Quantitative Assessment of Tongue-Trackpad Device Accuracy Using a CNC-machine

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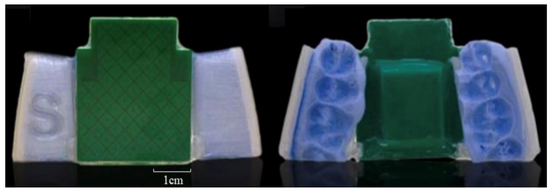
Introduction

Our team has developed the Tongue-Trackpad, an intra-oral tongue movement tracking wearable device [1].

Tongue Trackpad



Purpose:

Ensuring the precision and accuracy of the device which detects contact via capacitive sensing is critical. The quality assurance device and protocol developed in this work aims to reduce experimental error by ensuring the accuracy of each Tongue-Trackpad device prior to experimentation.

Methods

Experimental Tools:

- Computer Numerical Control (CNC):
  - Arduino UNO R3, GRBL firmware
    - G-code
      - Perform 12 linear passes across the sensing surface, advancing in 2.5 mm increments at constant velocity

Custom Hardware:

- Tongue-Trackpad Mount
- Connector from CNC to grounded ‘Simulated Touch’ head
- Electrically grounded ‘Simulated Touch’ CNC head

Data:

- Capacitive touch grid Tongue-Trackpad
  - Cartesian coordinates of touch position

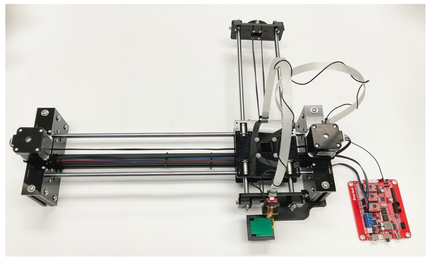
Analysis:

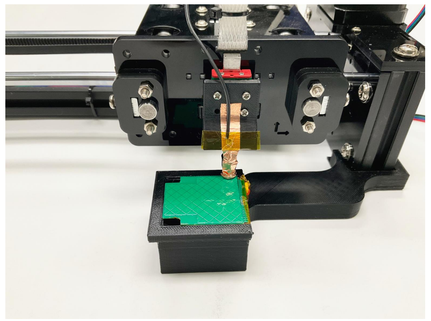
- Expected positions interpolated to real-time sensor timestamps
- Remove 0.5 mm border of edge points
- Identify rows by 2.5 mm perpendicular deviation
- Calculate mean positional accuracies, defined as the absolute deviation between expected and measured positions

Results

Experimental Setup

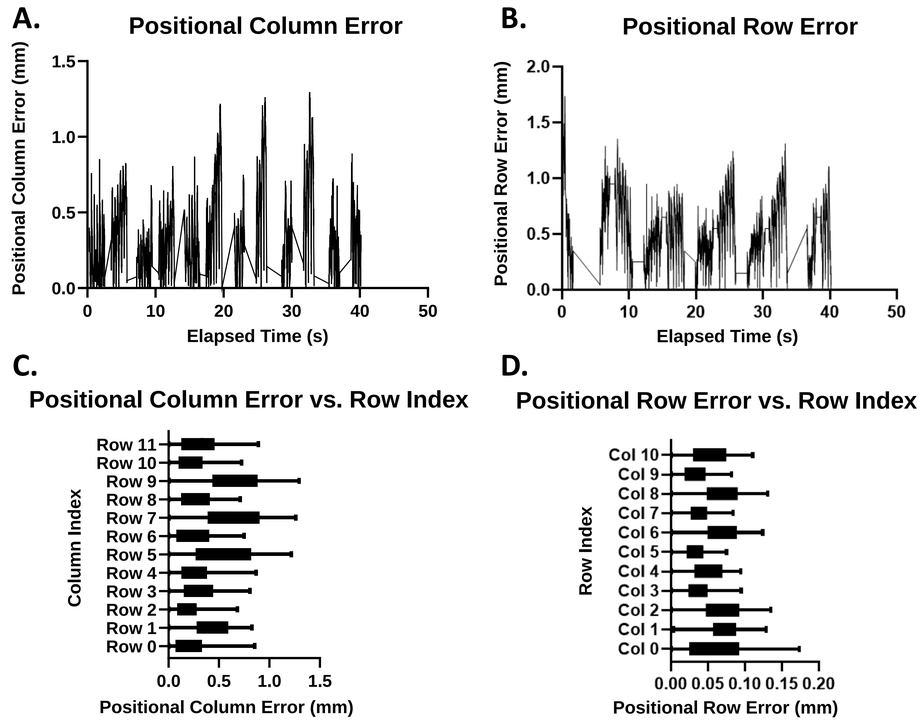
CNC fitted with a grounded ‘Simulated Touch’ of 1 cm in diameter contacting the Tongue-Trackpad

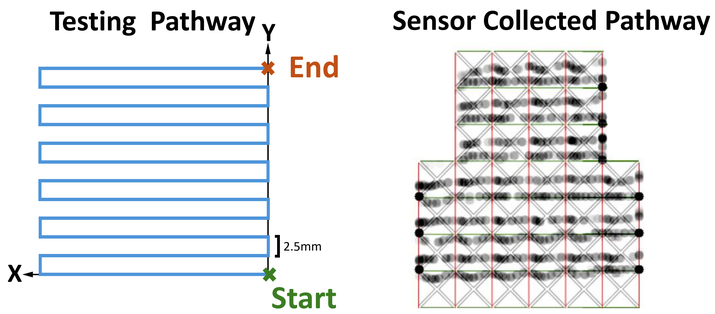




Positional Error Over Time and Rows

A. Positional accuracy over elapsed experimental time. Mean error of 0.36 ± 0.27 mm across columns **B.** Percent error of positional accuracy over elapsed time. **C.** Box-and-whiskers plot of positional accuracy over elapsed experimental time. **D.** Box-and-whiskers plot of percent error of positional accuracy over elapsed experimental time





Conclusions & Future Directions

We presented a custom CNC device and accompanying protocol designed to assess the positional accuracy of a single Tongue-Trackpad prior to human experimentation. The trackpad demonstrated mean positional accuracies, defined as the absolute difference between the actual and measured positions, of 0.36 ± 0.27 mm along the columns and of 0.53 ± 0.29 mm across the rows.

Moving forward, we aim to use the developed device and protocols to simulate a range of tongue contact patterns and sizes, conduct saliva simulation experiments, and precisely detect capacitance changes across all sensors

References

[1] V. Bratland et al, “Statistical evaluation of tongue capability with visual feedback,” *J. Neuroeng. Rehabil.* vol. 21. Jan. 2024.

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