A NEW FULLY AUTOMATED SYSTEM DESIGN FOR EVALUATION OF STANDARDIZED AND REPRODUCIBLE DATA IN INTRAORAL PHOTOGRAPHY OF GINGIVA

[1]SAHIN YILDIRIM, [2]CEM A. GURGAN, [3]M. YAKUP SARI, [4]EMIR ESIM, [5]SERTAÇ SAVAŞ, [6]TURGAY TEMEL

[1,4,5]Erciyes Üniversity, Engineering Faculty, Mechatronic Engineering Department, Kayseri, TURKEY
[2,3]Erciyes Üniversity, Dentistry Faculty, Periodontology Department, Kayseri, TURKEY
[6]Bursa Technical University, Nature Sciences Faculty, Mechatronic Engineering Department, Bursa, TURKEY
E-mail: sahiny@erciyes.edu.tr

Abstract- In spite of advanced and high technology, there is still some problems for positioning head and chin of dental patients during photographic recording. Furthermore, it is very important to get reproduciable photographic data for the evaluation of the dental treatment. In this study, a new designed system method is being introduced for the collection of standardized intraoral photographs and computer-assisted measurement of reproducible data. However, PLC based fully automated a photograpic device for fully automated intraoral photography and standart protocol for the mucogingival complex is also presented. However, the proposed fully automated system is consisted of camera equipment with two directions and head supporting linear sliding mechanism with two directions of Z axes and X axes.

Keywords- PLC, gingivomorphometry, intraoral photographs,

I. INTRODUCTION

This use offers advantages such as lower voltage drop when turned on and the ability to control motors and other equipment with a virtually unity power factor [1]. Few papers were published concerning dc machines controlled by PLCs. They have reported both the implementation of the fuzzy method for speed control of a DC motor/generator set using a PLC to change the armature voltage [2], and the incorporation of an adaptive controller based on the self-tuning regulator technology into an existing industrial PLC [3]. Also, other types of machines were interfaced with PLCs. Thereby, an industrial PLC was used for controlling stepper motors in a five-axis rotor position, direction and speed, reducing the number of circuit components, lowering the cost, and enhancing reliability [4]. For switched reluctance motors as a possible alternative to adjustable speed ac and dc drives, a single chip logic controller for controlling torque and speed uses a PLC to implement the digital logic coupled with a power controller [5]. Other reported application concerns a linear induction motor for passenger elevators with a PLC achieving the control of the drive system and the data acquisition [6]. To monitor power quality and identify the disturbances that disrupt production of an electric plant, two PLCs were used to determine the sensitivity of the equipment [7].

A proper diagnosis of the periodontal biotype is considered important with respect to decision making in aesthetic and implant dentistry. [8, 9]. Tissue biotypes are considered to be related to the outcomes of periodontal therapy, conventional prosthodontics, implant therapy and root coverage proceduresThe thick-flat biotype is described as distinct cervical convexities and broader contact areas located more close to the gingival area. Subjects with thin-scalloped biotype have very subtle cervical convexities present, very small contact areas in dimension and located close to the incisal edge of the tooth, tendency to have less attached gingiva and reacts to irritation by recession. This situation is primarily important for dental implant [10] where the stability in the long term is poor[11, 12]. Also, the thin-scalloped biotype shows more recession following periodontal treatment [13] and less stable marginal position in relation to the restorations[14,15].Clinical view of healthy show a macroscopic structure that varies from person to person [10]. Individuals with long narrow form of central incisors have a thin periodontium and show more recession compared to subjects with a wide, square form. [13].

II. DESCRIPTION OF PROPOSED INTRAORAL PHOTOGRAPHY AND PLC BASED MORPHOMETRIC MEASUREMENT SYSTEMS

Nowadays, human operated systems are used to make position of head of dental patiens. As can beseen in Fig. 1, there is plenty of disadavantages for exact positioning of phographingpatiens' chin in taking photographs. For that reason, in this section, the proposed fully automated and standarized intraoral phtography system is described. The proposed and designed system is consisted of two main positioning apparatus. The first one, the patient is in sitting or standing position and puts his/her head in a head holder. The chin is placed on a chin rest and the forehead rests against a traversal forehead holder. The height of chin rest height can be adjusted fully

automatically from patient's pervious positions (see Fig. 2(a)).

Second one, the camera is fixed to stands with quick mount attachment and can be moved along a circumferential quide rail at a range of 180^0 arround the virtual center in ~~the~~ patient's mouth by a servo motor and driver equipment. On the other hand, for eccentric and lateral ptotographs with mirror the camera poisition can be changed, recorded and seen at a scala undermeat the camera stand by a servo motor and driver using PLC. In addition to these developments, by using PLC based automation, height and rotation of camera position as well camera object distance can be changed automatically as previous measurements. The images are to be held on the measurements of clinical records by comparison with measurements of "reliability", repeated measurements with measurements on the display "consistency" to be tested. In addition, observer variation in determining deviation of repeated measurements is to be calculated, and these variances which occurred in the area of the teeth will be analyzed (see Fig. 2(b)).

For this purpose, first of all, an intraoral photography with high resolution taken from a healthy individual placed on a cylinder will be used to evaluate the and the calibration of photographic records (Fig. 3). The next stage for the evaluation of intraoral photographic records will be at clinical level.For this purpose, intraoral photographic recordings at 90 ° and 180 ° in the horizontal plane angles of each tooth at each jaw between first premolar teeth will be obtained for 10 dentally and periodontally healthy (Group 1) and 10 dentally healthy but periodontal treatments have been completed and at maintainance phase volunteer individuals (Group 2).Photographic records for ~~on~~ the gingival morphology and related parameters will be saved. Photographic~~y~~ and clinical recordings~~ search~~ will be repeated with 10-15 days.

The aims of this fully-automated system concept were first to introduce a device for standardized intraoral photographs and finally to test the reproducibility of this gingivomorphometric evaluation

III. THE PURPOSE OF TESTING THIS HYPOTHESIS

This section describes main hypotesis of the proposed fully automated PLC based ssytem in the following;

1-Reliability (Accuracy): the accuracy of measurements on photographic data will be compared to the direct clinical measurements obtained from volunteers groups (Group 1 and 2). Within 15 days intervals intraoral photographic recording will be repeated according to the previous data and the measurement errors will be calculated. Addition to the measurements visiual distortions such as enlargement or reduction resulting from different camera–object distances and changes of angulationswil be evaluated. Following the photographic recording dublicate measurements on the photgraphic data will be repeated within 15 days intervals. Standardized measurements of the acquired data – the 'morphometrical' part – will be based on the import of the acquired images into an open source medical image processing software (OSIRIX®). The acquired data files will be saved as JPEG files and first imported into an image processing software (e.g., PHOTOSHOP®) then, imported into OSIRIX® and processed in the 2D mode. All the measurements will be performed afterward as has been described by Weinlander et al. [16]..

The clinical recordings will be performed by an experienced clinicians and photographic data will be evaluated by two experienced clinicians who will be unaware of clinical situations

The proposed fully automated intraoral photography recording system is consisted of five main parts (Figure 4):

Part 1: the head and the Chin still placed, for each individual location as the original adjustable forehead and jaw snapping (jaw snapping part of vertical direction moving) parts.Part 2: digital camera image of the rear area of the oral cavity and can be saved in the desired angle of the mirror inside the mouth (0-180 ° angle within the limits of the width) moving in the horizontal plane rail system and offers these tracks on the vertical direction moving mirror and camera connections.Part 3: Jaw snapping, intraoral mirror and camera placed in the mechanisms used to control the movements of the joystick.Part 4: all auto mobile parts and running them with the engine table.Part 5: CPU and graphics processing capabilities and in our study, both photographic and digital radiographic image is to be used in the analysis of OsiriX can operate in compliance with the program and the high resolution images in the computer system even higher performance and mechanical mechanism is automatic and repeatable way to use software to function.

In order to obtain standardized and reproducible data forintraoral photography, three basic criteria have to be fulfilled to measure without any errors;

1. Standardized and reproducible patient positioning; The patient is in sitting or standing position and puts his head in a head holder. The chin is placed on a chin rest and the forehead rests against a transversal forehead holder. The chin rest height may be adjusted to the patient facial height, and its position is recorded on a scale mounted at the left side of the head holder as seen from the patient's position.

2. Standardized and reproducible camera positioning; The camera is fixed to a stand with a quick mount attachment and can be moved along a circumferential guide rail at a range of 180° around a virtual center in the patient's mouth. For photographs of the anterior teeth a fixed central camera position is available. For eccentric and lateral photographs with a mirror the camera position can be changed and

recorded at a scale underneath the camera stand. In addition, height and rotation of the camera position as well as the camera object distance can be changed. Each positional change of the camera can be recorded separately.

3. Standardized and reproducible mirror positioning for data collection in the premolar and molar regions. For photographs in the premolar and molar areas a mirror can be placed in a five-step protocol in the mouth of the patient. The construction allows for a cheek holding function of the mirror. All three-dimensional movements of the mirror can be recorded and reproduced at any time. The mirror positioning basically duplicates a rotating gallows construction with a lateral, height and transversal fixation of the mirror. Once in place, the mirror position itself can be varied rotationally. Again, each positional change of the mirror can be recorded.

The proposed system's block diagram as outlined in Figure 5, will be employed with computers, Apple iMac and IOS operating system. Apple iMac, it uses the operating system stability, high resolution screens with fast processors and radiology and digital imaging is one of the preferred hardware.

Figure 1. View of manuallypositioning system and description

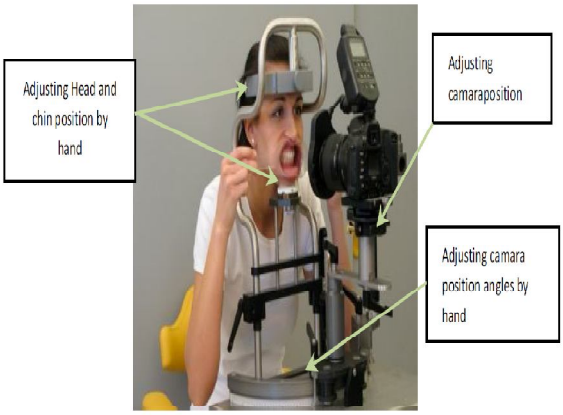


Figure 2 (a). General view of the proposed system

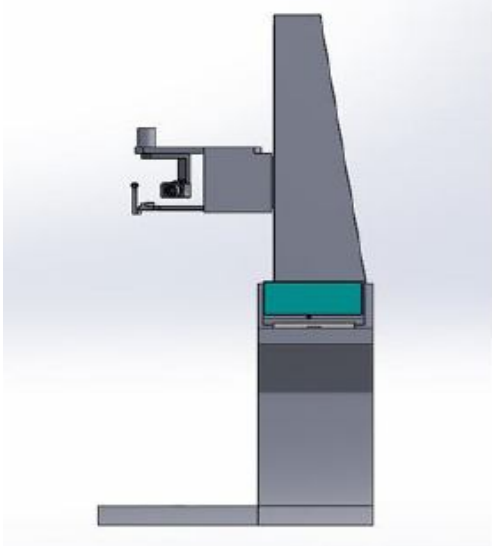


Figure 2 (b). The proposed fully automated system and main elements

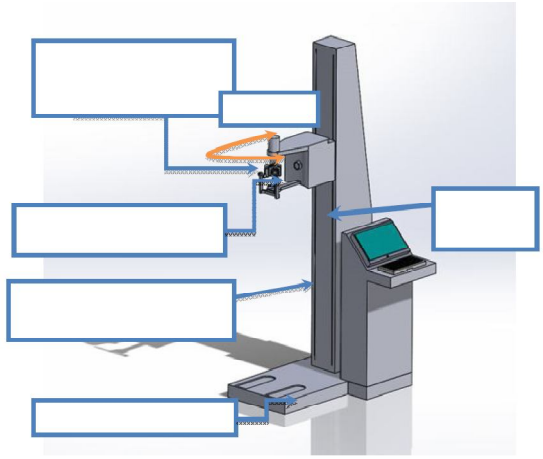


Figure 3. Camara and chin position apparatus

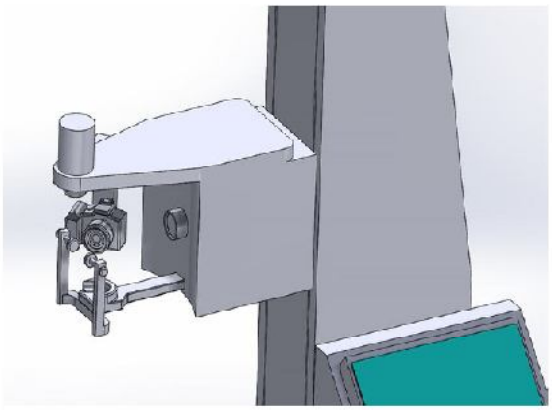


Figure 4. Maximum postioning of camara by PLC

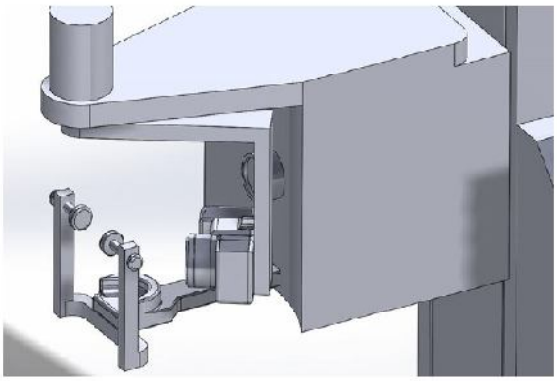
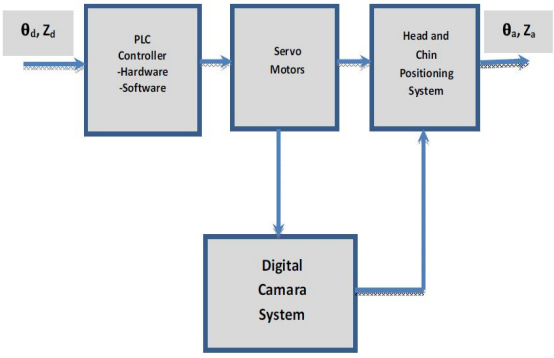


Figure 5. Block diagram of position control process



CONCLUSIONS AND DISCUSSIONS

The goals of proposed fully automated intraoral photography system are to obtain accurate and reproducibile stadart images. By using this system the errors occurred in positioning patient's head, photographer's senitivity in obtaing images and most of all, deviations observed in measuring distances between anatomical landmarks will be eliminated.Within these above mentioned features, the porposed system will be the first with computer-aided and fully automated. Additionally, both the observer variations in measurements and evaluation of clinical outcomes will be improved.

In all measurements, most of the errors are originated from the observer's decision in detecting the measurement points in every time-point. By using our system this will be improved by increasing the reproducibility.

Reproducibile and accurate evaluation of clinical outcomes is the ultimate goal for any instrument used in the clinic. By using our system, the obtained photographic data with various angulations can be evaluated later by unbiased observers which will definitely improved the objectivity of any clinical research in the field of dentistry.

With the method proposed in this paper the evaluation of for example the esthetically sensible anterior maxillary region is not anymore dependent on subjective estimations of different assessment criteria, but uses a more evidence-based method. Hard and soft tissue criteria are governed mostly by color and form. Forms are very important for the symmetrical and natural appearance of reconstructed dentogingival aspects. Because forms are strictly depending on perspective, distortions resulting from different angles of photographic view must be avoided. The exact measurement of forms as areas or distances can contribute to a more evidence-based evaluation of esthetic reconstructions. Changes occurring at soft tissue or dental level through any kind of dental treatment, or for example parafunctions, can so be measured and monitored. To help with a precise reproducibility of all reference points and prevent falsified measurements through soft tissue changes over time, a grid can be added to the photographs. Although the measurements performed in the present small prospective study were apparently accurate and reliable, linear measurements (mesial/distal papilla height) showed a lower coefficient of variation than area measurements (mesial and distal papilla area, soft tissue contour). Because all patients participating in this study were unaffected of dental disease in the area of interest, only positive values for recession were obtained for statistical comparison. Increased measurement accuracy by gaining experience of the present observer suggests that this is definitely a very sensitive technical method. It seems to be no shortcoming that the output of all measurements is expressed in pixels by the used program. Because all measurements usually are needed only for detection of relative changes over time, a calibration of pixel numbers to millimeters usually seems not needed.

The proposed Gingivomorphometry on standardized oral photographs can be considered an accurate and reproducible method for the evaluation and measurement of different dentogingival parameters. Advantages of this non-invasive method are reliability, objectiveness and standardization of the necessary parameters, particularly for the evaluation of the dentogingival complex in the esthetic region of the anterior maxilla. Further prospective evaluations with this evidence-based and computer-assisted method will be necessary to show the efficacy for monitoring long-term changes in the periimplant mucogingival complex.

Finally, the proposed system have superior performance for exact and fast measuring all details of patients in real time applications and testing.

ACKNOWLEDGMENT

Authors would like to express their deepest appreciation to Erciyes University, which provided us the opportunity to support TOA-2015-5584 coded this project for designing and experimental applications and testing.

REFERENCES

[1] A. R. Al-Ali, M. M. Negm, and M. Kassas,"A PLC based power factor controller for a 3-phase induction motor,"inProc. Conf. Rec. IEEE Industry Applications, vol. 2, 2000, pp. 1065–1072.

[2] A. M. Graham and M. Etezadi-Amoli, "Design, implementation and simulation of PLC based speed controller using fuzzy logic,"in Proc. IEEE Power Eng. Soc. Summer Meeting, vol. 4, 2000, pp. 2475–2480.

[3] A. A. Ghandakly, M. E. Shields, and M. E. Brihoum, "Design of an adaptive controller for a DC motor within an existing PLC framework," in Proc. Conf. Rec. 31st IEEE Industry Applications Society Annu. Meeting, vol. 3, 1996, pp. 1567–1574.

[4] A. S. Zein El Din,"High performance PLC controlled stepper motor in robot manipulator,"inProc. EEE Int. Symp. Industrial Electronics, vol. 2, 1996, pp. 974–978.

[5] A. Hossain and A. Ahmed,"A new integrated controller for switched reluctance motor,"inProc. Conf. Rec. 30th IEEE Industry Applications Society Annu. Meeting, vol. 3, 1995, pp. 1917–1921.

[6] J. F. Gieras, P. D. Hartzenberg, I. J. Magura, and M. Wing,"Control of an elevator drive with a single-sided linear induction motor,"in Proc. 5th Eur. Conf. Power Electronics and Applications, vol. 4, 1993, pp. 353–358.

[7] V. E. Wagner, A. A. Andreshak, and J. P. Staniak,"Power quality and factory automation,"IEEE Trans. Ind. Applicat., vol. 26, pp. 620–626, July/Aug. 1990.

[8]. M. Olsson, J. Lindhe,"Periodontal characteristics in individuals with varying form of the upper central incisors", J Clin Periodontol 1991;18:78-82.

[9]. J.H. Fu, C.Y. Yeh, H.L. Chan, N. Tatarakis, D.J.M. Leong,H.L. Wang,"Tissue biotype and its relation to the underlying bone morphology", J Periodontol 2010;80: 569–574.

[10]. R.T. Kao, M.C. Fagan, G.J. Conte,"Thick vs. thin gingival biotypes: a key determinant in treatment planning for dental implants", J Calif Dent Assoc 2008;36: 193–198.

[11]. C. Baldi, G. PiniPrato, U. Pagliaro et al. "Coronally advanced flap procedure for root coverage. Is flap thickness a relevant predictor to achieve root coverage" A 19case series. J Periodontol 1999;70: 1077–1084.
[12]. R. Pontoriero, G. Carnevale,"Surgical crown lengthening: a 12-month clinical wound healing study", J Periodontol 2001; 72:841–848.
[13]. H.P. Muller, N. Schaller, T. Eger, "Heinecke A. Thickness of masticatory mucosa", J Clin Periodontol 2000;27:431–436.
[14]. R.T. Kao, K. Pasquinelli," Thick vs. thin gingival tissue: a key determinant in tissue response to disease and restorative treatment" Journal of Calif Dent Assoc 2002;30:521–526.
[15]. T. Berglundh, J. Lindhe ,"Dimensions of the peri-implant mucosa. Biological width re-visited" Journal of Clin Periodontol 1996;23:971–973.
[16]. Weinlander M, Lekovic V, Spadijer-Gostovic S, et al. Gingivomorphometry esthetic evaluation of the crown-mucogingival complex: a new method for collection and measurement of standardized and reproducible data in oral photography. Clin Oral Implants Res 2009;20:526–30.

★★★