DisplaySwarm: A robot swarm displaying images "IROS 2011 open research demonstration"

Javier Alonso-Mora, Andreas Breitenmoser, Martin Rufli, Stefan Haag, Gilles Caprari, Roland Siegwart and Paul Beardsley

***Abstract*— DisplaySwarm is a swarm of mobile robots that represents images in a novel way and further proves concepts on reciprocal collision avoidance in cluttered environments and complex pattern formation. Each robot pixel is a small circle in shape, with controllable colored illumination using LEDs that glow under the translucent upper surface. The robots change position and color to represent both abstract patterns and representational images. Viewers react in an entirely different way than looking at a screen - our experience has been that people judge the robots to have personality, literally bringing emotion into the picture.**

***Index Terms*— Robot swarm, multi-robot, entertainment, pattern formation, collision avoidance, graphics, robotic art.**

I. Background

This project is the result of a fruitful collaboration between the Autonomous Systems Lab at the Institute of Robotics and Intelligent Systems of ETH Zurich and Disney Research Zurich. The ideas of the project originate from rethinking existing means of representation and interaction. DisplaySwarm is a novel robotic display, consisting of multiple robotic entities that are capable of displaying information in a dynamic and visually appealing way. The robotic display comprises a swarm of small mobile ground robots equipped with controllable RGB-color illumination, each of which represents a single pixel of the image. By coordination and rearrangement, the robots generate aesthetic effects that are out of reach of traditional 2D displays.

II. Description

A. The system

The portable robot swarm is formed of fifteen small differentially-driven mobile robots deployed on a circular flat ground. The area has surrounding space on three sides where visitors can view the performance. The rear area of the platform is occupied by a tripod with an overlooking camera. A mini projector and a small audio system may be used to enhance the performance.

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Fig. 1. Swarm of fourteen robots representing a triangle, a star and a humanoid.

The overhead camera tracks the robots and thus provides global localization. The algorithms (most of them distributed) run in a laptop and speed commands are sent to the robots via a radio unit connected to the laptop.

The demo will include the following:

- Distributed collision avoidance.
- Pattern formation and image display.
- Interaction where one or more robots are moved by hand.
- Robot and auto-charging stations on display.
- Small steel sheet to show vertical capabilities.

In Figure 1 a swarm of fourteen robots represents a triangle, a star and a humanoid.

B. The algorithms

The research challenges have been in the coordination of a large swarm of robots, in aesthetic pattern formation [2], and in reciprocal collision avoidance of differentially driven robots [1]. Furthermore, this demo demonstrates portability and robustness of the robotic display system. The current research direction is on displaying images with a large group of mobile robots [3].

C. The robots

Custom robots have been developed in collaboration with the Swiss robotics company GCtronics [6], with specific features required for this application: small, cheap, nice, one RGB LED, rapid radio for real time control (100 robots at 10Hz), vertical mobility and automatic charging. Figure 2 shows two robots and a charging station. One of the robots is open and the different parts are visible.

The robot has two magnetic wheels driven by two cheap geared motors and is thus able to drive both on any flat surface or a ferromagnetic vertical wall. The onboard microcontroller runs a fast controller measuring the wheel speed using back-EMF of the motor. The desired speed commandos are received constantly from the host computer through a 2.4 GHz radio with a specific protocol that ensures 10Hz for up

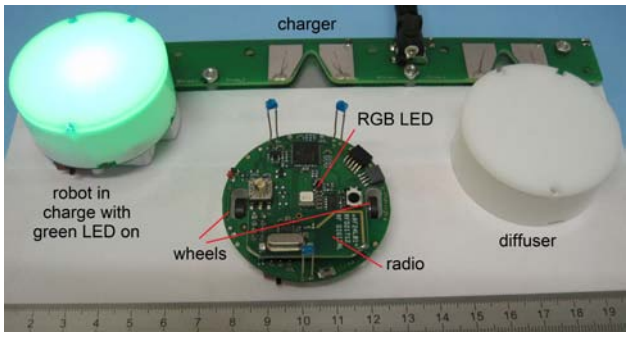

Fig. 2. Image showing two robots and a charging station. One of the robots is open and the different parts are visible.

to 100 robots. The robot has a circular shape with a light diffuser on top for the RGB LED plus three infrared LEDs. On the bottom it has two electrical contacts matching the charger station shape.

Here a list of the main features: 5 cm diameter; 2.7 cm height; 34 g; max. speed 10cm/s vertical and 50cm horizontal. Power consumption varies from 15 mW (waiting) to 1 W (all motor and LEDs on) giving a typical autonomy of 2 to 4 hours depending on the dynamics of the experiment.

D. Future applications

This unique robotic display is now opening up a new set of research directions in the unexplored intersection between robotics and graphics. Furthermore, we are building a large scale swarm of 75 robots to test multi-robot algorithms.

III. Novelty and entertainment

The Display Swarm offers both enjoyment and novelty. It is different to anything that people have seen, and people respond on two different levels - not just to the aesthetic experience of the images that are being created, but to the robots themselves. Our experience has been that people feel fascination with the robots, even asking about the behavior of individual robots, in addition to enjoying the moving and illuminated display. Even with increasing familiarity, a robotic display will remain fundamentally different to other types of display because it offers a new type of psychological engagement.

The consequence of the technology lies in the way mobile robots are becoming part of society and everyday life. The exhibit is capable of surprising people in the way they relate to the robots. When robots move and seem to act intelligently, humans immediately pay attention and start to attribute personality. Even our modest robots can indicate the amazing step that is likely to happen as we move into an age of smart objects and autonomous mobile robots woven into everyday life.

IV. Additional material

Two videos of the former version of DisplaySwarm are found on the Internet. These videos show the current capabilities of the system. First, collision avoidance of multiple differentially driven robots in [4] and second, artistic pattern formation in [5]. An image of the robot currently used in the new system is found in [6].

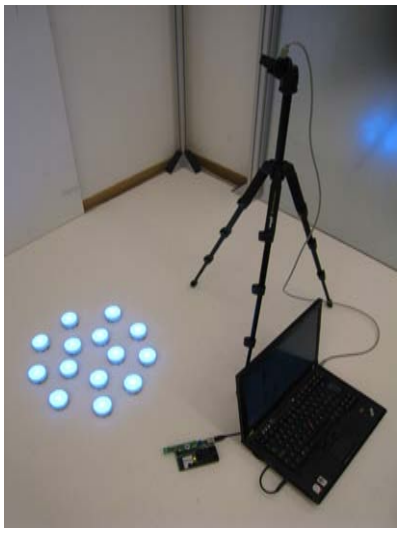

Fig. 3. Image showing the overall of the display swarm demonstration setup. Fourteen robots forming a circle, the overhead camera mounted on a tripod and the laptop with radio transmitter.

With this new system, we will take part in Scientifica, a local science exhibition in Zurich. More information is to be found in [7].

V. Equipment, maintenance and requirements

We will bring one presentation laptop, one laptop to control the swarm of robots, one camera and tripod (1.2m high), fifteen robots and 6 charging stations. Additionally a mini-projector and speakers might be added to support the demo. The area needed for the robots to operate is a flat ground circle of approximately 1-1.5m of diameter, this can also be a slightly elevated platform such as a low table. Figure 3 shows the full system. We would prefer an indoor location with constant illumination. The tracking uses infrared LEDS, so the installation cannot function outdoors or in bright sunlight. One to two people are expected to support the demo.

References

[1] J. Alonso-Mora, A. Breitenmoser, M. Rufli, P. Beardsley and R. Siegwart, "Optimal Reciprocal Collision Avoidance for Multiple Non-Holonomic Robots", *in Proc. of the 10th Int. Symp. on Distributed Autonomous Robotic Systems (DARS)*, 2010.

[2] J. Alonso-Mora, A. Breitenmoser, M. Rufli, R. Siegwart and P. Beardsley, "Multi-Robot System for Artistic Pattern Formation", *in Proc. of the IEEE Int. Conf. on Robotics and Automation (ICRA)*, 2011.

[3] J. Alonso-Mora, A. Breitenmoser, M. Rufli, R. Siegwart and P. Beardsley, "DisplaySwarm: Image display with multiple mobile robots", *in the Int. Journal of Robotics Research*, submitted.

[4] Optimal Reciprocal Collision Avoidance for Multiple Non-Holonomic Robots NH-ORCA, DARS2010: http://www.youtube.com/watch?v=s9lvMvFcuCE

[5] Artistic pattern formation with multiple robots, ICRA2011: http://www.youtube.com/watch?v=pJVS-9sMiVY

[6] GCtronic: http://www.gctronic.com/

[7] Scientifica: http://www.scientifica.ch/