SELF SENSING PNEUMATIC MUSCLE

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MARINE PROPULSION

Oars

Propellers

Biomimetics

Limitations:

- Lack of maneuverability
- Lack of obstruction avoidance
- Lack of flow tracking
- Corrosion
- Disturbance to marine life

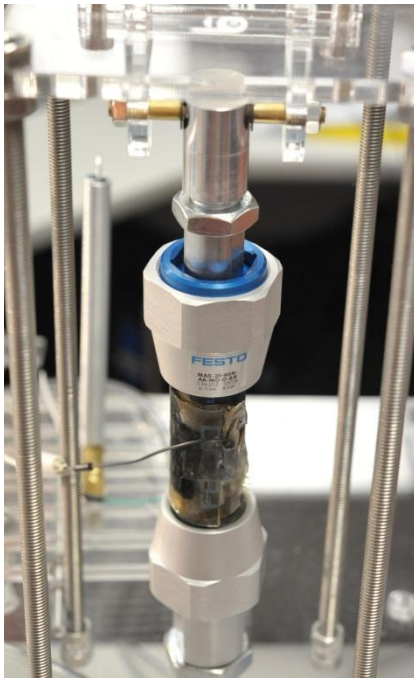
FISH PROPULSION

Proprioception

- Avoid obstacles
- Detect prey
- Active propulsion and maneuverability

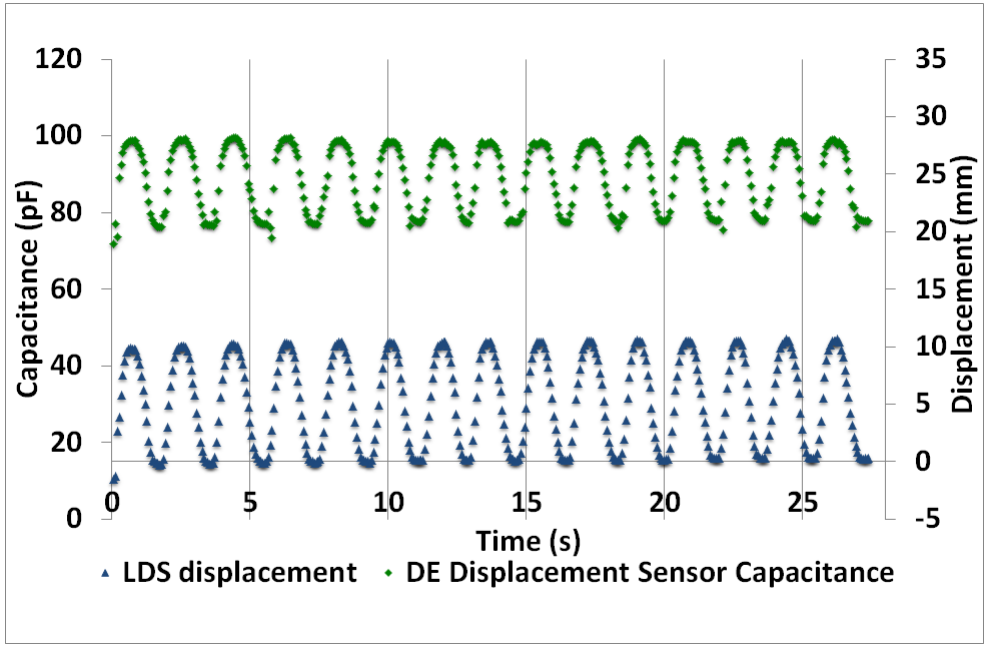
PRIOR ART

SUPERFICIAL SENSING



- ✓ Easy to attach and detach
- ✓ Easy and quick to manufacture
- ✓ Easily damaged
- ✓ Sensing surface only covers a fraction of the actuation area

SENSING PATCH RESULTS



SELF SENSING PAM

- Self sensing bladder
- Protected by silicon sheet and nylon mesh
- Sensing over entire actuation surface
- Extremely lightweight (10 g)
- Small dimensions

MANUFACTURING

1. Bladder: Medical grade latex tubing (Qcare 1/2x5/8x1/16)

2. Lubricating bladder inner surface area using baby powder

Paper cone

MANUFACTURING

3. Insert support rod.

4. Protect one electrode connection flap.

MANUFACTURING

5. Electrode Mixture: 1 part carbon black, 16 part kerosene, 4 part RS silicon.

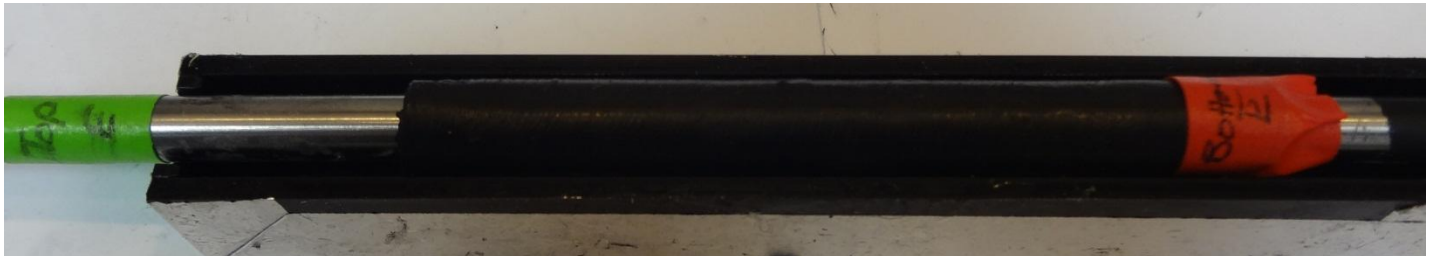
6. Paint electrode with soft bristle brush.

- Consistent electrode surface
- Thin layer
- Minimal inaccuracies

Stand to dry in fume cupboard for at least 1 hour.

MANUFACTURING

7. Remove protective label from first flap while covering the other flap.



MANUFACTURING

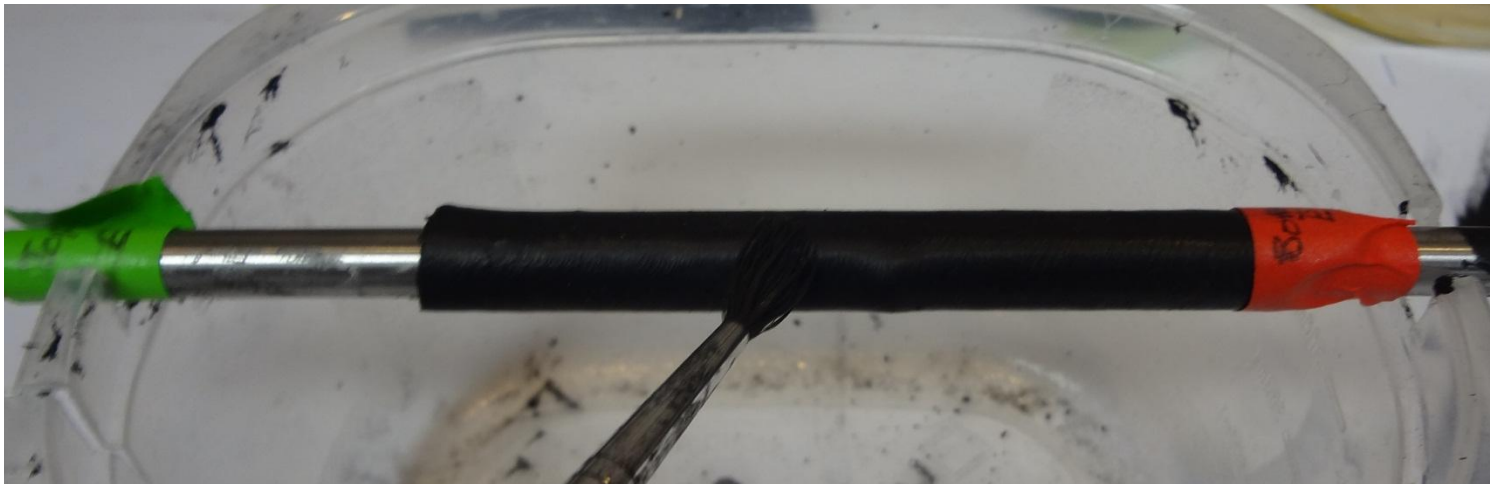
8.

- Dielectric mixture: 1 part RS silicon, 4 part kerocene
- Danfoss silicon sheet:
  - Width = bladder length
  - Length ~= twice the bladder diameter
- Brush small amounts on dielectric mixture onto silicon sheet with a small flat soft chisel.
- Carefully roll the dielectric over the muscle.
- Secure both ends and edge with a thin stroke of dielectric mixture.

MANUFACTURING

Let dry.

9. Paint second electrode layer.



MANUFACTURING

10. End Fittings:

- SMC reducder fitting: KQ2R06-10

- 10mm dia plastic rod

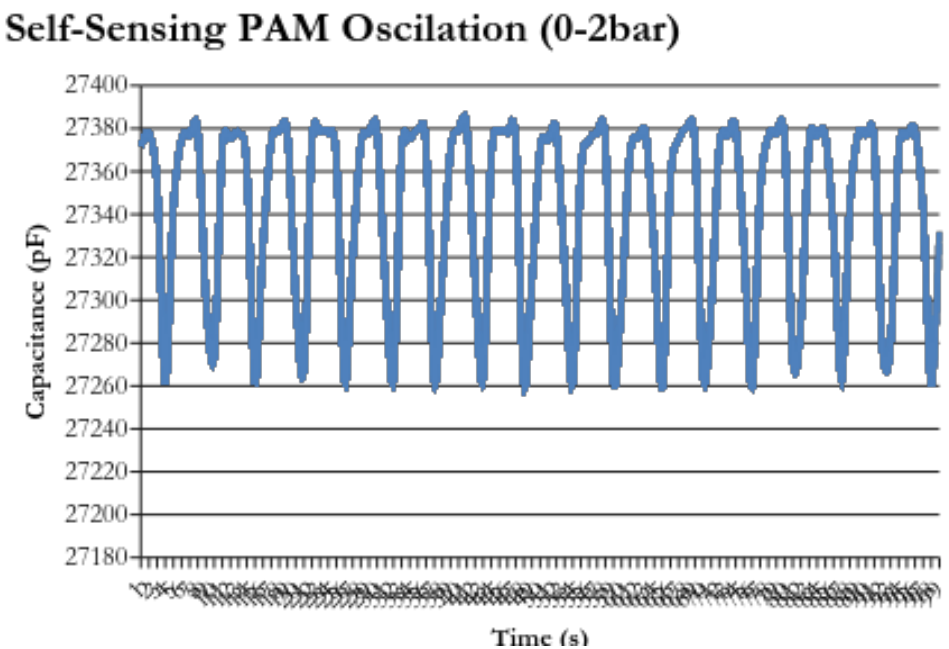
MANUFACTURING

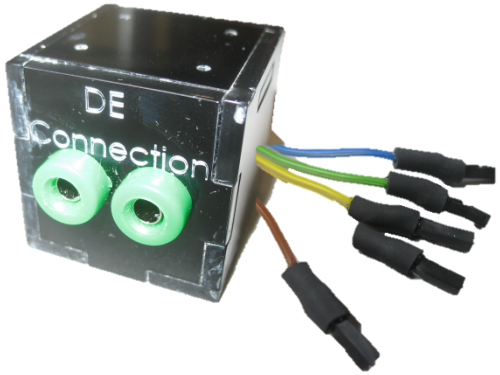
11. Nylon mesh (RS 170-5447)

Sizing in very important:

Diameter > 1-1.3 X bladder diameter works well

CAPACITIVE SENSING





FORCE TEST

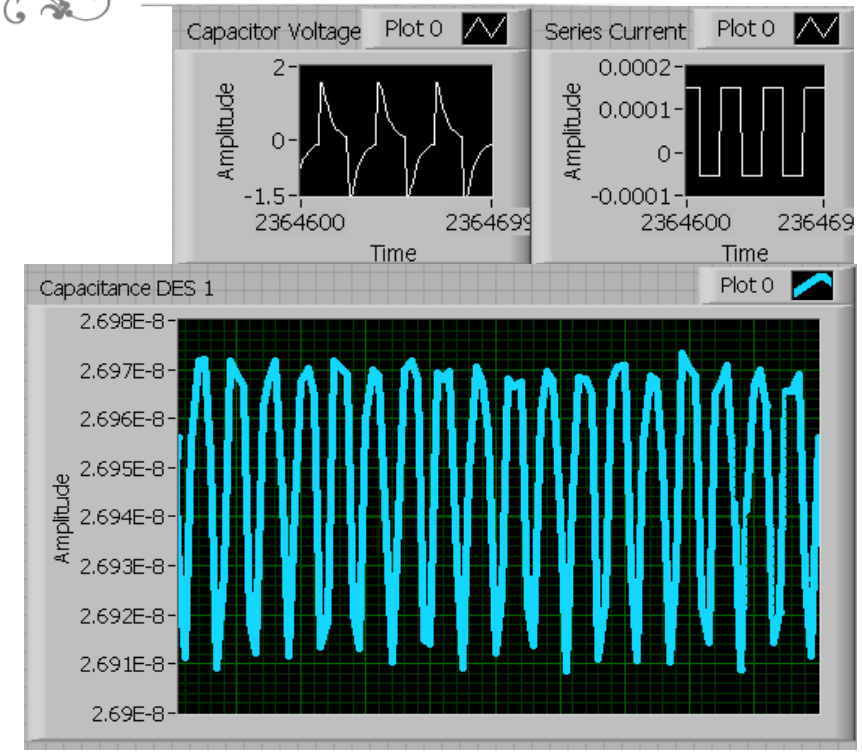
- $F = \frac{P}{A}$,

  $where\ F = force,$

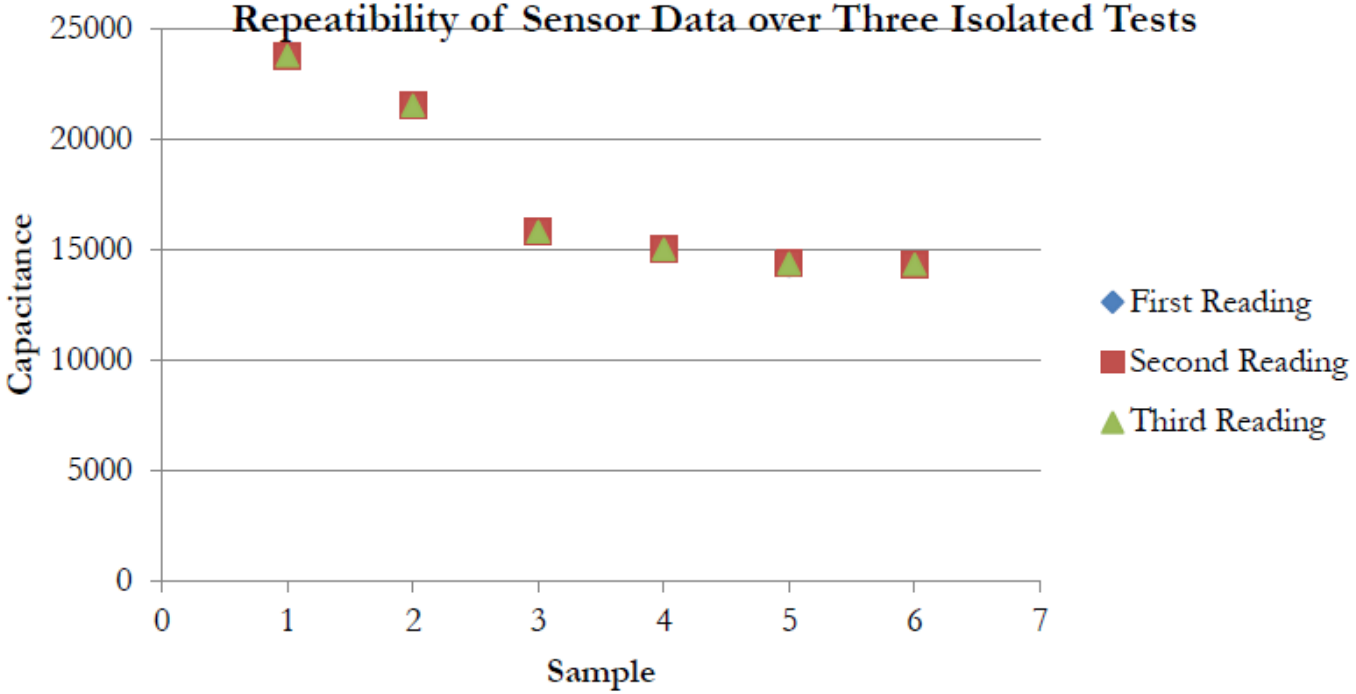
  $P = inner\ pressure,$

  $A = Muscle\ cross\ sectional\ area$

- $F = \frac{200KPa}{3.14E^{-4}} \approx 6.4\ kg$



REPEATABILITY OVER ISOLATED TESTS



FAILURE

- Failure at pressures greater than 3bar.

ADVANTAGES

- It does not need an exoskeleton to install rigid sensor, e.g. sliding and rotary potentiometers.
- Secondly, a higher accuracy and S/N ratio can be obtained by measuring the circumference displacement instead of directly measuring the axial displacement.
- The default position for the PAM is the relaxed state, as opposed to a pretension state required in past research.
- The sensor is along the entire circumference of the PAM and thus allows for an average value with reduced measurement error found in other sensors that are locally placed.
- The sensor is made from thin layers of carbon-silicon rubber which is inherently flexible and lightweight; therefore the flexibility and lightweight properties of the PAM are not lost.

FUTURE DEVELOPMENTS

- Application as robofish muscle
- Application as pump and valve
- Reducing size of dielectric
- Increasing operational pressure

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