Our Research Mission

To develop methodologies for modeling and controlling distributed, self-organized systems
To develop methodologies for automatic design and optimization of distributed, self-org. systems
To propose original swarm-intelligent algorithms based on recent findings about animal societies
To implement realistic simulation tools for distributed, real-time, embedded platforms
To validate methodologies and simulation tools on different multi-unit platforms (e.g., swarms of robots, networks of sensors and actuators, mixed natural-artificial societies, intelligent vehicles)
To contribute to the education of a new generation of interdisciplinary system engineers

Current Research Efforts

Sound localization using a multi-robot system

We use several small-scale robots to localize the source of a sound emission. If a robot is near the sound source, it can detect the direction of the emission using the correlation of the arrival times of two on-board microphones. If a robot detects a strong emission, it can call nearby robots using an infrared relative positioning system. These two tools allow a swarm of robots to maintain close proximity to the sound source despite having very noisy sensory capabilities. We plan to explore connections between search with real robots and Particle Swarm Optimization, a learning algorithm which uses virtual multi-agent search.

Primary contributors: J. Pugh, S. Bronee; related references: J. Pugh, Y. Zhang, and A. Martinoli, IEEE SIS-05

Swarm-robotic inspection of regular structures

We are examining simple behavior-based distributed control algorithms for the inspection of a regular structure using a swarm of autonomous miniature robots, equipped with only on-board local sensors. We capture the system characteristics at a higher abstraction level using probabilistic microscopic and macroscopic models. Both models achieve consistent prediction on the chosen swarm metric and deliver interesting qualitative and quantitative insights on further counterintuitive improvements to the distributed control algorithm.

Primary contributors: N. Correll, A. Prorok; references: N. Correll and A. Martinoli, ISER-04, DARS-04, ICRA-05

For more information, check http://swis.epfl.ch, or contact Alcherio.Martinoli@epfl.ch
Intelligent transportation systems

The possibility to equip cars with intelligent sensory systems could lead to greater safety and efficiency in traffic scenarios. Both realistic traffic simulation and abstract models are used in order to study the implications of distributed control algorithms and self-organization on the traffic system.

Primary contributors: O. Michel, J. Nembrini, C. Schwarzer, Y. Zhang (EDRL, Caltech); references: Zhang et al., IV-03

Mixed animal-artificial societies

Our goal is to understand the link between individual and collective behavior in animal societies, and how to exploit such mechanisms to influence the society by introducing artificial lures. Since physical experiments are time consuming, we have reproduced the physical setup in the realistic simulator Webots, to systematically investigate the resulting collective behavior.

Primary contributors: N. Correll, A. Tran Qui

Threshold-based algorithms for power aware load balancing in sensor networks

Under the highly restrictive constraints on energetic expenditure in a sensor network, an efficient power management scheme is necessary, especially in networks which may be deployed for event detection in rapidly changing environments. In order to address this problem in an intelligent and dynamic way, the network must be able to get feedback on the impact of its actions on its available resources. Using adaptive threshold-based control mechanisms, we are developing an in-network task allocation system which takes into account the remaining energetic resources of each node.

Primary contributors: C. Cianci, V. Trifa; references: C. Cianci, V. Trifa, and A. Martinoli, IEEE SIS-05

Mascarillons: self-assembling flying cubes

In bringing artists and scientists together, the project investigates the 3D self-assembly of flying cubical blimps for the purpose of architectural research and multi-media performance. Realistic simulations and abstract models are tools to explore the highly constrained design space.


Trajectory analysis of multi-robot systems

The goal of this project is to extract behavioral information from trajectories, automatically developing abstract control models from measured data. To this end, we introduce an extension of the Point Distribution Model (PDM) to analyse and classify trajectories in their spatial, temporal, or spatiotemporal dimensions.

Primary contributors: P. Roduit, Y. Lopez de Meneses (LPM)

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