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MIDAS: Characterizing Objects using Human Touch (Thermal Dissipation as a Sensing Modality)

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Idea: Piggybacking human touch

Innovative sensing modality that characterize objects and recognize a wide range of materials enabling a broad range of application.

Source: https://www.cleanpng.com/png-water-bottle-first-baptist-church-of-los-angeles-c-102053/preview.html

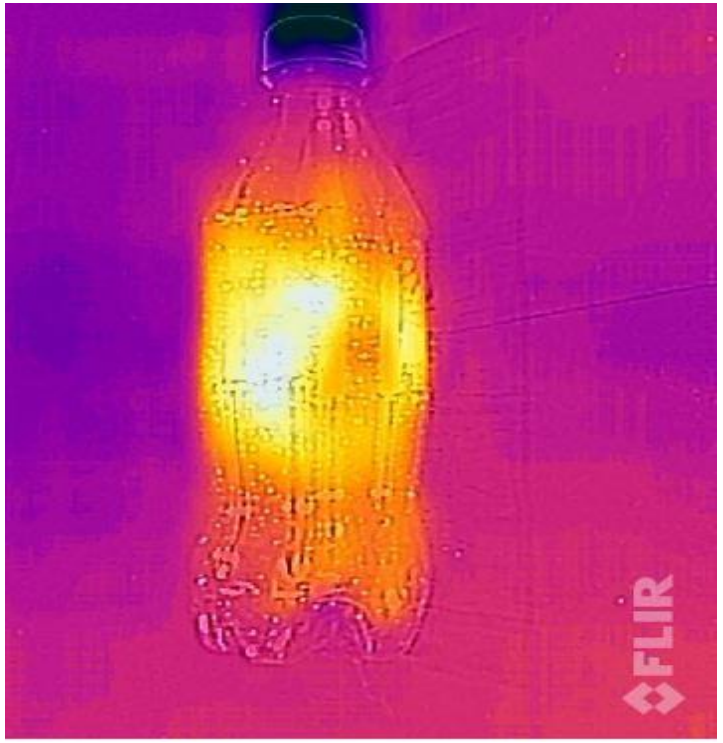


Fig: Plastic bottle that is exposed to ambient heat.

Contributions

- **New method:** We develop MIDAS as a novel sensing approach for characterizing materials using thermal dissipation footprints.
- **Novel insights:** We demonstrate that current state-of-the-art techniques based on computer vision are limited and only capable of recognizing products that are not mixed with other items.
- **Improved performance:** MIDAS significantly improves the classification of materials of different sizes and shapes and works robustly across different persons.

Feasibility analysis

- **Thermal emissivity coefficient of materials (Plastic material)**
- **Preliminary analysis of materials (Household objects)**

Fig A: Plastic materials

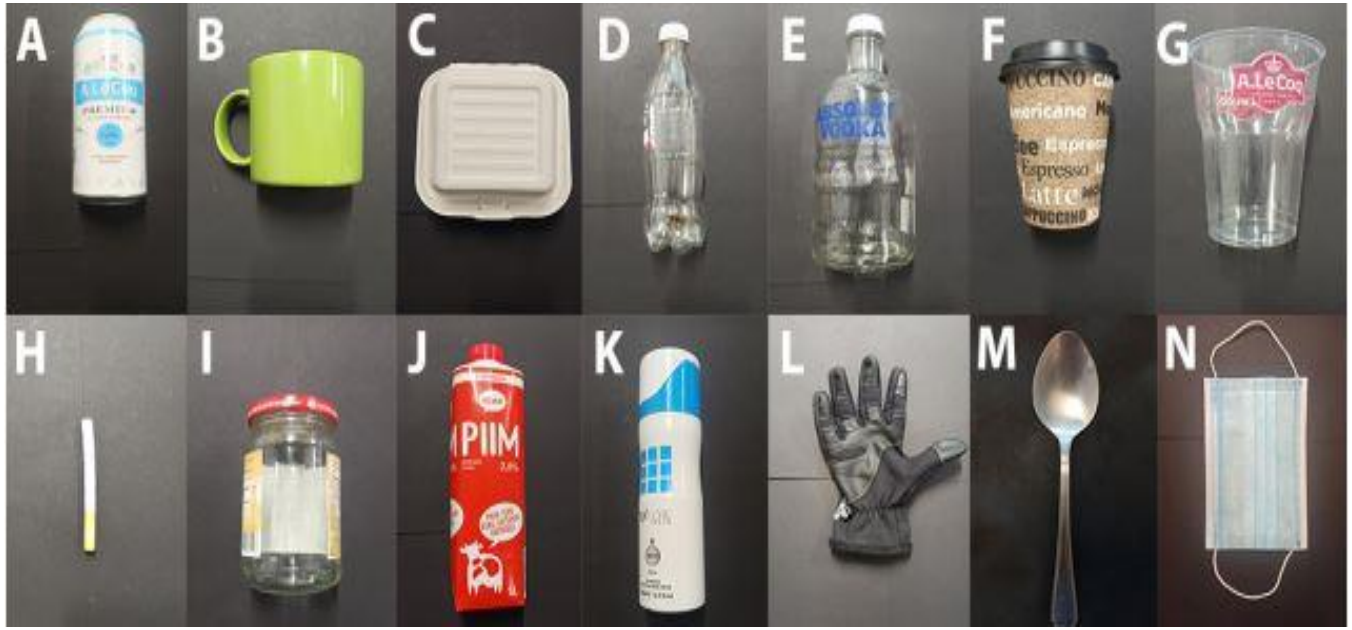


Fig B: Household objects

Feasibility analysis

Thermal emissivity of materials

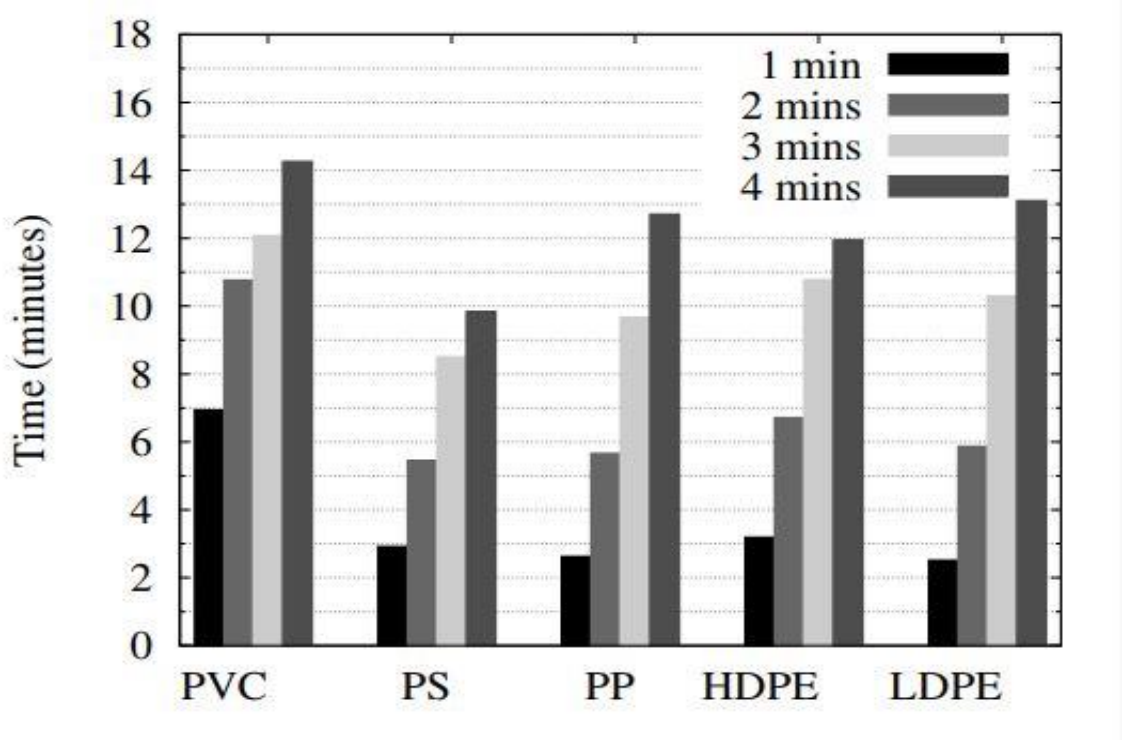


Fig A: Dissipation time of thermal footprints in different plastic materials.

Analysis with household objects

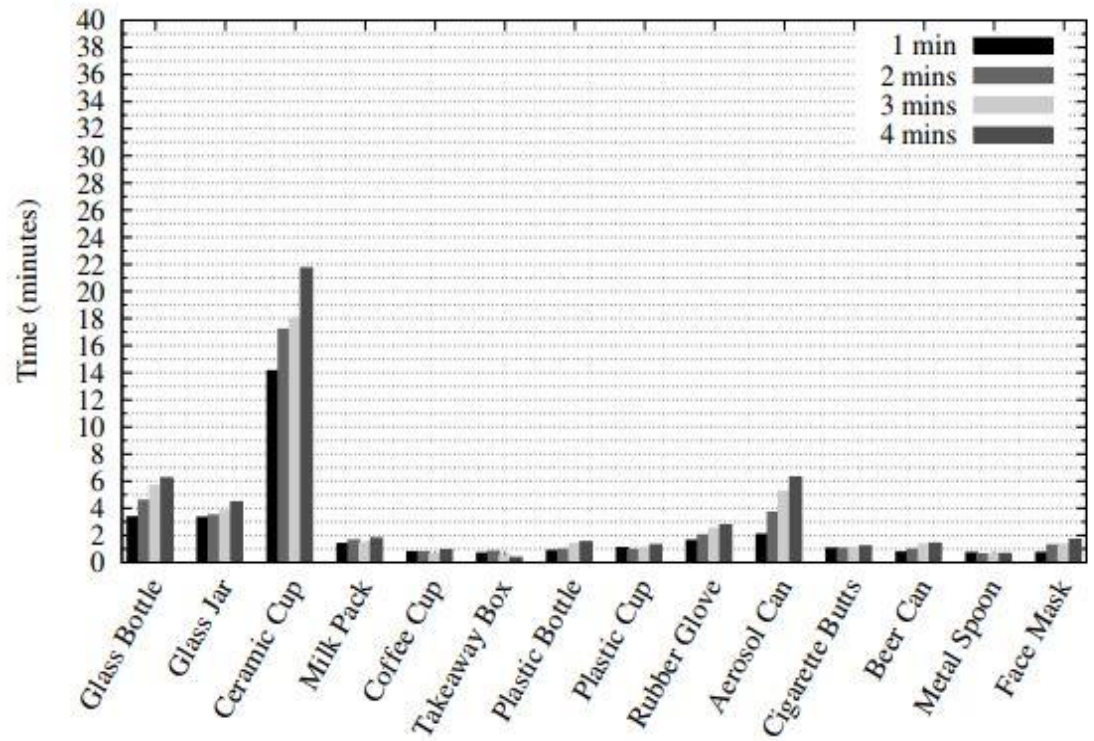


Fig B: Dissipation time of thermal footprints in thermometer scanner TG267 (Reference device with higher precision)

Modelling thermal footprint dissipation

MIDAS

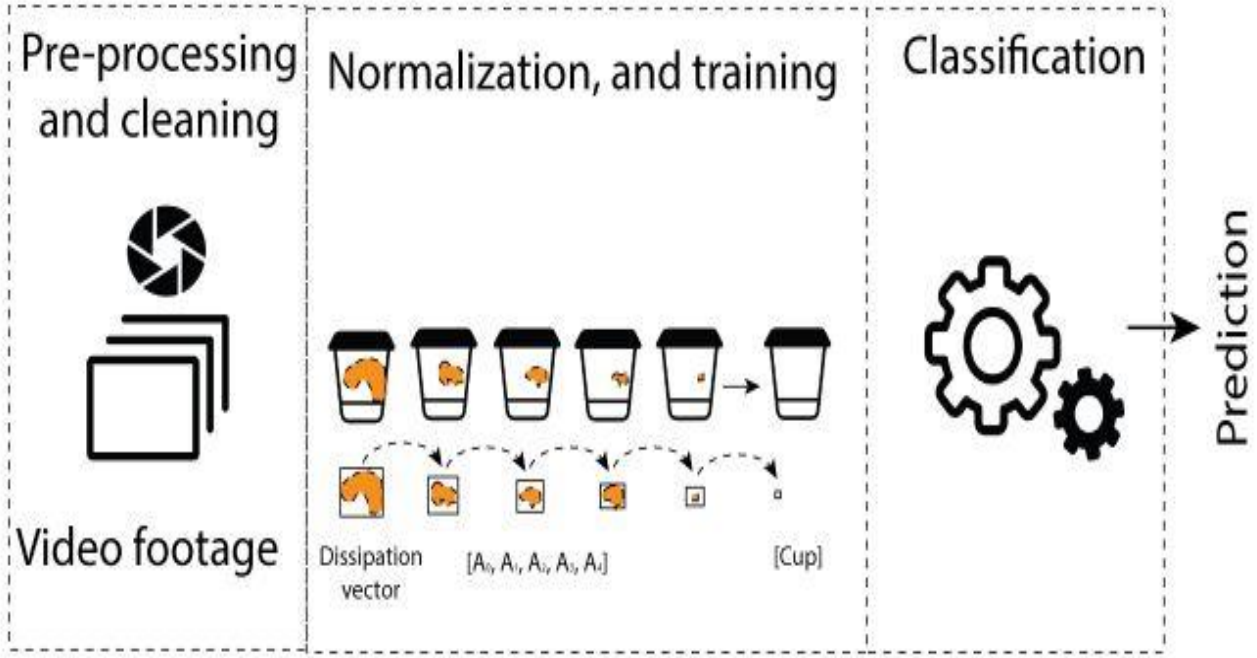


Fig: MIDAS Pipeline

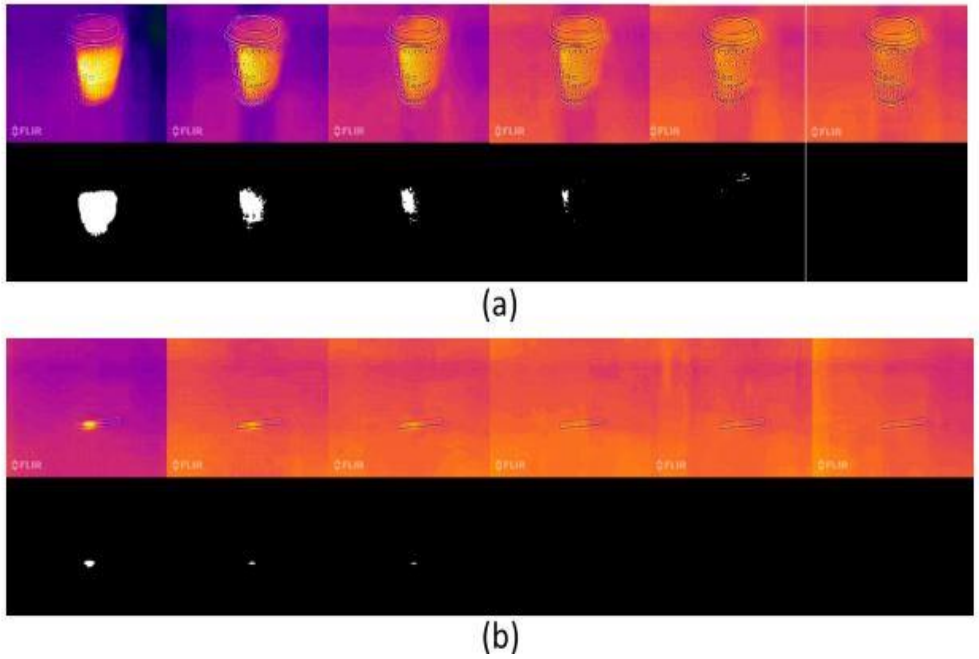


Fig: Dissipation time of thermal footprint for two different objects: a) Cardboard cup; and b) Cigarette butt.

Thermal Dissipation Fingerprint Testbed

Participants:

- N =18 participants (Male=9, Female=9)

Experiment design:

Thermal transfer type

- Fixed-hold (FH)
- Natural-hold (NH)

1 min

- Quick-hold (QH)

10 secs

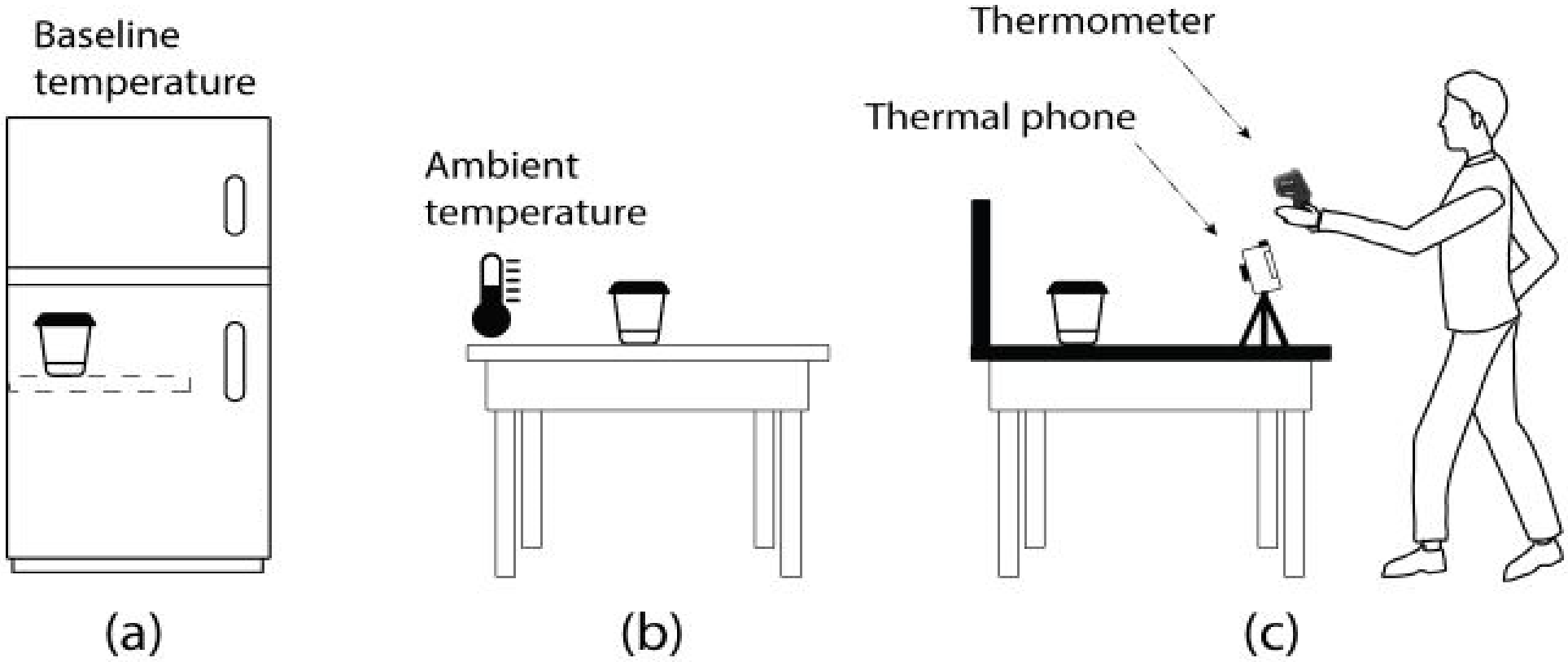
Material type

- Plastic bottle (BOTTLE)
- Cardboard cup (CUP)
- Cigarette butt (CIGAR)

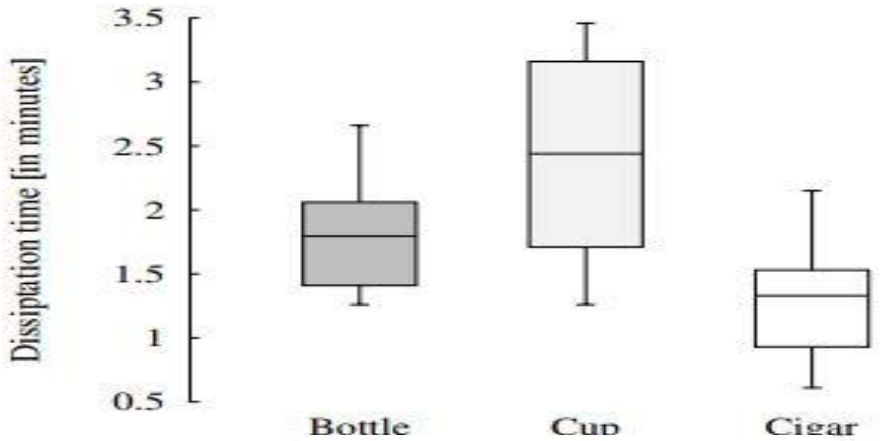
Apparatus

- Video footage was recorded with the CAT s60
- Reference photos were taken with the TG267

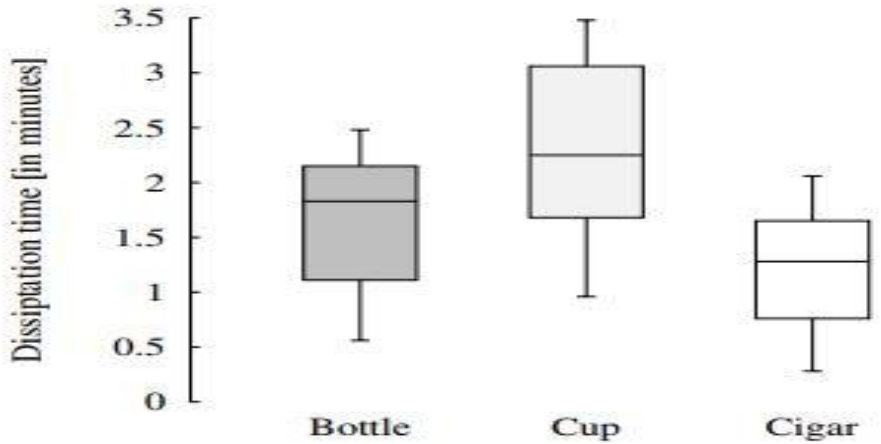
Procedure


Baseline
temperature
(a)
Ambient
temperature
(b)
Thermometer
Thermal phone
(c)

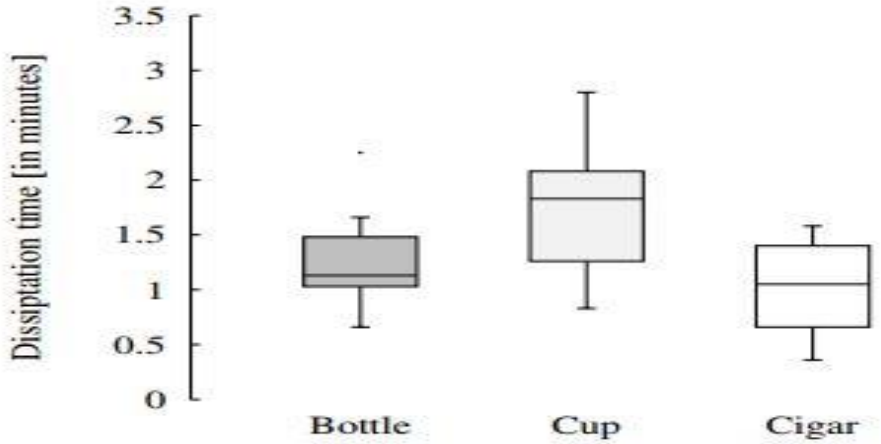
Human-emitted thermal radiation to object materials



Fixed-hold

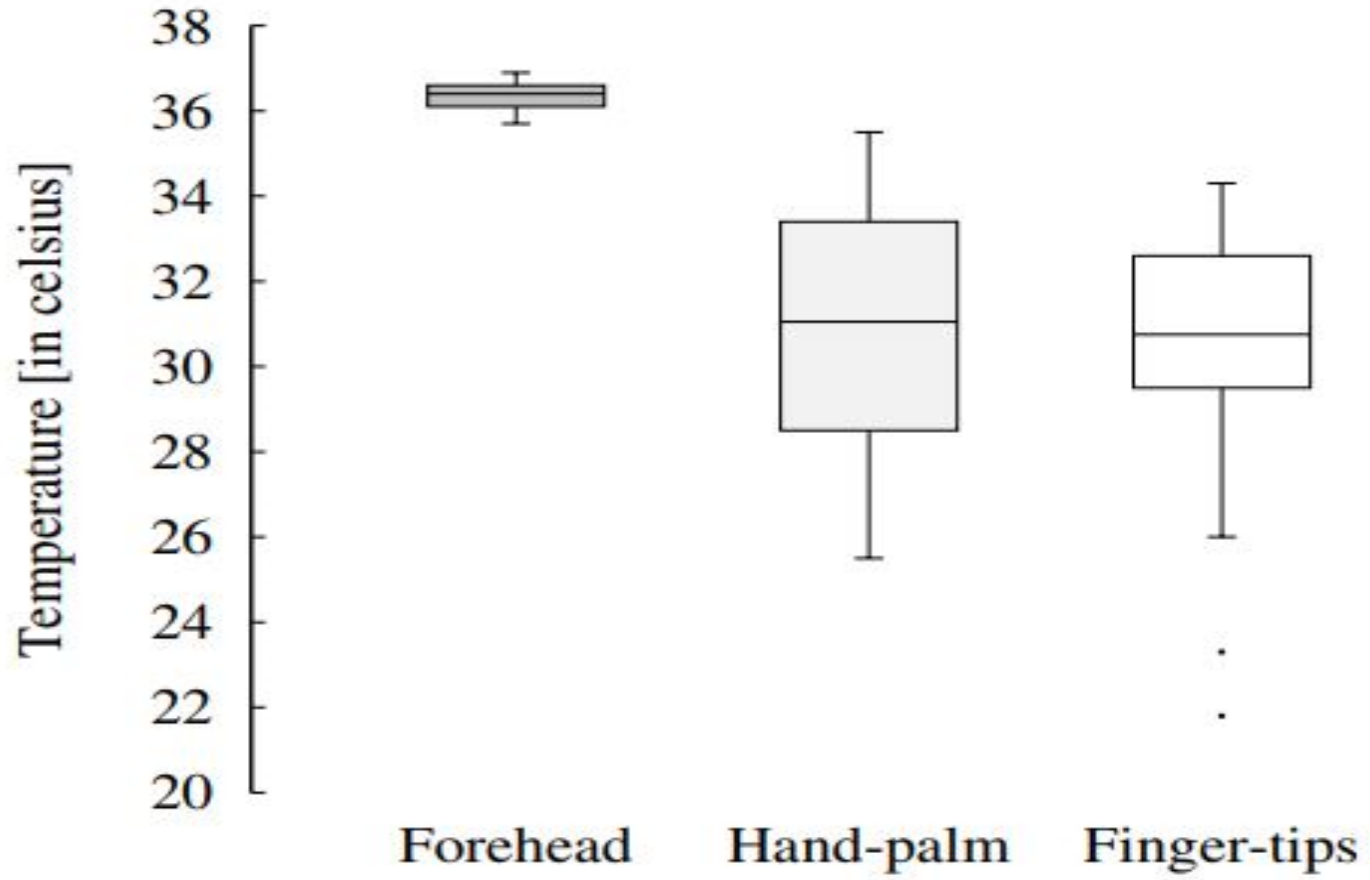


Natural-hold

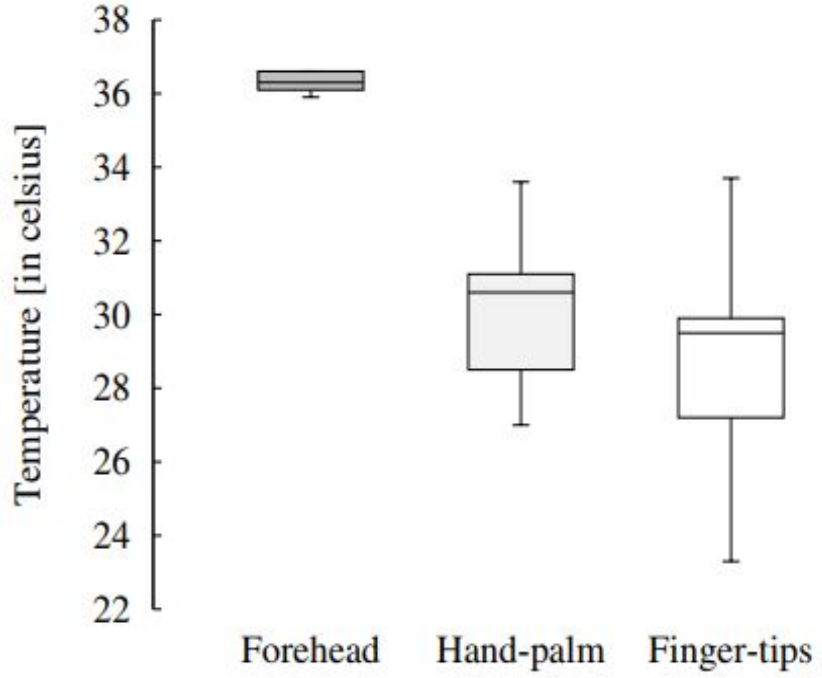


Quick-hold

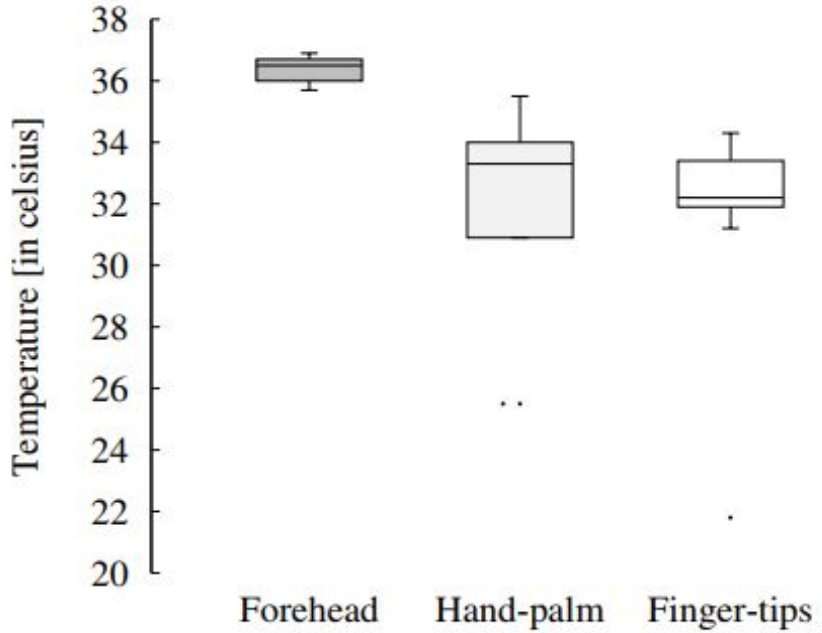
Differences in human temperature



Female vs male temperature (when using gender as the experimental condition)

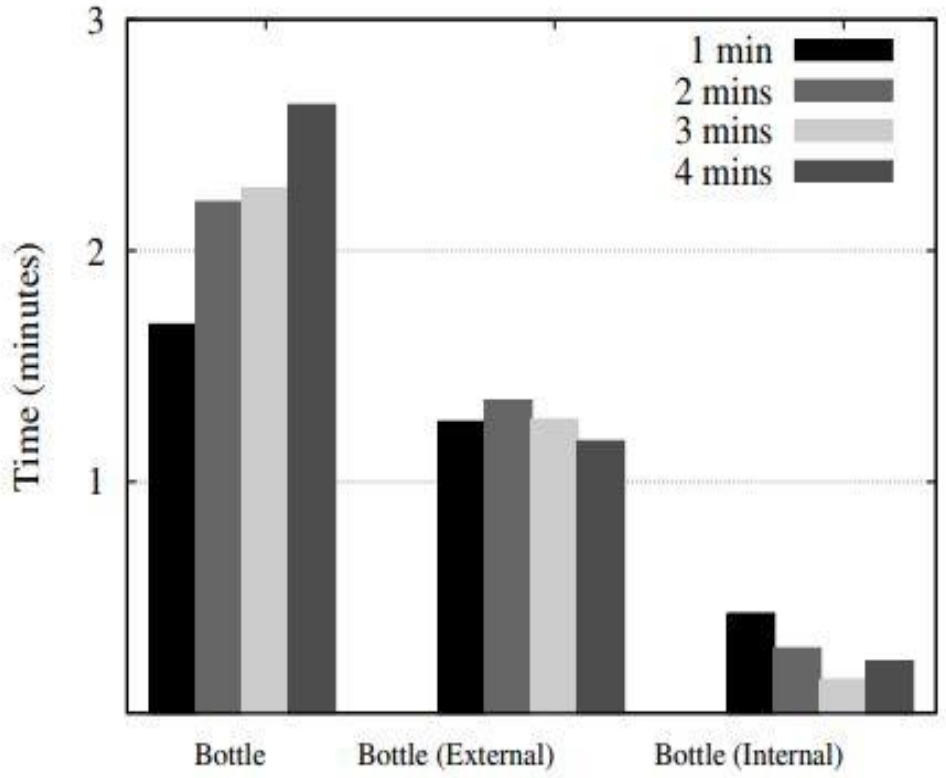


(a) Female participants

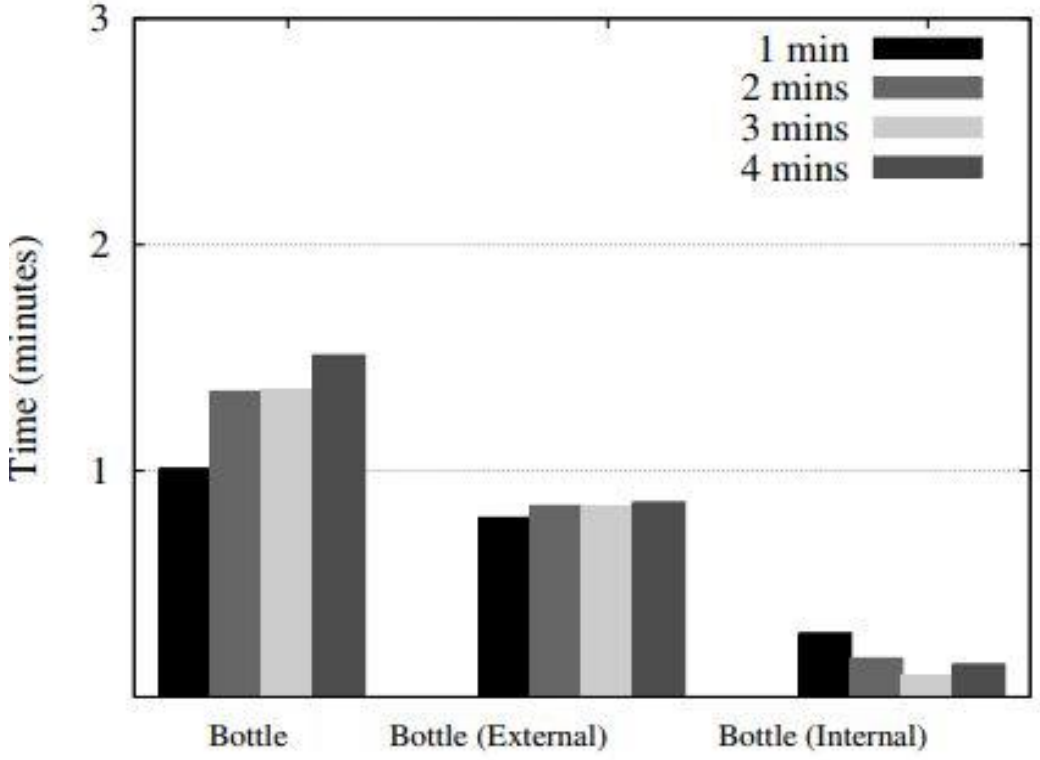


(b) Male participants

External temperature of ambient environment and Internal temperature absorbed from other objects

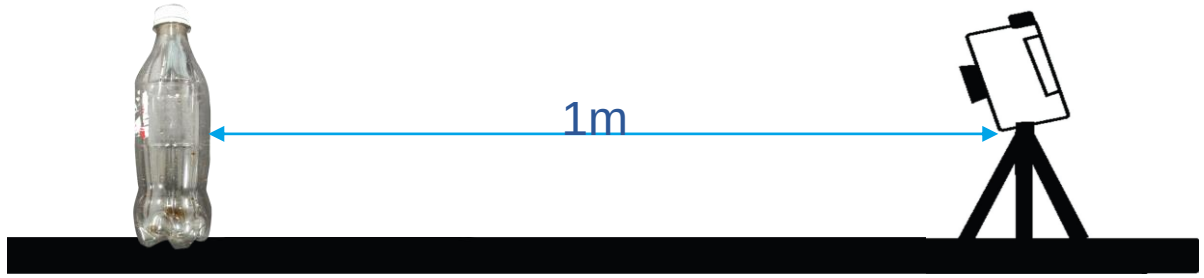


(a) CAT s60



(b) Thermometer Scanner

Distance between object and thermal camera



Other use cases: Detection of abnormal human temperature

Temperature	Dissipation Time (minutes)
36℃	3.33
37℃	3.73
38℃	4.23
39℃	4.34

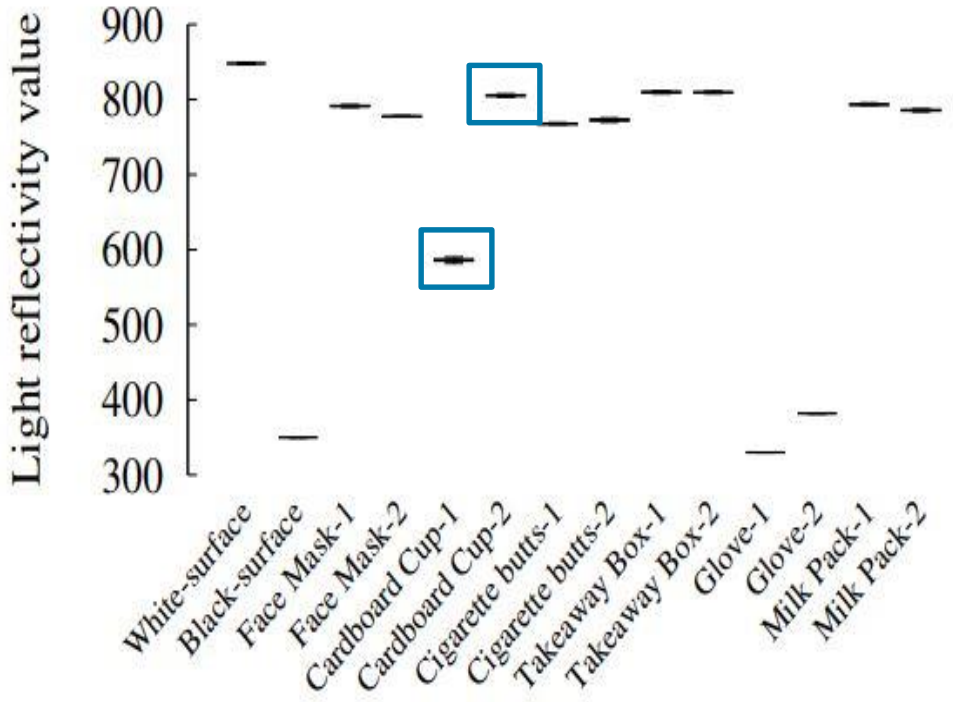
Dissipation time classification performance

Test	RF	SVM	MLPC	Average
Predicting Material (M)				
(Vector) →M	90.9	77.3	81.8	**83.3**
(Vector, Context)→M	90.9	77.3	81.8	**83.3**
(Vector, Gender)→M	90.9	86.4	81.8	**86.4**
(Vector, Context, Gender)→M	86.4	81.8	81.8	**83.3**
Average	*89.8*	*80.7*	*81.8*	***84.1***
Predicting Context, Gender				
(Material, Vector)→Context	77.3	81.8	72.7	**77.3**
(Material, Vector)→Gender	77.3	77.3	81.8	**78.8**
Average	*77.3*	*79.6*	*77.3*	***78.1***

Traditional approaches (Baseline experiment)

- Light and computer vision approaches have limitations and only capable of recognizing products that are not mixed with other items, and MIDAS helps to overcome those.

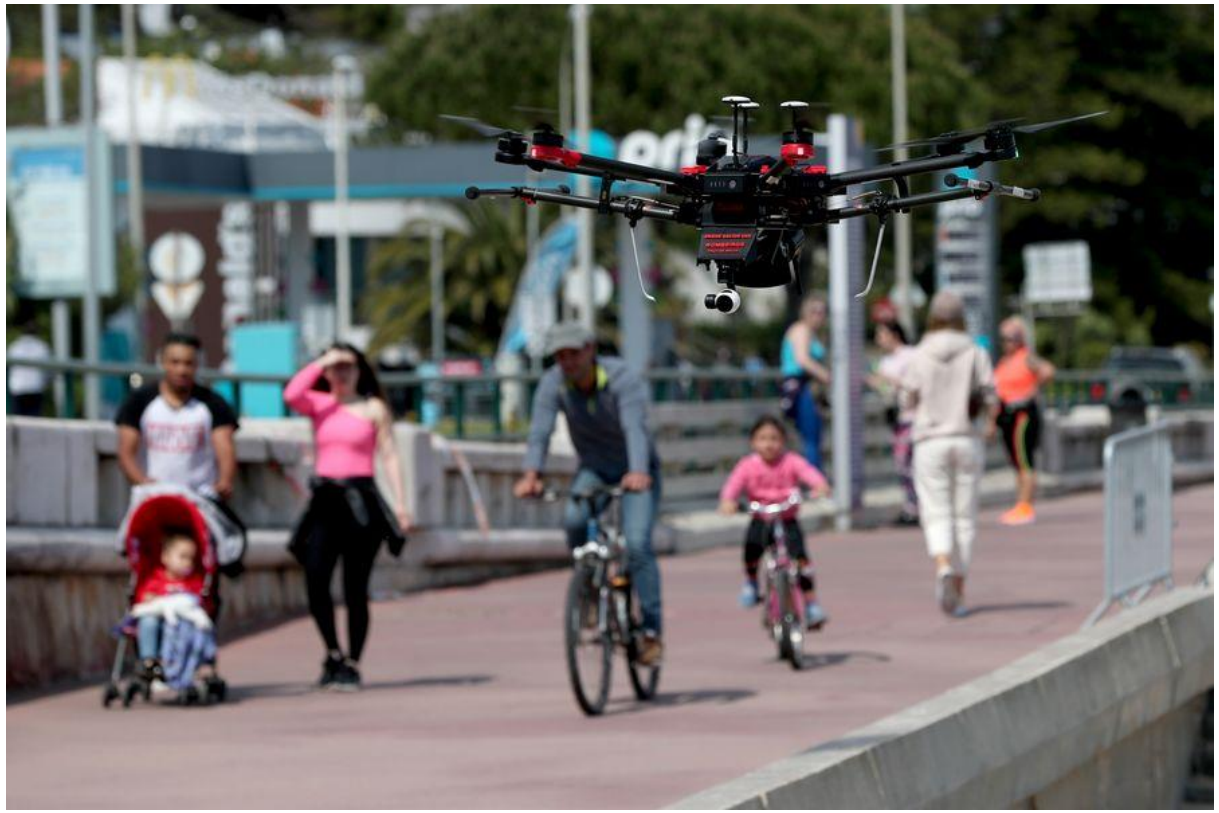
Baseline 1 (Computer vision)



Baseline 2 (Light reflectivity)

Future application areas

- Robots and autonomous devices
- Augmented reality
- Health system



Source: http://www.xinhuanet.com/english/2020-05/01/c_139024297.htm

Summary and conclusions

- We demonstrate that it is possible to Characterize materials just by touching them.
- Palm/finger tip temperatures can disclose personal information about individuals. e.g., gender
- Improved accuracy and distance when compared with other state of the art approaches.

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Questions?

Thank you! (Do not hesitate to reach us via e-mail)

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