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Steering motion control of a snake robot via a biomimetic approach

Key words: Snake robot; Central pattern generator; Cerebellar model articulation controller

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Motivation

1. By bending their elongated and slender bodies in several special ways, snakes generate thrust from the interaction between the movements of their bodies and the environment, which is considerably superior to the mobility of conventional wheeled and tracked vehicles.

2. Recent motion control approaches are hard to help snake robots achieve a desired motion.

3. Inspired by the vertebrate biological motor system paradigm, a hierarchical control scheme, which includes an effector controller, a locomotion generator, and a higher-level body motion controller, may control the biomimetic snake robots.

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Main idea

1. To mimic the movements of biological snakes, snake robots are usually designed in multi-link form.

2. In the locomotion generation part, an artificial CPG is implemented to generate serpentine locomotion for the snake robot with joint propulsion.

3. The body motion controller consists of a cerebellar model articulation controller (CMAC) and a proportional derivative (PD) controller.

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Method

1. The proposed artificial CPG acts as a coupled oscillator with several tunable parameters and these parameters are regulated by the higher-level body motion controller.

2. CMAC is proposed to compensate for the uncertainties and enhance the adaptability of the robot.

3. PD controller is employed to enhance the convergence speed of CMAC and guarantee the stability of the system at the early stage.

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Major results

1. A simulation is conducted to validate the effectiveness and feasibility of the proposed control scheme with environmental uncertainties.

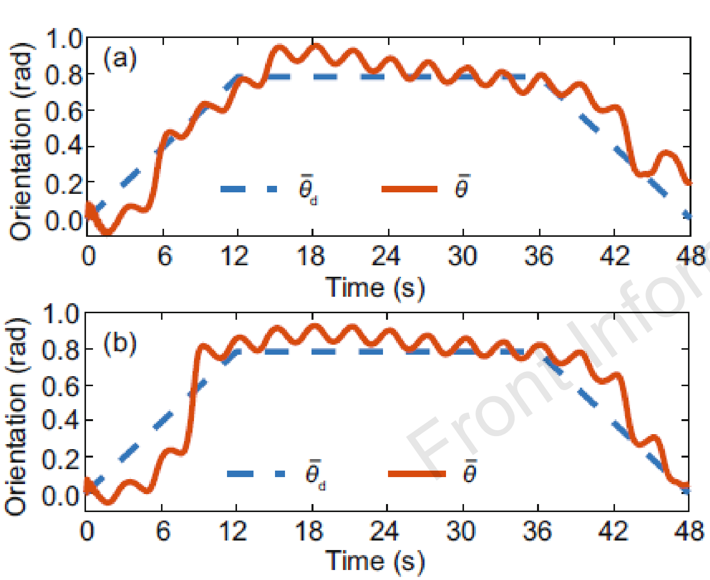

Fig. 11 Orientation outputs using the proposed controller while $c_t = 1$, $c_n = 3$ (a) or $c_t = 2$, $c_n = 6$ (b)

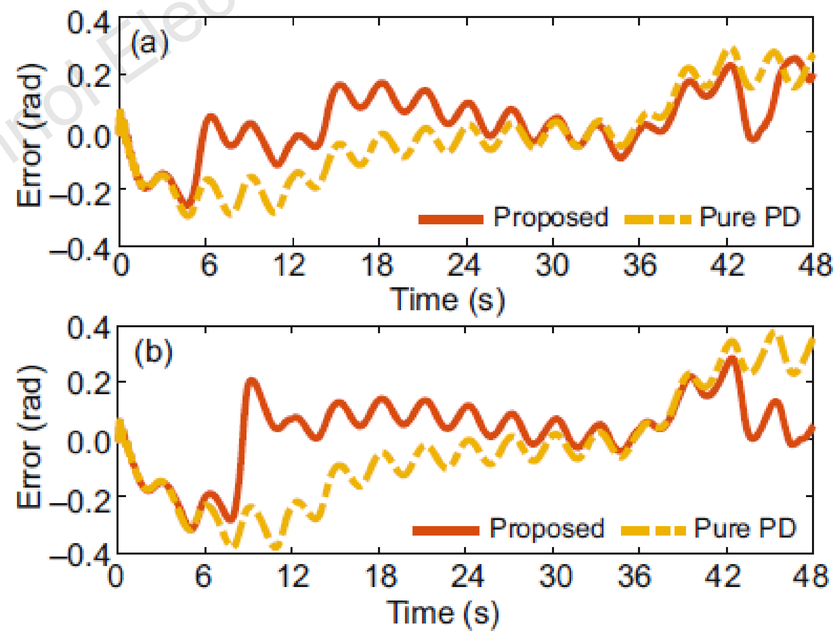

Fig. 12 Errors of the two different controllers when $c_t = 1$, $c_n = 3$ (a) or $c_t = 2$, $c_n = 6$ (b)

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Major results

2. An experiment using the snake robot prototype is conducted to validate the effectiveness and feasibility of the proposed adaptive learning control scheme.

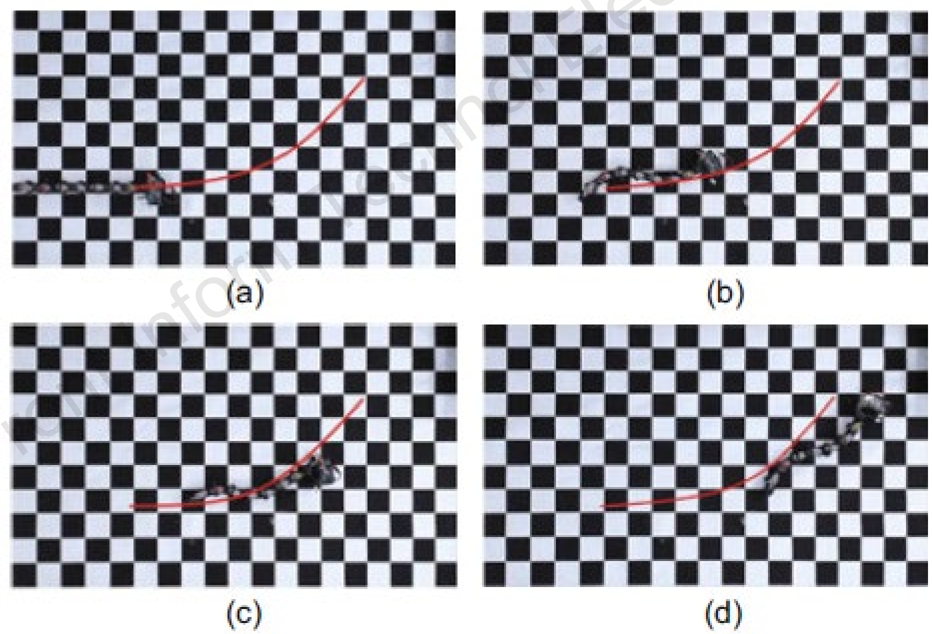

Fig. 13 A trajectory tracking experiment of the snake robot. (a) to (d) indicate the sequential photos during the steering motion control

Conclusions

1. An artificial central pattern generator (CPG) has been employed to generate serpentine locomotion in a snake robot.

2. The proposed motion controller, which consists of a cerebellar model articulation controller (CMAC) and a proportional-derivative (PD) controller, can drive the robot to track the desired orientation and adapt to unexpected perturbations.

3. Both numerical studies and experiments have proved that the proposed approach can help the snake robot achieve good tracking performance and adaptability in a varying environment.

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