Using Prognosis-Based Control for Fault Prevention in Multirobot Teams

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Abstract

Attaining the benefits of redundancy in multirobot teams is dependent upon the ability of the team members to properly handle faults. Much prior work has been done regarding fault detection, diagnosis, and recovery in robot systems, including some work in the context of multirobot teams. However, relatively little work in the multirobot domain has been done to anticipate failures prognostically, and then to take action to avoid those potential failures. While the general field of prognostics has studied important issues in the anticipation of faults, this prior work, especially in the robotics domain, has largely been application-specific. The goal of prognostics is well defined in the literature, but the implementation and mathematical models presented in typical approaches are tightly coupled to the systems that are undergoing prognostic analysis. Also, while much work has appeared regarding the identification of problems that lead to failures, the prior work does not typically handle fault conditions in such a way as to allow a multirobot system to extend its own useful life.

This talk presents research aimed at filling this gap by providing a mathematically sound framework from which general prognostic algorithms may be derived for the multirobot domain. The approach is to create a prognostic vector space across a multi-dimensional set of features that can be detected by the robot team while executing the team task. Through a prior learning phase, regions of the vector space are defined as fault regions. Then, during online task execution, the remaining useful life of the robot system is calculated based on the distance in the vector space of the current feature vector from the fault regions. Corrective actions that move the multirobot team away from fault regions are defined, either using model-based approaches or data-driven approaches. This results in the use of prognostics for control, such that the remaining useful life of the multirobot system is extended without requiring human operation interaction. We illustrate the system in multirobot applications that show how robots can employ prognostic techniques to avoid potential failures and thereby continue in fault-free task execution. We believe that the formulation of a general approach to prognostics for control that is applicable to multirobot systems will enable these teams to better achieve the benefits of robot redundancy by anticipating faults and taking appropriate action to avoid them.