Morphological design for a prosthetic hand: bone curvature and ridged skin

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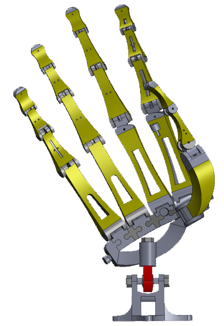
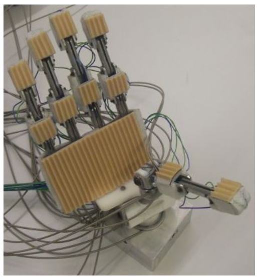
In this work, we propose two approaches for a robotic prosthetic hand that exploit the morphological properties of the human hand: (1) A lightweight robotic hand structure and (2) an artificial ridged skin for tactile feedback. Both approaches emphasize on the importance of morphological properties, rather than relying on computationally heavy means of achieving equivalent functionality.



Objective and motivation

The human hand is one of the most complex structures in the body, with large regions of the brain devoted to it. Traditional engineering approaches have mostly attempted to match such complexity without sufficiently stressing on the underlying mechanisms that its morphology encodes. We argue that by studying the morphology and biomechanics of the human hand, we can extract principles and concepts that can be used for advancing prosthetic research.



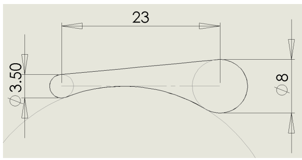
The artificial bone structure

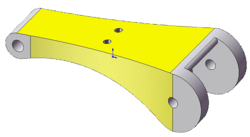
We propose a lightweight robotic hand employing a curved bone structure that matches the capabilities of heavier robotic hands without sacrificing structural integrity.

Such a bone structure has been shown to exhibit reduced strain in contrast to an identical straight one.

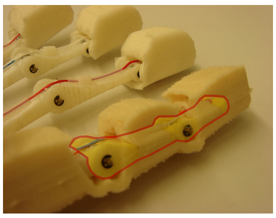
We designed a simple curved bone segment, with four variables:

❖Joint radii *R1*, *R2*;
❖Tangent curvature radius *R*;
❖Segment length *L*.





This curvature can be exploited to minimize the segment's volume, with the following benefits:



❖Decrease of gross skeletal weight

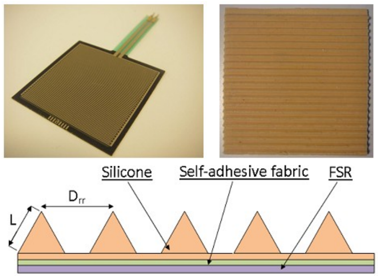
❖ Volume/weight gained utilized for additional sensory modalities

The artificial ridged skin

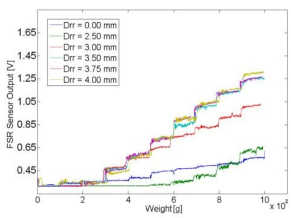
We propose an artificial skin able to encode, through its morphology, the tactile feedback of a robotic hand manipulating an object.

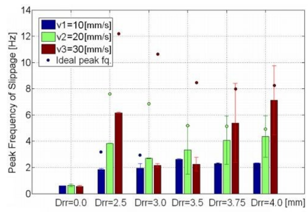
❖ Force Sensitive Resistor (4x4 cm)

❖Silicone ridges of triangular shape *L=2.5mm* and inter-ridge distance *Drr*

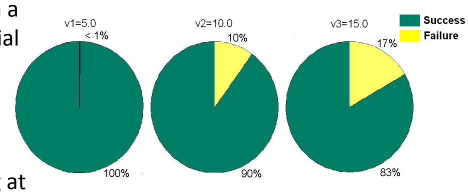


The silicone ridges affect the magnitude of grip and slipping frequency of an object. The skin with *Drr = 4mm* performs better in differentiating both weights and slippage frequencies.





Utilizing such a ridged artificial skin, a robot hand is able to grip and stop objects from slipping at various velocities *v (mm/s)*.



Conclusions

Pinpointing the role morphology plays, we can use it to filter information in such a way that the computational complexity is reduced. Consequently, the cognitive effort of a user interacting with such a device will be mitigated, allowing for smoother human-robot integration.

References

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