Sensory-Motor Control Architecture for Online Locomotion Learning for Robots with Different Morphologies

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Initial Idea and Objectives

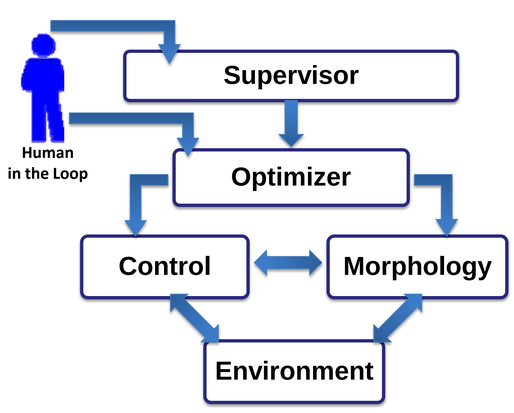
Project Description:

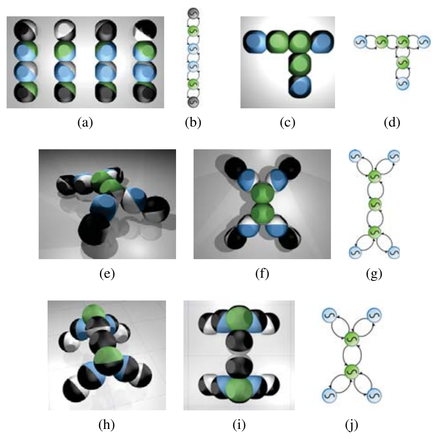
- Locomorph project funded by FET Embodied Intelligence.
- Applying the concept of morphology and morphosis.
- Efficient and robust robotic locomotion with studying Self-stabilization, Energy Efficiency, Maneuverability, and Adaptivity.

Objectives:

- Adaptive sensory-motor control and learning strategies.
- Dealing with voluntary and involuntary morphosis.
- Understanding the interaction between morphology and control.

Overall Architecture



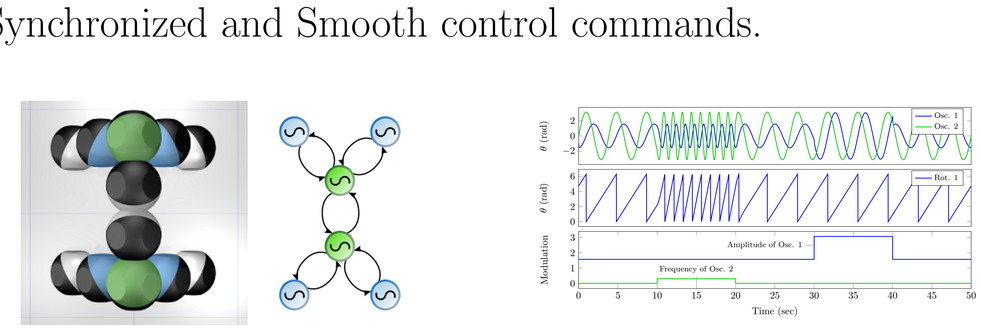


Robot Morphology

- Key point: easy-change of robots morphology (online and offline).
- Modular robotics platform for morphology exploration.
- Roombots: 3 DOF and diverse movements.

Locomotion Control:

- CPG-based Control (inspired from Central Pattern Generators).
- Extended to both *Oscillatory* and *Rotational* output patterns.
- Synchronized and Smooth control commands.

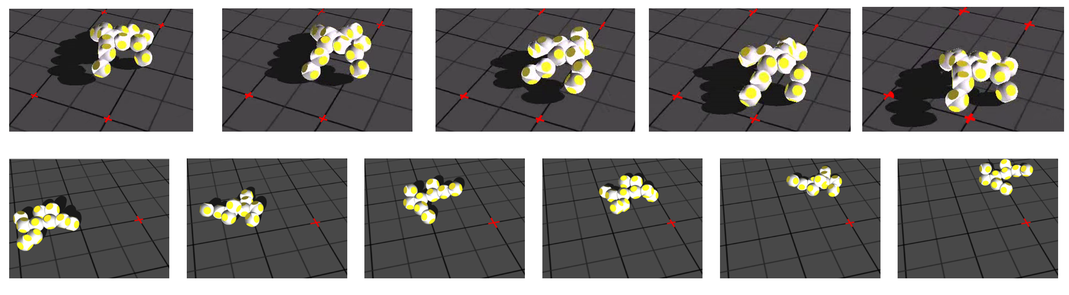


Robot morphology and its corresponding CPG (left). Rhythmic patterns for three coupled DOFs (right).

Gait Optimization:

- Stochastic optimization and Evolutionary Algorithms methods.
- Optimizing both the structure and parameters of CPG.
- Evolving both the Morphological and Control parameters.

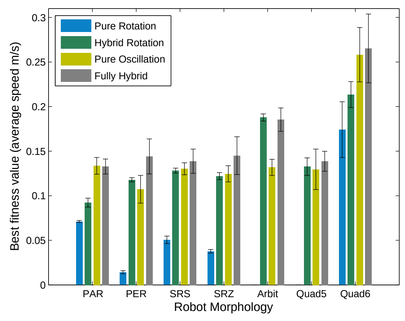
Generic Locomotion Control Framework

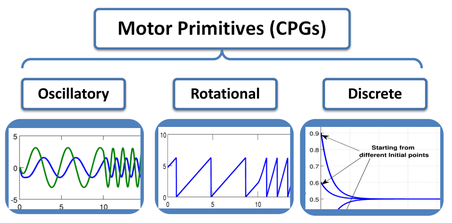


Snapshots of evolved gaits for two quadruped robots built by Roombots modules.

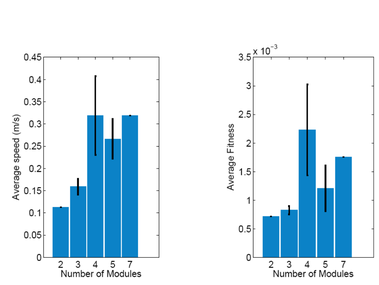
Experiments and Results:

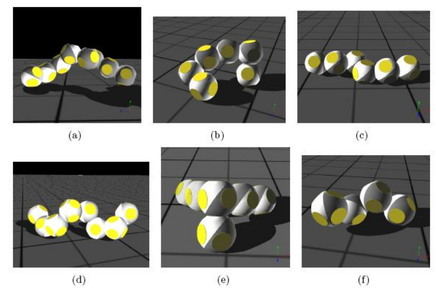
- Different morphologies including four different meta-modules, one asymmetric robot with three modules and two quadruped shapes.
- Optimizing four different control structures (Oscillatory or Rotational) for each robot.
- Out-performance of the *Hybrid* control structure.





Co-evolution of Morphology and Control





Experimental and Results:

- Control open parameters: amplitude, offset and phase lags.
- Morphological open parameters: No. of modules, inter-connections, connection types and No. of DOFs.
- Fitting speed, energy efficiency and smoothness of the gait.
- Robots with four modules have better and more diverse solutions.
- Several interesting solutions for the shape and also locomotion patterns are generated which would be are hard to hand-design.

Acknowledgments

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References

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[2] A. Sproewitz, R. Moeckel, J. Maye, and A. J. Ijspeert. Learning to move in modular robots using central pattern generators and online optimization. *The International Journal of Robotics Research*, 27(3-4):423–443, March 2008.

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