
Universidad Politécnica de Madrid
POLITÉCNICA
Engineering the future

Could robot fishes be used for leading schools of fishes?

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Centre for Automation and Robotics (CAR), UPM-CSIC

Workshop on 'A role for exercise in improving welfare in sustainable aquaculture'
Barcelona, Spain, July 2-3, 2010

FitFish Workshop on the Swimming Physiology of Fish

Outline

1. A brief State of the Art / Technology
2. Sheepdogs vs. school leaders
3. How to "fool" fishes?
4. Final considerations

Could robot fishes be used for leading schools of fishes?

Maurizio Porfiri et al.
Department of Mechanical and Aerospace Engineering
Polytechnic Institute of New York

See news at e.g. http://www.physorg.com/news195154190.html

Could robot fishes be used for leading schools of fishes?

Robofish leads the crowd to open up new studies in group dynamics

Published Monday 28th June 10

Leeds scientists have created the first convincing robotic fish that shoals will accept as one of their own. The innovation opens up new possibilities for studying fish behaviour and group dynamics.

It provides useful information to support freshwater and marine environmental management, to predict fish migration routes and assess the likely impact of human intervention on fish populations.

Jolyon J. Faria at al., Institute of Integrative and Comparative Biology, University of Leeds, Leeds

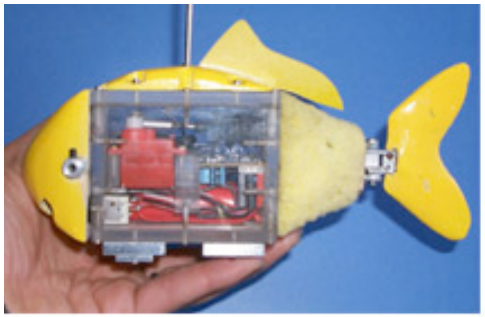
FROM: http://www.leeds.ac.uk/news/article/843/robofish_leads_the_crowd_to_open_up_new_studies_in_group_dynamics

Several examples of robot fishes can be found

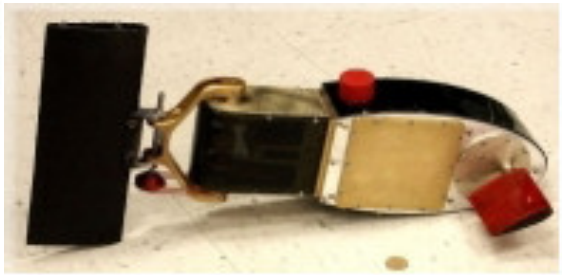
RoboPike - MIT

Jessiko V4 - ROBOTSWIM

Carp koi - Ryomei Eng.



PPF-04 - NMRI



Robofish - University of Washington

RoboTuna II - MIT

Robotic Shark

credits: http://www.robotic-fish.net

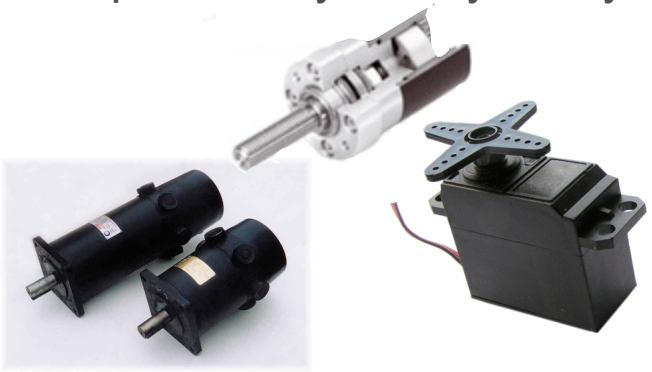
... and many more !

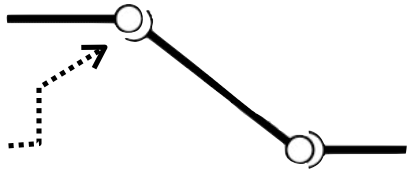
Several examples of robot fishes can be found

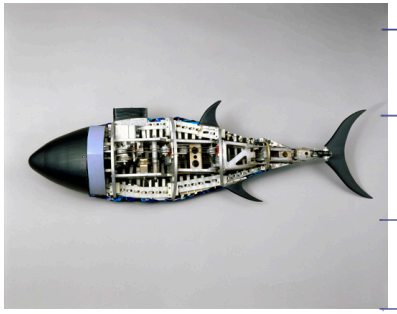
Current actuation technology:

- Electro-magnetic (motors/servos), pneumatic/hydraulic
- Movement transmitted by gearboxes, bearings, belts etc.

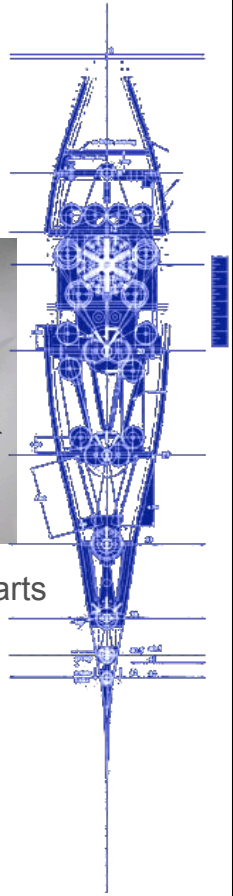
Complex, bulky, heavy, noisy...



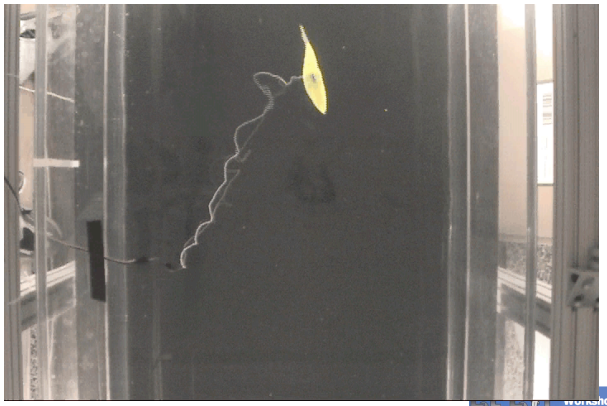




RoboTuna (MIT, 1994): **2,843** parts controlled by 6 motors



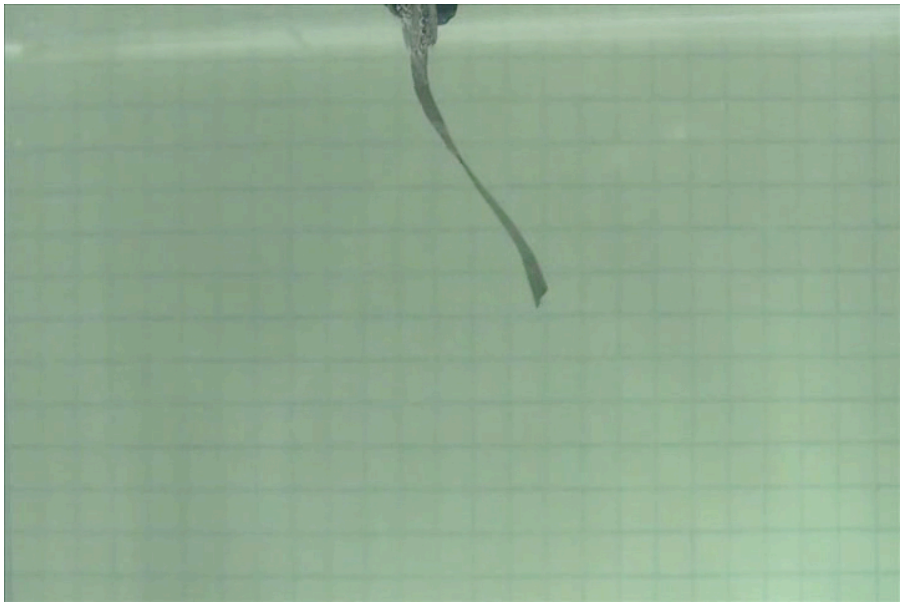
Few exceptions, e.g. Festo's **Airacuda** Pneumatically driven fish, MIT's "vibrating" fish

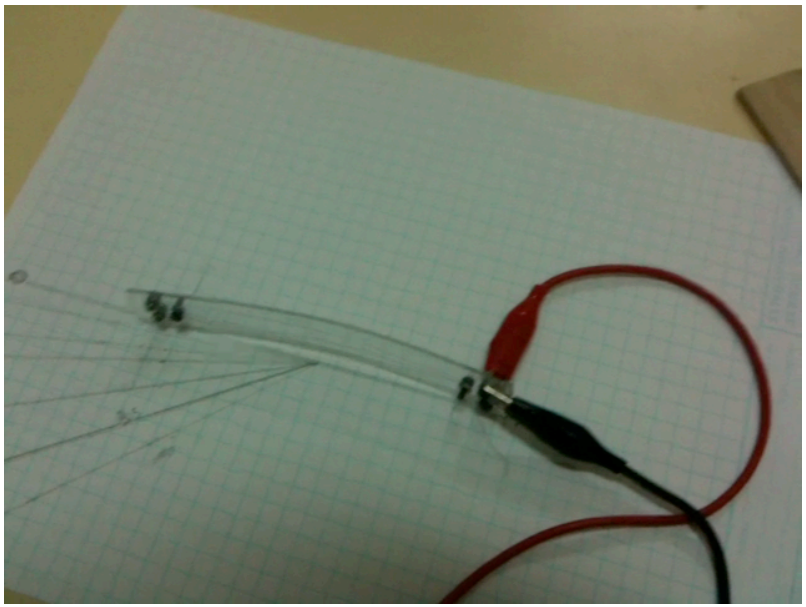


Emerging actuation technology:

- Smart materials (aka *functional* materials)
- Change shape according to electrical stimuli
  - Shape memory alloys
  - Electro-active polymers (big family)
  - Piezo-electric (composite) materials

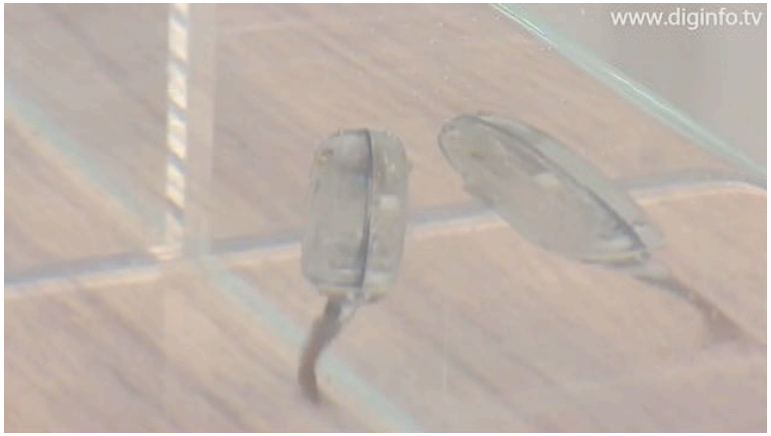
Light, quiet ... (but problems of strain, force, consumption)





Emerging actuation technology:

Allows more bio-mimetic designs

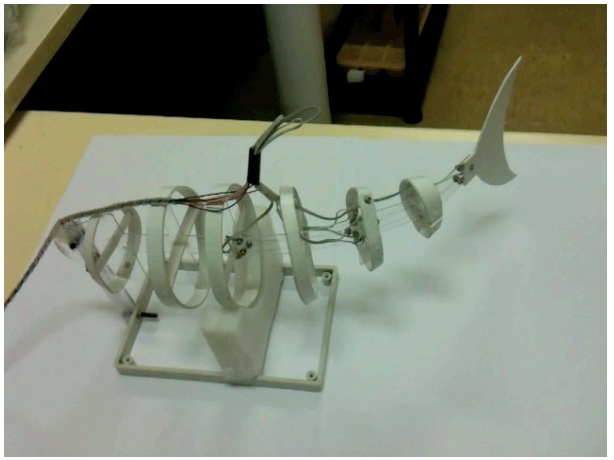


Yogo Takada,
Osaka City University
Graduate school of Engineering

Aiguo Ming, et al.,
Department of Mechanical Engineering and Intelligent Systems,
The University of Electro-Communications, Tokyo

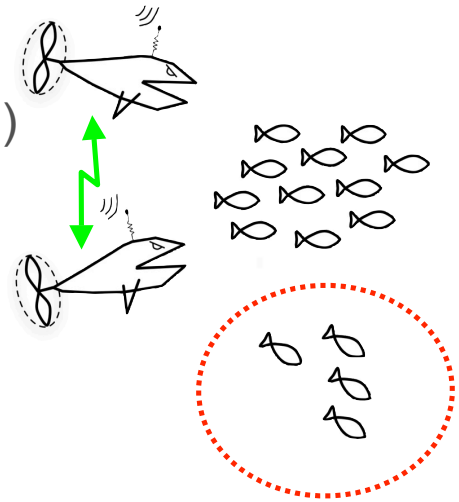
iTuna,
Centre for Automation and Robotics
Universidad Politécnica de Madrid

Fish robot toy,
EAMEX, Japan

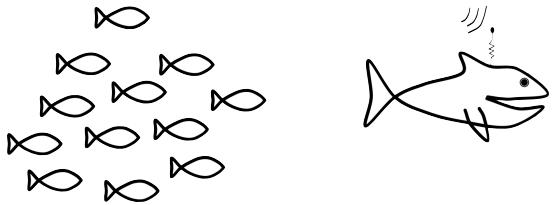


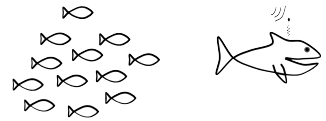
Can robot fishes be used for leading schools of fishes?

- Sheepdog robots
  - Any kind of underwater robot
  - Can use “standard” propulsion technology (propellers)
  - Simpler mechatronics, more complex “intelligence”
  - Perception a big issue
  - Need of multiple coordinated “sheepdogs”



- Leader robots
  - Must “fool” the school
  - Only one leader?





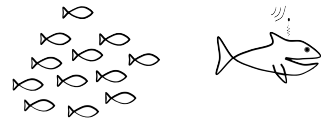
- Leader robots must “fool” the school
  - Appearance ?
  - Motion ?
  - Behaviour ?
  - Other signals (electrical, chemical) ?

- **Bio/zoo/ethological issues**
  - *Who and why is the leader ?*
  - Behaviour patterns
  - Perception (appearance)
  - Electrical/chemical (smell?)
  - Others ?

→

- **Technological issues**
  - Actuation (noise, vibrations)
  - Bio-mimetic mechatronics
  - Bio-mimetic motion patterns
  - Bio-mimetic behaviour patterns
  - Shape / appearance

- **NOTE: other technological issues**
  - operation time (batteries!)
  - reliability (robustness, safety)



Technological issues

- Actuation (noise, vibrations) ➜ New materials
  - Abandon electro-mechanical technology, towards *motor-less* and *gear-less* robots
  - A growing research field in Materials Engineering
  - Still not too much applied in robotics due to novelty and problems

✓ Bio-mimetic motion patterns
  - Swimming quite well studied, understood and applied as far as swimming
  - Huge gap in *manoeuvring* (fins based)

- Bio-inspired mechatronics design
  - Imitate fish physiology for a better implementation of motion patterns

✓ Shape / appearance
  - Not too difficult in principle

- Bio-mimetic behaviour patterns

- Other kinds of signalling

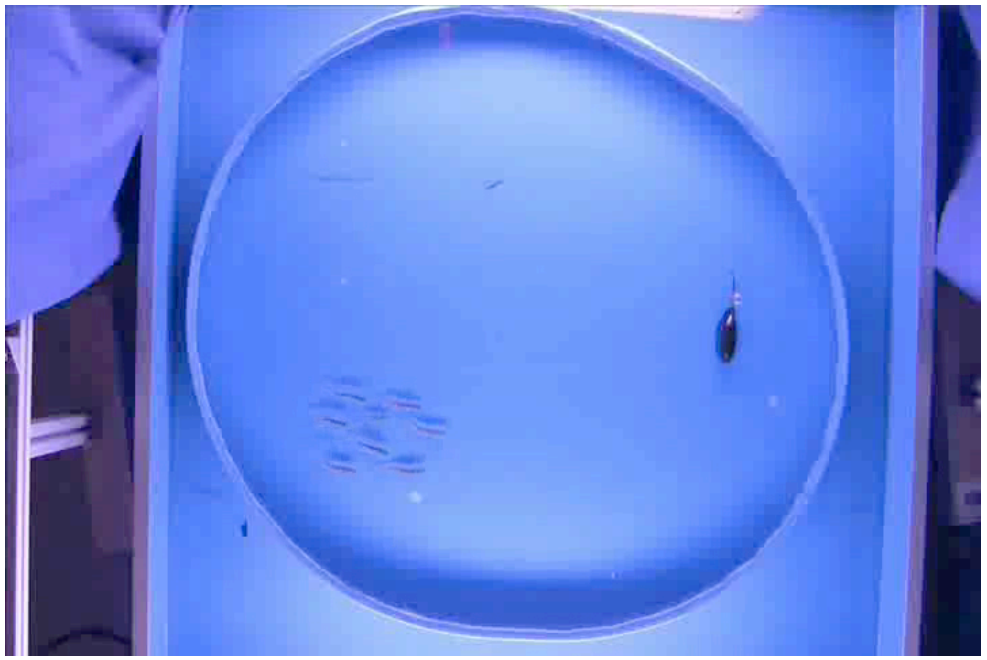
Need help from you !

Coelacanth - Mitsubishi Heavy Industries

Tai-robot-kun, Univ. of Kitakyushu, Japan

4. Final considerations

Maurizio Porfiri et al.
Department of Mechanical and Aerospace Engineering
Polytechnic Institute of New York

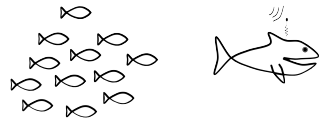


... is the robot recognised as a leader or is it just “curiosity” ?

- in the first case, why?
- in the second, how to maintain attention?

4. Final considerations

- Leader robot must “fool” the school
  - Appearance ?
  - Motion ?
  - Behaviour ?
  - Other signals (electrical, chemical) ?



- **Bio/zoo/ethological issues**
  - *Who and why is the leader ?*
  - *How many?*
  - Behaviour patterns
  - Perception (appearance)
  - Others ?

Thank you