Title: Study for Robot-Assisted Endodontic Treatment ver2.1

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1 Introduction (5-6 pages, at most 10 pages)

1.1 Motivation

(Introduce the procedure of the endodontic treatment- Open->Clean->Fill)

1.2 Previous Work and Problem Definition

(Briefly mention some dental robots)

(Focus on cleaning procedure)

(Two problem definition: prevent breakage of file, clean thoroughly)

1.3 The Prospect and Challenges of this Project

(Move to the infected teeth -> Root canal searching -> Repetitive drilling -> Apex Detection)

(Challenges: root canal is small, risk of file breakage)

1.4 Main Contributions of the Thesis

- Robot-Assisted System Design
- Self-Alignment of Root Canal Direction for Automatic Navigation
- Precaution against Endodontic File Fracture

1.5 Organization of the Thesis

2 Related Work and Literature Review

(Elaborate more details of NCTU paper, YOMI and even other dental robots)

(Why not Image processing and why force feedback?)

3 Robot-Assisted System

3.1 Requirement and Specification

(Payload, resolution and workspace)

(Why not RCM mechanism)

3.2 System Design- The DentiBot

(Why Robot Arm - Meca500, F/T sensor - Mini40, Customized Handpiece)

(DOF discussion)

4 Kinematics Analysis and Admittance Control (Tutorial, only variables without numbers and data) (cite some technical papers)

4.1 Kinematics Analysis

4.1.1 Coordinate Definition

(0~6 robot frame, Sensor frame, and tool frame)

4.1.2 Forward and Inverse Kinematics

4.1.3 Jacobian matrix (variables are shown in appendix because they are too long)

(How to obtain Jacobian matrix in frame 6 by Jacobian matrix in frame 0)

4.1.4 Tool Center Point

(How to find RCM by four-points-method)

4.2 Admittance Control

4.2.1 Gravity Compensation

4.2.2 Admittance Control based on F/T sensor

4.2.2.1 Control Scheme

(Block diagram, robot command choice)

4.2.2.2 Discussion about Affection of Parameter Setting

(K, Bi, Mi)

4.2.3 Reference Frame Changing of F/T sensor

(How to find the direction vector of the tool)

(From sensor frame to tool tip frame)

5 Self-Alignment of Root Canal Direction for Automatic Navigation Based on Force and Torque Feedback

5.1 Problem Definition

(Main cause of surgical failure)

5.2 The Proposed Method

(Peg-in-hole method based on F/T feedback)

5.3 The Implementation of the method

(What functions should we used to implement this method)

(Admittance control + Transformation from robot to tool + Transformation from sensor to tool + Motion Planning: based on admittance control)

5.4 Parameters Setting (get reasonable and suitable parameters first)

(Modes: Doctor Dragging and Auto navigation)

6 Precaution of Endodontic Files Fracture Based on Current Feedback

6.1 Problem Definition

(Main cause of Files Fracture)

(File property)

6.2 The Proposed Method and Theorem

(CACS2020)(Prototype 1)

(Motion Planning: sections)(Current threshold setting)

7 Preliminary Experiment Result

7.1 Experimental Setup

(Communication protocol – EtherCAT, RTOS – NI target)
For 7.2 experiment: (Stewart-Platform + PhaseSpace + markers)
For 7.3 7.4 experiments: (Acrylic root canal model + truth tooth)

7.2 Admittance Control

(Metrics: position comparison between the target and the robot)

7.3 Automatically Direction Changing

(Metrics: time, completeness and file breakage)
(Completeness definition: comparison of pixel area before and after experiment via image)

7.4 Repetitive Experiment

(Metrics: file breakage, compare with and without reverse)

8 Conclusions and Future works

(Patient move tracking via cable, root canals searching)