Radiation-Resistant Reconnaissance Robot

John Henrie, Brooklyn Noble, Richard Sisson, Nicklaus Traeden
Advised By: Ryan Schow, Drs. Tatjana Jevremovic, Bart Raeymaekers

Introduction

There are currently thirty-one operating nuclear research and test reactors in the United States, most of which are water-moderated.

This type of reactor consists of a deep pool filled with water, uranium fuel rods, and a few irradiation ports, in order to expose scientific samples to a specific radiation environment.

Any type of maintenance or visual inspection of the pool internals (pipes, fuel and control rods, etc.) require days of work by highly trained personnel such as the reactor supervisor or senior reactor operator.

There is an extensive and ongoing need for the development of a new method of operator-to-reactor communication and handling, as well as routine inspection and maintenance.

This need will be addressed via a submersible robot for use in the reactor pool by the reactor operator.

Design

The objective of this project is to develop a submersible radiation-resistant, tether-operated robot for use in a water-moderated reactor pool.

1. Radiation Resistance: Aluminum shielding provides protection from radiation for susceptible internal electronics and ensures the robot’s radiation level is as low as reasonably achievable after being exposed to the reactor environment.

2. Buoyancy Control: Two propellers on the underside of the robot provide depth control up to 7 meters.

3. Propulsion: Two propellers on either side of the robot provide horizontal motion control and rotational control about the vertical axis.

4. Streaming Video: Three cameras provide a 360° view of a fuel rod.

5. Electronics: Onboard BeagleBone microprocessor facilitates control and communication (not shown).


Prototype

Radiation Resistance

Calculations of induced radioactivity as a function of exposure time for robot materials indicate radioactivity of 200 µCi for continued exposure of 264 min. GEANT-4 simulations indicate 1/8" aluminum shields virtually all radiation from robot internals.

Control/Communication

The reactor operator controls the robot remotely with an Arduino controller which communicates to a computer via xBee. The computer is linked to the robot microprocessor via a tethered Ethernet connection.