Adaptive Evolutionary Rocket Operator (AERO)

Lee, Bo-Hyun (School: Korea International School, Jeju Campus)
Shin, Dongyun (School: Korea International School, Jeju Campus)
Cho, Ethan (School: Korea International School, Jeju Campus)

In the private-led “New Space” era, orbital launch attempts have surged by 186% over the past decade, yet the ability to independently reach orbit remains severely restricted to wealthy nations and elite corporations. A critical barrier is the guidance, navigation, and control (GNC) subsystem: space-qualified flight computers cost upwards of $200,000 per unit, pushing full GNC costs to $2-5M per mission and effectively locking out universities, startups, and developing nations. We developed AERO (Adaptive Evolutionary Rocket Operator), a novel neuroevolutionary control framework that unifies bit-shift weight encoding, hardware-aware topology search, and integer-only inference into a single pipeline to deploy closed-loop rocket attitude control on an 8-bit microcontroller. AERO eliminates post-quantization loss and executes directly on a resource-constrained device with just 2 KB of SRAM and no floating-point unit. Evaluated against a gain-scheduled PID controller across 500 Monte Carlo randomized scenarios in a purpose-built 6-DOF Hardware-in-the-Loop simulation, AERO reduces mean overshoot by 67%, cuts settling time by 47%, and consistently achieves stabilization within 4.24 seconds. Successful execution of AERO on a $5 8-bit microcontroller establishes its applicability to the chip’s $866 radiation-tolerant counterpart, enabling a shift away from an $18,471 32-bit processor and cutting costs by approximately 95%. 8-bit architectures promise substantial further savings in radiation hardening across flight computers and GNC subsystem. Thus, AERO’s core innovation is delivering competitive control directly on an 8-bit hardware, opening a low-cost entry point to rocket control for resource-limited teams worldwide.

Awards Won: