DETECTION OF INTERDENTAL CARIES AND CARVED TEETH USING IMAGE PROCESSING IN DENTISTRY

A THESIS SUBMITTED TO THE GRADUATE SCHOOL OF APPLIED SCIENCES OF NEAR EAST UNIVERSITY

By
AYŞE SEDA ÖZDEMİR

In Partial Fulfillment of the Requirements for the Degree of Master of Science in Information Systems Engineering

NICOSIA, 2019

AYŞE SEDA ÖZDEMİR
DETECTION OF INTERDENTAL CARIES AND CARVED TEETH USING IMAGE PROCESSING IN DENTISTRY
NEU 2019

DETECTION OF INTERDENTAL CARIES AND CARVED TEETH USING IMAGE PROCESSING IN DENTISTRY

A THESIS SUBMITTED TO THE GRADUTE SCHOOL OF APPLIED SCIENCES OF NEAR EAST UNIVERSITY

By
AYŞE SEDA ÖZDEMİR

In Partial Fulfillment of the Requirements for the Degree of Master of Science in Information Systems Engineering

NICOSIA, 2019

Ayşe Seda Özdemir: DETECTION OF INTERDENTAL CARIES AND CARVED TEETH USING IMAGE PROCESSING IN DENTISTRY

Approval of Director of Graduate School of Applied Sciences

Prof. Dr. Nadire ÇAVUŞ

We certify this thesis is satisfactory for the award of the degree of Masters of Science in Information Systems Engineering

Examining Committee in Charge:

Assoc. Prof. Dr. Kamil Dimililer	Department of Automotive Engineering, NEU
Assist. Prof. Dr. Yöney K. Ever	Department of Software Engineering, NEU
Assist. Prof. Dr. Boran Şekeroğlu	Supervisor, Department of Information Systems Engineering, NEU

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last name:
Signature:
Date:

ACKNOWLEDGMENTS

First of all, I would like to give thanks to my supervisor, Assist. Prof. Dr. Boran Şekeroğlu for his continuous and unceasing support, help and knowledge.

Also, I would like to thank all the engineering staff at Near East University Department of Information Systems Engineering.

I especially would like to give my thanks to my family they are always supported to me and help me any way and also I would like to thank my friends, Sevinç Gülçiçek Balada, Meliz Yuvalı, Deha Doğan, Nima Eini Yetarli and Ehsan Faramarzi who helped me in order to complete this thesis. Also, I appreciate to Mr. Şiyar Güler for all his effort and assistance. Their patience, guidance and vast knowledge was extremely valuable for the completion of this work. Sincerely, Thank you all. To my parents…

To my parents…

ABSTRACT

Nowadays, by new technology and increasing the knowledge of producing information more and more, human begins have been faced with the new methods and technologies in various fields of trade, industry, medicine, etc. Biomedical engineering is the use of engineering principles to reduce the gap between engineering and medical, to further the goals of health care, including diagnosis, monitoring and treatment that has become to a very strong assistant for doctors. One of the important fields of it is dentistry. Visualization in dentistry will be done with the purpose of disclosure and scrutiny of the internal structures of the teeth to the diagnosis and treatment of oral and dental anomalies. Patient issues are detected and improved faster and more accurate using X-ray images of teeth. But analyzing of the dental images by a dentist is tedious and time-consuming. As well as, there are always possibility of errors and misdiagnosis by a dentist in factors such as low quality images, optical illusions and etc. Therefore, exact identification of the damaged teeth by using dental image processing is very important to accelerate the healing process. Also among different types of dental injuries, "caries between the teeth" is selected as the target disease. The reason of this selection is that diagnosis this lesion is so hard without dental images. In this regard, the project has been investigated to analyze images bitewings dentistry. In the proposed method after improving the quality of the input image using morphological transformations, beginning is determined the range of the upper and lower with the calculation of the minimum row. Then intensity and derivative are used for separation and segmentation teeth image pixels. After this step, another process is implemented identify teeth with caries by using comparison between the average of intensity and derivative of pixels any single tooth. The MATLAB software is used for the programs implementation and suggested method evaluation is used. The assessment results have shown that the suggested method is somewhat suitable and it's able to find the damaged areas in the dental images.

Keywords: Interdental caries, dental image processing, x-ray images, tooth-wave images, morphology and medical engineering.

ÖZET

Günümüzde, yeni teknoloji ve daha fazla bilgi üretiminin artmasıyla insanlar ticaret, sanayi, tıp, vb. gibi çeşitli alanlarda yeni yöntem ve teknolojilerle karşı karşıya kalmıştır. Biyomedikal mühendislik, mühendislik ve tıp arasındaki boşluğu azaltmak, doktorlar için çok güçlü bir asistan haline gelen teşhis, izleme ve tedavi de dâhil olmak üzere sağlık hizmetinin amaçlarını ilerletmek için mühendislik ilkelerinin kullanılmasıdır. Bir diğer önemli alan ise diş hekimliğidir. Diş hekimliğinde görselleştirme, dişlerin içyapılarının açıklanması, incelenmesi ve oral ve diş anomalilerinin tedavisi amacıyla yapılmaktadır. Hasta sorunları, dişlerin X-ışını görüntülerini kullanarak daha hızlı ve daha doğru tespit edilir ve geliştirilir. Ancak diş görüntülerinin bir diş hekimi tarafından incelenmesi bıktırıcı ve zaman alıcıdır. Bunun yanında, düşük kaliteli görüntüler, optik illüzyonlar vb. Faktörlerde bir diş hekimi tarafından her zaman hata ve yanlış teşhis olasılığı vardır. Bu nedenle, diş görüntü işleme kullanarak hasarlı dişlerin tam olarak belirlenmesi, iyileşme sürecini hızlandırmak için çok önemlidir.

Ayrıca farklı tip dental yaralanmalarda, “dişler arasında çürük” hedef hastalık olarak seçilmiştir. Bu seçimin nedeni, bu lezyonun tanısının, dental görüntüler olmadan çok zor olmasıdır. Bu bağlamda, proje görüntüleri diş hekimliği analiz etmek için araştırılmıştır. Sunulan yöntemde, girdi görüntüsünün kalitesinin morfolojik dönüşümler kullanılarak iyileştirilmesinden sonra, başlangıç, minimum sıranın hesaplanmasıyla üst ve altların aralığı belirlenir ve daha sonra yoğunluk ve türev, diş görüntü piksellerinin ayrılması ve bölümlendirilmesi için kullanılır. Bu aşamadan sonra, başka bir işlem uygulanır, herhangi bir tek dişin yoğunluğunun ortalaması ile piksel türevi arasında karşılaştırma yaparak diş çürüğü olan dişleri tanımlanır. MATLAB yazılımı programların uygulanmasında ve önerilen yöntem değerlendirmesinde kullanılır. Değerlendirme sonuçları, önerilen yöntemin oldukça uygun olduğunu ve diş görüntülerinde hasarlı alanları bulabildiğini göstermiştir

Anahtar kelime: İnterdental çürük, dental görüntü işleme, x-ışını görüntüleri, diş dalga görüntüleri, morfoloji ve tıp mühendisliği.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1
INTRODUCTION

Nowadays, with the advent of new technologies, trade has taken another form of business as an e-commerce that has been replaced traditional commerce. One of the main benefits of e-commerce is the reduction of direct human intervention and process of automation that improve day by day. E-commerce requires new and different strategies, technologies and sciences. One of Effective and useful technologies in this business are image processing. The technology of image processing has two main branches with the name image enhancement and Machine Vision. In the progress of image processing, the process of analyzing and evaluating another image is not performed by humans this process is done automatically by computers. Therefore, the accuracy of speed, the result of analysis and the efficiency of the identification Detection of the goals set will increase significantly.

Considering that one of the most important applications of image processing is involve medical engineering however in past few years, image processing has been widely introduced in the field of medical engineering. Various algorithms and solutions have been proposed by researchers and engineers to analyze and accurately review medical images in different branches. The main objective of these algorithms are an analysis and evaluation of the patient's problem for physician, with greater accuracy and speed. Obviously, widespread advances in these methods and strategies can create enormous changes in the medical formation system. However, given the wide range of subjects and the diversity of medical images, could be a long way to go. In recent years, many efforts have been made to develop automated systems for medical and bioinformatics applications. One of the most important branches of medicine that has been taken care of by researchers and image processing specialist engineers in recent years is dentistry. X-ray images of dentistry are a great advanced enhancement in this branch of medicine and for dentists.

Many applications, such as the Human Identification System Ammar, H. (2008), system for diagnosis and tooth treatment Kang, J., & Ji, Z. (2010, May), are used to analyze dental images. In this regard, some researchers have examined the dental images with biometric information. These images show the location of the patient's tooth injuries and the dentist will identify and treat the affected areas after viewing and reviewing the images. The point to consider is that looking at the images manually is tedious and time-consuming process. Also in the visual review of images by physician, the probability Error detecting always exists.

1.1. The necessity and importance of the subject

In the present study, the analysis of dental images using image processing have been investigated. The necessity of processing dental images can be expressed in two directions: one in forensic medicine in order to identify people Post Mortem (PM) in adverse events such as flood, earthquake, fire, etc. In such events, soft tissues of the human body will be destroyed. Therefore, teeth can be used to identify corpses according to their hard tissue. Another Importance of Dental Image Processing is Identification of various oral and dental injuries, Since the evaluation of the tooth image can be a long and tedious task for dentists, the analysis and analysis of the tooth images by using image processing techniques will be very effective in speeding up the treatment process. On the other hand, in the examination of images by the dentist, the probability of misdiagnosis is due to factors such as Fatigue, eye error, poor quality of pictures etc… always are avoidable.

Considering the importance and applicability of the subject of dental image processing, the dental images are thoroughly investigated in this thesis. In addition, considering the strategies and algorithms presented in this field, a method is proposed for identifying a variety of dental injuries. The subject of this dissertation is selected as research-applied, so that the results and analyzes performed will help to implement a comprehensive dental-traumatic identification software. Therefore, the main goal of this project is to turn into an applied software in the field of medical engineering.

1.2. Research methodology and dissertation overview

The present thesis consists of V chapters. Chapter I introduces the definition of the problem and the importance of the subject. In the second part of the thesis, a brief description of the concepts of medical engineering science is presented then, in the following chapter, image processing and its application in medicine have been raised. Also, in this chapter, you will find a variety of dental illustrations. The third chapter examines the past work in the field of dental image processing. In this chapter, appropriate methods for identifying and departing teeth in the images are investigated. In Chapter IV, a method for identifying one of the common dental lesions known as proximal Caries is presented as target injury. The reason for this choice is that there are many difficulties in detecting the disease without using dental imagery. Considering that the implementation of the proposed method for identifying the desired injury (interdental proximal caries) and then examining and evaluating the proposed method to confirm the accuracy of the method is considered as an important step in any applied research, this chapter the proposed method has been implemented on dental images of the type of bit wing. Chapter V presents a summary of the proposed method for identifying dental proximal caries. There are also suggestions for continuing this route to those interested in this research topic. One of the most widely used areas in e-commerce is the medical engineering field, due to its many benefits, it has become widely accepted in the present era. By expanding the use of modern medical equipment, identifying and treating diseases is much easier, faster and more accurate. In this chapter, the science of processing images is expressed. The processing of images today is mostly referred to as digital image processing, which is a branch of computer knowledge that deals with signal processing, which is digitized or scanned by a scanner.

CHAPTER 2
BASIC CONCEPTS

2.1 Introduction

One of the most widely used areas in e-commerce is the medical engineering field, due to its many advantages, it has become widely accepted in the present era. With the increasing expansion of modern medical equipment, identifying and treating illnesses is much easier, faster and more accurate. In this chapter, the science of processing images is expressed. The processing of images today is mostly referred to as digital image processing, which a branch of computer knowledge that deals with signal is processing that is digitized or scanned by a scanner. The processing of images has major improvements to the image and vision of the machine. Improvement of images involves methods such as using a fader filter and increasing contrast to improve the visual quality of images and ensure that they are properly displayed in the destination environment (such as a printer or computer monitor), while in the car's vision there are ways in which the meaning can be And understand the content of the images to be used in robotics Majernik, J. (2012). This technology has been used in many areas and has revolutionized human life. Medical engineering is no exception.

2.2. Applications of Information Technology in Medical Sciences

Information technology and medical engineering have many uses in medical sciences. Some of the most important applications of information technology have been stated in this section Khairat, S. (2014, May) and Rakowsky, S. (2011).

- Diagnosis of medical errors:

One of the most important chalks around the world is medical errors that have hampered the health system in all countries. Strong moves and efforts to minimize medical errors, deaths, disabilities, and other consequences of medical errors. Several attempts have also been made in the field of medicine to prevent errors Medical treatment includes: monitoring of drug names, barcodes, re-control, notification of errors, patient placement, electronic prescription, computerized decision making. Given the increasing production of new drugs in the pharmaceutical industry, the occurrence of nominal analogies among drugs is inevitable, causing a large number of medical errors.

- Electronic prescription

With this version, it is no longer used for the writing of pen and paper, but it is used for this purpose. The widespread use of this program in hospitals has led to a significant reduction in medical errors, since problems caused by poorly-versed-verbal copies, similarity of drug names, or less patient-name changes have led to a reduction in medical errors. Although the use of electronic prescription systems reduces medical errors altogether, it has no effect on reducing the mistakes caused by the administration of an incorrect drug.

- Computerize decisions

In recent years, many computer software has been designed and implemented that have played a key role in clinical decision making about treatment. This software is known as clinical decision-making support systems.

Clinical decision support systems are interactive computer programs designed to help decision makers and other health professionals. In fact, these systems link health outcomes to medical professionals and influence health care choices for professionals to improve the quality of health care. The main purpose of decision support systems is to assist physicians during care, which means that a physician can interact with this system and help in analyzing patient data, diagnosis and other clinical activities. The use of decision-making systems in clinical practice increases the quality of care, reduces the amount of unnecessary diagnostic and therapeutic measures, and reduces the amount of medical errors. Various types of decision-making systems in various clinical settings including diagnosis of chest pain, acute abdominal pain, diagnosis in internal medicine, management of various diseases, especially chronic and prolonged diseases (including asthma, diabetes, cancer, etc.), vaccination management and scheduling and ... has been developed.

- Telemedicine

Remote medical is a new term that defines the use of electronic information and communication technologies to provide services and consumer protection. This is important when the distance between the two service and service groups is high. In fact, Remote Medicine is a general concept used to describe the various aspects of telemedicine care. The main idea of telemedicine is the transmission of information through electrical signals and the automation of clinical services and consultation with electronic medical equipment. Among the telemedicine goals are improving patient care, improving access to medical care for rural and deprived areas, giving physicians better access to counseling, making facilities available to doctors for conducting auto examinations, reducing medical care costs, building care services Medicine (at the geographical and demographic level) and reducing the transfer of patients to health centers. Remote medicine includes remote counseling, remote surgery, dermatologist remote therapy, remote ultrasound imaging, remote pathology, cognitive therapy for remoteness. Remote medicine has a wide range of applications and technologies that are designed to increase the health and well-being of individuals in the community. This phenomenon can be identified with the type of information sent (such as clinical and radiographic tests) and how this data is sent. In this section, a few simple examples of telemedicine applications that are used in practice are presented. Graschew, G., & Rakowsky, S. (2011).

- Remote therapy for the treatment of skin diseases

Diagnosis of skin diseases is performed by examining the history of the disease. In remote medicine, treating dermatology, high-resolution color images should be provided from the site. These images can be sent to specialized centers by post. Also, in the case of these types of diseases, interaction between the expert and the patient in real time is not necessary.

- Remote ultrasound imaging

An ultrasound imaging is a safe, painless and non-radiation method, with its hardware at a relatively low cost. The operator can easily learn how to illustrate ultrasound equipment, but cannot interpret the resulting images. This work must be done by an expert at the local ultrasound imaging clinics from the areas where the images are viewed as real time by a specialist physician.

- Remote Pathology

Pathologists provide slides for the benefit of other relevant professionals. In some cases, such as examining the biopsy of certain parts of the body, it is imperative that the opinions of experts be exchanged quickly and that they are held in the shortest possible time. A remote medical device is used to exchange pictures and slides between pathologists.

- Telesurvey

The method is to carry out medical surgeries without direct doctor contact with the patient during surgery, which is practiced by giving control of robotic design tools to physicians. The doctor can perform surgery almost everywhere, while the patient undergoes surgical robotic surgery with remote control. What enables a physician to control surgery is a strong Internet connection used to communicate between a doctor and surgeons, monitors and communication with experienced doctors.

- Virtual Hospital

This hospital is available to anyone who has registered and paid for membership on a permanent and permanent basis. After registration, patients can benefit from medical counseling. After registering a card, members will be provided with the information they provide as a member of the hospital. The services of this hospital include access to the drug database, web chat, and the ability to receive and store information and add information to the network. Patient information is protected by security protocols such as SSL, a secure way to transfer information, text, image, movie and sound. The whole system has many secret and protective layers that protect the network from the influence of virtual attackers.

2.3 Image Processing

In the specific sense of image processing, it is any kind of signal processing that is the input of an image, such as a picture or a scene from a movie. The output of the image processor can be an image or a set of special characters or variables related to the image. Most image processing techniques include collision with the image as a two-dimensional signal and implement standard signal processing techniques on them. Image processing often refers to digital image processing, but optical image processing and image analogue also exist [6].

Digital image processing is the processing of digital images by digital computers. Since sight is one of the most advanced human senses, it is not surprising that images have the most important role in human perception. Unlike humans that are limited to the electromagnetic spectrum of the visual bands, imagery machines cover almost the entire EM spectrum. These machines can operate on images produced from sources that humans are not familiar with. These resources include ultrasound, electron microscopy and computer generated images. Therefore, digital image processing encompasses a wide range of diverse areas of workflow.

Medical pictures are one of the most important diagnostic tools for physicians, which have always been a huge part of the research, given their internal state of the body. Today, with the increased use of digital imaging systems for medical diagnosis, the role of digital image processing in healthcare and medicine becomes more prominent. In addition to digital imaging techniques, such as computer tomography or imaging, MR, today analogue imaging methods, such as endoscopy and radiography, are also equipped with a digital sensor to analyze medical examinations using image processing techniques.

Image processing steps

There is a lot of processing on each image from the moment the image is logged in. By the time the output and output image outputs, these processes are different, depending on the type of image processing system and the system's intended application. But any image processing system has certain steps regardless of the methods and algorithms used in them. These steps are to the sequence is:

Get Input Image: At this stage, the image is read from the input and entered into the system. The image can be captured with a photo storage device or from a camera.

Image preprocessing: The general objectives of this step can be upgraded and eliminated unnecessary components of the image.

Image processing: The main purpose at this stage is to identify the features of the image that can be used for the intended application.

Image Analysis: In this step, we will analyze the image using the extracted features

Image processing in medicine

One of the most important applications of image processing in medical science. Because in medicine, in most cases, all photos need to be carefully reviewed, because it is necessary to see all the details in order to correctly diagnose the disease. In this dissertation is actually the science of processing images in medical use. In recent years, image processing mechanisms have been widely used in various medical fields to improve and expedite the timely identification and treatment of diseases and conditions such as lung and breast cancer tumors, in which time, an important factor in diagnosis of the disease. Due to the fact that in cancers, correct and correct diagnosis is important in the shortest possible time. Image processing mechanisms are simple and noninvasive methods for detecting cancer cells that speed up early detection and ultimately increase the chance of survival of cancer patients Craig, G. (2009). Endeavor and important advances in the field of ophthalmic image processing to provide automated systems for diagnosing various diseases on it. Such systems, in addition to providing the possibility of processing images in large volumes with minimal time and cost, are fatal and other weaknesses that can be detected by the detective. In this regard, other applications of image processing can be used to recognize the autoimmune borderline in ophthalmology. Because of the large amount of information in the EDI-OCT (Enhanced depth imaging optical coherence tomography) images, the non-automated analysis of these data is unlikely for an ophthalmologist. In fact, the main purpose for segmentation automatically in these images, helping ophthalmologists in the diagnosis of diseases related to the eye Cho, Y. S. (2012, July). Other applications of image processing in medical science can identify the utilization of dental X-rays of teeth, automatic detection of brain tumors, breast tumor detection in mammography can be mentioned.

2.4 Dental images and their applications

X-ray is a kind of energy that travels through waves. These waves can pass through or be absorbed by solid objects. The more the body to which X-rays enter, the more compact it will absorb more radiation and will pass through a smaller wave. The bones and teeth are very dense, so they absorb the radiation, but gums and species are less compact and allow this radiation to pass, which is why in one radiograph, 1 tooth of the species and gums are dark and the teeth are bright. Dental fillings that are very dense are completely white, and dentate caries are dark due to their low density Graschew, G., & Rakowsky, S. (2011). The maintenance and treatment of each denture requires the knowledge of the detritus and its complete examination. In this case, it is necessary to provide dental radiography. On the other hand, for many occasions, manipulation without complete knowledge of the teeth may be at the expense of the lives of the people. Dental radiography images have many uses, and some of these applications are referred to later in this section.

- That dental caries that are not detectable by direct eye vision, for example, show an interdental caries to the dentist. It should be noted that in this dissertation, an interdental decay disease has been selected as a target disease for identification using image processing methods.
- The cracks and other problems that have been exist in the tooth or the fillings in it.
- If a person has gum disease, will be aware of the amount of bone desorption that is caused by the disease.
- Radiography shows the problems in the canal and the nerve of the tooth. The dentist needs information through radiography to replace missing teeth with implants or artificial teeth, and orthodontic treatments.
- Various disorders, including cysts, tumors, cancers, and general-illness phenomena that occur in the jaw bones, are discovered through oral radiographs.
- In children, dental radiography, in addition to what has been said, helps determine the stages of dental and jaw growth, especially in the course of dentition and mixed teeth where children have both dental teeth and permanent teeth.
- The cracks and other problems present in the tooth or the fillings in it.
- The presence of extra teeth and high or low dental spaces can also be guessed by radiographs, and the dentist can help resolve long-term orthodontic problems with intermediate short-term treatments.

2.5. Tooth recordings

Tooth characteristics are usually extracted from different types of tooth records. The most common dental record is dental radiographic images. Radiographic images are not only photographed to store original features, but also dentists use them to examine the treatment process and final documentation. Dental radiography images are categorized according to the visual area. Common types of dental radiography images include: Bitewing, Periapical, Panoramic, and cephalometric. Films or digital technology could use to take radiographs as a traditional method. Various photos of the teeth are prepared. These photos may be in-or out-mouthpieces and may show a number of teeth (two or three) or all of them Graschew, G., & Rakowsky, S. (2011). In this section, some of the most widely used dental images will be described.

- Periapical radiography

This photo is one of the most common types of dental photos. Usually this photo is taken from a single tooth or a maximum of 2 to 3 teeth. From this photo, it is possible to identify rotating surfaces of the teeth. In addition, using this photo is the root canal treatment. An example of this image is visible in Figure are 2.1. Periapical images are taken to examine the whole area of a tooth including the tip of the root and the tissue around the tooth. These images are used to diagnose root-end problems; such as root fractures or deep caries. This type of radiographic images provides a complete view of the posterior tooth.

Figure: 2.1 Periapical radiography

- Radiography for children

The photo is for children like the previous one, with the difference that the movie has a smaller size than the child's pain. The amount of radiation needed to shoot baby teeth is less than that of an adult whose X-ray machine will adjust this amount. In Figure 2.2 an example of this image is visible.

Figure: 2.2 Radiography for children

- Panoramic radiography

Out of-the-box radiographs that the film takes out of the mouth when taking photos, Panorama's technique is very familiar to patients. This image is a large photo of all the teeth in the upper and lower jaw. This photo is visible in Figure are 2.3. One of the uses of this image is to investigate the fracture of the jaw due to an impact caused by an accident or falling. With this picture you can also check the presence of tumour 1 and cyst 2 in the jaws. You need to take this photo before orthodontic treatment or wisdom

Figure: 2.3 Panographic Radiography

Teeth surgery. Of course, this kind of image shows less detail than Bitewing and Peripatetic.

- Cephalometric radiography

In Figure are 2.4 this type of photo is displayed. This photo must also be provided at the centres equipped with a variety of radiograms. Usually, if you need orthodontics, you need to take this photo of your teeth. This photo is excellent for examining the growth of the jaw and face, and the skull, while also defining the path to the growth of the jaw and face patterns. Cephalometric images are viewed from the side view and are often used in orthodontic treatments.

Figure: 2.4 Cephalometric radiography

- Digital Radiography

In this method that taken with the help of modern technology, there is no conventional radiographic film, the radiation is brought to the intended use by a special tube, and its digital image is stored in the computer memory connected to the radiographic unit and the dental unit. The amount of radiation required for digital radiography is much lower than conventional radiology. The radiograph image of the dentist is received very quickly and stored in the computer's memory. Digital radiographic images are very clear and clear, and the details are perfectly illustrated. The image provided is comparable to previous radiographs. Enlarged the radiographic image with the help of the computer to the extent necessary and examined all the details. The main problem with digital radiography is their cost. These devices are very expensive, and as a result of widespread use of these devices, it is still not affordable for dentists in clinics and dental offices.

CHAPTER 3
FUNDAMENTAL OF IMAGE PROCESSING

3.1 Introduction

Some dental image processing systems are used to Body Identification1 in Forensic Dentistry Ammar, H. (2008), as well as to identify various oral and dental diseases Kang, J., & Ji, Z. (2010, May). On the other hand, in Forensic Dentistry, identification of individuals is done based on their tooth characteristics, and on the other hand, various processes such as dental implantation, orthodontics and jaw surgery in dentistry are based on computer analysis. Given the fact that all these processes require the analysis of dental radiographic images, it can be said that there is a need for a system for processing and analyzing dental images.

Considering the above mentioned issues, it is clear that accurate identification of damaged dental areas by using dental image processing is very important in accelerating the treatment process; therefore, considering the subject matter discussed in this thesis and considering the importance of the topic in this chapter Work will be done on the processing of dental illustrations.

3.2 An overview of research methods and literature

Diagnosis of oral and dental illness is one of the most important applications of the science of image processing in dentistry. In a computer-aided dental diagnostic system, there are 5 targets for identifying oral and dental diseases such as caries or detecting more serious oral and dental lesions, including cysts and tumors. All of these lesions are identified after teeth separation. The exact shape and volume of the tooth can only be achieved by precise teeth separation. As a result, tooth extraction in radiographic images is an essential step for achieving high precision at the next CADDS stage.

Another important application is the processing of biometric dentistry images. Biometrics is the recognition of individuals based on the measurement of their physical or behavioral traits, such as fingerprinting, iris, face, and sound. However, many of these traits are not suitable for PM identification because the victims of severe accidents such as heavy driving accidents, falls Aircraft, severe crimes, earthquakes, floods, etc., suffer from severe injuries and soft tissues of their bodies.

In such a situation, the teeth, the hardest and most intolerant part of the human body, are therefore considered to be the best way to identify the PM [33, 34]. In an auto-detecting system of teeth 1, which has been developed for the detection of PM, the teeth shape and size an important role is played; therefore, tooth extraction is a necessary step for achieving high accuracy in Forensic Dentistry.

According to the materials presented at the beginning of the first chapter, it is clear that teeth separation is very important in the processing of dental materials, in order to achieve optimal results in most of the work done in this field, before the teeth are separated, first, the image quality is improved by using different techniques and methods of image processing at a stage known as preprocessing.

Image preprocessing is a set of operations that runs on the whole or part of the image to prepare the image for comparison and other image processing. The aim of the image is first improved to reduce the noise and determine the boundary of the teeth. Then the improved images are used to identify and tag different segments of the image. Each tooth must be partly cut off from a radiographic image that is not combined with two neighboring teeth. Improving the quality of dental radiography images is a process for creating better quality images than input radiographs. The term "better quality" is a relative term that needs to be further investigated. Improving the quality of the image is calculated and implemented in terms of suitability for specific applications. The suitability of the radiographic image quality of the teeth should lead to proper segmentation. Correct segmentation requires accurate definition of the teeth borders. In the preprocessing step, changes are made to the image to be prepared for use in the next processing step. In dental radiographs, low contrast and unexpected irradiation make the dental segmentation more complicated. Usually, by improving the image, the process of fragmentation of the teeth is successful.

From the point of view of image processing, a radiographic image of a tooth is a gray level image. The radiography of the tooth is composed of three parts of the tooth, gum and air. The area of the teeth with the brightest gray surface (other than the pulp tissue inside it), the region's gum with an average light level, and the region of the area is dark with darkness, so changing the contrast in a small area indicates the transfer from object to other object. In order to have a good segmentation, the presentation of dental radiographic images is required by using an image enhancement conversion process that provides an acceptable level of contrast in the gray-field range . Also, in Kuo, C. H. (2013) the bottom-hat filter for improving image quality Used. They used the following for this purpose.

$$E\_Image = Image - bottom\text{-}hat\ (Image, SE) \qquad (3.1)$$

In the relationship mentioned above, three are a two-element structural. To further clarify the subject, we will look at the morphology operation in image processing.

3.3 Morphology

The language of mathematical mathematics is the theory of collections. In morphology, a uniform and powerful method is presented for a number of image processing problems. Collections in mathematical morphology represent objects in an image. For example, a set of all white pixels in a binary image is a complete description of the image. Mathematical math is a tool for extracting useful image components that are suitable for presentation and description of the main forms. In addition, morphology techniques are used for pre- or post-processing such as filtering, thinning, and spoofing. Selecting the size and shape of the structural element is an important stage in morphology operations. In general, the process of morphology uses set operators. More morphology is used to extract key points of the image, remove unnecessary points of the image and other similar items. Basic set operators include community, subscription, and the difference between two sets. If any binary image is considered a collection, the combination of two binary image equivalents will be the image in a pixel in the first or second image has a value of 1 in that image. To implement a community operator for two binary images, the corresponding pixels are collocated in two images.

The difference between two binary images of the same size will be the image in which the pixels of the first image with the value of one not in the second image will be of the same value. A single-operand complement operator is also a function that, after applying it to the binary image, in the resulting image, values from one to zero and zero values change to one.

To implement the complement operator, each pixel needs to be a binary binary image. The basis of multi crystalline processing, which is also the main operation in morphology, is:

- Dilation

The Dilation operation r is an operator that increases the size of the components in the image by one or several pixels. Due to this operation, points may be corrected from a binary image due to factors such as noise effects or undesirable threshold effects. Two parts of the image may be connected to each other. The filtering algorithm is incremented so that all black spots of the image are checked; if at least one of the selected neighbors is whitewash, the dot will be white or otherwise black will remain. As the operator name suggests, this operator extends the image points. The expansion extends the geometry of the image so that the objects in the binary image are "grown up" or "thicker". The method and the amount of this thickening are used to control the shape of the structural element. Extender also uses a mask (mask or window). Here, instead of a mask, that structural element is said to have the values of the structural element one or zero. $\oplus$ represents expansion.

- Erosion

The erosion operation is exactly the photo of the expansion operation. In this operation, unwanted spots will be deleted from the binary image, and other parts of the image will be thinner as well as one or more pixels. In erosion, all white points of the image are checked, if at least one of the selected neighbors is black, then that point will also be black. As the operator name suggests, this operator wears one of the points in the image. The erosion function reduces the size of the image, in short, thinning the objects in the binary image. Erosion can be considered as a four-dimensional filtering operation, in which details of the image that are smaller than the structural element are removed or filtered from the image. Like the expansion operator, an erosion operator also uses a structural element whose values of the structural element are one or zero. $\ominus$ indicates that it is unfocused. Also, the combination of the two main operations of expanding and eroding the morphology described above will result in another operation called Opening and closing the operation will be further elaborated further.

- Opening

In this process, the object's curve is usually smooth, narrow broken paths and thin bumps disappear. Applying the opening operator on a binary image will cause the narrow image of the image to be deleted and a relaxed image to be obtained. Open the image from the combination of erosion and expansion operators. Opening the F image with the structural element, b is displayed as $F \circ b$ and is defined as:

$$F \circ b = (F \ominus b) \oplus b \quad (3.2)$$

- Closing:

In image processing, closing with opening is used to remove DE noising of morphology. It removes small objects, while removing small holes. Eliminates the small holes in the foreground. Similarly, the closure of F with b, displayed as $F \bullet b$, is defined as follows.

$$F \bullet b = (F \oplus b) \ominus b \quad (3.3)$$

Up until now, foot and foot surgery have been introduced. In fact, the operation of the upper and lower hats is a combination of the initial operations of morphology described above. Thus, by combining the subtraction of the image with the opening and closing, it leads to converters known as "top" and "lower" caps. One of the main uses of these transformations is to remove objects from the image using the structural element in the open or close operation, which does not fit the objects to be removed. Then the differential operation creates an image in which only the deleted components remain. Converts the upper case for bright objects in the dark background and converts the bottom of the hat to the reverse operation. For this reason, sometimes referred to as white-headed white glossaries and black hairs are also used. The important application of these transformations is to correct non-uniform lighting effects.

Because the proper lighting (uniform) plays an important role in the process of extraction of objects from the background [40,41] , the bottom operator function used in the hinges is defined as:

$$\text{Bottom-hat}(F, b) = (F \bullet b) - F \quad (3.4)$$

Where F is the original image, b is a structural element and "●" is the morphological operator of the closure, the operator can filter an image so that the darker parts of the image become brighter, while the lighter sections become darker. Then the output of the conversion is placed in Eq.1.2 to obtain an improved image. In is references also used to improve the image quality in a similar way to the above method Huang, P. W. (2012).

In Zhou, J., & Abdel-Mottaleb, M. (2005), to reduce the effects of low contrast and unexpected irradiation, the two top-down caps and bottom caps were used on the original image. By improving the contrast of the image by brightening the severity of the dental areas and suppressing the severity of the bony areas and the field. They obtained the improved image using Eq. 5.2, thus adding the filter result of the header to the original image and subtracting the result from the bottom filter of the image hat.

Enhanced Image = Original Image + top-hat (Original Image) - bottom-hat (Original Image (3.5)

Another method used in Dighe, S. C., & Shriram, R. (2012, November) to preprocess and improve image quality is the histogram equalization method. In the following, a more detailed explanation of the histogram will be given and analyzed.

3.3.1 Image Histogram

In a scalar image, each image pixel has a specific value. Histogram is a graphical representation of the number of pixels for each brightness level in the input image. The horizontal axis of a histogram, the numbers related to the brightness of the image pixels and its vertical axis, shows the number of pixels corresponding to each brightness in the image.

In other words, if the input is a gray level image with 256 brightness levels, then each pixel of the image can have a value in the interval [255.0]. The division of zero for black and 255 for white is considered. In the histogram, the height of each vertical bar represents the number of pixels of that particular brightness. Histograms are the basis for many spatial processing techniques. Histogram manipulation can be used to upgrade the image that already used. The calculation of histograms is simple in software, and can also be implemented in hardware. As a result, an important tool in the processing of the image is immediately considered. One of the applications of histogram processing is to reduce the contrast of low-contrast images. When the image contrast is low, the difference between the smallest and most intense image brightness is low. In Dighe, S. C., & Shriram, R. (2012, November) histogram processing techniques are used more clearly. Figure ure 3.1 shows an example of a tooth image with high and low contrast with the histogram for each one.

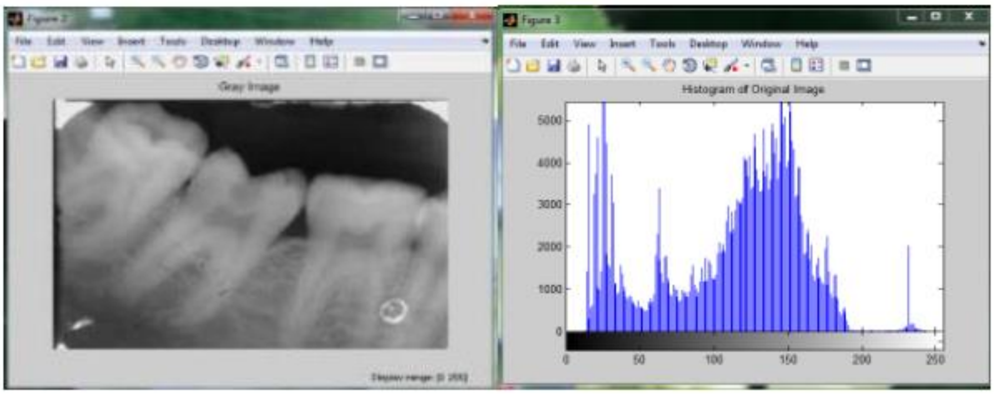


Figure: 3.1 a) image with low contrast and histogram

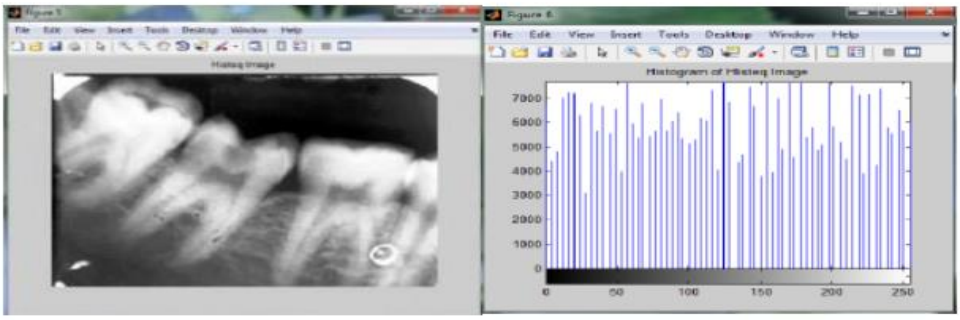


Figure: 3.1 b) high contrast image and histogram

3.3.2 Histogram adjustment

If the image is of poor quality or, in other words, the distribution of the histogram is not appropriate, the contrast can be improved so that the image histogram is well distributed within the appropriate range. Adjustment of the histogram will increase the contrast of the input image as much as possible, which means improving image quality and increasing the accuracy of subsequent processing. In the image processing, the adjustment of the histogram is a contrast adjustment method using the histogram of the image.

This method allows for a higher contrast ratio for regions with lower local contrast. In particular, the results of studies indicate that this method can lead to a better representation of bone structure in x-ray images and better details. The disadvantage of this method is that it is free of discrimination. This method can also increase the contrast of background noise, while reducing the useful signal. As we mentioned earlier, we know that improvement of dental radiography is a better quality image than the image quality of the dental radiograph. Most segmentation techniques require high resolution of object boundaries. Thus, histogram modulation is used to enhance the image. This method has also been used in Ammar, H. (2004, August) to improve the quality of radiographic images. Figure ures 3.2 and 3.3 show an example of dental radiographs and histograms before and after adjustments.

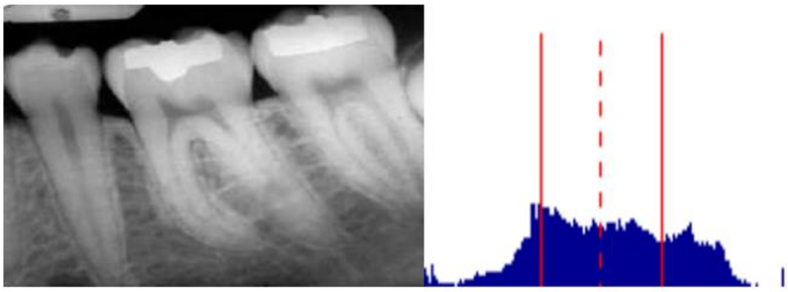


Figure: 3.2 Main dental radiographs and histogram graph

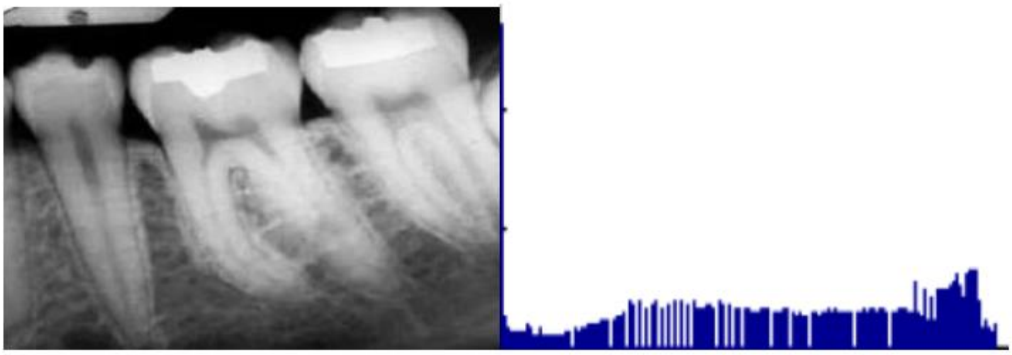


Figure: 3.3 Radiography of the tooth after the upgrade and its histogram graph

In Chen, T., Ma, K. K., & Chen, L. H. (1999). for the removal of salt and pepper noise, a middle filter is introduced. The median filter scans each pixel in the image and scans the nearest neighbors to change the pixel value based on the surrounding environment. The pixel is simply replaced by the mean value of the neighbor pixels.

In reference Ajaz, A., & Kathirvelu, D. (2013, April). a medium filter of size [15 15] was used to enhance the image quality. Also, in Kolivand, H. (2015)., taking into account the fact that imaging problems with regard to the limitations of the device are: low contrast image production or noisy image, to improve the image from the middle filter with size [4 4]. Considering that many programs Applied imaging problems are more prevalent in medical imaging. Regarding image enhancement, if the purpose of noise reduction is not to mimic the image, using the middle filter is a good solution. Medium filter is one of the most effective filters to remove noise in images. In this filter, each pixel is compared with the pixels next to it, and if there is a big difference in the light intensity of the pixels, that pixel will be replaced with its average pixels. The middle-of-the-box filter eliminates noise while retaining image clarity.

3.3.3 Image split techniques

With the segmentation operation, the image is divided into its constituent parts, the amount of segmentation depends on the subject; that is, if the object objects are separated in the image, the plotting process must be stopped Huang, P. W. (2012).

In a general definition of image segmentation, that is, separating the area of interest from the context and other parts of the image. The purpose of the segmentation is to find the area that represents the subjects or parts with the meaning of the subject of the image. Segmentation of medical images is usually done to separate structures from the body in order to see more precisely, estimate the volume of the desired part and identify abnormalities Huang, P. W. (2012).

In many ADISs, CADDS is the first stage of dental segmentation, which means dividing each tooth into a region so that each region contains only one tooth. Such a stage is generally known as tooth decontamination. Tooth extraction is a very important step for both systems, because this step directly affects the accuracy of the extraction of the feature and, as a result, will affect the final results of both systems.

In fact, the exact shape and volume of the tooth can only be achieved by the precise detachment of the tooth, resulting in the tear separation in radiographic images is an essential step for achieving high precision in the next stages of the process. For the analysis of teeth, the first step is to cut off and determine the boundaries of the teeth. As previously mentioned, if the tooth image is analyzed, it consists of three parts: a part with a high light intensity that is itself a tooth, a part of the photo that has a moderate light intensity that is the jaw and the bone of the tooth, and the other part Which has a low light intensity (almost dark) that relates to the areas of the gum and the background of the image. The problem is that the separation of these three light intensity intervals is difficult to separate the tooth from the background of the image. On the other hand, since dental radiographs often suffer from poor quality and low contrast, teeth separation in dental radiography is a very challenging task.

One of the most basic methods for teeth separation is the use of thresholding techniques. This method works on the basis of a threshold that is usually selected from the histogram of the images. The fact that the threshold values of the histogram of the image are obtained states that these techniques do not pose any importance to spatial information. The problem with these methods is the noise in the images and the uncertain edges in the images. Global thresholding is a simple statistical thresholding technique in which pixels are classified according to the amount of light intensity.

The method of choosing the correct threshold for the problem and the different databases varies. The threshold value is obtained by testing and repeating. This simple algorithm works well in situations where there is a clear gap between the histograms of objects and backgrounds. Other methods of thresholding are: selecting Iterative thresholding, Adaptive thresholding [50, 15].

As an example of the methods in which an Iterative threshold and adaptive thresholds are used to perform the exact dental segmentation, we can refer to the method presented in , in this work, to initialize the proposed algorithm, initialize the value The threshold was estimated using the detection of canny edges on the original image then, the opacity of the morphology was applied to the binary edge of the image to determine the pixels around the edge. By doing this, higher contrast pixels are found in the original image. After obtaining a magnified image of the mean gray values of the corresponding pixels, the original image is used as the initial value of the threshold value for the duplicate threshold. In summary, the method outlined is that they used the threshold for the separation of teeth from the field and bones. After partitioning, they used integral projection to separate each tooth from its surrounding tissue. In the simplest way, it delivers desirable results for segmentation and is one of the most commonly used segmentation methods in identification systems based on tooth characteristics. Before proceeding with this topic, the concept of edge detection will be explained.

3.3.4 Edge detection

Edge detection is one of the concepts of image processing. Edge detectors are local image processing methods designed to detect edge pixels. The aim of detecting the edge is to mark the points of an image in which the intensity of the light shifts sharply. The sharp changes in image attributes usually represent important events and changes in environmental characteristics. Edge pixels are pixels where the intensity of the image function changes suddenly. The edges or edges of the edges are collections of edge pixels. The edges may be subject to the view, that is, they can change by changing the point of view, and typically the geometry of the scene, objects that intercept each other and the like, or may be pointless, which usually reflects the features of the objects seen Such as markings and surface shapes. Identifying the edge is a research area in image processing and feature extraction. Pixels or a set of pixels that are edge-shaped generally have the same intensity or are close together. All edges include a change in the brightness of the image. The basic theory in most edge detection methods is to calculate a local derivative operator. Detection of changes in intensity to find edges can be done using first and second derivatives. In general, the size of the first derivative can be used to determine whether the pixel is located on the edge. The first derivative of the image is at any point equal to the gradient's magnitude. The second derivative is also obtained using Laplacian. If an edge is considered as a change in the intensity of light that is taken over a few pixels, edge detection algorithms are generally derived from this change in lighting intensity Majernik, J. (2012).

3.3.5 Edge Detection Algorithms

Various algorithms have been proposed for revealing edges. In the classical Edge Detection techniques, the local magnitudes of the image gradient are considered as the proper representative for the edge. The Roberts, Sobel, and Prewitt detectors belong to this category. Among other efficient algorithms in this area is the edge detector that is widely used for the ability to track the edges, as well as the ability to remove noise using the Gaussian filter. In all edge-finder algorithms, after the edge-finder algorithm is applied, the threshold action is performed, then the double-edged image of the edges for single-pixelation is thinned. Some of the most famous algorithms and methods are

- Sobel Edge Detector

Sobel operator, used for edge detection, calculates the slope of the image per pixel. This algorithm uses the first derivative to find the edges of the image. The slope of a two-dimensional image is a two-dimensional vector with partial horizontal and vertical derivatives as vector components. Mathematically, the recognition of the sable edge is performed using convolution of two 3×3 masks, one for the horizontal direction and the other for vertical orientation in an image that approximates the horizontal and vertical directions. Derivatives in x and y are calculated by two-dimensional convolution of the original image and convolution masks. If F is the original image and D_x and D_y are derivatives in X and Y, respectively, equations (3.1) and (3.2) show how the derivatives are calculated. (Where * denotes a two-dimensional convolutional operation)

$$Dy = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} * F \tag{3.1}$$

$$Dx = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} * F \tag{3.2}$$

This method derives the edges using the estimate, which returns the edges as the points in which the gradient of the F image is the maximum.

- Prevvitt Edge Detector

The prophet edge detector is similar to the Sobel detector because it also estimates derivatives using a convolution to find the local orientation of each pixel in an image. The convolutional structure used in prophet is different from Sobel. Peritate is more susceptible to noise than Sobel. Equations (3.3) and (3.4) show the difference between periet and sable detectors by presenting the periet structure. In these equations, the same variables, such as Sobel, are used. Structures are different for calculating derivatives. (Where * denotes a two-dimensional convolutional operation.

$$Dy = \begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix} * F \tag{3.3}$$

$$Dx = \begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 0 & 1 \end{bmatrix} * F \tag{3.4}$$

- Roberts Edge Detector

The detector is one of the earliest edge detection methods, and its function is reduced if noisy images are taken, but this method is still used, because it is simple and easy to implement and faster than other methods. Its implementation is carried out by convolutional image input with a 2 × 2 structure in equations (3.5) and (3.6).

$$Dx = \begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix} \tag{3.5}$$

$$Dy = \begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix} \tag{3.6}$$

- Kenny edge detector

The Kenny algorithm was first introduced in 1983, and it was welcomed by experts and users. This algorithm is now widely used as a detector in the industry. An objective method based on three goals, the low error rate, all edges, must be found, and the edges of the exposed should be closer to the original edges, the edge points must be well localized, that is, the distance between the point by the detector as The edge is marked and the center of the real edge is minimal, and the answer to the unique edge point, that is, the detector, should only return one point for each point of the real edge. The edge detector is very effective as an edge detection method, it can detect weak edges, even when noisy images are taken into account. The reason is that at the beginning of this process, the data is involved with a Gaussian filter. Filter

The Gaussian in a cipher image leads to the filter output to the noise pixels. Then the gradient of the image is calculated, similar to other filters like Sobel and Parit. Then the multilevel threshold method is used on the data. If the pixel value is less than the threshold, it will zero and if it is more than the threshold it will put it 1. Based on the targets mentioned for the mineral, the mineral edges detector first softens the image to eliminate the effect of noise. Then the image gradient picks up the regions with high changes (high spatial derivatives). Then the algorithm moves along these areas to avoid any pixel that does not have a maximum gradient (Find the local maximum.) Next, hysteresis concepts are used. Hysteresis uses two upper and lower thresholds. If the size and amount of intensity in pixels is lower than the first threshold (lower limit), its value is set to zero (not considered as an edge). If its value is between two thresholds, its value is zero unless one of the path of this pixel there will be another pixel with a gradient above the second threshold (upper limit). In other words, there is a connection between this pixel and the edge pixels, and if the pixel value is higher than the upper limit, that pixel is selected as the edge.

In the following, the mean value of the gray level of the entire image was considered as the threshold value of the threshold. Then a duplicate threshold was made so that assuming that f (i, j) is the gray level of the pixel (i, j) and Ti is the threshold value of the classification in step i. To obtain a new threshold value, the main image using The teeth threshold is divided into tooth area and non-tooth area. In the relationships (3.7) and (3-8) are $\mu^i B$ and $\mu^i O$ the mean values of the gray level for the two regions .

$$\mu^i B = \frac{\sum(i, j) \in background, f(i, j)}{\# background - pixels} \tag{3.7}$$

$$\mu^i O = \frac{\sum(i, j) \in dental, f(i, j)}{\# dental - pixels} \tag{3.8}$$

The threshold value for the i + 1 step is calculated using the relationship (3.9) as follows :

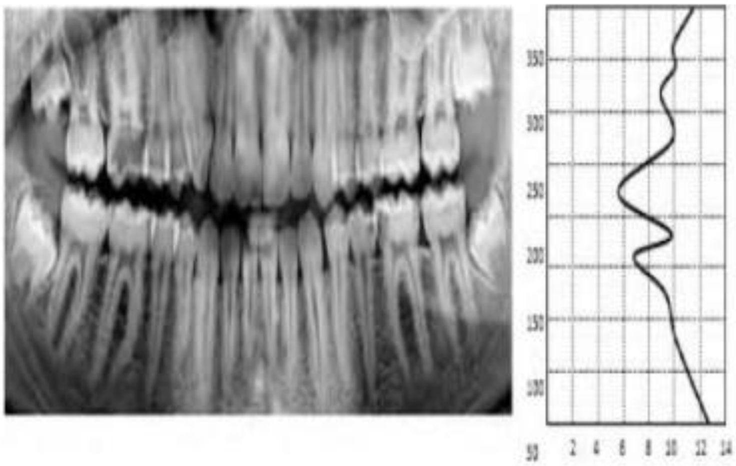
$$T_{i+1} = \frac{\mu^i B + \mu^i O}{2} \tag{3.10}$$

The update step of the threshold value in the repetition threshold continues until the threshold value is retained in two consecutive rehearsals. Ti = Ti 1 The final threshold value, the image is divided into two regions, the tooth area (pixels whose value is greater than the threshold value (Field area) (pixels with a value less than threshold value). After 4 to 12 repetitions, good convergence is achieved. Then they used the role integral to separate the upper and lower jaw teeth and to separate each tooth. The partitioning method was applied to 117 bytes wings. For all the maxillary separation images from the jaw are correctly performed. This method, in the simplest way, produces favourable results for fragmentation and is one of the most commonly used methods for determining automatic identification on the basis of tooth characteristics. Therefore, for segmentation of radiographic images and separation of each tooth area, has used.

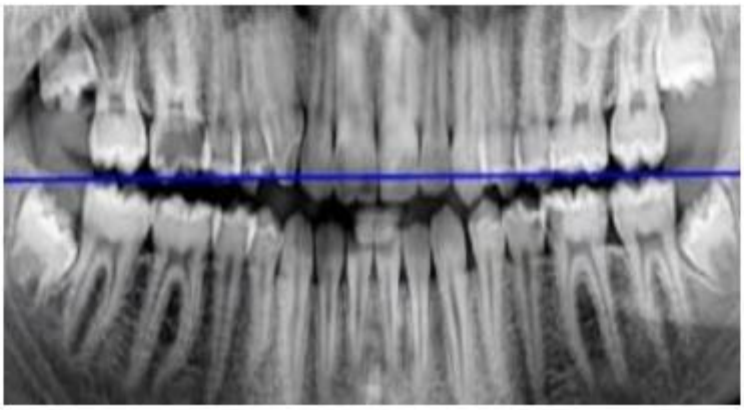
In Kuo, C. H. (2013), an effective dental isolation technique was proposed for dental X-ray images. Their proposed algorithm is to separate each tooth from the surrounding area using a horizontal Integral Projection, first divide the upper and lower jaws and then separate the teeth of the tooth by using the Vertical Integral Projection of the tooth. To do this, at first the total brightness intensity of each row of pixels is obtained from the parallel image of the x-axis, which is referred to as the horizontal projection of the image. To calculate the integral, the role of any horizontal line of the image of relation (3.11) is used as follows

$$H\ (y)\ = \sum_{x=1}^{m} F(x, y) \tag{3.11}$$

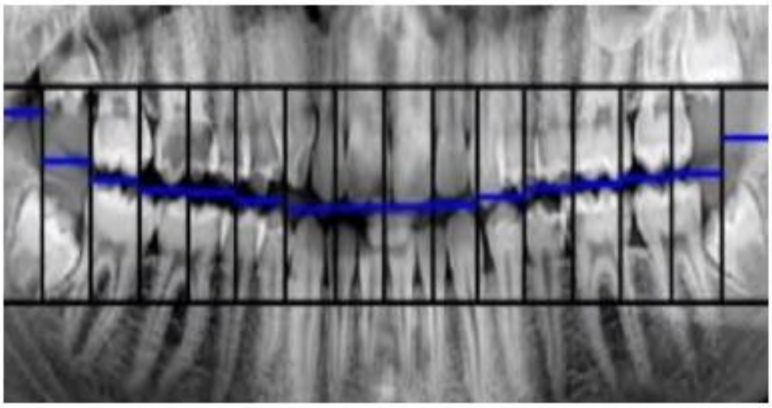
Where F (x, y), x = 1, ..., m, y = 1, ..., n, is the intensity of the gray level of the pixel in the position (x, y) in the image F. Then the main valley on the horizontal projection of the image in order to separate Upper and lower jaws were drawn from the location of the main valley of the separation line. They observed that in some cases, the teeth of the upper and lower jaw did not well disassemble. To solve this problem, the horizontal separation line obtained as a They used Strip-Widowing to fix the problem, using the horizontal separation line, and a series of strip windows, h × w of size H = 70 and W = 40 pixels to the center line of the tape on the line, From the left b They adjusted horizontally one after the other, then they obtained horizontal projection for each tape separately, thus the horizontal separator line for each bar is identified, then the pixel is located in the middle of each line and labelled as a point. Finally, by connecting the obtained points, the curve drawn from all points obtained is drawn and the jaws are separated up and down. The point to be noted is that the height (H) of each window bar should be sufficient It is large enough to cover part of the crown area of the toothpaste on each side of the horizontal separation line and the width (W) of each strip of the window should be only part of the width of the tooth So that the piece of line obtained from each window bar can separate the teeth better. To separate each of the teeth, they used the same way as the horizontal separation of the jaws, and used vertical projection and window strip for vertical separation of each maxillary jaw teeth. As shown in Figure 3.4, in [52], a similar method is used for image segmentation and tear separation in which strips of 20 × 70 are used.



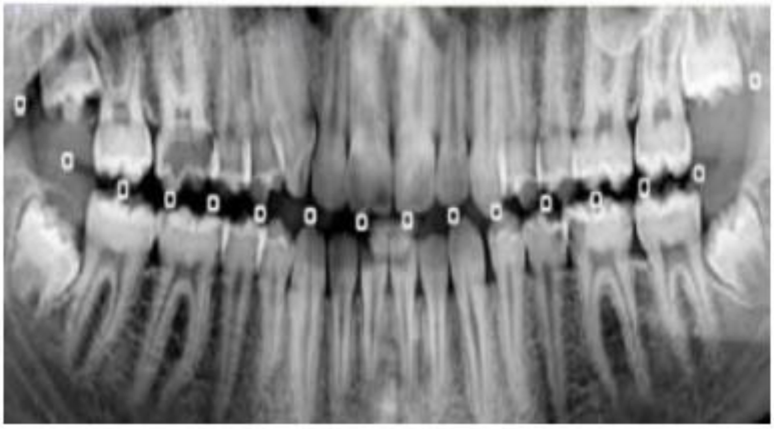
(a)



(b)



(c)



(d)

Figure: 3.4 Horizontal separation: (a) Horizontal projection diagram of the image, (b) Primary separator line, (c) The window bar and the horizontal line drawn on each strip, (d) Locating the middle points of each line in each strip [52]

In [52], a semi-automatic method for measuring the Root Canal Length is proposed. The process of measuring root canal length is very important in root canal treatment. In fact, this requires that you separate the areas of the root of the tooth from the background and the bones, which refers to the problem of tooth decontamination in radiographic images. Considering the fact that the incorrect estimation of the length of the canal can prolong the treatment and root infection, the importance of the subject can be realized. For this purpose, in the proposed method, an edge detection was used to estimate the root canal length of the tooth. In this study, different edge detectors have been investigated. In the meantime, the best result is from the edge of the mineral detector. Then the edges are added to the upgraded image from the pre-processing stages. In this way, the edges appear more intense in the image. Finally, Threshold Otsu's Method is used to obtain a binary image in order to measure and accurately determine the root length in the image. In Zhou, J., & Abdel-Mottaleb, M. (2005) ,ADIS is proposed for use in legal dental and PM detection. The system uses Binding images to identify corpses. Because these systems often look at the shape of the grinding teeth, they are considered to reduce the storage space in the system byte wing. As noted above, the segmentation and separation of teeth in such systems is very important. The purpose of the segmentation in these systems is the separation of the teeth from the background in the bitewings, the extraction of the crown contours, the roots and fillings of each tooth. The proposed fragmentation method Zhou, J., & Abdel-Mottaleb, M. (2005) consists of three steps: determining the desired area, improving the image and separating the tooth from the image. In the beginning, the role of the teeth of each of the upper and lower jaws was separated from each other by the help of the integral. As previously mentioned, they used the two main filters to reduce the effects of low contrast and unexpected irradiation. Then, using the matching threshold window, while the effect of non-uniform noise and irradiation in the bone areas of the enhanced image was reduced, pixels belonging to the tooth and the field were also determined. The idea behind the matching threshold is that the local neighbour's intensity values are evaluated for each pixel. So that if the intensity of the pixel is greater than the average intensity of its neighbour's, it categorizes it as a tooth, otherwise it considers the background to be. After getting the primary contours of the teeth, an active contour is used to obtain the exact contour of the teeth.

CHAPTER 4
METHODOLGY

4.1 Introduction

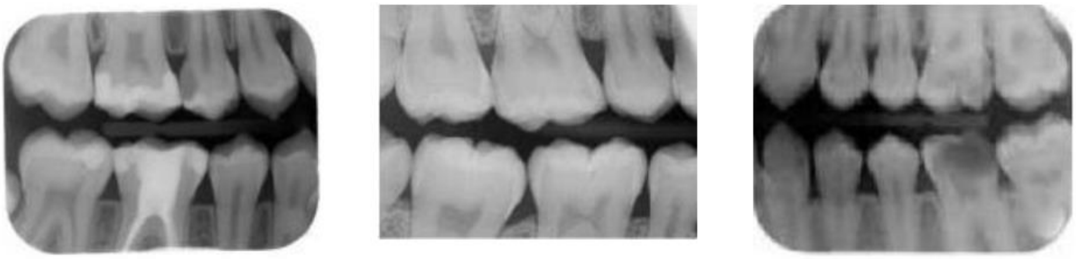
According to the materials mentioned in the preceding chapters, the importance and necessity of the processing of dental materials was fully expressed. In this regard, this chapter presents a method for identifying one of the most common dental injuries. Before the proposed method is presented in this chapter, the type of tooth injury and the type of radiograph used will first be determined. It should be noted that in this dissertation, the MATLAB software is used to implement the proposed idea. In the following chapter, the first step of its preprocessing is to improve the image quality of the input. Then, how to separate the upper and lower jaws and detachment of each individual tooth is explained. Finally, a proposed method for identifying damaged teeth is presented

4.2 Determine the target disease

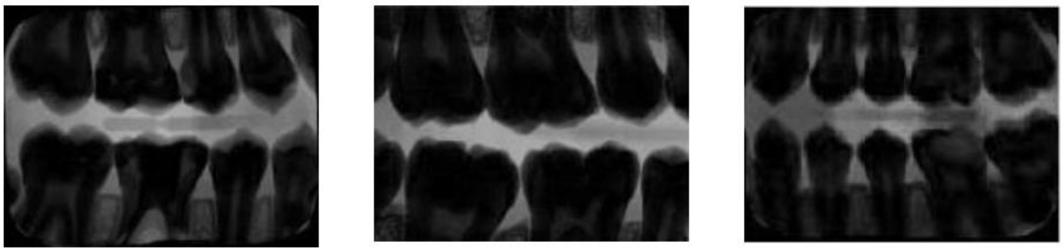
First of all, it should be determined which of the dental injuries is considered. Dentists identify many dangers with dental imaging. It is also necessary to specify the type of image. As in the second chapter, there are different images in dentistry, each of them for specific disease. In this Thesis, the decay disease, specifically decay carcinoma, has been selected as a target disease for identification in dental illustrations. Since the interdental surfaces are not cleaned due to the lack of penetration of the toothbrush hair, they are therefore considered to be areas that are prone to decay and gingivitis. The reason for this choice is the prevalence of the disease among different people and the difficulty of diagnosing the disease by dentists without the use of dental illustrations. It should be noted that the purpose of the disease in this thesis has been taken directly by the dentist. Tooth decay can be classified according to the location, cause, progression and hard tissues affected. The development of an algorithm for decay detection and measurement of dental damage is a topic in which studies focus on it. Due to the similarity of features in some dental areas, and also the close proximity of the severity of different dental areas in Radiographic images can be said that one of the most important and challenging problems in this research is to find a method for extracting the features of dental areas including decay and non-decay, to find the exact area of the caries in the tooth and to find the wrong judgments. Tooth decay is visible in X-ray changes and can be detected by the doctor from dental radiographic images. The project uses Bitewing images. The reason for this is that the identification of teeth with decay, especially interdental caries that often occurs in hind limb teeth, is in these thumbnail images Dentists usually use these images to detect rotten teeth. The proposed scheme in this thesis explains how image processing techniques will help to investigate X-ray images to cause decay (teeth Decayed).

4.3 Preprocessing

At first, the tooth image is received as an input by the program. The MATLAB software is used to read the input image using the command imread. This idea needs to be pre-processed before entering the main program. In this stage is used to improve the image quality of the morphology filter. First, the bottom hat filter is applied to the image. Then, using the relationship (3.1), the image input quality is enhanced. In SE (3.1) one structural element of the circles with radials is 1/1 of the width of the input image, as shown in Figure are (4.1). A sample of the results of the image upgrade is presented.



(a)



(b)

(c)

Figure: 4.1 Image enhancement: (a) original image, (b) filtered image with low cap filter, (c) enhanced image

4.4 Separation of the upper and lower jaws

After upgrading the image quality, it is necessary first to process the tooth image to separate the upper and lower jaws. For this purpose, a horizontal line in the middle of the image, which is actually the upper and lower separation line, is to be identified. Before finding the horizontal line between the upper and lower divisions, given the fact that the upper and lower parts of each image byte wing radiography is related to root and gingival areas, and since the objective is to investigate interdental caries, there is no need to examine and process these areas. Therefore, to reduce processing at the beginning of these sections, the image is disconnected from the image.

To separate additional parts of the image, the size of the input image (F number of rows and columns of image), which is read from the input, is first placed in a matrix [n m]. Therefore, to reduce processing and using a cut, these areas are separated from the image. Here, ST are the same parts of the image that are separated from the top and bottom. Then the extra areas from the top and bottom of the image are arranged with the commands in figure are (4.2).

```
[m          n]=size          (F);
cut=4;
st=floor(m/cut);
F_st=F(st:(cut-1)*st,:);
```

Figure: 4.2 Separation of additional areas

F_st; is the part of the image that remains after separating the extra areas from the top and bottom (for example, the numerical number for understanding **F_st).** If the total number of rows in the input image is 222 lines, that is, m = 200, if cut = 4, it is obvious that st = m / cut is st = 50, so 52 pixels up and 52 pixels should be separated, that is, Disconnected image values: F_st = [50: 150]. If you want, you can display the main image and image after being cut in a window. In Figure ure (4.3), for the sake of a better understanding of this part, the regions of st and F_st are identified.

Figure: 4.3 Results of separated areas

Up to now, additional parts have been removed from the input image. In the next step, for the separation of the upper and lower maxilla, a radiographic image is used. Thus, with regard to dental radiographic images, it is clear that the space between the two maxillary jaws and down in these dark-colored images appear. As noted in the previous chapters, the lower the physical density of the X-rays is, the more they will appear in the dark-colored image. Since the space between the two upper and lower jaws also have a low density (there is air in these parts), so the value of the pixels in the lower division region of the jaw is low and low. This feature is used to separate the maxillary and lower jaw. So first using the first line of the commands in Figure ure (4.4), in MATLAB, the total pixels of each row are calculated from the input image.

```
u_sum=sum(F_st,2);

[u_min1 indx1]=min(u_sum);
```

Figure: 4.4 Separation of the upper and lower jaws

The above command calculates the sum of the pixel values of each row. In MATLAB, a sum can be used to add a numeric value. Here the sum statement is used to obtain the sum of the pixels in each row. So that F_st is the input image after cutting the extra areas. U_sum is a column vector m × 1, the value of the row of this vector is in fact the same sum of the pixels in each row of the input image. After calculating the total values of the input image columns and considering the above-mentioned materials, it is clear that the line of the input image, which has the smallest value, is the same as the upper and lower divisor dividing line. The second line defines the orders of the form (5-4) which has the lowest value. In MATLAB, the min statement is used to calculate the minimum of a matrix. After calculating the total number of pixels, using the min command, we find the line separating the maxillary divisor and the lower row or the same row with the lowest value. Here index1 is in fact the same middle line.

Up to this stage of the program, the image of the entrance to the maxillary jaw is divided up and down. The image of the upper half of the jaw is marked with I1 and the image of the lower half of the jaw is marked with I2. According to the instructions in Figure: 4.5 it is obvious that the image is half the upper jaw (I1) is from the first row to the row for index1, and the half-jaw part(I2) is from index1 to the last

```
F_st(indx1,:)=255;

I1=F_st(1:indx1,:);

I2=F_st(indx1:end,:);
```

Figure: 4.5 Determine the upper and lower maxillofacial range

4.5 Segmentation and tooth Separation

Each tooth should be separated individually in each half of the jaw. Dental image segmentation means extraction of certain teeth or teeth from the background of the image including gum and jaw. Each tooth extracted from the image represents the ROI area, which contains important information that is used for later stages. Tooth extraction is a very important step for the diagnosis of dental disease using both computer and automatic dental identification systems, since it indirectly affects the accuracy of extraction of the feature and, consequently, affects the final results of both types of systems. Image partitioning is typically defined as the process of extracting objects from the image background. From the perspective of dental illustrations, the division is to recognize the entire tooth of a person in the X-Ray image or parts of the tooth such as the crown and root of the tooth, which is an integral part of the processing of dental images. In this thesis, in this section two methods for tooth separation in dental images are proposed. In the first method, which is used for fragmentation and separation of teeth, after dividing the image into two jaw and lower jaws, each single tooth is separated in each jaw. In this way, by finding the distance between each tooth with its lateral tooth in each jaw, the teeth in each of the jaws are high and low. Figure ure 4.6 shows these areas. To this end, the pixel properties of the dental radiographs are still used.

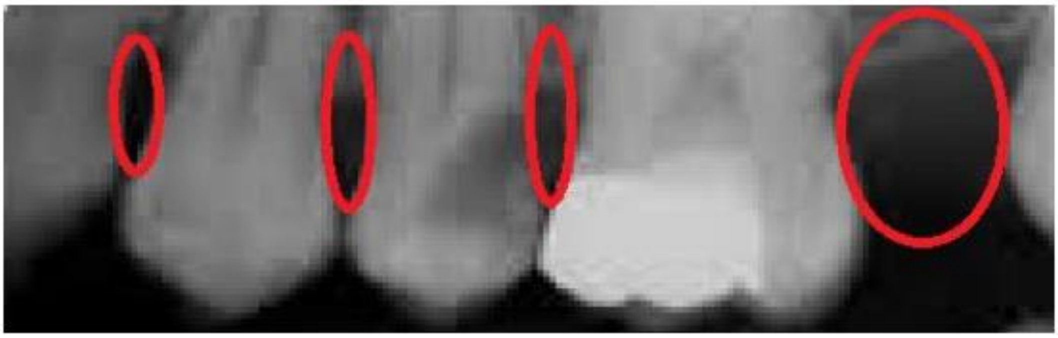


Figure: 4.6 The Areas between teeth

So, to separate each tooth from the side of the tooth, you should find the column between the two teeth. Looking at radiographic images it is clear that the space between two teeth is less than the distance between two jaws. The teeth areas are more intense because the teeth are dense, so they will appear as clear areas in the radiograph, so there will be a passage through the space between the two teeth and vice versa, the change in pixel intensity. Mathematically, calculations must be derived. Since these changes occur along the horizon, the derivative is calculated along the horizon. Thus, in each row, each pixel is derived along the horizon. To calculate the derivative of a function, Figure ure 4.7 is used.

```
D1n=createD1matrix(n);

D_I1=(D1n*I1')';
```

Figure: 4.7 Derivative calculation along the horizon

In the above statement, D1n is a function that calculates the horizontal derivative. So that this function is a matrix in n dimension, where n is the same number of columns of the input image matrix, then multiplied by I1 to calculate the derivative of this matrix in the input image transposition (maxillary image). The derivative of each pixel is then computed along the horizon. Then to find there are 2 pixels in each row in the area between the two teeth;

- The intensity of the pixel is less than half the average pixel intensity of that row.
- The pixel derivative is the target of the average derivative of the horizontal pixels of that row.

Studies have shown that if these two conditions are met, the pixel selected is the pixel component in the space between the two teeth. Hence, after calculating the derivative of each pixel in each row, the average intensity of the pixels of the horn and the average of the horizontal derivatives of each row are calculated. The mean command in MATLAB is used to compute the mean.

As previously mentioned, in order to separate each tooth from its adjacent tooth, it is necessary to identify the line (column) in this area. To identify the column, the pixels that are in each row belong to this column. In order to achieve this goal, two conditions are considered. Firstly, the pixel intensity should be less than half the average pixel intensity in that row (because: In the space between each tooth with its adjacent tooth, we change the severity from high to low and vice versa.

Because the teeth are bright and the space between the two teeth is dark, it is expected that in these areas the intensity of the pixel is less than the average pixel intensity of that row), and secondly, the pixel derivative must be larger than the derivative of the pixels of that row (cause: we know In the space between two teeth, from the tooth area (bright pixels) to the non-tooth area (dark pixels), and vice versa, so much change, On the other hand, mathematically, a lot of changes mean a lot the derivative of the derivative is derived, so we expect that the pixel derivative in these areas will increase in line with the horizon; therefore, if the derivative of the pixel is greater than the average derivatives of that row, it is true in the condition. If both quantities are true, the pixel is 1 and otherwise 2. At this point, it is expected that the pixels between the two teeth in each row, I-thresh, are identified.

Since processing pixels per pixel in each row, it is likely that after identifying a pixel as the target pixel (pixel between two teeth), the next pixel also applies to the terms and the program as pixels the goal is to consider (two pixels stacked), which, in some cases, makes the space between two the teeth are also identified as a separate part (one tooth). To avoid creating such an error with the command; T=floor(n/5) for each pixel of the next pixel is set to the distance t of pixel, where n is the same number of columns of the input image, that is, after identifying the first pixel, the next search of the pivots with the pivot T pixels starts later It should be noted that at first, the value of t was considered 22 pixels, but the results showed that this interval is very small for some images and does not work properly. The indexes related to the pixels that are expected to be in the area between the two teeth are placed in an array called idxx. So that in the first line I-thresh the pixels whose values are 1 and have a certain distance (Up to T pixels) are separated, separated. Thus, in each row there is an index of the pixels that are present in the space between the teeth; therefore, by identifying these points in each row, the column separating each tooth from its adjacent tooth will be determined. Up to this stage of work, after improving the image quality, the upper and lower jaws were first separated and then with putting two conditions for the pixels of each row and checking them, the pixels that apply to both conditions were identified and their related index was placed in an array. So far, every teeth have been separated from the side of her teeth.

In order to more accurately evaluate each single tooth in subsequent processes with the purpose of identifying rotten teeth, they are categorized using a function in MATLAB and determining the pixel processing phases of each single tooth. The phase value, which in fact determines the number of phases to check each single tooth, is defined herein. That means that intensity the pixels of each single tooth are placed in five categories after being separated. This process further analyzes the tooth pixels it will help in future processing. For this purpose, the EMSeg algorithm is used. In MATLAB, this algorithm is used to segment a gray level image in different classes. It is expected that after applying this function to the image, there is a maximum fragmentation of the image. The image I11, which is in fact the same image of each single tooth after separation, is given as an input to this function.

After the application of the EMSeg function and phasing each single tooth in five intensities, the single-tooth images are displayed. It should be noted that to show the partitioned image of each single tooth, the part of st, which was separated from the top and bottom of the input image at the start of the work, is also added to each piece of the image. Generally, here, after separating the maxillary maxilla from the main image, each of the teeth from the side of the tooth (with two conditions) for processing and examination

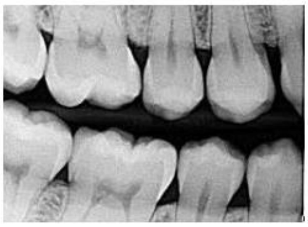
More isolated. In summary, the steps involved in doing this work are as follows.

- By applying the waveform filter, the image quality of the input is improved.
- In order to reduce processing by using a cut, the extra parts of the top and bottom of the image that are not related to the area of the tooth are cut and removed.
- The sum of the pixel values for each row is computed.
- Finding the sum of the minima for the separation of the upper and lower jaw, as it is dark in the radiographic image of the upper and lower jaw space, so it is clear that the maxillary and maxillary separator line has the least amount.
- After finding a two-jaw separator line, the image is divided into two parts of the upper jaw and lower jaw. (I1; upper jaw and, I2 down jaw).
- After separating the upper and lower jaws, the next step is to separate each of the teeth individually, for this purpose, the line (column) located in the space between the two teeth should be found. In the space between the teeth, the amount of pixels is low and the intensity changes are high; on the other hand, mathematically, the calculation of the changes means derivative calculation, that is, wherever the changes are more severe, the derivative increases; therefore, with the consideration that changes in intensity from the tooth area

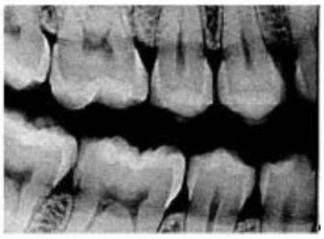
The space between two teeth occurs (in reverse) along the horizon, the derivative is calculated along the x-axis (horizontal).

- The average pixels for each row and the average of the horizontal derivatives of each row are counted.
- In each row, pixels whose intensity values are less than half the average of the intensity of the pixels of the same row and the derivatives of them are more than the derivatives of the pixels of the desired row are identified (if they are in both defined conditions, as the target pixel identifies (1), otherwise, the pixel will not be in the space between the two teeth. (2) In fact, we expect the pixels between the two teeth in each row to be known at this stage.
- The pixel indexes that we expect to be in the area between the two teeth are placed in an array called idxx.
- Then, for further investigation and analysis of each single tooth, the EMSeg function is used to categorize the pixels of each tooth in terms of severity. Here, the pixels of each tooth are classified in five parts (in five suffering from severity). This work was carried out to examine the various points of each toothache in order to be used in subsequent treatments for tooth analysis and further investigation.
- In order to find the line in the space between the two teeth and the isolation of each single tooth, the process of identifying the index between the knees should be performed for all maxillary rows, thus, with the percentage of errors in each of the maxillary teeth (lower).

- In the following, several examples of the results of the proposed teeth separation algorithm are shown using the first method. This algorithm is based on a number of tooth-wave dental radiographs, these images are used to evaluate interdental caries is used by dental practitioners. In Figure s (4.8) and (4.9) these observation results are visible.

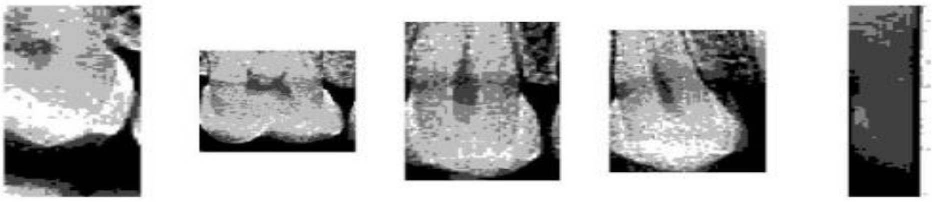


(a)



(b)

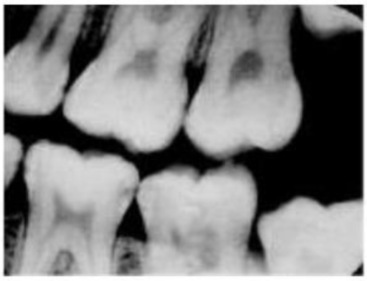
(c)



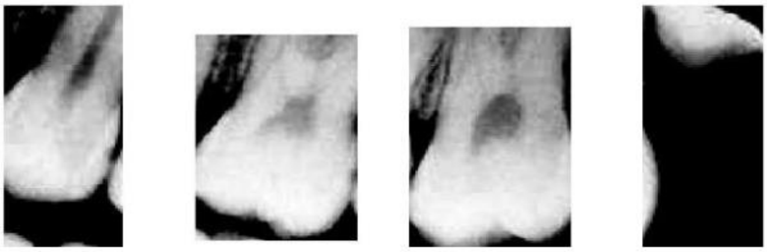
(d)

Figure: 4.8 a) Input image. b) Improved image c) The result of detaching each single tooth in the upper jaw. d) the result of applying EMSeg to the isolated teeth

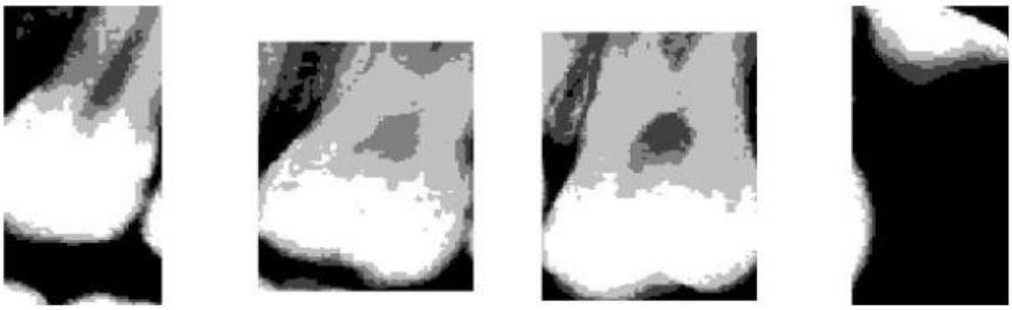
(a)



(b)



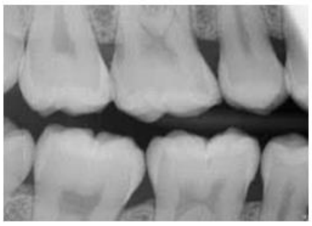
(c)



(d)

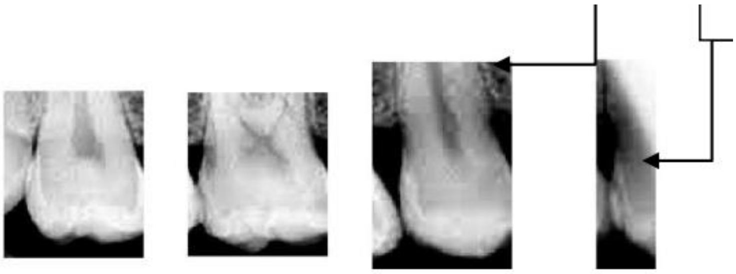
Figure: 4.9 a) Input image. b) Improved image c) The result of detaching each single tooth in the upper jaw. d) the result of applying EMSeg to the isolated teeth

The results of the implementation of the first method showed that the program failed in the isolation of single teeth and in some cases separated more than one tooth in one piece. Examples of this state are shown in Figures (4.10) and (4.11).

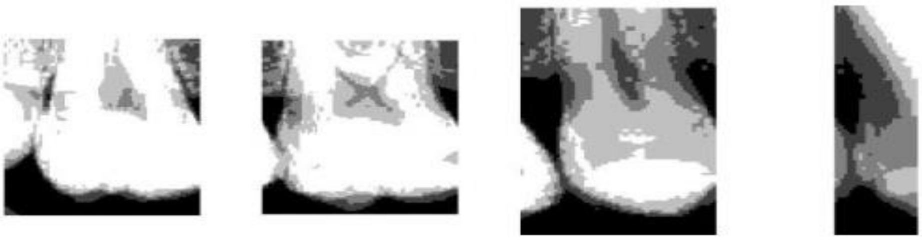


(a)

(b)



(c)

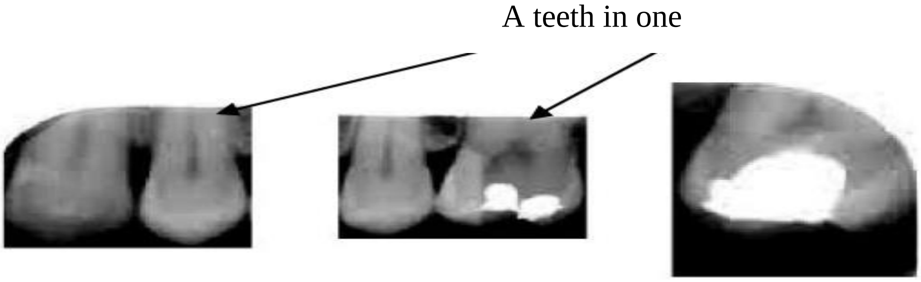


(d)

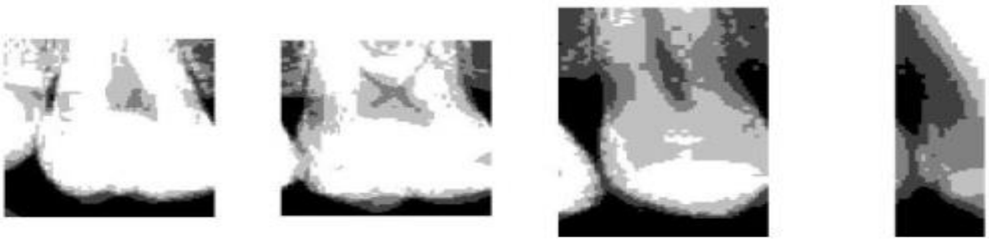
Figure: 4.10 Error in the implementation of the first method: a) Input image. b) Improved image c) The result of detaching each single tooth in the upper jaw. d) the result of applying EMSeg to the isolated teeth

(a)

(b)



(c)



(d)

Figure: 4.11 Error in the implementation of the first method: a) Input image. b) Improved image c) The result of detaching each single tooth in the upper jaw. d) the result of applying EMSeg to the isolated teeth

According to the results of the first method for the separation of teeth, it has been observed that the program in some cases, as given in Figure (4.10) and (4.11) has encountered an error in the separation of each tooth from its lateral tooth. So by removing more than one tooth in one section and considering two or more teeth as a single tooth and giving it a separate piece. Therefore, in order to overcome this problem, changes were made to the first method, so that the resulting changes resulted in better results from teeth separation. In the remainder of this section, the second program for the separation of teeth has been studied.

Regarding the results of the implementation of the first method, it was observed that in some cases, the edges are weaker, the program encountered an error and two teeth, even in some cases more than two teeth in one piece. To solve this problem, in the second method, the sum of the intensity values and the derivative of each column are used to separate the teeth. So that all the steps of the first method are on the sum of the intensities and the derivatives of each column is done. Also, in the second method, to increase accuracy and to achieve better results, teeth separation, cut and T values have also been changed.

In this method, the process is initially cut off from the top and bottom of the input image after reading the initial input image and improving the image quality by considering cut = 5. Then, for the separation of the upper and lower jaw, the same procedure was used. As before, for this purpose, the sum of the intensity values in each row of the image is calculated first, with considering that the dividing line of the maxillary and upper and lower jaw has the least amount, since the space between the two teeth in the radiographs is dark, the row is marked with min. By this row, the image of the entrance to the maxillary divisor is divided into the columns I1 and I2, respectively.

Afterwards, each teeth should be removed from each side of the teeth in each half-jaw. To do this, in this method, unlike the first method, instead of computing the intensity values and derivatives of each pixel in each row, first, using the commands shown in Figure (4.13), the sum of the values The intensity is calculated for each column as well as the sum of gradient values for each column.

```
SUM_col_I1=sum(I1);

 SUM_col_DI1=sum(D_I1)
```

Figure: 4.13 Calculates the intensity values and derivatives of each column

In the Upper commands, **SUM_col_I1** is the sum of the intensity values of the pixels for each column of the maxillary image and **SUM_col_DI1** the sum of the pixel gradient values for each column from the maxillary image. As previously mentioned, the sum statement in MATLAB is used to compute the sum and the derivative of the D1n function is used to calculate the derivative. This function creates a matrix that is calculated by multiplying it in the pixel-derived image. The program then calculates the sum of the image columns, the average intensity and the derivative average for the pixels of each column using the commands shown in Figure are (4.14) in MATLAB is calculated.

```
mean_sumI1=mean(SUM_col_I1);
mean_sumDI1=mean(SUM_col_DI1);
```

Figure: 4.14 Calculate the mean intensity and derivative of each column

Then, regarding that fact which the separating column of the two adjacent teeth in the space between the two teeth is low (because it is in the dark area) and a high derivative (since in the space between two teeth, the movement is from light to dark and vice versa, so in this The column of intensity changes means the same derivative is high), a new condition for teeth separation has been defined. In fact, the column located on the border between the two teeth has the highest gradient and the lowest intensity. In the second method, the condition defined for the column located in the space between the two teeth is:

- The intensity of the column (total intensity of the column pixels) should be less than the average intensity of the column under consideration.
- The derivative of the desired column (total pixel derivatives of the column) must be greater than the expected derivative of the desired column.

As same with the first method, after finding the first column in the space between two adjacent teeth, in order to prevent the error in identifying the columns, the next column will look for the next column with the designated T of the first column. In this method, to increase accuracy and achieve better results, the amount of this interval is slightly more than before.

After completing the steps mentioned above and finding the separating columns of each tooth with its adjacent tooth, as in the first method, the index related to these columns is poured into an array called ***idxx***. Then these indices are used to separate each tooth and display each individual tooth. In this section, several examples of the results of teeth separation implementation using the second method Figure ares (4.15), (4.16) and (4.17) are given. The results of the implementation showed that the changes applied in the second method were successful and improved the process of tooth decontamination.

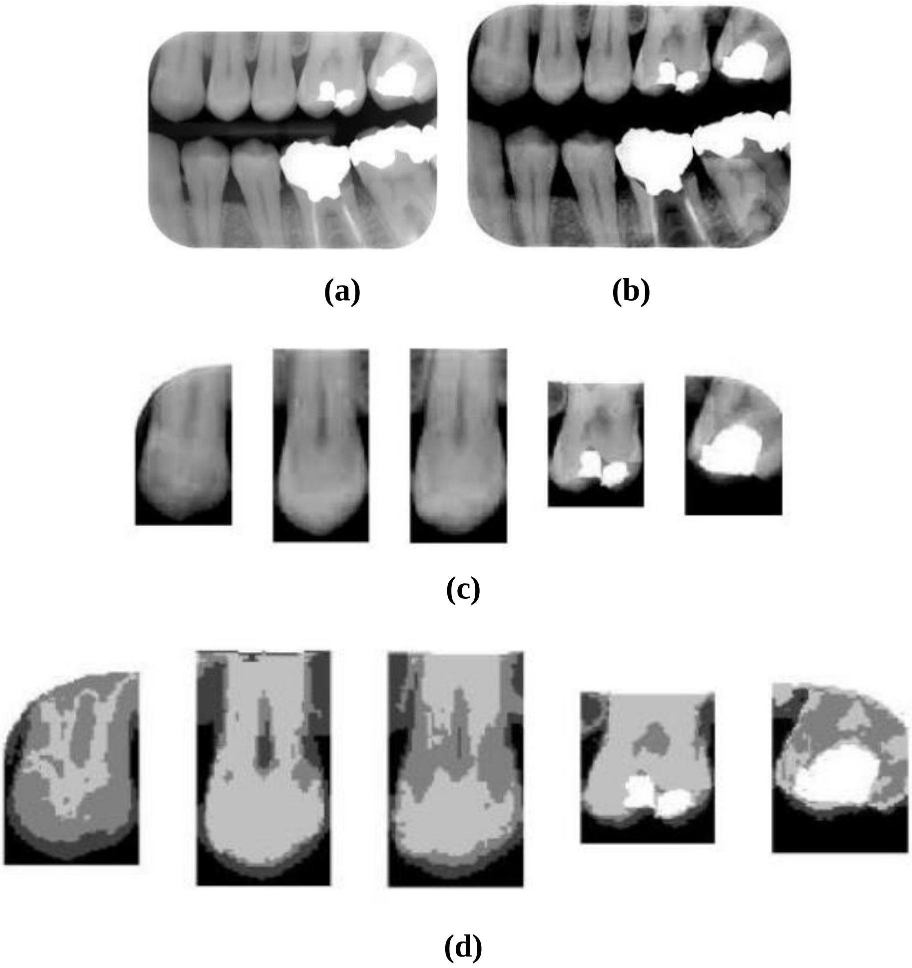
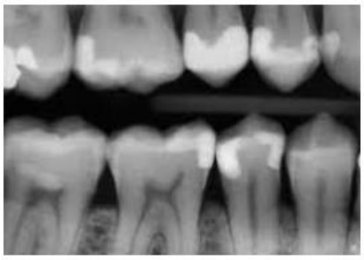


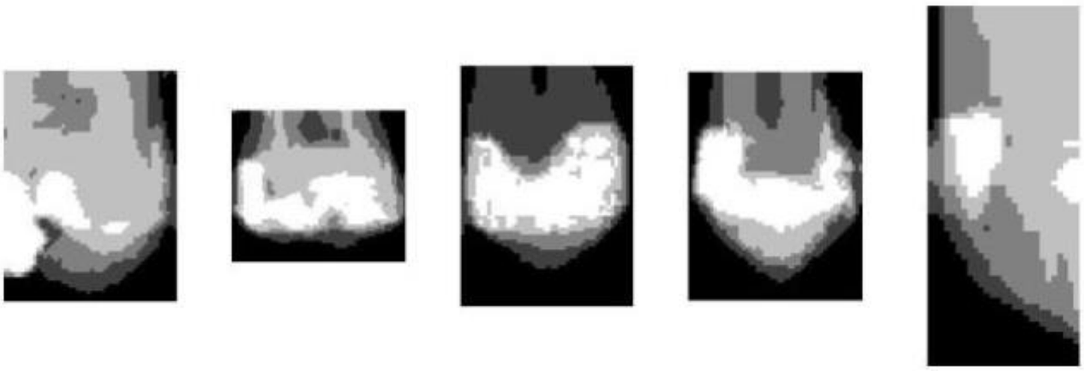
Figure: 4.15 a) Input image. b) Improved image c) The result of detaching each single tooth in the upper jaw. d) the result of applying EMSeg to the isolated teeth



(a)

(b)

(c)



(d)

Figure: 4.16 a) Input image. b) Improved image c) The result of detaching each single tooth in the upper jaw. d) the result of applying EMSeg to the isolated teeth

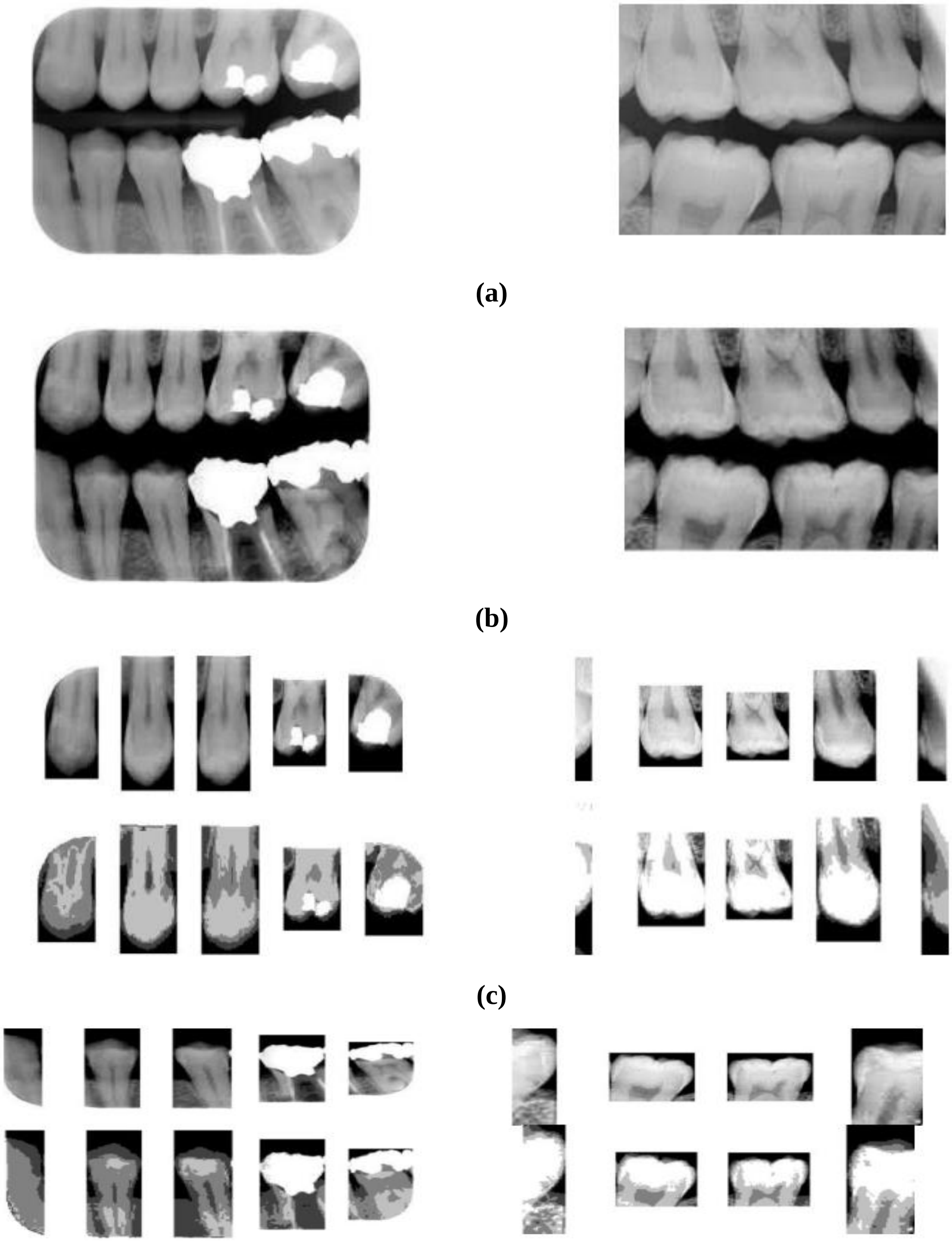
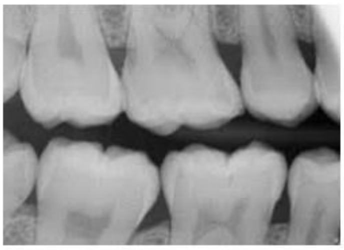


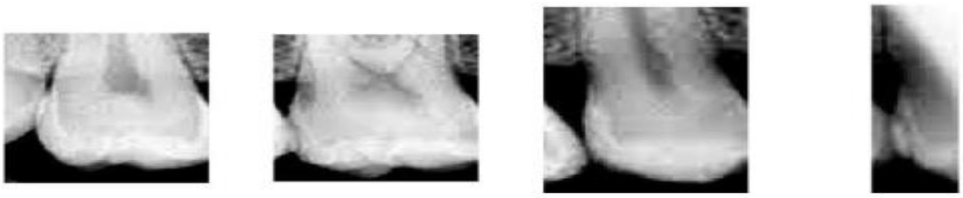
Figure: 4.17 a) Input image. b) Improved image c) The result of detaching each single tooth in the upper jaw. d) The result of detaching each single tooth in the down jaw

In the following, a comparison of teeth separation using the first and second methods is shown in Figure s. (4.18), (4.19) and (4.20). By comparing these images, the differences between these two methods are visible.



(a)

(b)



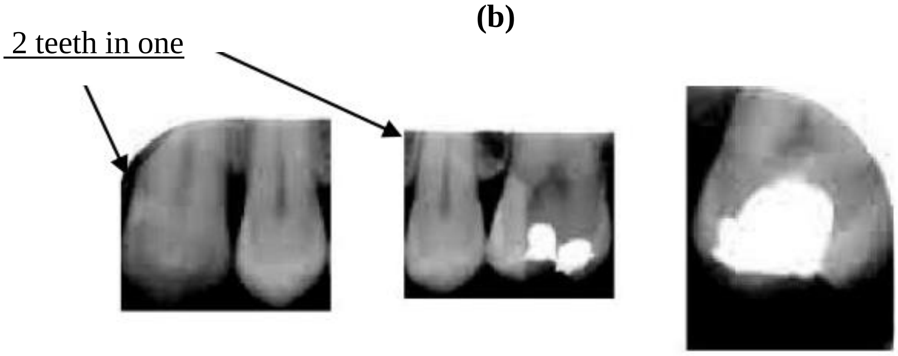
(c)

(d)

Figure: 4.18 Comparison of tooth decontamination by the first and second methods. a. Input image. b) Improved image. c) The result of the teeth separation by the first method. d) the result of the tooth extraction with the second method

(a)

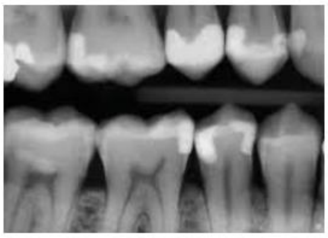
(b)



(c)

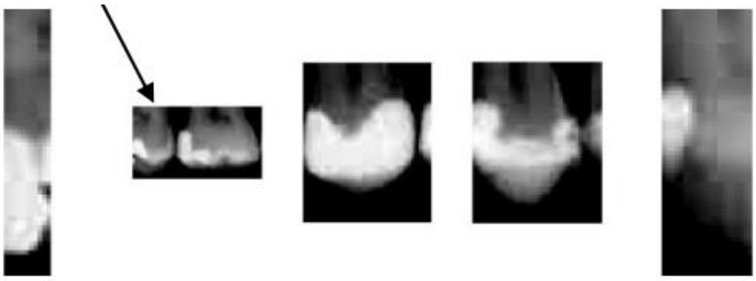
(d)

Figure: 4.19 Comparison of tooth decontamination by the first and second methods. a. Input image. b) Improved image. c) The result of the teeth separation by the first method. d) the result of the tooth extraction with the second method



(a)

(b)



(c)

(d)

Figure: 4.20 Comparison of tooth decontamination by the first and second methods. a. Input image. b) Improved image. c) The result of the teeth separation by the first method. d) the result of the tooth extraction with the second method

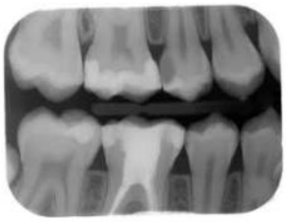
4.6 Scale- Detection of tooth decay

After the separation and fragmentation of the teeth, it is time to recognize the decay of the tooth. After the teeth are separated, the output of the teeth separation algorithm, which includes isolated teeth, is considered to be rotten or healthy. It should be noted that for the evaluation of each tooth, the multiphase segmentation result is used using the EMSeg function at the end of the proposed teeth separation algorithm. To check if the tooth is rotten No, two conditions are considered. If both conditions are present, rotting teeth are known and otherwise they will be healthy.

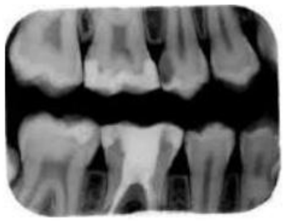
The rotten parts in the tooth have a low density, so they pass through most of the twisted x rays during capture. This causes the rotten areas to appear in the dental radiography image, so it can be concluded that the total intensity of the pixels in the rotten tooth is low. On the other hand, in decay teeth, variations in severity in pixels are high, rotten areas and healthy areas are clear; we know that high variation is a derivative of large amounts, so we expect to increase the total pixel-derived rot in the tooth. According to the notes on rotten teeth, using these features, two conditions are defined for tooth decay. Terms defined for decayed tooth are:

- The total intensity of the individual tooth image pixels is less than the mean intensity.
- The total number of single pixel derivative derivatives is higher than the average derivatives.

If both conditions are true for a dentist, that rotten tooth will be introduced. In other words, in a decayed tooth diagnosis program, the main idea is that if the dent is rotten, the changes in its image are higher than normal, and on the other hand, as the rotten area is dark, the intensity of the brightness in the rotten areas is less, so start with two total indicators Derivatives and total mean intensity are taken, then the index of images whose total derivatives are greater than the mean, and the total of their severity is lower than the mean, is introduced as rotting tooth. In the following, see Figure ures (4.21), (4.22), (4.23) Examples of implementation of the program are shown.

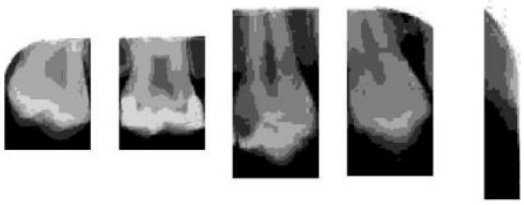


(a)



(b)

(c)



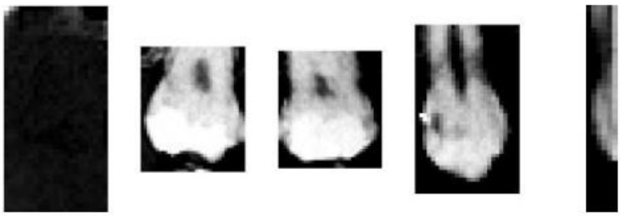
(d)

(e)

Figure: 4.21 Identify rotten teeth. A. Input image. B) Improved image c) The result of detaching each single tooth in the upper jaw. D) The result of applying EMSeg to the isolated teeth. E) Tooth decay is detected

(a)

(b)

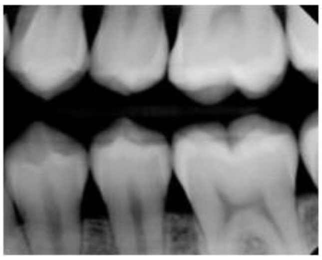


(c)

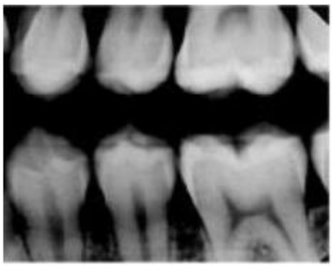
(d)

(e)

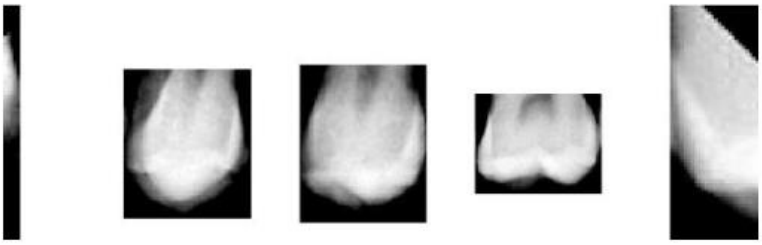
Figure: 4.22 Identify rotten teeth. A. Input image. B) Improved image c) The result of detaching each single tooth in the upper jaw. D) The result of applying EMSeg to the isolated teeth. E) Tooth decay is detected



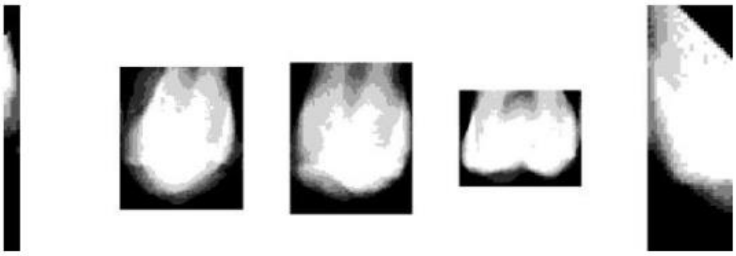
(a)



(b)



(c)



(d)

There are not any destroyed teeth

(e)

Figure: 4.23 Identify rotten teeth. a) Input image. b) Improved image c) The result of detaching each single tooth in the upper jaw. d) The result of applying EMSeg to the isolated teeth. e) Tooth decay is detected

In this chapter, a proposed method for analyzing the x-ray image of the tooth (a byte-winning image) with the goal of interdental caries examination is presented using image processing techniques. In this method, after improving the image quality of the input, with the calculation of the min line is the line that has the lowest total number of pixels. The upper and lower jaw range is distinguished. Then, two methods for separation and fragmentation of each single tooth were presented and the results of the implementation of these two methods in the images of Each other compared. Each of the images of the teeth was then isolated in a cell and then another processing was performed to identify the teeth with decay using a comparison of the mean intensity and pixel derivative. Thus, decayed teeth were detected in the images by this method. It is also worth mentioning in this chapter of the software MATLAB is used to implement programs and methods.

CHAPTER 5
RESULTS

5.1 Introduction

In the preceding chapters of the general, the importance and necessity of the topic was expressed. It also spoke about the science of processing images, features, and uses of this technology. The science of image processing has opened up to the world of science and technology and has revolutionized many of the ways in which modern human life has become a modern science in engineering. Medical science is not separate from this. The science of image processing in medical engineering has also done a lot. In this thesis on one of the uses of science in the processing of images are concentrated in the field of dentistry. Dental Image Processing to Find Dental injuries are an important and practical goal in using this science in the field of medical engineering. In this study, "Interstitial caries" were selected from dental injuries. The reason for this choice is a lot of difficulty in diagnosing this disease without using a dental image. In this chapter, a summary of the proposed method for identifying dental caries with the results of this method is presented.

5.2 Summary of the proposed method

In this section, the suggested methodology presented in the previous chapter is briefly reviewed. As stated in the beginning of the dissertation, one of the main goals of the project is to turn the project into a specialized software application for dentists after completing the research process and identifying other injuries in dental images and optimizing the programs. On the other hand, as previously stated, teeth separation is an integral part of the processing of dental images, and the implementation of this part of the program is necessary to identify other dental injuries. Therefore, in this section, a proposed method for the separation of teeth is presented in the form of a function. This function receives the image as an input and applies the proposed method to it and displays the results in the output. The results presented at the outlet in the next stages of processing are used to identify rotten teeth or to identify other dental injuries in future work. Function of 5.1 receives information including the tooth image and the disassembled image of each tooth, along with the result of its multiphase fragmentation within the S cell, the input parameters are as follows:

Function S=SEG_DENT2 (F, cut, space, phase) (5.1)

F= Input image

Cut= A feature to cut the image into regions with more dental information and remove the gingival image section.

Space= this factor is explained below

Phase= A factor is to determine the number of areas in the multi-metal segment for each tooth image

The size of the input image is specific and the size of the cut parameter from the top and bottom of the image is eliminated to better identify the border between the two teeth and better separation of the teeth. The cut image is stored in F-st.

```
[m n]=size (F);
st=floor(m/cut);
F_st=F(st:(cut-1)*st,:);
```

Figure: 5.1 Remove additional image parts

To determine the area between the jaws and the separation of the maxilla and the lower mandible, according to the instructions of figure ure (5.2), the minimum of the sum of the values is calculated, the index of the dividing line is placed in indx1 and the upper jawed image is stored in I1.

```
u_sum=sum (F_st, 2);
[u_min1 indx1]=min(u_sum);
I1=F_st(1:indx1,:);
```

Figure: 5.2 Upper jaw separation

In the proposed method to separate each single tooth, the main idea is that the boundary between the two teeth is a pillar that has two features.

- The total pixel derivative in these columns is the highest compared to other columns.
- The amount of pixel values in these columns is the smallest relative to the columns located inside the tooth.

Therefore, in the commands shown in Figure are 5.3, the total sum of the column values (SUM_col_I1) and the sum of the column derivatives () SUM_col_DI1 and then the mean of both values (mean_sumI1) and mean_sumDI1 are calculated, the matrix of the semantic row (SUM_col_thresh) has been constructed for the index of columns whose aggregate derivatives are greater than the mean and their aggregate intensities are less than average 1 and in other cases is 0.

```
SUM_col_I1=sum(I1);
SUM_col_DI1=sum(D_I1);
mean_sumI1=mean(SUM_col_I1);
mean_sumDI1=mean(SUM_col_DI1);
SUM_col_thresh=(SUM_col_I1<mean_sumI
1).*(SUM_col_DI1>mean_sumDI1);
```

Figure: 5.3 Calculate the mean and sum of the intensities and derivatives of each column

The next step is to determine the index of the columns that are located on the border between the two teeth. First, by dividing the total number of columns into a space (empirically calculated according to the number of teeth in a byte-winning image from 4 to 7 is desirable), the minimum distance T between the two columns is determined as the boundary between the two teeth.

Then, the index of columns that are firstly in a matrix is one, secondly, at least T pixels are separated in the idxx array. To display and segment each tooth completely added the rows removed at the beginning of the program to the image. The expected endpoints of each index in the idxx array are the image of a tooth. If the images are dedicated to 4 teeth the distance between the first column and the first index does not include teeth. The image of each maxillary tooth is stored in the first row of the S cell. Then the same piece is sent to the EMSeg function for multiphase fragmentation. This function is a read-only code on the math work site. Then, the output results of this function in the subsequent processing to identify the rotten tooth, as in explained in the previous chapter is used. Also, the output of this function can be used to identify other dental injuries in future tasks and programs. The results of this function are shown in tables 5.1 and 5.2.

Factors	**Decayed teeth**	**Segmentation of each tooth**	**Every tooth image**

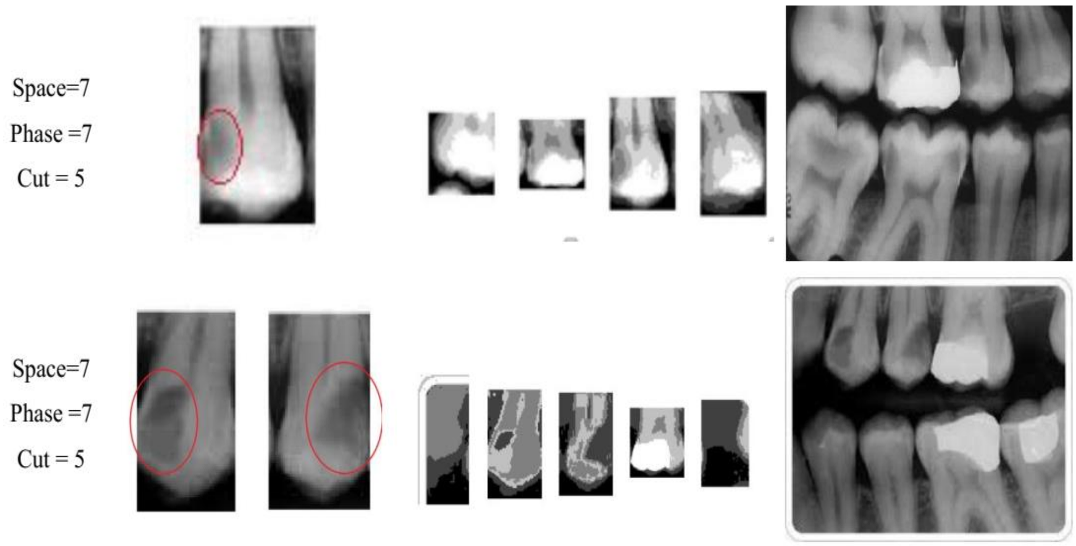


Figure 5.4. Separation and identification of decay results

Row	scheme	Total number of images	Number of correct images Answered	Number of wrong images Answered	Correct percentage	execution time (Average)
1	separation upper and lower Jaw	50	43	7	86%	0.59 Sec
2	Tooth separation (first method)	50	23	27	46%	1.9259 Sec
3	Tooth separation (second method)	50	41	9	82%	1.9904 Sec
4	decay detection	50	36	14	72%	3.5155 Sec

Table 5.1. Statistical Results Implementation of the proposed models

CHAPTER 6
CONCLUSIONS

Undoubtedly, the purpose of any research and the reason for choosing any scientific project is to solve the problem and challenge that exists in a scientific subject. This challenge attracts the attention of the project's collectors and makes them effective in removing it. This is a general and permanent rule in all scientific research. This thesis is no exception. After the necessary examinations in the field of medical engineering, a serious challenge was found in this section, and it was a lack of intelligent and automatic software for dental offices. All dentists use X-RAY tooth images to diagnose and treat dental illnesses, but there is no software that can do this automatically in Iran, so the design and construction of this system was urgently needed. This dissertation and other research in this field begin a long and hard way to reach the first native software for identifying oral and dental injuries.

6.1 Research results

In this research, a complete review of the processing of images and its applications in medical engineering was carried out. Image processing techniques were analyzed and analyzed in dental images, and then a method for identifying one of the most commonly used Dental injuries were presented. The purpose of this study was to process dental images to identify dental injuries Is. Considering the dentist's view that the prevalence of interdental caries among different classes of society, the target illness in this study was selected between dental caries. Dentists are looking for more and more accurate data on this type of caries the special radiography images are called bitewing. The proposed model is applied to the images in the four sections below;

- Improved image quality.
- Upper and lower Jaw separation.
- Separating and dividing each single tooth.
- Identify rotten teeth.

Considering the importance of processing dental images and considering that the process of separating the tooth and identifying dental caries from the images is a very important and at the same time difficult and challenging step, in this thesis proposed methods for separation as well as identification the rotten teeth were investigated in Bin Sing radiographs. The results of the implementation of 52 images byte wing, taken by the dentist, in table (2-5) show that the proposed method is somewhat acceptable. Of course, this method should be used in conjunction with other methods as the main purpose of the software is to identify dental injuries and the software should have a correctness of more than 15%. Hence, this is just the beginning of a difficult but clear process for other researchers.

6.2 Proposals and Future Work

This dissertation is a model for identifying tooth injuries. The results of the implementation of the proposed method in terms of the correctness and timing of implementation as a suitable research project is acceptable, but not necessarily complete and complete. On the other hand, given that the main purpose of this project is to create a complete specialized software in this area, it is undoubtedly a long way in There are many things to be done so that this applied research is completed and ready for implementation in the form of a perfect product. Some of the ways and plans for the future of this project that can be considered by the enthusiast are;

- Identification of optimal methods in terms of speed and accuracy for tooth separation and identification of rotten teeth.
- The region of rotten region is detected in decayed teeth.
- Tooth numbering and presentation output based on damaged tooth number.
- Research on other dental injuries and finding ways to identify them.
- Applying methods for identifying dental injuries on all types of dental images.
- Design and implement a user-friendly and user-friendly software environment for physicians.

REFERENCES

Ajaz, A., & Kathirvelu, D. (2013, April). Dental biometrics: Computer aided human identification system using the dental panoramic radiographs. In *2013 International Conference on Communication and Signal Processing* (pp. 717-721). IEEE.

Chen, T., Ma, K. K., & Chen, L. H. (1999). Tri-state median filter for image denoising. *IEEE Transactions on Image processing*, *8*(12), 1834-1838.

Chen, H., & Jain, A. K. (2005). Dental biometrics: Alignment and matching of dental radiographs. *IEEE transactions on pattern analysis and machine intelligence*, *27*(8), 1319-1326.

Dighe, S. C., & Shriram, R. (2012, November). Dental biometrics for human identification based on dental work and image properties in Periapical radiographs. In *TENCON 2012 IEEE region 10 conference* (pp. 1-6). IEEE.

Graschew, G., & Rakowsky, S. (2011). *Telemedicine Techniques and Applications*.

Harandi, A. A., & Pourghassem, H. (2011, May). A semi-automatic algorithm based on morphology features for measuring of root canal length. In *2011 IEEE 3rd International Conference on Communication Software and Networks* (pp. 260-264). IEEE.

Hills, Z., & Khairat, S. (2014, May). Teledermatology: Using collaborative technologies to enhance public health awareness. In *2014 International Conference on Collaboration Technologies and Systems (CTS)* (pp. 423-427). IEEE.

Huang, P. W., Lin, P. L., Kuo, C. H., & Cho, Y. S. (2012, July). An effective tooth isolation method for bitewing dental X-ray images. In *2012 International Conference on Machine Learning and Cybernetics* (Vol. 5, pp. 1814-1820). IEEE.

Hudak, R., Penhaker, M., & Majernik, J. (2012). *Biomedical Engineering-Technical Applications in Medicine*.

Hunter, K. D., & Craig, G. (2009). Pathology of the teeth. *Diagnostic Histopathology*, *15*(6), 286-295.

Jain, R., Kasturi, R., & Schunck, B. G. (1995). *Machine vision* (Vol. 5, pp. 385-395). New York: McGraw-Hill.

Jain, A. K., Ross, A., & Prabhakar, S. (2004). An introduction to biometric recognition. *IEEE Transactions on circuits and systems for video technology*, *14*(1).

Kang, J., & Ji, Z. (2010, May). Dental plaque quantification using mean-shift-based image segmentation. In *2010 International Symposium on Computer, Communication, Control and Automation (3CA)* (Vol. 1, pp. 470-473). IEEE.

Kumar, S., & Marescaux, J. (Eds.). (2008). *Telesurgery*. Springer Science & Business Media.

Li, S., Fevens, T., Krzyżak, A., Jin, C., & Li, S. (2007). Semi-automatic computer aided lesion detection in dental X-rays using variational level set. *Pattern Recognition*, *40*(10), 2861-2873.

Lin, P. L., Lai, Y. H., & Huang, P. W. (2012). Dental biometrics: Human identification based on teeth and dental works in bitewing radiographs. *Pattern Recognition*, *45*(3), 934-946.

Lin, P. L., Huang, P. W., Cho, Y. S., & Kuo, C. H. (2013). An automatic and effective tooth isolation method for dental radiographs. *Opto-Electronics Review*, *21*(1), 126-136.

Makela, T. (2009). Dental x-ray image stitching algorithm. *Helsinki University of technology*, 1-30.

Mikulka, J., Kabrda, M., Gescheidtová, E., & Peřina, V. (2012, July). Classification of jawbone cysts via orthopantomogram processing. In *2012 35th International Conference on Telecommunications and Signal Processing (TSP)* (pp. 499-502). IEEE.

Nassar, D. E., Abaza, A., Li, X., & Ammar, H. (2008). Automatic construction of dental charts for postmortem identification. *IEEE Transactions on Information Forensics and Security*, *3*(2), 234-246.

Nomir, O., & Abdel-Mottaleb, M. (2005). A system for human identification from X-ray dental radiographs. *Pattern Recognition*, *38*(8), 1295-1305.

Nomir, O., & Abdel-Mottaleb, M. (2007). Human identification from dental X-ray images based on the shape and appearance of the teeth. *IEEE Transactions on information forensics and security*, *2*(2), 188-197.

Ogirala, M. (2005). *Multi-resolution dental image registration based on genetic algorithm*. West Virginia University.

Oliveira, J., & Proença, H. (2011). Caries detection in panoramic dental X-ray images. In *Computational Vision and Medical Image Processing* (pp. 175-190). Springer, Dordrecht.

Reddy, M. B., Sridhar, V., & Nagendra, M. (2012). Dental X-ray image analysis by using image processing techniques. *International Journal of Advanced Research in Computer Science and Software Engineering*, *2*(6), 184-189.

Oliveira, J., & Proença, H. (2011). Caries detection in panoramic dental X-ray images. In *Computational Vision and Medical Image Processing* (pp. 175-190). Springer, Dordrecht.

Oprea, S., Marinescu, C., Lita, I., Jurianu, M., Visan, D. A., & Cioc, I. B. (2008, May). Image processing techniques used for dental x-ray image analysis. In *2008 31st International Spring Seminar on Electronics Technology* (pp. 125-129). IEEE.

Peerez-Ferre, N., & Calle-Pascual, A. (2011). Advances in telemedicine: applications in various medical disciplines and geographical regions. *Rijeka, Croatia: InTech*

Rad, A. E., Rahim, M. S. M., & Norouzi, A. (2013). Digital dental X-ray image segmentation and feature extraction. *TELKOMNIKA Indonesian Journal of Electrical Engineering*, *11*(6), 3109-3114.

Rad, A. E., Amin, I. B. M., Rahim, M. S. M., & Kolivand, H. (2015). Computer-aided dental caries detection system from X-ray images. In *Computational Intelligence in Information Systems* (pp. 233-243). Springer, Cham.

Reyes Silveyra, L. J. (2012). *Investigations on automated methods for dental plaque detection* (Doctoral dissertation, University of Birmingham).

Said, E., Fahmy, G. F., Nassar, D., & Ammar, H. (2004, August). Dental x-ray image segmentation. In *Biometric Technology for Human Identification* (Vol. 5404, pp. 409-, 418). International Society for Optics and Photonics.

Schreier, G., Hayn, D., Kastner, P., Koller, S., Salmhofer, W., & Hofmann-Wellenhof, R. (2008, August). A mobile-phone based teledermatology system to support self-management of patients suffering from psoriasis. In *2008 30th Annual International Conference of the IEEE Engineering in Medicine and Biology Society* (pp. 5338-5341). IEEE.

Schuller-Götzburg, P., & Suchanek, J. (2007). Forensic odontologists successfully identify tsunami victims in Phuket, Thailand. *Forensic Science International*, *171*(2-3), 204-207.

Sebastian, T. B., Tek, H., Crisco, J. J., Wolfe, S. W., & Kimia, B. B. (1998, October). Segmentation of carpal bones from 3D CT images using skeletally coupled deformable models. In *International conference on medical image computing and computer-assisted intervention* (pp. 1184-1194). Springer, Berlin, Heidelberg.

Sharma, N., & Aggarwal, L. M. (2010). Automated medical image segmentation techniques. *Journal of medical physics/Association of Medical Physicists of India*, *35*(1), 3.

Sonka, M., Hlavac, V., & Boyle, R. (2014). *Image processing, analysis, and machine vision*. Cengage Learning

Vashishth, A., Kaushal, B., & Srivastava, A. (2014). Caries Detection Technique for Radiographic and Intra Oral Camera Images. *International Journal of Soft Computing and Engineering (IJSCE)*, *4*(2), 2231-2307.

Vincent, L. (1993). Morphological Grayscale Reconstruction in Image Analysis: Applications and E cient Algorithms. *IEEE transactions on image processing*, *2*(2), 176-201.

White, S. C., & Pharoah, M. J. (2014). *Oral radiology-E-Book: Principles and interpretation*. Elsevier Health Sciences.

Zhou, J., & Abdel-Mottaleb, M. (2005). A content-based system for human identification based on bitewing dental X-ray images. *Pattern Recognition*, *38*(11), 2132-2142.11, pp. 2132-2142.