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Tele-Operated Dental Assistant

Sivatmiga T N
Department of Robotics and Automation Engineering
PSG College of Technology
Coimbatore, India

Idhazh Priyaadharshini M J
Department of Robotics and Automation Engineering
PSG College of Technology
Coimbatore, India

Dr. Anbarasi M P
Department of Robotics and Automation Engineering
PSG College of Technology
Coimbatore, India

Abstract **- The focal aim of the project being wireless and teleoperated is to hold significance over being a non-contact method of diagnosis, which will prove to be useful in times of communicable pandemic situations such as COVID - 19. Medical procedures require precision and acute attention to details for a good diagnosis. In the field of dentistry, routine dental check - ups that are usually done by a dental assistant in person, are effectively transformed in such a way that the project replaces the dental assistant with a "teleoperated dental assistant" setup. This setup consists of a high-quality Intra - Oral Camera (IOC) with the ability to wirelessly transmit (via Wireless-Fidelity) the recorded dental data and a robotic arm to proficiently grasp and manipulate (via Bluetooth) the movements of the IOC inside the patients' mouth using the principles of teleoperation and thereby no contact as the dental assistant and the patient can be potentially seated in separate rooms.**

Keywords- Dental diagnosis, Intra-Oral Camera, Tele-operation, Wireless – Fidelity, Bluetooth

I. INTRODUCTION

This new era of evolution has made our lives more comfortable even in some pivotal moments of the prevailing pandemic. Dental practitioners confront the greatest risk of COVID-19 infection and so, suspension of routine dental care was instated in many nations worldwide. As a notion to safely tackle this impending circumstance and to make routine dental check-ups much safer in times of a contagious pandemic, a decision to develop a corresponding system for a Teleoperated Dental-Assistant was made. This setup consists of a high-quality Intra - Oral Camera (IOC) with the ability to wirelessly transmit (via Wireless-Fidelity) the recorded dental data and a robotic arm to proficiently grasp and manipulate (via Bluetooth) the movements of the IOC inside the patients' mouth using the principles of teleoperation and thereby no contact as the dental assistant and patient can be potentially seated in separate rooms.

The idea was inspired by several researches relating to robotics in implantology and dentistry that was seen in an orthodontic clinic where "Robot Assistant for Dental Implantology" delves into the development of robotic assistants for dental implant procedures, while "A Compact Dental Robotic System Using Soft Bracing Technique" investigates a compact dental robotic system that incorporates soft bracing techniques for improved dental care. "Robotics in Dentistry: A Narrative Review" provides a comprehensive overview of how robotics is being applied in the field of dentistry. "Automation of end effector guidance of robotic arm for dental implantation using computer vision" focuses on automating end effector guidance for dental implantation through computer vision. "Accuracy of Surgical Robot System Compared to Surgical Guide for Dental Implant Placement: A Pilot Study" compares the accuracy of surgical robot systems to traditional surgical guides in dental implant procedures. "A Review on Robot in Prosthodontics and Orthodontics" presents an overview of robotic applications in prosthodontics and orthodontics. "Intelligent automation of dental material analysis using a robotic arm with Jerk optimized trajectory" explores the use of intelligent automation in dental material analysis with optimized robotic arm trajectories. "Optics-guided Robotic System for Dental Implant Surgery" discusses an optics-guided robotic system designed specifically for dental implant surgery. Lastly, "Robotics in Dental Implantation" provides insights into the application of robotics in dental implant procedures and its potential implications for the field of dentistry.

II. SYSTEM DETAILS

A. Objectives

- To set up a non-contact mode of diagnosis in order to overcome the drawbacks of the suspension of routine care in many countries around the world.

- To broaden the range of communication via Wireless Fidelity and Bluetooth mode.
- To record minute details that may go unnoticed to the naked eye efficiently using the Intra - Oral Camera (IOC) whose movement is decided by manipulating the robotic arm with servo motor embedded at each of its joints.
- To infuse the principles of teleoperation, where a sub-system of the total set up is controlled from a distance, and in our case, control of the robotic arm occurs from a nearby room.

B. *Block Diagram*

The following diagram depicts the block diagram of the whole teleoperated dental assistant setup:

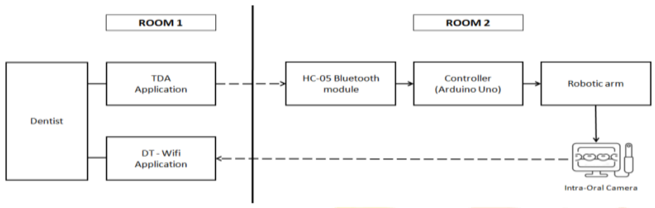

Fig 1 Block Diagram

C. *Working Principle*

The system consists of a HC-05 Bluetooth module, a Robotic arm with 5 DOF degrees of freedom), an Intra - Oral Camera (IOC), an application developed by MIT pp Inventor named as "TDA" which stands for "Teleoperated Dental Assistant" and a controller board – Arduino Uno.

The Bluetooth module is configured as per user's liking (setting the name, baud rate etc). An app is created via blocks of code using MIT App Inventor and interfaced with the HC-05 Bluetooth module via an android device. This app is set to control a 5 DOF robotic arm that holds an Intra - Oral Camera in its gripper. The intra-oral camera upon movement will transfer video and image data to its corresponding app (DT-Wifi) installed in any android device. The intra - oral camera is set up in such a way that the operator can be in a nearby room and watch the Intra - Oral camera's data via DT – Wifi app and control the required movements of the robotic arm using the app created by MIT app Inventor called "TDA".

III.SYSTEM ORIENTED HARDWARE COMPONENTS

A. *List Of Components*

The list of components is as follows:

S.NO	COMPONENT	QUANTITY
1.	Arduino Uno	1
2.	HC – 05 Bluetooth	1
3.	Intra – Oral camera	1
4.	Robotic Arm	1

Table 1. List of components

1. *Arduino Uno*

Arduino Uno is a well-liked open-source hardware foundation tailored for electronics aficionados, creators, and technical professionals, enabling the development of a broad spectrum of projects and devices. Centered on a microcontroller, it is available in diverse iterations, each offering unique functionalities and features.

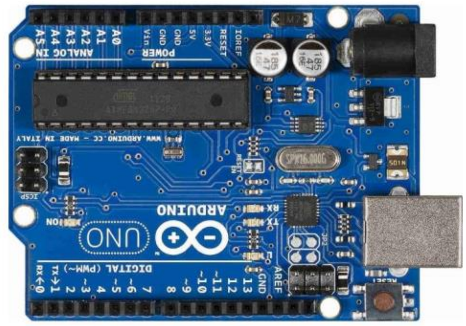

Fig 2. Arduino UNO's pin layout

2. *HC 05 Bluetooth Module*

The HC-05 Bluetooth Module is a straightforward Bluetooth SPP (Serial Port Protocol) module designed for establishing a transparent wireless serial connection. It utilizes serial transmission, which simplifies its connection to a controller or PC. It operates within the 2.45GHz frequency band, providing a data transfer rate of up to 1Mbps and a range of up to 10 meters. The HC-05 module is compatible with power supplies ranging from 4V to 6V and supports various baud rates including 9600, 19200, 38400, and 57600. Bluetooth serial modules facilitate the interconnection of serial devices using Bluetooth technology. The module consists of 6 pins, including 1 key/EN pin, which is employed to trigger the Bluetooth module's response to AT commands.

Fig 3. HC 05 Bluetooth Module

3. *Intra Oral Camera*

It serves as a valuable resource for patient's education and planning of treatment. It is very simple to use and has no cables, and it's compatible with all Android devices. Oral disorders of all types are evident, and they may be solved. An app must be interfaced correspondingly.

- It finds application in oral cancer screening. Patients considered high-risk for oral cancer, such as individuals who are heavy consumers of alcohol and tobacco, undergo screenings for this ailment. An intraoral camera is employed to identify lesions or tumors that may be indicative of oral cancer. The images captured during this screening are transmitted to an oncology specialist for a more precise evaluation, providing a detailed description and measurement of the lesion or tumor inside the oral cavity, as opposed to the conventional clinical observations made by a general practitioner or dentist.

- It is utilized for patient education. The majority of dental hygienists and dentists utilize intraoral cameras to educate their patients about their oral health. Through the use of this camera, the patient gains insight into the condition of their teeth, aiding the dentist in discussing the dental health status and potential preventive measures.
- It plays a crucial role in persuading patients to undergo dental treatments that can potentially salvage teeth and gums from irreversible damage. The videos and images recorded with the camera assist the dentist in elucidating the dental health condition to the patient and how the proposed dental intervention can effectively manage the situation.

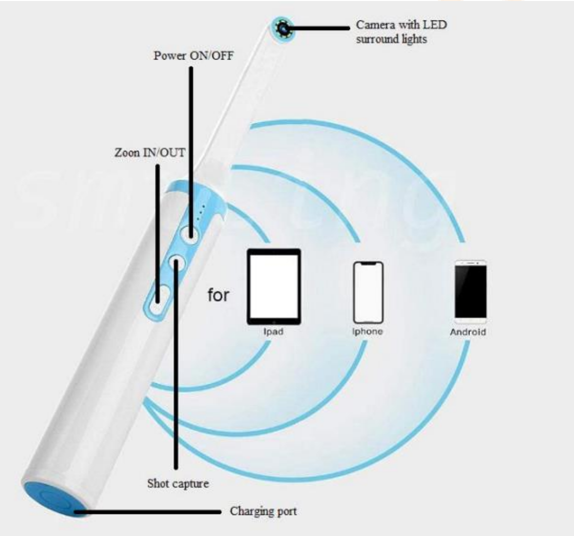

Fig 4.Endoking Intra Oral Camera (IOC)

4. *Robotic Arm*

The Robot Arm was designed using Solidworks 3D modeling software. The arm has 5 degrees of freedom. For the 3 axes, waist, shoulder and elbow, MG996R servos are used, and for the next 2 axes, wrist roll and wrist pitch and also gripper, 3 small SG90 micro servos are used.

Fig 5. 5 DOF Assembled Robotic Arm

5. *Servo Motor*

A servomotor is a highly precise device that functions as either a rotary or linear actuator. It effectively manages angular or linear positioning, speed, and acceleration by combining a well-matched motor with a position feedback sensor for accuracy.

Fig 6 Servo Motor - MG996R

IV.SYSTEM ORIENTED SOFTWARE ELEMENTS

A. *Arduino IDE*

Integrated Development Environment (IDE) of Arduino has a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino hardware boards to upload programs and communicate with them.

B. *Programming using Arduino*

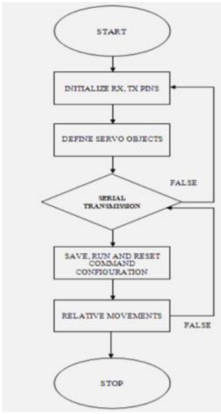

Fig 7. Bluetooth code flowchart

C. *MIT APP Inventor*

MIT App Inventor is a web application integrated development environment originally provided by Google, and now maintained by the Massachusetts Institute of Technology.

1. *App creation steps*

Step 1: Go to create apps option in MIT App Inventor home page.

Step 2: Sign up with required details.

Step 3: Go to Project – Start New Project.

Step 4: Go to Blocks option and drag and modify blocks as per application requirements.

Step 5: Design your app using the Designer option.

D. *DT WIFI App*

DT-WiFi is designed for integration with Wi-Fi-enabled devices. It operates as a Wi-Fi device companion application, enabling live image transmission. This technology allows for precise visual inspection of locations that may be challenging to discern with the unaided eye. Its applications extend to the dental and endoscopy sectors.

Fig 8. DT Wifi Application icon

V. SYSTEM INTEGRATION

A. *Interfacing Intra - Oral Camera with App*

Step 1: According to the guide manual received with the packaging, one must follow the steps and assemble as required.

Step 2: According to the guide manual received with the packaging, one must charge the intra-oral camera with the given power cable.

Step 3: After charging the camera, one must switch the IOC on by long pressing the power button out of the three buttons.
Step 4: After switching it on and the camera lights up, check your WIFI networks page to get interfaced to the intra-oral camera.

Step 5: After getting connected to its WIFI network, tap on the DT WIFI app in your respective android device. You can see that whatever it captures will get live-streamed in your android device.

Step 6: Using the various options in the app, one can remotely capture image and video data from the live stream and can store it in your Android gallery if necessary.

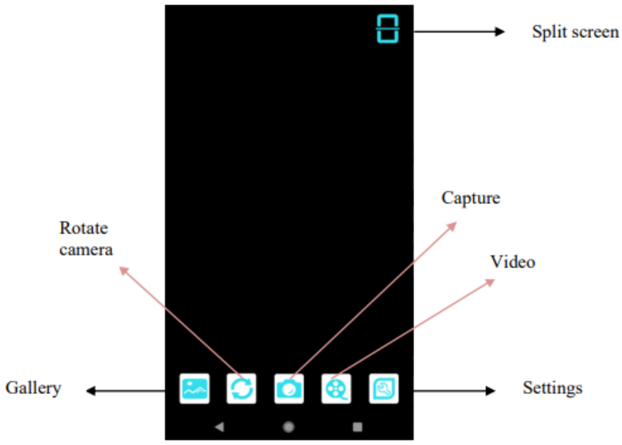

Fig 9. DT Wifi Application's features

B. *Interfacing Robotic Arm with App*

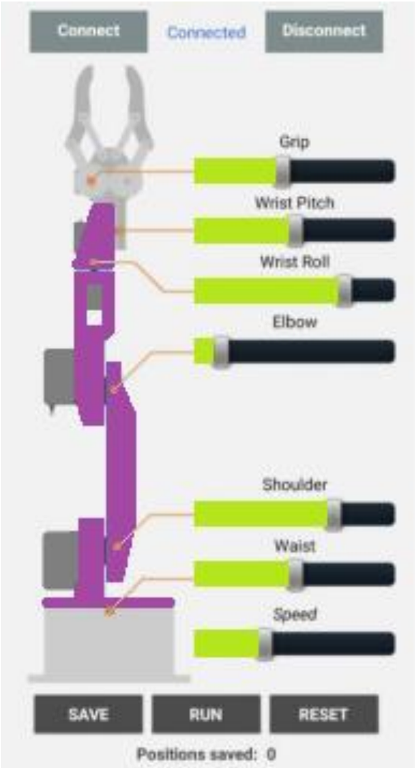

Fig 10. Robotic Arm control application UI

Step 1: After creating the app as per requirements, download its .apk file into a device that will be easier to control.

Step 2: Make sure to install the app after downloading the .apk file.

Step 3: Power up your HC-05 Bluetooth module and give necessary inputs in the AT command mode like setting baud rate and name for the module. Then exit from AT Command mode by removing the enable pin.

Step 4: Enable the Bluetooth option in the device where the app is installed.

Step 5: Go the app and click on the connect option. Only after the Bluetooth option is enabled in your device, the app can recognize the network.

Step 6: After successful communication establishment, by swiping on the sliders, the respective servo motors in the robotic arm move upto that level. One can save, run and also reset the positions according to requirements. If sliders can't enable appropriate increments, one can change the option of sliders to buttons or any other form of actuating object in MIT App Inventor and then download its .apk file.

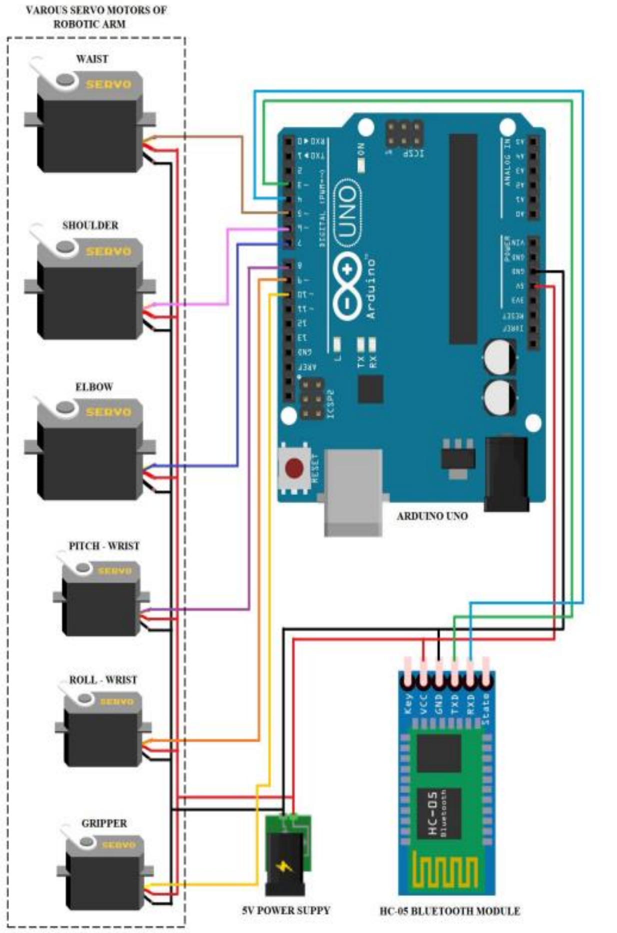

Fig 11. Connection diagram

VI. ASSEMBLY AND TESTING

The final setup will be placed in two separate rooms divided by a see-through wall enabling the dentist to ensure the robotic arm's movement correspondingly to let the IOC capture and record dental data as required for further analysis and thereby no contact where the dash lines represent wireless communication taking place either via Bluetooth or Wireless-Fidelity.

A. *Room 1 setup*

The Room 1 setup consists of:

- Seating arrangements for the dentist.
- An android device or a monitor screen to use the TDA application.
- An android device or a monitor screen to use the DT-Wifi application.

After setting up the aforementioned set of items in room 1, the application created using the MIT App Inventor platform is installed on the android device's screen or the monitor for ensuring whether the User - Interface is displayed as intended and if the control sliders or movement buttons work.

After checking whether TDA application's display is working as intended, the DT Wifi app is installed on the android device's screen or the monitor for ensuring whether the User - Interface is displayed as mentioned on the app preview and if the video, image capture, zoom in, zoom out, gallery options of the app works as intended. The DT-Wifi app's resolution is extremely high in close proximity, and so the picture depicts a long range view that is pixelated.

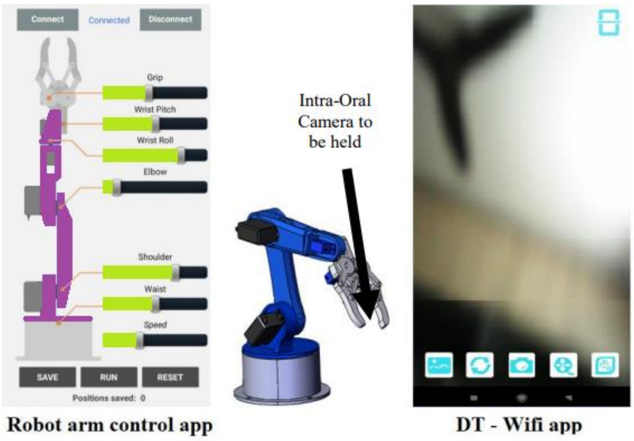

Fig 12. Screens available in Room 1

B. Room 2 setup

The Room 2 setup consists of :

- Flexible seating arrangements for the patient.
- An overhead light beam for focusing the dental data to be captured.
- A Y-shaped fixture (a flat rest piece in our case) upon which the patient can rest their chin.
- A plank upon which the Robotic arm and the Y-shaped fixture are permanently attached to enable steady navigation of IOC into patient's mouth.
- The dental equipments required to keep the patient's mouth open upon navigation to capture dental data.
- Sanitization equipment to wipe/clean the tools after each check-up.

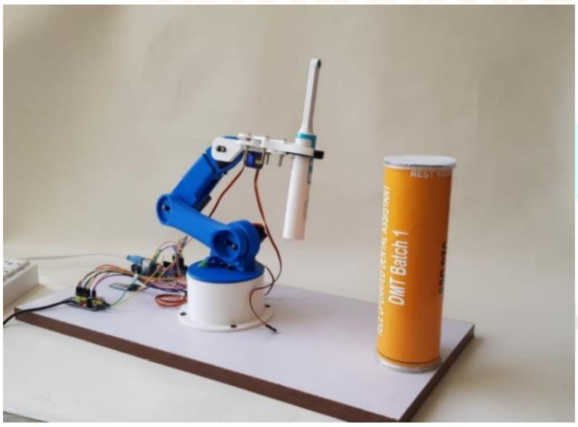

Fig 13. Robotic arm placement

VII. CONCLUSION

The aftermath of the COVID-19 pandemic has been unfathomable and almost every sector within health care industry was drastically affected, with dentistry being one in all to withhold devastating damage. The field of dental practice as well as dental education had subsequent repercussions due to loss in terms of delayed to no treatments, finances and most significantly breaks in ongoing dental education and research practices. As dental professionals are at highest risk of COVID-19 infection due to constant exposure, there even have been unforeseen changes in teaching practices and curriculum to form pedagogy more efficient in these times. However, dental practices all over the world has striven endlessly to redeem itself using safety measures like tele-triages, screening of patients with questionnaires and digital thermometers, use of PPE (personal protective equipment) by dentist and auxiliaries and extensive sanitization during dental procedures. The practice of tele-consultation, time-bound appointments and following social distancing have been explained to patients before entering clinics so on prevent overcrowding and cross contamination in clinical settings. As a notion to tackle the crisis faced by the dental community as aforementioned, the teleoperated dental assistant system can be considered a solution in miniature, beginning at basal routine dental- check ups.

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