

A Collective Adaptive Approach to Decentralised k -Coverage in Multi-robot Systems

DANILO PIANINI, FEDERICO PETTINARI, and ROBERTO CASADEI, Alma Mater

Studiorum—Università di Bologna, Italy

LUKAS ESTERLE, Aarhus University, Denmark

We focus on the online multi-object k -coverage problem (OMOkC), where mobile robots are required to sense a mobile target from k diverse points of view, coordinating themselves in a scalable and possibly decentralised way. There is active research on OMOkC, particularly in the design of decentralised algorithms for solving it. We propose a new take on the issue: Rather than classically developing new algorithms, we apply a macro-level paradigm, called *aggregate computing*, specifically designed to directly program the global behaviour of a whole *ensemble* of devices at once. To understand the potential of the application of aggregate computing to OMOkC, we extend the Alchemist simulator (supporting aggregate computing natively) with a novel toolchain component supporting the simulation of mobile robots. This way, we build a software engineering toolchain comprising language and simulation tooling for addressing OMOkC. Finally, we exercise our approach and related toolchain by introducing new algorithms for OMOkC; we show that they can be expressed concisely, reuse existing software components and perform better than the current state-of-the-art in terms of coverage over time and number of objects covered overall.

CCS Concepts: • **Computer systems organization** → **Self-organizing autonomic computing**; *Robotic autonomy*; • **Theory of computation** → **Self-organization**; • **Computing methodologies** → *Distributed programming languages*; *Self-organization*; • **Software and its engineering** → *Application specific development environments*;

Additional Key Words and Phrases: Location based services, Internet of things, online multi-object k -coverage, smart cameras, multi-robot, aggregate computing

ACM Reference format:

Danilo Pianini, Federico Pettinari, Roberto Casadei, and Lukas Esterle. 2022. A Collective Adaptive Approach to Decentralised k -Coverage in Multi-robot Systems. *ACM Trans. Auton. Adapt. Syst.* 17, 1–4, Article 4 (September 2022), 39 pages.

<https://doi.org/10.1145/3547145>

The idea and initial effort behind this work originated from the discussion during the GI-Dagstuhl Seminar 18343 “Software Engineering for Intelligent and Autonomous Systems (SEfIAS).” This work has been partially supported by the Italian PRIN project N. 2017KRC7KT “Fluidware.”

Authors’ addresses: D. Pianini, F. Pettinari, and R. Casadei, Alma Mater Studiorum—Università di Bologna, Via dell’Università, 50, 47522 Cesena (FC), Italy; emails: danilo.pianini@unibo.it, federico.pettinari2@studio.unibo.it, roby.casadei@unibo.it; L. Esterle, Aarhus University, Nordre Ringgade 1, 8000 Aarhus C, Denmark; email: lukas.esterle@eng.au.dk.

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than the author(s) must be honored. Abstracting with credit is permitted. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from [permissions@acm.org](https://permissions.acm.org).

© 2022 Copyright held by the owner/author(s). Publication rights licensed to ACM.

1556-4665/2022/09-ART4 \$15.00

<https://doi.org/10.1145/3547145>