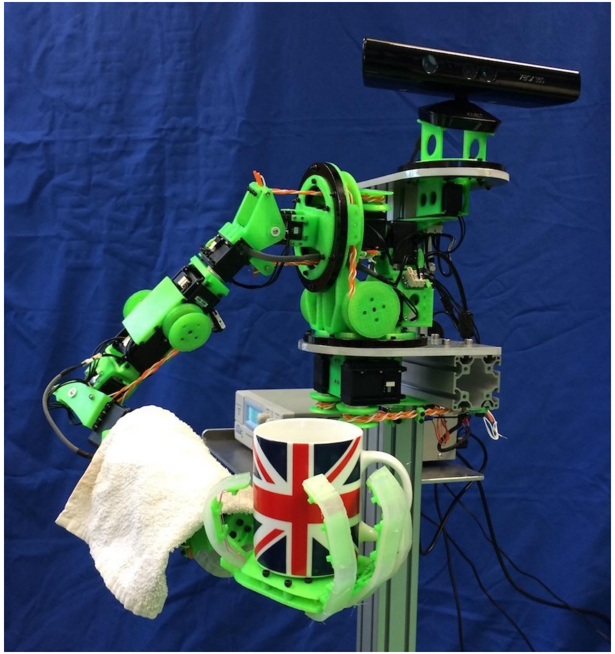
Group Project Kōans

ShanghAI Lectures 2016

The GummiArm in India

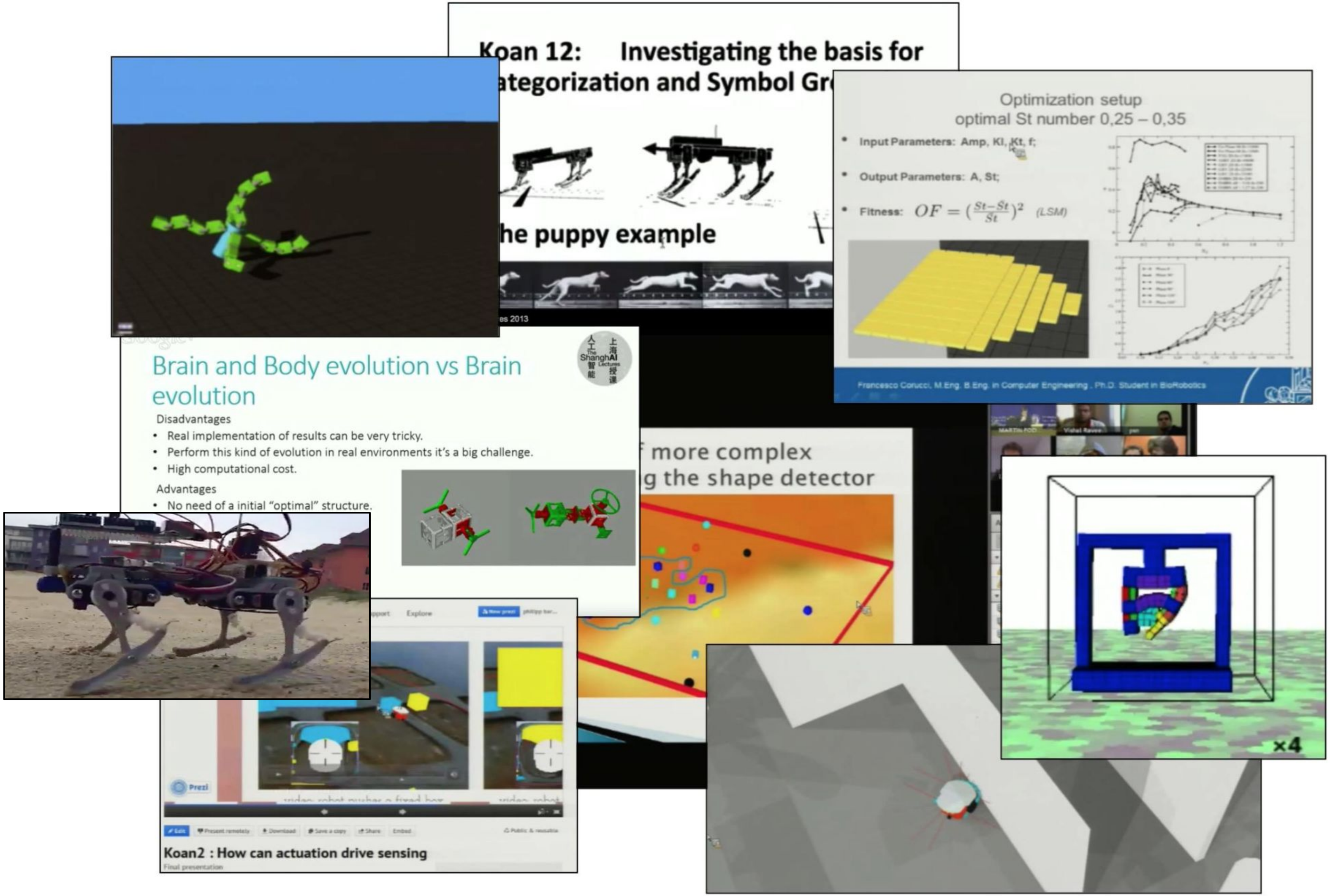
- Soft and variable-stiffness
- 3D printable and open source
- India-UK Tech Summit



http://mstoelen.github.io/GummiArm/

“A **Kōan** (公案) … is a story, dialogue, question, or statement, which is used in Zen-practice to provoke the ‘great doubt’, and test a student's progress in Zen practice.”

Wikipedia


Koan 12: Investigating the basis for
ategorization and Symbol Gr
he puppy example
es 2013
Optimization setup
optimal St number 0,25 – 0,35
Input Parameters: Amp, Kl, Kt, f;
Output Parameters: A, St;
Fitness: $OF = (\frac{St-\hat{St}}{\hat{St}})^2$ (LSM)
Francesco Corucci, M.Eng. B.Eng. in Computer Engineering , Ph.D. Student in BioRobotics
Brain and Body evolution vs Brain evolution
The ShanghAI Lectures
Disadvantages
Real implementation of results can be very tricky.
Perform this kind of evolution in real environments it's a big challenge.
High computational cost.
Advantages
No need of a initial "optimal" structure.
f more complex
g the shape detector
Explore
Prezi
Koan2 : How can actuation drive sensing
Final presentation
×4

Resources, timeline and grading

https://shanghai-lectures.github.io/koans/

Kōan 1: Wearable soft robotics

- Soft robotics provides tools for making safe and comfortable wearable devices ranging from power-assist and rehabilitation to shape-changing clothing.
- *Design a wearable soft device, and fabricate a prototype of it.* Use your imagination.
- Good places to start for ideas:
  - Soft Robotics Toolkit*
  - PneuFlex Tutorial**
  - JamSheets***
- How is the soft mechanism coupled with the human body? How is this related to the lecture topics?

Marty McFly with self-adjusting jacket, Back to the Future Part II

Do you have other ideas?
Feel free to be creative!

*http://softroboticstoolkit.com/
**http://www.robotics.tu-berlin.de/index.php?id=pneuflex_tutorial
***https://vimeo.com/73164578

Kōan 2: Throwing robot with elastic energy storage

- Humans are capable of impressive throwing performance with spears, balls, etc
- We actively use a backstroke to increase the velocity of the projectile on release
- Our elastic muscle-tendon structure enables energy storage during the backstroke
- Design and build a robot arm that exploits elasticity to enable faster-than-actuator throwing movements
- Explore the role of the backstroke, and compare with human motor control literature

*Checkout the **qbmove**-based 2 DOF robot throwing:* https://youtu.be/iPfGOKRIFJc

Can you do better, perhaps more human-like? A longer backstroke?

Hammer in a nail instead?

Optimal throwing is hard, see background below. Can you simplify with bio-inspiration?
Braun, D.J., Howard, M. and Vijayakumar, S., 2012. Exploiting variable stiffness in explosive movement tasks. Robotics: Science and Systems VII, p.25.

Do you have other ideas? Feel free to be creative!

Kōan 3: From passive to actuated dynamic walking

Do you have other ideas?
Feel free to be creative!

- A passive dynamic walker exploits its own intrinsic dynamics to generate a “natural” and energy-efficient gait, but with several limitations:
    - It typically requires a downward slope for adding energy
    - It is typically limited to a very even and obstacle-free surface
- Could you add actuators? Where?
- What about sensors on the sole of the feet? Reflexes?
- What potential applications exist for very energy-efficient walking?

65 km on one charge - the Cornell Ranger:

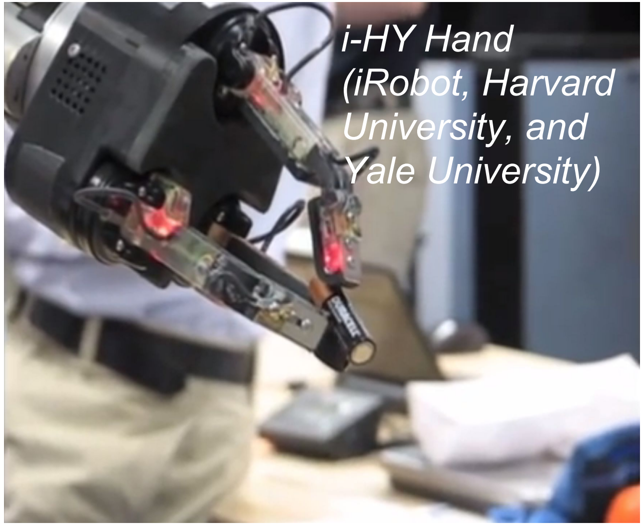
P. Bhounsule, et al., Low-bandwidth reflex-based control for lower power walking: 65 km on a single battery charge, International Journal of Robotics Research, vol. 33 no. 10, pp. 1305-1321, 2014. DOI: 10.1177/0278364914527485.
http://ijr.sagepub.com/content/33/10/1305.refs.html

Do you have other ideas?
Feel free to be creative!

Kōan 4: A soft touch

- Explore designs of hands (and arms?) with different degrees of passive compliance.
  - E.g. rigid links connected by springs
  - Implement a physical design
  - Optionally model in e.g. VoxCad*
- What objects can be “grasped” when:
  - Hand falls on top by gravity?
  - One, two or more actuators are used? 2, 5 or more fingers?
- Discuss the impact on controller design and movement planning required

*http://www.creativemachineslab.com/voxcad.html

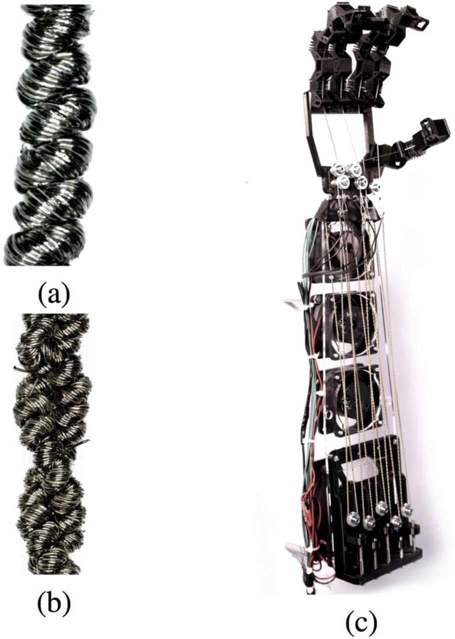


Check out the ***Soft Robotics Toolkit*** *for inspiration:*

http://softroboticstoolkit.com

Kōan 5: Variable-stiffness actuator with “super-coiled” polymers

- “Super-coiled” polymer (SCP) actuators have recently shown great promise:
  a. Low cost and weight
  b. High strength and speed
  c. Compliance and damping
- Build a prototype joint with this actuator, for example variable-stiffness agonist-antagonist type
- Test and document the properties of the designed actuator, and compare with the state-of-the-art
- Forced air cooling? Liquid?



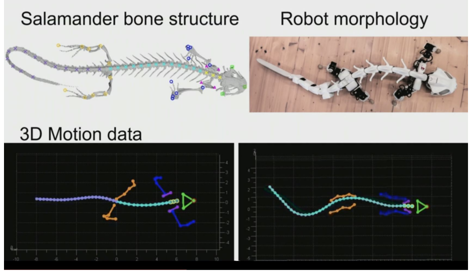
Example super-coiled polymer actuators, from:
Yip, M.C. and Niemeyer, G., 2015, May. High-performance robotic muscles from conductive nylon sewing thread. In 2015 IEEE International Conference on Robotics and Automation (ICRA) (pp. 2313-2318). IEEE.

A good starting point:
Haines, C.S., Lima, M.D., Li, N., Spinks, G.M., Foroughi, J., Madden, J.D., Kim, S.H., Fang, S., de Andrade, M.J., Göktepe, F. and Göktepe, Ö., 2014. Artificial muscles from fishing line and sewing thread. *science*, *343*(6173), pp.868-872.

Kōan 6: A variable-stiffness and 3D-printable snake robot

- Snake robots are being proposed for tasks in hard-to-reach areas, e.g.:
  - Nuclear decommissioning
  - Underwater inspection
- Search the relevant literature to take inspiration from the skeletal and muscular structure of snakes
- What is role of stiffness variation for water and land snake locomotion?
- Build a 3D-printable snake robot (land and/or water) with variable stiffness

*Checkout the **qbmove**-based variable stiffness snake:* *https://youtu.be/khGqOYmWv3Q*



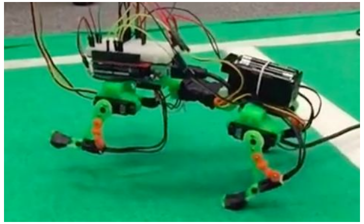
*Checkout **Auke Ijspeert's TED talk** on a 'soft' salamander for inspiration:* *https://www.ted.com/talks/auke_ijspeert_a_robot_that_runs_and_swims_like_a_salamander?language=en*

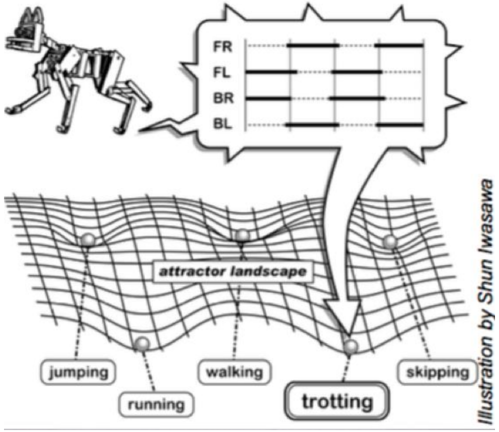
Perhaps start here, stiffness regulation in fish:
Long, J.H. and Nipper, K.S., 1996. The importance of body stiffness in undulatory propulsion. *American Zoologist*, *36*(6), pp.678-694.

Do you have other ideas? Feel free to be creative!

Kōan 7: Attractor States as the basis for Symbol Grounding

- Use the Puppy platform from Webots, or build your own
- Can Puppy categorize its gaits using its sensor input?
- What role do command data and proprioceptive data have?
- Why would Puppy need to change its gait? Environment and/or intrinsic motivation?





Attractor states

Pfeifer, R. and Bongard, J., 2006. *How the body shapes the way we think: a new view of intelligence*. MIT press.

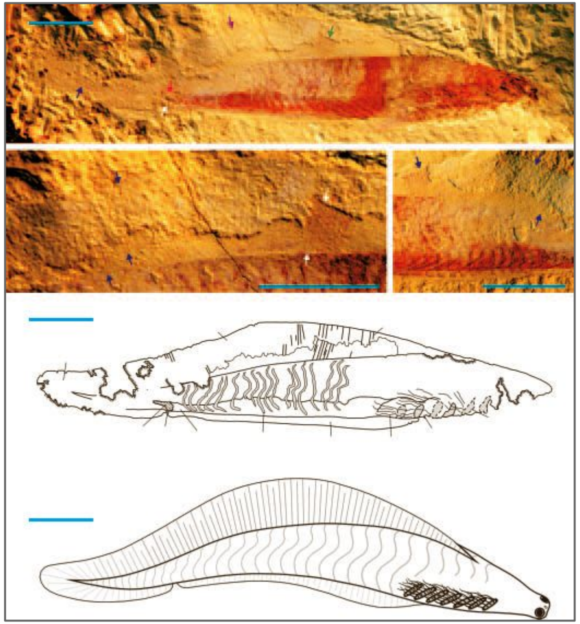
https://www.youtube.com/watch?v=dTAExarRs8w
https://www.youtube.com/watch?v=UEV5jJJWhFE
https://www.youtube.com/watch?v=iSr6adUvd_I

demoPuppy repository (with CAD and printable files):
https://dermitza.github.io/demoPuppy/
Previous year's group repository:
https://bitbucket.org/koan12/shanghai-lectures-k-an-12

Kōan 8: Learning how to swim like a fish

- Fossil remains of extinct fish give us insights on the evolution of species
- The way these species lived and moved can only be roughly estimated by looking at the features of the fossilized fishes
- Design a robot-fish[1] and a machine learning algorithm[2] allowing the fish to efficiently learn how to "swim" either in simulation[3] or using a robot
- Can you gain insights on the way extinct fishes swam?
  - If yes, what can you tell about the fish from the obtained results?

Haikouichthys* lived 525 million years ago



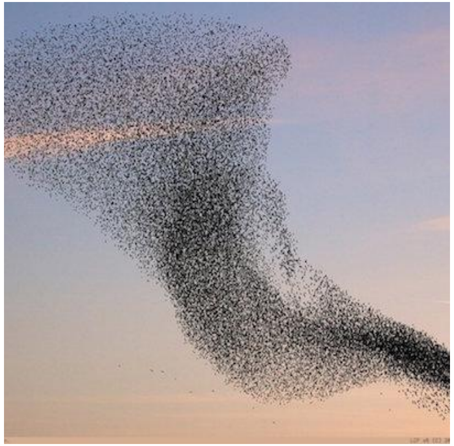
Zhang & Hou, 2004, p. 1163

[1] Software or hardware.
[2] The proposed method would be applicable to different fishes and validated with non-extinct species of fish.
[3] 2D simulator [here](#) or 3D simulator [here](#).
* https://en.wikipedia.org/wiki/Haikouichthys

Kōan 9: “Useful” robot collaboration from local rules

- Implement a swarm of simple robots of your choice in a large virtual environment
- Use biological systems as inspiration, e.g. a flock of birds or school of fish
- Under “normal” behavior individuals follow three rules
  - Move in the same direction as your neighbours
  - Remain close to your neighbours
  - Avoid collisions with your neighbours
- There are two main events that trigger a reaction:
  - Response to a predator attack* (escape)
  - Response to food (gather)
- How to model these reactions?

Do you have other ideas? Feel free to be creative!



https://en.wikipedia.org/wiki/Swarm_behaviour
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2234121/

* https://youtu.be/m9mn7EB1H6k

Kōan 10: Define your own kōan

- Have an idea for a kōan you would like to explore?
- Why not propose it, maybe other students are also interested!
- There are two main conditions:
  - The kōan must be related to the topics covered in class
  - The group must be open to all students (max 5 in group)
- Contact us first, so we can help you organize:
  - Martin F. Stoelen: martin.stoelen@plymouth.ac.uk
  - José Carlos Castillo Montoya: jccmontoya@gmail.com

Group allocation

- Assigned according to kōan preference
    - Max 5 students per group
    - We aim to make groups as international as possible

- We encourage HW solutions (e.g. 3D printing)
    - Local core of students ok for local HW (contact us)
    - But must remain open to students from other sites

- Thinking outside the box required!
    - No single “correct” answer to any of the Kōans

Student TODOs

1. Read through details of the different kōans
   - This presentation is available from website (kōans tab)
   - A living document, may be updated as we go along

2. Register for participation in the kōans
   - Through Eventbrite, click here (or see website)
   - Select your preferred kōan when prompted
   - You will be assigned group and tutor