Title: Robot-Assisted Endodontic Treatment ver2.1

**Blue lines are contents**

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

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

* 1. Previous Work and Problem Definition

(Briefly mention the existing dental robots)

(Focus on cleaning procedure)

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

* 1. The Proposed Method

(Move to the infected teeth -> Root canal searching -> Repetitive drilling -> Apex Detection)   
(Challenges: root canal is small, risk of file breakage)  
(Solutions: 1. Build a robot; 2. Force-guided alignment; 3. Control the file rotation speed)

* 1. Main Contributions of the Thesis
* Integrate a 6-DoF robotic manipulator with 6-DoF F/T sensor for performing endodontic treatment.
* Develop a framework for robot alignment regarding the position and orientation of root canal.
* Protect the endodontic file from fracturing by controlling file rotation speed.
  1. Organization of the Thesis

1. State-of-the-Art

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

(Why not Image processing and why force feedback?)

1. Design and Analysis of the Dental Surgical Robot - DentiBot
   1. Requirement and Specification

(Payload, resolution and workspace)

(Why not RCM mechanism)

* 1. Design of the DentiBot

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

(DOF discussion)

* 1. Kinematics Analysis

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

Forward Kinematics, Inverse Kinematics, and 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)

* 1. Tool Center Point

Transformation from robot to tool (How to find RCM by four-points-method)

1. Force-Guided Robot Alignment (Tutorial, only variables without numbers and data) (cite some technical papers)
   1. Problem Definition (Main cause of surgical failure) (Peg-in-hole method based on F/T feedback) (Modes: Doctor Dragging and self-alignment)
   2. Integration of F/T sensor (Gravity Compensation)
   3. Alignment to the Root Canal (Dragging for alignment)
      1. Admittance Control based on F/T sensor
         1. Control Scheme

(Block diagram, robot command choice)

* 1. Alignment to the Root Canal (Drilling and self-alignment)
     1. Reference Frame Changing of F/T sensor

(Transformation from robot to tool [Chapt. 3.4]+ Transformation from sensor to tool)

(How to find the direction vector of the tool)

(From sensor frame to tool tip frame)

* + 1. Motion Planning: based on admittance control

(Block diagram, robot command choice)

* 1. Discussion about Affection of Parameter Setting

(K, Bi, Mi) (w/o numbers)

(Modes: Doctor Dragging and Auto navigation) (w/ numbers; get reasonable and suitable parameters first)

1. Control of Endodontic File Rotation
   1. Problem Definition

(Main cause of Files Fracture)

(File property)

* 1. The Proposed Method and Theorem

(CACS2020)(Prototype 1)

(Motion Planning: sections)(Current threshold setting)

1. Experimental Results
   1. Experimental Setup

(Communication protocol – EtherCAT, RTOS – NI target)

For 6.2 experiment: (Stewart-Platform + PhaseSpace + markers)

For 6.3 6.4 experiments: (Acrylic root canal model + truth tooth)

* 1. Drilling and self-alignment

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

* 1. Control of Endodontic File Rotation

(Metrics: time, completeness and file breakage)

(Completeness definition: comparison of pixel area before and after experiment via image)

* 1. Preclinical Evaluation

(Repetitive Experiment)

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

1. Conclusions and Future works

(Patient move tracking via cable, root canals searching)