StiCo in Action

(Demonstration)

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ABSTRACT

StiCo is a **Sti**gmergic **Co**verage approach, which is previously designed for dispersion of robots in a communication-limited environment. In contrast to the existing coverage approaches, **StiCo** does not rely on direct communication between robots, and does not require any data storage or computational power for the robots. The main building block of **StiCo** is using environmental markers for transferring information between robots. Therefore, in this paper the practical requirements for implementation of **StiCo** in a real world experiment with a swarm of e-pucks are described and the coverage behavior of **StiCo** is validated by various experiments.

Categories and Subject Descriptors

I.2.9 [**Artificial Intelligence**]: Robotics—*Autonomous vehicles, Commercial robots and applications*

Keywords

Swarm Robotics, Multi-Robot Coverage, Stigmergy

1. INTRODUCTION

A robotic swarm is composed of large number of simple physical robots, for which an efficient collective behavior emerges from the interactions between the robots and interactions of robots with the environment. Since emergence of swarm robotics, many complex missions are accomplished successfully by taking advantage of simplicity and large population of robots in the swarm. For instance, multi-robot coverage of an environment can be used for various monitoring, rescue, and patrolling missions. In recent years many researchers have studied this problem. E.g. Cortes et al. [1], presented control and coordination algorithms for robotic swarms, in which robots were required to measure their distance with their neighbors, computing their Voronoi region, and driving toward the center of the Voronoi region. In contrast, our stigmergic approach called **StiCo** [4, 5] does not need any direct measurement of distances or complex communication and, moreover, the environment is not required to be modeled as a graph. This makes **StiCo** an appropriate coverage approach for unknown, complex, and communication-limited environments.

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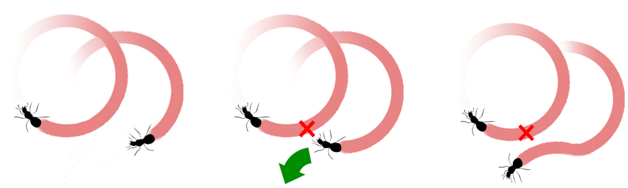
In our previous work, we suggested following motion policy for **StiCo**: *Each robot circles around with a fixed radius, and while moving, marks its path with evaporable markers, which denote the borders of robot territory. Simultaneously, if a robot detects a trail while circling around, it changes its circling direction immediately.* This behavior is illustrated in Fig. 1. For more details, we refer to [4] and [5].



(a) (b) (c)

Figure 1: StiCo coordination principle: (a) robots circle around. (b) the right robot detects pheromone. (c) the right robot changes circling direction.

In [4, 5], we used various computer simulations to show that **StiCo** coverage is very simple, but efficient, robust, and even extendable.

In the rest of this paper, the simplicity, scalability, and robustness of **StiCo** is verified by means of a real experimental setup in which a group of e-puck robots are used. The efficient behavior of StiCo is also illustrated in the video available at:
`http://swarmlab.unimaas.nl/stico/aamas-2013-demo`

2. PHYSICAL SETUP

Different insects and even some animals use chemicals, called pheromones, to communicate with each other via the environment. However, despite of a few reports of using chemicals in robotic experiments (e.g. [2]), due to difficulties in implementation and limited extendibility, this approach didn't provide sufficient applicability in swarm scenarios. Therefore, inspired by the technique proposed by Kronemann and Havner in [3], we take advantage of a glow-in-the-dark foil (i.e. a foil covered by phosphorescent material which absorbs UV light and re-emits the absorbed light at a lower intensity for up to several minutes after the original excitation).

As robots need to emit light to the glow-in-the-dark foil, each e-puck robot is equipped with a UV-LED pointing toward the floor. For detection of the glowing trails, in contrast to the simple method used in [3], in which photo-sensors were used to detect glowing trails, we take advantage of the e-puck on-board camera. By capturing an image and applying a green filter to it, we can extract the exact pattern of green trails in the image. Afterward, this pattern can be analyzed for making the appropriate decision. Due to simplicity of **StiCo**, we just scan one row of the image, and then compute the intensity of green color in left half part and the right half part, which will be used during the decision making process. Moreover, we use the simple IR sensors of e-puck for obstacle detection and avoiding robots from bumping into each other, or bumping into the walls.

Finally it should be mentioned that, as filtering the green color in the captured image is very sensitive to environmental light, all of the experiments are carried out in a darkroom. The experimental setup is shown in Fig. 2.

Figure 2: Darkroom with glow-in-the-dark floor. The e-puck robots circle around and emit UV light to the floor.

More technical details and the detailed algorithm which is implemented on real e-pucks, are provided in:
`http://swarmlab.unimaas.nl/stico/indoor-experiments`

3. EXPERIMENTAL RESULTS

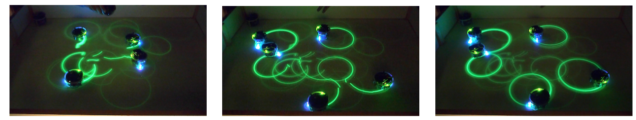
Different experiments are carried out by implementing **StiCo** on robotic teams of up to 5 robots. Implementation of **StiCo** on two, three, and five robots in a simple environment is shown in Figs. 3, 4, and 5, respectively. **StiCo** is also implemented on 5 robots in presence of an obstacle which is illustrated in Fig. 6. In all the figures initial, intermediate, and final configurations are shown.

(a) initial (b) intermediate (c) final

Figure 3: StiCo implemented on 2 robots

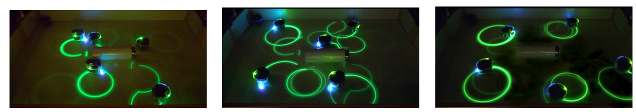
(a) initial (b) intermediate (c) final

Figure 4: StiCo implemented on 3 robots



(a) initial (b) intermediate (c) final

Figure 5: StiCo implemented on 5 robots



(a) initial (b) intermediate (c) final

Figure 6: StiCo implemented on 5 robots in presence of a cylindrical obstacle

4. CONCLUSIONS

StiCo was previously proposed as an efficient coverage approach for communication-limited environments. In this paper, firstly, we described how to design the required physical setup for implementation of **StiCo** in real world, and secondly, we illustrated the experimental results, which verified the efficient coverage behaviors of **StiCo**. This demonstration paper, shows that **StiCo** is fully applicable in real world scenarios.

5. REFERENCES

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