FIELD OF STUDY

Vibrations, structural health monitoring, and biomedical devices

DISSERTATION TOPIC

REPLICATION OF FORCE SENSING BEARINGS AND FEASABILITY OF STRUCTURAL HEALTH MONITORING IN TOTAL KNEE REPLACEMENTS

EXAMINING COMMITTEE

Dr. Steven Anton (Mechanical Engineering) (Chair)

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ABSTRACT

Modern medical technology has made Total Knee Replacements (TKR) a powerful tool for drastically improving the lives of people with severe orthopedic conditions such as osteoarthritis. The demand for TKR has only increased with the gradual aging of the American population. Despite recent developments with TKRs, a subset of patients will continue to experience discomfort with their new joint. In some circumstances, patients will even experience failure of their artificial joint, resulting in painful and costly revision surgeries. What the medical community demands is a system to detect the mechanical conditions inside of the TKR as well as detect potential failure due to tibial loosening before it becomes a hazard to the patient. This thesis builds upon past research into a sensing system that is embedded inside of the TKR and performs force sensing as well as structural health monitoring in order to improve patient outcomes and predict mechanical failures.

The work presented falls into two main thrusts: replication of force sensing bearings and feasibility of structural health monitoring. The first thrust involves using modern rapid prototyping techniques, such as 3D printing, to quickly produce economically viable surrogate implant bearings for the purpose of future in-vitro testing. The second thrust of this work which comprises much of this thesis begins by performing fundamental validation of electromechanical impedance based structural health monitoring in detecting damage at the cemented interface between the TKR's tibial component and the tibial bone. This is done initially with a geometrically simplistic test sample which is comprised of the materials found at this interface. From there, additional studies are performed using an actual tibial tray in a more realistic bone environment. In this second portion of SHM experimentation, two modes of failure are investigated: implant-cement and cement-bone failure. The intention of this work is to lay the foundation for future studies into the use of force sensing bearings as well as cadaver and actual patient implementation of impedance-based SHM.

BIOGRAPHICAL SKETCH

Robert Ponder was born and raised in Knoxville, TN. He was homeschooled by his parents for most of his secondary education, graduating from Maryville Christian School. He attended Tennessee Technological University, graduating in May of 2017 with a Bachelor of Science in Mechanical Engineering. Robert joined the Dynamic and Smart Systems Lab (DSSL) during the last semester of his undergraduate education. Robert joined DSSL as a Graduate Research Assistant in the fall of 2017 after completing a two-month internship at Indiana University Hospital at Saxony under Dr. R. Michael Meneghini and Evan Deckard. Robert's current research interests include vibrations, structural health monitoring, and biomedical devices.

EDUCATION

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TENNESSEE TECH

The Department of

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Announces the Thesis Defense

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