UNC CHARLOTTE
The WILLIAM STATES LEE COLLEGE *of* ENGINEERING

Senior Design Project Description

Company Name	Center for Precision Metrology	**Date Submitted**	June 23, 2017
Project Title	Design of Optical Sensing Systems (CPM_OKE/CPM_OKN)	**Planned Semester**	Fall 2017

Personnel

Typical teams will have 4-6 students, with engineering disciplines assigned based on the anticipated Scope of the Project. 250 hours are expected per person. Complete the following table if this information is known, otherwise the Senior Design Committee will develop based on the project scope:

Discipline	Number	Discipline	Number
Mechanical	4	Electrical	2
Computer	0	Systems	0
Other ( )			

Note: The numbers above are per team. So 6 per team, total of 12 for both projects.

Project Overview:

The objective of this project is to apply recent research discoveries to the design of novel measurement systems.

Dual Project

The underlying technology for both teams is the optical knife edge sensor (see references below for technical details of the sensor). One team with use the optical knife edge sensor, or OKES, to measure the dynamics of a cutting tool while cutting in a CNC machine tool. The students will need to design a housing to mount the sensor and all its optical components (beam splitter, mirrors, photodetectors, etc.) and protect it from coolant and metal chips while also allowing the sensor to measure the outer diameter of the cutter. The team will have the ability to change every part of the sensor design to produce the most appropriate components and housing to achieve the highest sensitivity. The data collected from the sensor will be calibrated to displacement data using a capacitance sensor. The team will take displacement data and extract machining dynamics from the data with the help of the mentors.

The second team will use the optical knife edge to create a novel CNC touch probe and tool set station. The team will design a flexure-based housing that encloses the optical knife edge sensor within a flexure that allows motion in the x, y and z axis. A similar approach will be used to also produce two single axis touch probes to act as a tool set station for CNC milling machines. The students will have design freedom to create the flexure, design the most sensitive geometry and mechanical amplification.

An electrical team of students will be responsible for designing the laser diode power supply, the photodetector circuit, signal conditioning, amplification and communication. The touch probe and tool set station must be able to communicate with the CNC machine tool. A communication strategy and protocol will be designed to get the collected data into either the machine tool's preferred format or into report form for the user to identity the machining dynamics.

References:

Lee, ChaBum, Rui Zhao, and Seongkyul Jeon. "A simple optical system for miniature spindle runout monitoring." Measurement 102 (2017): 42-46.

Lee, ChaBum, Sun-Kyu Lee, and Joshua A. Tarbutton. "Positioning control effectiveness of optical knife edge displacement sensor-embedded monolithic precision stage." Sensors and Actuators A: Physical 233 (2015): 390-396.

Lee, ChaBum, et al. "Cross-coupling effect of large range XY nanopositioning stage fabricated by stereolithography process." Precision Engineering 46 (2016): 81-87.

Jeon, Seongkyul, et al. "Knife-edge interferometry for cutting tool wear monitoring." Precision Engineering (2017).

Lee, ChaBum, Sun-Kyu Lee, and Joshua A. Tarbutton. "Novel design and sensitivity analysis of displacement measurement system utilizing knife edge diffraction for nanopositioning stages." Review of Scientific Instruments 85.9 (2014): 095113.

Initial Project Requirements:

Dynamic Stability Measurement Device:

Use the Optical Knife Edge Sensor to design a novel displacement measurement device that can measure the dynamic stability of a cutting tool during CNC milling.
The system must be able to detect machining dynamics up to 4kHz.
The system must be able to communicate the machining dynamics to the user every second.

Touch Probe and Tool Set Station:

Use the Optical Knife Edge Sensor to design a touch probe measurement device that can measure the location of a work piece with 1um accuracy in x, y, and z axis.
This device must fit in an ER collet with a CAT40 tool holder.
Based on similar design principles, use the Optical Knife Edge Sensor to design a touch probe measurement device that can measure the location of tool's outer radius (x-direction) and length (z-direction) with an accuracy of < 1um.
The system must be able to communicate the tool diameter and tool length offset to the CNC controller.

Expected Deliverables/Results:

Two completely designed prototypes of the touch probe and tool set station.

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Disposition of Deliverables at the End of the Project:

Return all prototypes to sponsors.

List here any specific skills, requirements, knowledge needed or suggested (If none please state none):

Mechanical students should be able to work in the machine shop and have strong CAD skills. Electrical students should have familiarity with circuit design and simulation including sending design files to be fabricated.