Journal of Engineering and Applied Sciences 13 (24): 10468-10473, 2018
ISSN: 1816-949X

A Research on the Developing Smartphone Application for Automatic Dental Caries Detection

[1]Yong-Keum Choi and [2]Kyung-Oh Lee
[1]Department of Dental Hygiene,
[2]Department of Computer Engineering, Sun Moon University, 31460 Chungnam Asan-si,
221-70 Sunmoonro, South Korea

Abstract: To check the status of oral health patients should visit dental clinics and professionals to check inside the mouse and sometimes they take photos or X-ray. There are previous research to detect the dental carries automatically. They often use X-ray (Radiograph), Qualitative Light-induced Florescence using florescence light (QLF), Ultrasonic Caries Detector (UCD), Fiber Optic Trans-Illumination (FOTI) and Electronic Caries Monitor (ECM) mechanisms. But these require the devices built in dental hospitals. Now a days according to the development of modern technology, we can use smartphone to diagnose dental carries. Furthermore, the resolution of smartphone is very high and many people have smartphones. It is very convenient if, we use smartphone to detect the dental carries. We developed a system which makes the users self-diagnosis dental carries using smartphone. So, they do not need to go to dental clinics to check oral health and enhance the possibility to find dental carries in an early stage. Smartphone photos of teeth are sent to the system and after diagnosis processing the results are delivered to the user and dentist. With our system people can easily check the status of dental carries and it will increase the oral health of people

Key words: Dental caries detection, application, image processing, oral health, smartphone, dentist

INTRODUCTION

According to World Health Organization report on oral health at April 2012, worldwide 60-90% of young children and almost 100% of adults experienced dental caries (Tavakolian *et al*., 2017). Computer aided detection is a technology which interprets digital images and retrieves some valuable knowledge from images. In the area of medical science, computer aided detection systems are usually developed for extracting useful information from medical images (e.g., ultrasound, radiography, MRI, PET, etc.) and providing helpful data to doctors. Previous study shows that computer aided detection system can improve doctor's performance and reduce the diagnosis time (Senel *et al*., 2010; Muramatsu *et al*., 2013; Berdouses *et al*., 2015).

There are previous research to detect the dental carries automatically. They often used X-ray (Radiograph), Qualitative Light-induced Florescence using florescence light (QLF), Ultrasonic Caries Detector (UCD), Fiber Optic Trans-Illumination (FOTI) and Electronic Caries Monitor (ECM) mechanisms (Wenzel, 2001). But to check the status of oral health and diagnosis patients should visit dental clinics and professionals check inside the mouse and sometimes they take photos of X-ray or CT even though, automatic detection mechanisms are applied. These require the devices built in dental hospitals (Hastar *et al*., 2012; Kavitha *et al*., 2012).

Now a days according to the development of modern technology, we can use smartphone to diagnose dental carries. The resolution of smartphone is very high and furthermore a lot of people have smartphones. Since, they carry smartphone all the times it is very convenient if, we use smartphone to detect the dental carries. This research aims to design an automated system to detect caries based on optical images of the teeth surface taken by smartphones. The images are delivered to the main system through the smartphone applications and users can get the intermediate results of automatic caries diagnosis. These information can be stored on the system and dental professional can review the results and draw the better decision. If users get some bad signals they will go to the dentist and get the proper treatment. This system can help to increase the oral health of the people.

MATERIALS AND METHODS

The dental caries or decay have 4 stages. Stage 1 is the first stage and the symptom is minor and stage 4 is sever stage in Fig. 1. We describe the details as follows.

Corresponding Author: Kyung-Oh Lee, Department of Computer Engineering, Sun Moon University, 31460 Chungnam Asan-si, 221-70 Sunmoonro, South Korea

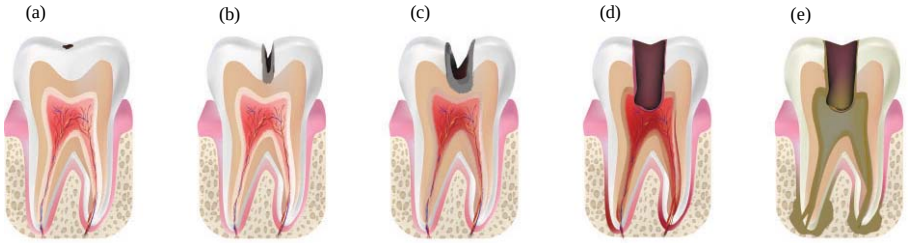

Fig. 1: Stages of dental carries; The stages of carries development: a, b) Enamel caries; c) Dentin caries; d) Pulpitis and e) Periodontitis

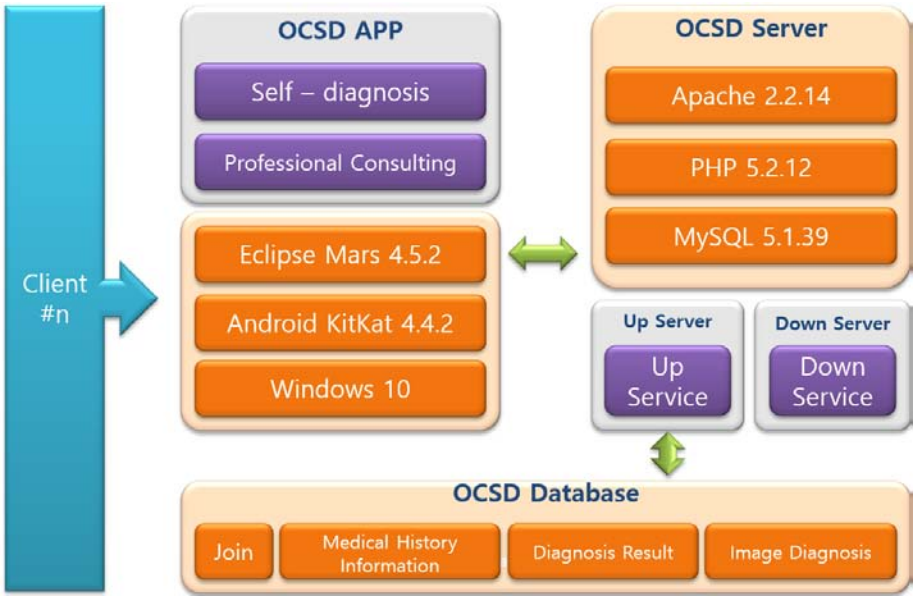

Fig. 2: Basic technologies applied to develop the dental carries self-diagnosis system

Stage 1; Initial lesion: The first stage in tooth decay is painless. No symptoms are easily noticeable. Tooth decay affects the enamel. Without a check-up carried out by a dentist, it can go unnoticed.

Stage 2; Enamel decay: Tooth decay then attacks the dentine, the substance that forms the major part of the tooth. At this stage the tooth decay becomes painful.

Stage 3; Dentin decay: Tooth decay does not stop at destroying the dentine. It can continue to reach the tooth pulp where the tooth's blood vessels and nerves are located. This infection is very painful.

Stage 4; Pulp decay: If nothing is done, the tooth decay can then go on to affect the tissue surrounding the tooth: ligaments, bone and gum. A dental abscess, far more painful than tooth.

Our goal is to detect the stage of dental caries automatically with smartphones. To make patients not need to go to the dentist from the beginning, we used the several modern technologies. The basic software structure is in Fig. 2. Our system consists of smartphone application and application server. To implement the smartphone application we used Eclipse Mars 4.5.2, Android KitKta 4.4.2 and Windows 10. For the server, we applied Apache 2.2.14, PHO 5.2.12, MySQL 5.1.39. Users access the system by smartphone application but the data need to be processed by the server and stored in database.

In the diagnosis system image processing, image segmentation and increasing the accuracy of images are important and these are coded by C++. Using PHP photos are uploaded and user data is sent or retrieve from the server. On Android phones users can execute self-diagnosis and reply some questionnaires. Users can find the dentist near to user's location and can get some advice from professionals. We used MySQL to construct database to manage the membership data, medical history, diagnosis results and images. Figure 3 shows the functional chart of our self-diagnosis system.

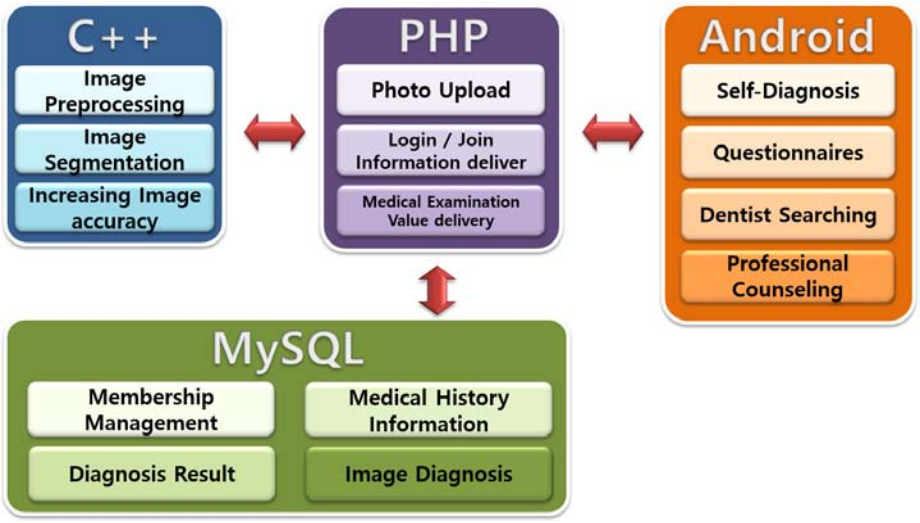

Fig. 3: Functional chart of the dental carries self-diagnosis system dental carries

Image preprocessing-lighting removal algorithm: At first, we need to process light removal. In photos, image data captured by cameras restrain errors related brightness of the pixels. These errors should be corrected using appropriate mathematical models like statistical or definite models. To improve its visual quality we need image enhancement and it is the modification of image by changing the value of pixel brightness. Image enhancement consists of several techniques that are used to improve the visual appearance of an image or to convert the image to a better form suited for machine or human interpretation. We applied, Chitradevi and Srimathi (2014) mechanism to remove the light effect of images.

Image segmentation-adaptive threshold algorithm: And next step is image segmentation. In various applications like face tracking and image retrieval skin detection is an important area of research. However, currently available algorithms are based on static photos of the skin color or require much amount of computation. On the other hand, skin detection algorithms are not suitable to deal with real-world conditions, like change of intensity, lighting effects and background noise. This situation can be improved by using dynamic features of the skin color in a sequence of images. In our research study, we used algorithm proposed by Tavakolian *et al*. (2017) based on adaptive 'Hue thresholding'. We need the teeth classifier and it is based on the Hue histogram of teeth pixels and adapts itself to the color of the teeth of the persons in the smartphone photos.

Increasing the correctness-dilate, erode algorithm: The final stage, we need to increase the correctness of images and we used algorithm proposed by Gil and Kimmel (2002) and Tracy *et al*. (2011).

Gil and Kimmel (2002) proposed a deterministic and efficient algorithm for computing the one-dimensional erosion and dilation (min and max) sliding window filters. The algorithm constitutes a deterministic improvement over the best previously known algorithm, independently developed by van Herk and by Gil and Werman (the HGW algorithm). We deal with the problem of computing the dilation and erosion filters simultaneously as required, e.g., for computing the unbiased morphological edge. In the case of identically distributed inputs, we implemented our system in which simultaneous computation can be done more efficiently then separately computing each. We used Gil and Ron's algorithm to increase the correctness of images and we got the satisfied results (Silvertown *et al*., 2017).

RESULTS AND DISCUSSION

The main screen of self-diagnosis system is shown in Fig. 4. It consists of self-diagnosis, questionnaires, searching nearest dentist and counseling with professionals. After login users can use these functions. Figure 5 shows some sample images taken by smartphone. It simply shows the final results but the images are sent to servers and processed image preprocessing, image segmentation and increasing the correctness. After running the image comparison algorithm, we can get the final results as seen in Fig. 6 the status of decay.

Figure 7 shows the sample questionnaires of the system. Users answers the questions and the data is stored into the database thought the application server. Later dentists or other professionals refer this data to evaluate the user's oral health status.

Fig. 4: The main screen of dental carries self-diagnosis system

As we can see in Fig. 8, user can easily find the dentist near. And user can browse the dentist information and can make a reservation.

Fig. 5: The sample photos from smartphone

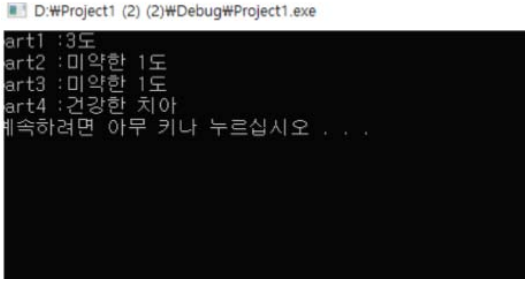

Fig. 6: The automatic diagnosis result

(a)

(b)

Fig. 7a, b: The sample questionnaires of the system

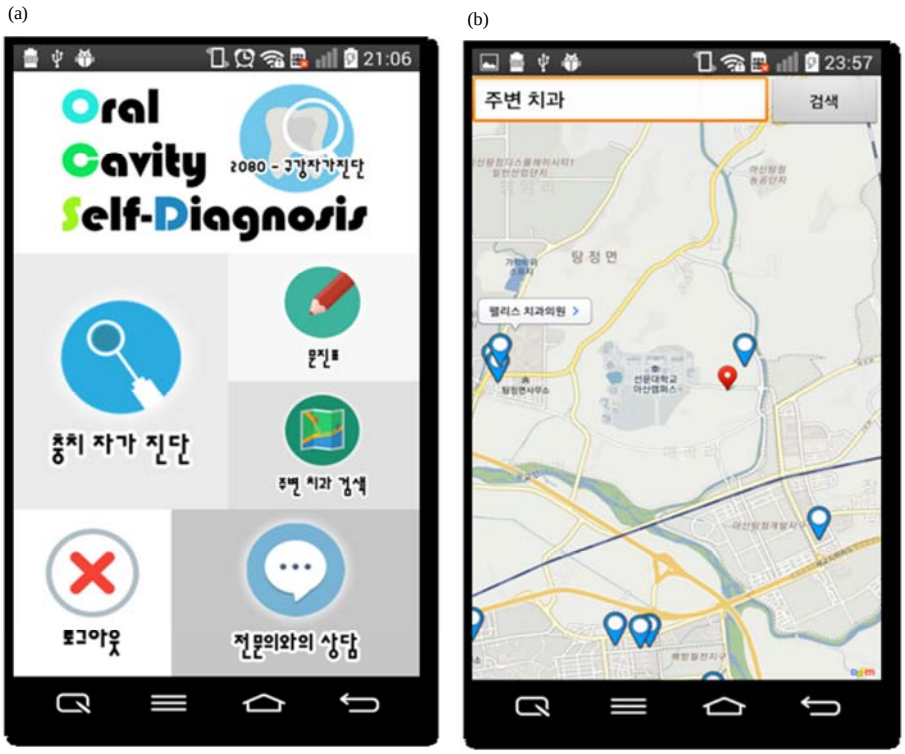

Fig. 8a, b: Finding nearest dentist according to the user's location

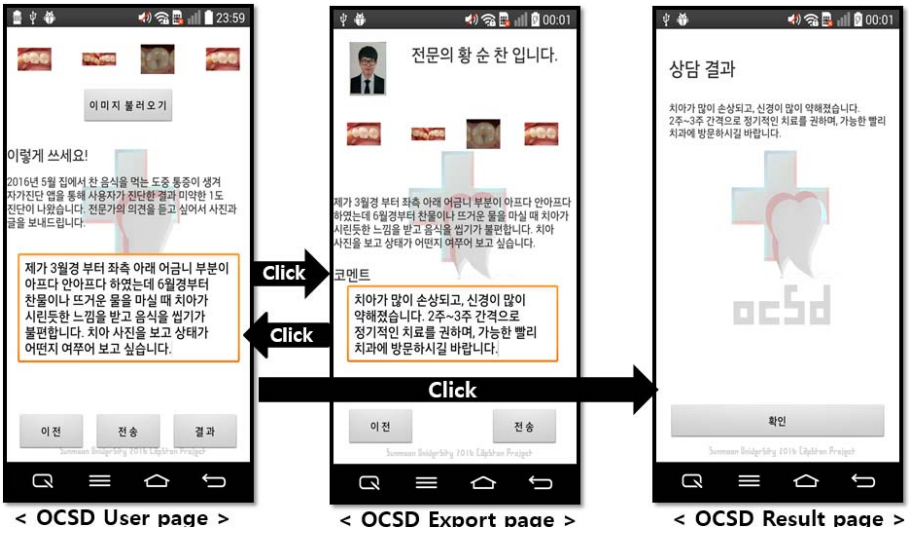

Fig. 9: Counseling process between users and dental professionals

Using our system users can get the advice from dentists or some dental professionals. User can submit more information with the automatically generated data. Dental professionals can do some counselling and the counselling process between users and dental professionals is give in Fig. 9.

Now a days according to the development of modern technology, we can use smartphone to diagnose dental carries. The resolution of smartphone is very high and furthermore a lot of people have smartphones. Since, they carry smartphone all the times it is very convenient if, we use smartphone to detect the dental carries. We developed a system which makes users perform self-diagnosis dental carries using smartphone. So, the patients do not need to go to dental clinics to check oral health but enhance the possibility to find dental carries in

an early stage. Smartphone photos of teeth are sent to the system and after diagnosis processing the results are delivered to the user and dentist. With our system people can easily check the status of dental carries and it will increase the oral health of people.

CONCLUSION

Our system automatically recognizes the status of tooth decay but the successful suggestion is about 80%. We need to improve the correctness using more recent image processing technologies.

ACKNOWLEDGEMENTS

This study was supported by research fund from the National Research Foundation of Korea (NRF-2017RIC1B5017185).

REFERENCES

Berdouses, E.D., G.D. Koutsouri, E.E. Tripoliti, G.K. Matsopoulos and C.J. Oulis *et al*., 2015. A computer-aided automated methodology for the detection and classification of occlusal caries from photographic color images. Comput. Boil. Med., 62: 119-135.

Chitradevi, B. and P. Srimathi, 2014. An overview on image processing techniques. Intl. J. Innovative Res. Comput. Commun. Eng., 2: 6466-6472.

Gil, J.Y. and R. Kimmel, 2002. Efficient dilation, erosion, opening and closing algorithms. IEEE Trans. Pattern Anal. Mach. Intell., 24: 1606-1617.

Hastar, E., E. Yildiz and A.M. Aktan, 2012. The effect of fissure sealants on the values of two different caries detection devices. Photomed. Laser Surg., 30: 683-687.

Kavitha, M.S., A. Asano, A. Taguchi, T. Kurita and M. Sanada, 2012. Diagnosis of osteoporosis from dental panoramic radiographs using the support vector machine method in a computer-aided system. BMC. Med. Imaging, 12: 1-11.

Muramatsu, C., T. Matsumoto, T. Hayashi, T. Hara and A. Katsumata *et al*., 2013. Automated measurement of mandibular cortical width on dental panoramic radiographs. Intl. J. Comput. Assisted Radiol. Surg., 8: 877-885.

Senel, B., K. Kamburoglu, O. Ucok, S.P. Yuksel and T. Ozen *et al*., 2010. Diagnostic accuracy of different imaging modalities in detection of proximal caries. Dentomaxillofacial Radiol., 39: 501-511.

Silvertown, J.D., B.P. Wong, S.H. Abrams, K.S. Sivagurunathan and S.M. Mathews *et al*., 2017. Comparison of the Canary System and DIAGNO dent for the in vitro detection of caries under opaque dental sealants. J. Invest. Clin. Dent., 8: 1-5.

Tavakolian, P., K. Sivagurunathan and A. Mandelis, 2017. Enhanced truncated-correlation photothermal coherence tomography with application to deep subsurface defect imaging and 3-dimensional reconstructions. J. Appl. Phys., 122: 023103-1-023103-10.

Tracy, K.D., B.A. Dykstra, D.C. Gakenheimer, J.P. Scheetz and S. Lacina *et al*., 2011. Utility and effectiveness of computer-aided diagnosis of dental caries. Gen. Dent., 59: 136-144.

Wenzel, A., 2001. Computer-automated caries detection in digital bitewings: Consistency of a program and its influence on observer agreement. Caries Res., 35: 12-20.