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A soft robot arm that feels its own shape

Real-Time Embedded Shape Sensing and Closed-Loop Control of a Tendon-Driven Soft Continuum Robot

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An arm with no joints



Bends like

an octopus arm

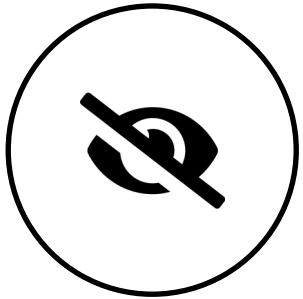
or an elephant trunk

Bends smoothly

Safe near people

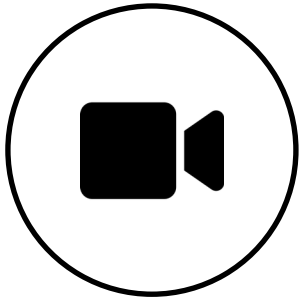
Tight spaces

The catch: a blind arm



Shape is hidden

no joints, no readings



No camera view

cannot see inside the body



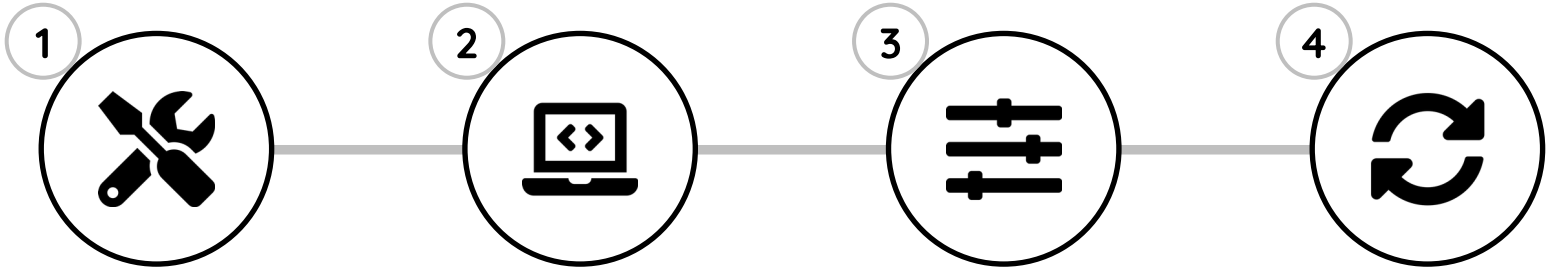
Sensors cost a lot

cheap ones drift

So how can a soft arm know its own shape, cheaply?

Our aim

Build a low-cost soft robot arm that feels its own shape and corrects itself.



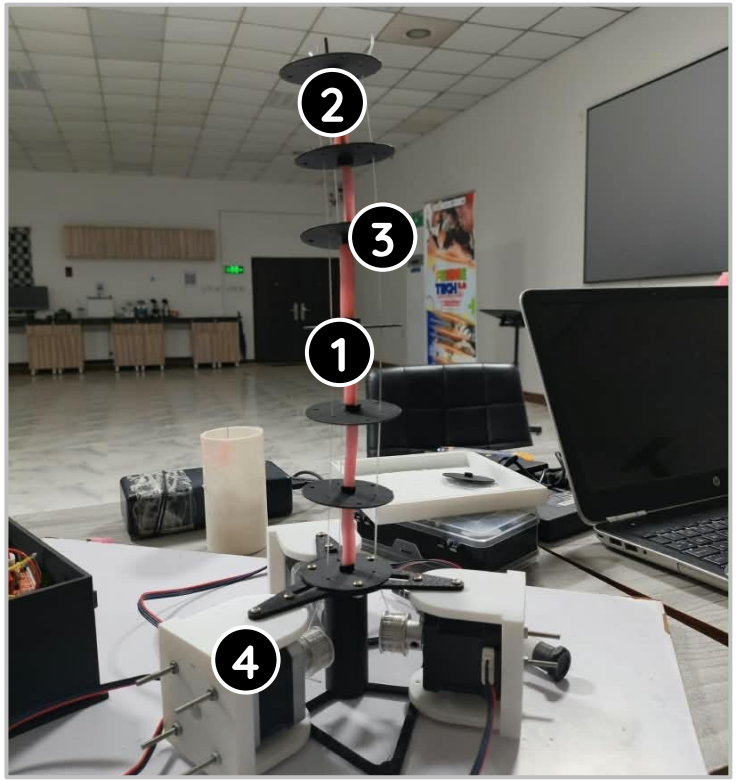
Build
the robot

Simulate
on a computer

Test
the real arm

Compare
with and without feedback

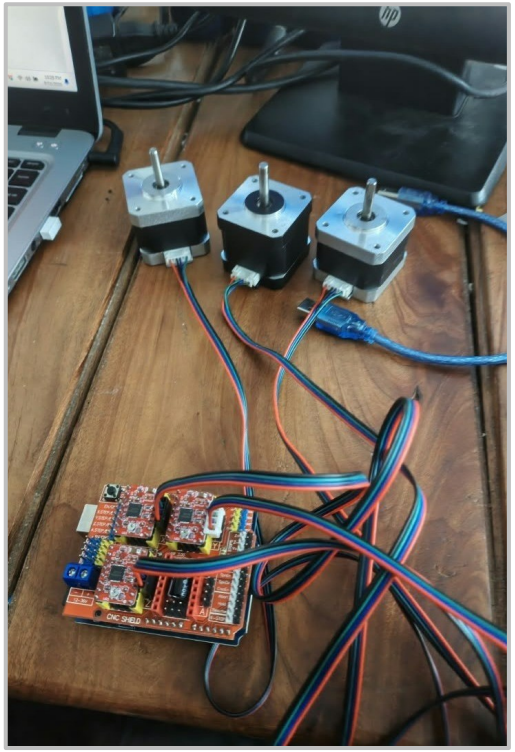
Meet the robot we built

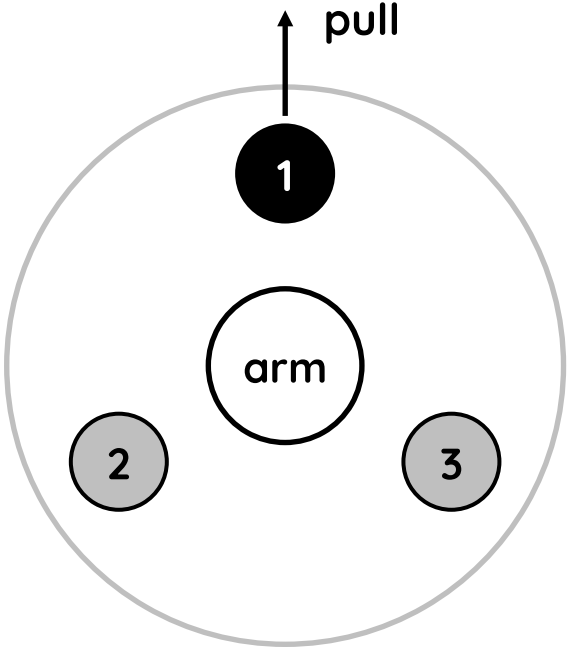


1. **Steel backbone**
   thin and springy
2. **Spacer disks**
   six, 3D printed
3. **Cables**
   three, evenly spaced
4. **Motors**
   one pulls each cable

About 30 cm tall

Pull a cable, bend the arm





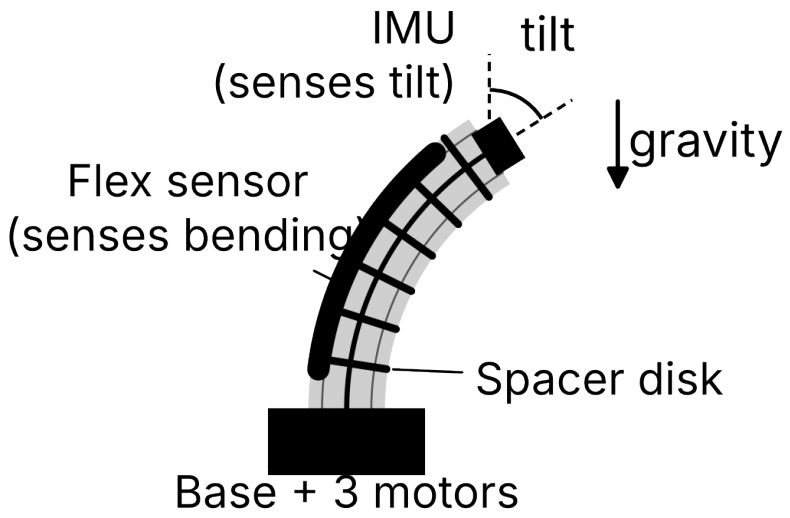
top view of the three cables

Pull cable 1,

and the arm bends towards cable 1.

Pull two together, and it bends in between.

How it feels its shape



Flex sensor

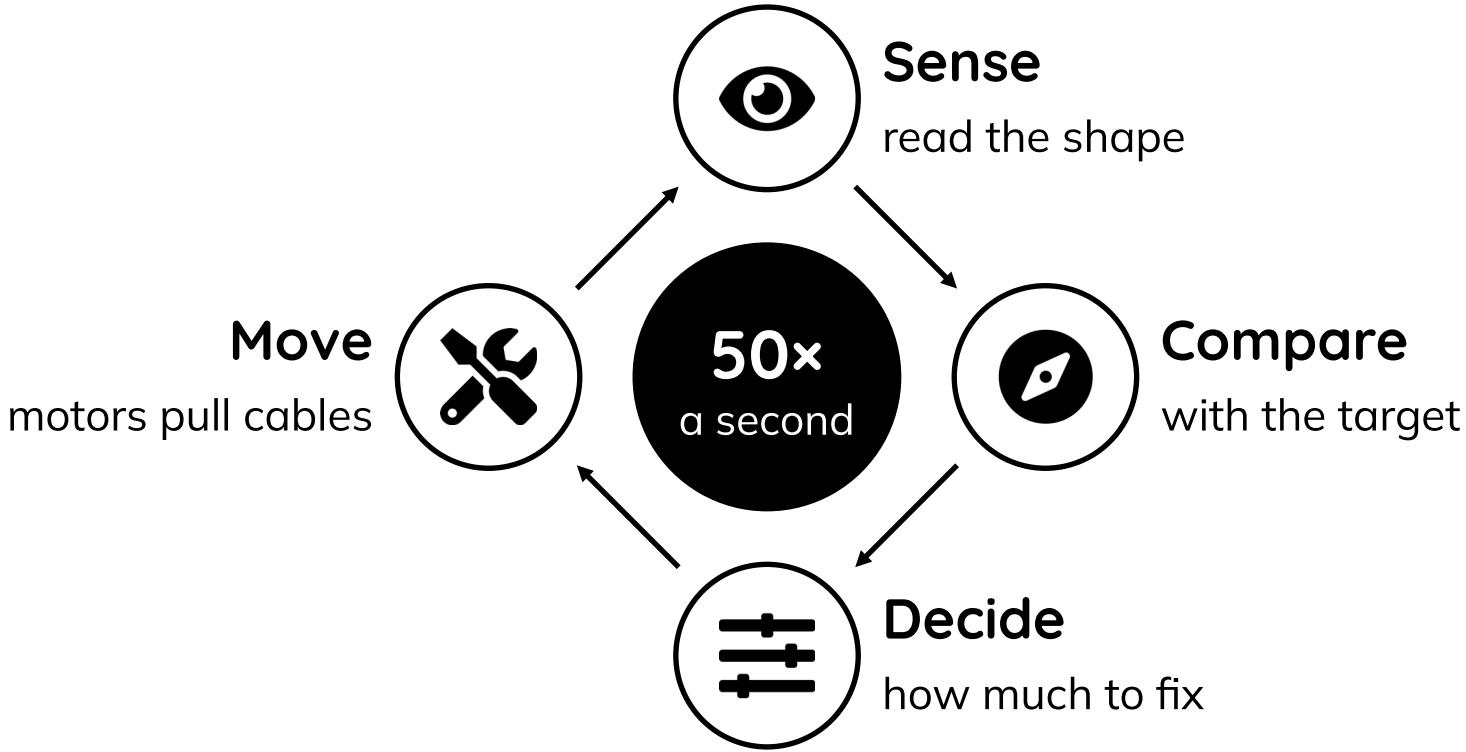
feels how much the body bends

IMU sensor

feels how far the tip tilts

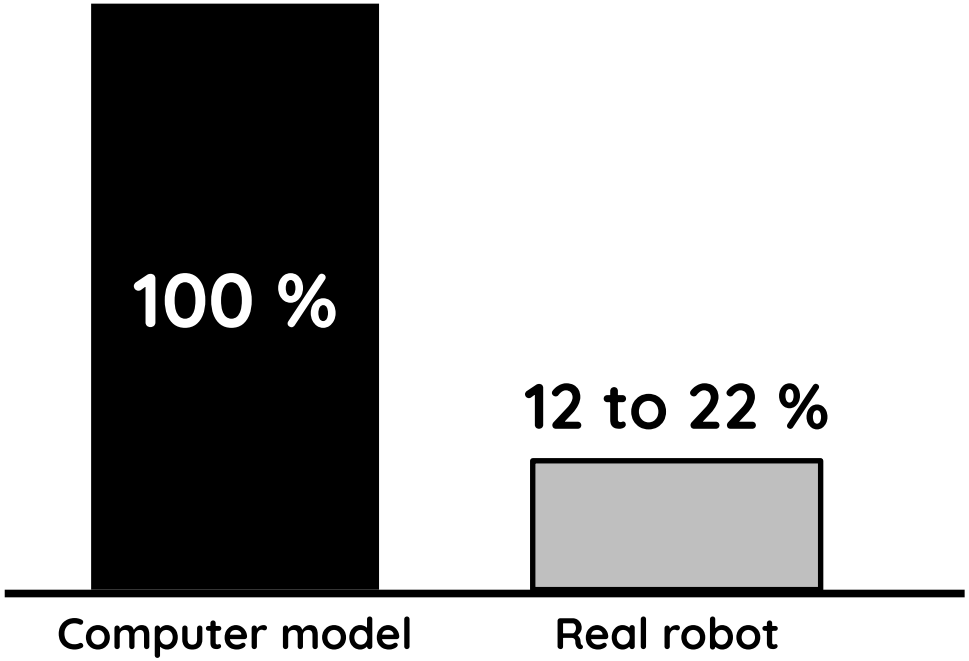
Together: one best guess of the shape

How it corrects itself



Model versus reality

How much the arm bends



The real arm bends much less than the maths says.

Friction, weight and stiff materials get in the way.

So it needs sensors and feedback.

How we tested

1



Simulate

on a computer

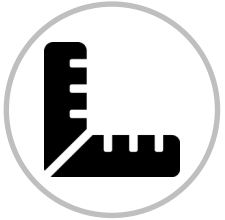
2



Check sensors

are readings steady?

3



Bend the arm

up to 40°

4



No feedback

motor steps only

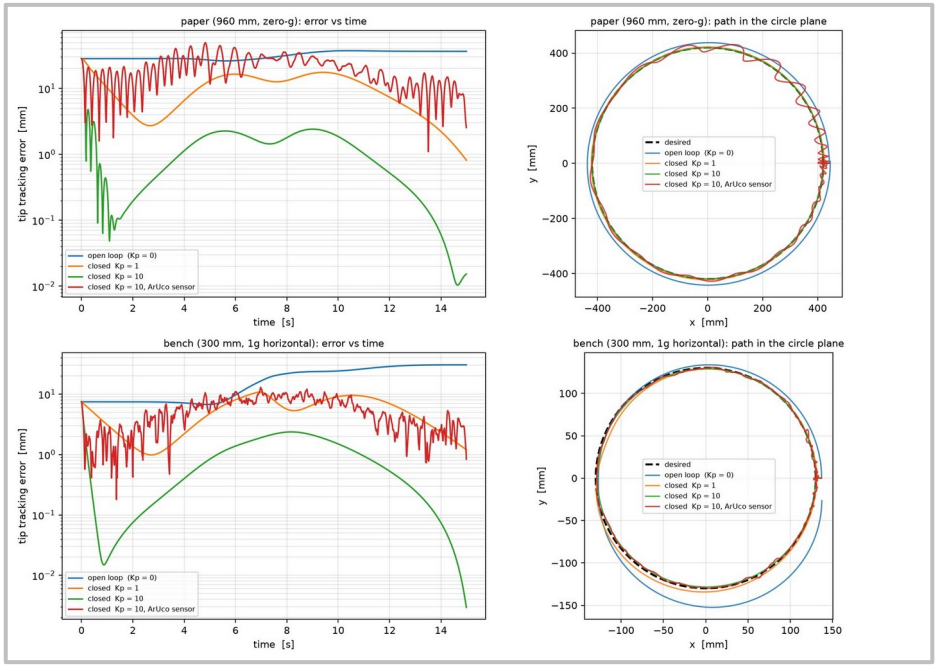
5



Feedback on

arm corrects itself

Result 1: the computer test



The arm traced a circle.

94 %
less error

Blue: no feedback
Green: with feedback

Result 2: the real robot





98.6 %
of the error
removed

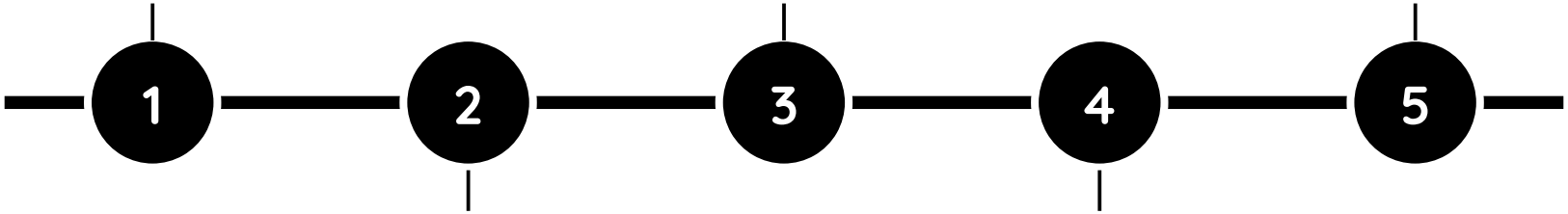
0.8 s
to settle on target

What comes next

Fine-tune
balance cable tension

Better sensor
a second flex sensor

Richer model
springier metal rod



Add a camera

confirm accuracy

All directions

use all three cables

Take-home message

Feels its own shape

two cheap sensors, no camera

Corrects itself

50 times every second

98.6 % less error

on the real robot



Thanks!

Questions welcome

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