Ecoles Polytechniques Fédérales de Lausanne
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Jumping via Deformation

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Deformable Soft Robot

Agenda

- Principle of Crawling and Jumping
- 2D Motion of Circular Robot
- Simulation
- 3D motion of Spherical Robot
- Conclusion

Principle

Charge/Discharge of Potential Energy

Stable | Unstable | Stable with high energy

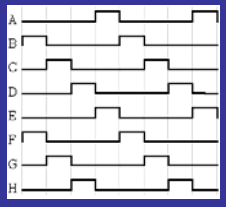
Circular Robot (2D motion)

8 SMA coils for crawling
Toki corp. BMX-100

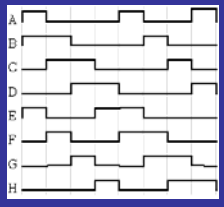
diameter 40mm weight 3g

Control

Open loop PWM control of SMA coils

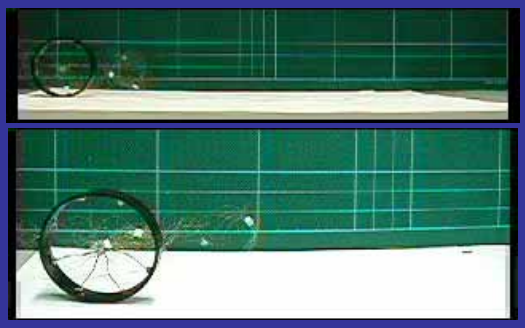


crawling



hill-climbing

Crawling

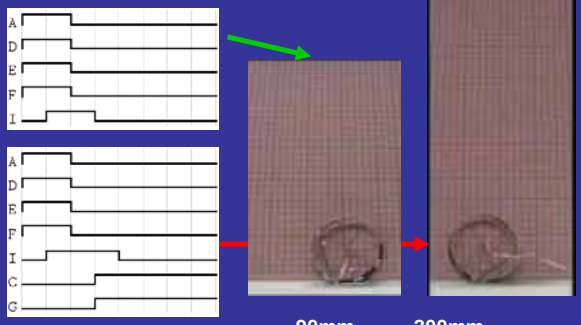


25mm/s (65% of diameter per second)

Slope Climbing

20 degrees

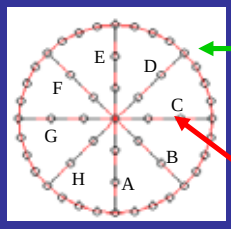
Jump



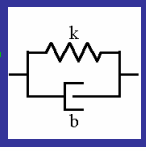
90mm

300mm
(3 times diameter)

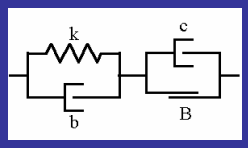
Simulation model



Particle-based model

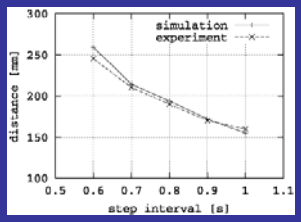


Voigt model

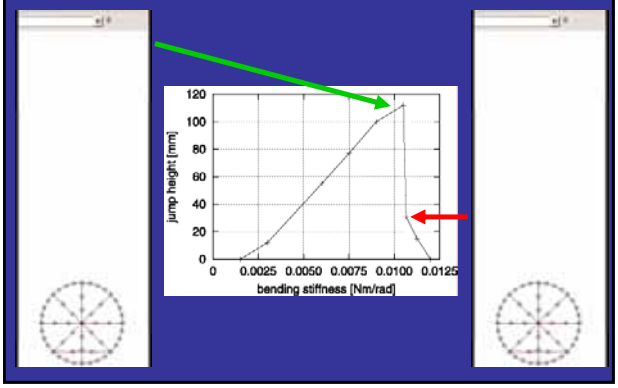


three-element model with slider

Simulation results



Simulation results



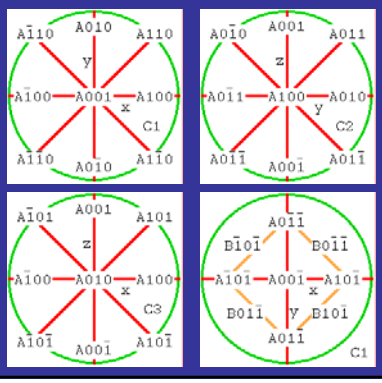
Spherical Robot (3D motion)

22 SMA coils
18 for crawling + 4 for jump

200mm 140g (core 75g)

90mm 5g

SMA coils in spherical robot



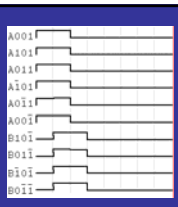
18 for crawling

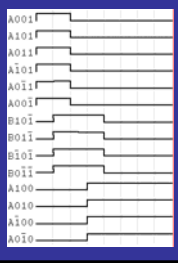
4 for jump

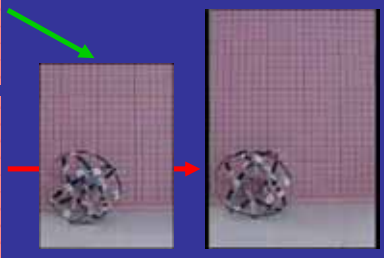
Slope Climbing

Crawl across arcs
Slope of 10 degrees

Jump



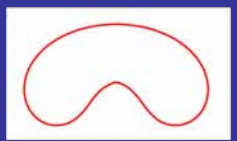




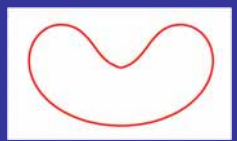
70mm

180mm
(twice diameter)

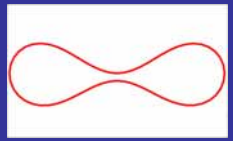
Initial shapes with same energy



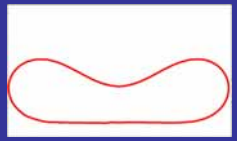
(a) Cap shape



(b) Cup shape



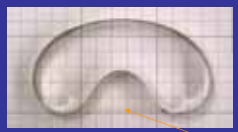
(c) Peanut shape



(d) Dish shape

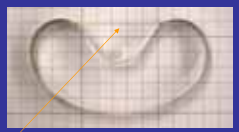
16.0×10^{-2}Nm

Initial shapes with same energy

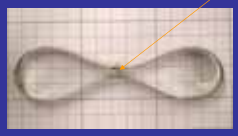


(a) Cap shape

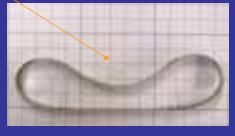
thread



(b) Cup shape



(c) Peanut shape

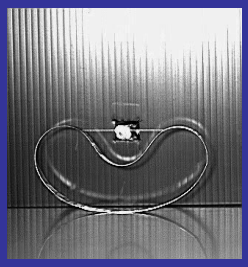


(d) Dish shape

16.0×10^{-2}Nm

Experiments (1/2)

(a) Cap shape



(b) Cup shape

frame rate: 1 KHz

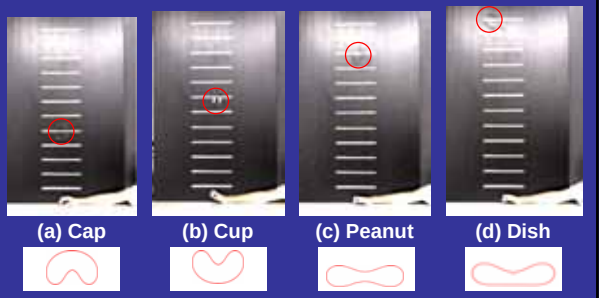
Experiments (2/2)

(c) Peanut shape

(d) Dish shape

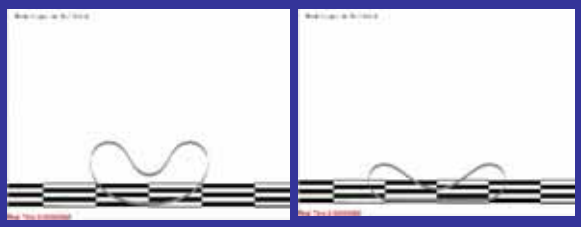
frame rate: 1 KHz

Effect of initial shapes



(a) Cap (b) Cup (c) Peanut (d) Dish

Simulation

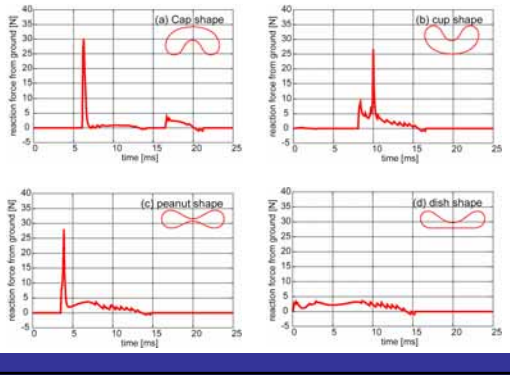


(b) Cup shape (d) Dish shape

Jumping heights

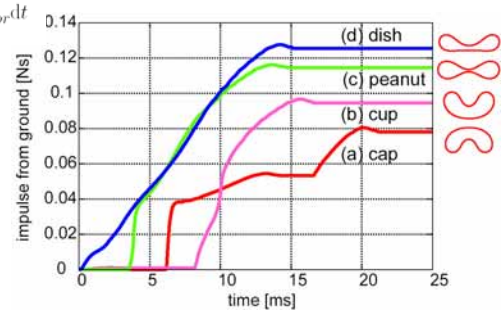
	experiment [mm]	simulation[mm]
(a) cap	480	457
(b) cup	670	669
(c) peanut	970	980
(d) dish	1180	1171

Reaction force



Impulse

$\int_0^T F_{floor} dt$



Summary

- Circular robot (2D) jump
  - three times its diameter
- Simulation
  - particle-based modeling works well
- Spherical robot (3D) jump
  - twice its diameter
- Jumping height depends on initial shapes
- "Dish shape"
  - small force but long contact time
  - large impulse, higher jump

Thank you for your attention