MOBILE ROBOTICS PRESENTATION

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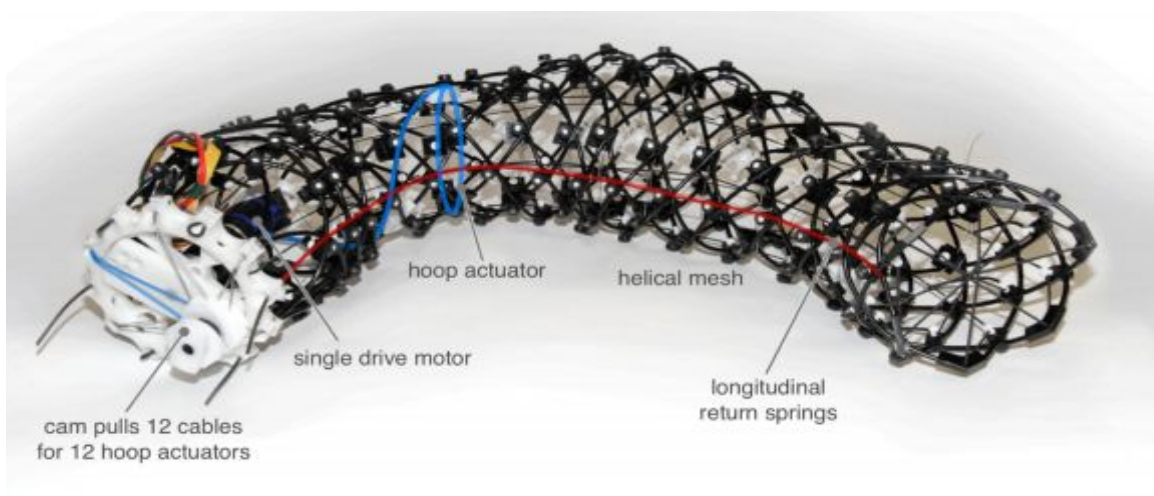
01. 06. 2017

LIGHT-POWERED CATERPILLAR ROBOT

INTRODUCTION TO WORM-LIKE ROBOTS

- Worm-like robots are a break-through in the emerging field of soft robotics
- Bio- inspired structure and nature



WHY SOFT ROBOTICS

- Traditional robots are more like machines, made from metals and plastic
- Soft robots mimic biological organisms and are made of non-rigid, deformable materials like silicon based polymers and elastomers, compliant mechanical parts like springs.

MECHANICAL GRIPPER

SOFT GRIPPER

HOW BIO-INSPIRED?

The use of soft materials allow for continuous deformation

HOW DO WORM-BOTS WORK

- Pneumatically controlled
- Basic sensors commonly used - pressure, proximity, optical, position etc
- Air pressure is regulated by specialised programmed pumps
- Movement of manipulator is directed by soft actuators and soft sensors
- Soft-bodied animals like earthworms, sea cucumbers, snails use *peristalsis* for locomotion that provide inspiration for soft robotic platforms
- Most worm robots use large discrete actuators link in series.

CATERPILLAR ROBOT

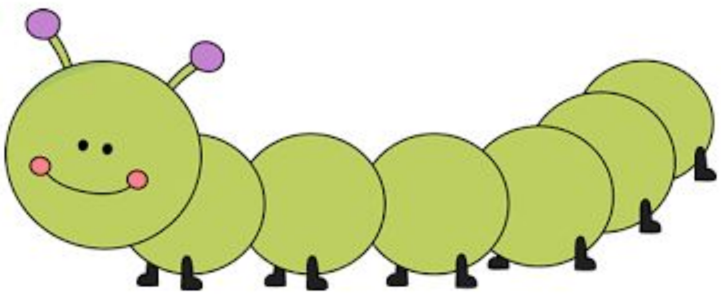
CHALLENGES

Size

- Available actuators prevent miniaturization
- External power supply usually via wires or tubing

Motion Control

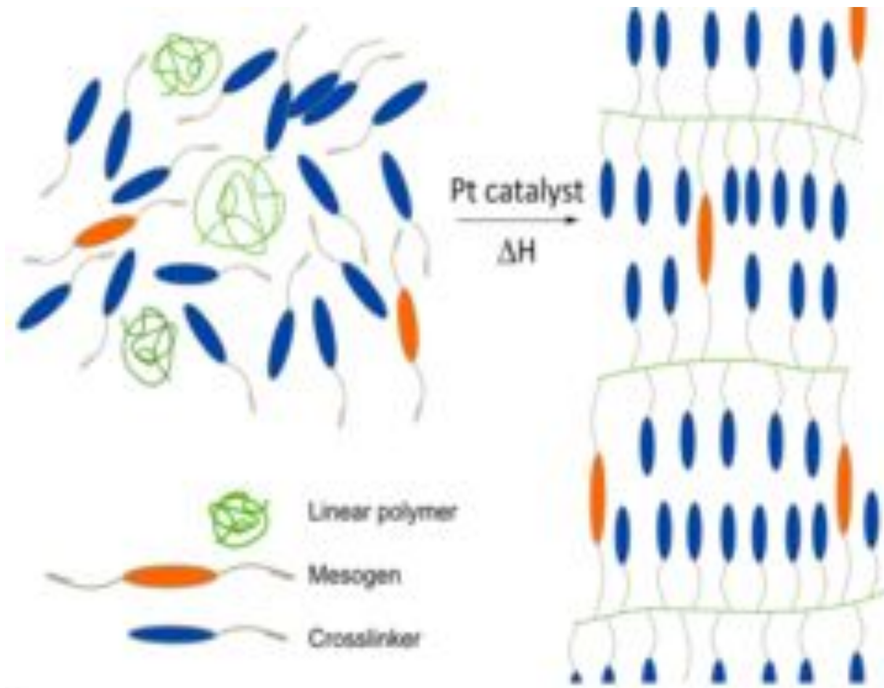
Travelling wave motion requires many discrete actuators to be controlled in synchrony



NATURAL SCALE CATERPILLAR SOFT ROBOT

In 2016, researchers at the Faculty of Physics at the **University of Warsaw** with collaborations from LESN (Italy) and Cambridge (UK) developed a natural-scale, 15-mm long soft caterpillar robot.

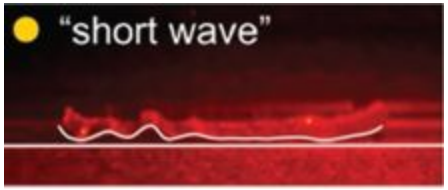
LIQUID CRYSTAL ELASTOMERS

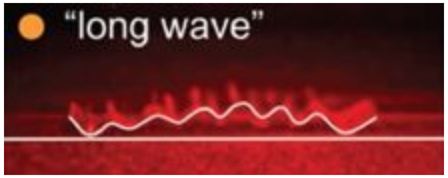


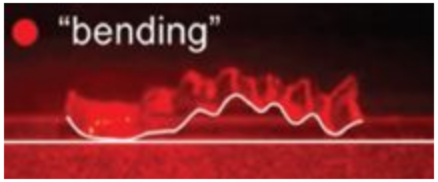
- Change their shape reversibly after the application of external stimulus.
- Light-induced deformation can vary with illumination conditions
- Used as materials for actuators.

MECHANISM OF THE ROBOT

- Robot's body is made of a light sensitive liquid crystalline elastomer stripe with patterned molecular alignment
- No individual actuators for use as active legs
- Light-induced deformation allows the monolithic LCE structure to perform complex actions without discrete actuators
- By controlling the travelling deformation pattern, the robot mimics different gaits of a caterpillar (see below)





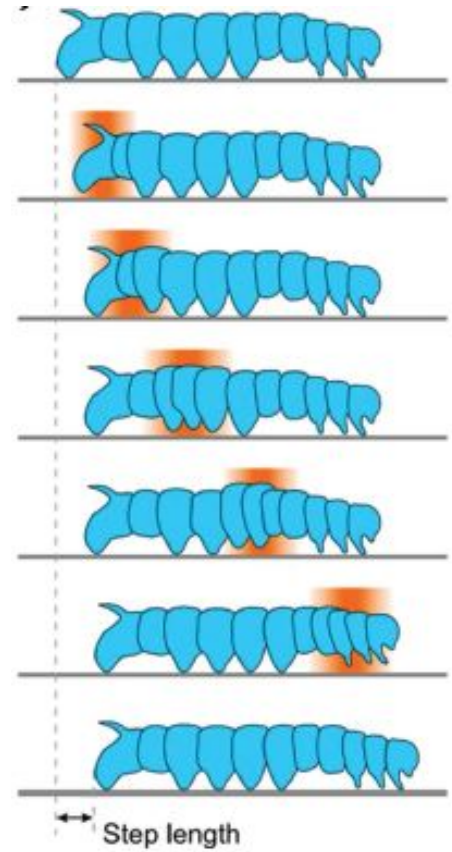


CATERPILLAR MOTION

– Caterpillars propel by contracting a part of their bodies and at the same time detaching the respective legs from the ground.

– The deformation wave travels from the tail to the head.

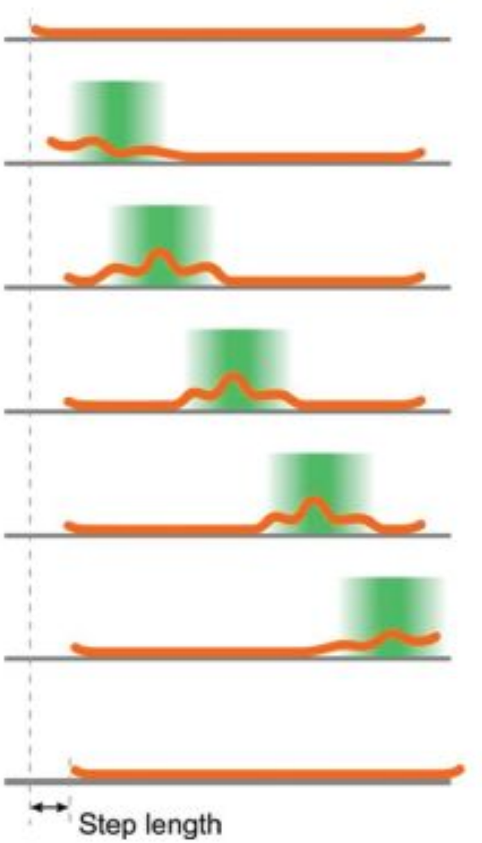
– Orange shading indicates the region of the contracted and lifted segments.



CATERPILLAR ROBOT MOTION

- The soft robot mimics the caterpillar gait by local contraction associated with curly bending

- Green shading indicates the area illuminated with laser beam that induces the robot curling deformation



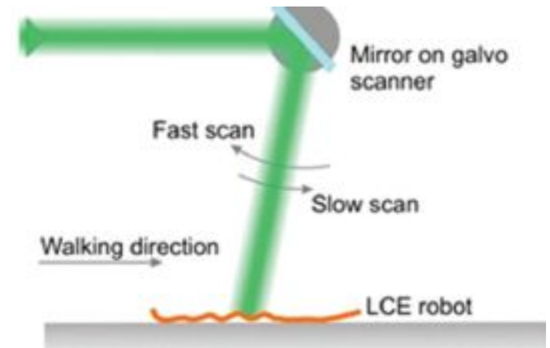
STEPPING DYNAMICS

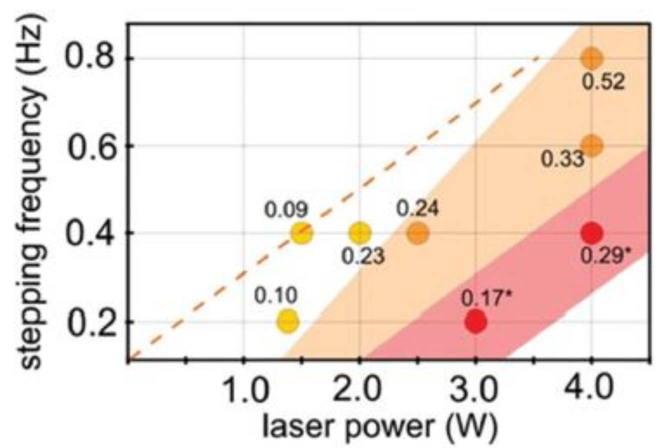
- Two **time constants** of the LCE film deformation

  - Curling (with absorption of the light energy)

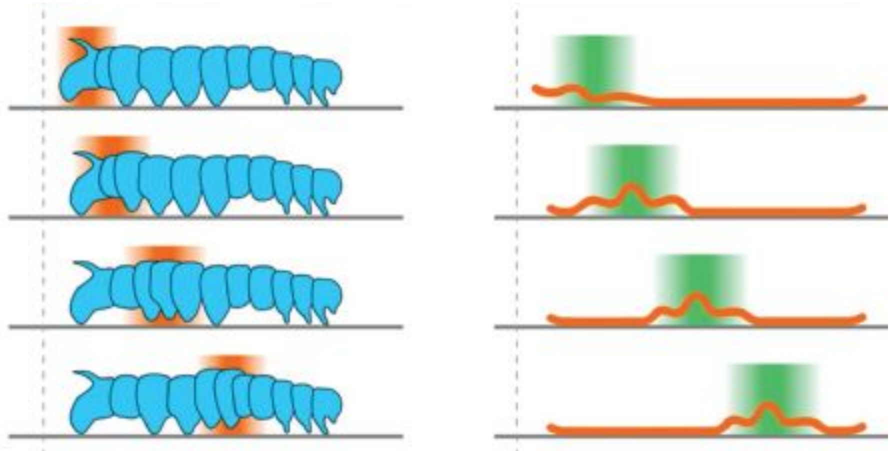
  - Release to the original state (after switching off the light)

- The laser scanning speed and average power determining the amount of energy absorbed by the dye embedded in the LCE film
- The heat diffusion in the polymer and its characteristic time scale
- The laser spot size in the film that affects the activated body area.





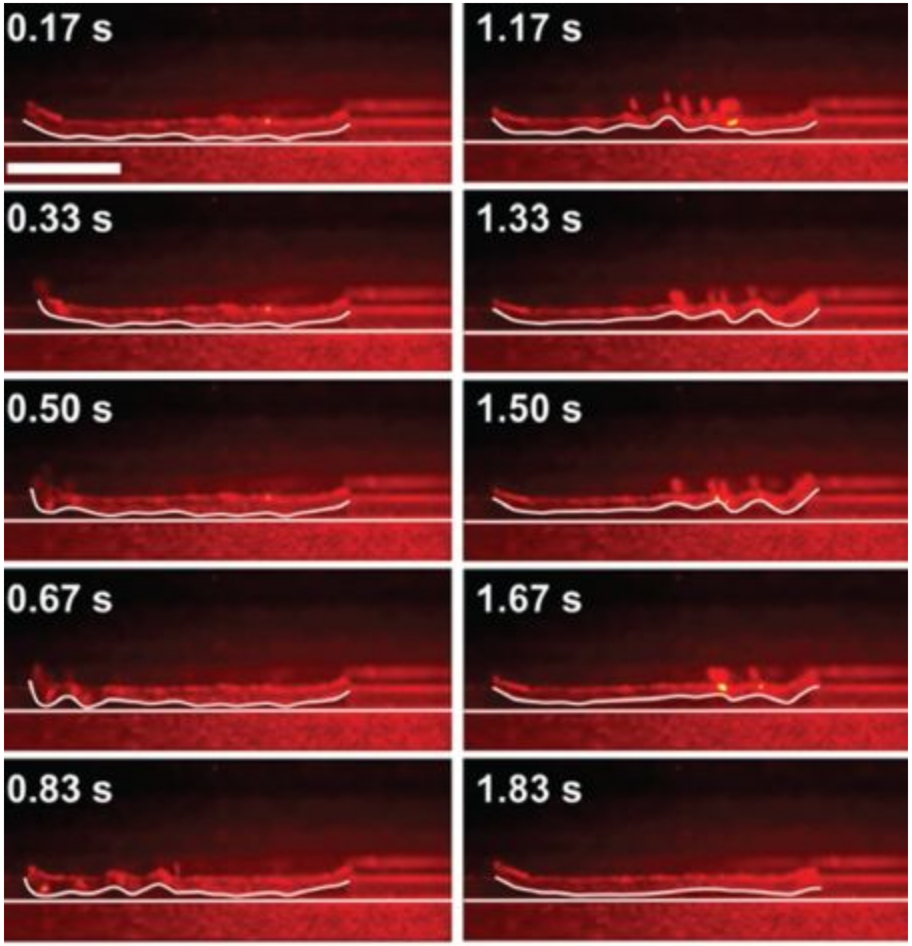
COMPARISON



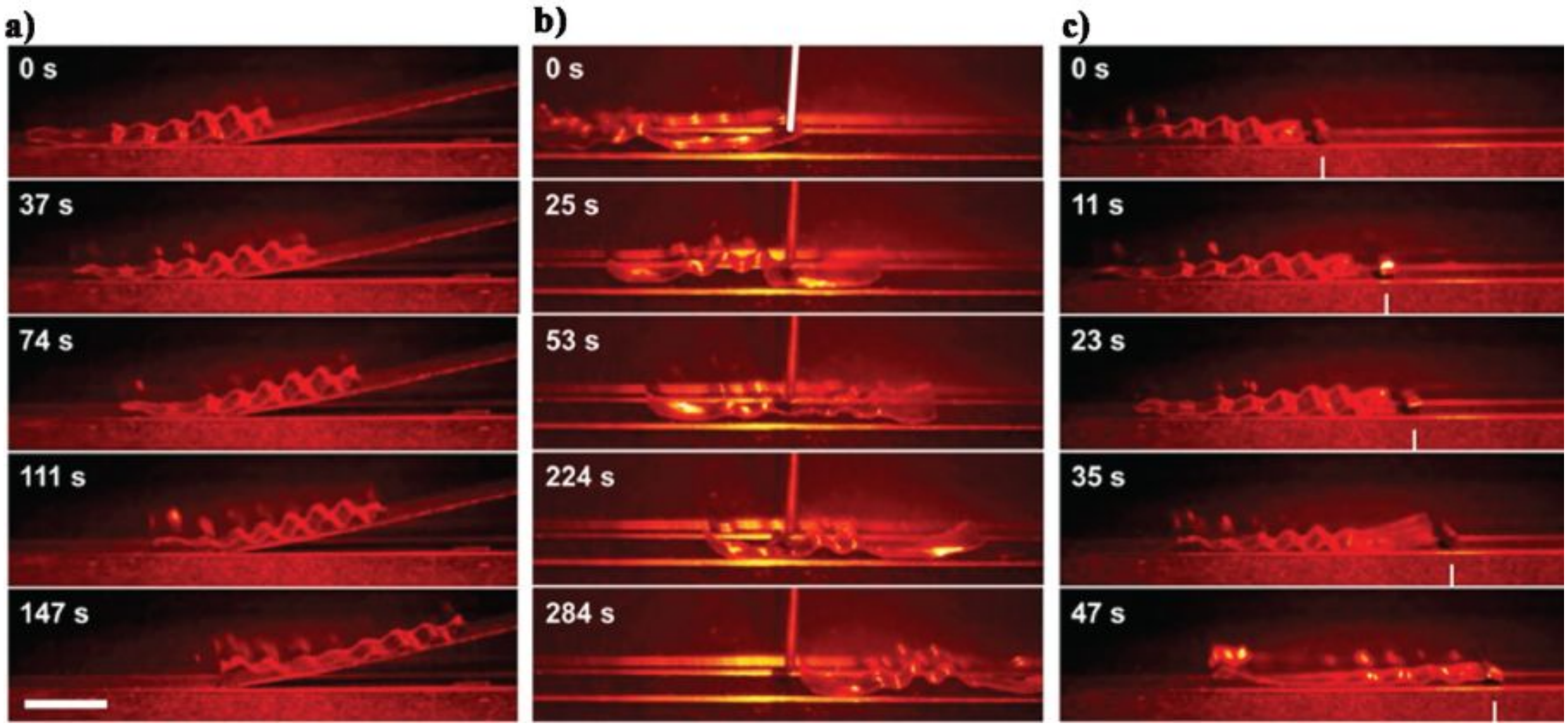
	Body length [mm]	Stepping frequency [Hz]	Step length [mm]	Average speed [mm s^{-1}]
LCE robot	14.5	0.2–0.8	0.2–0.8	0.1–0.5
C. verbasci	12	2	3.1	6.2
P. ruralis	24	1.7	6	10.2
T. jacobaea	26	1.8	4.2	7.5

Table: Kinematic parameters of select caterpillar species and the LCE soft robot

WALKING MODES OF THE LCE SOFT ROBOT



LCE SOFT ROBOT IN VARIOUS TASKS



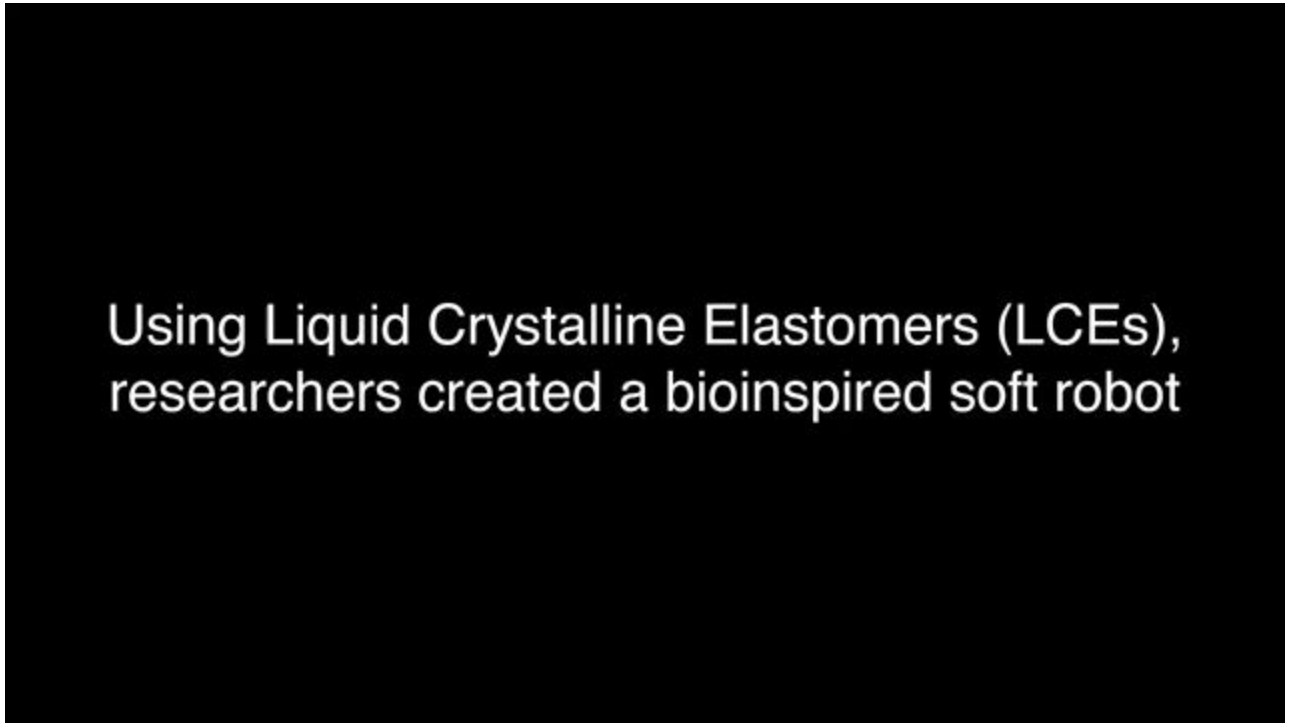
(a) Climbing an 11 degree slope.

(b) Squeezing through a 9mm high slit

(c) Moving a cylinder with 0.2mm/s speed

SUMMARY

- Light can be a useful energy source for micro-robot actuation and control, driving complex movements in soft matter structures.
- Different robot gaits are attained by choosing the appropriate light excitation conditions.
- Light actuation of LCE opens up new horizons in micro-actuation and complex, remotely powered and controlled soft-robotics in milli-meter and micrometer scales.
- Exploring efficient actuators with gripping control remains a challenge for soft robotics in the quest for matching the efficiency of natural species.


Using Liquid Crystalline Elastomers (LCEs),
researchers created a bioinspired soft robot

THANK YOU !!