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He is director of an 8 academics and 40 researchers Autonomous Systems and Robotics Research Group and executive member of Sheffield Robotics with 150 members in Sheffield. Between 2002 and 2012 he was professor of control sciences at the University of Southampton where his funded research interests were system identification for control, vibration control, satellite formation flying, formal verification of autonomous underwater vehicles and engineering of autonomous spacecraft software.

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Methods to Address Uncertainty Challenges in Robotics

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Most autonomous robots rely on logic inference to keep themselves to safe, socially and legally permitted behaviour. Equipped with a set of rules, it is important that the robot is able to establish the consistency between its rules, its uncertain, perception-based beliefs, its planned actions and their uncertain consequences. This talk investigates how a robotic agent can use model checking to examine the consistency of its rules, beliefs and actions and resolve some uncertainty. The robots rule set is modelled by a Boolean evolution system with synchronous semantics that can be transformed into a labelled transition system (LTS). We show that stability and consistency can be formulated as properties expressible in computation tree logic (CTL) and linear temporal logic (LTL). Some algorithms are presented to aid fast realtime consistency and stability checks, respectively. The implementation of the algorithms provides us a computational tool, which can form the basis of efficient consistency checks and aiding uncertainty resolution on-board robots.

Based on this theory, fast consistency resolution is embedded into a new agent architecture for autonomous decision making under the name of Limited Instruction Set Agent (LISA). The LISA architecture is based on previous implementations of AgentSpeak/Jason and it is simpler than its predecessors. The simplification aims at facilitating design-time and run-time verification methods.

A process of abstracting the LISA system to two different types of discrete probabilistic models (DTMC and MDP) is introduced and illustrated. The LISA system provides the means for complete modelling of the agent and the environment for probabilistic verification in a unified and readable document in the sEnglish™ agent programming system.

For uncertainty assessment, any LISA program can be automatically compiled into a code under the probabilistic model checker PRISM for design-time model checking of probabilistic temporal logic specifications.

The automatically generated model can also be used for run-time verification to be performed by the robot in action. The theory of runtime verification by the LISA agent is briefly presented and illustrated as a mechanism for probabilistic prediction and value assessment of future outcomes based future alternatives of actions.

The methodology is illustrated on autonomous surface boats and unmanned aerial systems.