Data Storage and Interaction using Magnetized Fabric

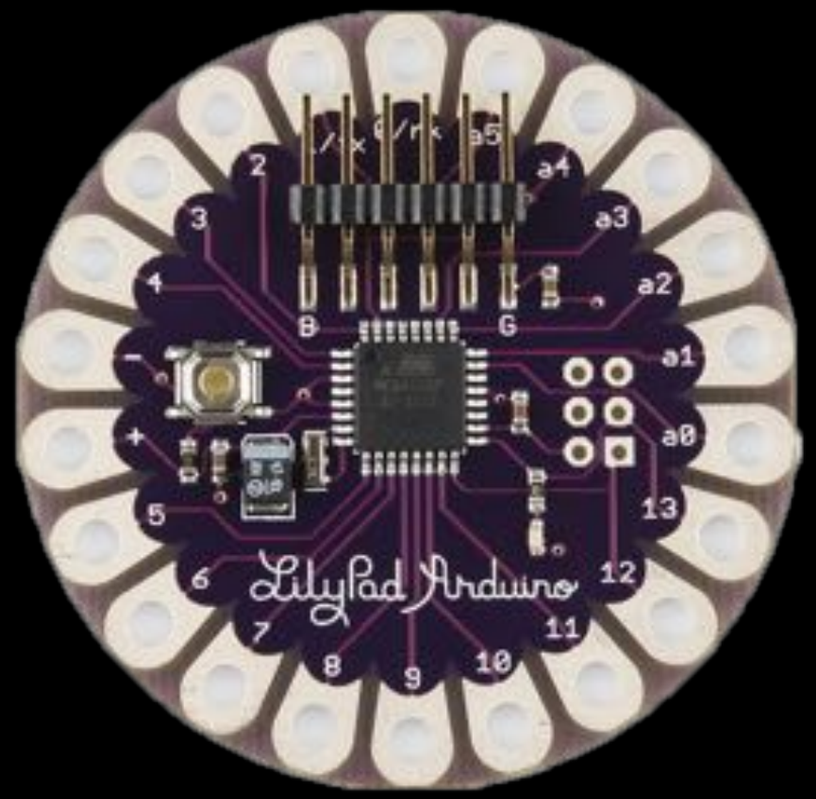
Justin Chan
Shyam Gollakota

PAUL G. ALLEN SCHOOL
OF COMPUTER SCIENCE & ENGINEERING

Existing approaches

PROJECT JACQUARD

LILYPAD ARDUINO



Requires batteries

Can we create a smart fabric design without any onboard electronics or batteries?

Smart fabrics without electronics

BATTERY-FREE

WATERPROOF

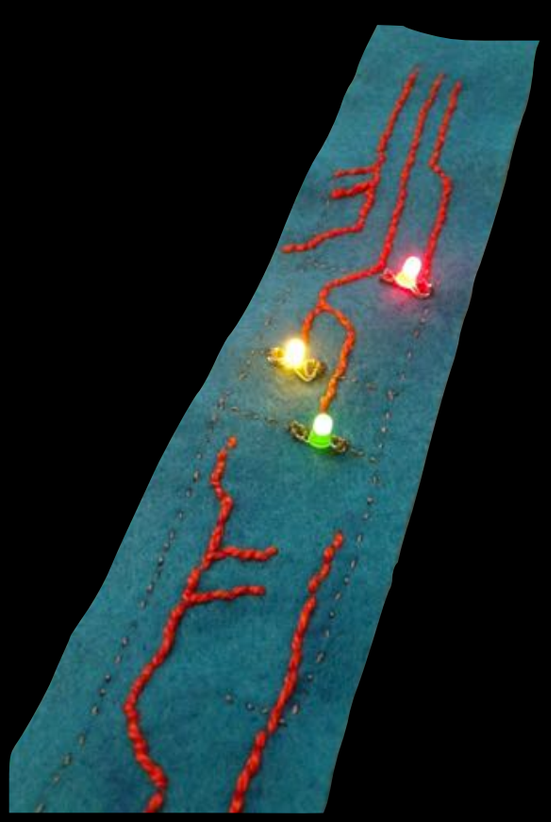
Clothes with memory

CODES

IMAGES

Interact with a smartphone in your pocket

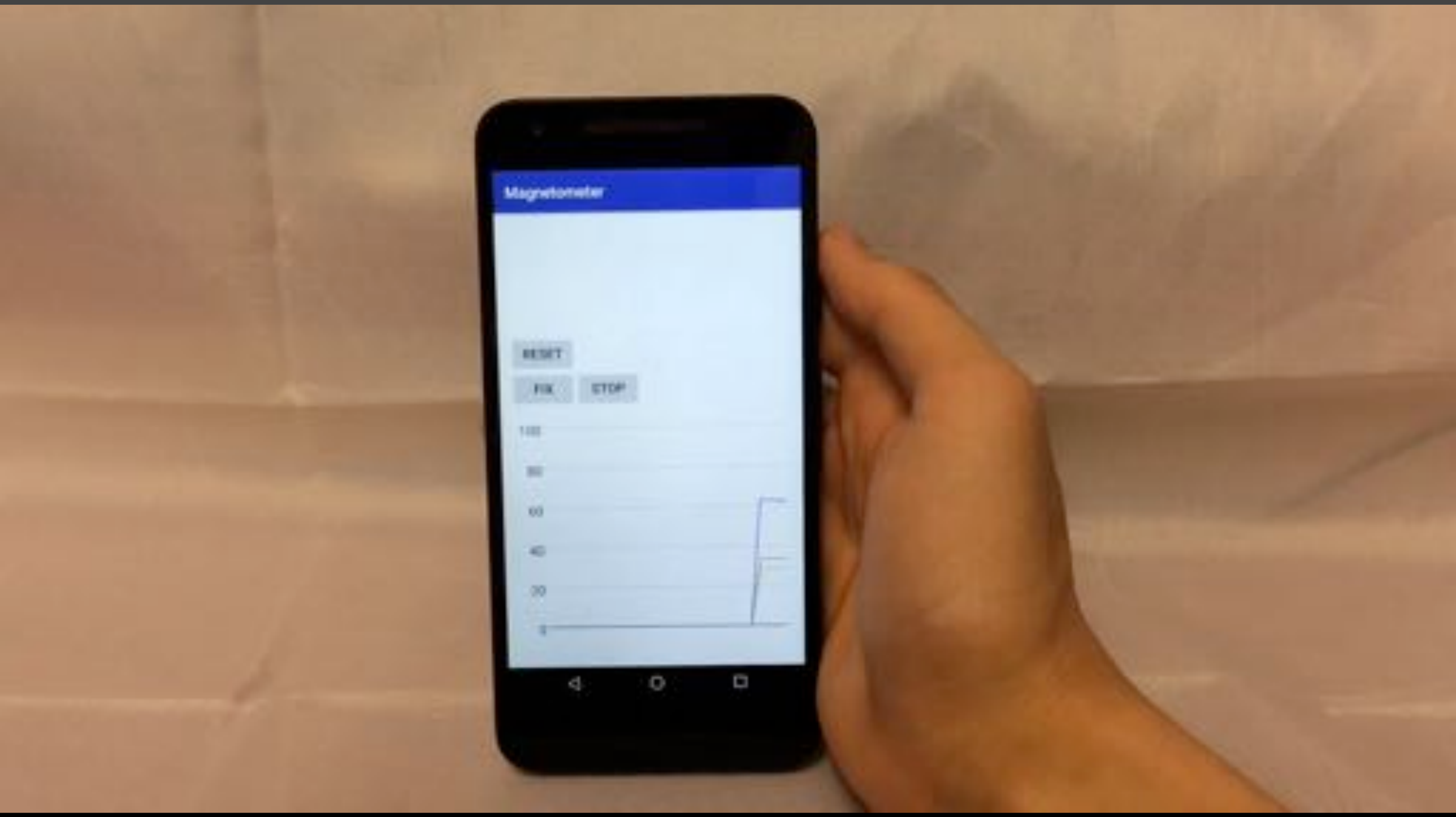
What are conductive threads used for?



Key Observation

Leverage magnetic properties of conductive thread

Smartphones have magnetometers



Our Contributions

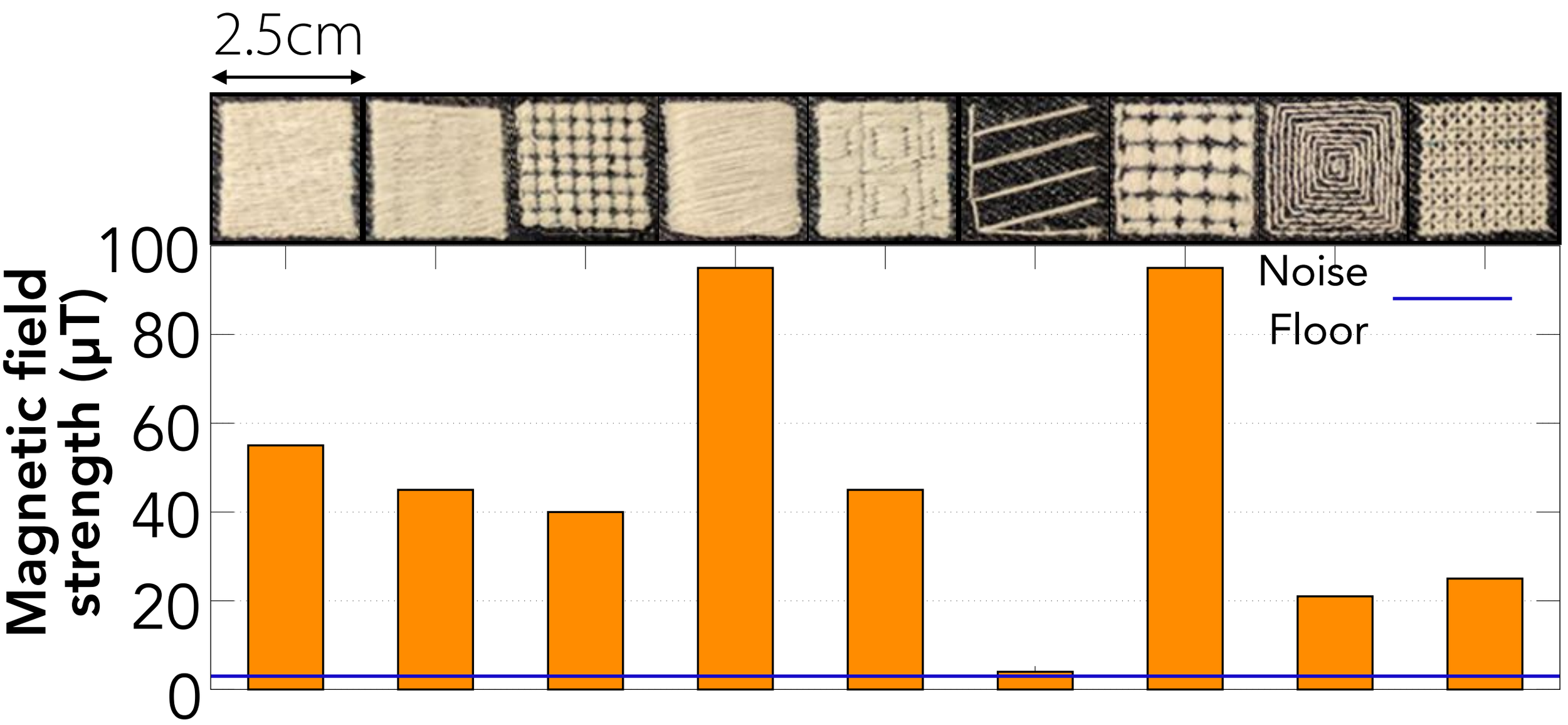
- First to harness the magnetic properties of conductive fabric for interaction
- Provide a detailed characterization of magnetized fabric
- Build electronic-free data storage and gesture recognition applications on fabric

Characterization of magnetized fabric

What do we care about?

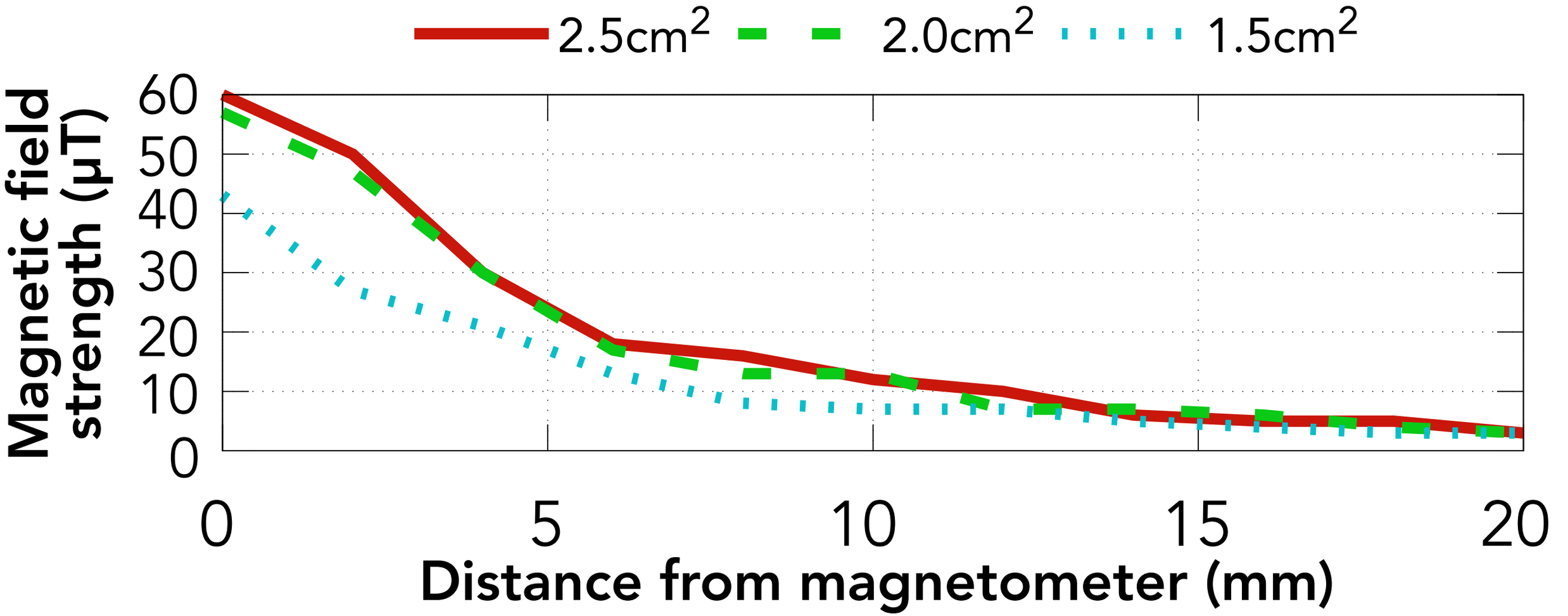
- Embroidery style
- Decay over distance
- Decay over time

How does embroidery style affect field strength?



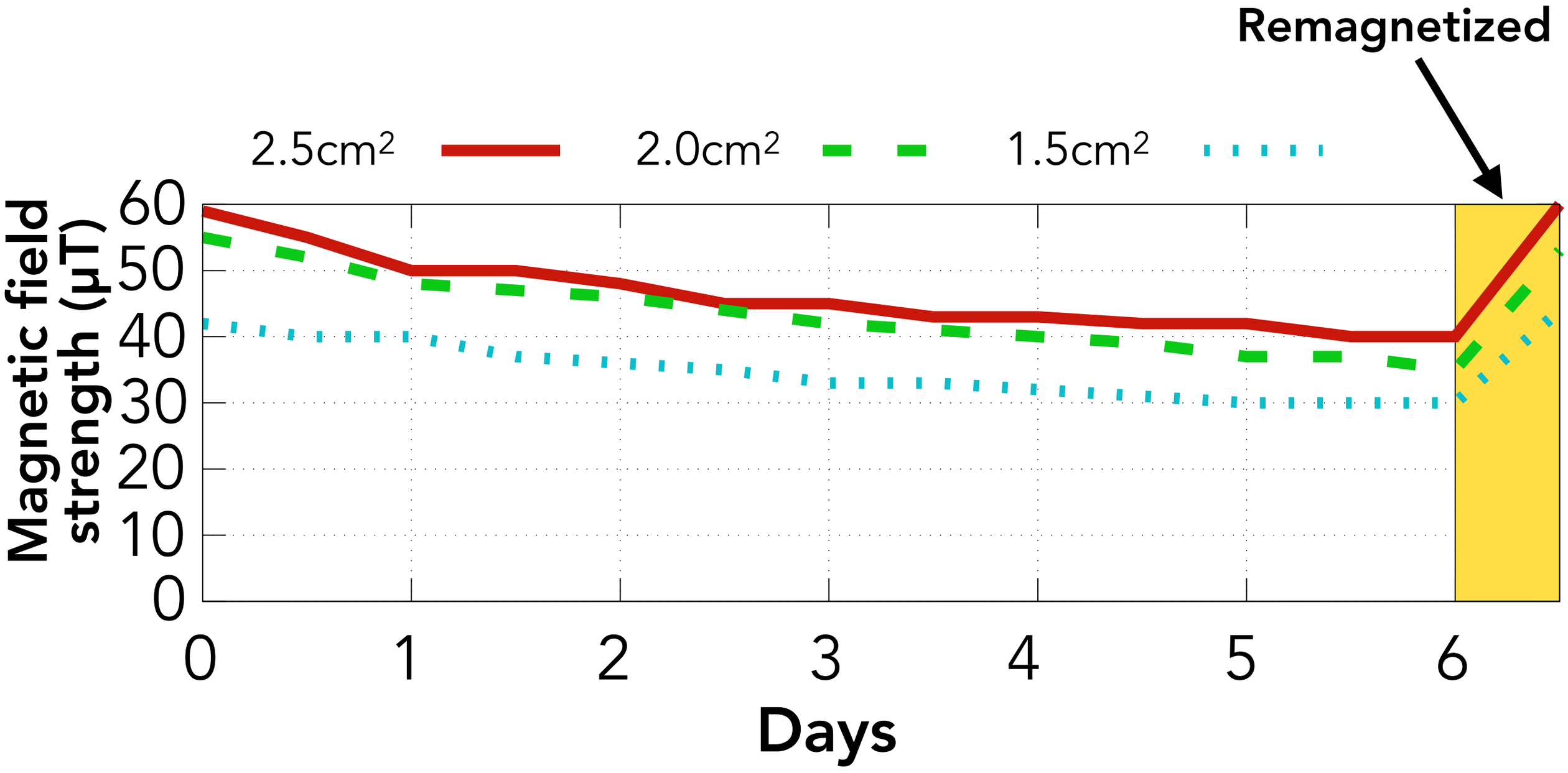
Denser styles have higher field strength

How does field strength decay over distance?

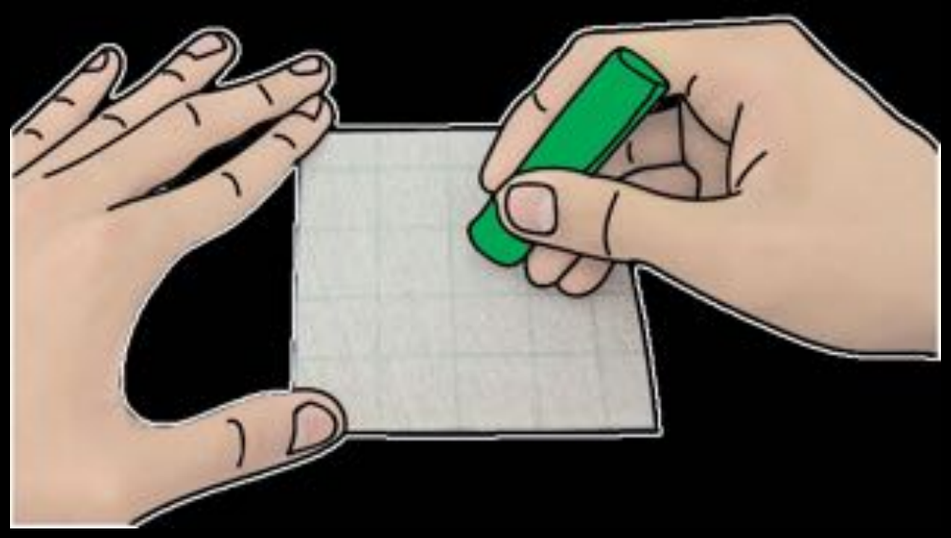


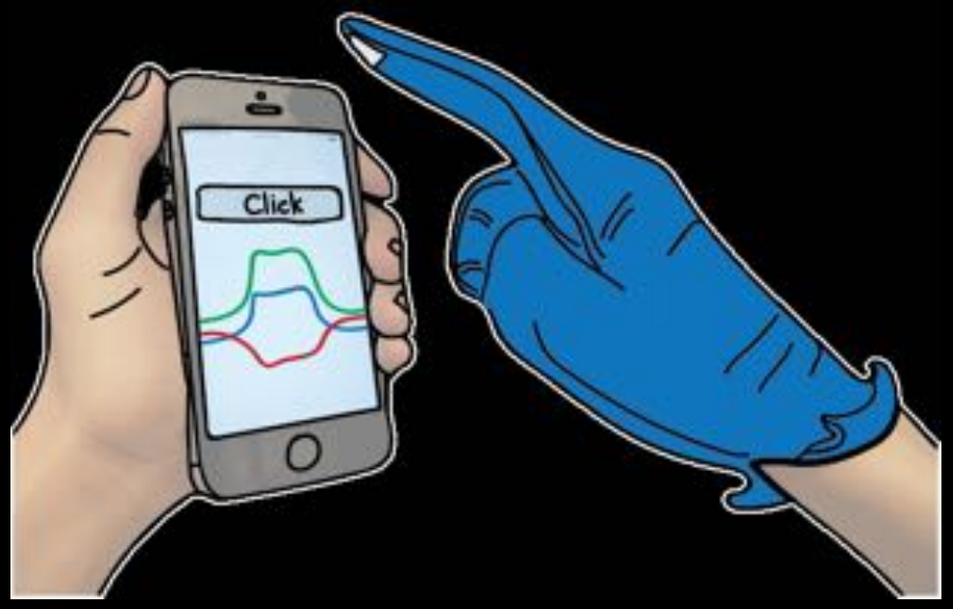
Works up to distances of 1 cm

How does field strength decay over time?



28-36% decrease over a week





DATA STORAGE

EMBEDDING INVISIBLE IMAGES

GESTURE RECOGNITION

How do we tag clothing?

> $500-$2000

Unreadable on smartphones

Reading and writing codes

5mm

Guard band

1cm

2cm

Magnetometer

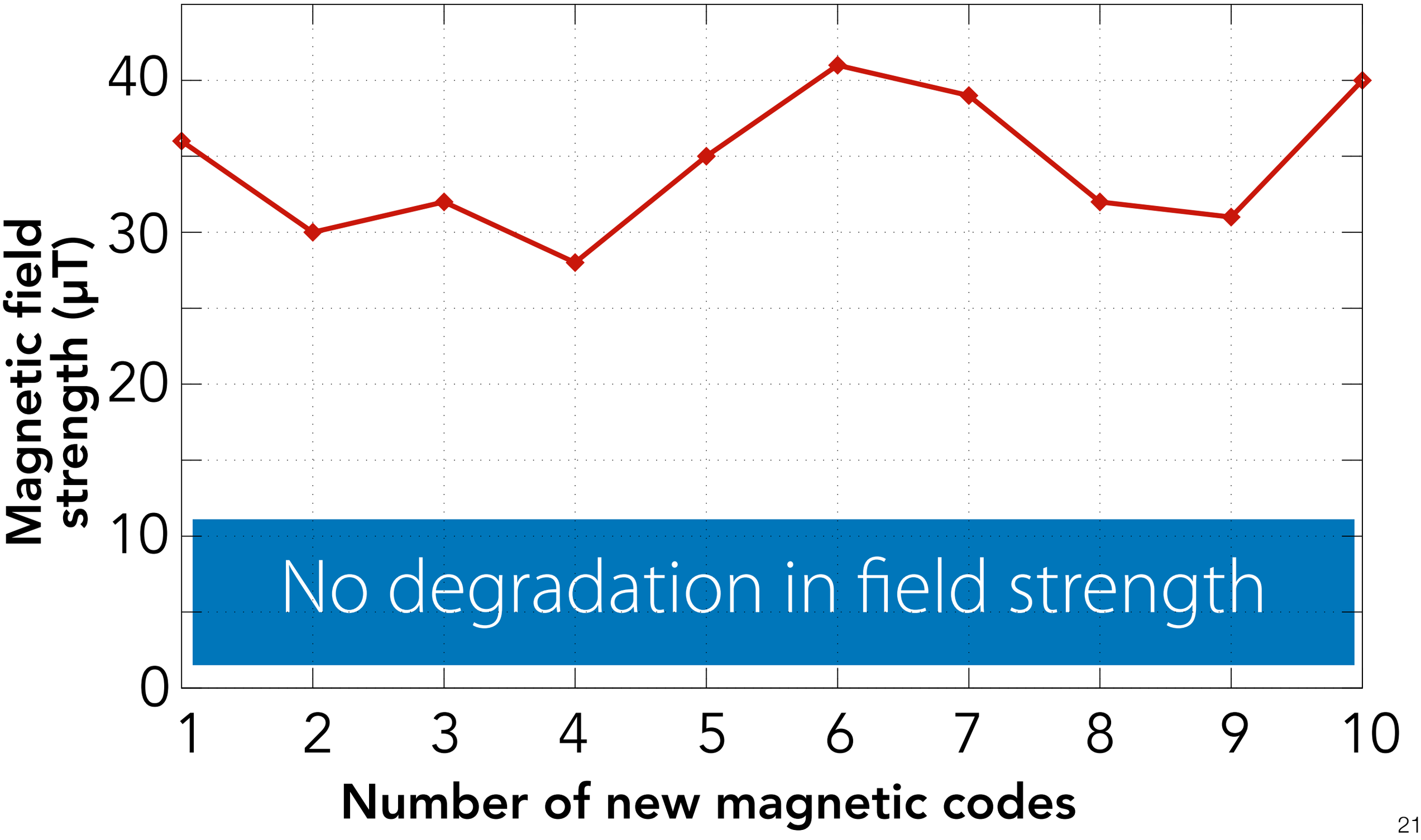
< $0.17

Reading the tag on a smartphone

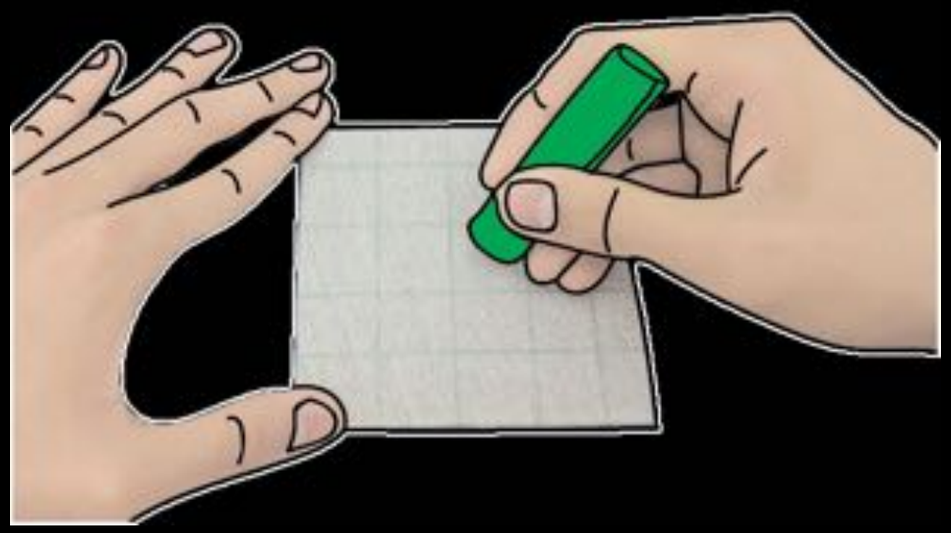
How durable are our tags?

	Change in field strength
Hand wash	11%
Machine wash	5%
Drying	9%
Ironing (160°C)	1%

Are our tags reprogrammable?

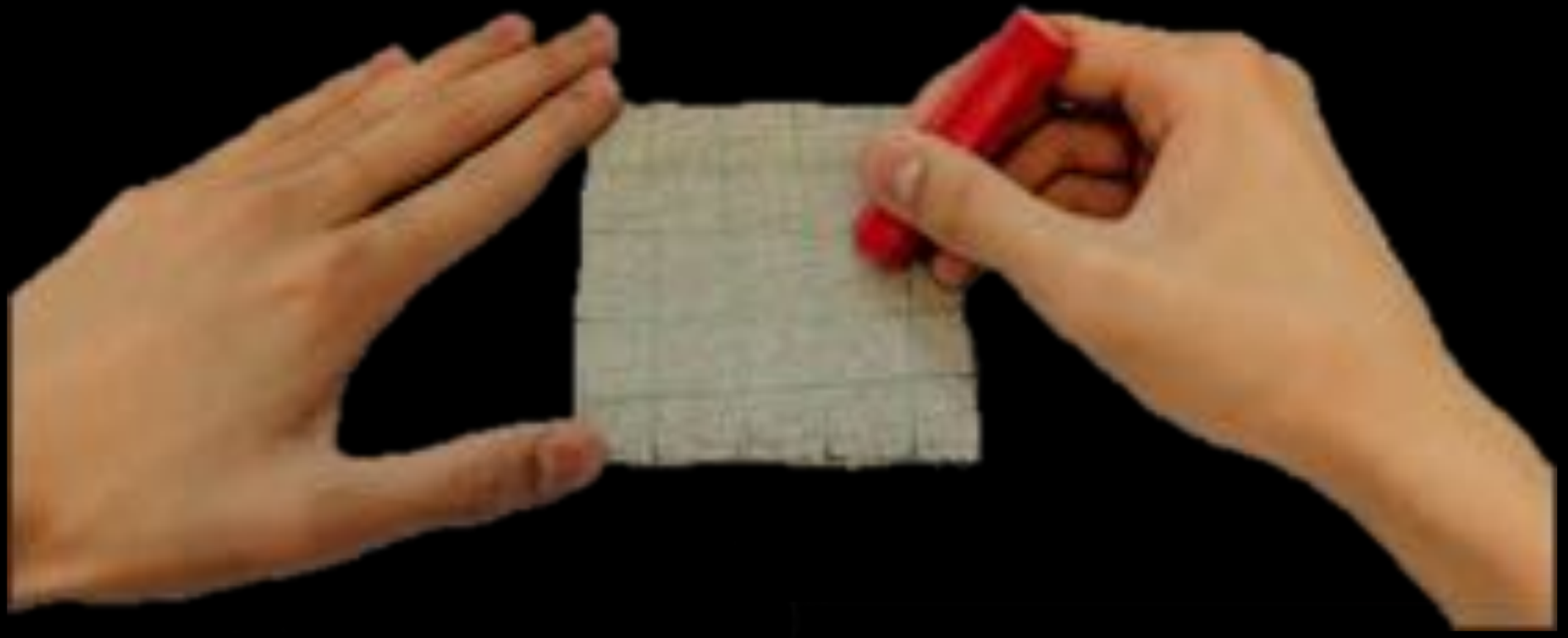


Fashion accessories with memory

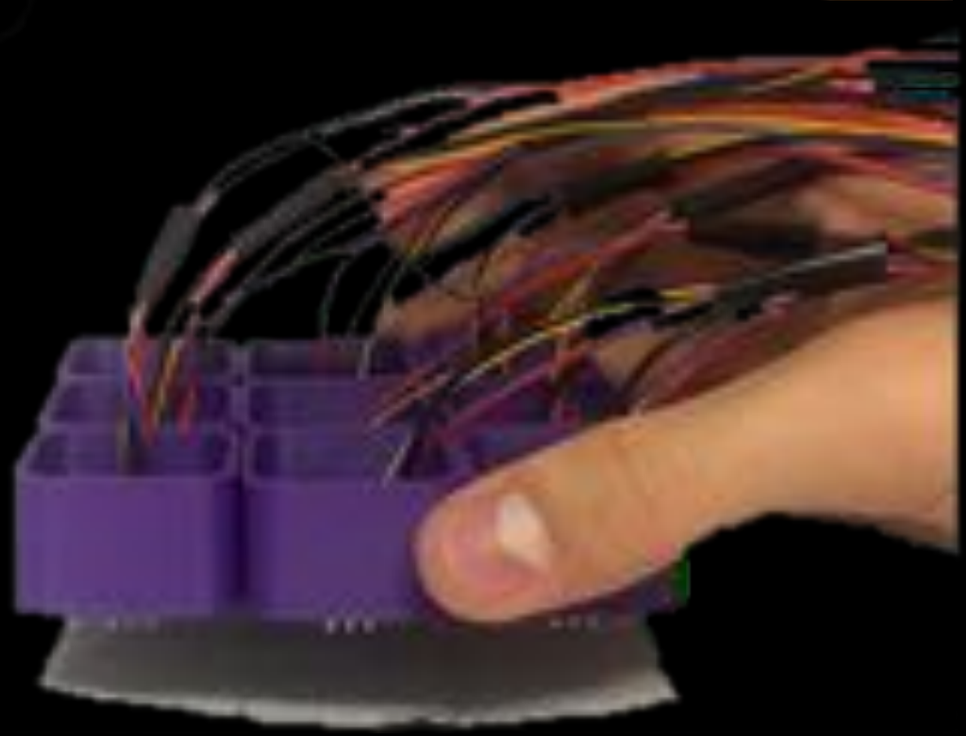


EMBEDDING INVISIBLE IMAGES

Drawing and reading images

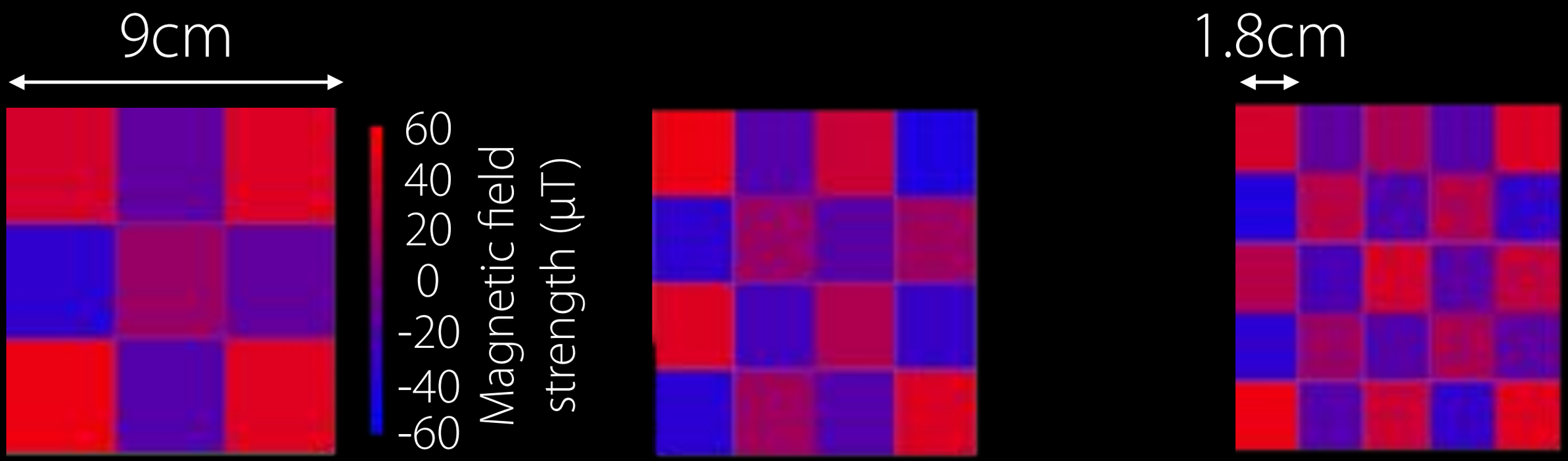


ENCODING



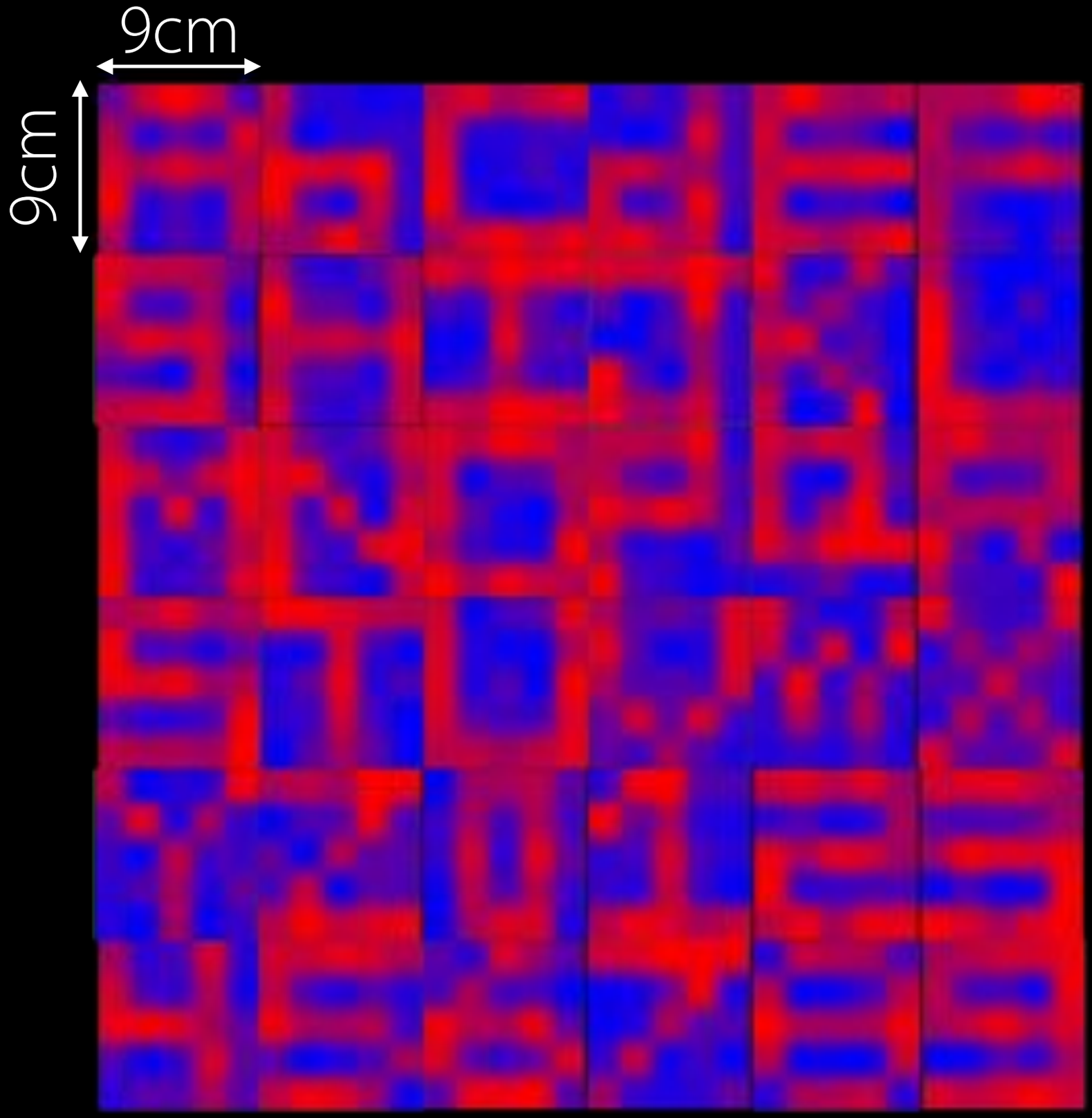
DECODING

How small can each pixel be?



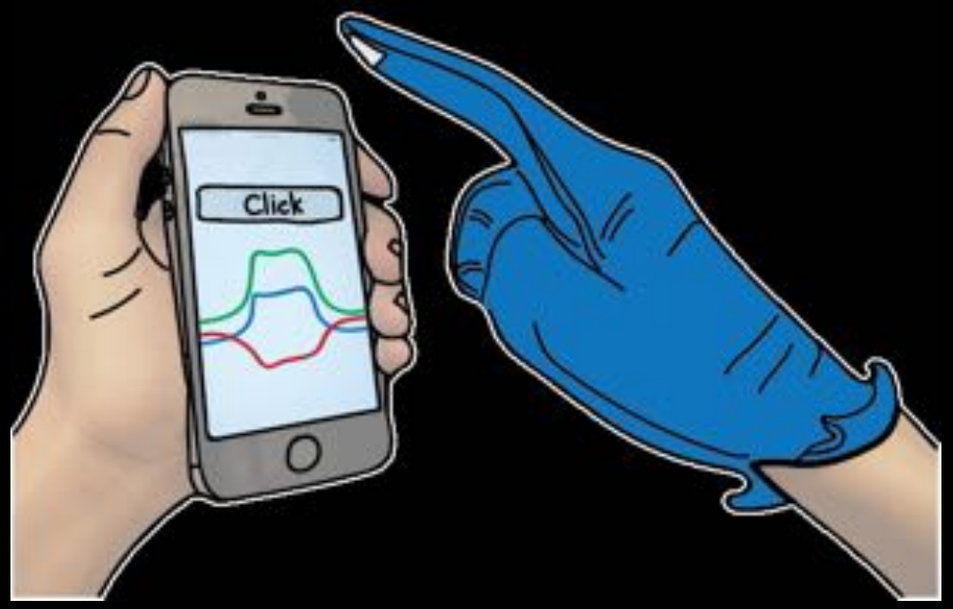
Smallest pixel size: 1.8 cm^2

Expressivity of images



$2^{25} \approx 33$ million possible images

AUTHENTICATION



GESTURE RECOGNITION

Smartphones in pockets

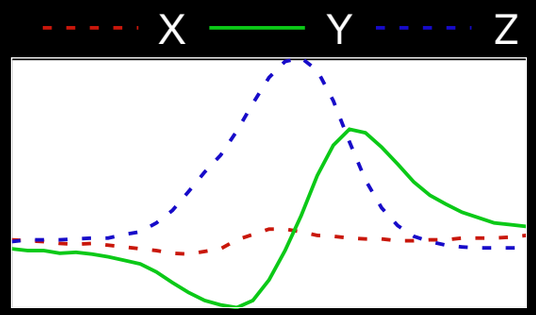
Magnetometer

Low-power IoT devices

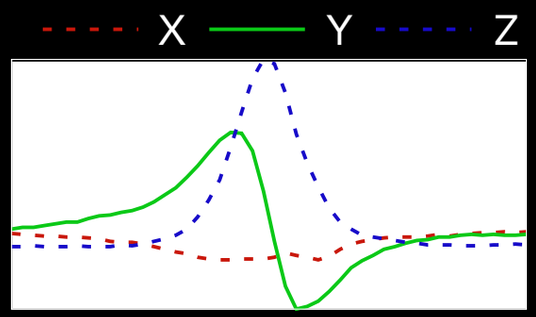
Power:
72µW

Cost:
$0.80

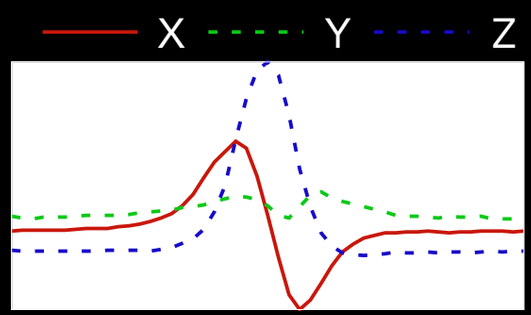
Recognizing gestures



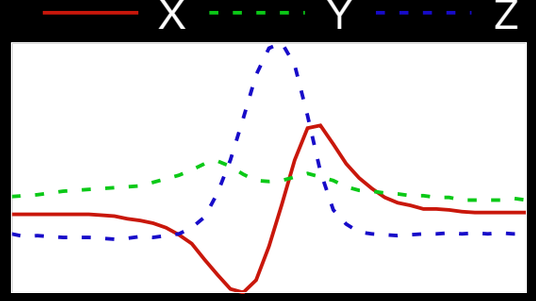
UP



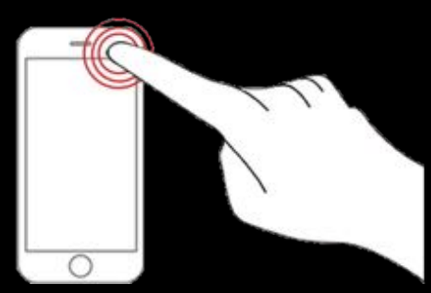
DOWN

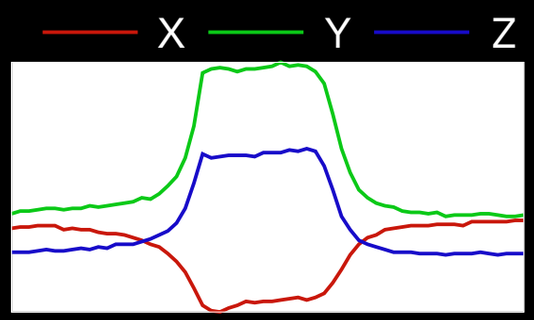


LEFT

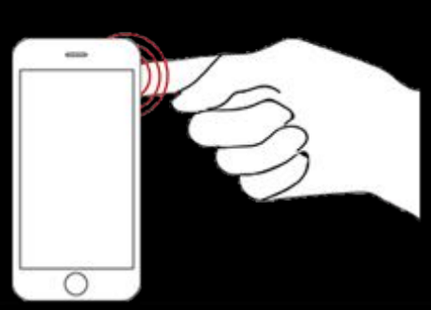


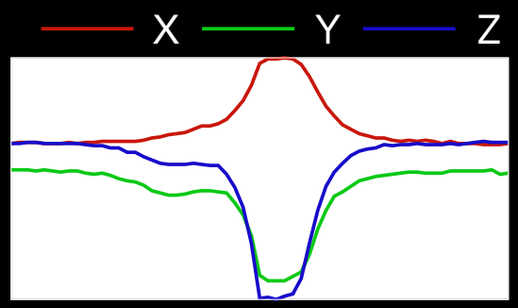
RIGHT





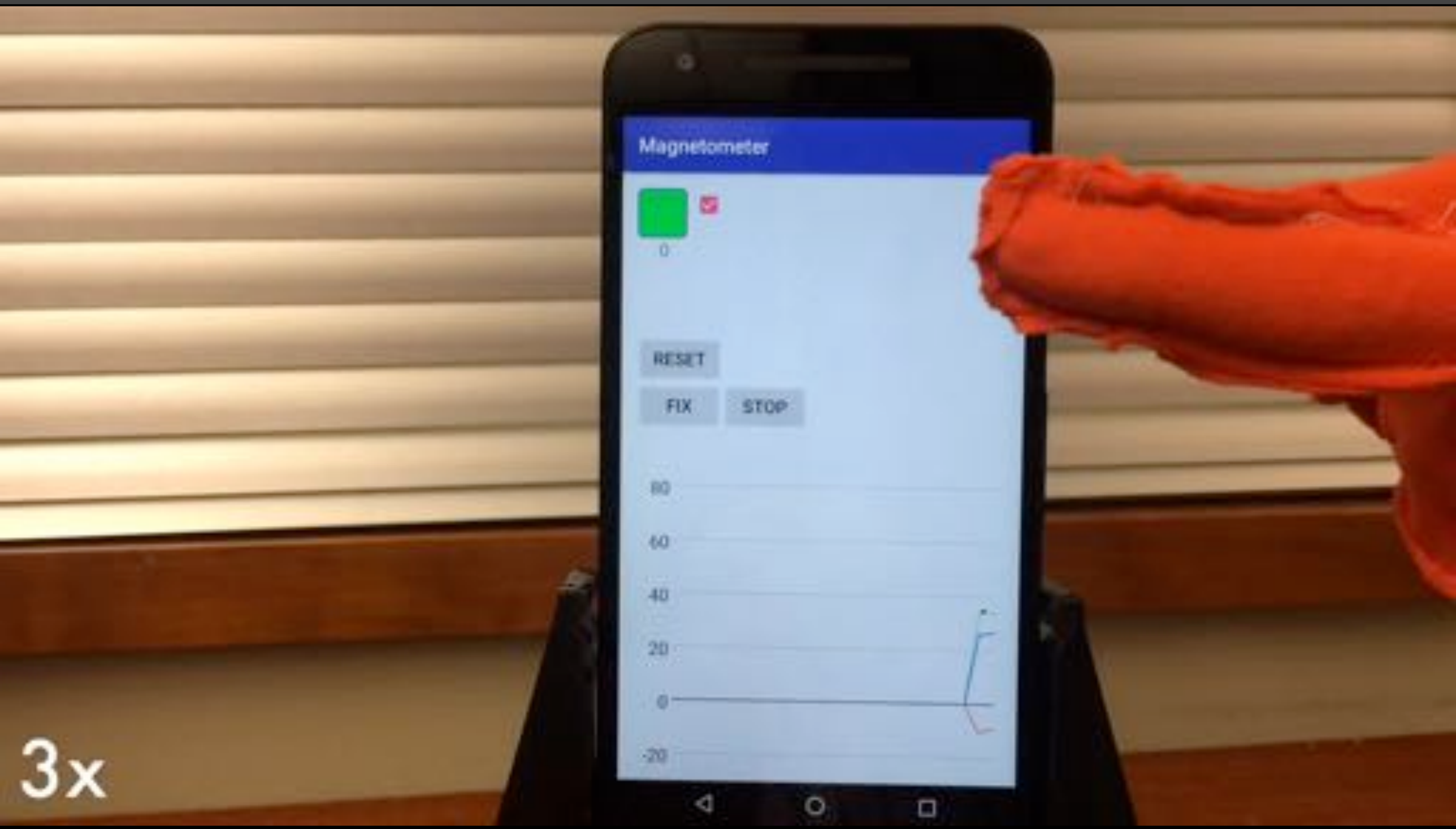
CLICK





BACK CLICK

Real time classifier



Classifier accuracy

Actual Gesture Performed	Up	Down	Left	Right	Click	Back Click	Not seen
Up	0.91	0.01	0	0.01	0.04	0.03	0
Down	0	0.9	0.02	0.03	0.03	0.01	0
Left	0	0.03	0.87	0.06	0.02	0.01	0
Right	0.04	0	0	0.94	0.02	0.01	0
Click	0.01	0.01	0	0.01	0.92	0.02	0.02
Back Click	0	0.06	0	0.02	0.04	0.86	0.03

Gesture Classified

7 users

20 repetitions

90.1%

accuracy


THROUGH-POCKET
SENSING

How do we improve this?

Custom designed textiles +
a precise magnetic reader and writer

- Generate stronger fields
- Increase bit density
- Longer bit lifespan

Conclusions

- Harness the magnetic properties of conductive fabric for interaction
- Provide a detailed characterization of magnetized fabric
- Build electronic-free data storage and gesture recognition applications on fabric