MagX

/ˈmæg ˈeks/

Untethered, Mobile Hand Tracking with Passive Magnets

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Nintendo Power Glove

DESIGN FEATURE

INSIDE STORY ON...

Combine the hottest video game with a $10,000 computer peripheral, shape it into an inexpensive yet futuristic 'glove,' and you've got this year's smash toy

Dana L. Gardner, Associate Editor

THE POWER GLOVE

Throw away your joysticks, kids. Punching out the heavyweights and zapping alien spaceships on your home video screen has evolved from two-dimensional wrist-wringing to 3-D arm-swinging. The Mattel Power Glove® has elevated the level of video interaction by an order of magnitude—the difference between a toggle switch and a ray gun.

In design terms, a versatile, $72 commercial product—replete with sensors, programmable keypad, and microprocessor—was quickly gleaned from a $10,000 computer peripheral used by NASA robots in space. Teams of engineers on both coasts bridged the price and application gaps so quickly that even the Japanese decided it would take too long to develop their own.

Ever since Japan's Nintendo Entertainment System® and video game cartridges invaded the minds of America's youth a few years ago, toy designers and inventors have been scrambling to devise the next generation of electronic games. Abrams Gentile Entertainment, Inc. (AGE), New York, stifled its claim on a 3-D peripheral that puts the player through the actual motions of the game. Rather than beat Nintendo, AGE and Mattel engineers joined them by relying on the Nintendo system, but adding a better link between kid and machine.

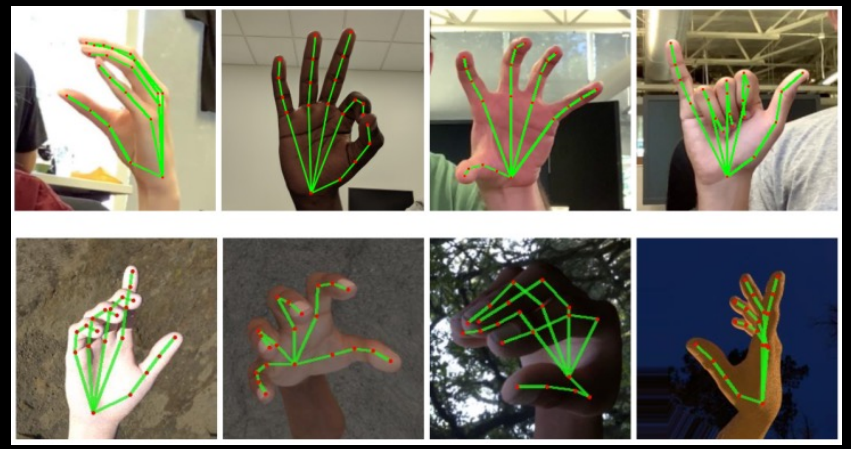
Ultrasonic transmitters on the top of the Power Glove feed positioning information to the L-shaped microphone on the top of the television (not shown). Triangulation algorithms give 3-D positioning of the glove wearer's hand in relation to the activity of the figures on the screen. (Stuart Watson photo)

Design: News/12-4-89/93

Oculus

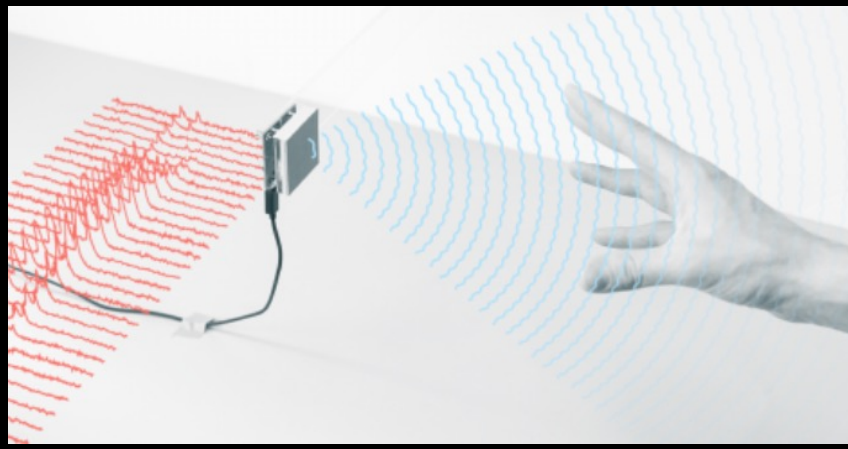
UltraLeap

Google's Hand-tracking Tool

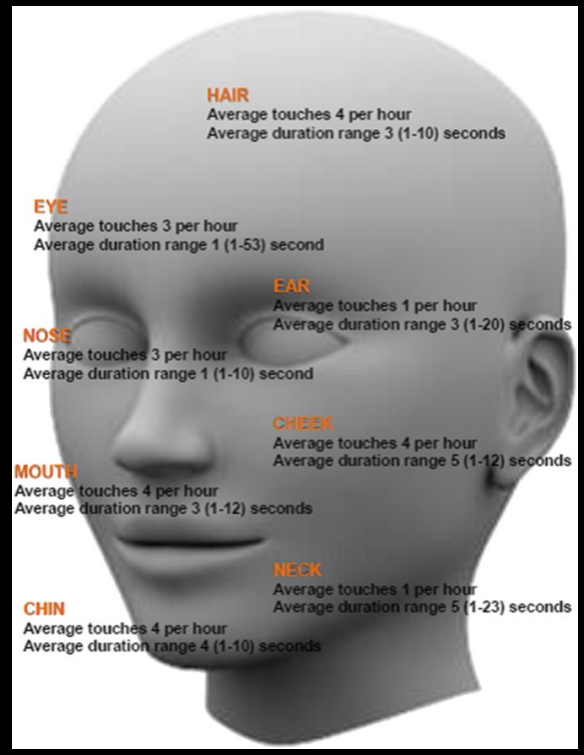


Microsoft's HandPose

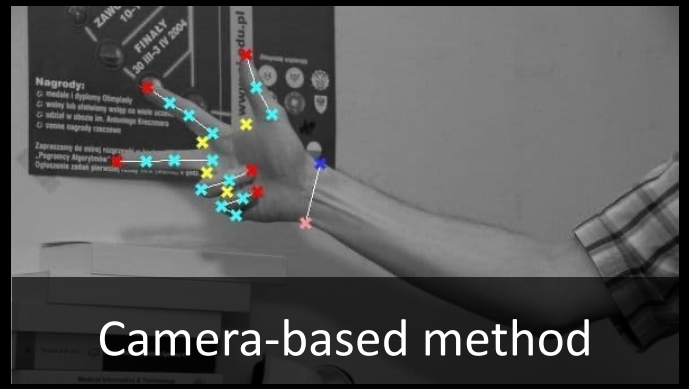
Google's Project Soli

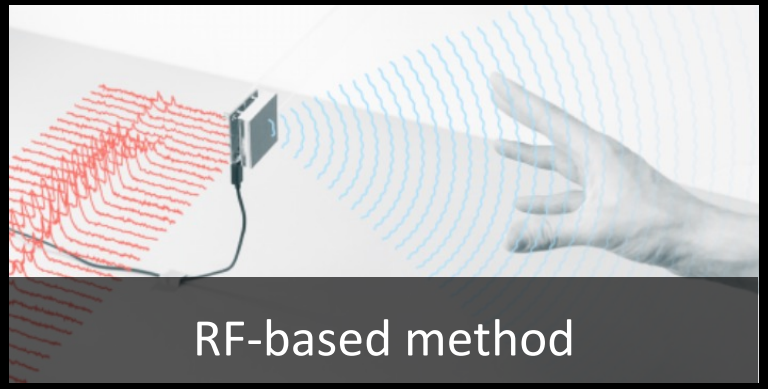


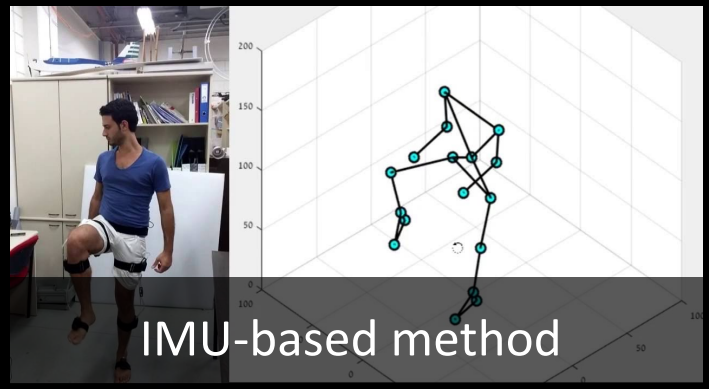
Detecting the face touching behavior



- Detecting unhealthy behavior, e.g., face touching, for personal hygiene


Camera-based method

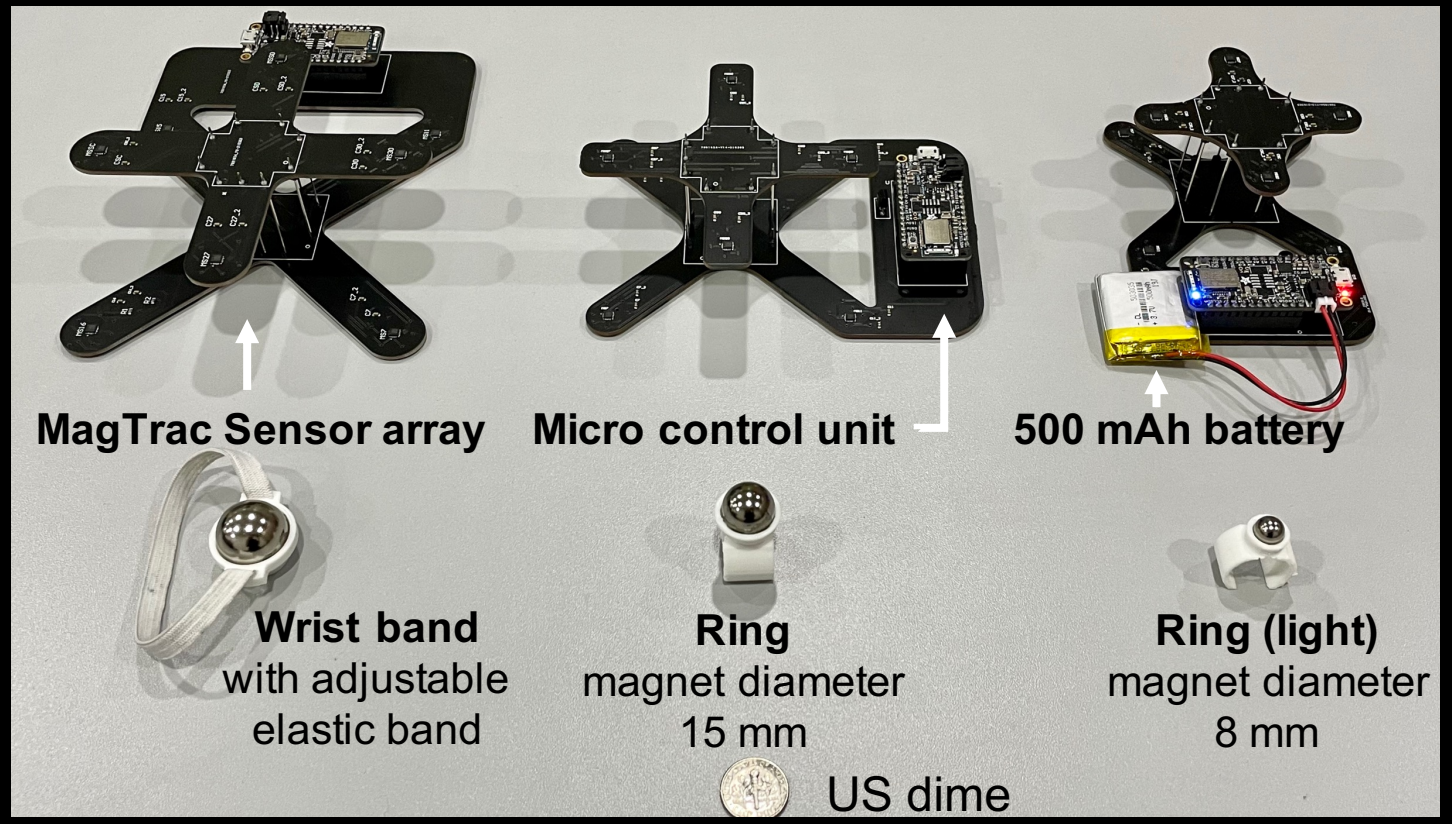

RF-based method


IMU-based method

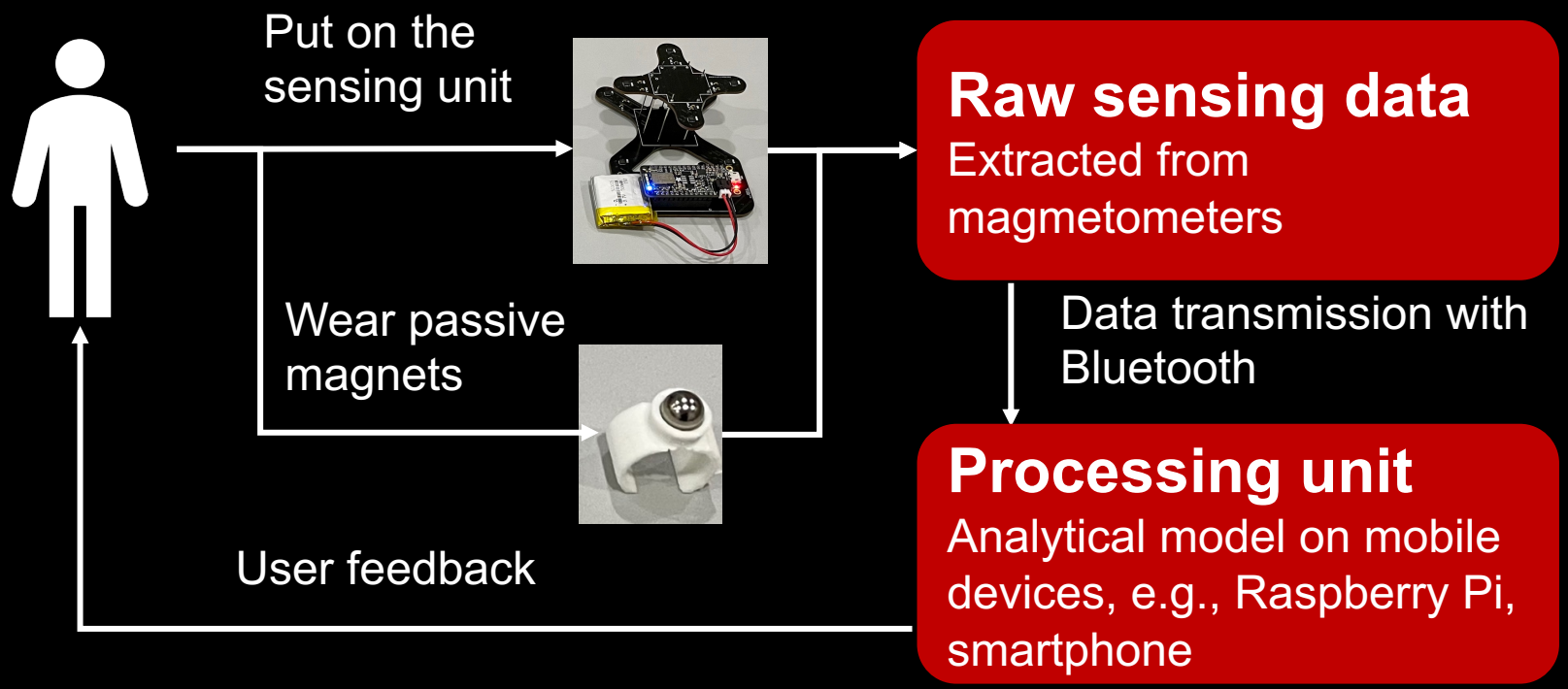
	Accuracy	Sensing range	Resilient to NLoS	Privacy preserving	Power Consumption
Vision-based	Low	Large	No	No	Intense
RF-based	High	Directional	No	No	Moderate
IMU-based	Drifting issue	N/A	Yes	Yes	Intense
Magnetic Tracking	Yes	30cm	Yes	Yes	Ultra Low

Introducing MagX

- A fully untethered on-body tracking system utilizing passive magnets and a novel magnetic sensing platform



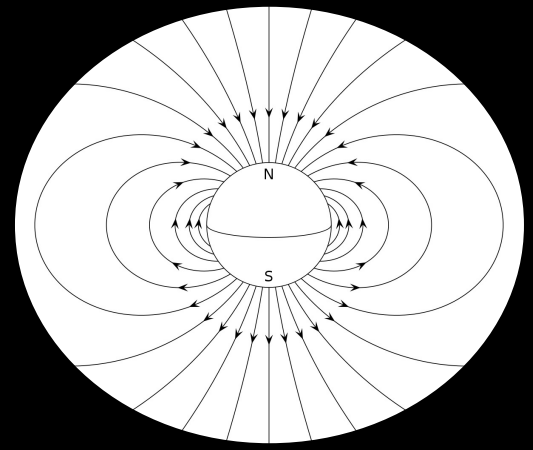
The Overview



Tracking Passive Magnet on Mobile Platform

- The **dipole** magnetic field model

$$\vec{B} = \frac{\mu_0}{4\pi}\left(\frac{3(\vec{m}\cdot\vec{r})\vec{r}}{|\vec{r}|^5} - \frac{\vec{m}}{|\vec{r}|^3}\right)$$

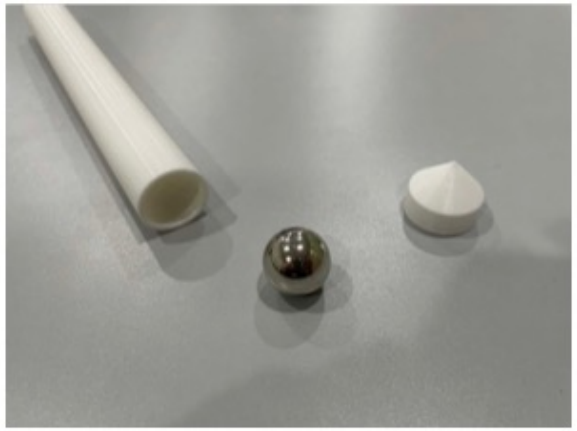


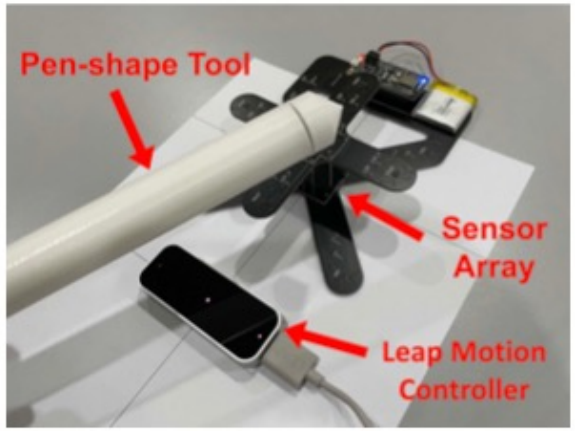
- The sensor reading can be denoted as the **linear combination** of each **magnet's field** and the **background magnetic field**:

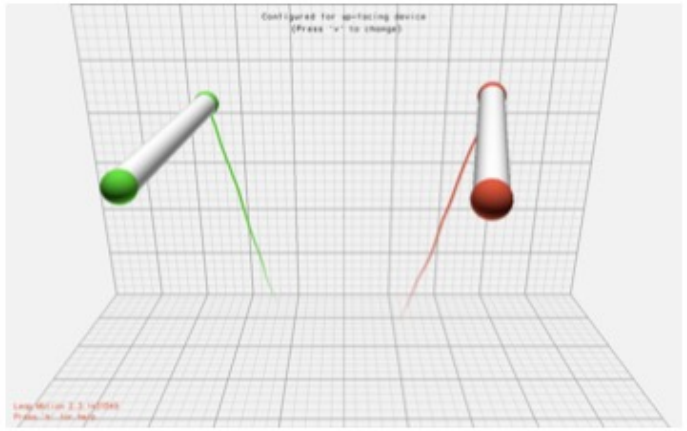
$$\overrightarrow{B_i} = G + \sum_{j=1}^{j=M} \frac{\mu_0}{4\pi}\left(\frac{3(\overrightarrow{m_j}\cdot\overrightarrow{r_{ij}})\overrightarrow{r_{ij}}}{|\overrightarrow{r_{ij}}|^5} - \frac{\overrightarrow{m_j}}{|\overrightarrow{r_{ij}}|^3}\right)$$

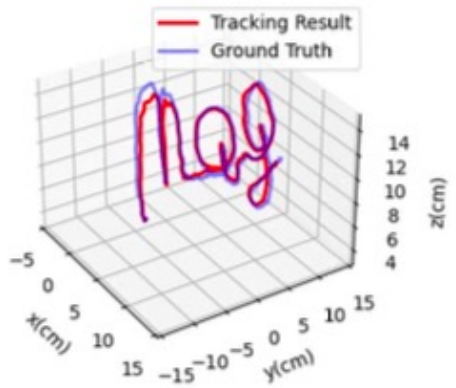
Ground Truth Collection

- Collecting the ground truth is **essential** for evaluating our performance
- Our proposed a LeapMotion-based platform for data collection
  - Can track at an accuracy of within $2.5\ mm$
  - Cost $< \$200$

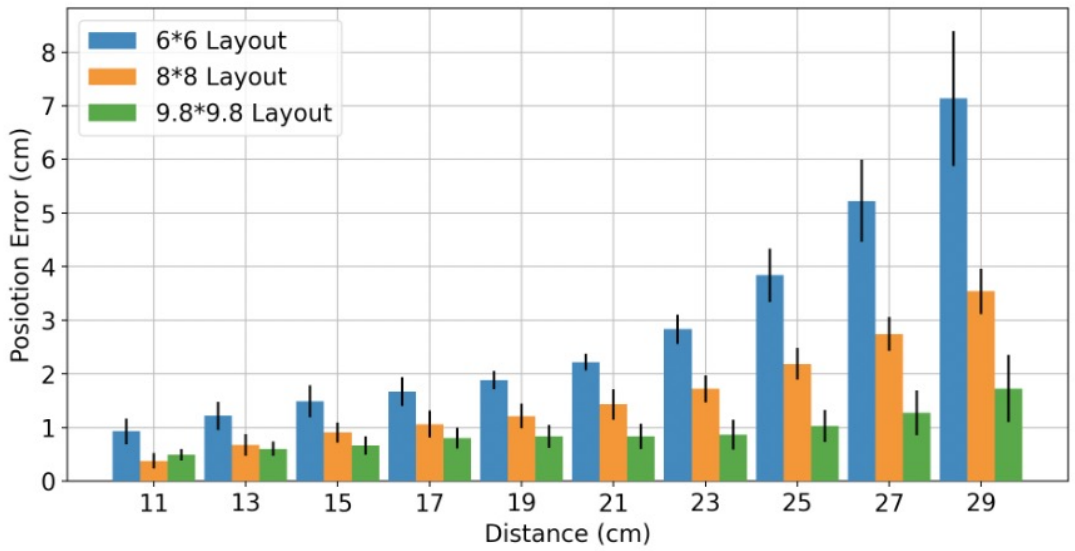




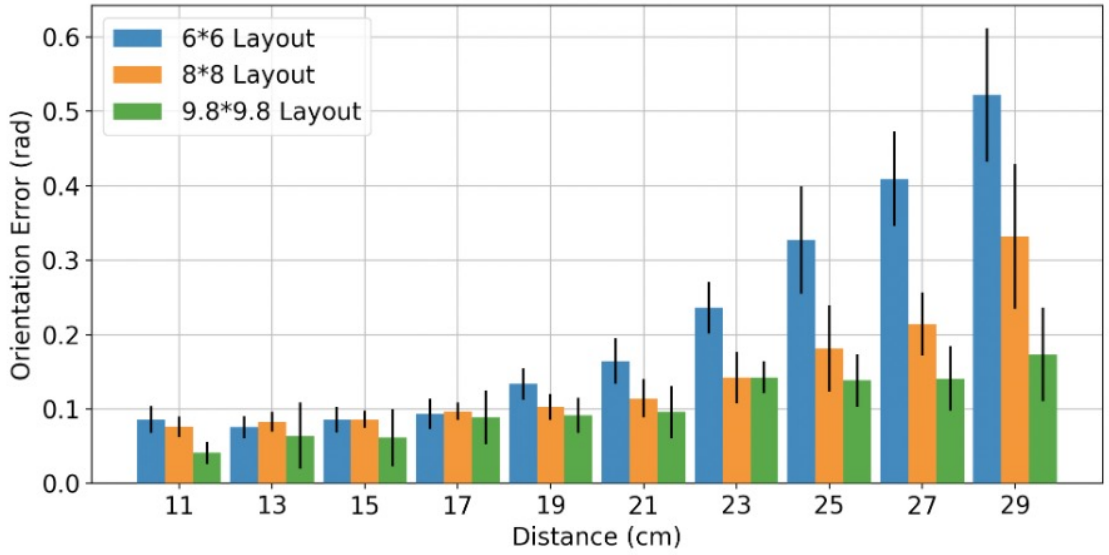




Performance Evaluation



(a) Position error of tracking **one** magnet



(b) Orientation error of tracking **one** magnet

- MagX can achieve **millimeter** accuracy within **~25 cm** distance (9.8*9.8cm^2 layout)

System Overhead

For the sensor array

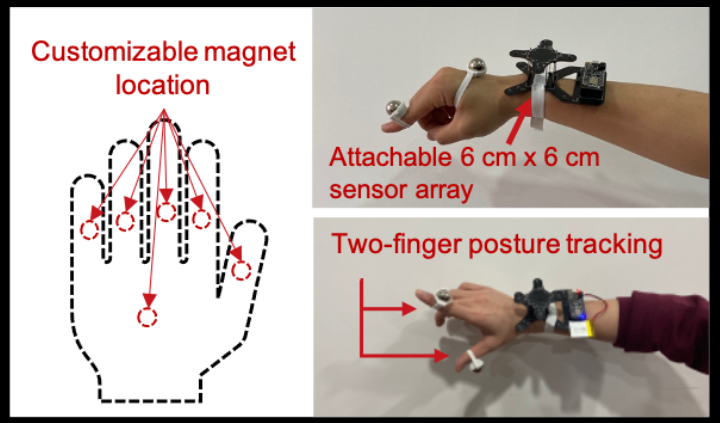
MagX incurs **0.22 W** power drain , **8-hour** usage on small battery pack (**500 mAh**)

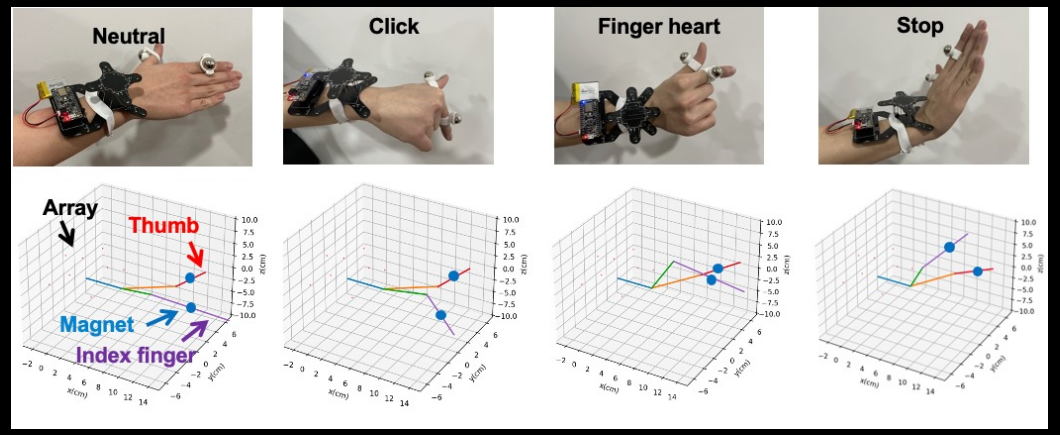
For the mobile device

Computing Modality	CPU Usage	Average FPS	Power Drain (W)
Raspberry Pi	181.21%	1213.89	0.64
Raspberry Pi Zero (emulated)	23.79%	514.23	0.16

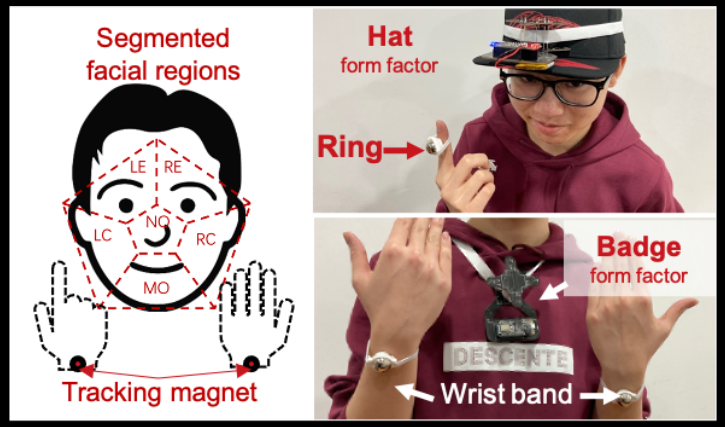
Exemplary Use Cases

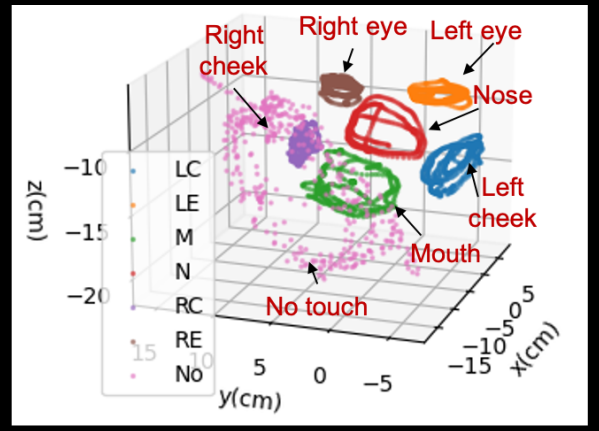
AR interaction

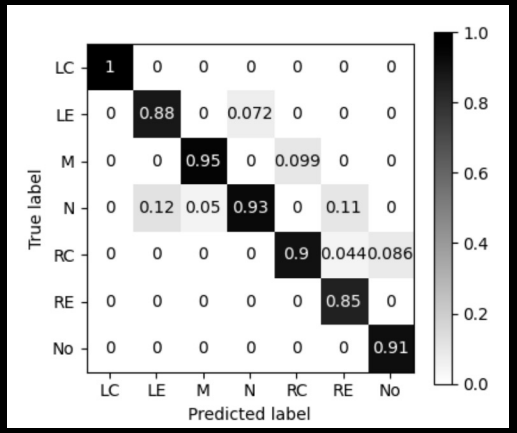




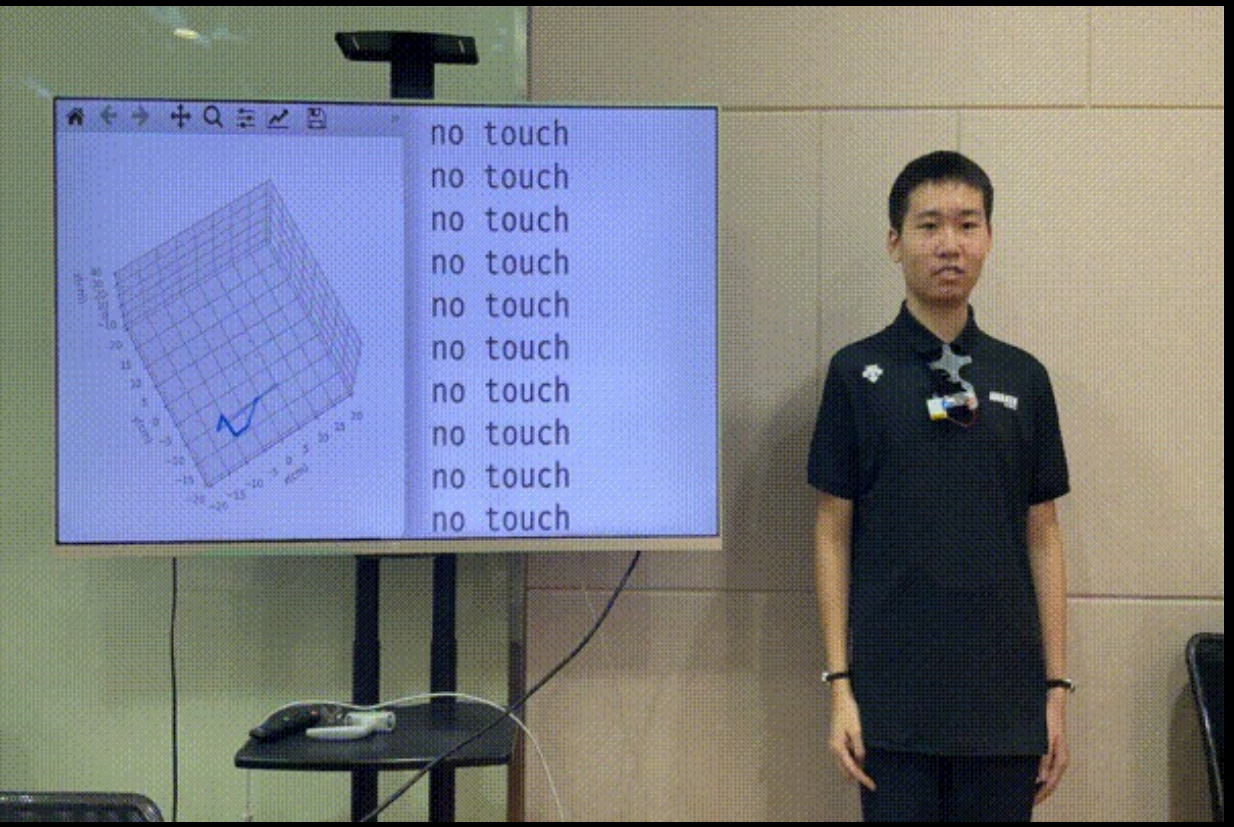
Face touching detection



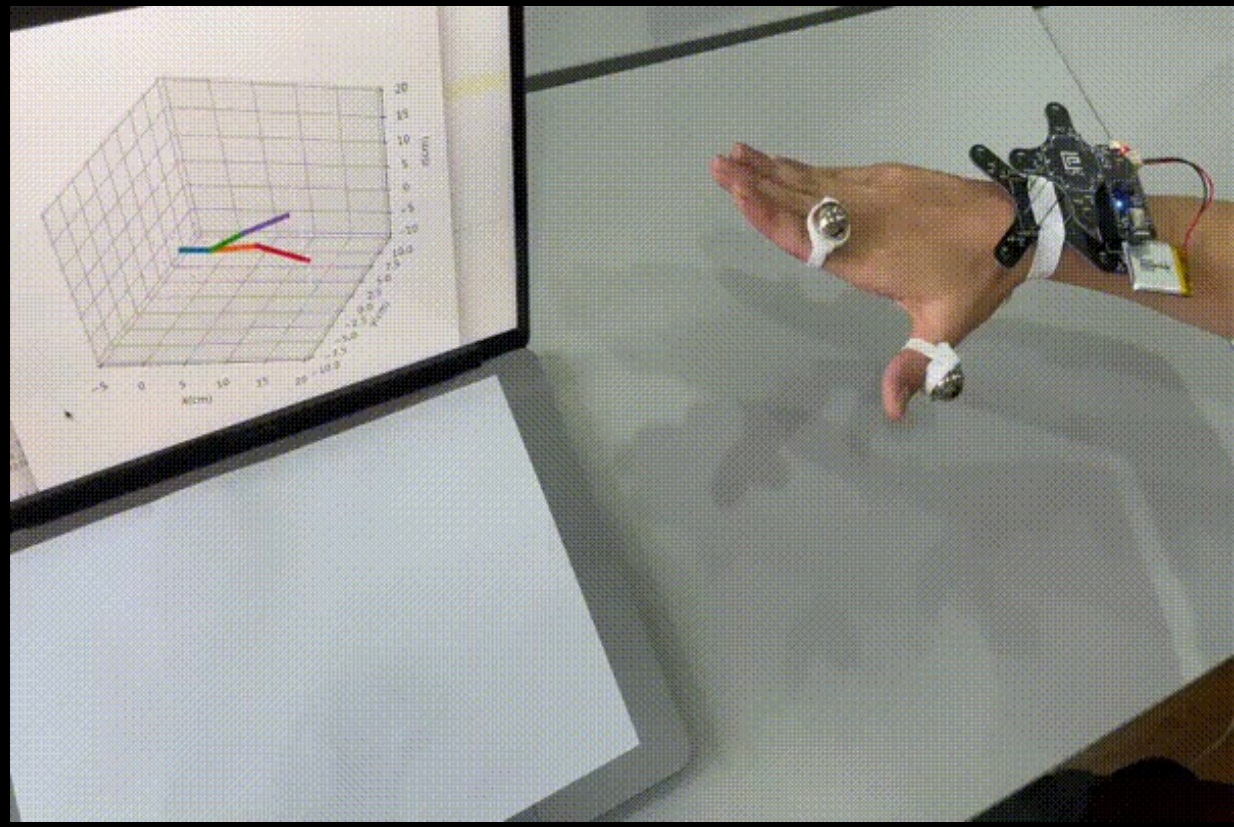




MagX in Action



- Face touching detection



- AR interaction

Customizable Magnet Sizes for Different Form Factors

⌀ 20 mm

⌀ 15 mm

US quarter

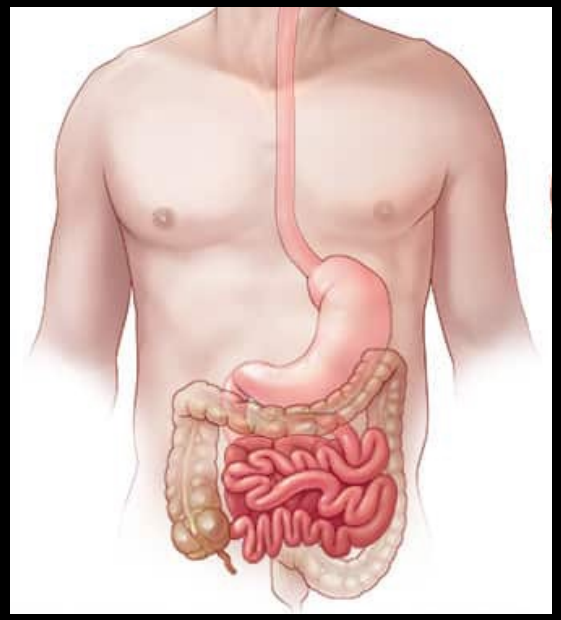
⌀ 12 mm

⌀ 4 mm

⌀ 8 mm

Procedure of Capsule Endoscopy

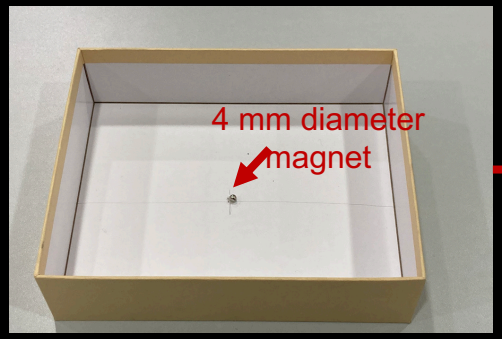
Endoscopy capsule



Gastrointestinal tract

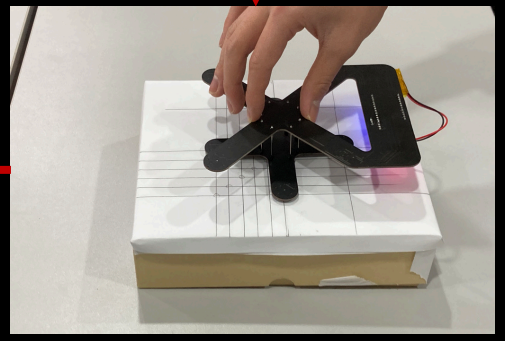
Internal imagery

Capsule Endoscopy demo

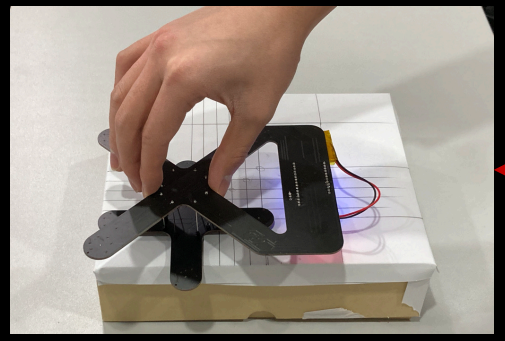


Magnet deployment

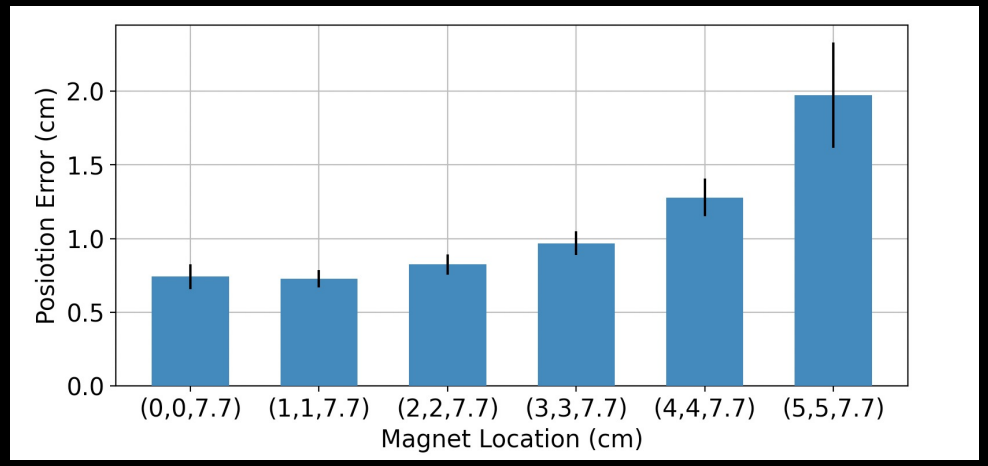
6.3 cm pork belly overlay



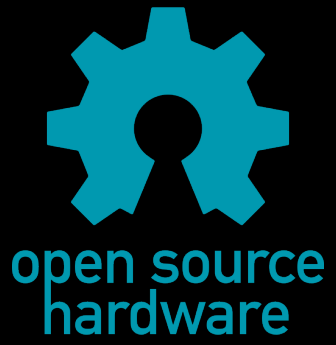
Tracker measurement



Adjust the placement



YES, MagX is open-source



https://github.com/dychen24/magx

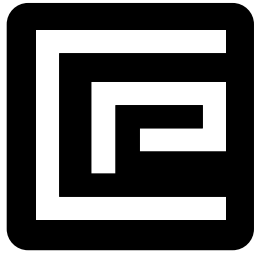
Conclusion

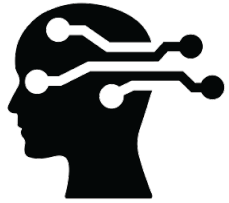
- MagX is an untethered and fully mobile hand tracking system. It uses a novel magnetic sensing scheme to achieve high tracking performance.
- Future directions includes:
  - Addressing hard and soft iron disturbances
  - Redesigning the form factor

Thanks!

Q & A

Research Presented by:





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