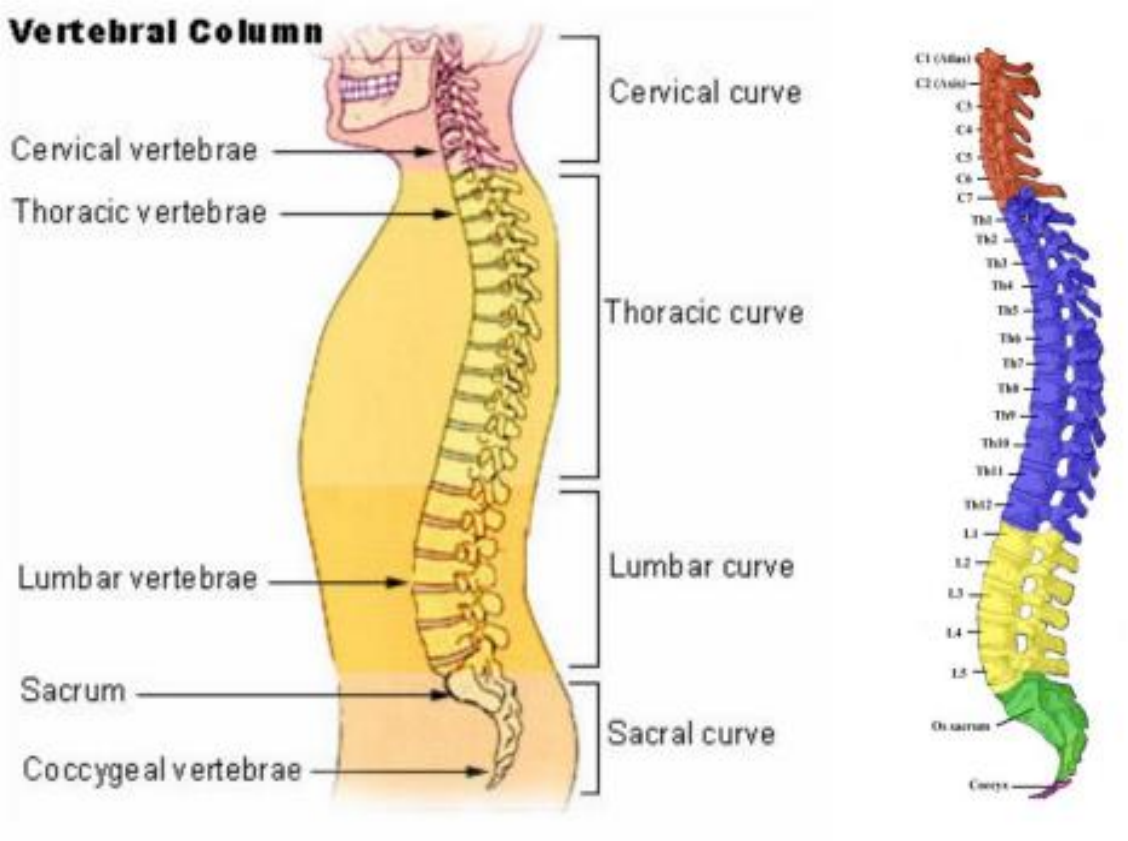


Figure (2-1) shows the anatomical division of the spine (taken from Reference No. 3)

1-1-2 Sections of the vertebrae of the spine:

The spine is divided into five sections based on the structure of each section. Below we will explain these sections:

1- Cervical vertebrae: They are seven vertebrae located at the beginning of the spinal column from the top, starting from the first vertebra.

Known as the "atlas" and then the "axis" vertebra followed by the remaining five vertebrae, the cervical vertebrae are characterized by

Containing the following structures:

• Spina bifida.

• Transverse hole.

• Triangular vertebral foramen.

2- Dorsal vertebrae: The dorsal vertebrae carry the thoracic ribs and are twelve vertebrae following the cervical vertebrae.

The pre-sacral area is concave forward and is numbered from 1 to 12.

3- Lumbar vertebrae: The lumbar vertebrae are located between the back and sacrum. They are characterized by a kidney-like body and sacral plates.

Short and thick, they are five backward-concave vertebrae followed by numbers 1 through 5.

4- The sacral vertebrae: They are five vertebrae fused together to form a triangular-like structure with a top and a base.

The apex is sometimes fused with the coccygeal vertebrae.

5-Coccyx: It is located at the end of the spine after the sacrum and consists of:4 vertebrae connected by gelatinous discs,

The coccyx acts as a link between some of the pelvic floor muscles and also helps in the process of balance.

Body while sitting (taken from reference no.4).

2-1-2 Installation of the vertebrae of the spine:

The vertebrae of the spine consist of two main parts as follows:

1- Anterior vertebral body: The body consists of spongy bony material and red marrow surrounded by sphenoid membranes.

The upper and lower vertebrae are surrounded by a ring of compressed bony plates and represent the anterior part of the vertebra.

It is larger the further down the spine we go, because the vertebral body is responsible for carrying the weight.

The weight and therefore requires more force to carry the increased weight to the lower part of the body.

2- The posterior vertebral arch: It is the back part of the vertebra and consists of bony protrusions to which the muscles are attached.

Ligaments and joints divide these bony protrusions into five sections as follows:

1) Spinal process.

2) Transverse protrusion.

3) The neck.

4) The plate.

5) Articular process.

The vertebrae are separated from each other by intervertebral discs, which are made of fibrous tissue.

Collagen and cartilage provide shock absorption for the vertebrae, and each pair of vertebrae creates a unit.

Animated (taken from reference No.4).

3-1-2 The spinal cord and its functions:

The spinal cord extends within the vertebral canal, which is formed by the posterior parts of the vertebrae. Thirty-one pairs of nerves branch out from the

Nerves travel from the spinal cord through the vertebrae, carrying messages between the brain and every part of the body.

The spinal cord is a long cylinder made up of nerves that extend from the base of the brain through the spinal canal.

The spine, and the spinal cord, are part of the central nervous system in the brain.

The spinal cord is divided into different segments, each containing roots and a pair of nerve fibers.

The spinal cord is about 45 cm long and 1 cm in diameter in adults. It has many

Important functions in the body (taken from reference No. 4).

There are three layers that protect the spinal cord and these layers are called "meninges" and they are as follows:

Meninges: This is the outer layer of the meninges in the spinal cord.

Epidural space: Located between the dura and the arachnoid space, where doctors can inject a local anesthetic to reduce...

From pain during childbirth and some surgeries.

Arachnoid mater: The middle layer that covers the spinal cord.

Subarachnoid space: Located between the arachnoid mater and the pia mater, and the cerebrospinal fluid is located in this space.

The square.

Pia mater: The pia mater is the layer that directly covers the spinal cord.

If we take a horizontal slice of the spinal cord, we will see a circular area in the middle covered with protective layers.

(Meninges) From this circular area extend nerves that extend from the spinal cord to provide sensation to areas of the brain.

Different in the body.

The main areas of the spinal cord transverse section include the following: as shown in Figure (2-2):

1- Gray matter: It is the dark, butterfly-shaped area of the spinal cord that consists of:

From nerve cell bodies.

2- White matter: White matter surrounds the gray matter in the spinal cord and contains:

On cells coated with myelin, which makes the transmission of impulses occur more quickly. Nerve cells in

Gray matter is not myelinated.

3- Posterior root: It is a part of the nerve that branches from the back of the spine.

Vertebral, looking at the cross-section of the spinal cord, the upper wings of the gray matter "butterfly" reach

To the bones of the spine and the wings point towards the front of the body and its internal organs.

4- Anterior root: It is a part of the nerve that branches from the front part of the spine.

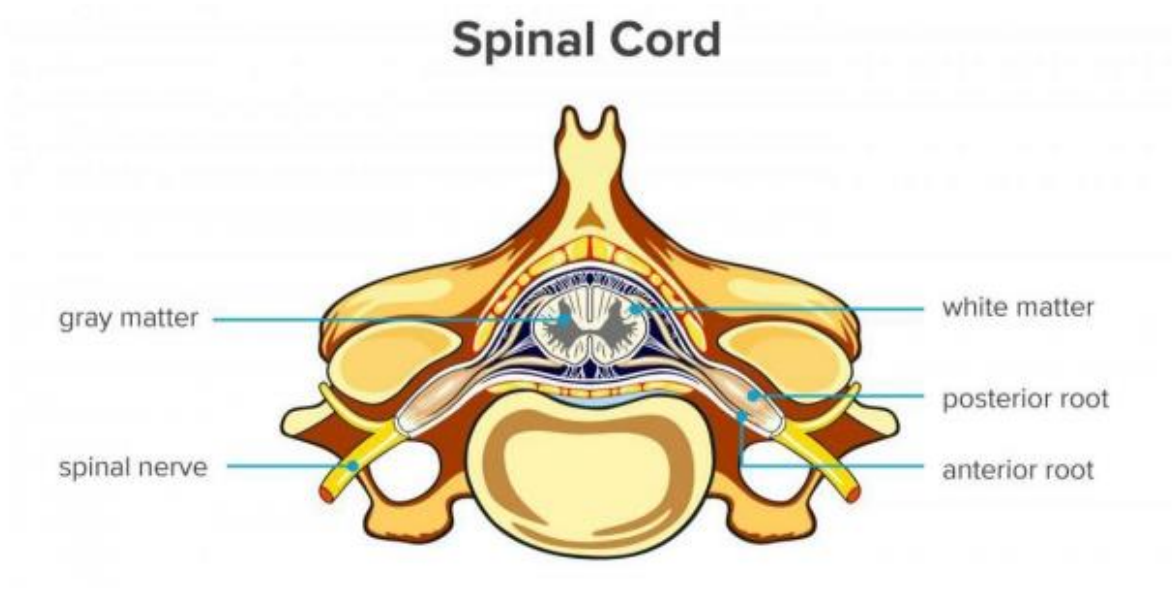
Backbone.

5- Spinal ganglion: It is a group of nerve bodies that contain nerve cells.

Sensory nerve.

6- Spinal nerve: The posterior and anterior roots come together to create the spinal nerve.

These nerves control sensation in the body as well as movement, and as we mentioned, their number is 31 pairs.



Shape (2-2) Schematic diagram showing the different anatomical locations of a spinal cord tumor (taken from Ref. number5)

4-1-2 Functions of the spinal cord:

1- Electrical communications: Electrical signals are carried up and down the spinal cord, thus

It allows communication between different parts of the body and the brain as it passes through different levels of

trunk

2- Walking and movement: Many muscle movements in the legs are coordinated during movement.

3- Reflexes: It is an involuntary response that can be predicted through stimuli that include the brain and the spinal cord.

Spinal, nerve, and peripheral nervous system (taken from reference 4).

5-1-2 Parts of the spinal cord:

The spinal cord is a single unit, receiving and sending signals to and from the brain and to the rest of the body.

The body is the link between the brain and the body. The spinal cord consists of a group of sub-parts.

Specifically, each one has its own function.

The spinal cord consists of several parts:

1- The cervical spinal cord: It extends along the first seven cervical vertebrae and plays an important role in:

Critical functions such as breathing and upper trunk movement, so if this area is affected, it may suffer.

The person is quadriplegic, and it can sometimes be fatal.

2- Thoracic spinal cord: It extends along and within the 12 thoracic vertebrae and helps the spinal cord

Thoracic coordination of movement in the lower body.

3- The lumbar spinal cord: It is located inside and along the five lumbar vertebrae, where the spinal cord coordinates...

Lumbar pain is a sensation in the lower parts of the body. If this area is affected, it may affect the bladder.

And sexual functions.

4- The sacral spinal cord: extends inside the sacral vertebrae, and is responsible for chronic pain.

5- Coccyx: It is the tail bone and consists of 3 to 5 distinct bones that are joined together.

2-2 Intervertebral discs:

They are the structures located between the vertebrae of the spine and work to absorb and distribute pressure and load on the spine.

The vertebral discs are made up of different components and are characterised by different thicknesses in different parts of the spine.

The spine, moreover, connects and holds the surfaces of the vertebrae.

Components of the intervertebral discs:

Each intervertebral disc consists of two main components: the nucleus pulposus (hydrogel) in the center of the disc and the annulus fibrosus.

It is a collagen ring surrounding the nucleus.

The nucleus pulposus is composed mainly of water, proteoglycans, and collagen molecules. Water represents more than

80% of the nucleus weight in children and young people.

Proteoglycans are the large molecules responsible for attracting and retaining water and thus maintaining

Nucleus pulposus moisture.

The annulus fibrosus is made up of multiple concentric collagenous layers called lamellae that surround

By nucleus

These plates are composed of collagen fibers that align in alternating directions and are the basic component of the ring.

It is also water, but at a lower concentration than the nucleus of the disc (60-70%). On the other hand, the ring has a higher

High concentration of collagen (about 50% of dry weight) which is responsible for the strength of the disc.

The core and annulus work together as a functional unit to equally distribute the compressive load of the body weight.

And resistance to tensile and loads resulting from extension, flexion and rotation, and with the aging of the intervertebral disc, which is subject to

To changes in its composition and structure that significantly affect its functions (taken from reference No. 4).

3-2 Spinal diseases

1-3-2 Intervertebral disc degeneration:

Disc degeneration has recently been defined as “an aberrant cellular response to progressive structural failure.”

The degenerative process involves dehydration of the disc nucleus and weakening of the annulus, resulting in decreased load-bearing capacity.

And absorb shock and thus reduce disc function (taken from reference 6).

2.3.2 Causes:

The concept of disc degeneration and its causes has changed dramatically over the past decade, primarily due to injuries

Physical stress has been identified as the primary cause of disc degeneration. However, recent studies have shown that

Research on the influence of genetic factors on the development of disc degeneration has shown that heredity plays a major role. In addition,

Therefore, it has become clear that degenerative changes are part of aging and it is a process in which degenerative changes appear.

As early as the second decade of life, 20% of adolescents have mild signs of

Disc degeneration increases sharply with age and 60% of all discs have degenerated by age 18.

70 (Taken from references 7, 8, 9 and 10).

3-3-2 Biochemical modifications:

The degenerative process begins when demolition disrupts the synthesis of matrix proteins. Furthermore, fragmentation

Proteoglycans break down into smaller fragments, which can lead to leakage from the disc tissue.

The proteoglycan content of the disc is the most important change caused by intervertebral disc degeneration because it affects

Directly on the ability of the disc to retain water (taken from references 6 and 9)

4-3-2 Types of disc degeneration:

According to the nomenclature project guidelines, the term intervertebral disc degeneration includes any or all of the following:

Real or apparent dehydration - fibrosis - narrowing of the disc space - diffuse bulging of the annulus outside the disc space

Disc - extensive fissure (i.e., multiple annular tears) - annulus mucosal degeneration - defects and sclerosis

End plates and bony prominences.

These modifications in the disc tissue are associated with biochemical changes as the loss of proteoglycan content,

This results in the appearance of a desiccation disc, which causes the nucleus to shrink. This narrows the disc space.

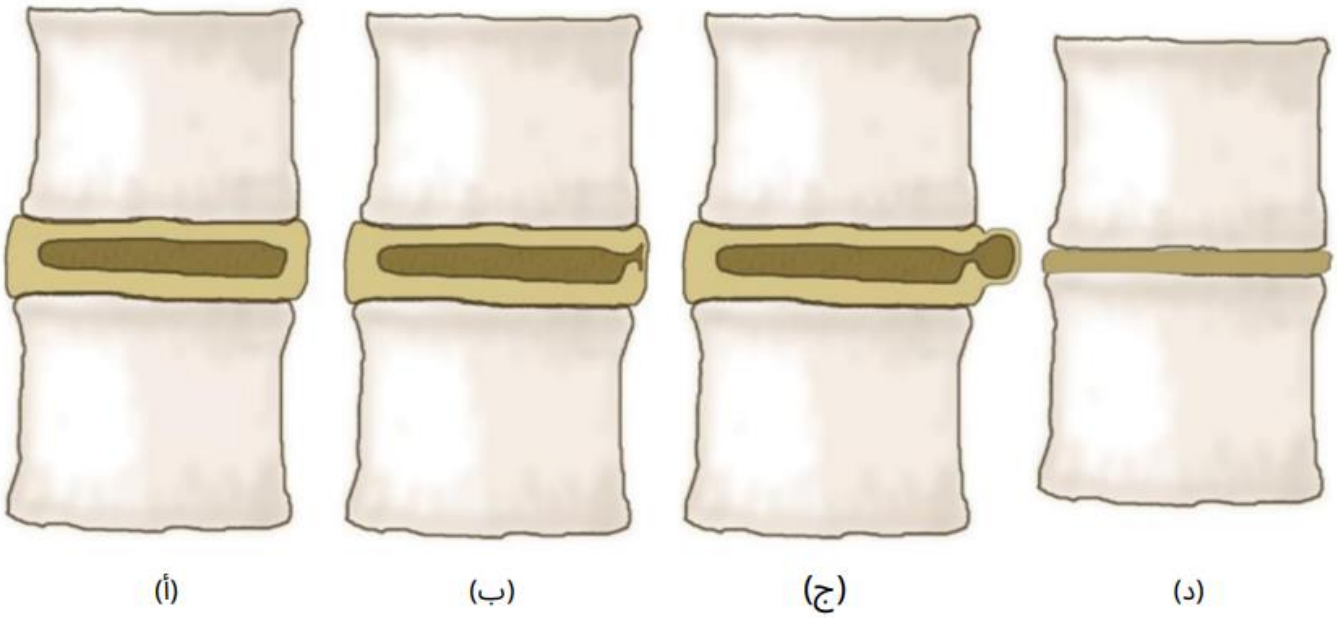
And the ring is swollen.

At the same time, the annular dehydration makes the tissues harder and weaker, the annulus gradually encroaching on the nucleus, which

It results in loss of nucleus and annulus distinction and the disc becomes less flexible and therefore more prone to cracking. Figure shows

(3-2) Some of the most common morphological alterations related to disc degeneration.

(Taken from references 6, 11, 12, 13, and 14).



Shape (3-2) Schematic representation of the median disc reductions illustrating the most common morphological modifications.

Common conditions affecting the intervertebral discs: (A) normal condition, (B) annular tear, (C) disc herniation and (D)

narrow disk space

These visible changes are manifestations of architectural distortion and structural failure of the intervertebral disc.

Disc stenosis is a direct result of dehydration, and the increase in the size of the nucleus leads to disc bulge, which leads to

Extensive displacement of disc material covering 50-100% of its circumference.

While a disc herniation as defined by the nomenclature project is a localized displacement of disc material out of the

Disc space boundaries.

Finally, from a functional point of view, dehydration negatively affects the disc's ability to withstand compressive loads.

The disc becomes stiffer and its ability to absorb shock decreases.

Narrowing of the disc space results in a reduction in the space between adjacent neural arches as the ratio

The greater the compressive load needs to be taken by the braces and this is associated with osteoporosis in

Joints.

In addition, the change in stress distribution leads to the formation of bony protrusions called osteophytes around the

Margins of vertebral bodies.

Furthermore, a herniated lumbar disc can cause compression of nerve roots, resulting in radiating pain.

To the lower extremities.

5-3-2 Disc degeneration and lower back pain:

Disc degeneration is a major cause of lower back pain and studies show multiple relationships between the two.

Degenerative results, such as: narrowing of the disc space - disc herniation and subtle changes in the adjacent vertebrae -

The occurrence of low back pain from a clinical point of view.

Degenerative processes are responsible for more than 90% of spinal surgeries. However, this does not

This means that disc degeneration is an indicator of pain, or that it requires treatment. On the contrary, many

Degenerative results are common among individuals who do not show symptoms.

Considering the socioeconomic context, low back pain has been described as a “major public health problem in

Western industrial societies" so that it affects a large proportion of the population and imposes a huge economic burden due to

Patient treatment costs and decreased productivity (taken from references 9, 15, 16, 17, 18).

6-3-2 Treatment:

Currently, the treatment of disc degeneration aims to reduce pain and reverse disability.

It is a conservative and palliative treatment. Possible treatment options include the use of analgesic and anti-inflammatory medications.

And do exercises to strengthen your back muscles. Furthermore, current guidelines recommend physical activity.

Bed rest is discouraged in cases where conservative treatment is ineffective, and when there is pain.

Severe pain accompanied by persistent neurological symptoms leads to lower back surgery being recommended.

Surgical options include spinal decompression, spinal fusion, and total disc replacement.

Surgery has been shown to improve patient outcomes, but is only recommended for a small number of patients because the majority of cases

Improves with conservative treatment.

The disadvantage of surgical procedures is that they alter the biomechanics of the spine.

New treatments such as growth factor and gene therapy aim to repair the intervertebral disc, rather than treating it.

With only its symptoms.

Growth factor therapy works by modifying the activity of intervertebral disc cells. Growth factors are proteins that when...

Injections into the intervertebral disc can stimulate an increase in proteoglycan synthesis. However, this treatment is

Only short term because growth factor levels in the disc decrease over time.

Manual gene therapy could, on the one hand, provide a more sustainable solution since gene therapy involves transferring

The genetic material responsible for producing the growth factor of interest in the target cells. Therefore, these are implanted

Cells in the disc produce growth factors and increase proteoglycan synthesis.

Currently, these methods are experimental and have many obstacles to overcome before they can be used in practice.

Clinically. A specific treatment may currently be out of reach, however, these approaches hold great potential.

Future treatments for disc degeneration (taken from references 19, 20, and 21).

4-2 Clinical imaging of the lumbar spine:

1-4-2 Introduction:

Diagnosis of disc degeneration involves a clinical examination and imaging of the spine, and a variety of techniques are used.

Imaging methods, such as X-rays, computed tomography (CT), and magnetic resonance imaging (MRI)

MRI

Additional imaging modalities include myelography and discography in addition to X-rays or MRI.

Sectional.

This section provides a brief summary of the types of disc degeneration imaging and discusses their advantages and limitations (taken from

Reference 13).

2-4-2 Plain radiographs:

In plain radiographs, the intervertebral disc does not have visible optical density due to the nature of the tissue.

soft, and therefore cannot be visualized directly. However, adjacent vertebral bodies provide indirect information.

directly from the disc tissue. Specifically, it is used

Plain radiographs to evaluate a variety of

Conditions related to disc deterioration such as narrowing of the space

Disc, endplate sclerosis, and cell development

Bony over adjacent vertebrae.

Disc space narrowing has been researched as a good indicator of progression.

Disc degeneration. However, its validity has been questioned.

Studies have shown that the disc space is narrower when

Young middle-aged men.

(Taken from references 13, 22, 23, and 24).

Figure (2-4) shows a wide-angle lateral radiograph of the lumbar spine (taken from Reference No. 3).

3-4-2 CT scan:

CT scan provides excellent visualization of the vertebrae of the spine, and also images the discs.

Vertebral. On a CT scan of the spine, the outer ring of the disc appears slightly denser than

The nucleus and inner ring are likely due to their high collagen content. The degenerative findings shown in

CT scans show: disc space narrowing, bulging, herniation, calcification, and vacuum phenomenon.

CT scan provides a good visualization of a herniated disc, as shown in Figure (2-5). Since it is a method

Volumetric imaging allows visualization of the spine at any level.

CT spine scanning is a rapid, non-invasive method of imaging the spine with high-resolution imaging technology.

3D. Although it is used less nowadays due to advances in photography.

MRI, however, still plays an important role in evaluating disc disease. CT is

CT is particularly useful for imaging patients who cannot undergo an MRI scan, such as:

Patients with claustrophobia, implants, or pacemakers.

(Taken from reference No.13).

Shape (5-2) CT scan of the spine with intervertebral disc herniation

4-4-2 Magnetic resonance imaging:

MRI is a good way to image the spine and the most sensitive way to evaluate degeneration.

Intervertebral disc. It provides high soft tissue contrast, allowing good visualization of the intervertebral disc as well as

surrounding nerves, ligaments, and muscles. Additionally, it is non-invasive and does not use ionizing radiation.

MRI provides morphological and biochemical information of the internal disc structure, facilitating

Evaluation of disc degeneration. Specifically, morphological alterations such as loss of annular differentiation have been demonstrated.

Disc space narrowing, disc fissures, bulging, and herniation are clearly evident on MRI.

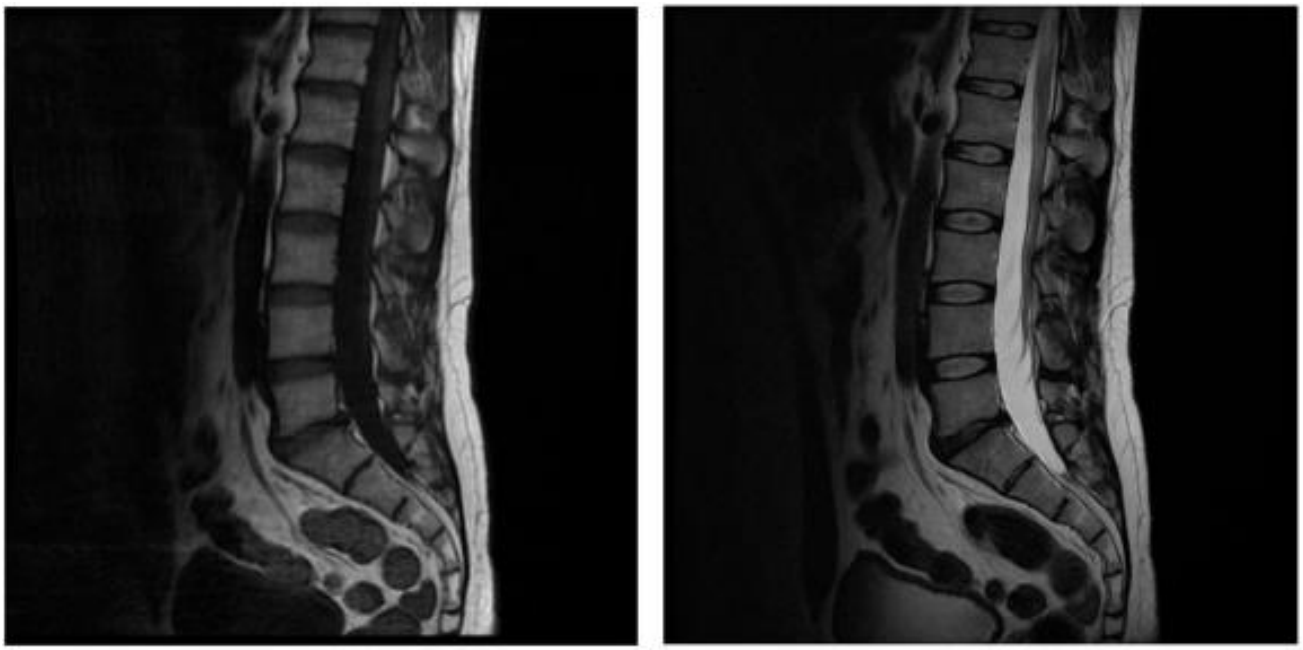
Therefore, biochemical information is encoded in the MR signal intensity, providing an indirect assessment of the content of

Disc of water and proteoglycans, in clinical practice, MRI protocols are used

Standard for lower back imaging.

The spine consists of sagittal T1- and T2-weighted images, complemented by axial T1- or T2-weighted images at

Specific levels.



(أ) (ب)

Shape (6-2) Examples of (a) T1-weighted

(b)For the lumbar spine, T-weighted images of the Midsagittal MR.

Figure (2-6) shows two images of the mid-sagittal plane of the lumbar spine. The weighted images show

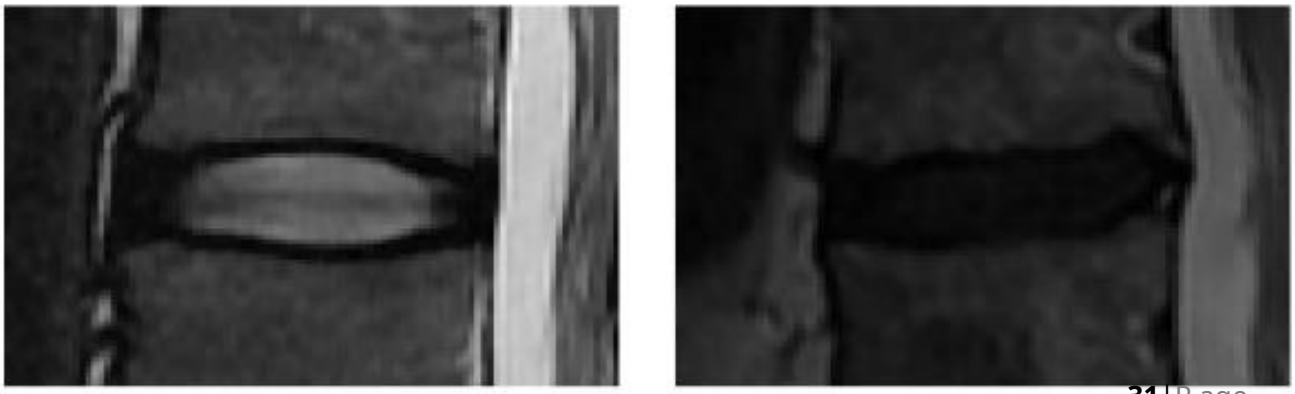
Cortical bone and high signal intensity of the spinal cord (CSF) Low signal intensity of the cerebrospinal fluid (T1)

The bone.

Shape (7-2) Examples of (a) a normal disc and (b) a degenerated intervertebral disc as shown in Fig.

Weighted 2MR.

(for) **(A)**



(Figure 2-7) clearly depicts the anatomy of the spine and is used to examine the vertebral bodies. On the other hand,

T2-weighted images show high signal intensity of structures with high water content such as CSF and nuclei.

Disc. T2-weighted images are used to examine the intervertebral discs and assess their structural integrity. Furthermore,

It is commonly used to classify the disc according to the severity of degeneration. On sagittal T2 images, the intervertebral disc appears

The normal nucleus is a bright ellipse surrounded by a dark ring, while the plates and bands appear

The terminal is also dark as shown in (Figure 2-7) looking in more detail at the path

In normal disc degeneration, a young, healthy disc is well hydrated and appears with a homogeneous, bright nucleus on imaging.

MRI.

Fibrous transformation of the nuclear matrix results in an intranuclear cleft that appears as a dark band on fluorescence images.

T2. Progressive degeneration includes further desiccation of the disc and encroachment of the annulus into the nucleus. The disc appears

The apiary is darker because dehydration causes a decrease in signal intensity as shown in (Figure 2-7). Damage appears

The endplate is clearly visible on MRI, while excellent visualization of disc herniation and bulging is possible.

Accurate diagnosis of these conditions. Furthermore, MRI can show changes

In the endplate of the vertebrae (also known as Modic changes) which are related to cracking and disruption of the plates

Peripheral, as well as bone marrow degeneration.

This is actually the only method that depicts moderate changes that are a useful indicator of lower back pain.

Although MRI provides accurate imaging of disc morphology, its value in

The diagnosis of low back pain is limited by its low specificity. This is due to the high prevalence of findings.

Degenerative conditions such as dryness, cracking, and swelling can occur in asymptomatic individuals. Therefore, the results should be evaluated.

MRI along with patients' clinical symptoms, to avoid overtreatment.

The same applies to CT scans and X-rays of the spine. However, there are some findings.

Specific to MRI, such as disc herniation and minor changes are rare among individuals who do not have

Symptoms closely associated with lower back pain (taken from references 13 and 15).

Another disadvantage of MRI is its relatively high cost.

In our project, we will rely on cases captured by magnetic resonance imaging (MRI).

5-2 MRI:

1-5-2 History of the emergence of the MRI device:

The first appearance of magnetic resonance imaging technology was in 1946 AD, when the two physicists

Felix Bloch and Edward Purcell independently discovered the phenomenon of resonance.

Magnetic resonance, and from that period until the seventies the use of magnetic resonance was limited to chemical analyses.

And physics until the physician and physicist Raymond Damadian in 1971 AD

By proving that the use of magnetic fields in diagnosing tissue tumors is better than its use in conducting studies.

On the diseases that scientists were seeking to accomplish, and with the development of computer science in 1973 AD it became possible

The development of magnetic resonance imaging technology, and this technology has remained on the path of development for 20 years until

Today, it is worth noting that both scientists Felix Bloch and Edward Purcell have won the Nobel Prize for

Their discovery of the phenomenon of magnetic resonance in 1952 AD (taken from website No. 1).

2-5-2 The working principle of the device:

Images of the body's skeleton are produced using technology that includes magnetic resonance imaging, radio waves,

In addition to a computer, it is called magnetic resonance imaging.

The device used in this technique is (Magnetic Resonance Imaging – MRI).

A tube into which the patient is inserted on a moving bed, and a giant circular magnet surrounds the tube to create...

A strong magnetic field causes hydrogen protons in the human body to compact and then rotate after being exposed to it.

For radio waves, a faint signal is produced that the scanner receives to produce an image of the body. It can also be used

Gadolinium as a contrast agent to increase image resolution,A 3D image can be produced using MRI.

Magnetic resonance imaging, using additional fields, exists in several forms of MRI.

Here are the most common forms:

- Diffusion MRI: This form was known about 15 to 20 years ago.

Its working principle depends on how water molecules diffuse through the body's tissues. Some diseases, such as tumors,

Stroke may reduce its spread, so it can be diagnosed this way.

Functional MRI: Its importance lies in neuroscience, especially...

Brain, it depicts the functional activity of the brain by measuring blood flow to its various parts, in order to monitor

The brain and assessing some of the damage that may affect it, such as Alzheimer's disease or head injuries.

(Taken from website No. 1).

3-5-2 Uses of MRI:

The use of MRI technology is expanding over time, to be used to detect many

Diseases, including:

1- Anomalies of the brain and spinal cord.

2- Abnormalities in different areas of the body, such as tumors and abscesses.

3- Breast cancer screening, especially for women at high risk of developing it.

4- Injuries or deformities of joints such as the back and knee.

5- Specific types of heart problems.

6- Diseases of the organs in the abdomen, such as: liver diseases.

7- Fibroids, endometriosis, and other pelvic pain problems in women.

8- Evaluating infertility cases in women, by detecting abnormalities in the uterus.

9- Cases of nucleus pulposus herniation.

(Taken from website No. 1).

4-5-2 MRI examination steps:

Before starting the MRI test, the person is asked to remove all metal objects that

Wearing it, such as: accessories, and metals that are found in clothing, so in some cases it may be required to

The person wearing a special clothing for photography, as well as people whose bodies contain a medical device

Or metals, such as pacemakers and cochlear implants, cannot

Perform an MRI test. It should be noted that some cases require quality improvement.

The image produced by the device, and this is done by injecting the person with a specific dye, and plugs are also placed or

Earphones are used to mask the loud sound of the device. After the device starts working, the person is asked to remain still and not

Do not make any movement, as this may affect the result of the imaging. Some types of imaging may require abstinence.

The person should hold his breath for a while, and if he feels uncomfortable, he can contact the imaging technician and ask for

The device is turned off, and after the imaging is completed, the results are sent to the radiologist to write a report on

The image is based on the person's health condition and sent to the specialist doctor (taken from website No. 1).

5-5-2 Development of MRI scanning devices:

MRI devices are currently being developed to become smaller, and may

Becoming portable, these new devices help increase the efficiency of detecting tumors and infections in

Soft tissues in the knees, elbows, and feet. It is worth noting that some

These devices are currently being tested for medical use in the near future (taken from website No. 1).

Chapter Three

Previous studies

Chapter Three

Previous studies

1-3 Study 2023*et al.,*Pyeoungkee

Automatic Detection, Classification, and Grading of Lumbar Intervertebral Disc Degeneration Using an Artificial Neural Network Model

- Automatic detection and classification of lumbar disc degeneration using an artificial neural network model.

Objective of the study:

Deep learning AI models represent a potential tool for rapidly detecting and visualizing intervertebral disc degeneration.

and automatically. This study investigated the use of deep convolutional neural networks (CNNs) to detect and classify

intervertebral disc degeneration

Method: T2 MRI images were obtained, and then the region of interest was identified by

I specialize in radiology, and then classify the images based on the PFIRMANN system with the help of a radiologist.

Due to the relatively small sample size, to prevent overfitting, all images were randomly augmented using

Python package, a software package focused on providing functions that are frequently used in creating

Image data for machine learning: The segmented images were randomly shuffled for training. The final dataset contained

800 MRIs in the training dataset (80%) and 200 MRIs in the

Test data set (20%). In each group, disc degeneration was classified based on a classification system.

Pfirrmann

Result: We collected a training dataset of lumbar intervertebral disc MRI from

An open-source dataset, which included a total of 1,000 disc levels from 515 adult patients.

The data was augmented and used to train and evaluate the models.

Based on the Pfirrmann classification system, the results found 220 grade 1 cases, 530 grade 2 cases, and 530 grade 3 cases.

Second, 170 third, 160 fourth, and 20 fifth.

3-2 Study 2021,.*et al.*Raja's

Automatic Diagnosis of Lumbar Disc Herniation with Shape and Appearance Features from MRI

Automatic diagnosis of lumbar disc herniation using morphological and appearance features of MRI images.

Objective of the study:

Automated diagnosis of herniated discs aims to reduce the heavy burden on radiologists who have to

Hundreds of cases are diagnosed every day using MRI.

How it works:

Shape characteristics are the main factor in detecting a hernia because of the significant change in shape caused by it.

On the other hand, the intensity levels of herniated discs are lower than normal discs because when they leak

Inner core (herniation), the water contents of the disc spread over a larger area, however it may indicate

Low levels of severity of the disc to other deformities and therefore, we jointly use the features of

Look and feel for maximum effectiveness

Result:

He used 33 MRI scans of the lumbar region to train and test the appearance models.

Figure 1. We achieve over 91% accuracy in detecting hernias in the cross-validation experiment with 91% specificity.

And sensitivity of 94%.

3-3 Study 2012, Zobel et al.

Magnetic Resonance Imaging Quantification of Early Lumbar Intervertebral1T

Disc Degeneration in Healthy Young Adults

Quantitative T1-weighted MRI of early lumbar disc degeneration in adults

healthy people

Objective of the study:

Evaluation of early intervertebral disc degeneration (IDD) measured by T1 and T2 MRI

It is likely in young people who do not have symptoms and the T1 value is related to the Pfirrmann score, gender and index.

Body mass index (BMI).

How it works:

The intervertebral disc begins to deteriorate early with loss of proteoglycan content in the nucleus pulposus.

T1- and T2-weighted images of the lumbar spine were obtained from 63 asymptomatic individuals (34 men and

29 women (mean age 23 years) were examined by MRI. T1 maps and values were obtained in the nucleus pulposus.

and the fibrous ring (n = 315).

The degree of degeneration was assessed using T2 images, according to the Pfirrmann scale. Differences in T1 values were determined.

Gender (male and female), BMI, and linear regression analyses with determination of degenerative degree.

Result:

The T1 values of the nuclei pulposus were significantly higher than those of the annulus fibrosus at all levels, and were

T1 values were significantly lower in women at L3-L4 and L4-L5 discs. T1 values decreased linearly with

Degenerative degree. However, non-degenerative discs (Pfirrmann grades 1 and 2) showed a wide range of

T1 relaxation time. No significant correlation was observed between T1 value and BMI.

4-3 Study 2015,.*et al*/R. Menezes-Reis

T1ρ and T2 Mapping of the Intervertebral Disk: Comparison of Different Methods of Segmentation

T1ρ and T2 mapping of the intervertebral disc: a comparison of different segmentation methods

Objective of the study:

The biochemical composition of the intervertebral disc in vivo can be accessed by measuring relaxivity.

We did not find studies in the literature comparing different segmentation methods for data extraction using these T1 and T2.

Techniques. Our goal was to compare different manual segmentation methods used to extract T1 relaxation times and

For intervertebral discs from MRI. Seven different T2 disc segmentation techniques were compared.

Partial with full disk fragmentation as a benchmark.

How it works:

Sagittal T1 and T2 maps were generated using MRI. Fifty-seven asymptomatic volunteers aged

20 and 40 years. Two hundred and eighty-five (258) lumbar discs were separated into two groups: intact disc

In fragmentation (third and fourth degree Pfirrmann) and the disc is damaged (first and second degree Pfirrmann)

The entire disk is fragmented into all partitions. Partial disk fragmentation methods include fragmentation

The disc was divided into 6, 5, 4, 3, and 1 sagittal section. The circular region of interest was also used.

The data were compared with the T2 and T2 segmentations identified in the nucleus pulposus and annulus fibrosus to extract 1 ROI.

The entire disc.

Result:

In the healthy disc group, segmentation of 5 or more sagittal sections showed no statistical difference with disc segmentation.

Completely. All remaining partial disk segmentation methods and circular regions of interest showed different results from

Entire disk fragmentation. In the degraded disk group, all methods were statistically similar for fragmentation.

The entire disk. All sub-segmentation methods, including circular ROIs, showed a strong linear association with segmentation.

The entire disk in both deteriorated and healthy disk groups.

Chapter Four

Practical part

Chapter Four

Practical part

1-4 MATLAB:

MATLAB is one of the leading programs for engineering and mathematical applications and is one of the most widely used programs by engineers and scientists worldwide. Produced by MathWorks, it is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. Typical uses include:

Mathematics and computation, algorithm development, modeling, simulation and prototyping, data analysis and exploration, scientific and engineering graphics, application development, including GUI building.

MATLAB is an interactive system whose basic data element is a dimensionless matrix. This allows you to solve many technical computing problems, especially those involving matrix and vector constructions, in a fraction of the time it would take to write a program in a non-interactive numerical language such as C or Fortran. MATLAB has evolved over the years with input from many users.

In university settings, it is the primary teaching tool for introductory and advanced courses in mathematics, engineering, and science, and in industry, MATLAB is the preferred tool for research, development, and high-productivity analysis.

It is divided into two sections: add-ons specific to MATLAB and add-ons specific to Simulink. Add-ons specific to MATLAB are called toolboxes. These boxes differ from each other.

If each box has a scientific specialty that it handles, it contains programming instructions that lead to solving scientific problems in the specialty for which the tool was created, such as the image processing tool, which handles the specialty of image analysis and writing algorithms to arrange pixels.

Simulink's add-ons are called blocks, which apply physical or mathematical theories to your model to give you a simulation of how this model would behave if it were subjected to these physical or mathematical theories in real life.

For example, in Simulink, a block that simulates aircraft, spaceships, and propulsion systems is called:

Aircraft manufacturers take advantage of this block to subject their aircraft to Aerospace Blockset factors.

Certain weather conditions such as atmospheric pressure and its effect on the aircraft structure virtually and see the results of their aircraft's performance on Computer with the help of the simulation program Simulink. (Website2)

Doctors and biomedical engineers also use this software to draw nucleic acids that have complex and overlapping shapes.

MATLAB also allows you to draw three-dimensional shapes after writing their mathematical equations in a specific window.

After drawing shapes, the color and size of the object can be changed using a special toolbar. When drawing complex shapes, certain parts can be made semi-transparent so the user can see the other parts behind them. This program is also used for drawing two-dimensional graphs and solving complex mathematical equations.

4-2 Introduction to Image Processing:It is a department of computer science that works on improving and processing Images are processed according to specific criteria, such as removing blemishes, enlarging the image, coloring it, clarifying certain aspects of it, or other tasks that serve to improve the images completely to facilitate their use.

It is worth noting that they are widely used in the medical field. We find images of the internal parts of the human body, organs, and visual representations of a group of functions, which are shared, sent, and received in the medical field.

This technology began to emerge in the 1960s, with the advent of medical imaging and character recognition technologies. The goal of digital image processing in the medical field at that time was to enhance images, with the input being a low-quality image and the output being enhanced, high-quality images.

Digital image processing involves many processes and steps used to improve the display of images and change their features, including converting a specific image to black and white or cutting and dividing it into small structures.

Some techniques in digital image processing in the medical field include making blurry images clearer and changing their composition to make them easier to transmit and store.

Digital image processing in the medical field has many advantages, and is one of the reasons that led to the development of the medical field. Not only that, but digital image processing in the medical field is penetrating to become one of the analytical tools through which medical devices recognize images, such as the computed tomography (CT) scanner or the magnetic resonance imaging (MRI) scanner (website).3).

4-3 Lumbar disc herniation image processing:

Through the following cases, we will begin building image processing algorithms. We will rely on images in the anatomical time T2, which is an effective technique that provides accurate and detailed images of the soft tissues in the human body, and because of the clarity it shows in the tissues containing fluids, which will help us in identifying and segmenting with greater efficiency.

We will start by identifying the cases captured using MRI that were processed in Table (1-4):

the name	Sex	the age	Medical photography	BB injury	Diagnosis
Hope (status First)	feminine	50 years	Hama is recovering in my country	Goths on the Nile	Fat bag between lumbar vertebrae (5) The sacral nerve (L) (S1) died and in the middle of the class Foramen narrowing Which paragraphs? Irrigation degree in the middle of the same Good
Fadhel	male	50 years	Hama is recovering in my country	for Hama and Raf'a heavy money	Fat nucleus pulposus in the intervertebral disc Cotton tree and Kha Touch (L5) Large r size

(the condition Second)					And Blo pressure SHa'i degree Sh bead on the side the Ye Bec et with hanging N H And down
Darine (the condition Third)	feminine	40 years	M Hama is recovering tha and My country	shel On loads Trus Ught	Fat cleus pulposus in the intervertebral disc R Cotton the L4 and Kha Touch (L5) Large r size And narrow foramen vertebral R ight hand side Jurisprudence and degree SD ida

Table (4-1) for the cases used

While explaining the algorithms used, we will use (the first case) to explain the effects of instructions on the image.

In our cases, we cannot segment the hernia directly because the gray levels of the hernia are close to the gray levels of the noise.

But we can segment the spinal cord because its gray levels are dense (pixel values are high and close to). Therefore, White our study will focus on two main points: the first is extracting (segmenting) the spinal cord and the second is...

Extraction of the hernia area.

4-4 Action steps:

We will explain in detail through the following diagram:

❖ Block diagram of processing algorithms:

Block diagram (4-1) of the algorithm's stages

1-4-4 Reading the medical image:

We first selected one sagittal plane image from the slide sets included in each case file which would be in DICOM format (.)file.dcm

The formula has been adopted.Which is (DICOMStandard for communication and management of medical imaging information and related data The connectionBecause it displays pixel values in a full digital range, whereas any other format may reduce contrast accuracy, it is widely adopted by hospitals and imaging devices for storing and transmitting medical images.

That is, in the case of our system, the image can be entered directly from the resonator device (Or any medical device that outputs (MRI) In DICOM format and processing.

We enter the image with the following instructions:

- InstructionTo read metadata from a dicom file, enter the file path: dicominfo

  (file storage location)

- Instruction To read image data: dicomread

- Instruction The purpose is to display the image in: imshow

  MATLAB.

Figure (1-4) shows the original image of the first case after entering it into MATLAB.

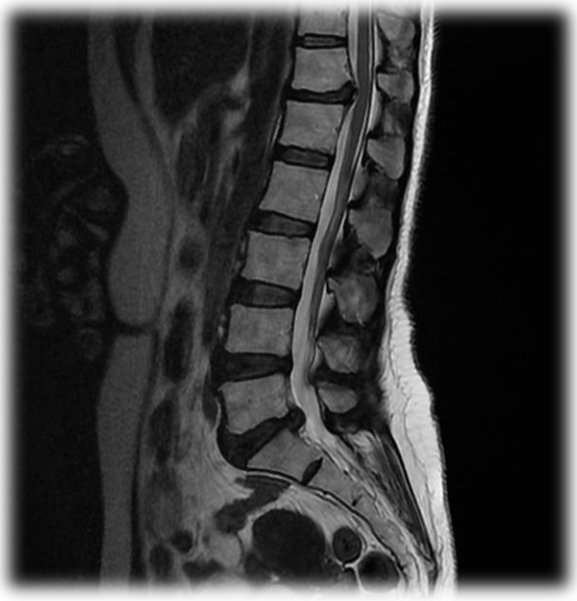


Figure (4-1) Output for the image reading stage

2-4-4 Image enhancement algorithms:

We will use several techniques to increase clarity and reduce noise in the image using the following instructions:

▪ InstructionAn instruction to adjust the histogram or equalize it, i.e. the pixel values are changed so that: histeq

Pixels are distributed across the entire range of levels to increase the overall contrast of the image.

▪ Instruction:imadjust

An instruction to blur a range of values in the image such that the values between [0.75, 0.95] are positioned between [0, 1].

▪ InstructionThis instruction represents a flat structural element which is an essential part of any morphological process: strel

It has a binary input value, in other words, it is an array of (0 or 1) that creates a disk-shaped structure element (using the ' property(where the radius is specified by the number 'disk')3(.

▪ InstructionIt is a morphological operation applied to an image: imopen

Grayscale or binary uses the structuring element.

(strel)

The morphological opening process is an erosion process followed by a dilation process, using the same structuring element for both processes (morphological processes will be explained later).

▪ Through the previous algorithm, we reduced the noise obtained from

The image, Figure (2-4) shows the output of the algorithm.

Shape (2-4) Exit to image enhancement stage

3-4-4 Morphological process:

This morphological operation can be used to extract or enhance distinct objects from an image.

- The image to be enhanced is the mask image.Where a second image is used, which is the (Mask) image.

The markTo mark the areas to be extracted or emphasized. The areas marked in (Marker)

The brand image is considered the basic pillar that spreads to fill the mask image, and this can be thought of as:

The process is seen as a repeated expansion of the mark image.

▪ Instruction(CLAHE) is the adaptive variance-constrained histogram equation (adapthisteq mask).

Enhance the contrast of a grayscale image by transforming the values using a limited adaptive histogram equalization.

Contrast.

▪ InstructionIt is a morphological process that leads to the erosion of the binary image with a gradient (imerode).

Grayscale or binary using the structuring element.strel

▪ InstructionMorphological process of reconstructing

Image construction based on its inputs (mask illusion)And the mark (Mask

(Marker)

The number 8 specifies whether the pixels' edges or corners are touching.

Figure (3-4) shows the output of the algorithm for the first case.

Figure (3-4) Morphological process output

4-4-4 Convert to binary image:

Figure (4-4) Binary image output

After the enhancement and noise reduction processes from the previous stages, we will convert the image from a grayscale image to a binary (black and white) image.

▪ InstructionIt is a process of converting from an image: imbinarize

Grayscale to binary (black and white) image with

Set a threshold of (0.65) on the range [0,1].

Any gray level with a value less than 0.65 on this field will turn black, and any value higher than that will turn white.

This instruction is important and plays a major role in removing noise and helping with segmentation later.

Figure (4-4) shows the output of the algorithm for the first case.

5-4-4Multiply the resulting image by the original and blur:

In the image we have a body similar to the spinal cord in shape and gray levels (body (1)). Therefore, this body must be segmented first so that we can subtract it from the image. The process of multiplying the image and building the ring is the initial stage of this segmentation.

▪ InstructionIn the picture (img instruction to multiply the image resulting from the algorithms)6: immultiply

(original)(In the image resulting from the algorithms, every pixel is white, (img1) It is replaced by pixels.

Of the same gray level as the original image and black pixels (0) are not affected and will remain as they are.

▪ Blur ring: This ring is designed to blur the image and extract the noisy object (1) In proportion to

Grayscale range (maximum array elements).

Since the fields differ from one image to another, the desired threshold values differ. Therefore,

we arrived at specific values for each field, such that:

▪ If the image levels are between]800,1000[so the value will be

Threshold]650[.

▪ If the image level is between]350,800[The threshold value will be

]300[.

▪ If the image resolution is greater than1000 or less than 350

So we will use the Otsu (automatic thresholding) method to determine the

threshold using the instruction.graythresh

Body (1)

Figure (4-5) Output of the image multiplication and

grading stage

Maximum variance method between classes is proposed.

(Otsu Threshold) by the Japanese researcher Otsu in 1979, is considered one of the best methods for automatically determining the threshold.

After determining the Otsu threshold, the output of level and the image Img7 are entered into the instructionTo apply the threshold, imbinarize.

The loop relies on the maximum number of array elements condition using the)):(instruction.max(img7

Figure (5-4) shows the output of the algorithm for the first case.

Before we complete the segmentation steps, we will start by defining the morphological operations.

Morphological operations: A broad group of image processing operations that process images based on

shapes.

The goal of using morphological operations is to remove defects in the image structure.

Most of the processes used here are a combination of two processes, dilation and erosion.

The process uses a small matrix structure called a structuring element. Determining the shape and size of the structuring element has a significant impact on the final result.

6-4-4Application of algorithms for spinal cord segmentation (primary segmentation):

As we explained previously, we will remove the body similar to the spinal cord from the image, so the process of applying the cord segmentation algorithms will be divided into two stages:

- The first stage: body segmentation (1), the principle of operation of this algorithm is that we will apply a morphological process to

The image, then we invert the colors of the image and apply an instruction to fill in the gaps, which will be the structure of these gaps.

The spinal cord and any other body (1), then we reverse the image so that we only have the body (1)

We subtract it from the original image.

▪ InstructionStructuring element (explained previously): strel

Creates a disk-shaped structure element (using the 'where the radius is specified,'disk) The number (5) specifies the number of structural elements used to approximate the disc shape.

▪ InstructionStrel is the process of expanding a grayscale or binary image using the structuring element: imdilate.

As we saw in the previous figure (5-4), the remaining parts of the spinal cord contain incomplete spaces and therefore will not...

We can fill in the blanks as long as they are in this form, so the instruction was applied.To expand these spaces and help imdilate

In deleting it

▪ Instruction(It is a process of inverting a binary image so that the white pixel is: imcomplement1)

It becomes black (0) and vice versa.

▪ InstructionInstruction to fill holes in a gradient image: imfill

Gray. In this formula, the hole is defined as

An area of dark pixels surrounded by lighter pixels.

Figure (4-6) The output of the first stage of the initial segmentation of the spinal cord.

Then we returned the image to its natural form by applying

the instruction imcomplete again.

▪ Instructionimg Subtracts each element in the array 6: imsubtract

From the corresponding element in the array img13 (extracted image

1) The body contains the difference in.img14

Thus, we have removed the noise object (1). Figure (6-4) shows the algorithm output for the first case.

- The second stage: Apply the following instructions:

▪ InstructionIn the picture (img instruction to multiply the image resulting from the algorithms)15: immultiply

Original.(img

▪ InstructionStructural element: strel

▪ InstructionIt is a morphological process applied to a grayscale or binary image. It uses: imopen.

Structural elementIt is a process of erosion followed by a process of expansion using the same structural element for both processes (strel).

▪ InstructionIt is a morphological instruction to delete all :bwareaopen Objects smaller than 1600 pixels

So we have segmented the spinal cord for two out of three cases, so we will build an algorithm to ensure that the spinal cord is segmented for any case that enters the system via the next stage.

Figure (7-4) shows the output of the algorithm for the first case.

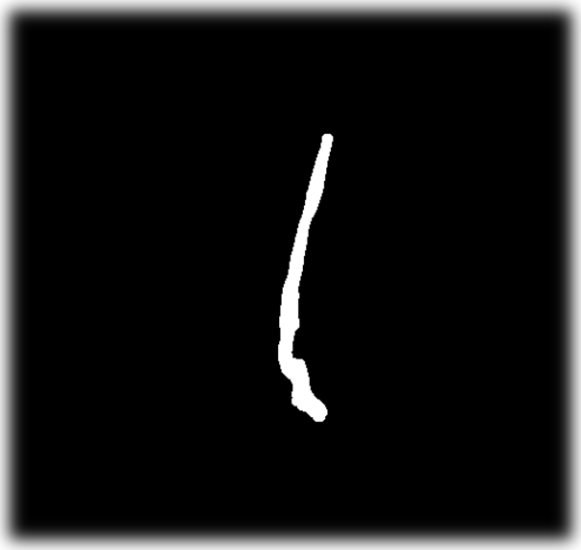


Figure (4-7) The output of the second stage of the initial segmentation of the spinal cord.

7-4-4Image properties measurement:

The measurement is done using the following instructions:

▪ InstructionThe coordinates of the rows B follow the boundaries of the region in the binary image, where:bwboundaries and columns for border pixels, L is a matrix representing the number of objects in the image, and the property 'noholes'Makes the instruction search only for object boundaries for better performance.

▪ InstructionIt is an instruction to measure the properties of image regions: regionprops

Properties).....,Major Axis Length,'Centroid',Area(They are the properties that provide measurements of the shape.

8-4-4 Spinal cord segmentation:

- The first stage: Despite the previous algorithms we built, segmenting the spinal cord was not sufficient for all cases.

So we built a loop to ensure complete partitioning of our existing states and any other state entered into the system by setting the loop condition according to the number of objects (structures) in the image.

Therefore, if the image contains more than one object, as in the third case (Figure (8)), it will enter the loop and algorithms similar in principle to the first stage of applying spinal cord segmentation algorithms will be applied to it.

We will find the unwanted object or structure and subtract it from the image resulting from the previous steps.

The stage is applied with the following instructions:

▪ Instruction)Inside an array, where rows of this array stats to specify the size: [rows, cols]= size(stats

The rows are the columns of the matrix and the cols are the values.

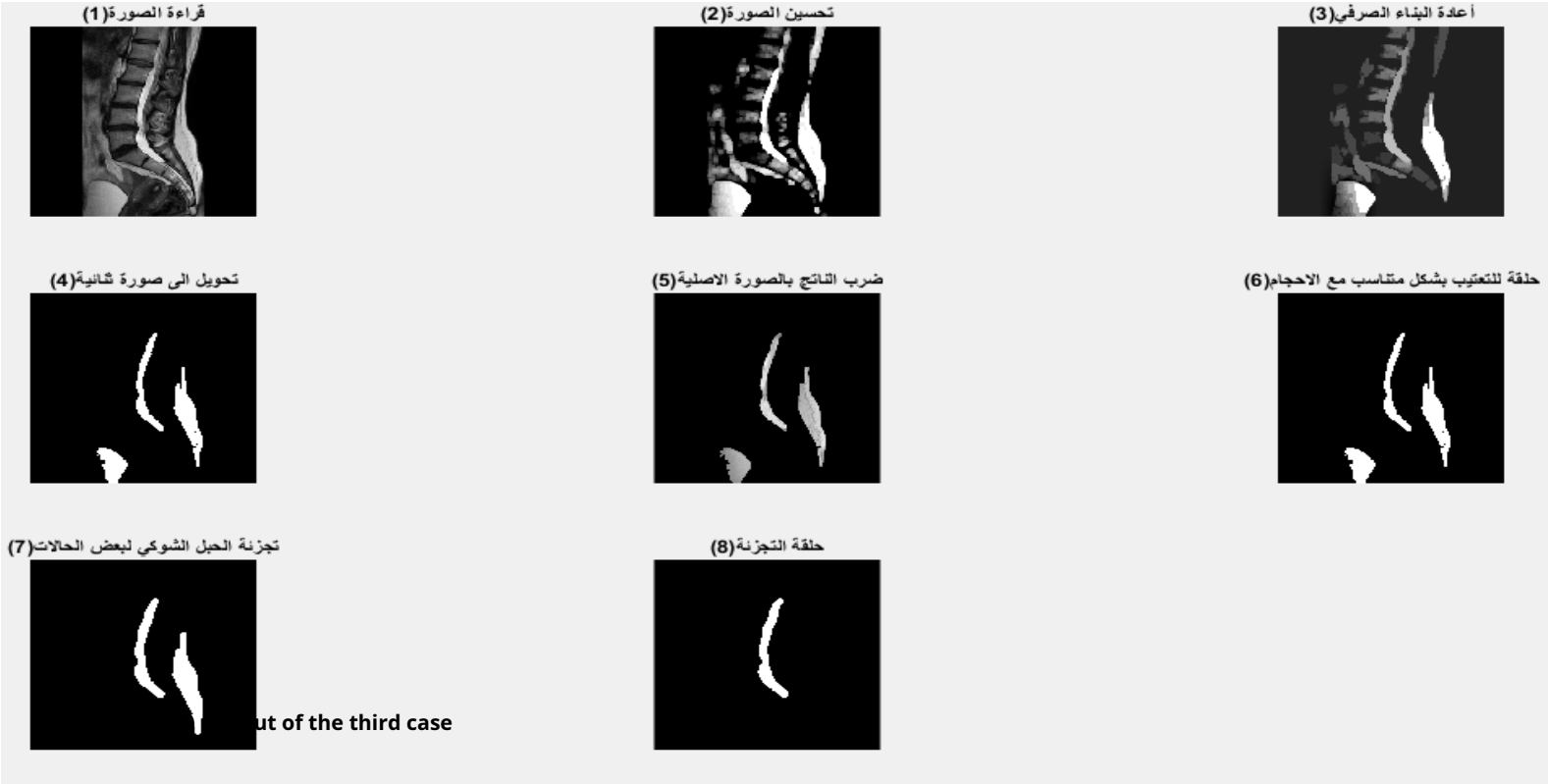
in)'Centroid'....,Area,img21,tableAs we explained, stats = regionprops (will be stored The image properties are within an array, and each row of the array represents the properties of one object (structure). Therefore, if the array has more than one row, then there is more than one object in the image, so we will rely on rows to be the loop condition.

▪ Ring: The morphological opening process will be applied, which is a process of erosion followed by expansion using a structural element.

In the shape of a disk (using the 'disk' property), where the radius is specified by the number 10

Using this procedure, the spinal cord is removed and the unwanted body is left.

This is then followed by a subtraction process to remove the unwanted body, leaving small bodies of it.



ut of the third case

Figure (8-4) shows the stages of spinal cord segmentation for the third case (the case that met the ring condition).

The remaining body parts are removed using the bwareaopen directive, which removes objects smaller than 1000 pixels.

This completes the first stage, which is segmenting the spinal cord.

- The second stage: In this stage, we will delete the unimportant areas of the spinal cord that do not contain...

Atelectasis and away from the hernia to reduce the area of interest, using the following algorithm:

We used two morphological operations to extract the desired parts, which are the opening and closing operations using an element.

Structural, 24" long and 55° angle.

Then we subtract the image img24 from the image img26

After subtraction, small objects will remain in the image and will be removed using the bwareaopen instruction. Then we multiply the resulting image by the original to find the gray levels.

Then we use operations to blur, remove small objects, and a morphological expansion operation, then we multiply the resulting image by the original.

Figure (9-4) shows the output of the algorithm for the first case.

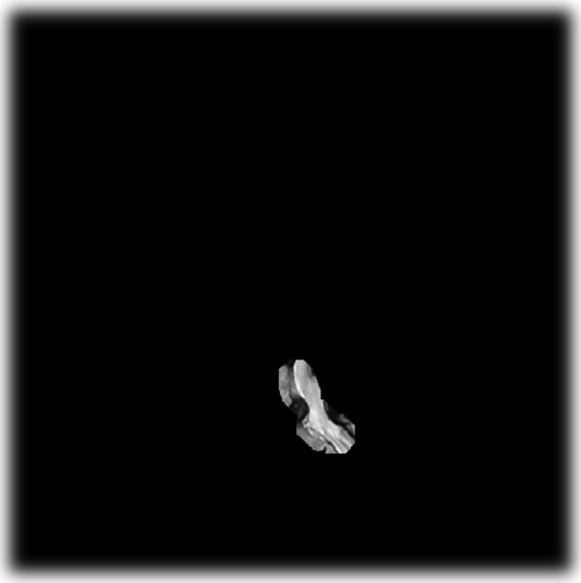


Figure (4-9) Output of the spinal cord segmentation stage

9-4-4 Complete identification of the hernia:

▪ At this stage, we will first apply the morphological opening process to reduce the area of interest, and then we will multiply

The result is in the original image. In the resulting image, we can see that the level of the hernia is close to the black color (i.e.

At the lower limits of gray levels, we blur the image at a value of 120 to completely remove the hernia.

From the image, we subtract the resulting image from the original image and then apply a morphological operation.imerode

To reduce the size of objects

At this stage we will need a loop based on)After specifying the image properties (MinorAxisLength Resulting from previous operations.

Whereas)It is the condition of the ring, and it represents the value of the length of the minor axis of the ellipse (MinorAxisLength).

So we will use the instructionIn the ring with different values depending on the length of the axis bwareaopen

Figure (4-10) shows the results of the spinal cord segmentation stage (on the right) and the results of the complete hernia identification stage (on the left) for the first case.

10-4-4 Determine the area of interest on the original image:

After we have finished segmenting the hernia completely, we will select the area on the original image to display it, using the following instructions:

At this stage we perform morphological operations to expand the area of interest (hernia) using a linear structure.

(using the 'line' feature) at an angle of 105 degrees

Another structure is in the form of a disk (using the 'disk' property), where the radius is specified by the number (10).

Figure (4-11) Defining the region of interest on the original image

Then we combine the original and final images, determine the pixels in img42, and determine the size of the line surrounding the area of interest, as we see in Figure (11-4) for the first case.

The previous work stages have been translated into software code.

Found in Appendix A

11-4-4 Building the graphical interface to display the image and apply the algorithm:

Graphical User Interface: An interactive interface between the user and the computer.

It is used to facilitate interaction between the user and various programs or applications on the computer.

Figure (12-4) shows the graphical interface used in our project application, which contains three buttons and display axes.

The first button (load the image) is to load the image to be processed from the computer.

The second button)To download the code and apply it to the image, then view all (RUN the code stages Selection stages.

The third button)To download the code and apply it to the image, then display the final result. The final output of the code, and a axis to display the DICOM image (the original image).

The GUI development and algorithm implementation phases have been translated into code, which is found in Appendix B.

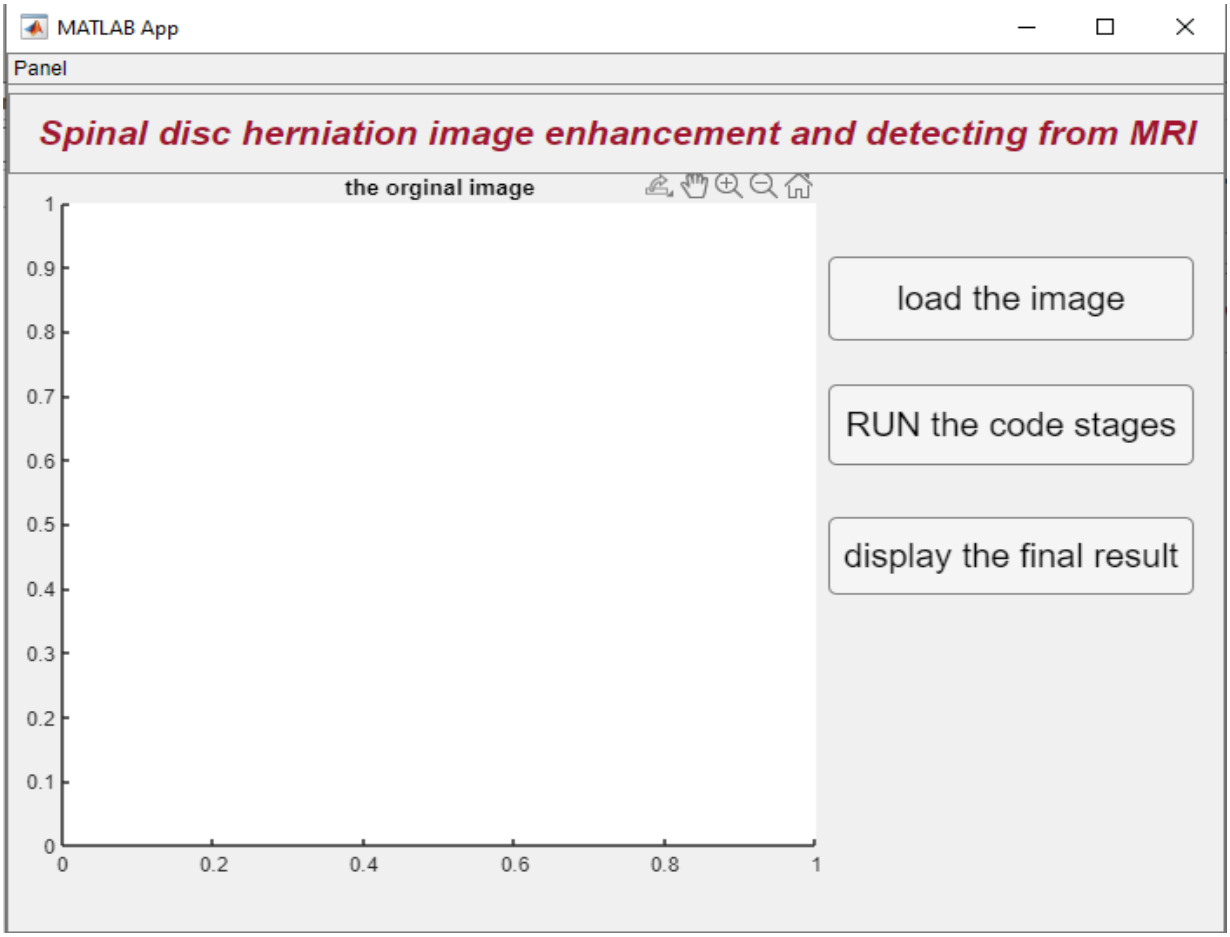


Figure (4-12) Graphical interface for the code application

Appendix A

Area of interest (hernia) identification code

Medical image reading stage (1)

```
;)'Good evening r file'Info = dicominfo (➢
Img = dicomread(info);➢
Imshow( img , [] ) ;➢
```

Image enhancement stage (2)

```
img2 = histeq(img);➢
; ) ][ , ] 0.95  img3 = imadjust ( img2 , [ 0.75➢
;) 3,diskse = strel (➢
img4 = imopen( img3 , se );➢
```

practical stage

Morphology (3)

```
, Distribution, 0.2 ,' clipLimit 'isteq ( img4 ,  Mask = adapt➢
;)' d ' Rayleigh 'se
;) 7,isk '  = strel (➢
ode(mask, se);  marker = imer➢
nstruct(marker, mask, 8);  img5 = imreco➢
```

Multiplication stage (4)

```
g5, 0.65);  Img6 = imbinarize ( im➢
```

Algorithm application stage

Primary fragmentation (5-1)

```
g, img6);  Img7 = immultiply ( im➢
;) ):( img_max = max ( img7➢
& ( img_max <= 1000 ) ( img_max > 800 ) &if➢
(img_max > 350 img8
) && ( img_max <= 800 )  = img7 > 650;elseif➢
img8 = img7 > 300;
else➢
) img8 = imbinarize( img4 ,
level);  level = graythresh( img7
end
```

Algorithm application stage

Primary fragmentation (2-5)

```
;)  5,diskse = strel(➢
g8, se ) ;img9 = imdilate ( im➢

nt(img9);   img10 = imcompleme➢
;)holes, 0      img11 = imfill ( img1➢
nt(img11);   img12 = imcompleme➢

img6, img13 ) ;   img14 = imsubtract (➢
;)'global'img11,     img15 = imbinarize (➢
```

Algorithm application stage

Primary fragmentation (5-3)

```
y ( img , img15 ) ;  Img16 = immultipl➢
;) 3,   diskse = strel (➢
img16, se ) ;  img17 = imopen (➢

; 15img18 = img17 > 2➢
;) 2,   diskse = strel(➢
img18, se ) ;  img19 = imdilate (➢

en ( img19 , 1600 ) ;  img20 = bwareaop➢
```

Image properties measurement stage

(6)

```
;)'noholes'(img20,   [B,L] = bwboundaries➢

,'Centroid',Area,img20,ble'  'tastats = regionprops (➢
,'Eccentricity',norAxisLength'  'Mi,Major Axis Length
;)'Solidity'  ,'PixelList',ConvexArea
```

Cord segmentation stage

Al-Shawki (7-1)

```
(stats) ;  [rows, cols] = size➢
                    rows > 1if➢
;)  10,diskimg21 = imopen
20, se ) ; ( img se = strel (
img22, 1000);   img23 = bwareaopen
mg21, img22); ( img22 = imsubtract ( i
                          else➢
                imshow ( img23 , [] )
                          end➢
```

Cord segmentation stage

Al-Shawki (7-2)

```
;) 55, 24,'    lineSe = strel (➢
( img23 , se ) ;  img24 = imclose➢
img24, se ) ;  img25 = imopen (➢

ct(img23, img25);  img26 = imsubtra➢
ly ( img27 , img ) ;  img27 = bwareao➢
pen(img26, 100);  img28 = immultip➢

; 300  img29 = img28 >➢
pen ( img29 , 15 ) ;  img30 = bwareao➢

;) 15,   diskse = strel (➢
( img30 , se )  img31 = imdilate➢
```

Hernia identification stage

Completely (8)

```
;) 30, 21,   ' line 'Se = strel (➢
img31, se ) ;  Img34 = imopen (➢
ly ( img34 , img ) ; Img35 = immultip➢
; 120  Img36 = img35 >➢
ct(img35, img36);  Img37 = imsubtra➢ disk
;) 2,   Se = strel (➢ Img38 =
( img37 , se ) ;   imerode➢ [B1, L1] =
;)'noholes'ndaries ( img38 ,  bwbou➢ Stats2 =
,Centroid,' Area ',img38,tableps (    regionpro➢ ',' Conv '
,BoundingBox,MinorAxisLength  MajorAxisLength ',
;)Solidity,' PixelList ',exArea     Eccentricity P = stats2 .
Length MinorAxi

P <55if➢
pen ( img38 , 70 ) ;  img39 = bwareao➢
else➢
pen(img38, 110);  img39 = bwareao➢
end➢
) 'montage'39, img32,  imshowpair ( img➢
```

Define area of interest

On the original image (9)

```
;) 105, 70,'    lineSe = strel (➢
e ( tar , se ) ; Img40 = imdilat➢
;) 10,'    diskSe = strel (➢
iply ( img , img41 ) ;Img41 = imdilat➢
e ( img40 , se ) ;          Img42 = immult➢

verlay ( img , img42 ) Imshow (label➢
) er Original Image '  Mask OvTitle (➢

wperim(img42);  BWoutline = b➢
Segout = img ;➢
line ) = 800; Segout ( BWout➢
t, [] ) Imshow ( Segou➢
```

Appendix B

GUI code

```
classdef tareq < matlab.apps.AppBase


    % Properties that correspond to app components
        EditField matlab.ui.control.EditField
        Panel matlab.ui.container.Panel
        UIFigure matlab.ui.Figure properties
    (Access = public)
    displaythefinalresultButton matlab.ui.control.Button
    RUNthecodestagesButton matlab.ui.control.Button
        loadtheimageButton matlab.ui.control.Button
        UIAxes matlab.ui.control.UIAxes
    end
        properties(Access = public)
            imgor = 0 ;
    end
        % Callbacks that handle component events
            methods (Access = private)
     [fn, pn] = uigetfile({'*.dcm'},'select dicom file');
    function loadtheimageButtonPushed(app, event )
    % Button pushed function: loadtheimageButton
            complete = strcat(pn,fn);
        app.imgor= dicomread(complete);
     imshow(app.imgor,[],'parent',app.UIAxes);
    end
 function displaythefinalresultButtonPushed(app, event)
% Button pushed function: displaythefinalresultButton
            Process(app.imgor)
    end
  function RUNthecodestagesButtonPushed(app, event ) %
 Button pushed function: RUNthecodestagesButton
            process2(app.imgor)
    end
    end
        methods (Access = private )
        % Component initialization
```

```
% Create UIFigure and components
function createComponents(app )
% Create UIFigure and hide until all components are created
app.UIFigure = uifigure('Visible', 'off');
colormap(app.UIFigure, 'bone');
app.UIFigure.Position = [100 100 700 544];
app.UIFigure.Name = 'MATLAB App';
% Create Panel
app.Panel = uipanel(app.UIFigure);
app.Panel.Title = 'Panel';
app.Panel.Position = [1 1 700 544];
% Create UIAxes
app.UIAxes = uiaxes(app.Panel);
title(app.UIAxes, 'the original image' )
colormap(app.UIAxes, 'bone' )
app.UIAxes.Position = [11 35 462 435];
% Create loadtheimageButton
app.loadtheimageButton = uibutton(app.Panel, 'push');
app.loadtheimageButton.ButtonPushedFcn = createCallbackFcn(app ,
app.loadtheimageButton.FontSize =
20; @loadtheimageButtonPushed, true);
app.loadtheimageButton.Position = [472 366 210 52];
;'load the image'app.loadtheimageButton.Text =
%Create RUNthecodestagesButton
;)'push'app.RUNthecodestagesButton = uibutton(app.Panel,
app.RUNthecodestagesButton.ButtonPushedFcn = createCallbackFcn(app ,
app.RUNthecodestagesButton.FontSize =
20; @RUNthecodestagesButtonPushed, true);
; app.RUNthecodestagesButton.Position = [472 289 210 50];
'RUN the code stages'app.RUNthecodestagesButton.Text =
%Create displaythefinalresultButton
;)'push'app.displaythefinalresultButton = uibutton(app.Panel,
app.displaythefinalresultButton.ButtonPushedFcn = createCallbackFcn(app ,
app.displaythefinalresultButton.FontSize =
20; @displaythefinalresultButtonPushed, true);
; app.displaythefinalresultButton.Position = [472 209 210 48];
display the final resultapp.displaythefinalresultButton.Text =


% Create EditField
```

```
;)'text'; app.EditField = uieditfield(app.Panel,
centerapp.EditField.HorizontalAlignment =
; app.EditField.FontSize = 21;
bold; app.EditField.FontWeight =
'italic'app.EditField.FontAngle =
app.EditField.BackgroundColor = [0.9412 0.9412
0.9412]; app.EditField.FontColor = [0.6353 0.0784 0.1843];
app.EditField.Position = [1 469 699 50];
'Spinal disc herniation image enhancement and detectionapp.EditField.Value =
;from MRI'
end
end
end
```

the reviewer

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