Research Statement
Robotic Systems with a Guaranteed Quality of Service under Uncertainty

As robots become more prevalent in healthcare, manufacturing, and on our roads, there is a growing need for safe and reliable autonomy. Safety and reliability can be quantified through *formal guarantees*, i.e. specifications the robot will always satisfy. For example, an autonomous vehicle may guarantee that road rules are violated in less than 1% of its operation time. To obtain robust guarantees, robots require accurate *models* of the environment, and how its actions affect it. Existing robot deployments often assume limited, controlled environments which admit simplistic, deterministic models. However, real world environments are stochastic, with numerous sources of uncertainty which affects the outcome of robot actions, their duration, and the robot's ability to observe its surroundings. Identifying relevant sources of uncertainty for a problem is challenging, and introduces trade offs between accuracy and the scalability of formally verifying the system.

Formal guarantees should coincide with efficient robot behaviour. If a robot performs poorly, guarantees have little use, as there is little benefit in deploying the robot. Therefore, we require decision-making techniques which synthesise robot behaviour that satisfies a given guarantee or specification. Similar to verification, decision-making techniques rely on accurate models. If a model is inaccurate, our expectations of robot behaviour during decision-making diverge from what we observe during execution, limiting performance.

Any decision-making or verification model will contain inaccuracies. Therefore, robots should be embodied with techniques to reason over the epistemic uncertainty in their models: how much do they know, and how certain are they of it? With this, robots may choose to explore to improve their model, and guarantees may provide bounds given model uncertainty.

My research goal is to develop robotic systems which provide a guaranteed quality of service under uncertainty. This requires robots which can i) learn accurate models of their environment and improve them over time; ii) use these models to synthesise efficient behaviour; and iii) provide formal guarantees over this behaviour. This research is inherently cross-disciplinary, combining techniques from the AI, robotics, and formal verification communities.