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FDIR for a Biologically Inspired Trenchless Drilling Device

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Abstract— Failure Detection, Isolation and Recovery (FDIR) of autonomous systems working in hazardous conditions is essential. Methods of detection and recovery without intervention are required. This work describes the failure modes currently identified with an autonomous biologically inspired trenchless drilling robotic system. Inverse Simulation is used for detecting failures and is demonstrated on a simulation model of the robotic system. Results from the experiments, show that Inverse Simulation can be used to detect and identify system failures.

Keywords—FDIR, Biologically Inspired, Control, Robotics

I. INTRODUCTION

The RoBot for Autonomous unDerGround trenchless opERations, mapping and navigation (BADGER) [1] project is developing an autonomous robot that is able to carry out trenchless drilling, i.e. a tunnel is excavated with minimal surface disturbance. The tunnels drilled are then used to route services (water, communication, power) through. The BADGER system is provided with the route to travel and then carries out the drilling operation autonomously. A robust FDIR system is required to monitor the system for faults that effect the drilling process and the system as a whole. The first stage in the development of the FDIR system is to identify the potential faults that could affect the operation of the system and hinder movement. The FIDR system uses Inverse Simulation [2, 3, 4] to monitor the system for faults relating to the motion.

II. BASIC MOTION

The motion of BADGER is worm-like: areas of BADGER expand and contract as required. Elements of the system (clamps) provide anchoring to the tunnel's sidewalls. When one section is anchored, another section extends, providing the required Weight-On-Bit (WOB) to the drill head. The section that lengthened then anchors allowing the previously anchored section to contract towards the newly anchored section. Repeating this process allows the system to move along the tunnel being drilled. With motion feedback and knowledge of the actual control signal applied, an FDIR system is developed. For laboratory experiments, the Kinematic Investigation Testbed (KIT) is used, Fig.1, (100mm diameter vs 250mm of BADGER).

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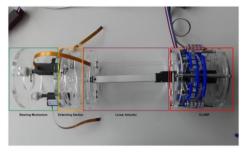


Figure 1: KIT with various parts highlighted

III. FDIR USING INVERSE SIMULAITON

Inverse Simulation for FDIR has been first demonstrated in [4]. Inverse Simulation is applied to detect faults in both the system's inputs (faults in the outputs of the actuators, faults with how the actuator output is applied) and the outputs (the actual movement). The system's outputs are provided to the FDIR algorithm and it calculates the corresponding inputs, which are then compared with the actual. If the inputs are not within a reasonable margin of error, then further work is implemented to locate the source of the fault.

IV. CONCLUSIONS

This work presents the initial findings of applying FDIR using Inverse Simulation to the BADGER system. Using a model of the system and an Inverse Simulation based FDIR algorithm, faults with the system's motion are detected as well as input faults and faults between subsystems.

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