Mobile robots are increasingly being deployed in the real world in response to a heightened demand for applications such as transportation, delivery and inspection. The motion planning systems for these robots are expected to have consistent performance across the wide range of scenarios that they encounter. While state-of-the-art planners, with provable worst-case guarantees, can be employed to solve these planning problems, their finite time performance varies across scenarios. This thesis proposes that the planning module for a robot must adapt its search strategy to the distribution of planning problems encountered to achieve real-time performance. We address three principal challenges of this problem.

Firstly, we show that even when the planning problem distribution is fixed, designing a non-adaptive planner can be challenging as the performance of planning strategies fluctuates with small changes in the environment. We characterize the existence of complementary strategies and propose to hedge our bets by executing a diverse ensemble of planners.

Secondly, when the distribution is varying, we require a meta-planner that can automatically select such an ensemble from a library of black-box planners. We show that greedily training a list of predictors to focus on failure cases leads to an effective meta-planner. For situations where we have no training data, we show that we can learn an ensemble on-the-fly by adopting algorithms from online paging theory.

Thirdly, in the interest of efficiency, we require a white-box planner that directly adapts its search strategy during a planning cycle. We propose an efficient procedure for training adaptive search heuristics in a data-driven imitation learning framework. We also draw a novel connection to Bayesian active learning and propose algorithms to adaptively evaluate edges of a graph.

Our approach leads to the synthesis of a robust real-time planning module that allows a UAV to navigate seamlessly across environments and speed-regimes. We evaluate our framework on a spectrum of planning problems and show closed-loop results on 3 UAV platforms - a full-scale autonomous helicopter, a large scale hexarotor and a small quadrotor. While the thesis was motivated by mobile robots, we have shown that the individual algorithms are broadly applicable to other problem domains such as informative path planning and manipulation planning. We also establish novel connections between the disparate fields of motion planning and active learning, imitation learning and online paging which opens doors to several new research problems.