Towards the formal verification of correctness and robustness of robot swarms (Invited talk)

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We were honoured to have the opportunity to share with the ICTCS and CILC 2017 attendees some of the recent work in our lab on verifying robot swarms. The talk was given by Alessio Lomuscio; the key topics discussed are based on joint work with Dr Panagiotis Kouvaros, previously at Imperial College London. The references below are given for the benefit of those seeking more details on the methods presented during the talk.

Robot swarms are large collections of small robots, typically running lightweight programs, interacting with their neighbours and the environment. In recent years swarm robotics has shown considerable applicability in a wide range of domains, including search and rescue, automatic mining, and plant monitoring.

I began by arguing that swarm systems benefit from logic-based specification languages typically used in AI and multi-agent systems that go beyond plain temporal logic, but also concern the knowledge, the intentions, and the strategic abilities of the agents in the system. To motivate this, I drew parallels with the area of multi-agent systems where approaches based on symbolic model checking [1], also in combination with symmetry reduction [2], parallel model checking [3], and SAT [4], are now common place.

I then started discussing the specific case of swarms. One of their key feature is that the number of agents is unbounded at design time. I illustrated a semantics based on agent templates and introduced the parameterised model checking problem (PMCP) as the decision problem of establishing whether all infinitely many concrete instances of a swarm design based on agent templates satisfies a given temporal-epistemic specification. Cut-off procedures from [5–7] solving the PMCP for different classes of swarms were presented, together with alternative approaches such as counter-abstraction [8]. This enabled us to ground the discussion on concrete protocols such as opinion formation [9] and briefly discuss related topics such as the verification of emergence in swarms [10].

I concluded by exploring the issue of resilience of a swarm against adverse functioning conditions. Again I drew parallels with our previous work on safety analysis in the context of autonomous systems [11–13]. To do this, I introduced the parameterised fault-tolerance problem as the decision problem of establishing whether any concrete system in which the ratio of faulty versus total number of agents is bounded by a parameter, satisfies a given temporal-epistemic specification. I illustrated how faults can be injected automatically into correct designs so that the resulting mutated models can be automatically analysed and conclusions on the resilience of the original design can be drawn [14].

References

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