Urban swarms for autonomous waste management

October 31 2018, by Ingrid Fadelli

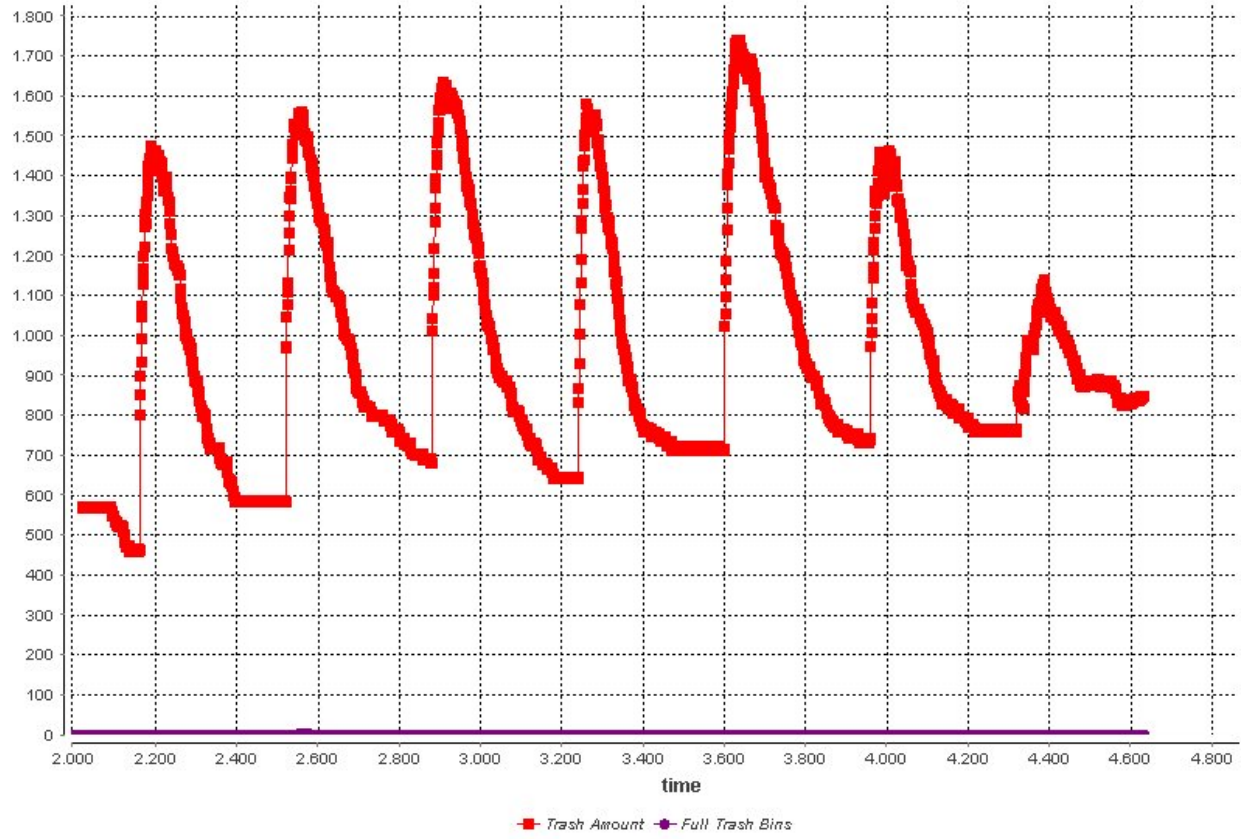


Image showing how quickly the dumping of new trash into the urban environment is disposed. Credit: Alfeo et al.

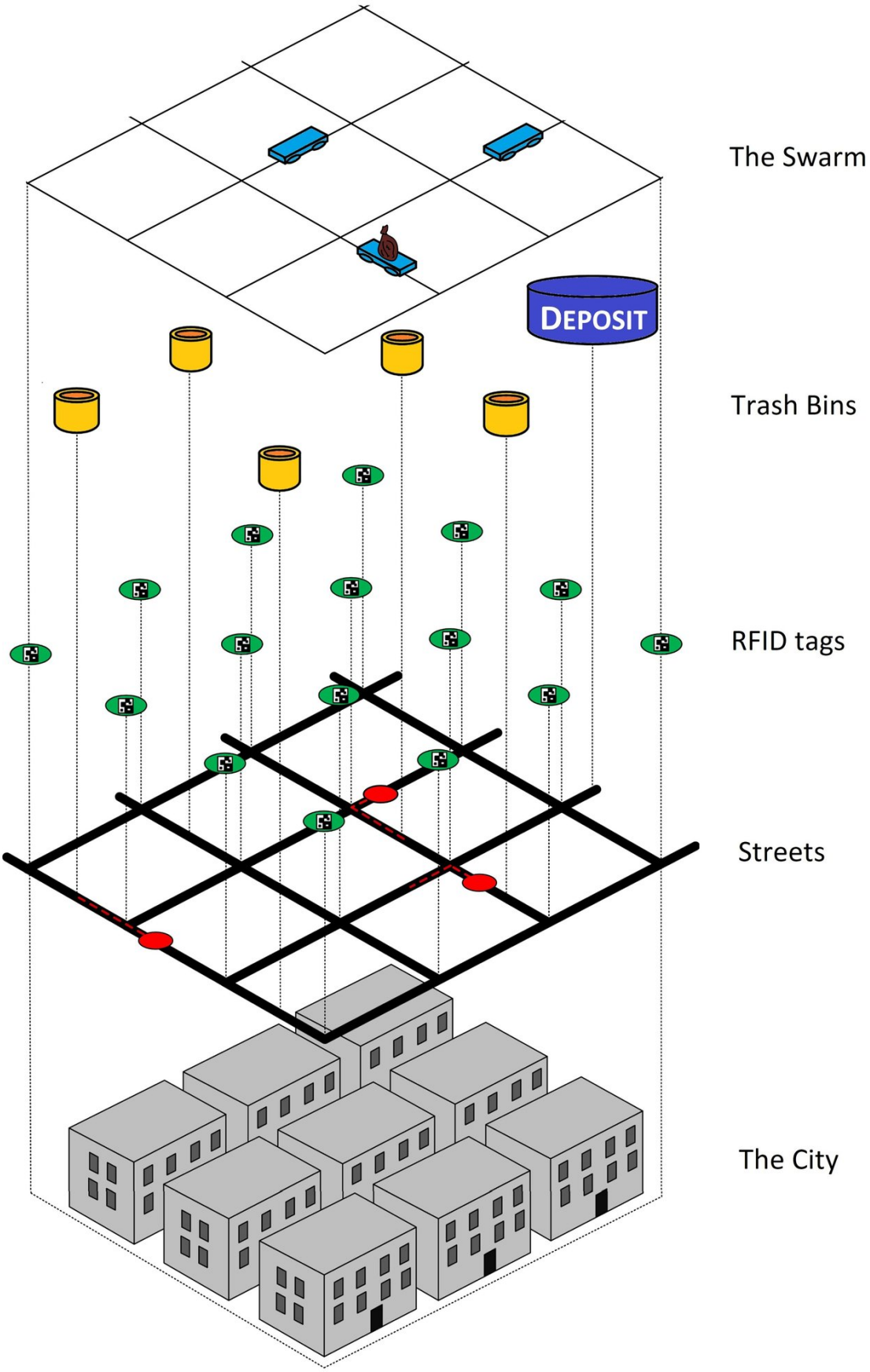
Researchers at MIT Media Lab, the University of Pisa, and Université Libre de Bruxelles have recently explored the feasibility of using swarm

robotic systems for autonomous waste management. Their approach, outlined in a paper pre-published on arXiv, applies bio-inspired foraging methods to swarm robotics, with the aim of improving the efficiency and autonomy of waste management in cities.

"With autonomous vehicles, swarms of drones for deliveries and teams of robots organizing warehouses, the city of the future will be a cybernetic ecosystem consisting of machines and humans," Antonio Luca Alfeo, one of the researchers who carried out the study told Tech Xplore. "This is a fascinating scenario, as well as a huge technological challenge. The management of such systems results in a complexity that grows exponentially as more machines are deployed, especially if we want them to actually 'live with us' and react autonomously to the changing needs of their surrounding environment."

Nature offers several examples of how similar coexistence problems can be brilliantly and effectively solved. In their study, the researchers tried to apply these nature-inspired solutions to the management of robot swarms.

"We propose a trash disposal system with swarms of robots whose self-organization is based on the behavior of social insects, also known as stigmergy-based foraging," Alfeo explained. "The proposed system deals with the disposal of trash, from trash bins to a few central deposits."


The Swarm
DEPOSIT
Trash Bins
RFID tags
Streets
The City

"Virtual pheromones" released by other robots on RFID tags in the urban environment. Credit: Alfeo et al.

The robots developed by Alfeo and his colleagues are not controlled and given directions by a remote service. Instead, all of their decisions are made in the spur of the moment, based on their perceptions and real-time observations.

"Among these perceptions, there are also 'virtual pheromones' released by other robots on RFID tags in the urban environment," Alfeo said. "These mark the most convenient path from one or more non-empty trash bins and the nearest deposit. Most importantly, thanks to its collective behavior, the swarm is able to autonomously self-organize in order to target the areas with the greatest amount of garbage, always providing an effective response."

The design of this innovative solution required a vast variety of skills and covered different areas of expertise. The team that developed it is hence highly interdisciplinary, with backgrounds in city science, bio-inspired robotics, and data science.

"Team members specialized in city science provided the model of the robot used in the study and dealt with the modeling of urban space in GAMA, a multi-agent simulation platform," Alfeo said. "Those skilled in the behavioral design of swarm of robots realized and tested the logic of the swarm in a properly augmented model of the urban environment. Finally, the analysis of the implications of each design choice was supervised by highly-proficient data scientists."

Alfeo and his colleagues evaluated their swarm system for waste management and found that it outperformed existing approaches. Their study also offered valuable insight into how to best design and customize swarm robotic systems.

"We showed that a swarm of self-organized robots could lead to great improvements in the context of waste management, without any external information source or prior knowledge about the trash disposal demand," Alfeo said. "Moreover, we provided insight on the design of such a system with the aim of balancing its two main properties, that is, the exploratory capability and the responsiveness of the swarm. The first can reduce the occurrence of full trash bins, while the latter helps to reduce the amount of trash in the urban environment."

The research carried out by Alfeo and his colleagues is a fascinating and useful example of how swarm robotics systems could be applied within urban environments. Their results are highly promising, opening new interesting possibilities that could be explored further in the future.

"The proposed approach is not specific to waste management and it could be tested in a number of different applications, such as autonomous vehicles," Alfeo said. "Since in this case safety is a critical factor, however, the design of such a system should include further specific solutions, such as block-chain technology."

More information: Urban Swarms: a new approach for autonomous waste management. arXiv: 1810.07910 [cs.RO]. arxiv.org/abs/1810.07910

Citation: Urban swarms for autonomous waste management (2018, October 31) retrieved 10