Task Persistification for Robots with Control-Dependent Energy Dynamics

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Abstract: — This paper presents a solution to the problem of executing robotic tasks over time horizons that exceed the robot's total battery capacity. In the presented robotics application, the robot's mission is to satisfy two tasks: environmental exploration and environmental monitoring, both of which need to be executed over long time periods. These tasks need therefore to be persistified. Ensuring the longevity of the system requires to consider a maximum energy consumption at all times. Including a dependency of battery voltage dynamics on the control input introduces a quadratic term in the battery's dynamic equation, making previous persistification approaches no longer directly applicable, as they used control affine dynamics. In this paper an alternative task persistification approach is formulated. The control strategy used is based on Control Barrier Functions (CBFs). Using which, the generated controller renders the system state variables, position and battery voltage, to remain within the boundaries of their safe sets. This generated safe controller minimally modifies the nominal controller, which commands the robot to satisfy its environmental mission. Once the CBFs are selected, the minimization problem that results is one with a quadratic cost and two nested scalar constraints: one of which is quadratic and the other is linear. This new class of problems is noted as Quadratic Cost Scalar Linear and Quadratically Constrained (QCSLQC) problems. An analytical solution to the general QCSLQC problem is presented.