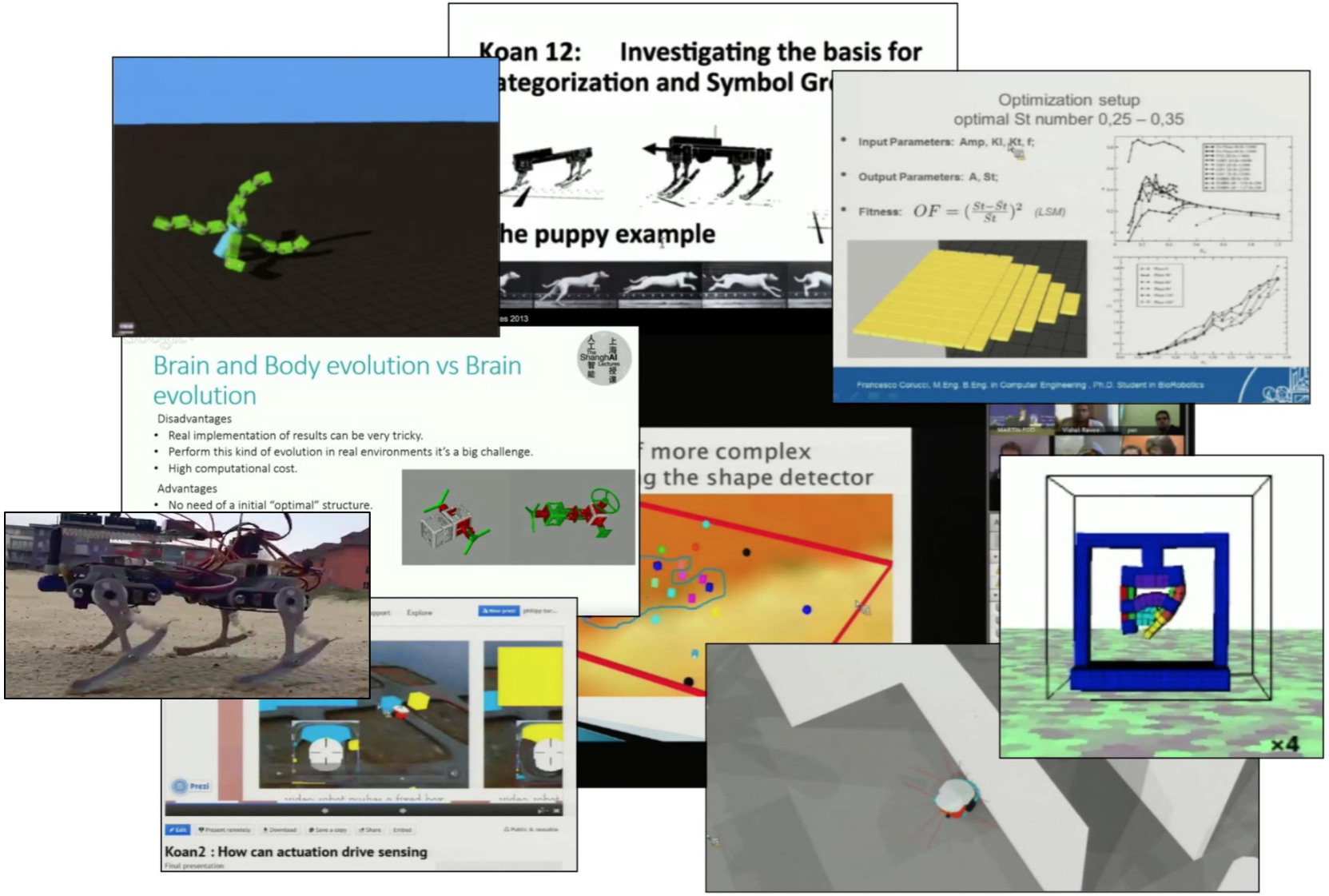
Group Project Kōans

ShanghAI Lectures 2020

“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

*Best **Kōan** projects will be invited to write a research paper!*


Koan 12: Investigating the basis for
ategorization and Symbol Gr
he puppy example
Optimization setup
optimal St number 0,25 – 0,35
Input Parameters: Amp, Kl, Kt, f;
Output Parameters: A, St;
Fitness: $OF = (\frac{St-\hat{St}}{St})^2$ (LSM)
Francesco Corucci, M.Eng. B.Eng. in Computer Engineering , Ph.D. Student in BioRobotics
Brain and Body evolution vs Brain evolution
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.
more complex
g the shape detector
×4
Koan2 : How can actuation drive sensing

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/iPfGOKRlFJc

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

Hammer in a nail instead?

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

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.

Kōan 3: Orchestrated control for shape changing passive walkers

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 exploit the compliance or change shape to change speed? Where?

65 km on one charge - the Cornell Ranger:

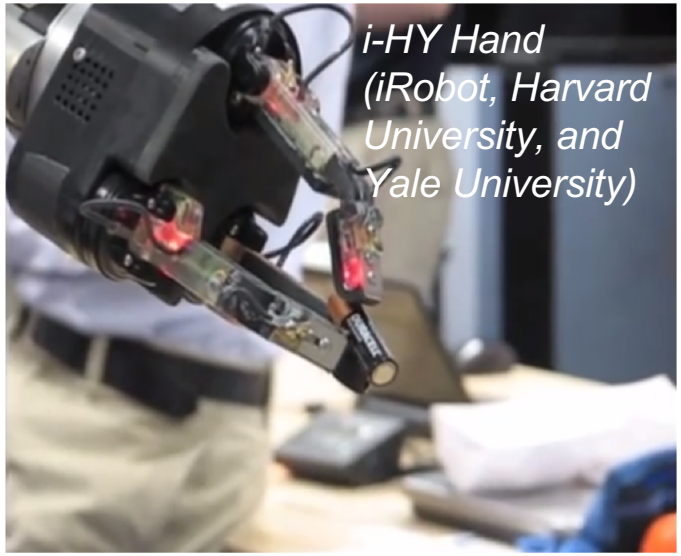
P. Bhounsule, et al., Low-bandwidth reflex-based control for lower power walking: 65 km on a single battery charge, International Journal of Robotics Research, vol. 33 no. 10, pp. 1305-1321, 2014. DOI: 10.1177/0278364914527485.
http://ijr.sagepub.com/content/33/10/1305.refs.html

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



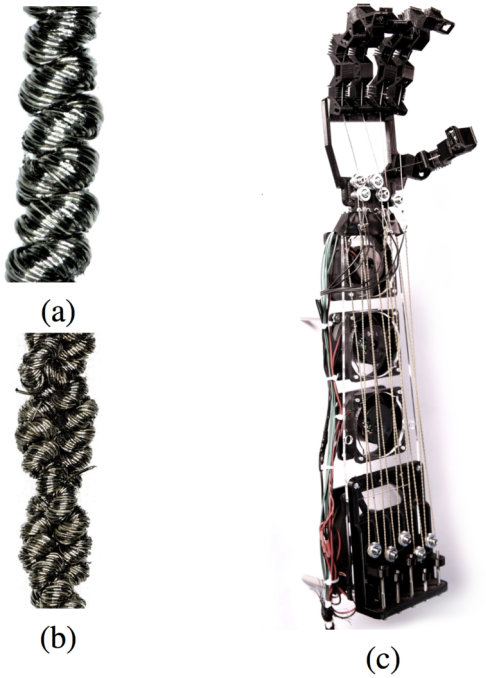
i-HY Hand (iRobot, Harvard University, and Yale University)

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

http://softroboticstoolkit.com

Kōan 5: Variable-stiffness actuators

- Build a prototype joint with variable stiffness actuators, for example variable-stiffness agonist-antagonist type
- Explore ‘fabric-like’ weaved designs
- Could you distribute control and sensing? How?
- Test and document the properties of the designed actuator, and compare with the state-of-the-art



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.

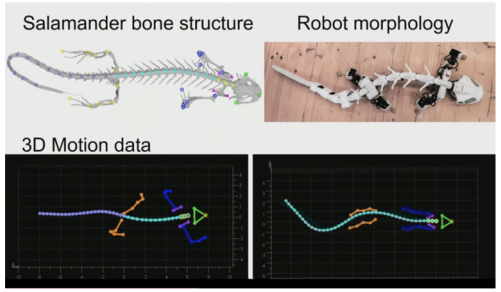
A good starting point:
Haines, C.S., Lima, M.D., Li, N., Spinks, G.M., Foroughi, J., Madden, J.D., Kim, S.H., Fang, S., de Andrade, M.J., Göktepe, F. and Göktepe, Ö., 2014. Artificial muscles from fishing line and sewing thread. *science*, *343*(6173), pp.868-872.

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

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.

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

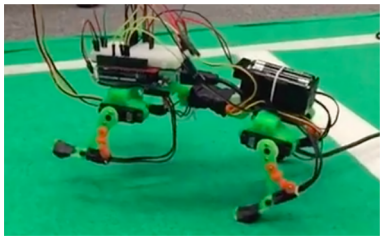


*Checkout **Auke Ijspeert's TED talk** on a 'soft' salamander for inspiration:*
https://www.ted.com/talks/auke_ijspeert_a_robot_that_runs_and_swims_like_a_salamander?language=en

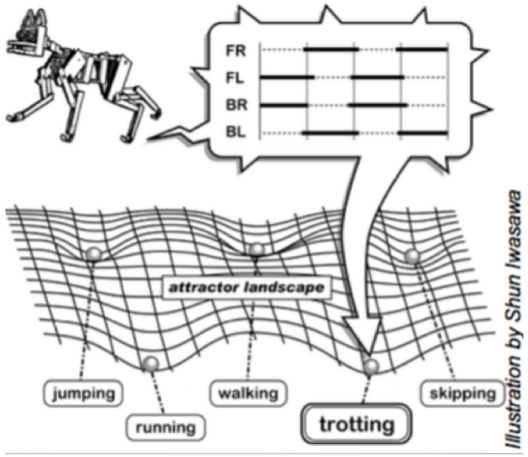
Do you have other ideas?
Feel free to be creative!

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?



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



Attractor states

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

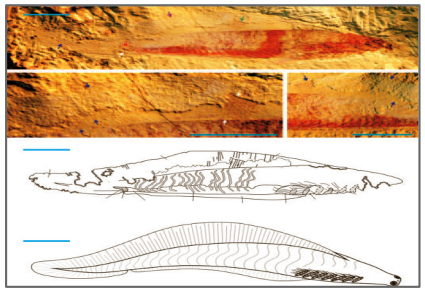
demoPuppy repository (with CAD and printable files):
https://dermitza.github.io/demoPuppy/
Years ago group repository:
https://bitbucket.org/koan12/shanghai-lectures-k-an-12

Kōan 8: Learning how to swim like a fish in a solar system ocean

- 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
- There are many Ocean Worlds[4]. Do the liquid density and gravity field matter?
- Can you gain insights on the way extinct fishes swam?
    - If yes, what can you tell about the fish from the obtained results?
- Can you gain insights about the morphology of an Europa fish?

(feel free to choose another exo-ocean!)

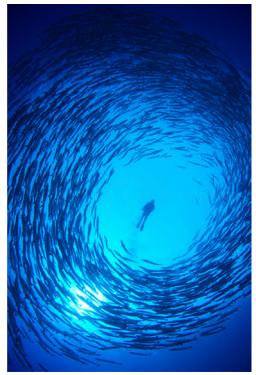
Haikouichthys* lived 525 million years ago



Zhang & Hou, 2004, p. 1163

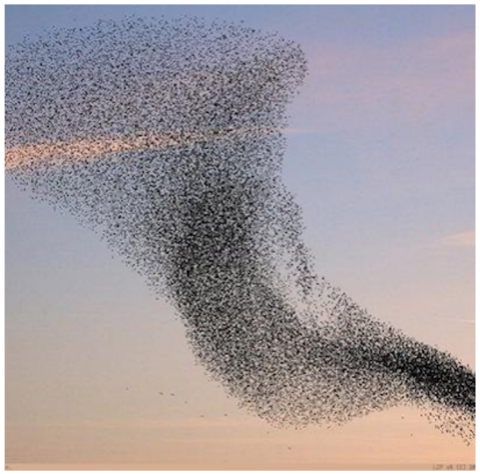
[1] Software or hardware.
[2] The proposed method would be applicable to different fishes and validated with non-extinct species of fish.
[3] 2D simulator here or 3D simulator here.
[4]https://www.nasa.gov/specials/ocean-worlds/
** https://en.wikipedia.org/wiki/Haikouichthys*

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?
- How may you control a swarm? How can you let it move from point A to point B?

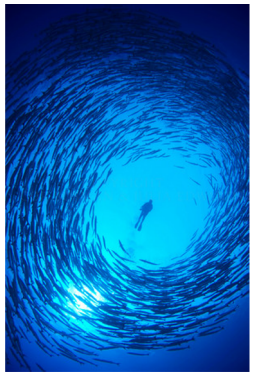
Do you have other ideas?
Feel free to be creative!



* https://youtu.be/m9mn7EB1H6k

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

Kōan 10: Softness and Stiffness of a swarm



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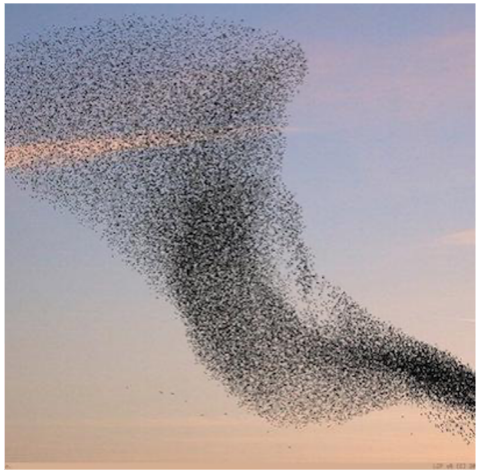
- Under “normal” behavior individuals follow three rules
  - Move in the same direction as your neighbours
  - Remain close to your neighbours
  - Avoid collisions with your neighbours
- How to model these reactions?
- How may you control the perceived/measured stiffness of a swarm? How could you measure it?

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



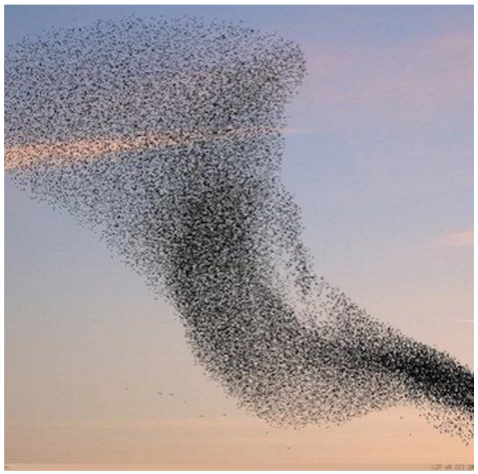
* https://youtu.be/m9mn7EB1H6k

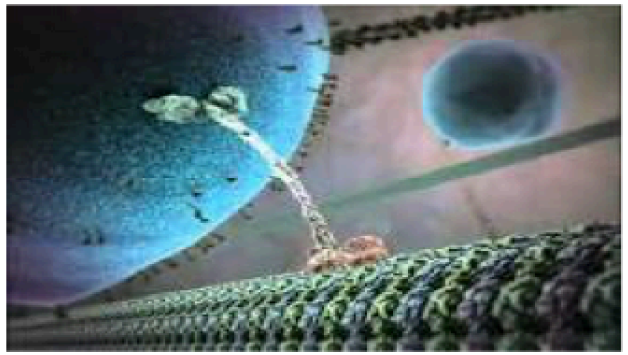
https://en.wikipedia.org/wiki/Swarm_behaviour
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2234121/

Kōan 11: Model (part) of a cell as a swarm

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

- Implement a swarm of simple agents of your choice in a large virtual environment mimicking a set of cellular process ideally a cell
- 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
- How to model these reactions?
- Why would a membrane help?





* https://youtu.be/m9mn7EB1H6k

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

Kōan 12: Passive walkers on Mars

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

- Understand how passive walkers walk down a slope
- Undestand how the Cornell Ranger walk
- What's the role of gravity?
- Design a passive walker for Mars surface and compare with terrestrilal ones
- What happens to human's brains on the ISS when moving???

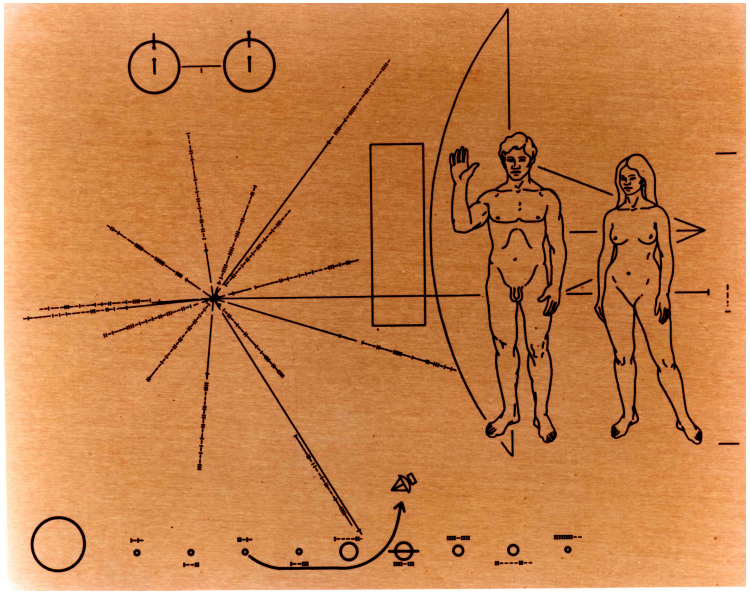
From Collins et al. 2001

You may start form here: http://ruina.tam.cornell.edu

Kōan 13: Talking to Aliens

- How the body affects cognition?
- Remember Lakoff and Nuñez: Where Mathematics comes From
- What if aliens only ‘see’ sounds?
- What if they see in different bandwidths?
- A Turing test for aliens?
- How to convince an alien with a different body (much bigger, smaller, diffrently shaped, diffrent sensors) that _we_are intelligent?

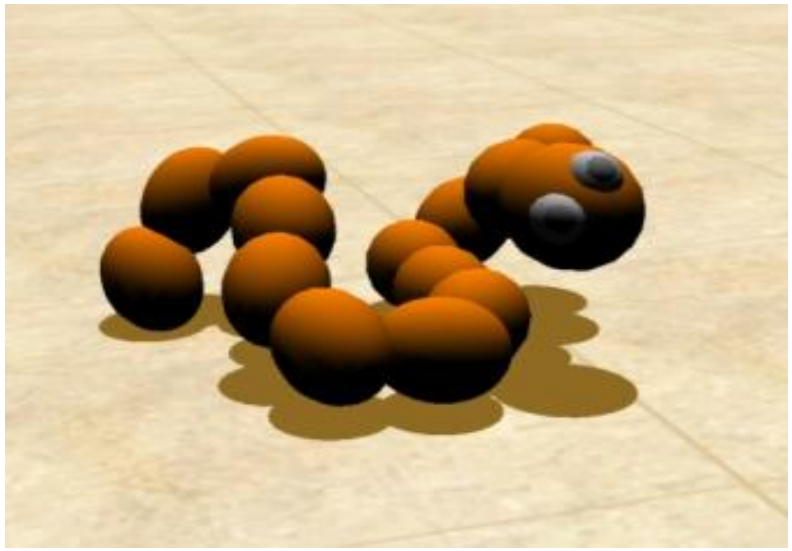
Do you have other ideas?
Feel free to be creative!



Kōan 14: X-TanevBot

- Remember the Snakebot by Tanev
- Can you reproduce it?
- Let's define a X-TanevBot any 'robot' whose behavior can be evolved by maximizing the same information metrics (Snakebot is then the Snake-TanevBot)
- Can you imagine a different implementation of TanevBot?
- Ant-TanevBot inspired by Holk Cruse?
- Fish-Tanev Bot?
- Does gravity value matter for Snakebot and in general TanevBots
- Which are the pros and cons of TanevBots wrt 'GOF Robotics implementations?

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



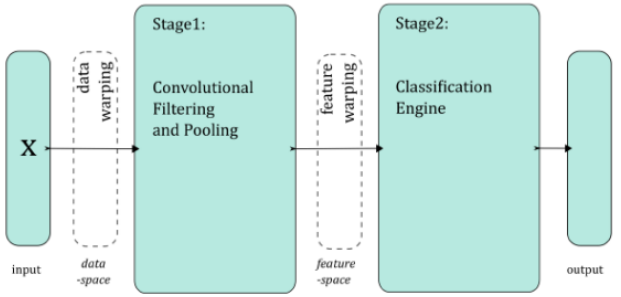
see: Tanev et. al, IEEE TRO, 2005

Kōan 15: Exploiting Data Augmentation techniques using Convolutional Neural Networks and Body Morphology

Proposed by: Abdul Haleem Butt, Xiaojuan Mo, MD Riaz Pervez

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

- Deep learning Constraints?
- Should we use simulation?What we should simulate? is it helpful?
- Understanding data augmentation for classification: when to warp?
- When it is better to conduct data augmentation in *dataspace* or *feature-space*?
- Design of Body Aware Convolution Neural Network for the Classification of Parkinson and Healthy Subjects



Sebastien C Wong, Adam Gatt, Victor Stamatescu, and Mark D McDonnell. Understanding data augmentation for classification: when to warp? arXiv preprint arXiv:1609.08764, 2016.

Kōan 16: Societal Issues

- Let's assume Oxford and Frey are right
- What should we do?
- Change working hours?
- Should organization of companies change?
- Political institutions?
- Role of the state?
- Role of the markets?
- Role of the citizens/parties?
- How this relate to Climate Change issues?

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

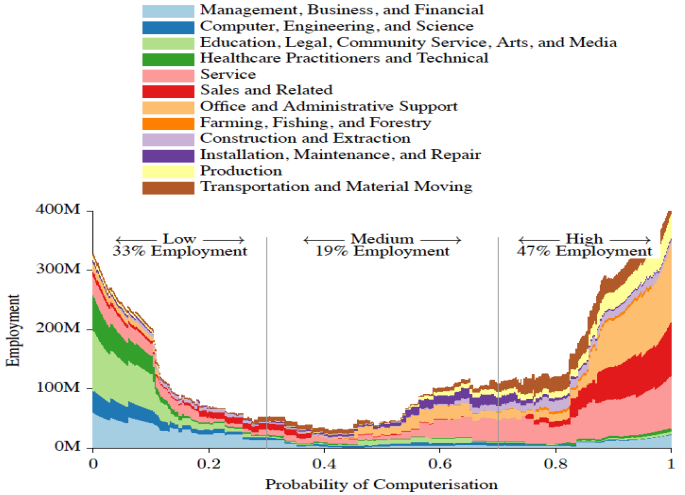


FIGURE III. The distribution of BLS 2010 occupational employment over the probability of computerisation, along with the share in low, medium and high probability categories. Note that the total area under all curves is equal to total US employment.

see: THE FUTURE OF EMPLOYMENT, C.B. Frey and M. A. Osborne, 2013

Kōan X: 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 6 in group)
- Contact us first, so we can help you organize:
  - Fabio Bonsignorio: fabio.bonsignorio@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 of the box required!**
  - **No single “correct” answer to any of the Kōans**

Students' TODOs

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

1. Register for participation in the kōans by December 10 23:59 CET
   - just drop an email by December 10 at the latest (please put [2020 Koans] in the subject)
   - Indicate your preferred ones (3 in order of preference)
   - You will be assigned group and tutor

2. When you are ready tell us, 6 months limit (6 May 2021 23:59 CET last deadline. Monthly cut-off dates until February then bi-monthly
   - just drop an email when you are ready to discuss