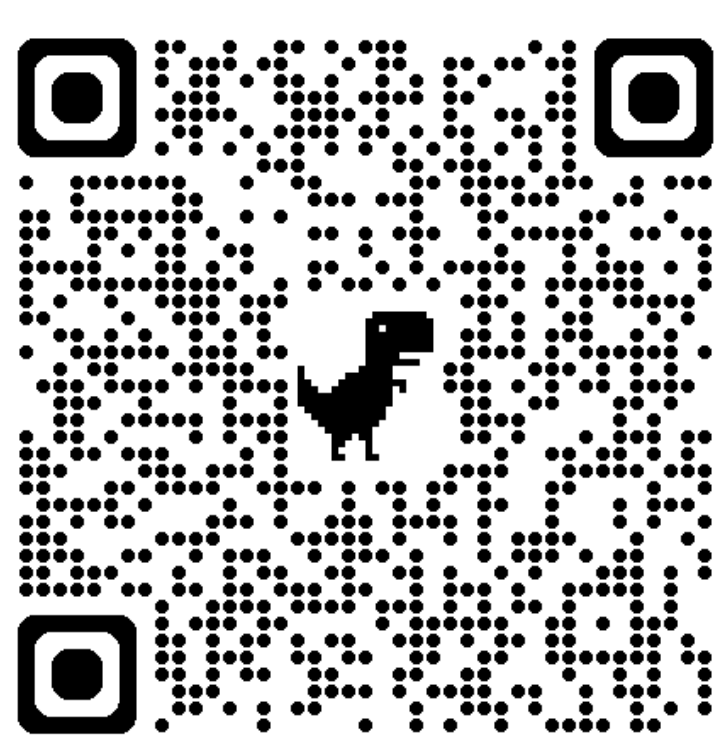




Explore
Touch2Know

Touch2Know: Dexterous In-Hand Liquid Sensing via Mutual-Capacitance Fingerprints

What's inside the bottle? Just grasp it.

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Angelo Cangelosi, Senior Member, IEEE, Wuqiang Yang*, Fellow, IEEE

The University of Manchester



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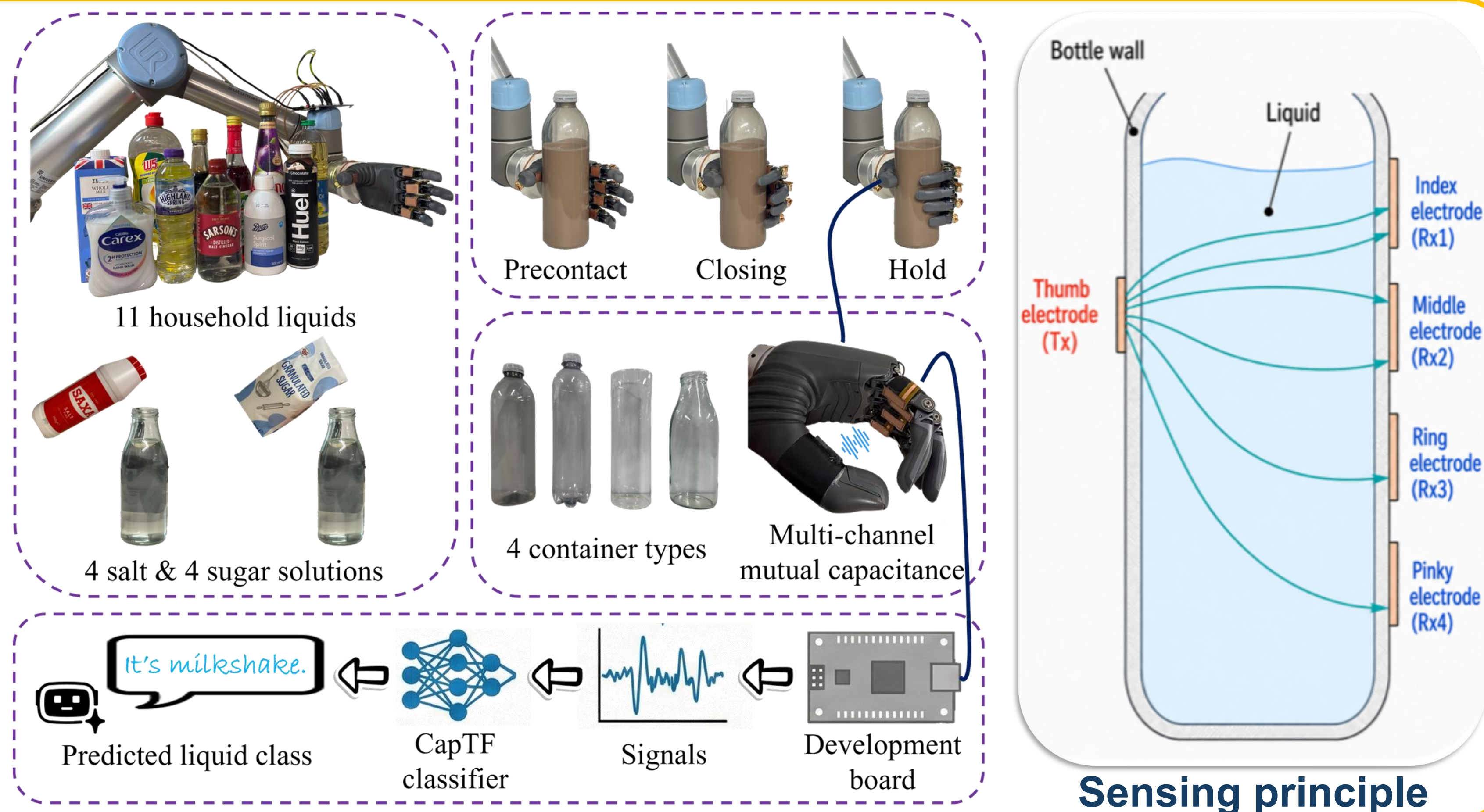
Motivations

Can a dexterous hand identify a liquid without opening the bottle?

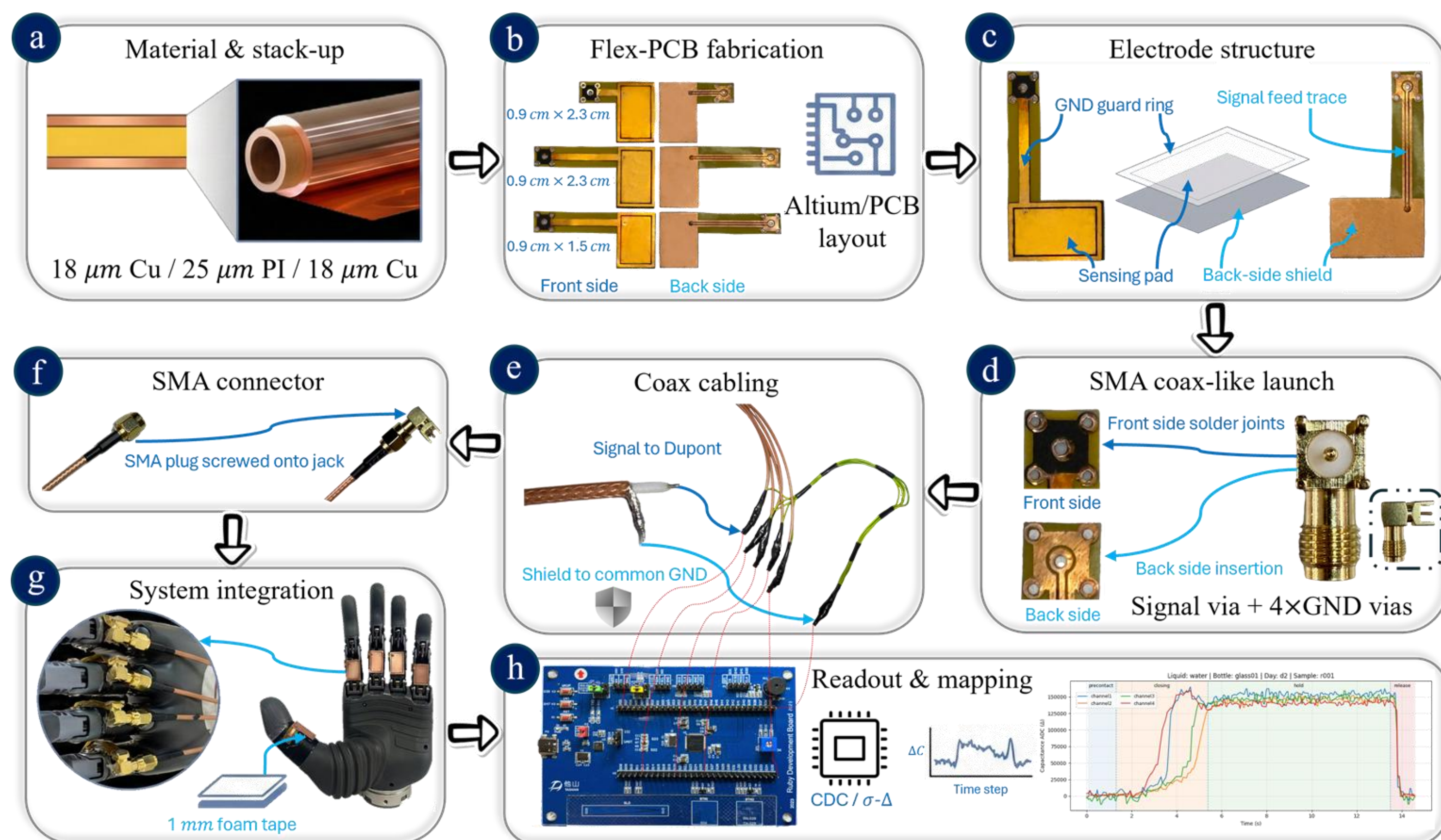
- Opaque bottles hide the liquid from vision.
- Shaking, tilting or opening adds extra actions.
- Many non-visual approaches need specialized hardware.
- Touch2Know turns the grasp itself into sensing.

Core idea:

grasp → sense through the wall → recognize

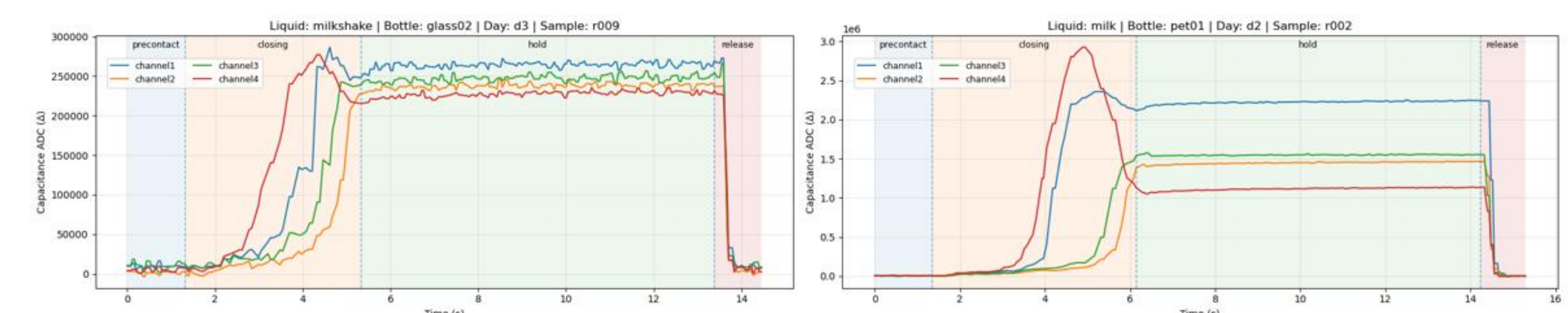


Methodology



HOW TOUCH2KNOW WORKS

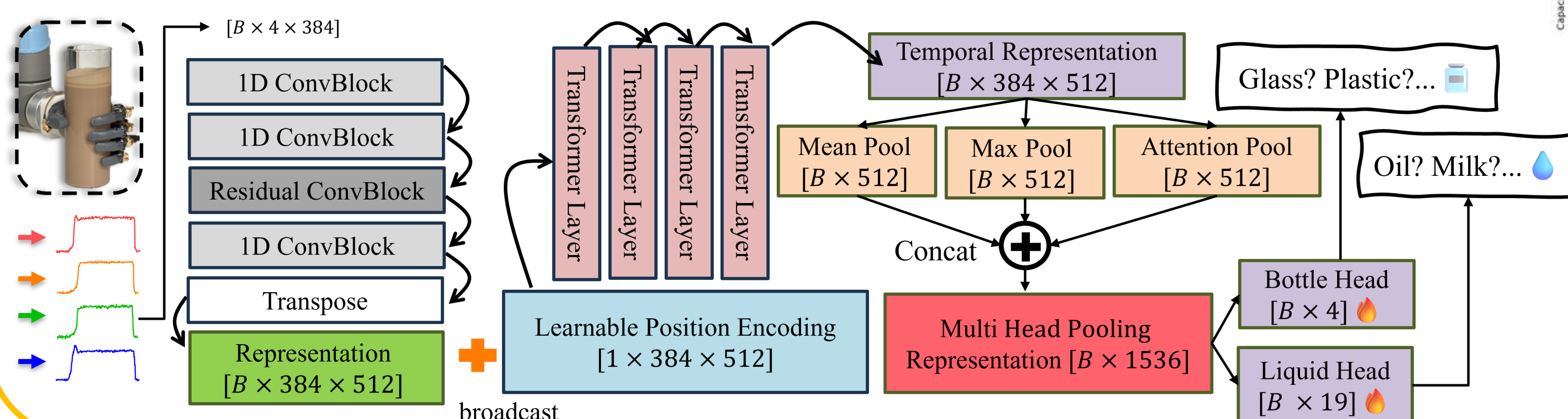
- 1 Adaptive grasp**
 - Each finger closes independently until stable contact.
- 2 Mutual-capacitance sensing**
 - Thumb = Tx; Index, middle, ring and pinky = four Rx Channels.
- 3 Per-trial calibration**
 - A 5s baseline before each grasp suppresses drift.
- 4 CapTF classification**
 - CNN-Transformer jointly predicts liquid and container.



Why CapTF?

- CNN captures local contact dynamics.
- Transformer models the full grasp sequence.
- Multi-task learning leverages container cues.

CapTF — Capacitive Temporal Fusion



Results & Insights

19 Liquid Classes | 4 Container Types | 4 Days | 3,040 Grasp Trials

95.07%

LIQUID ACC.
Random split

90.00%

LIQUID ACC.
Cross-Day test

99.34%

CONTAINER ACC.
Random split

98.16%

CONTAINER ACC.
Cross-Day test

What improves performance?

Baseline subtraction

80.15% → 95.07% Random split

68.82% → 90.00% Cross-Day test

Multi-task learning

92.11% → 95.07% Random split

86.51% → 90.00% Cross-Day test

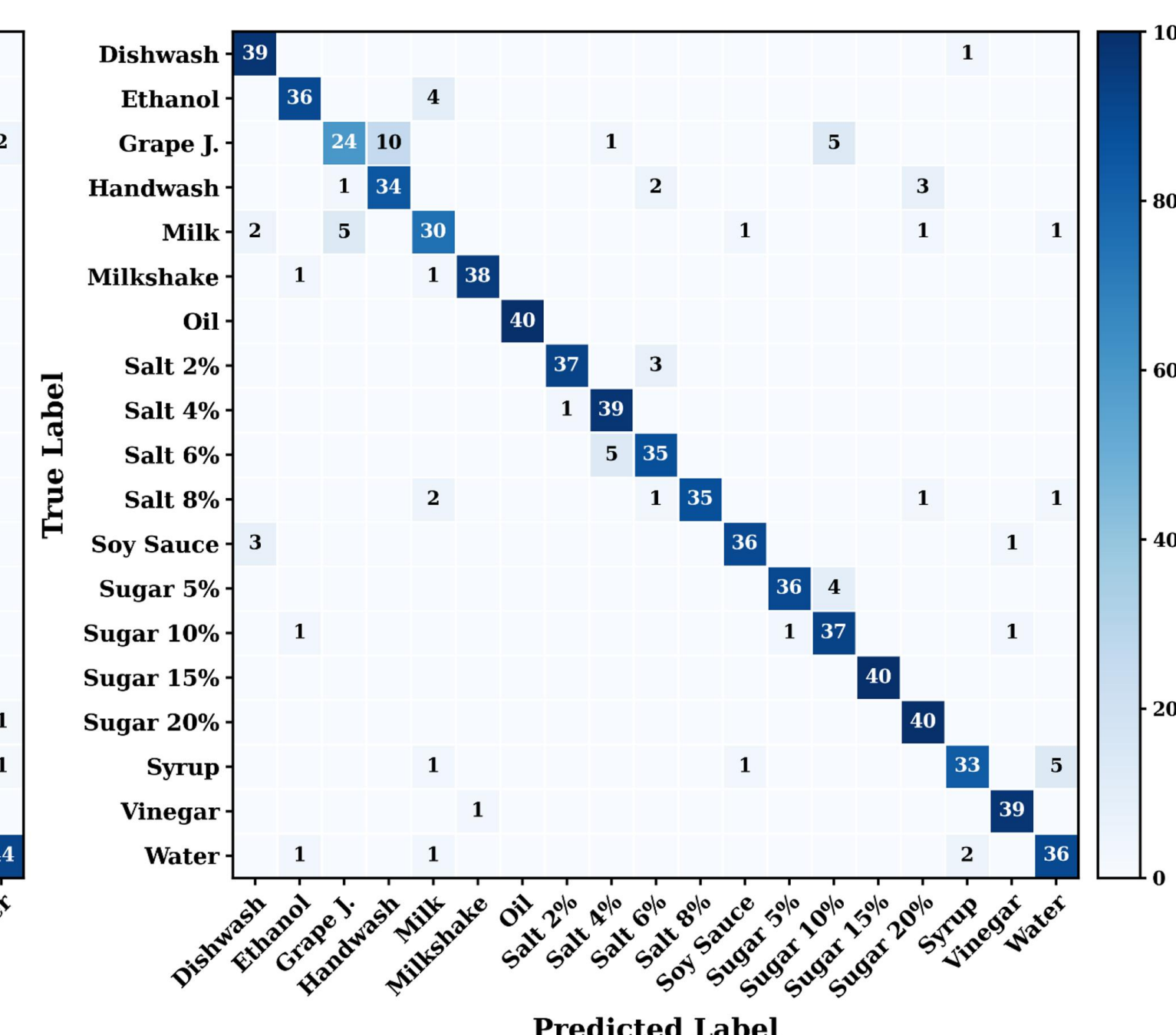
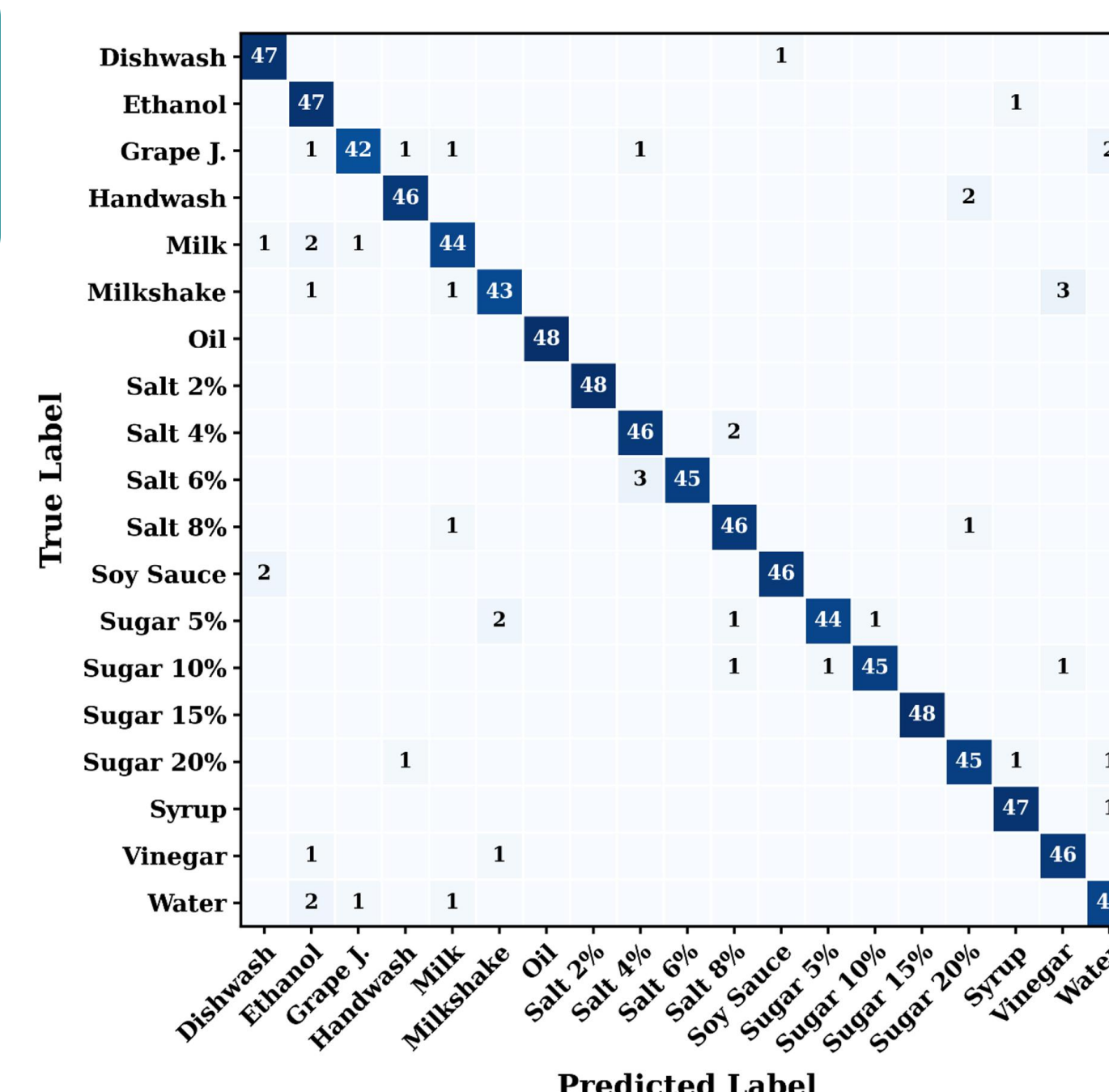
Future Work

- Different fill levels
- Temperature effects
- Liquid relative permittivity prediction

Classification Performance

Random Split — 95.07%
70% Train · 30% Test

Cross-Day Test — 90.00%
Train: Days 1–3 · Test: Day 4



COROLAB
A "robot home!"

MANCHESTER
1824
The University of Manchester



IROS
Contributed paper

Manchester Tashan Joint Laboratory (UK) of Touch Sensors for Domestic Robots × Cognitive Robotics Lab