Reconfigurable Indeterminate Robotic Architectures for Indeterminate Environments via Geometry Based Evolution and Collaboration

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I. Problem Statement

In indeterminate, unstructured environments; while a specific task cannot be realized by existing robotic structure(s), it can still be achievable in a collaborative multi-robot settings where the singular units/robots have ability to compose a joint, mutual structure or by evolving the existing structure(s). From this perspective, in the scope of the project, reconfiguration and collaboration capabilities of modular robotic systems for possible operation scenarios in indeterminate, cluttered environments are searched through the concept of evolutionary snake-like robotics. Therefore, in the scope of the project, the answer for the question *'what if also architecture of the robots would have capacity to adapt (or evolve) based on environmental conditions and aimed purpose?'* will be searched from the geometric perspective.

II. Description of the Project

In the referenced articles [1][2][3][4], reconfigurable modular robotic units with various capabilities are presented while they can form different electro-mechanical architectures to realize a specific functionality whereas it cannot be achieved with single units or existing architecture without re-composition. To solidify the concept, in PolyBot example [2], different types of robotic locomotion are realized based on the composed kinematic structure via modular, reconfigurable (almost identical) components. And as another implementation, in Roombots example [3], self-reconfiguration ability is employed for generation of adaptive furnitures.

Therefore, it can be stated that higher-level relatively complex operations or locomotion/manipulation characteristics can be realized via improved architecture. In this way, the multi-robot collaborative settings can be handled also for the relatively more complex tasks which cannot be realized by individual systems.

Additionally, while computational geometry techniques especially Voronoi diagrams are used for mainly path planning in the referenced articles [5] [6], the corresponding techniques will be implemented for the evolution of the robotic architecture's itself in this case. In other words, the corresponding techniques will be employed not for path planning but planning of the robotic architecture.

III. Methodology

In the scope of the stated problem, the following subjects will be taken into account as preliminary ideas where they will be elaborated and purified in the following phases;

1) A greater organism which has superior capabilities in terms of manipulation and/or locomotion is composed through the integration of heterogeneous, non-identical components which will directly require attaching meaning for sequential ordering and functionality in the geometry.
2) Evolutionary shape optimization for reconfigurable modular robots in 3D environments is realized by using convex hulls and/or Voronoi diagrams to analyze and optimize evolved architecture for the corresponding task.
3) Geometry-based evolutionary strategies for multi-robot cooperation by using computational geometry techniques like Delaunay triangulation and Voronoi partitioning are employed to optimize how multiple snake robots coordinate in an environment.
4) Computational geometry techniques are employed for the evolution of the robotic structures in dynamic environments where classical evolutionary approaches generally remain incapable, inadequate.

In this context, MATLAB will be used as the programming and simulation environment to design the structured and unstructured environments with robotic units and correspondingly architectures.

References

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