Artificial Robotic Skins

Hydrogels which Sense and Heal

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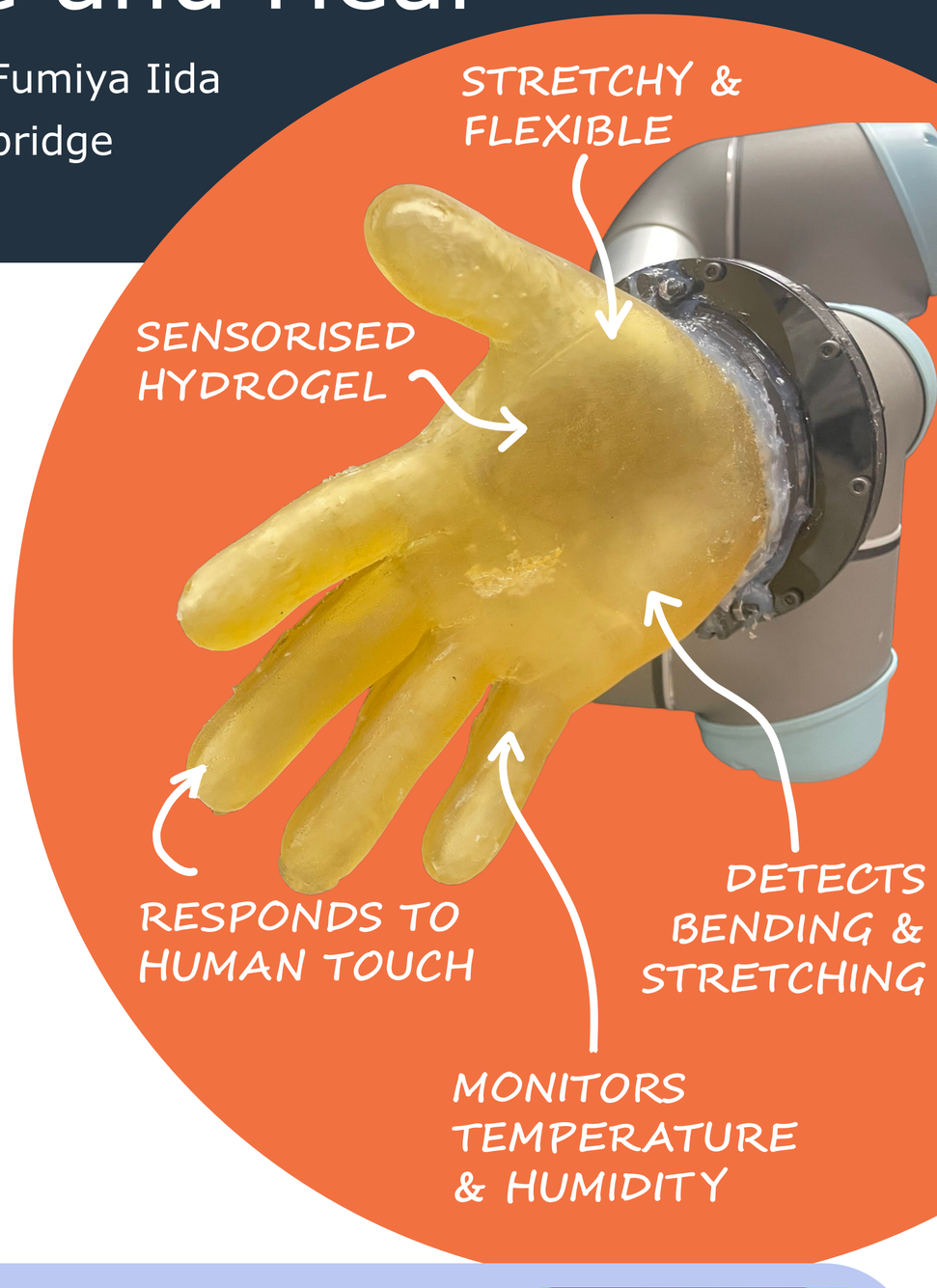
My research uses **3D-printable hydrogels** to make **sensorised skins** which can be wrapped around existing **robots** or **prosthetic devices**.



Why do robots need skins?

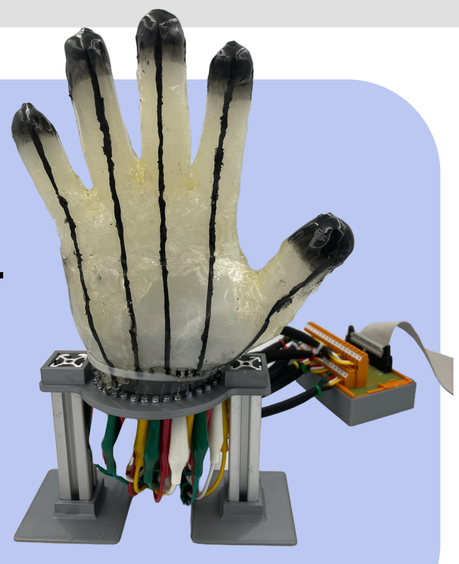
Human bodies are incredible multi-purpose machines which can perform much more complex physical tasks than our best robots.

In particular, our skins have a lot of jobs: they provide a barrier to the outside world, detect presses, forces, and temperature changes, and heal if we injure ourselves.

To make robots which can perform the same range of tasks as humans, we need to replicate these properties.

The Challenges

- All materials need to be soft to enable small-scale manipulation.
- Soft sensors tend to have very messy and nonlinear outputs.
- Multiple information channels are required, but every new connection is a fragile point.



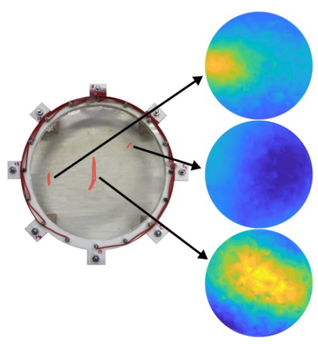
The Solutions

- Hydrogels are soft, flexible, and stretchable.
- Our gelatin-based hydrogel changes resistance linearly with strain.
- Electrical impedance tomography uses electrodes at the sensor's edges to map resistance changes inside.

Case Studies

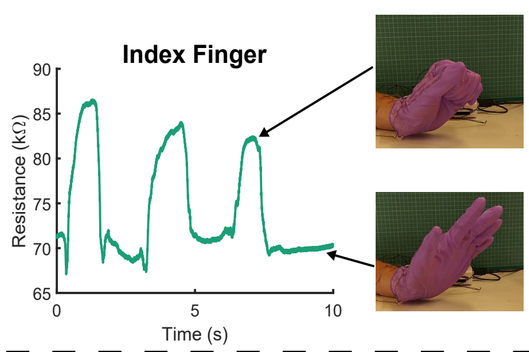
Soft Sensorised Membrane [1]

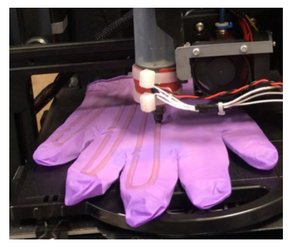
This skin learns to predict where it is being pressed by a robotic arm: using this knowledge, it can also reliably predict where it is damaged.



3D Printed Wearable Sensor [2]

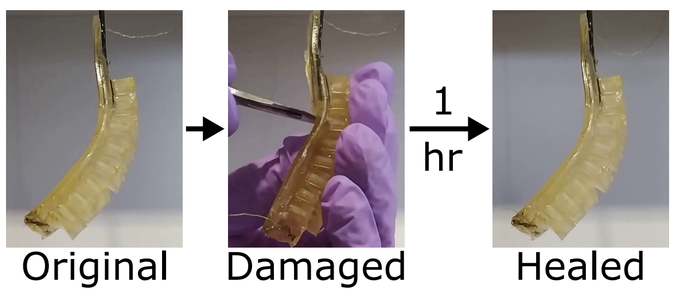
This glove can detect the hand poses of its wearer using 3D printed hydrogel channels.





Syringe-based extruder

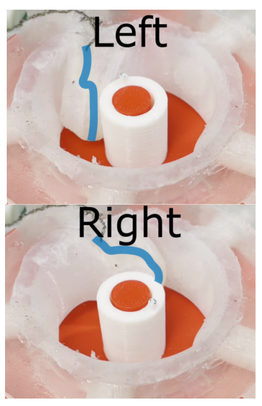
Self-Healing Pneumatic Finger [2]



Hydrogen bonding allows this hydrogel actuator to regain functionality after being pierced.

Localised heating gives even stronger healing.

Peristaltic Stomach Valve [3]



Engineers needed a way of sensing how their prosthetic stomach valves were deforming: to do this, I embedded hydrogel channels to into a skin.

Current work looks to integrate reliable **temperature and humidity monitoring**.

Once this has been added, we plan to extend beyond the hand seen here, creating the skin for a **fully-sensorised humanoid**.

REFERENCES

1 **David Hardman**, Thomas George Thuruthel, Fumiya Iida (2023), *Materials Today Electronics*

2 **David Hardman**, Thomas George Thuruthel, Fumiya Iida (2022), *NPG Asia Materials*

3 **David Hardman**, Ryman Hashem, Fumiya Iida (2023), *International Conference on Soft Robotics*

WATCH VIDEO HERE!

www.dshardman.co.uk