Hybrid Evolutionary Framework for Designing and Implementing Autonomous Modular Robotics

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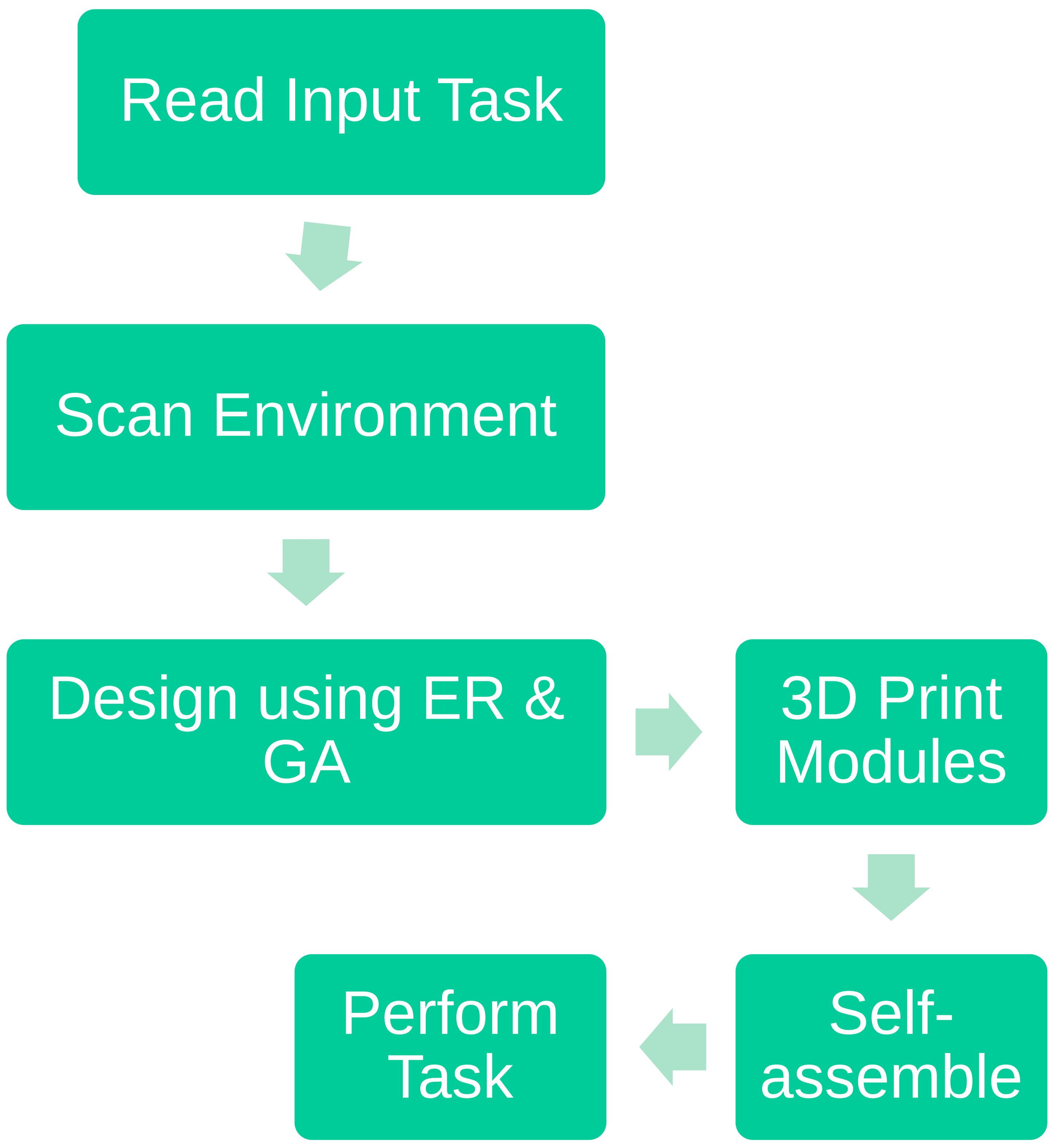
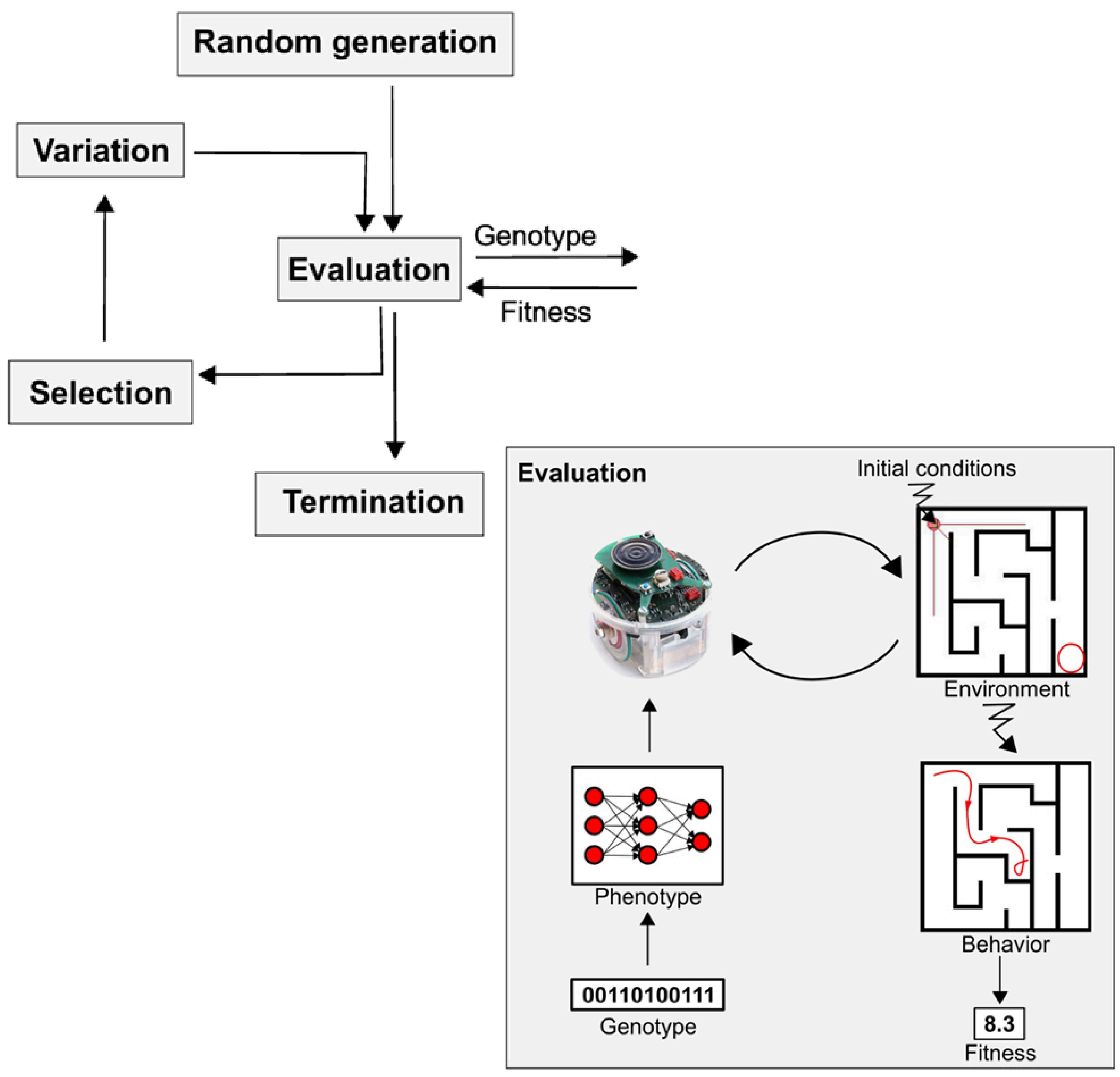
Abstract

This paper proposes a novel framework for automatically designing feasible robots that are made up of various heterogeneous modules and raw materials already existing in the surrounding environment. Moreover, it highlights the interrelationship between the robot's morphology, control, and environment by analyzing the coevolution of morphology and control in robots and allowing the initial set of robots to use the available units in the environment to self-assemble, self-reconfigure, and self-repair. In addition, digital fabrication technologies such as 3D printing are utilized to produce new units if needed and available.

Architecture



Evolution



Task I - Walking

$$fitness = \begin{cases} dist, if\ dist < dist_{th} \\ dist + \frac{f_{max}}{N}.(N-n), if\ dist > dist_{th} \end{cases}$$

The distance travelled by the robot is $dist$.
$dist_{th}$ is a distance threshold value.
f_{max} is a fitness reward of a robot with 0 modules.
N is the maximum number of modules.
n is the current number of modules.

Task II - Painting

The painted portion of the surface, paint, and the fitness are:

$$paint = \sum_{i=0}^{R} \sum_{j=0}^{S} f_{ij}$$

$$fitness = \begin{cases} paint, if\ paint < paint_{th} \\ paint + \frac{f_{max}}{N}.(N-n), if\ paint > paint_{th} \end{cases}$$

Conclusion

This paper presented the basic results obtained using our proposed hybrid evolutionary framework that is capable of automatically designing complete feasible robots that can be manufactured. The initial set of robots can self-assemble, self-reconfigure, self-repair, or make another robot to adapt to the environmental changes and undertake the target task efficiently.

References

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