Key Technologies (7)
Key Technologies (1) (1)

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A PARTICLE FILTER APPROACH FOR FAULT DETECTION AND ISOLATION OF ROVER IMU SENSORS

Abstract

Robotic rovers are one of the key elements of unmanned planetary exploration. Among others, missions involving mobile robot vehicles such as Spirit, Opportunity, Curiosity provided an extraordinary amount of data about Mars, enhancing our knowledge of the Red planet. The possibility for such missions to successful achieve their goals strongly depends on robustness, reliability and autonomy of the rover. These vehicles operating for a long period autonomously or with relatively little intervention, should be capable of tackling faults or failure of some rover part autonomously. This goal leads to the need of on-board fault detection and diagnosis capabilities, helping in determining the true state of the vehicle and stating which actions are safe to perform. Detection, localization and mitigation of faults in a complex system are often labeled as fault detection, isolation and recovery (FDIR). Among FDIR techniques one of the simplest, from a conceptual point of view, is model-based detection which relies upon the use of a model of system behaviour to foresee system properties. Foreseen properties are compared to those of the actual system. Comparison leads to the generation of features, which enable isolation and (if possible) attenuation of system faults. Nevertheless, FDIR model-based techniques are usually critical because of external disturbance and/or typical non-linear system behaviour. Both phenomena may cause a significant number of false or missed fault detections and a high probability of wrong identifications. This paper aims to tackle the problem to detect and isolate faults of sensors of inertial measurement units(IMUs). In space planetary robotic rovers IMU is a fundamental element of navigation systems: pitch and roll are required for both soil navigation and vehicle safety. Thus, IMU failures may significantly affect rover performances in several important tasks such as autonomous driving or antenna pointing. Paper contribution will deal with a model-based approach exploiting a Monte Carlo integration (namely a particle filtering technique) to detect and isolate faults affecting IMU gyroscopes and accelerometers. Effectiveness of the proposed approach will be stated in terms of false/missed alarms and time of detection, through a campaign of experimental simulations by using a proof-of-concept system involving a mobile robot driven in an open field terrestrial environment equipped with two IMUs, namely Crossbow model VG700CA. Different kinds of realistic faults will be considered in order to show the effectiveness of the proposed FDI approach.