

Recent work on Construction and Excavation by Double-Tailed SAW Robots

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This poster will summarize important findings and recent extensions to a publication on double tailed Single-Actuator Wave (SAW) robots for construction and excavation [1]. In that publication, we described a minimalistic robot mechanism that was capable of many construction behaviors in dry granular material including locomotion, climbing, leveling, subtraction, addition, transport, and burrowing. The design extended upon a SAW mechanism [2] with the insight that two tails can be used both for locomotion in and manipulation of granules. For simplicity, experiments were limited to 2 manually controlled or 2 open loop robots operating in a quasi-2D vertical arena filled with packing peanuts. We demonstrated and characterized construction by single- and multi-robot systems, with special attention to how mechanism improvement, autonomy, and 3D operation could be achieved. Remarkably, we found that the majority of behaviors were robust -- that is, the double-tailed SAW robots could achieve the intended functionality through open loop control, largely eliminating the need for sophisticated perception. The experiments indicate an unprecedented, simple robotic solution to many of the classic construction challenges.

Since this publication, we have revamped the onboard electronics towards autonomous operation and demonstrated closed-loop motion control based on encoders, wireless IR communication, localization against a color gradient, and closed-loop response to surface inclines. The next step will be to demonstrate robust, autonomous execution of individual (and eventual composition of) construction behaviors.

References:

[1] L. R. Huang, A. Zhu, K. Wang, D. I. Goldman, A. Ruina, and K. Petersen. "Construction and Excavation by Collaborative Double-Tailed SAW Robots," in *IEEE Robotics and Automation Letters*, vol. 7, no. 2, pp. 3742-3748, April 2022, doi: 10.1109/LRA.2022.3146562.

[2] D. Zarrouk, M. Mann, N. Degani, T. Yehuda, N. Jarbi, and A. Hess, "Single actuator wave-like robot (saw): design, modeling, and experiments," *Bioinspiration & biomimetics*, vol. 11, no. 4, p. 046004, 2016.

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