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X-ray Sensor Used for Digital Dental Imaging

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ABSTRACT

The purpose of this study is to redesign a digital x-ray sensor for dental utility, lower cost than the traditional sensors in the markets, wider field of view comparing to other x ray dental sensors, and easier to access to the images and easier to process them.The images were taken by system contains small diameter USB camera, Screen intensifier, and shielded housing to prevent the entrance of x-ray. The image that captured as a result had fine resolution because of lack in the materials availability in Iraq, and also without image processing. The produced sensor was easy to use, simple to maintain, cheap in price. But consideration must be taken especially in shielding process, the quality of intensifier screen, the resolution and focus distance of the camera.

Keywords: Dental radiographs, x-rays, digital radiography, intensifying (or intensifier) screen

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INTRODUCTION

Technological advancements continue to affect the way we deliver oral health care. Although new methods for diagnosing disease and treatment planning comprehensive care have been introduced, dental radiographs, the images produced by x-rays, remain the basis for many diagnostic procedures and play an essential role in oral health care. Radiography is the making of radiographs by exposing an image receptor, either film or digital sensor.[1]

Dental radiographs are valuable diagnostic tools when the image quality is adequate for proper interpretation. Film-Based and digital dental radiographs both require the use of careful technique and precautions to maximize the diagnostic and interpretative value of the radiograph while at the same time minimizing patient exposure to radiation. [2]

The application of x-rays plays a vital role in the practice of dentistry as radiographs are required for a majority of the patients either as part of a routine examination, diagnostic purpose, treatment planning or for follow-up evaluation of the patients. Radiographs are important in the routine investigation of dental caries and its sequel, evaluation of periodontal diseases, identification of osseous pathologies such as cysts and tumors as well as in the evaluation of traumatic injuries involving the jaws and facial bones, and also useful in the evaluation of growth and development. [3]

Passing the x-rays through a structure to be examined and capturing the resultant image on a photographic emulsion of the film make a radiographic image. The number of x-rays reaching the film determines the overall exposure or blackening of the emulsion. Hard and mineralized structures absorb a great deal of radiation, whereas the soft tissues permit the passage of x-rays. The amount of radiation absorbed (attenuated) by the structures determines the radiodensity of the shadows. [4]

In digital radiography, instead of the silver halide grain, the image is constructed using pixels or small light-sensitive elements. These pixels can be a range of shades of grey depending on the exposure and are arranged in grids and rows on the sensor, unlike the random distribution of the crystals in standard film. However, unlike film, the sensors are only the radiation detector and the image is displayed on a monitor. [5]

The signal that is produced by the sensor is analog, i.e. a voltage that varies as a function of time. The sensor is connected to the computer and the signal is sampled at regular intervals. The output of each pixel is quantified and converted to numbers by a frame grabber within the computer. The number of grey levels relates to contrast resolution and the size of the pixels is related to spatial resolution.[6]

METHOD

The method demonstrates the designs that used to extract the pictures by transforming the x-ray photons that penetrate the object to visible radiation photons using intensifying screen then the image captured by the camera and so processed. **The endoscope camera model**: it used because it small in size and can be connected to the personal computer that can be easier to process the image.

The camera specifics are:

- Resolution = 640*480
- Imaging sensor = 1/6-inch (4.23mm) cmos
- Frame rate = 30 frame per second
- Camera outside diameter = 5.5mm
- Focal distance = (3-10) cm
- Horizontal viewing angle = 60 degree

By using identical screen intensive Kodak green 400 screen that putted on paper holder (to not effecting the x-ray) that fastened ahead of teeth impression kit, all elements are fastened within a box made up of cardboard to mimic the intraoral and to provides the darkness that required to create the fluorescence image clearer to capture.

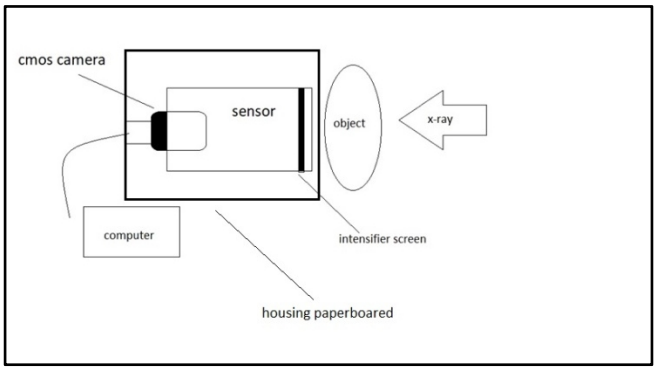

Figure 1: the endoscope camera model

Pc endoscope camera with protective shielding model

The same model above was used however now with changing the paperboard to plastic housing that encompasses a form of a tapered cone that matches with dimensions of optical lens aperture angle and camera focusing spot.

In the beginning the camera putted in the tip of the plastic cone and in the other side where the intensifier screen located, and on the open side and facing rectangular leaded glass because it's not easy to cut a circular shape piece due to the nature of the leaded glass, the glass stick by epoxy adhesive with intensifier screen in the side facing the camera and with plastic disc in the opposite side for giving darkness to the internal chamber and also for protection as shown below.

In the second experiment on this model, The camera was placed on the narrow side of the cone and the intensifier screen on the wide base, and for shielding process the overall cone covered with thin lead sheet while a carefully cut leaded glass disc putted behind the intensifier screen to prevent the scattered and unwanted x ray from saturating the camera electronics and also for filtering the incident beam, and then an O ring is used to fix the intensifier screen and the glass on the wide opening instead of using adhesives that may affect and giving a misleading results.

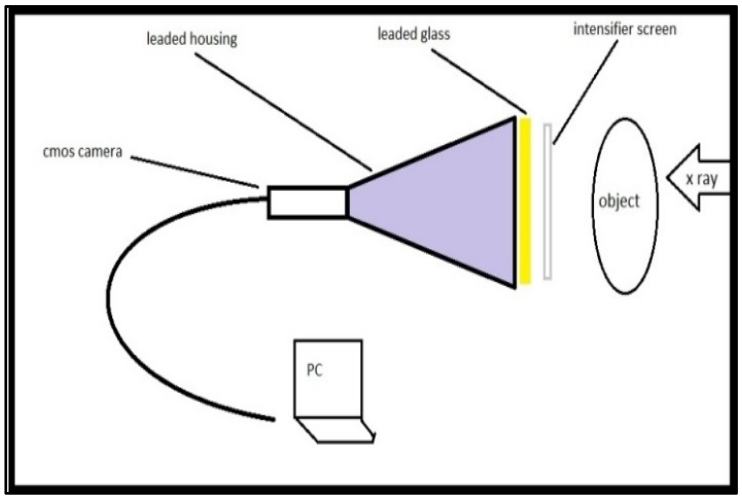

Figure 2: shape and the parts of the sensor

In case of dealing with ionization radiation the safety instructions must obtained to avoid hazardous effect of radiation that may cause cancer, so the protective clothe must be worn to avoid exposed to direct or scattered radiation.

RESULTS

The results that's lead to design X-ray sensor used for digital dental imaging by showing the multiple ways that used for reaching appropriate image and problems of each design comparing to others, beside that there were many difficulties happen; first few cameras that could be found in Iraqi market because the camera should be small and compactible as much as it could be with short focus point as possible, second thing finding a sensitive intensifier screen was not easy the available found are old and not working or expensive, and third the exposure to x-ray for long periods and day after day might cause a radiation hazard that affects the researcher and people around even with low doses of radiation. Each model that uses in the experimental trails had some problems that prevent capturing images and for that reason, the design altered.

Pc endoscope camera model

This model was expected to work and giving x-ray image but that do not happen because of saturation and effect of camera electronics during the exposure of x-ray that blind the camera and showing only noise that couldn't process to an image as shown below.

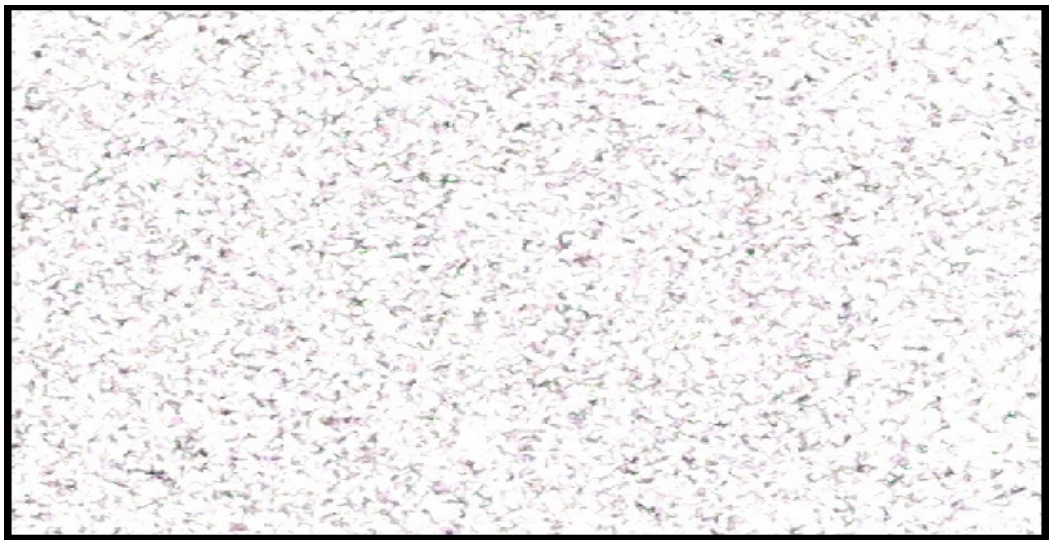

Figure 3: noise of Pc endoscope camera model under high dose.

Pc endoscope camera with protective shielding model

This model was the last one was reached after modifying the previous one by shielding the housing with leaded sheet and leaded glass to protect the camera electronics from any interface with x-ray radiation that may cause noises and reduce it as possible,

Noticing two difficulties appear on shielding the leaded glass had hardness more than the regular window glass and also more brittle that made it not easy to cut the appropriate shape; also, the lead is a toxic substance to human body, so the precautions took while using it in shielding. In the beginning the leaded glass tested to notice if the method working or not the following images captured.

The noises appear as salt and pepper because the test piece of glass was not protecting the camera perfectly and x-ray penetrate through its lens (the used dose 57 kV 6.30mAs).

In the second experiment where the cone used the results showed a noisy image because the leakages of x-ray to the camera electronics through its lens and sides.

Figure 4: noise effecting on image due to x-ray leakage

From figure (4), it can be seen that the brightness is less with more noise on the image the dose that used is the same of previous one (57 kV 6.30mAs)

The third test was the last because the result was good but not perfect with little amount of noise due to sensitivity of intensifier screen and the quality of shielding in the end it was handmade shielding which lacks professionally work and factory perfection, a key used to get the first image of this model took to examine the contrast, brightness, and noise.

The image obtained for the key shows different of thickness on the key surface while the x-ray penetrates the key carrying the information then reacting with intensifier screen changing the radiation to green light having the same information after that the leaded glass suppress x-ray and only light can through which could capture by the camera sensor with minimum noise. The test was for synthetic mandible with its teeth and taking an image for incisors and image for canines and premolars figure (5) and figure (6) shown that.

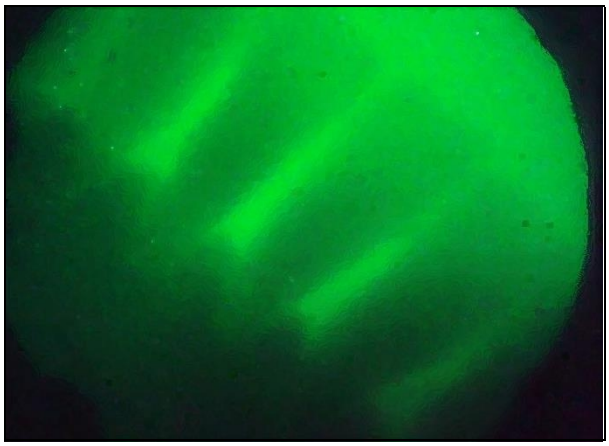

Figure 5: captured x-ray image for synthetic mandible with its teeth (incisors)

Figure 6: canines and premolars x-ray image

CONCLUSION

A. X-ray sensor used for digital dental imaging is benefited due to its simple way to use only by connection the sensor to pc directly without the need of interface between the sensor and pc, besides that the sensor has cheap price comparing to the other commercial sensors, the total cost of it is less than 50 dollars while the Chinese sensor has a price of 1500 dollar and above, and sensors that made in Europe has price more than 5000 dollars.

B. To make an efficient x-ray sensor two consideration must be taken; first the transformation of x-ray radiation to visible light that could be captured by the CMOS (complementary metal-oxide-semiconductor) detector of the camera, the intensifier screen must be used for that purpose, the looking for appropriate screen is not easy because it should be sensitive to various amount of x-ray doses and also should have enough brightness when incident x-ray beams hit the screen. Second thing protection of camera internal circuit and electronics from direct and scattered x-ray radiation because the ionization property of x-ray stimulate and saturate the electronic components of the camera; the best way to avoid this problem is by shielding all possible area that the radiation may penetrate the internal electronics of the camera by covering those areas with lead and for little amount of dose a sheet of lead is enough for this purpose.

ETHICAL CLEARANCE

The Research Ethical Committee at scientific research by ethical approval of both environmental and health and higher education and scientific research ministries in Iraq

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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