Verification Techniques for Swarm Robotics

University of York

Qualification type: PhD
Location: York
Funding for: UK/EU students
Duration: Funding is available for 3 years
Funding amount: Full coverage of tuition fees and annual stipend at RCUK rate, that is, £14,777 for 2018/19
Hours: Full Time

Placed on: 10 April 2018
Closes: 31 July 2018

The project

RoboChart is a domain-specific notation for modelling mobile and autonomous robot controllers, their hardware, and their environments. RoboChart models can be checked by automated analysis, including techniques for simulation, testing, model checking, and theorem proving. These techniques overlap substantially, and each has its pros and cons. This project specifically concerns model checking and theorem proving.

Model checking is a push-button technique, but this is complicated when the state space is too large; theorem proving handles infinite state spaces, but usually requires skilled interaction to find proofs. This suggests combining the two techniques, where theorem proving is used to reduce a verification problem to finite-state form, so that model checking can then take over and finish the job. This decomposition of the verification task forms the basis of SRI's Symbolic Analysis Laboratory (SAL), a framework for combining different analysis tools for transition systems via a common intermediate language.

A qualitative property of a program is typically one of the following: a condition that must be true before execution of the program; a condition that is guaranteed to be true after its execution; or an invariant that is guaranteed to hold at all points during its execution. It is qualitative because it is simply either true or false. A quantitative property, on the other hand, is typically a qualitative property that holds with probability p.

As well as qualitative properties, RoboChart supports modelling quantitative properties involving probabilistic and real-time behaviour. There is a useful connection between theorem proving and probabilistic model checking (McIver, 2006, listed below), and we propose to further develop this result.
Model checking is particularly challenging in the area of swarm robotics. This is an approach to the coordination of large numbers of simple individual robots. Collective behaviours emerge from the interactions between a robot and its peers, and with the environment. Swarm robotics is inspired by biological metaphors arising from the study of birds, insects, and other natural organisms where swarming behaviour occurs. Models for swarm robotics applications have a very large number of states.

This project will explore how verification can be effective in combining theorem proving and model exploration. The research objective is to establish that this can be used to check the quantitative performance of design decisions early in the development cycle. Part of the project is to learn about the following techniques: theorem proving in Isabelle/HOL; probabilistic model checking in PRISM and Storm; and statistical model checking (discrete-event simulation) in PRISM.

The application area will be in swarm robotics. Applications and examples are available from https://www.cs.york.ac.uk/circus/RoboCalc/ and the York Robotics Laboratory (https://www.york.ac.uk/robot-lab/).

RoboChart is supported by RoboTool (https://www.cs.york.ac.uk/circus/RoboCalc/robotool/) and is described in a reference manual (http://barom.org.uk/robochart/documents/robochart-reference.pdf). Recent publications on RoboChart are as follows:


Selected relevant publications on verification are as follows:


Research supervision


Award funding

If successful, you will be supported for three years. Funding includes:

- £14,777 (2018/19 rate) per year stipend
- Home/EU tuition fees
- RTSG (training/consumables/travel) provision

Funding requirements

To be considered for this funding you must:

- meet the entrance requirements for a PhD in Computer Science
- be eligible to pay home/EU fees

We will look favourably on applicants that can demonstrate knowledge of verification techniques and who have strong programming and mathematical skills.

Apply for this studentship

1. Apply to study
   - You must apply online for a full-time PhD in Computer Science.
   - You must quote the project title (Architectural and Data Modelling for Robotic Applications Studentship) in your application.
   - There is no need to write a full formal research proposal (2,000-3,000 words) in your application to study as this studentship is for a specific project.

2. Provide a personal statement. As part of your application please provide a personal statement of 500-1,000 words with your initial thoughts on the research topic.
Deadlines

The closing date for the receipt of applications is 31 July, 2018.

Interviews are expected to take place within approximately 14 days of the closing date.

The studentship must begin as soon as possible, and in any case no later than 1 October, 2018.

Informal enquiries

Project enquiries

Professor Ana Cavalcanti: https://www-users.cs.york.ac.uk/~alcc/

Application enquiries

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