DESIGN AND FABRICATION OF ARTIFICIAL SKIN USING EMBEDDED MICROCHANNELS AND LIQUID CONDUCTORS
CRITICAL TECHNOLOGY.

Robots are expected to work more autonomously.

Biomedical science has made a lot of progress.

The robotics community comes closer towards the realization of skin-like tactile sensing.

Flexibility and stretchability expands the scope of applications of sensors.

Pressure sensors and tactile interfaces must be elastically soft and remain functional when stretched to several times their natural length.
Due in part to their simple structure, skin substitute and cartilage replacements were the first engineered tissues to reach the market.

Besides serving as burn coverings, engineered skin substitutes can help patients with diabetic foot ulcers.

‘DERMAGRAFT’ healed more chronic ulcers and healed them faster, than conventional therapy alone.
To start the process, the foreskin cells are separated into two types: dermal fibroblasts and epidermal cells.

- Tissue growth occurs over 20 days in several stages.
- First, the lower, or dermal, layer of skin grows on a scaffold made of collagen (from cows), which is set in a shallow, round dish well-bathed in nutrient medium.
- Then a technician adds epidermal cells, which spread over the dermis to form the upper skin layer.
- Finally, the skin is lifted out of the culture bath so the top is exposed to air.
- The first step would be to automate the addition and removal of nutrients.
- An electronically controlled system would make the process more precise and reproducible.
A particular type of conductive liquid materials i.e., eutectic gallium-indium (EGaIn).

Due to its high surface tension and high electrical conductance, EGaIn is an ideal conductor for a soft sensor.

When the microchannels filled with EGaIn are deformed by either pressing or stretching.
Strain Sensing

- The design concept of strain sensing is adapted from a rubber strain sensor that contains mercury in a rubber tube.
- When the material experiences strain in the axial direction of the channels, the overall channel length increases and the cross-sectional areas of the channels decrease.
This results in an increase in the overall resistance of the channel. Since the microchannels are filled with EGaIn, the strain sensor is highly flexible and stretchable.
Pressure Sensing

Pressing the surface of the elastomer skin decreases the cross-sectional area of the microchannels and increases their electrical resistance.
Skin design

Polymer-based sensors generally have a certain amount of hysteresis.
The sensor prototype was fabricated using a layered molding and casting process, as shown in Figure (a) and (b). The first step is to cast separate sensor layers. The second step is to bond layers to make a single sensor structure.
In the final step, EGaIn is injected into the microchannels using two syringes. One syringe injects EGaIn, and the other syringe extracts air captured in the microchannels Figure(g).
Figure shows the experimental setups for three different calibration tests: x and y-axis strain tests and z-axis surface pressure test.
Strain Response

The strain response of the skin prototype was calibrated by applying axial strains in two perpendicular directions, the x and y axes.

Pressure Response

z-axis pressure response is characterized by applying compression multiple times at the center of the top surface of the skin with a flat circular surface.
Hysteresis Analysis

- Polymer-based sensors generally have a certain amount of hysteresis. All the calibration test results contain loading and unloading loops to characterize the hysteresis levels is shown in fig.

- While the prototype displays negligible hysteresis in strain sensing, it shows noticeable hysteresis in pressure sensing especially in a high pressure range over 40 kPa.
1 Stimulus Differentiation

- Since the signals from the three sensor layers displayed different responses in each experiment, the prototype is able not only to measure the magnitude of the stimulus but also to identify the type of stimulus.
  1) If $V_1 > 0$ and $V_2 < 0$, the stimulus is $x$-axis strain,
  2) If $V_1 < 0$ and $V_2 > 0$, the stimulus is $y$-axis strain,
  3) If all three sensor signals are positive, the stimulus is $z$-axis strain.
Humanoid robots, robotic prosthetics, soft wearable robots human-friendly robots for human-robot interactions (HRI) and human-computer interface (HCI).

Due to the highly flexible and stretchable properties and thin form-factor, this soft skin technology can be directly integrated with any type of soft actuator.
Pulsed ultrasonic sound techniques may be used for:
- Imaging of skin structures
- Measurements of blood flow in the skin.

Multifrequency shear wave method may be used for:
- solve mechanical properties of epidermal tissues.
The main contribution of this work is the design of a multi-layered soft artificial skin and the development of a novel fabrication method. The current design provides multimodal sensing capability requiring no additional sensors.
ARTIFICIAL SKIN

SREEPRIYA

INTRODUCTION

ONLY SKIN

DEEP...

SKIN FACTORY

DESIGN

strain sensing
pressure sensing
skin design

FABRICATION

CHARACTERIZATION

Strain response
Presssure response
Hysteresis analysis
Stimulus differentiation

APPLICATIONS

PROMISING POSSIBILITIES...

CONCLUSION

Gratitude

THANK YOU