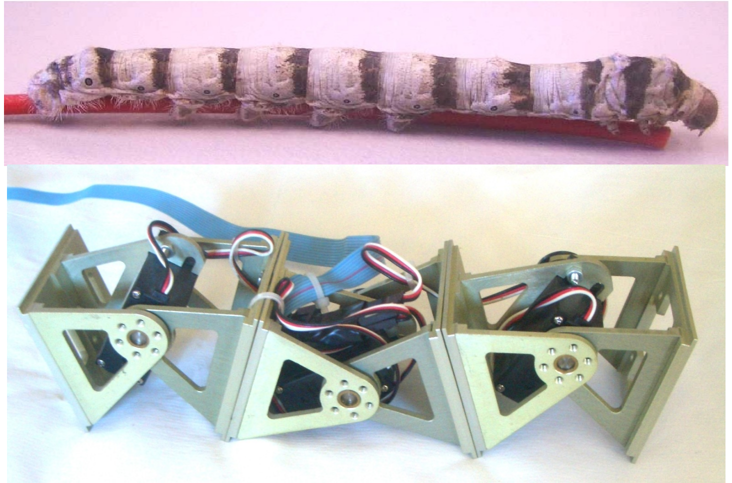
A New Application of Modular Robots on Analysis of Caterpillar-like Locomotion



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Ph.D. Juan González-Gómez. IEEE International Conference on Mechatronics. Málaga. April-17th-2009

Outline

1. **Introduction**
2. Kinematics
3. Locomotion
4. Experiments
5. Conclusions and future work

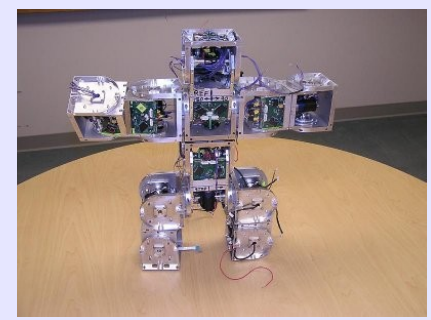
Modular robots overview (I)

- Composed of equal modules
- Modules as building bricks
- Self-reconfigurable
- Shape adapted to the terrain

Polybot
Yim et al. PARC

Modsnake
Wright et al.

M-TRAN
Murata et al. AIST



SuperBot
Shen et al. ISI

Modular robots overview (II)

- Very few groups in Europe working on modular robotics

Applications of modular robots:

- Space exploration
- Urban search and rescue
- Educational purposes
- Bioinspire research

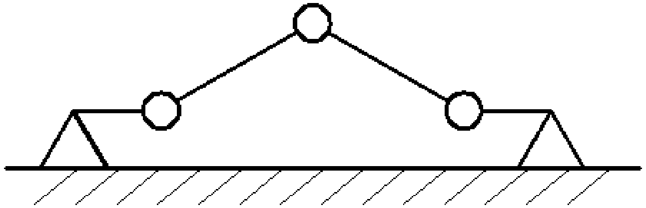
Yamor
Moeckel et al. EPFL

Cube Revolutions, Hypercube
Gonzalez-Gomez et al. UAM

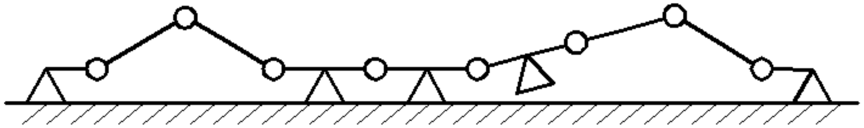
Cube-M
Zhang et al. TAMS

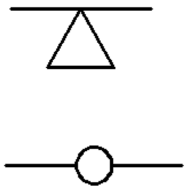
Locomotion of caterpillars

Inchworm



Manduca sexta larvae





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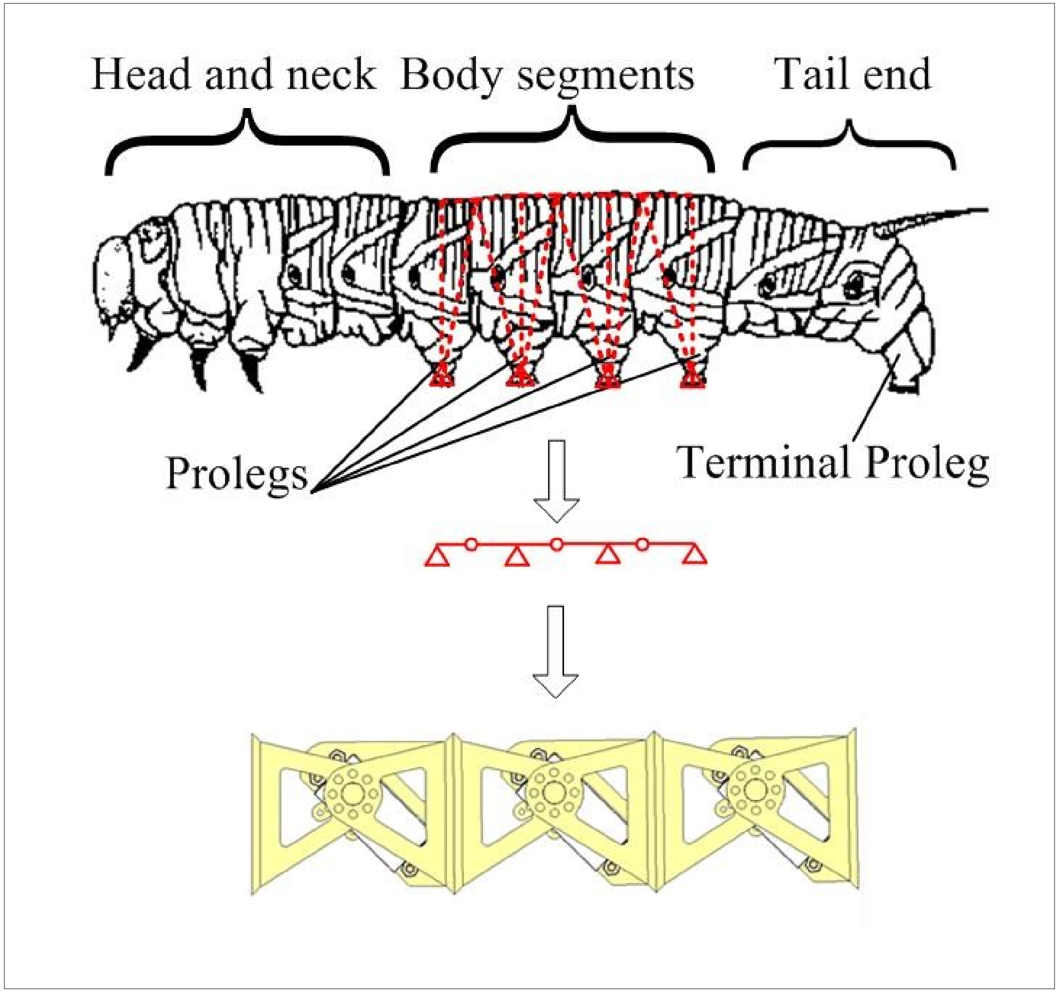
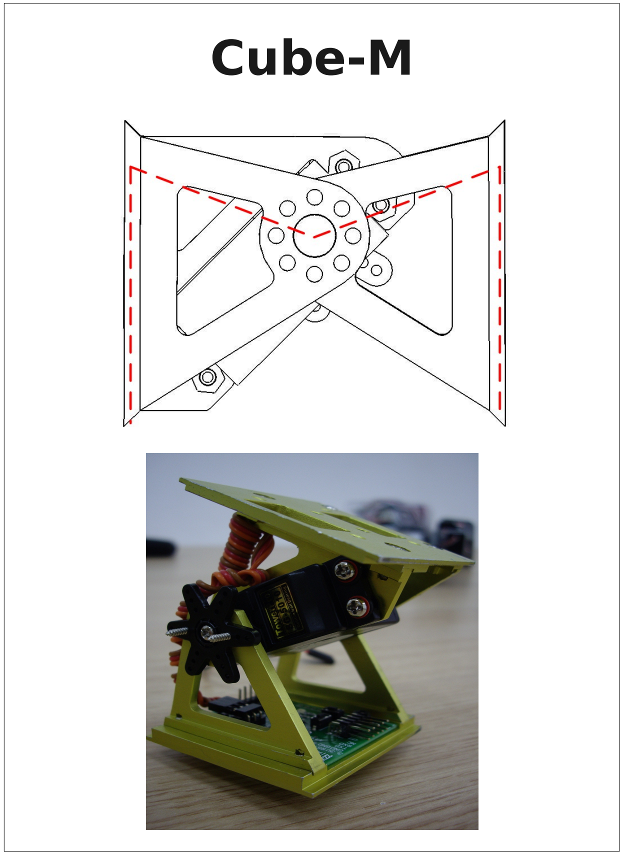
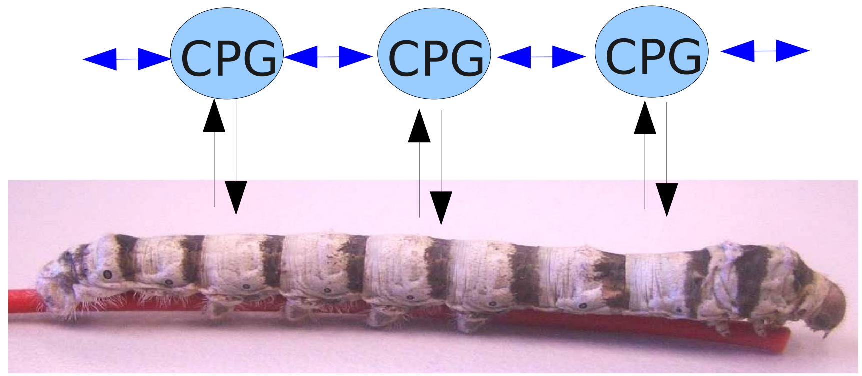


- Body modeled as a chain of three Cube-M modules:



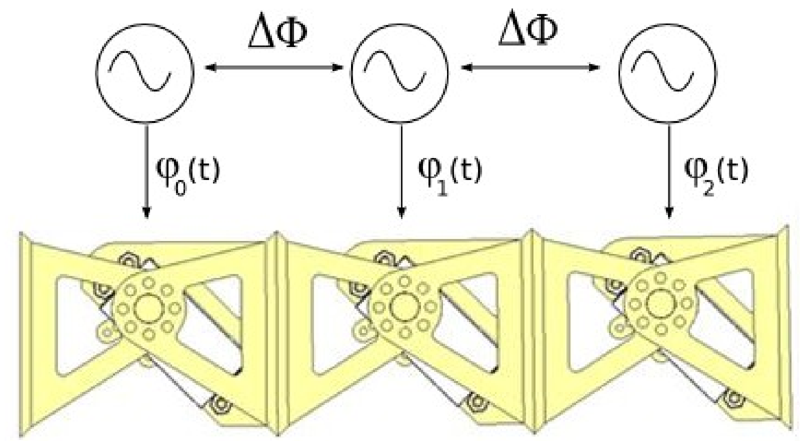
Locomotion algorithm (I)

In Nature



- Central pattern generators (CPGs)
- Each CPG controls a group of muscles

Our model



- Sinusoidal generators
- One generator for each module
- The bending angle is controlled

$$\varphi_i(t) = A \sin\left(\frac{2\pi}{T} t + i \Delta\Phi\right)$$

Locomotion algorithm (II)

- The same amplitude A for all the modules
- The same phase difference
- The same period T

$$\varphi_i(t) = A \sin\left(\frac{2\pi}{T} t + i\,\Delta\Phi\right)$$

- Control space of two variables: $A, \Delta\Phi$
- Exploration of **the best working point** for locomotion
- Step, Power and Ratio as a function of $A, \Delta\Phi$

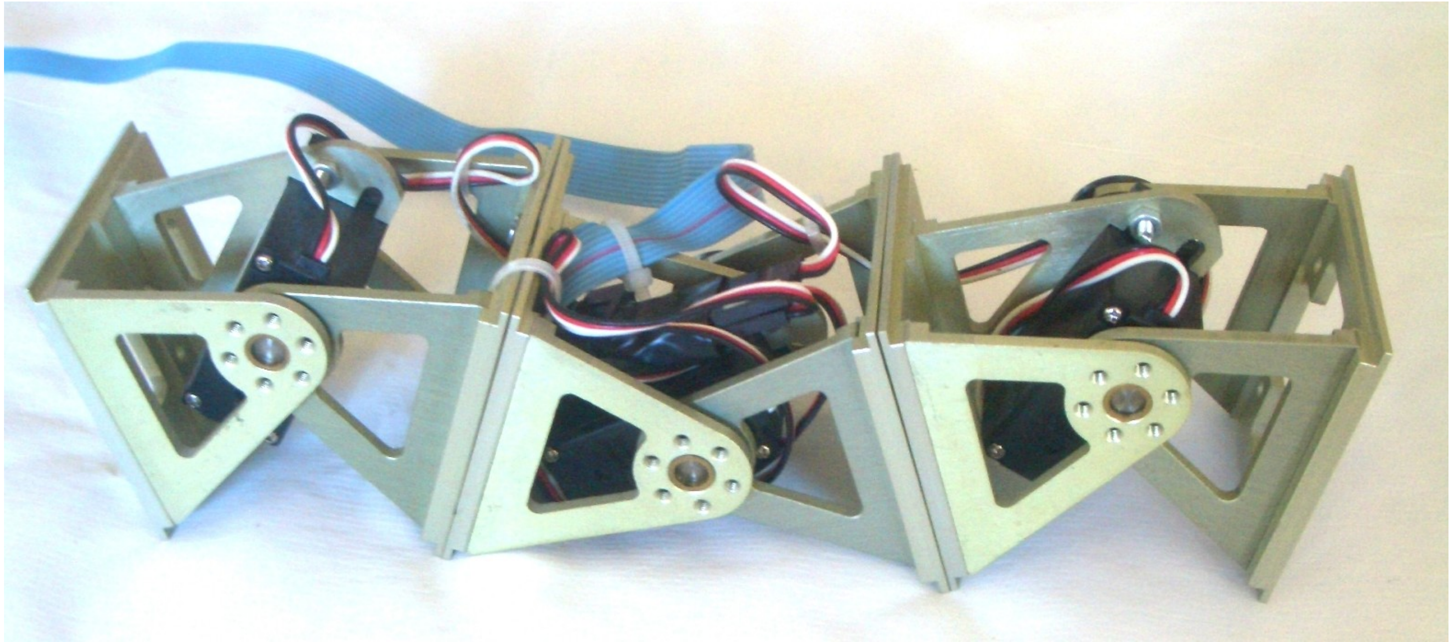
Step $\Delta x = s(A, \Delta\Phi)$

Power $P = P(A, \Delta\Phi)$

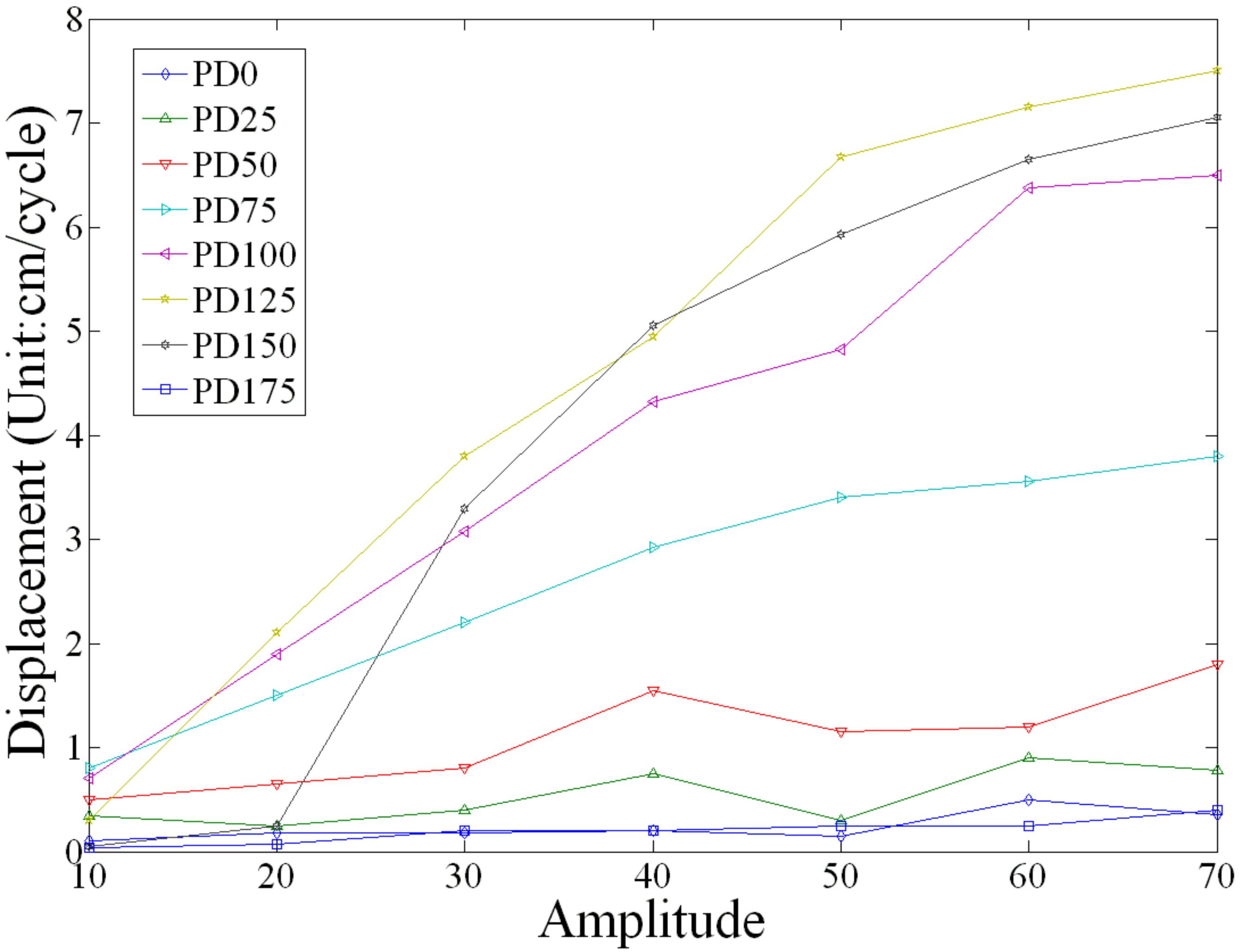
Ratio $\eta = \frac{P}{\Delta x} = \eta(A, \Delta\Phi)$

The Cube-M modular robot

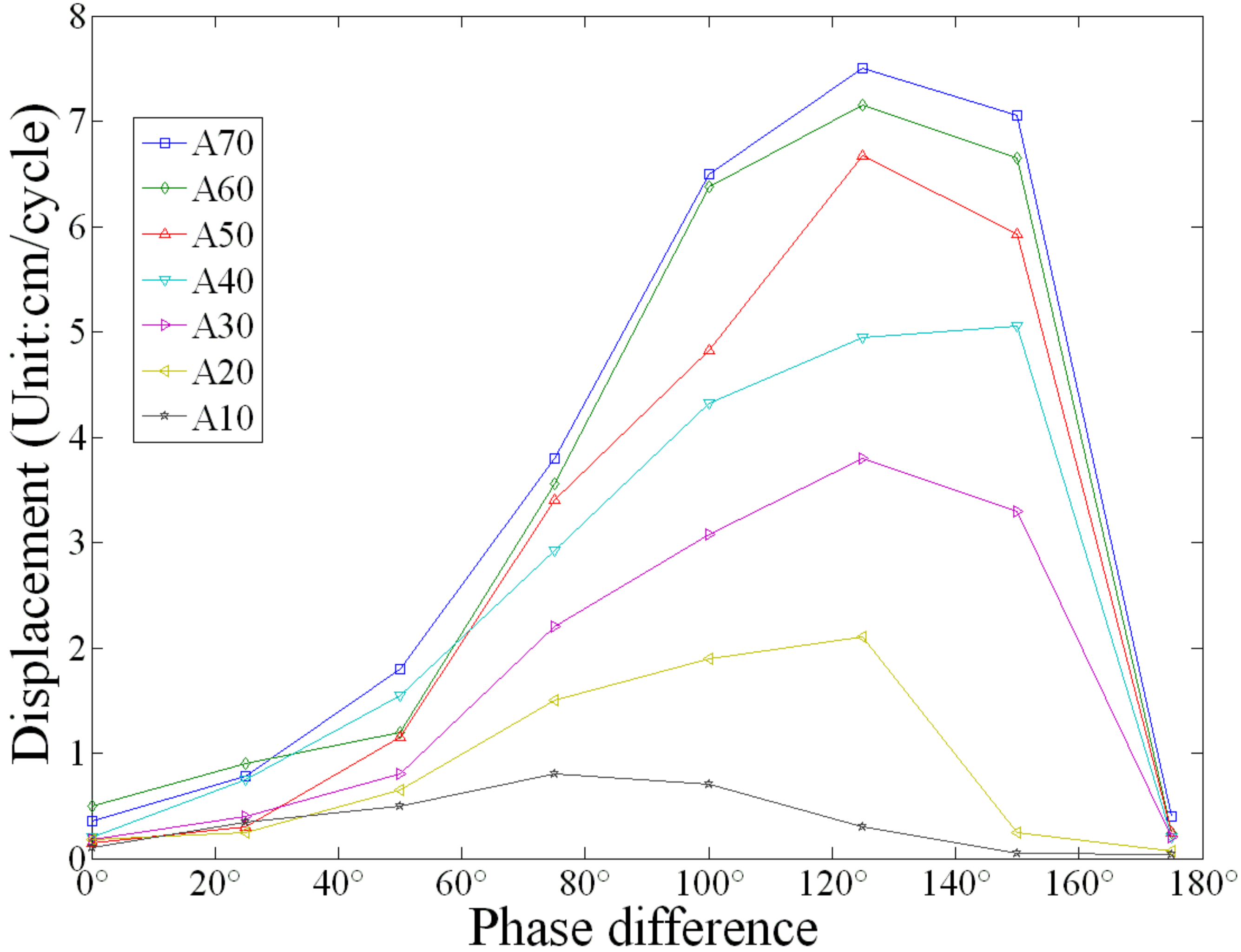
Video



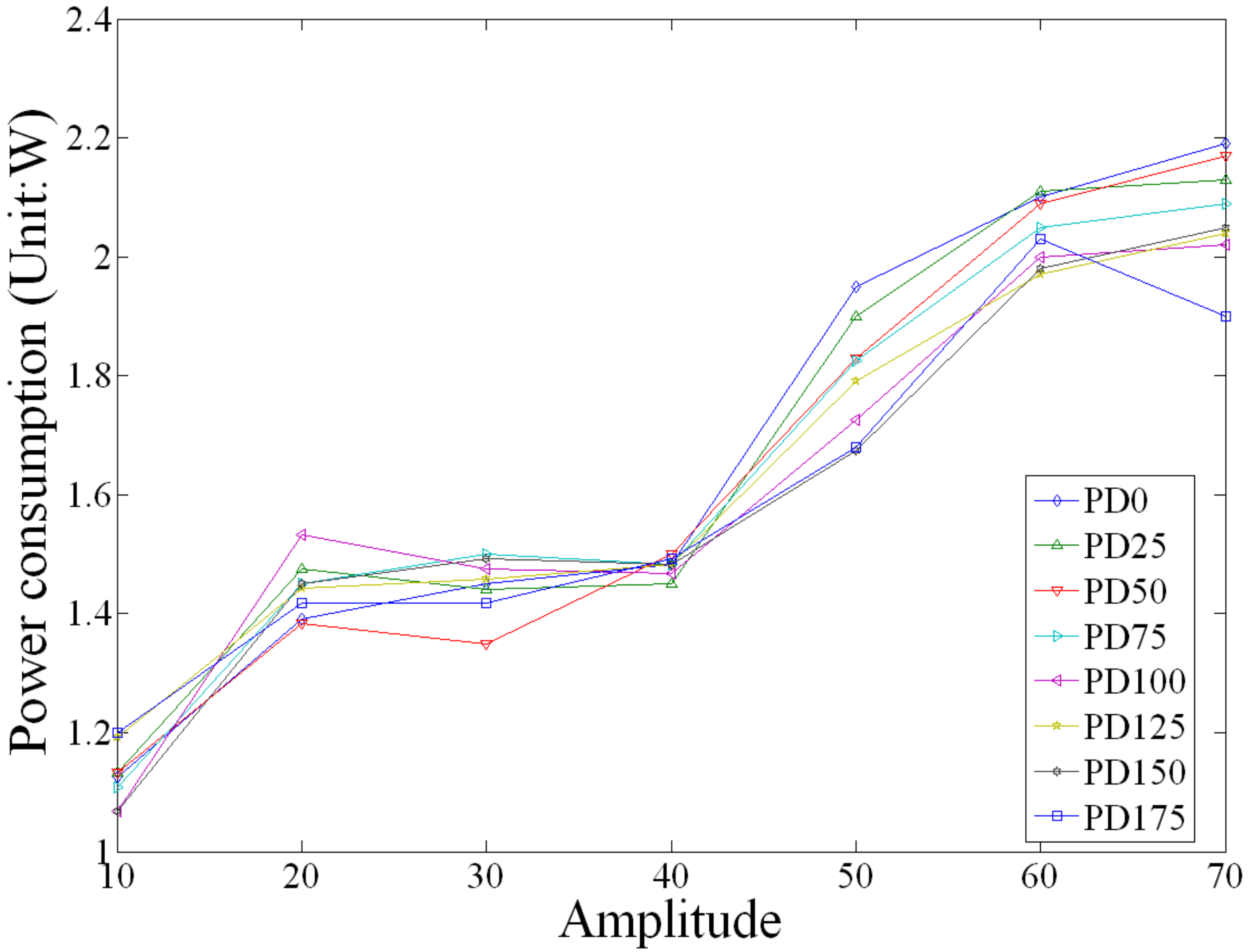
Experiments (I): Step



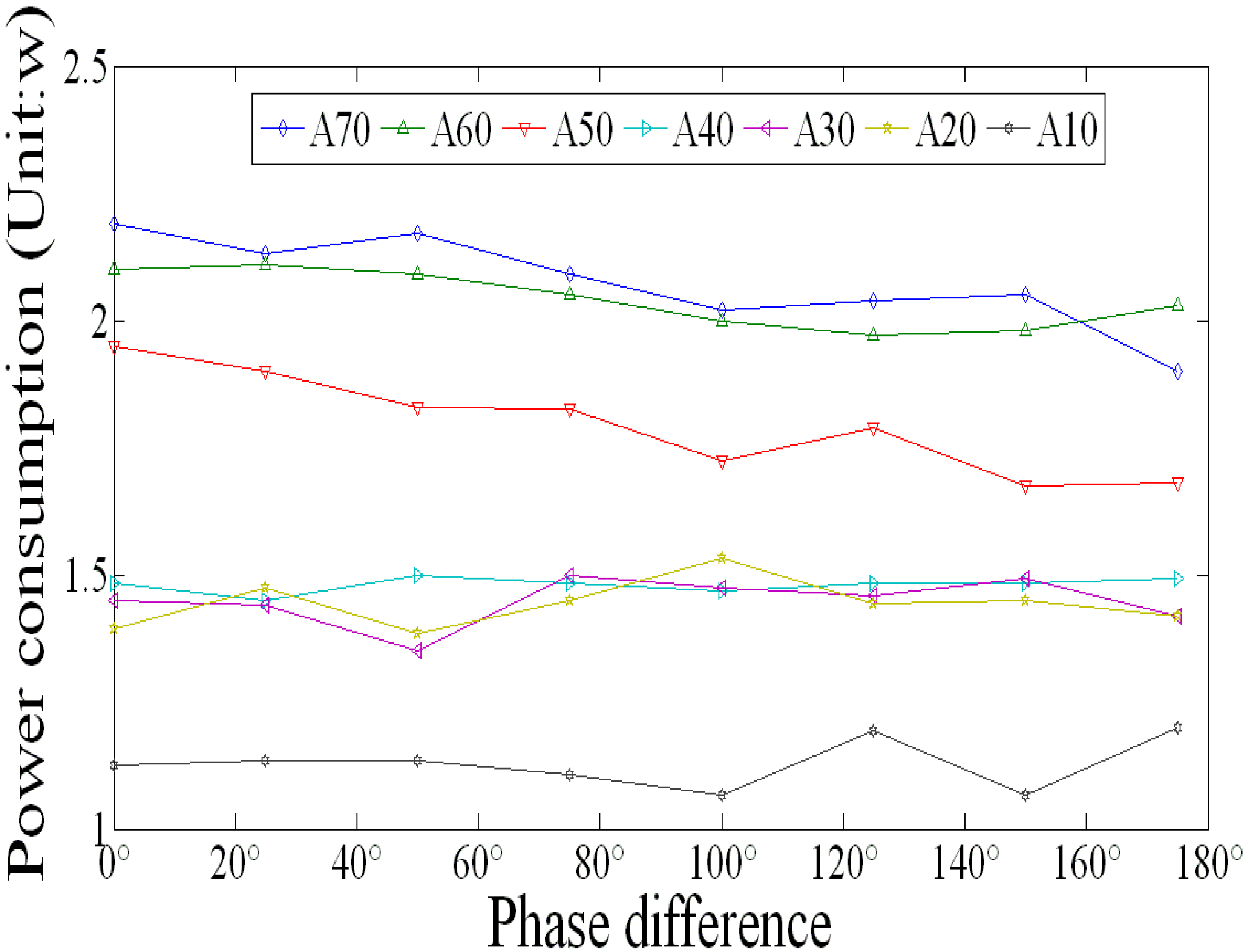
Experiments (II): Step



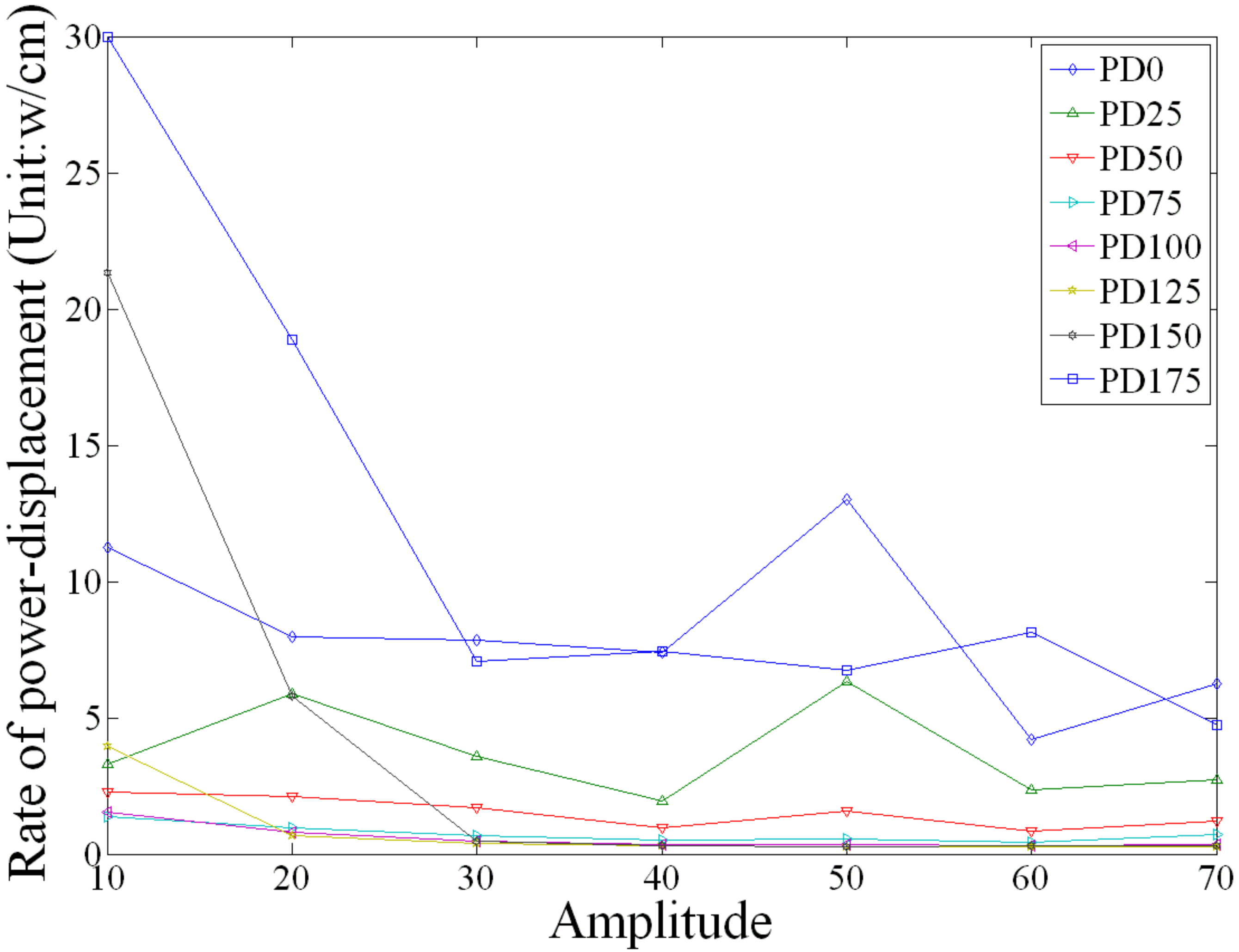
Experiments (III): Power



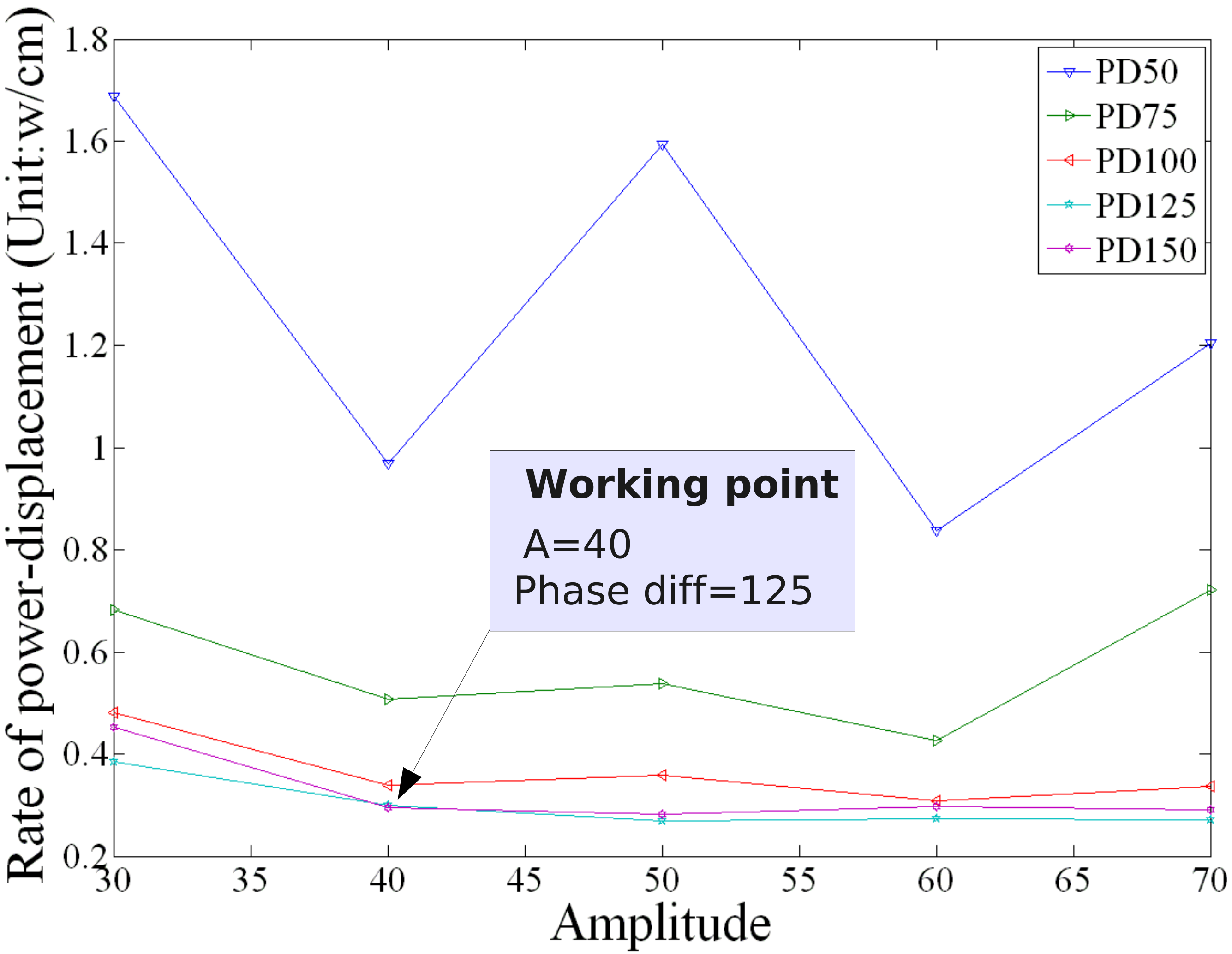
Experiments (IV): Power



Experiments (V): Ratio



Experiments (VI): Ratio



Conclusions and future work

- Investigation of caterpillar-like locomotion using our cost-efficient and robust modular robot Cube-M
- The experiments show that when the phase difference is around 125 degrees the movement is smooth, fastest and power consumption is lowest

- Further experiments and simulations
- Addition of sensors on the module to get more moving information
- Application to the design on climbing caterpillars

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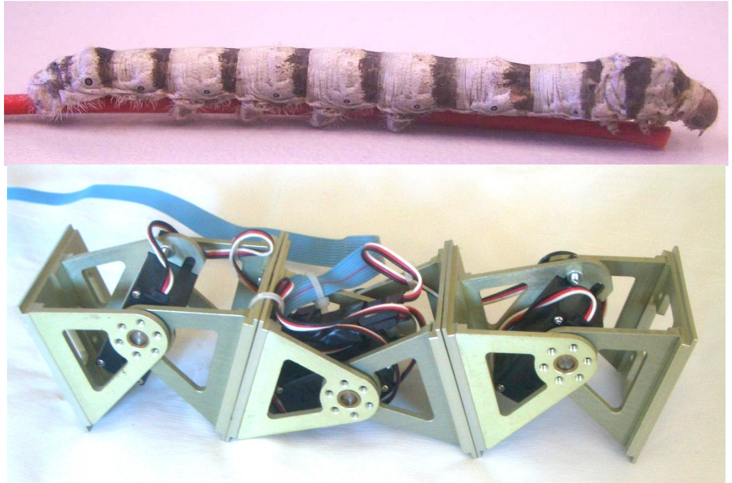

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