Laser-Etching Flexible Sensors For Robotic Touch Recognition

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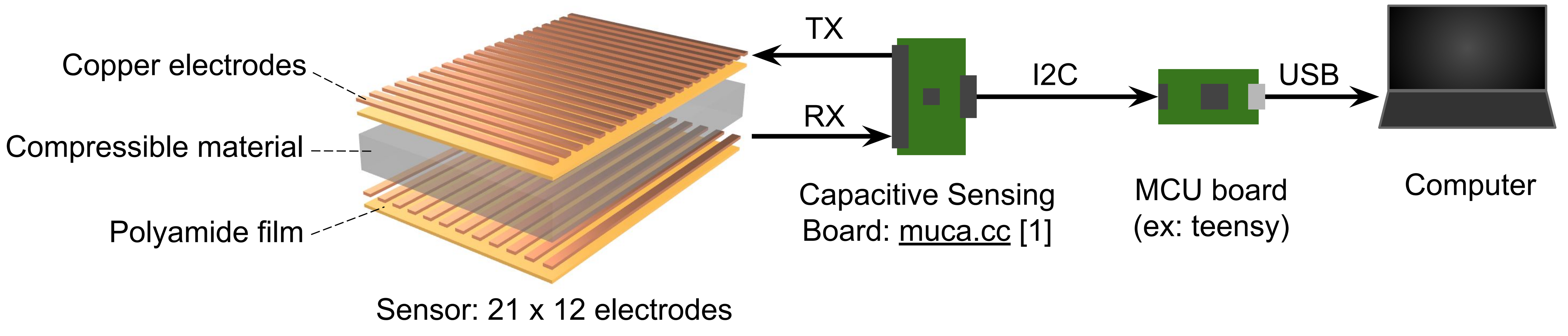
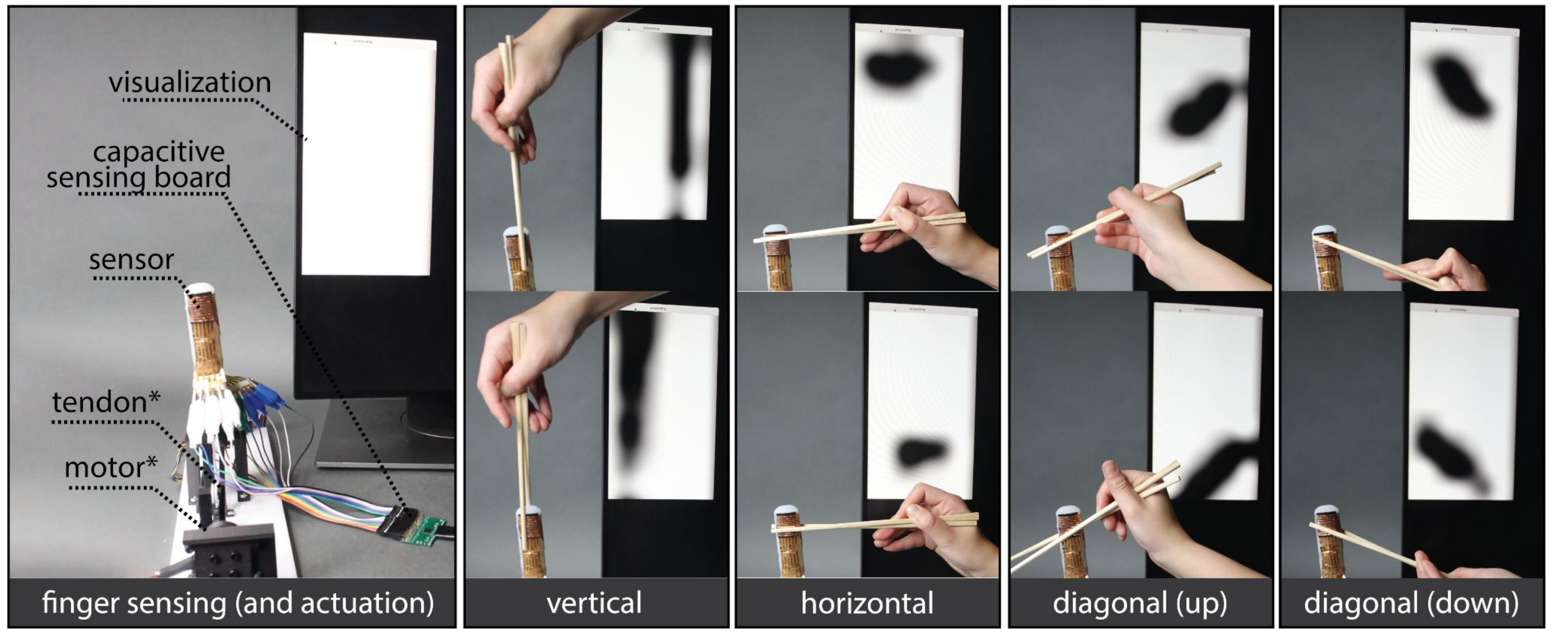
Abstract
We present a robotic touch sensor fabrication method that repurposes touch screen sensors, for flexible and robust sensing applications. This sensor allows high-level data processing such as block tracking, which can enable real-time slip detection. To fabricate the sensor, we laser traces in copper tape with a q-switched laser (also called “fiber laser”), and use Kapton tape (polyamide film) as a substrate, which ensures flexibility. The sensor can be robust thanks to encapsulation with a latex glove finger, or silicone coating. Our approach has the potential to provide an affordable and customizable solution for various sensing applications.

Sensor Fabrication
Our sensor consists of five layers: horizontal copper traces, polyimide film, compressible material, vertical copper traces, and another layer of polyimide. The copper traces were laser cut using a fiber laser cutter with a wavelength of 1064 nm on a substrate of polyimide tape. This process allows for precise patterning of the copper traces. The compressible material (3d mesh, or spacer fabric) was placed in between the copper traces and polyimide layers to enable allow variable capacitive sensing. The layers were then assembled together on the surface of a robotic finger [0] (also denoted with a star* in the photos), creating a robust and flexible sensor that can be used in a wide range of sensing applications.

System Architecture



Advantages
- **Robustness:** Our approach is more robust than conductive ink printing because sintered ink tends to crack when deformed. Using laser patterning on copper and Kapton tape, our sensors offer greater durability and longevity. Also, its stretchability can be enabled using accordion folding structure.
- **Affordability and scalability:** Our approach offers an affordable and scalable solution as laser patterning has a limited set-up cost compared to other processes such as injection molding or 3D electronic functionalization. This makes our approach accessible to a wider audience and allows for the production of sensors at a larger scale.
- **Computer vision possibilities:** Our capacitive sensing chip enables the implementation of simple computer vision techniques, such as blob tracking. This allows for real-time slip detection, making our sensors useful for applications such as grip force monitoring in robotics or slip detection in wearable devices.



finger sensing (and actuation) | vertical | horizontal | diagonal (up) | diagonal (down)

Data Processing
We connected the electrodes from the sensor to a capacitive sensing board [1]. It sends its data to a microcontroller which can be used to actuate accordingly, and/or display the processed data in a computer.
The code is open source: github.com/HCIELab/MuCa_Finger
Video demonstration: is.gd/MuCa_Finger

Future work
- **Physical interpolation:** To improve the sensing resolution and allow for more algorithmic possibilities, we can use interdigitation between electrodes to achieve physical interpolation [2]. This would enable more precise sensing and interpretation of data at the intersection between electrodes.
- **Active shielding:** Adding an active shielding mechanism to protect from capacitive sensing interferences caused by touching metal would be beneficial. However, an extra conductive layer would be needed, which may decrease flexibility slightly.

References

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