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Integration of close range photogrammetry and expert system capabilities in order to design and implement optical image based measurement systems for intelligent diagnosing disease

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ABSTRACT

In medical applications and disease diagnosis devices, image is considered as a tool for measurement and data acquisition. Most of the imaging methods usually used in medical applications are invasive and have several side effects on human body. So, other types of image based measurement systems should be developed for medical applications. The systems must be able to use the images captured in visible part of the electromagnetic spectrum. In this research a new image based disease diagnosis method has been developed which uses optical images for measuring required symptoms. In the systems which are implanted based on the suggested method measurement capabilities of close range photogrammetry and decision making ability of expert system are integrated. The integrated system can be used for the diseases whose symptoms are visible or appear as deformations out of body and around the affected area. For evaluation of the suggested method, an integrated system has been designed and implemented for intelligent diagnosing foot deformity.

1. Introduction

Measurement plays an important role in medical applications [1]. In medical applications and disease diagnosis devices, image is considered as a tool for measurement and data acquisition. Using images and their interpretation in medical sciences is known as a beneficial and valuable tool in a way that nowadays medical imaging is mostly used and the best tool for disease diagnosis. According to increasing requirements in this field and software and hardware developments, presented methods and devices are being improved. The methods such as Computer Tomography (CT), Magnet Resonance Imaging (MRI), Color Doppler Ultrasound (US), Single Photon Emission Computed Tomography (SPECT) and Positron Emission Tomography (PET are only capable of capturing 2D images) [2]. In some cases it is essential to reconstruct 3D model of desired location in the body. So, methods such as 3D Ultrasound [3], Space encoding projector [4], Laser scanning [5–9] and X-ray [8] are used. Most of these methods are useful for the cases such as examination of internal parts of body or bone inspection in which unequipped eye cannot see the affected area.

In some diseases related to outer parts of body, although medical experts can fully see the site for examination, according to some limitations such as inability to direct contact and inability to do precise measurement, it is necessary to develop a method which could be able to process the images captured at visible part of electromagnetism spectrum. The method suggested to overcome the problems is Close-range photogrammetry (CRP) which is

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capable of generating accurate and precise 3D model of an object using overlapped images.

In the image-based medical diagnosis instruments, interpretation of acquired images is an important step. Usually, interpretation process is carried out by human experts who do it based on their knowledge and experience. According to developments in the field of intelligent systems, using the capabilities of these systems can improve the interpretation process of medical images. One of the systems can be used for intelligent interpretation of medical images is expert system. Expert system is capable of decision making using human expert's knowledge and is used as an intelligent decision making unit in a medical devices [10].

Recently, some investigations have been carried out in the field of integration of medical imaging and expert system capabilities for disease diagnosis [11–13].

According to the measurement capabilities of close range photogrammetry as a data acquisition method and expert system abilities as an intelligent decision making system, the main idea in the research is to suggest an image based medical diagnosis method by integration of these systems which can be useful in clinical environments for non-expert operators. In the system designed and implemented based on the suggested method in this research, accurate measuring of 3D coordinates of selected points around the area which includes the symptoms is used instead of direct examination of the affected area. 3D model generated using the measured points is processed and analyzed by the expert system and the disease is diagnosed intelligently.

2. Background

2.1. Close-range photogrammetry

Close range photogrammetry is a high precision 3D spatial data capture technique using 2 or more images of scene [14]. Its basis is triangulation, whereby intersection of converging rays in space is used to determine the position of points in all three dimensions. To do so, the orientation of cameras for each captured image is needed. The orientation parameters of cameras are calculated through resection process. To be able to run this process, at least 12 well-disturbed points on each image are needed. Some advantages of close range photogrammetry as a measurement technique are:

- It is a non-contact, non-invasive and instantaneous technique (synchronized for all measurements).
- It offers high-accuracy measurements.
- It provides possibility of measuring any number of points on the object [9].
- It provides possibility of a fully automatic measurement [15].
- It uses optical images which are remotely taken and has no side effect to the human organism [16].

According to the advantages and capabilities of the close range photogrammetry, nowadays, one of the special domains which it is applied, is medicine. In this application, the subject of imaging is human and the method called Medical Photogrammetry. The aim of medical photogrammetry is to assist in health matters. It usually is used to diagnose a disease or monitor its effects. It also is applied to prevent diseases which are probable during sports and ergonomic studies [17].

2.2. Expert system

Expert systems are computer programs designed to emulate the work of experts in specific domains of knowledge. An expert system stores the knowledge and uses it to make decision.

An expert system has 4 main elements as follows [18]:

- Knowledge-based (KB).
- Inference engine.
- Explanatory interface.
- Knowledge acquisition module.

Knowledge base is the most important part of an expert system and as mentioned in [19], power of an expert system depends on its knowledge base. The knowledge after acquisition in specific domain is stored and represented in the knowledge base as rules. The rules are used as the representation of knowledge in the knowledge base [13]. The inference engine analyses and interprets the stored knowledge. Explanatory interface is the part of an expert system which user can interact with system, enter questions about a problem and get the responses of the system. Knowledge acquisition module allows the user to enter new knowledge to the knowledge base and develop its knowledge domain. Fig. 1 illustrates relations between elements of an expert system.

Medical expert system is a common type of intelligent systems in medical applications. The knowledge of a medical expert system is usually defined in a limited specific domain. So, as a medical expert, a medical expert system can make decision about limited domain of diseases.

3. Integration of close range photogrammetry and expert system for medical applications

The suggested system needs 3 main sections in order to have an acceptable responsibility during disease diagnosis process. These sections are:

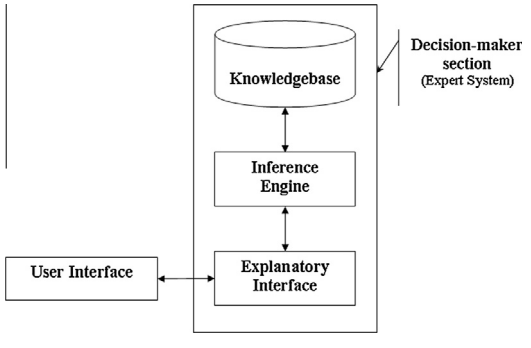

Fig. 1. Main structure of an expert system.