Knocker

Vibroacoustic-based Object Recognition with Smartphones

Taesik Gong[1] Hyunsung Cho[1] Bowon Lee[2] Sung-Ju Lee[1]

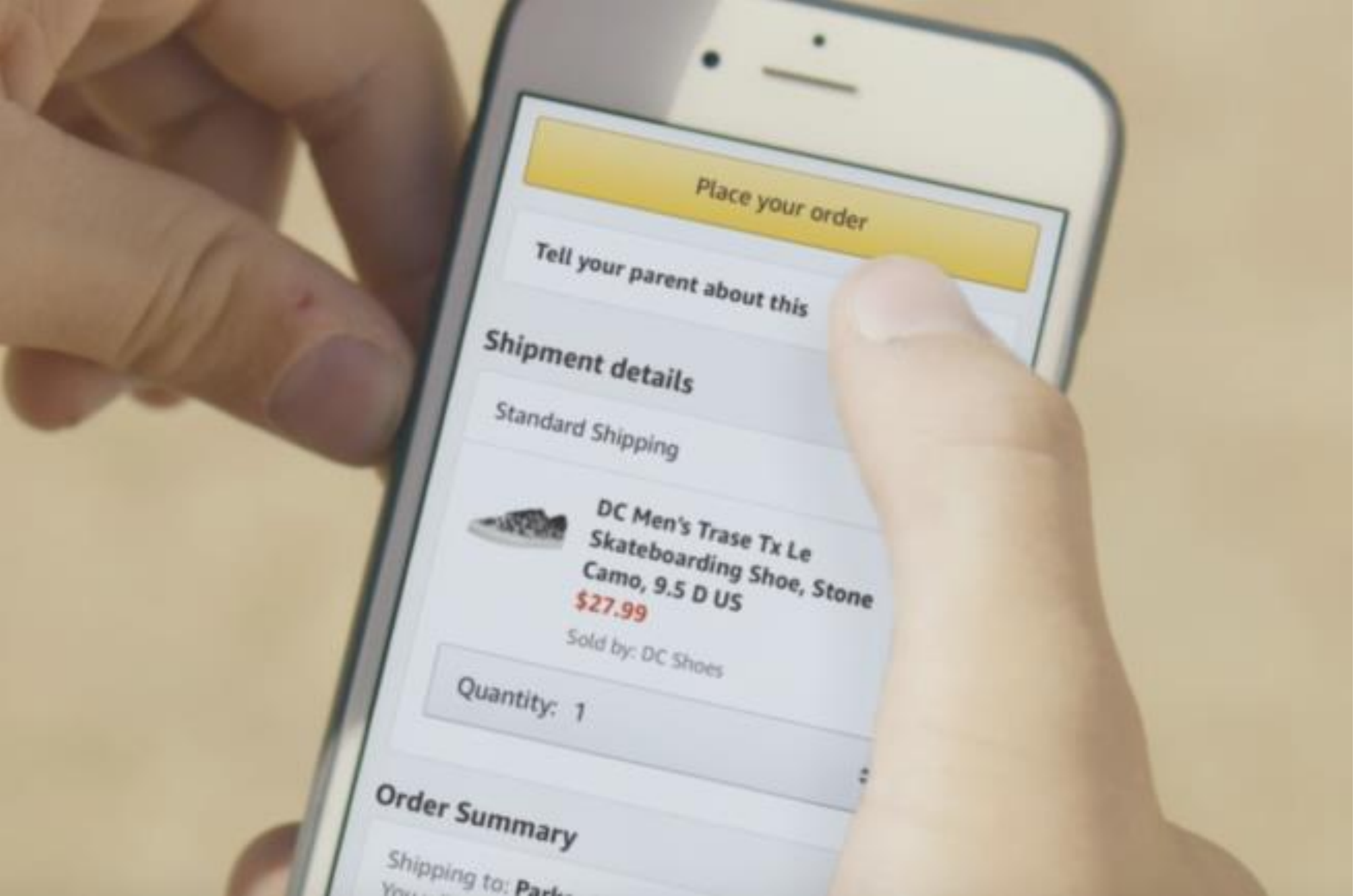
NMSL Networking & Mobile Systems Lab

1 KAIST 1971

2 인하대학교 1954 INHA UNIVERSITY

UBICOMP 2019

Smartphone for **human-object interaction**


Place your order
Tell your parent about this
Shipment details
Standard Shipping
DC Men's Trase Tx Le Skateboarding Shoe, Stone Camo, 9.5 D US
$27.99
Sold by: DC Shoes
Quantity: 1
Order Summary
Shipping to:

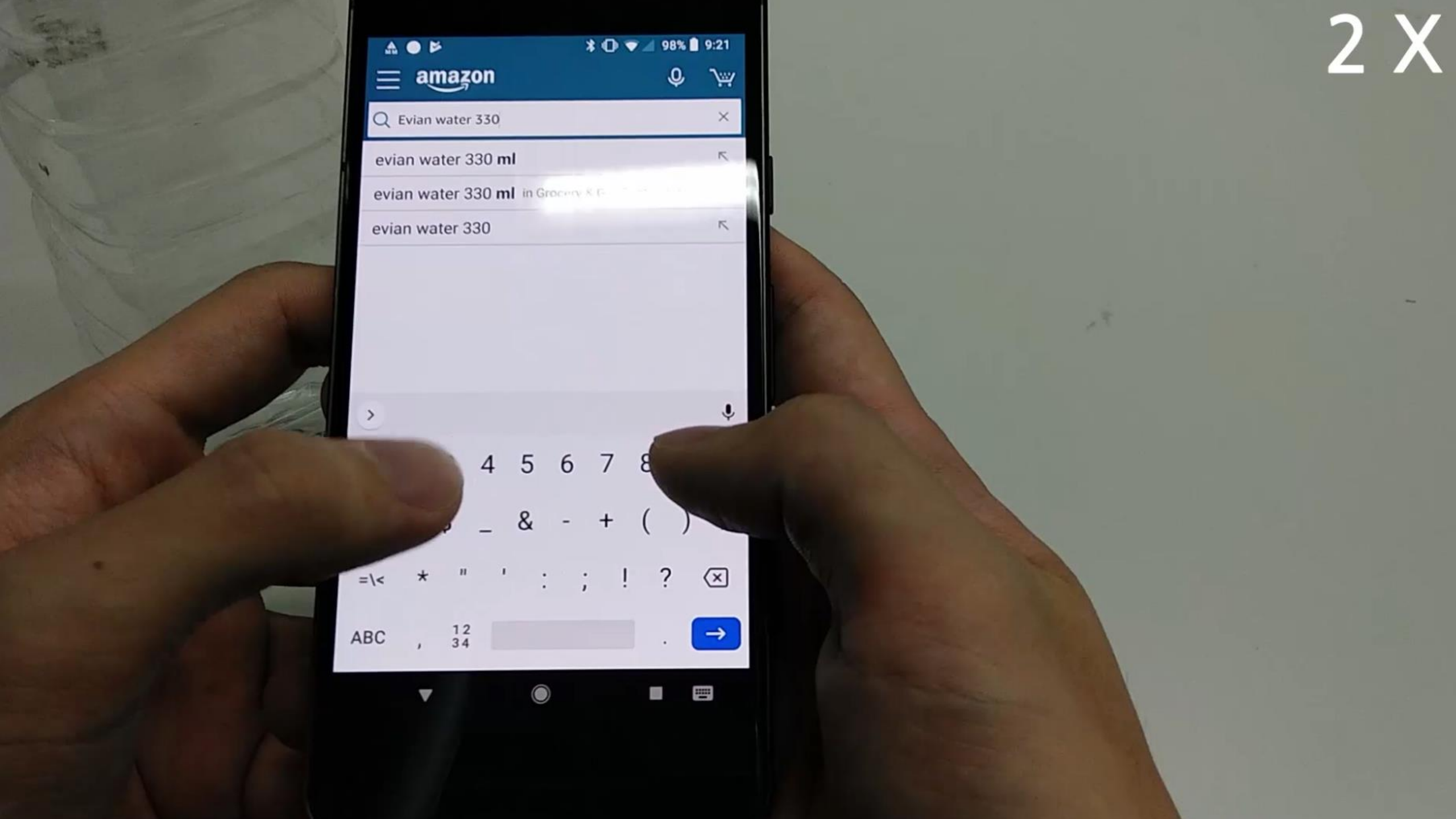

coffee
prepare system
coffee strength
coffee size
milk foam

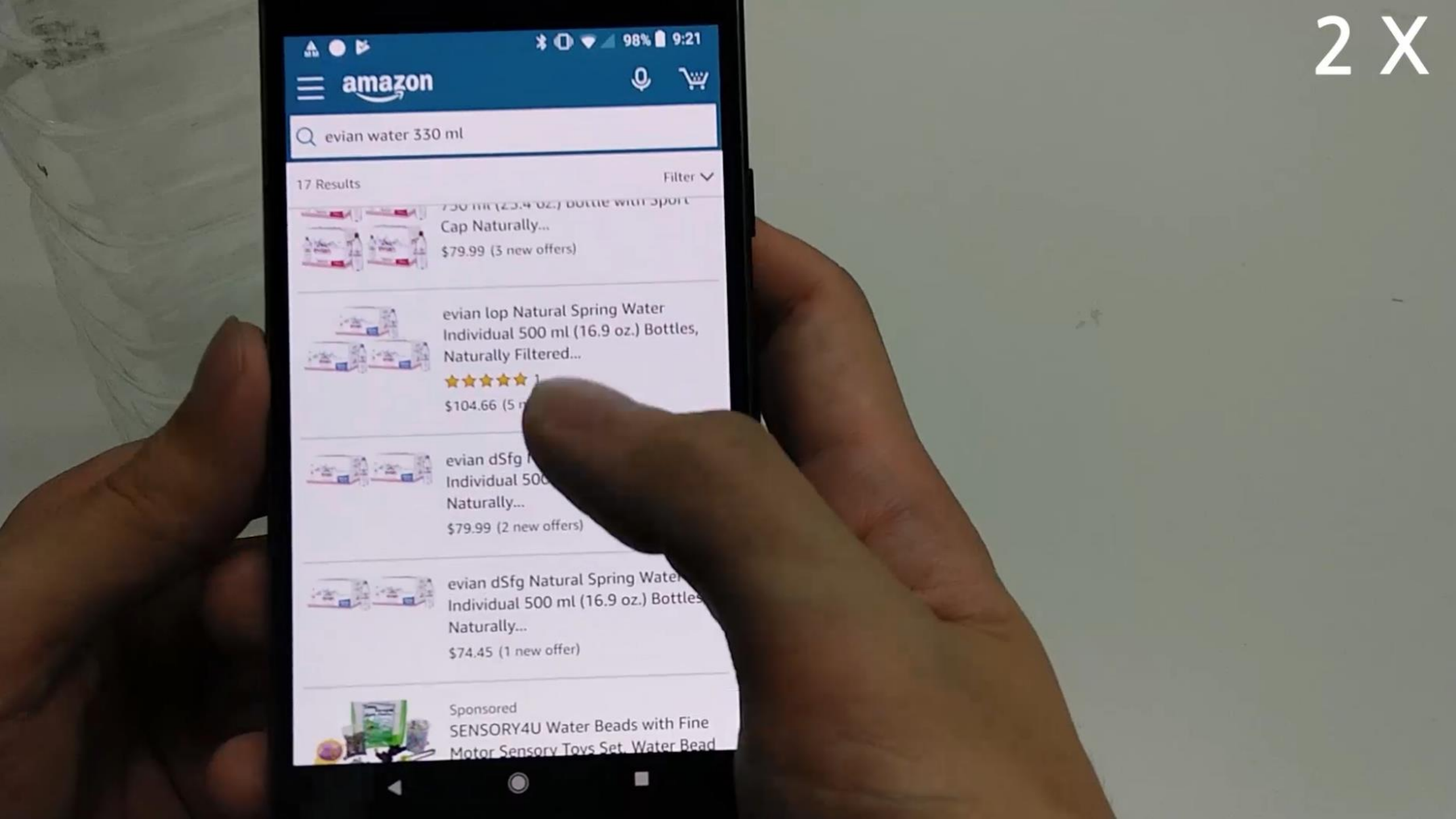

Back
Device
Lamp
100%

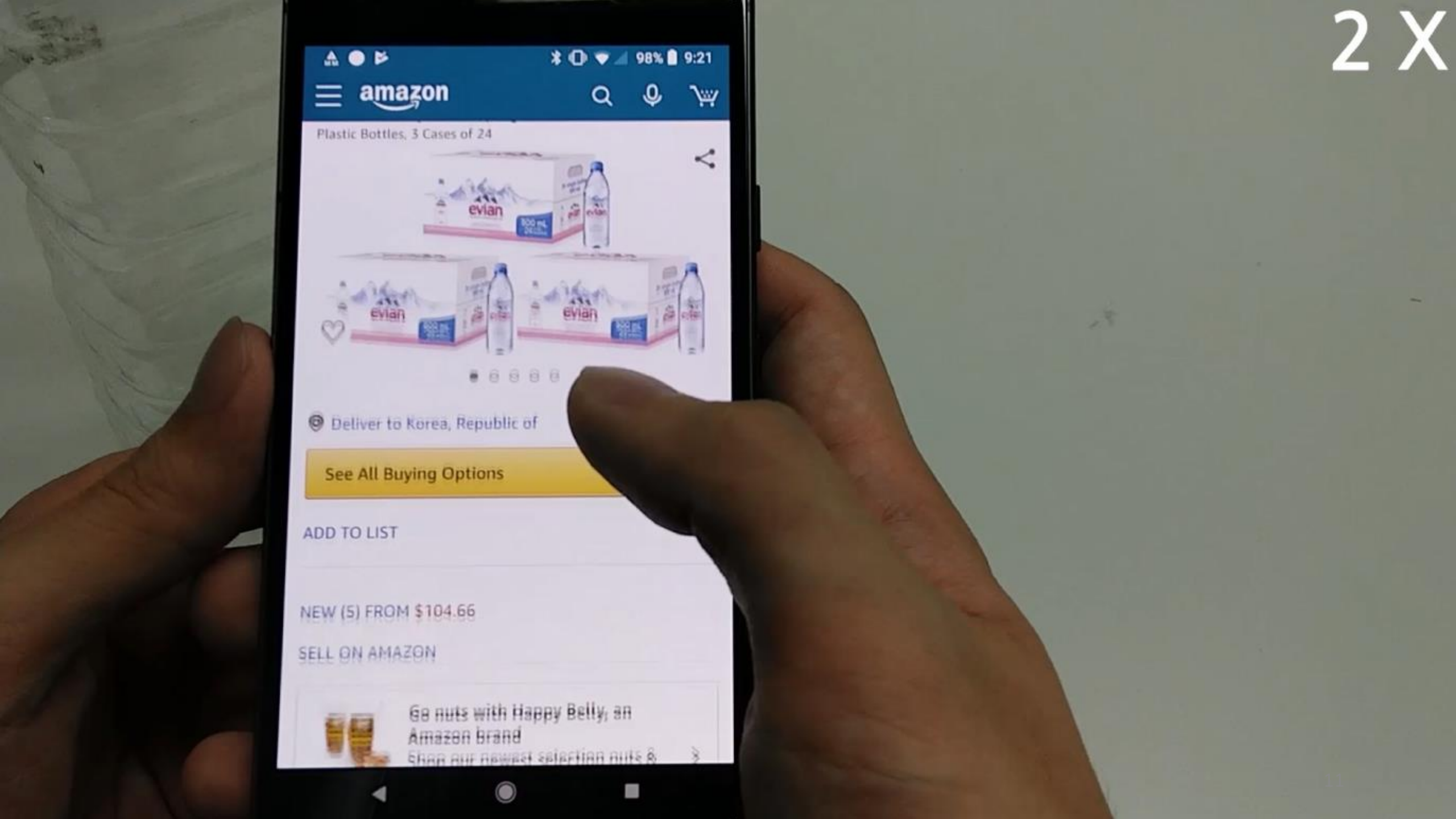
Often requires cumbersome process…

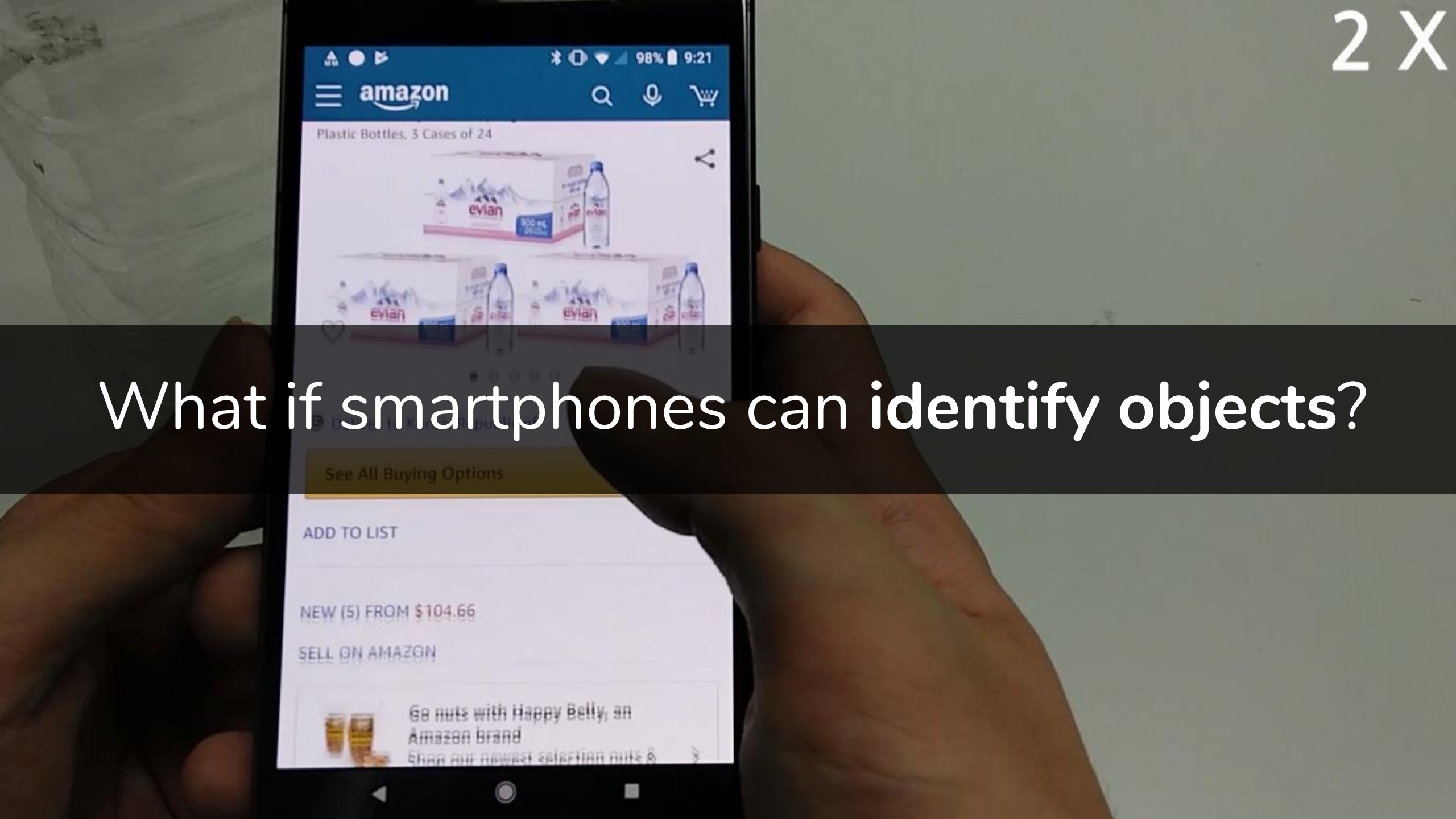

2 X


2 X
98% 9:21
IFTTT
Home
Fake Locat
August
Hue
Amazon Sh
Metronom
Soundbren
Expo
Metronome
Metronome
Tabs
Wear OS
Music Viz
Bluefruit
Simblee
For Mobile


2 X
98% 9:21
amazon
Evian water 330
evian water 330 ml
evian water 330 ml in Grocery &
evian water 330
4 5 6 7 8
_ & - + ( )
=\< * " ' : ; ! ?
ABC , 12 34 .

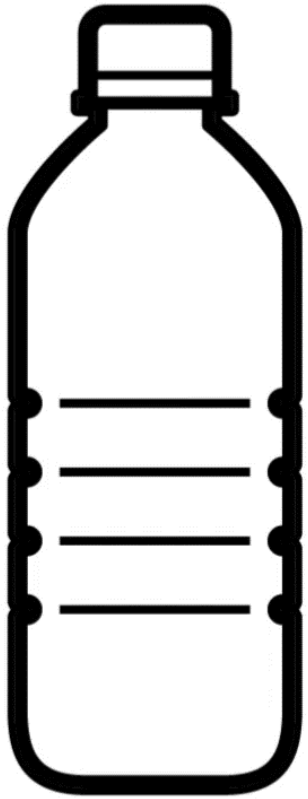

2 X
98% 9:21
amazon
evian water 330 ml
17 Results
Filter
Cap Naturally...
$79.99 (3 new offers)
evian lop Natural Spring Water
Individual 500 ml (16.9 oz.) Bottles,
Naturally Filtered...
$104.66
Naturally...
$79.99 (2 new offers)
Naturally...
$74.45 (1 new offer)
Sponsored
SENSORY4U Water Beads with Fine

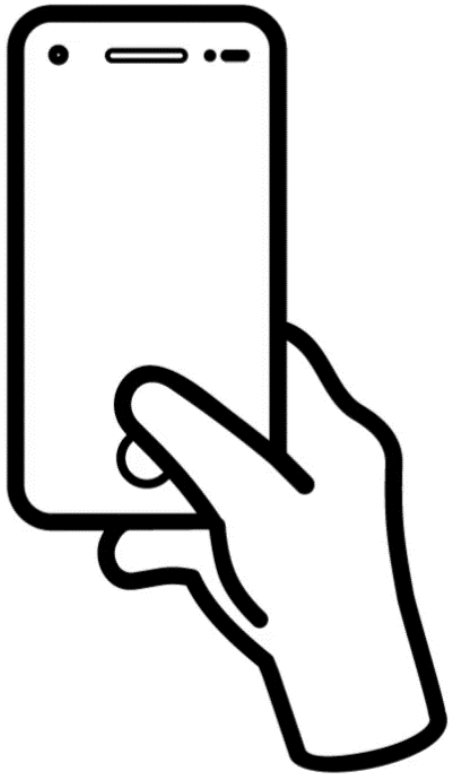

98% 9:21
amazon
Plastic Bottles, 3 Cases of 24
evian
Deliver to Korea, Republic of
See All Buying Options
ADD TO LIST
NEW (5) FROM $104.66
SELL ON AMAZON
Go nuts with Happy Belly, an Amazon brand
Shop our newest selection nuts &
2 X



What if smartphones can **identify objects**?

Knocker

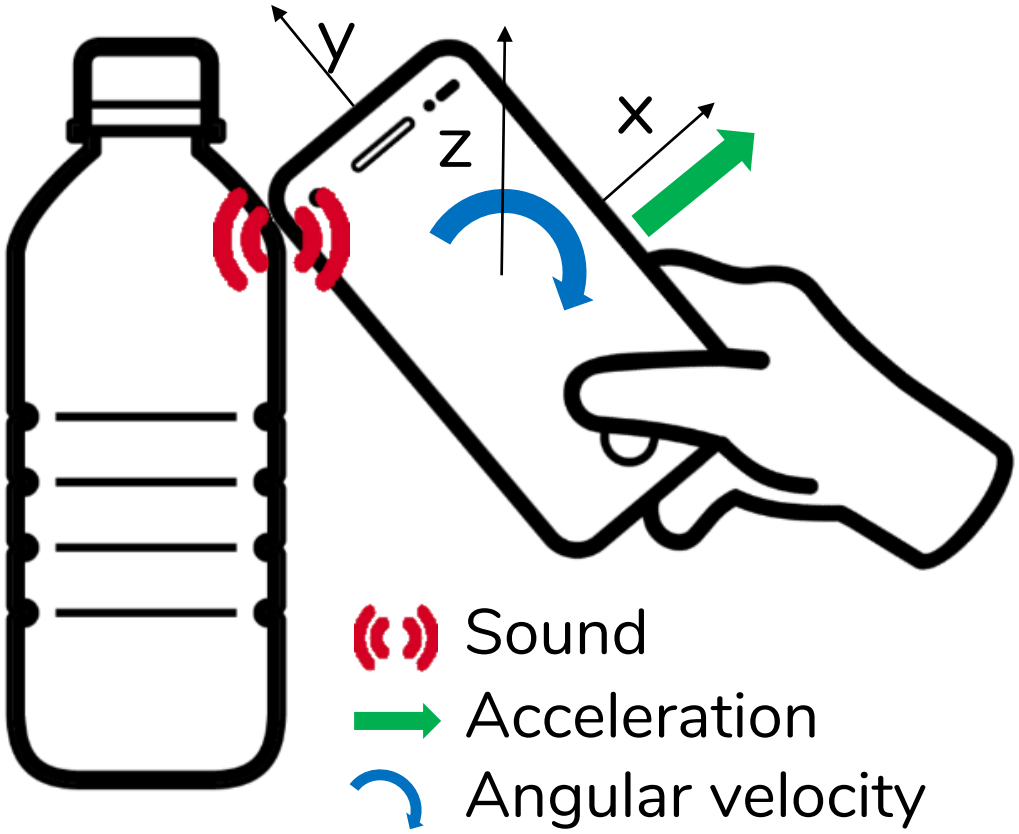


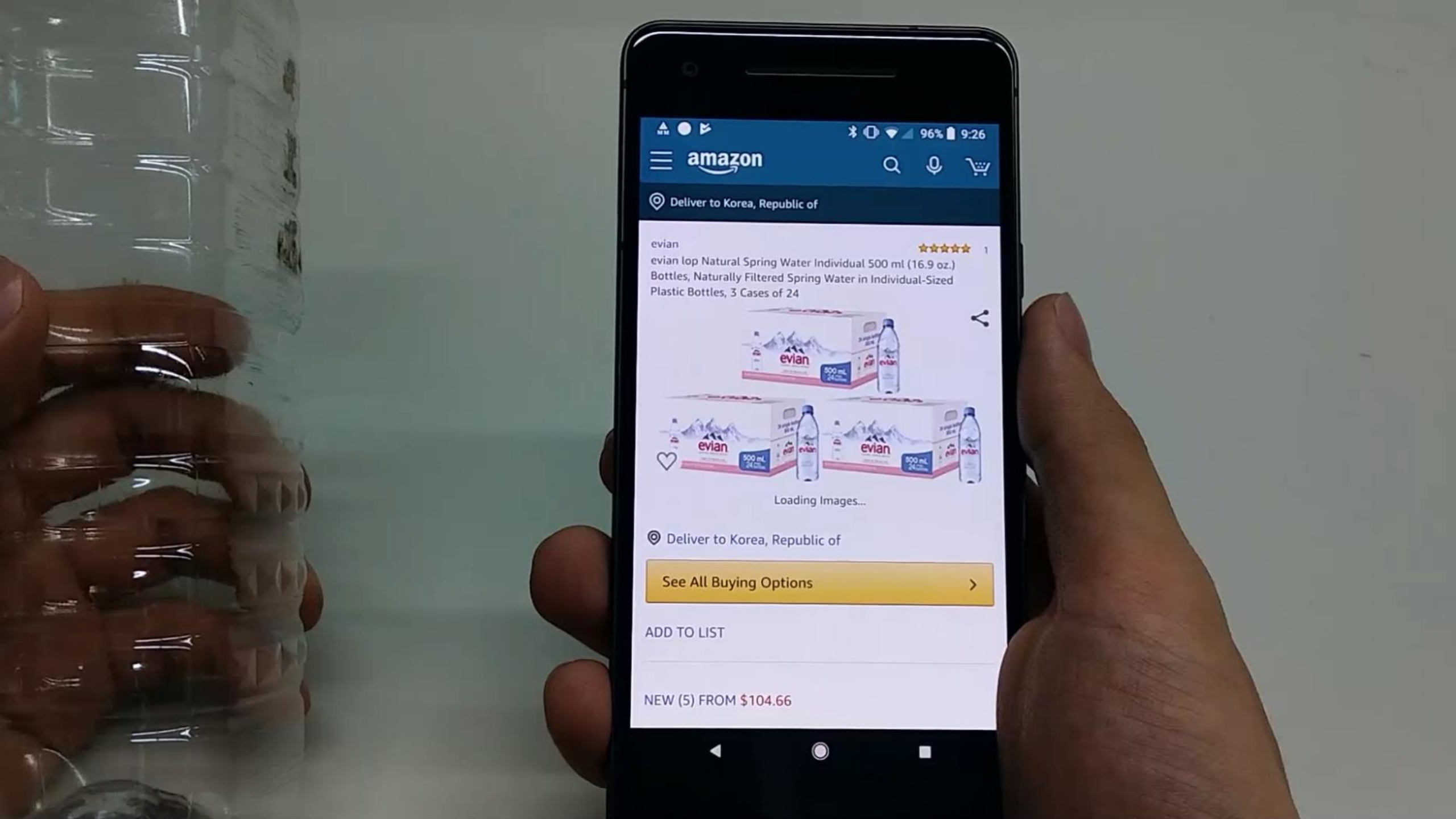


Knocker

Knocker

A unique set of responses per object




96% 9:26
amazon
Deliver to Korea, Republic of
evian
1
evian lop Natural Spring Water Individual 500 ml (16.9 oz.) Bottles, Naturally Filtered Spring Water in Individual-Sized Plastic Bottles, 3 Cases of 24
Loading Images...
Deliver to Korea, Republic of
See All Buying Options
ADD TO LIST
NEW (5) FROM $104.66

Live Demo

OBJECT-SPECIFIC APPLICATIONS

Tag-based approaches

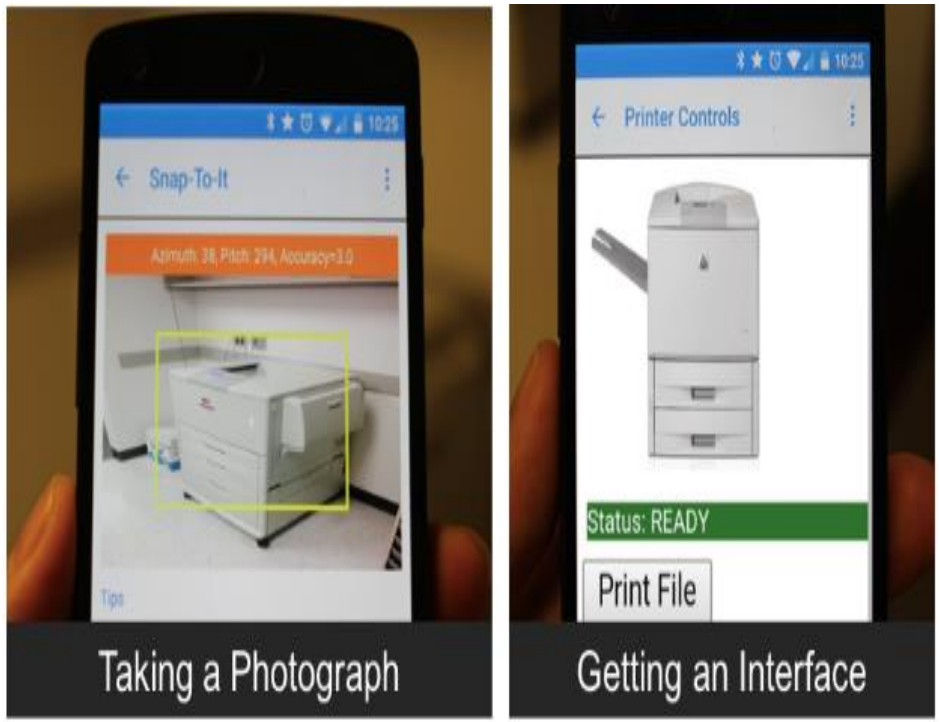
QR Code

RFID

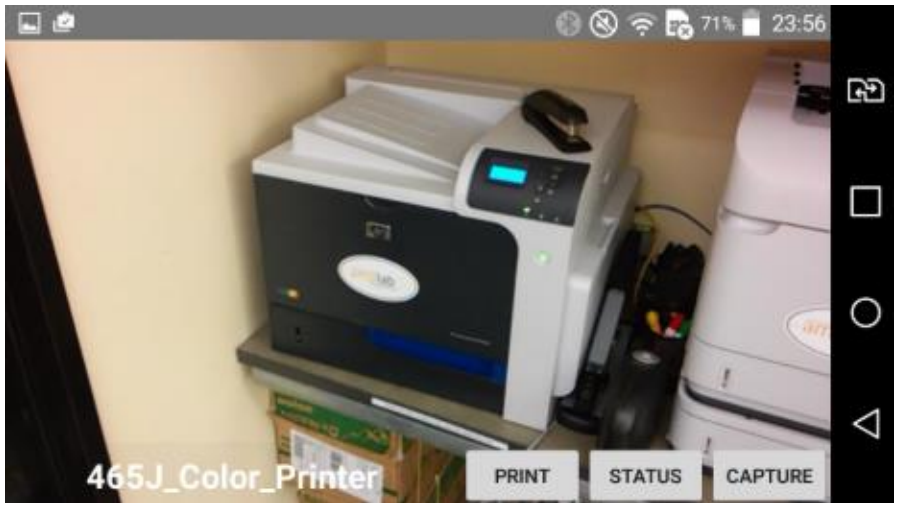
- Deployment cost and effort

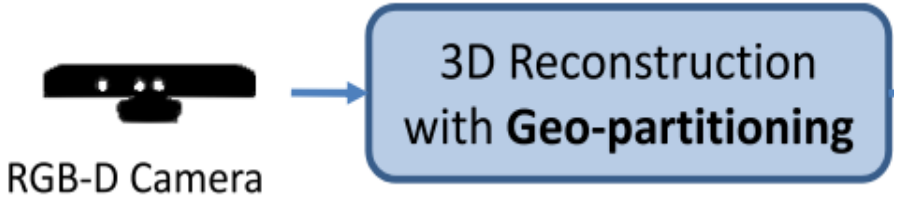
Camera-based approaches

Snap-To-It (CHI ’16)



SnapLink (IMWUT ’17)

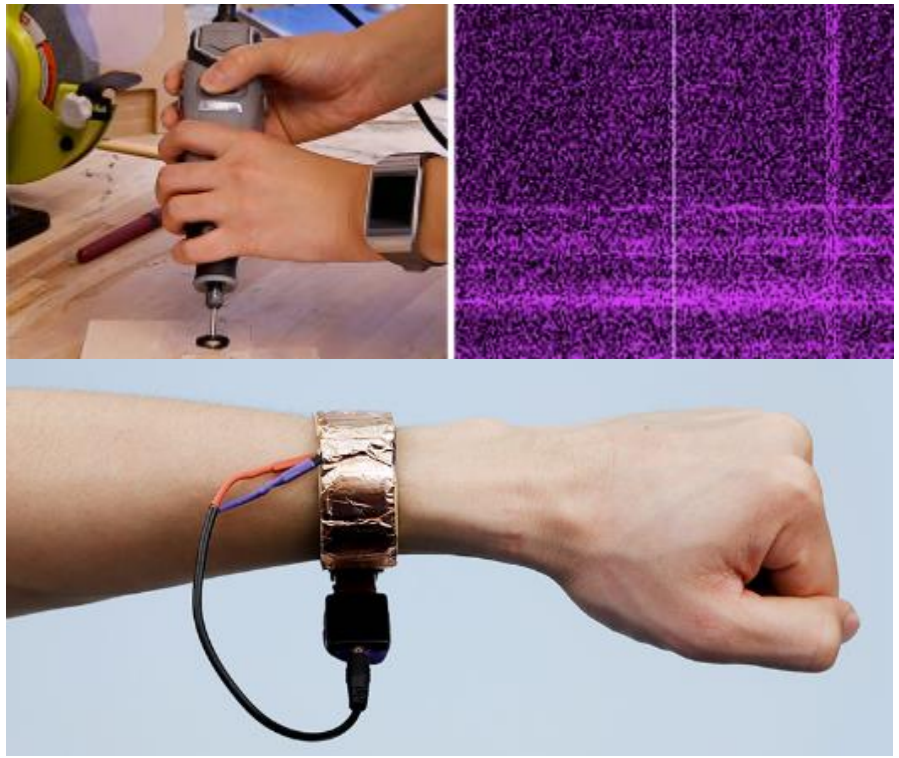




- Light conditions, angles, orientations, etc.

Electromagnetic (EM) noise sensing

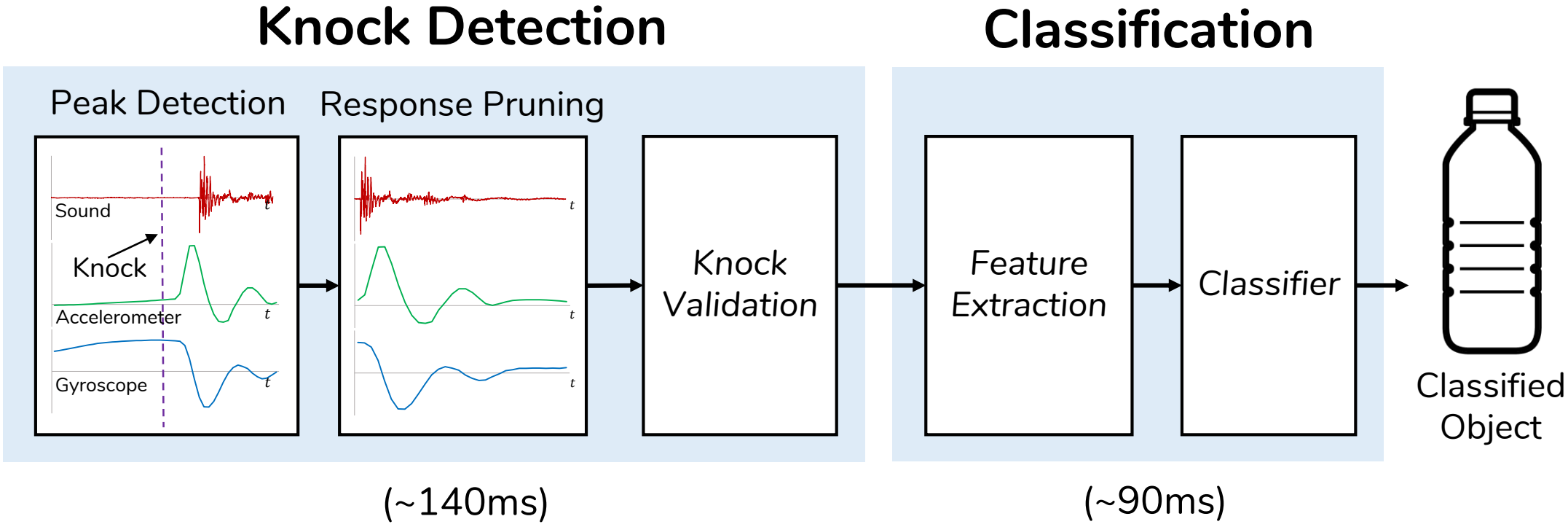
EM-Sense (UIST '15)



Deus EM Machina (CHI '17)

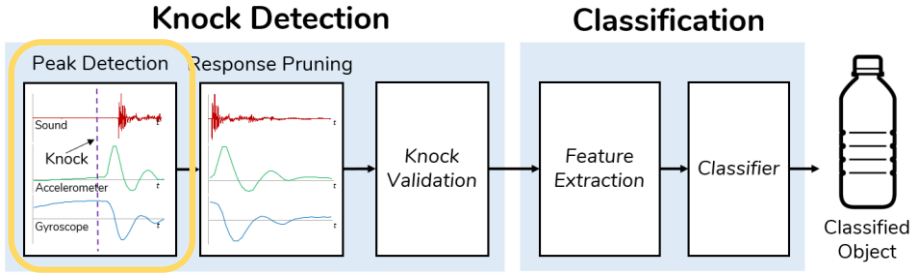
- Requires special h/w & limited to electric appliances

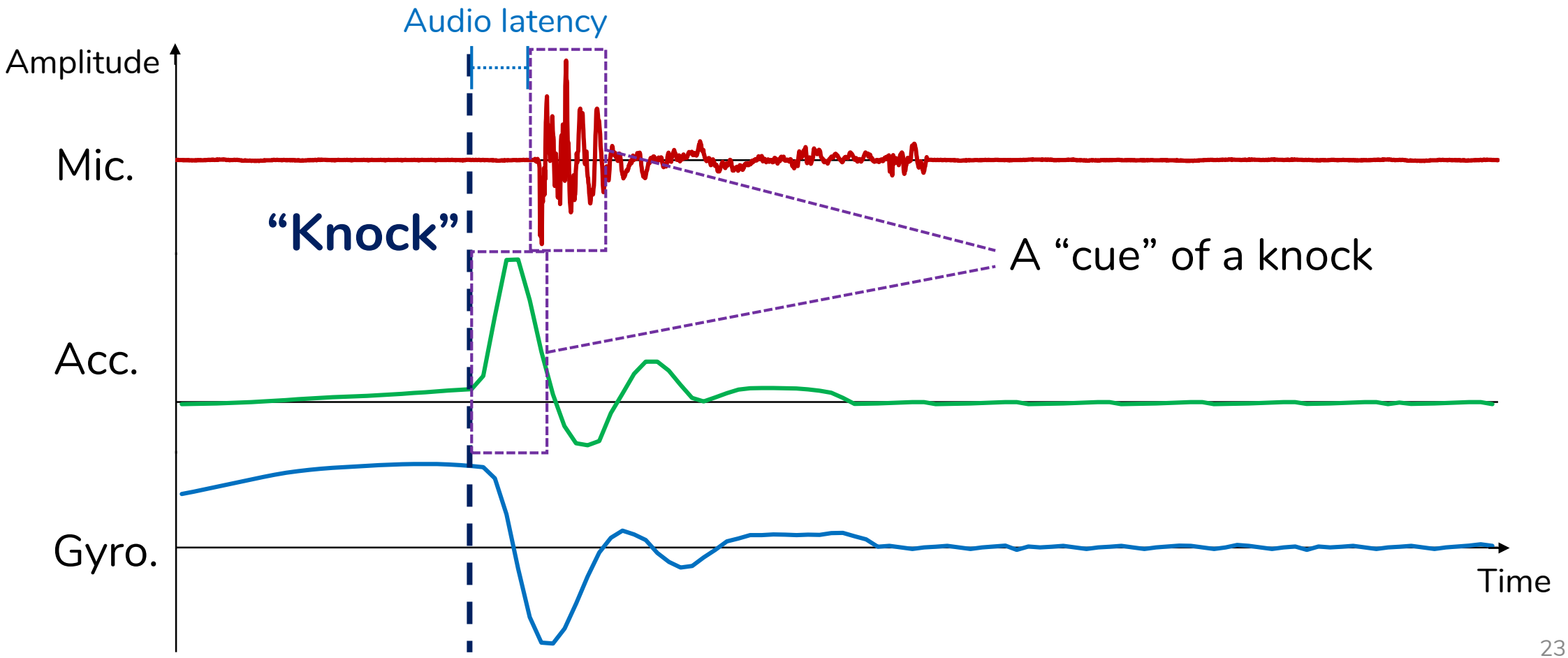
How Knocker works



Knock Detection

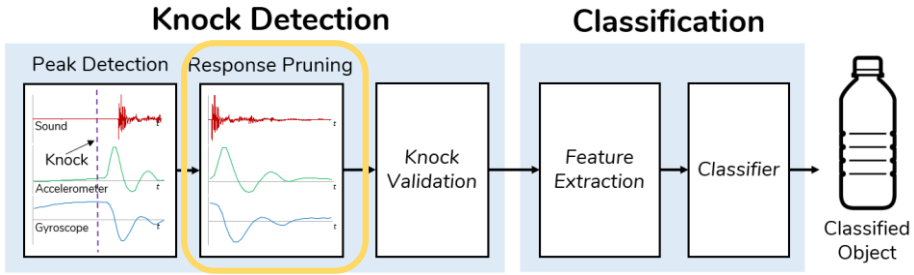
(1) Peak Detection





Knock Detection

(2) Response Pruning



Mic.

"Knock"

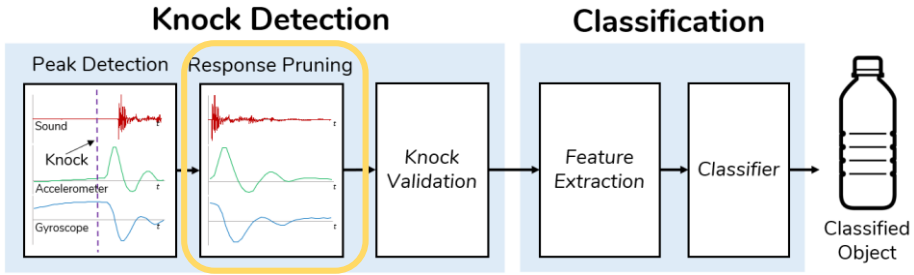
Acc.

Gyro.

Time

Knock Detection

(2) Response Pruning



Response: ~80ms

Mic.

"Knock"

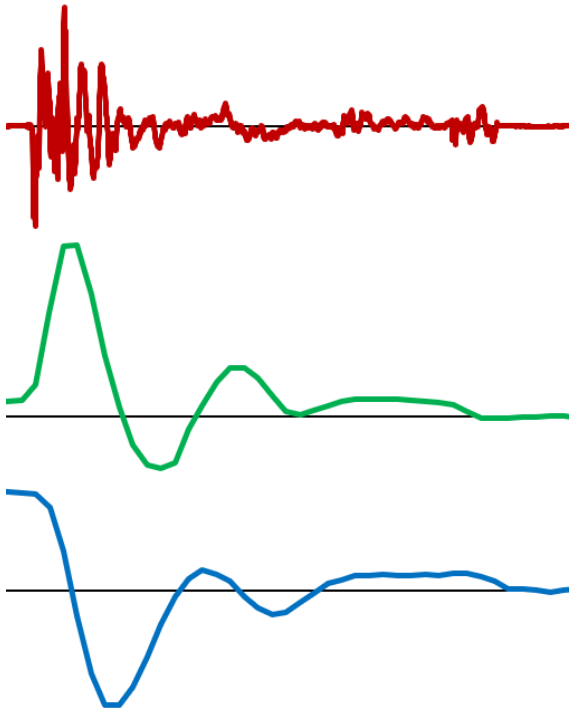
Acc.

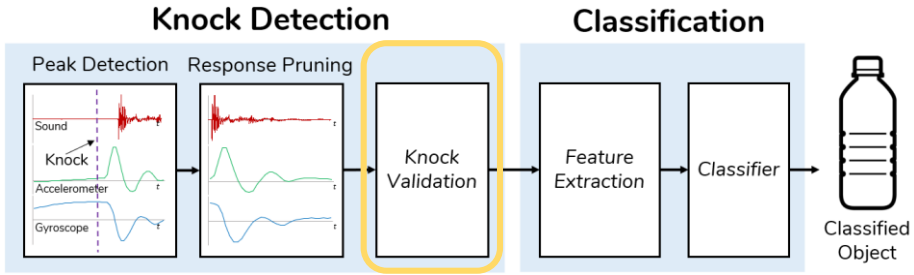
Gyro.

Time

Knock Detection

(3) Knock Validation

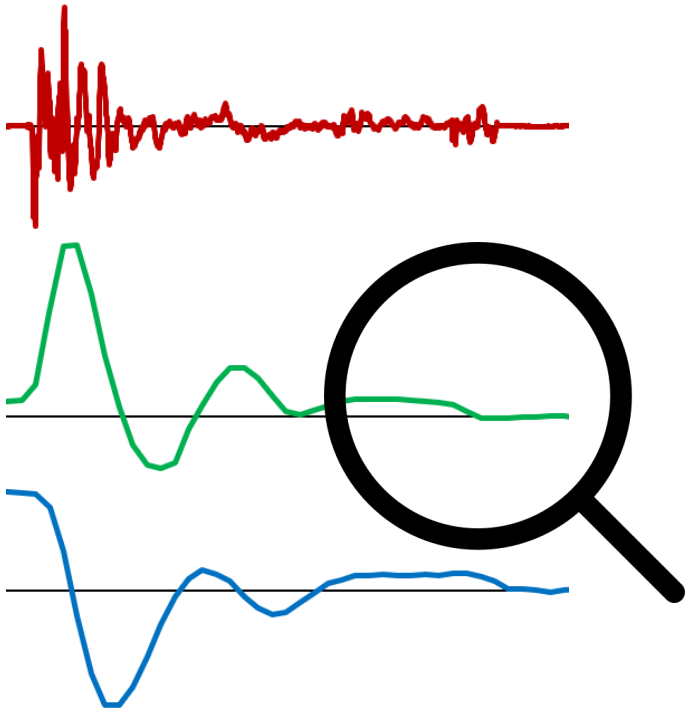




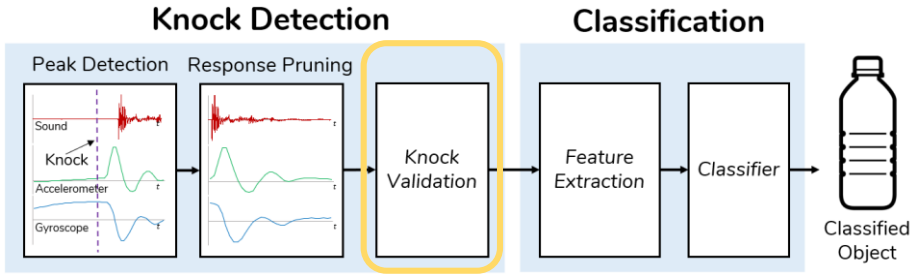
How to reduce false positives?

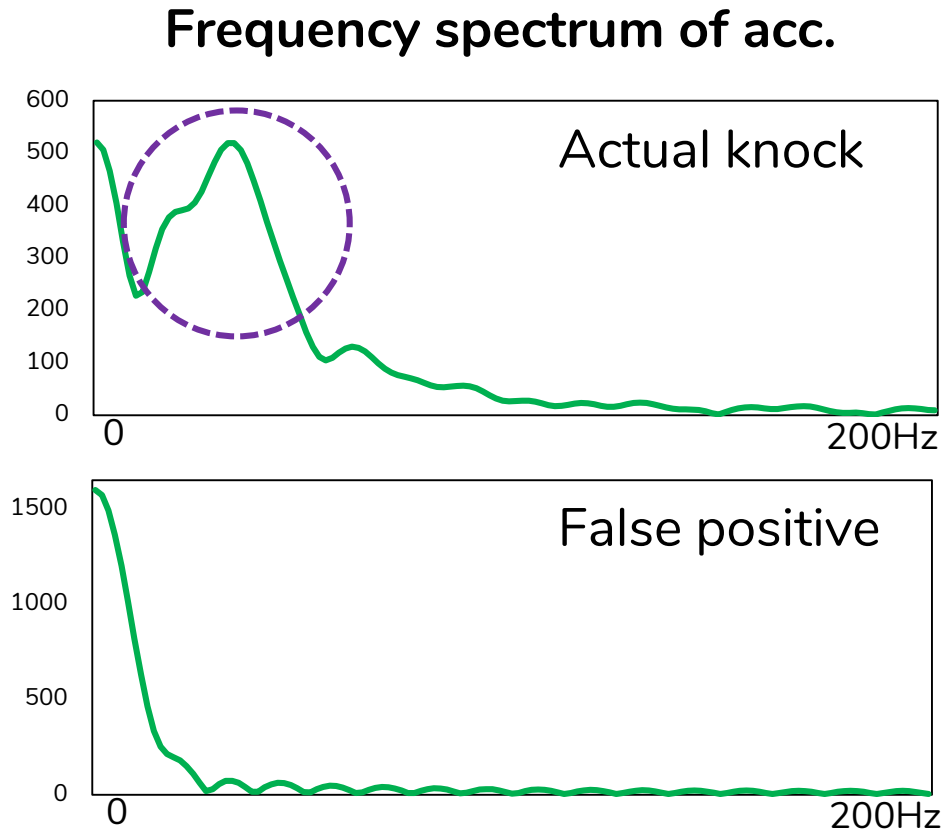
Knock Detection

(3) Knock Validation



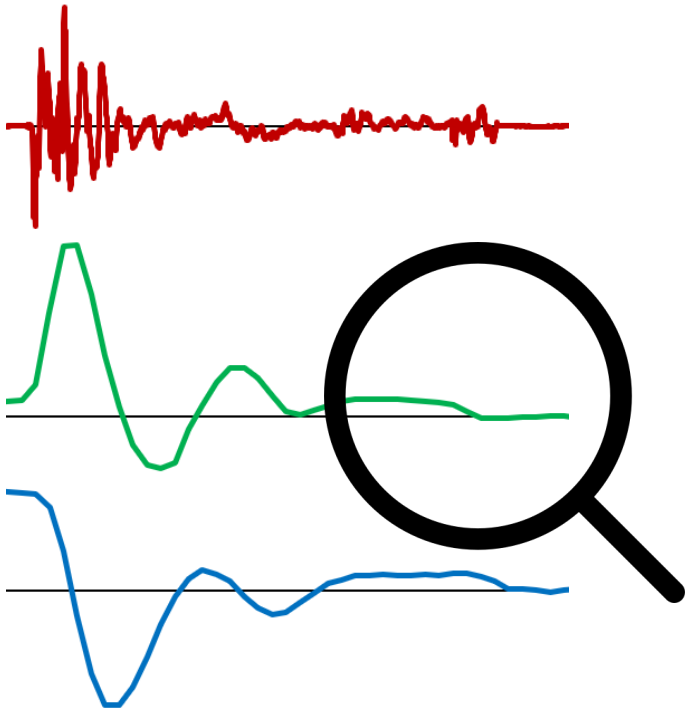
How to reduce false positives?



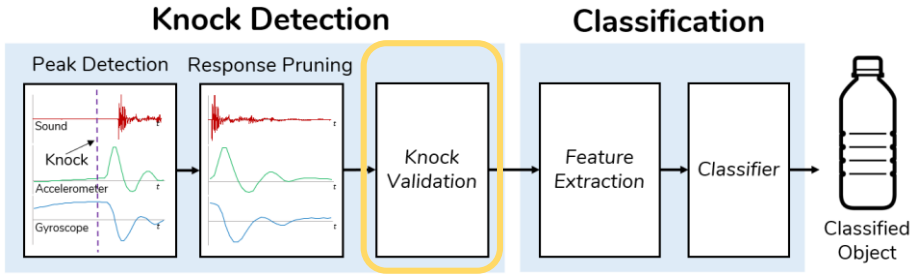


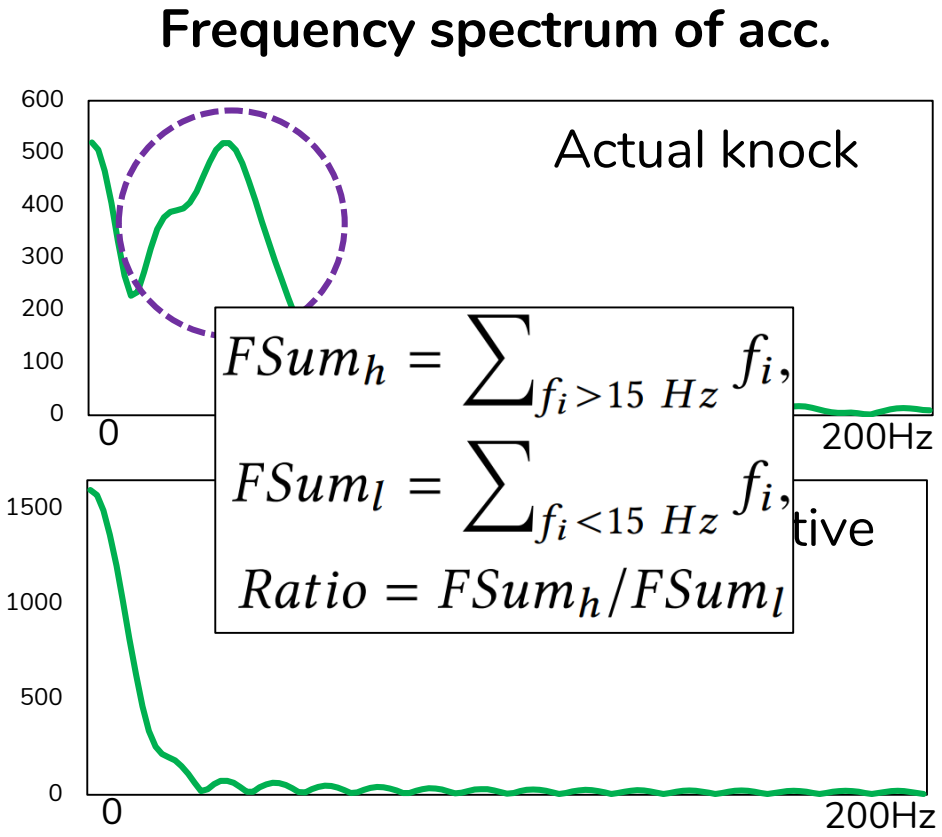
Knock Detection

(3) Knock Validation

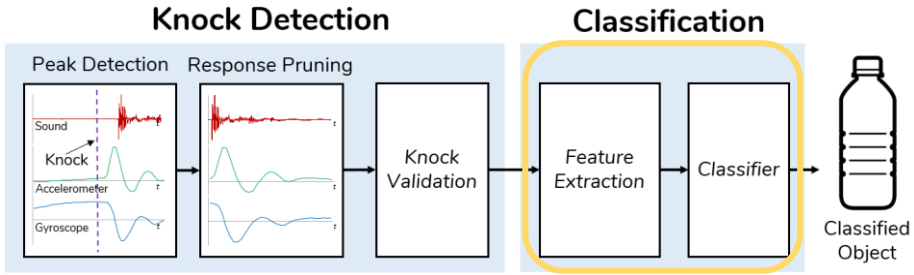


How to reduce false positives?





Classification



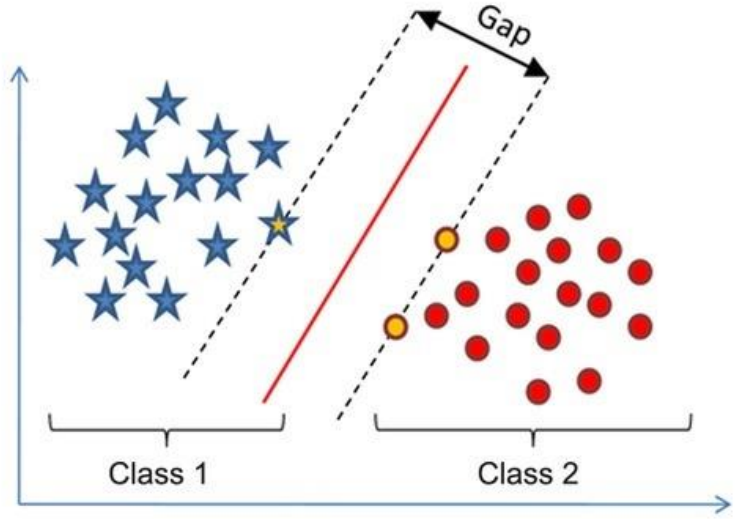
Extracted Features

Sound:
- Magnitude spectrum
- Log magnitude spectrum
- MFCCs

Accelerometer:
- Magnitude spectrum

Gyroscope:
- Magnitude spectrum

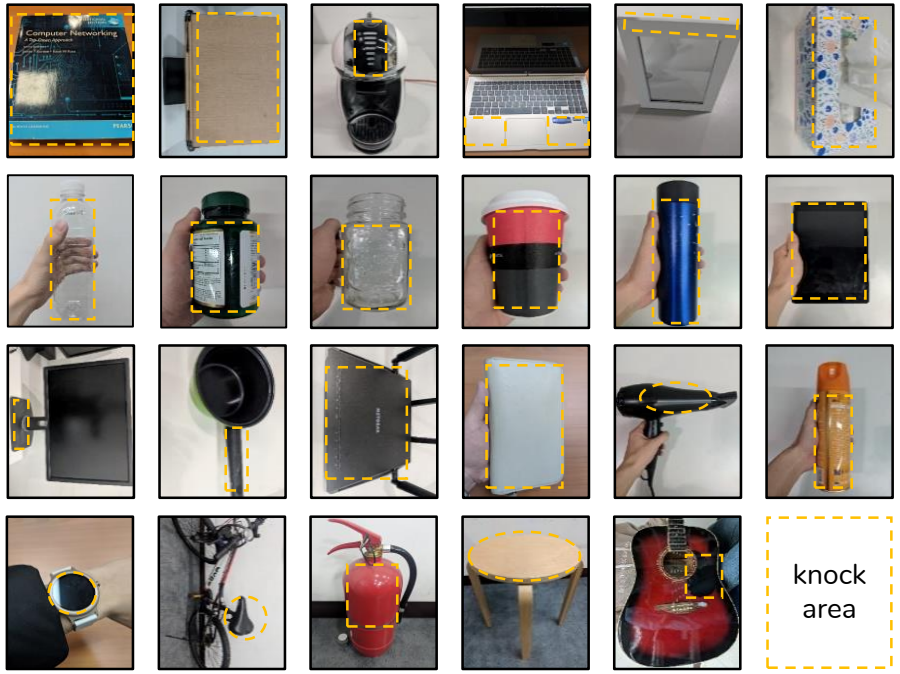
Support Vector Machine

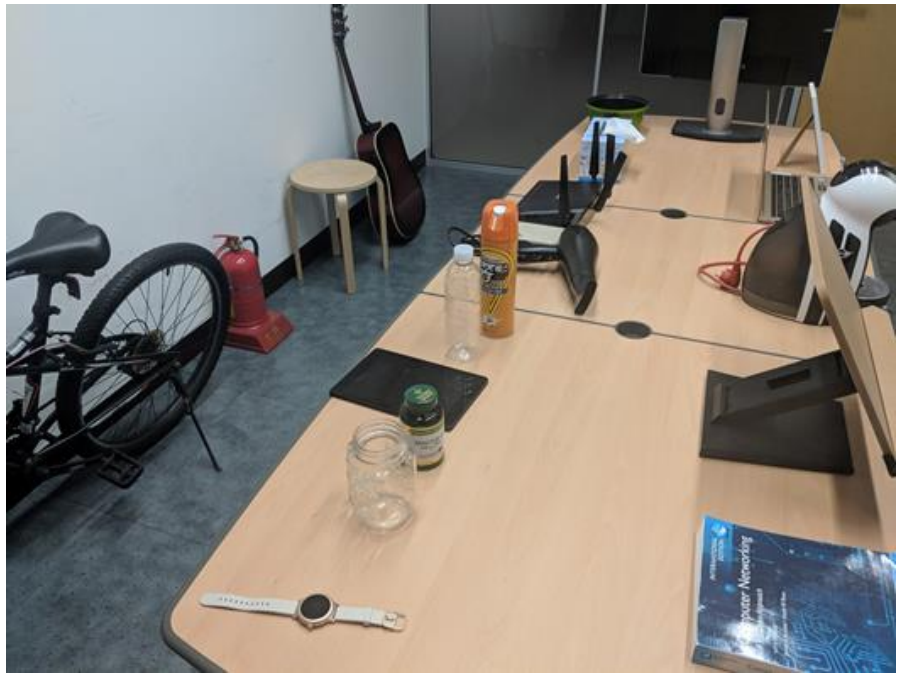


Evaluation

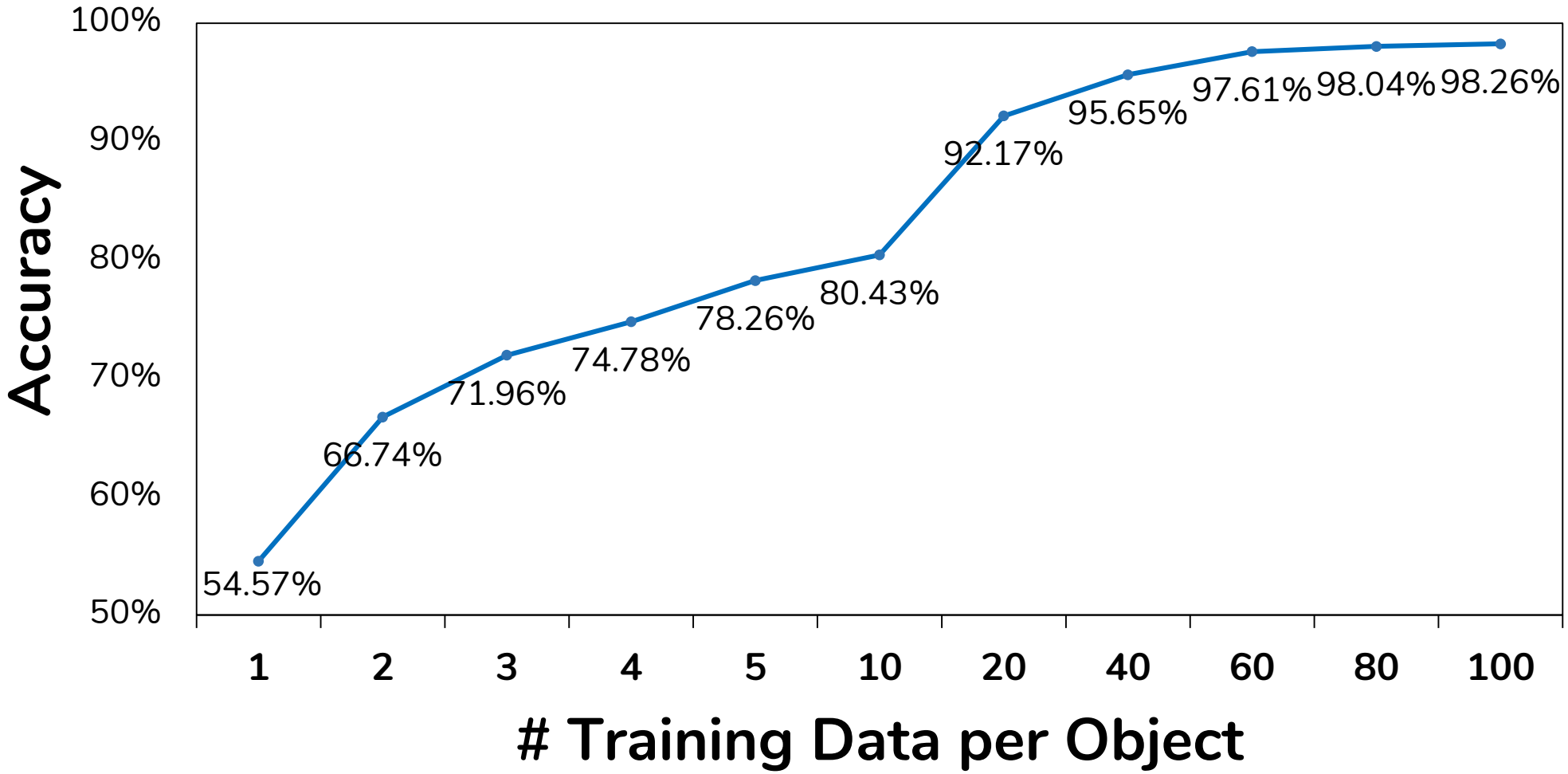
20 users

23 everyday objects



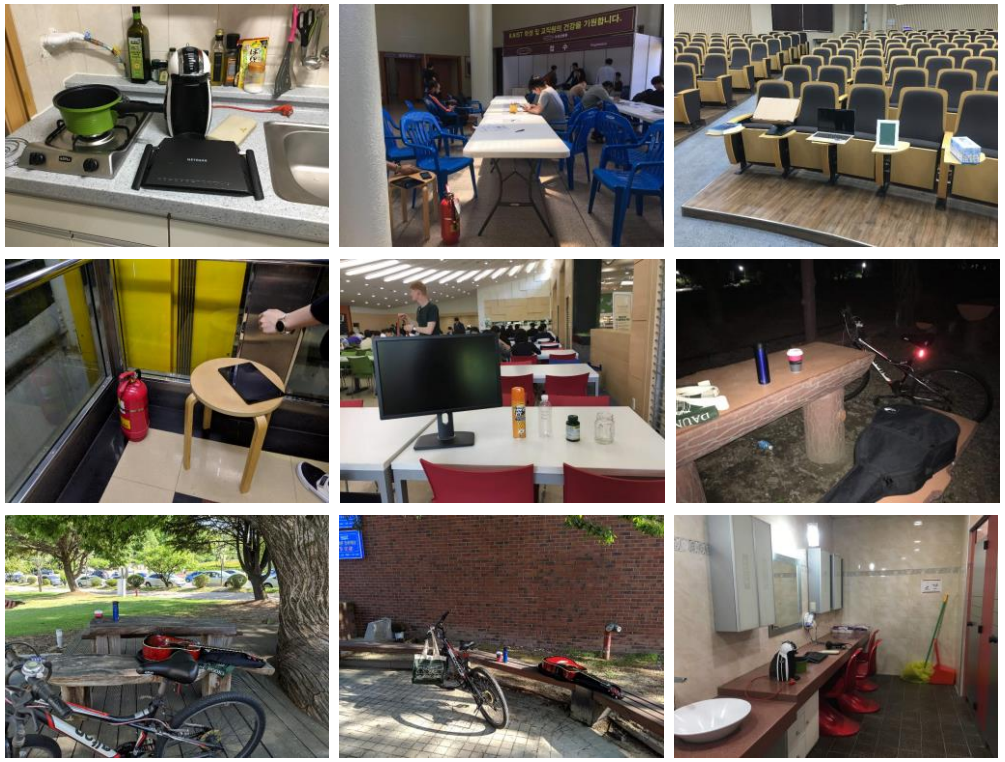


Impact of the number of training data



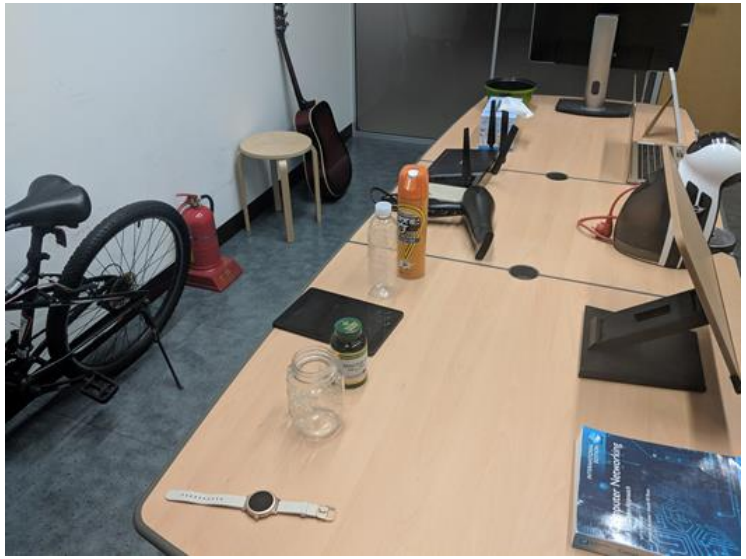
In-lab vs. In-the-wild

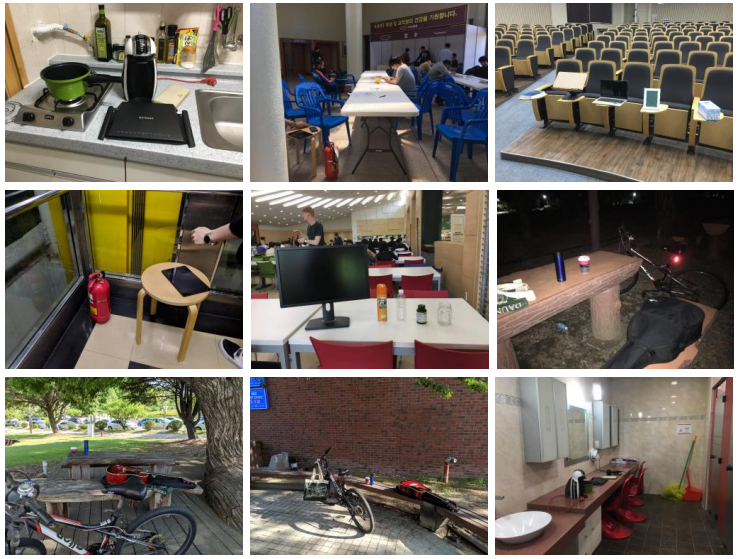
Trained in a quiet room



Tested in 50 environments with
- various types of noise
- underlying object changes

In-lab vs. In-the-wild





Sound feature only:	95.00%	77.08%
Sound + Acc. + Gyro.:	**96.74% (+1.7%)**	**83.02% (+6%)**

Conclusion

- Knocker is a **new object recognition technique** that greatly simplifies the interaction with objects via smartphones

- Knocker leverages **built-in sensors** for identifying objects **without modification** of smartphones and objects

- Knocker's **motion features** improves accuracy especially under **noisy environments**

Knocker

https://nmsl.kaist.ac.kr/projects/knocker

Dataset is available!

Taesik Gong: taesik.gong@kaist.ac.kr