



UNIVERSITY OF TARTU  
Institute of Computer Science



# Foundations of Autonomous Pervasive Sensing

Distributed and Pervasive Systems  
Group

<https://dps.cs.ut.ee/>

**Huber Flores**

ASSOCIATE PROFESSOR

Tartu, Estonia, 05/11/2021

# About us

**November 2019**

Established the Distributed and Pervasive Systems Group

**November 2021 (To date)**

Four (4) doctoral students

One Lecturer

One Associate professor

... several master students

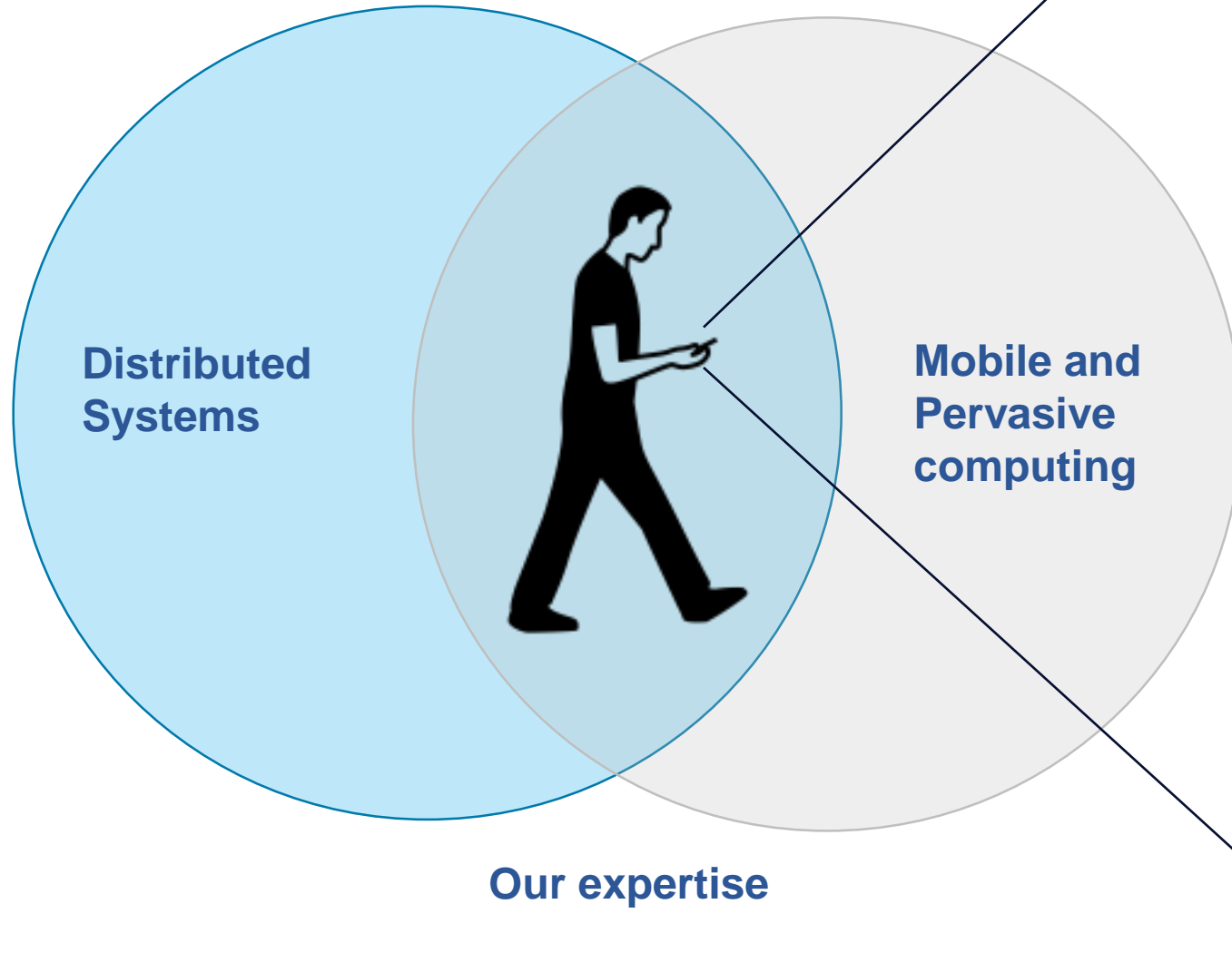
**Further growth**

One new postdoc



# About us

Research agenda.



Drink (liquid) identification



Energy management



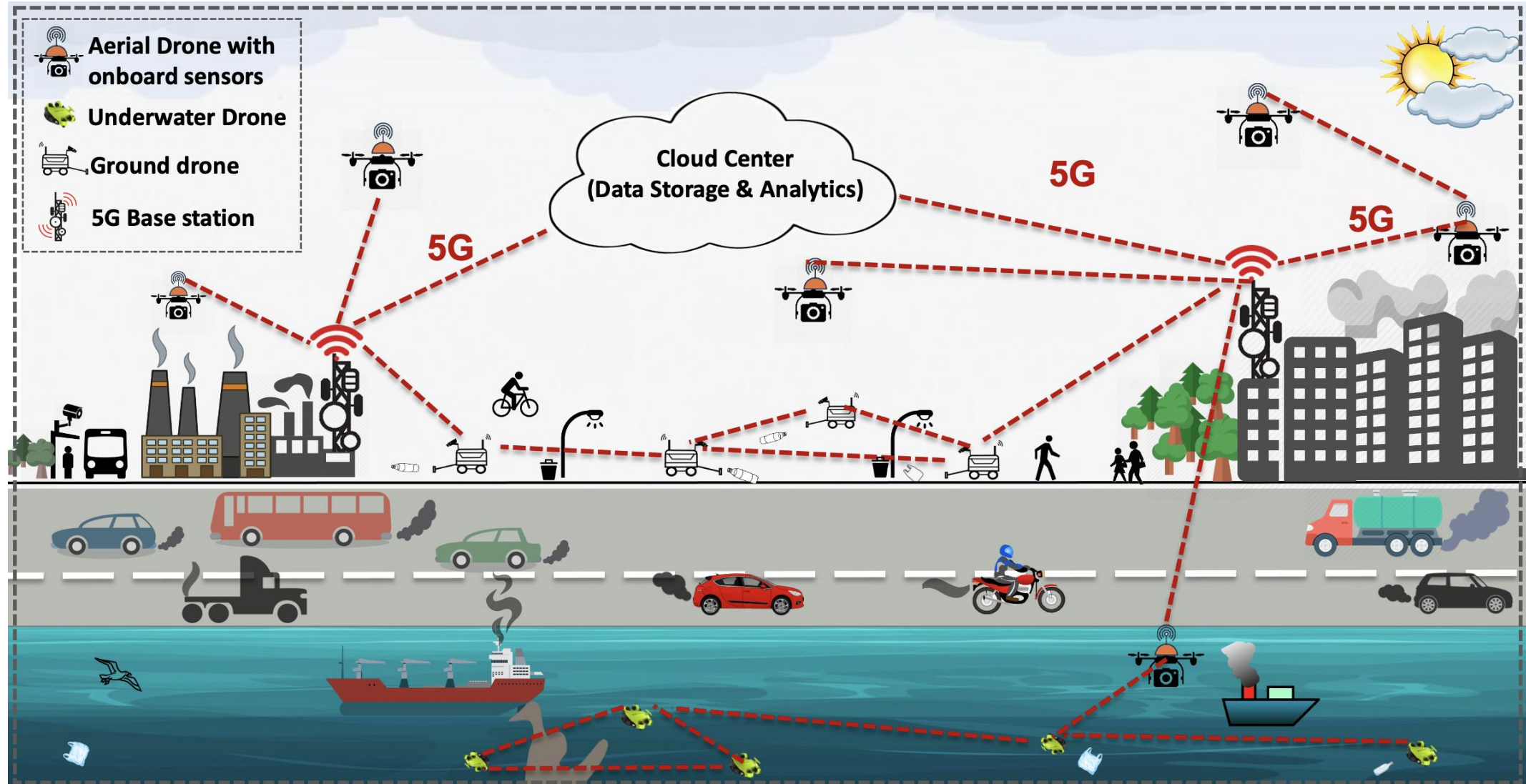
Health indicators



**Examples** <sup>3</sup>

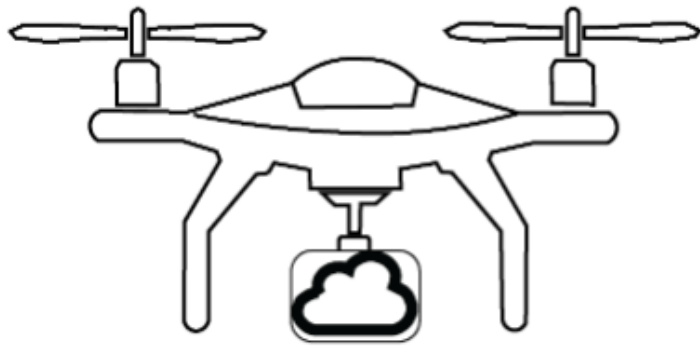


# Foundations of Autonomous Pervasive Sensing

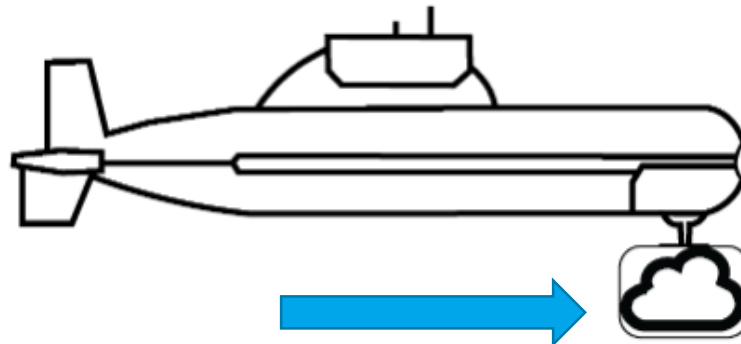


# Research

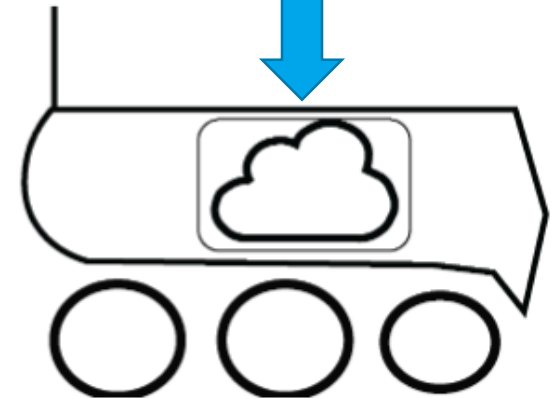
## Foundations of Autonomous Pervasive Sensing



Additional  
processing units  
(cloudlets)



Additional  
processing units  
(cloudlets)



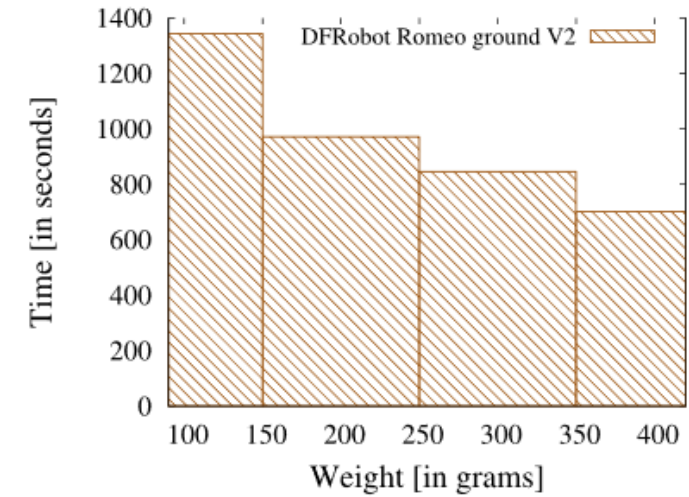
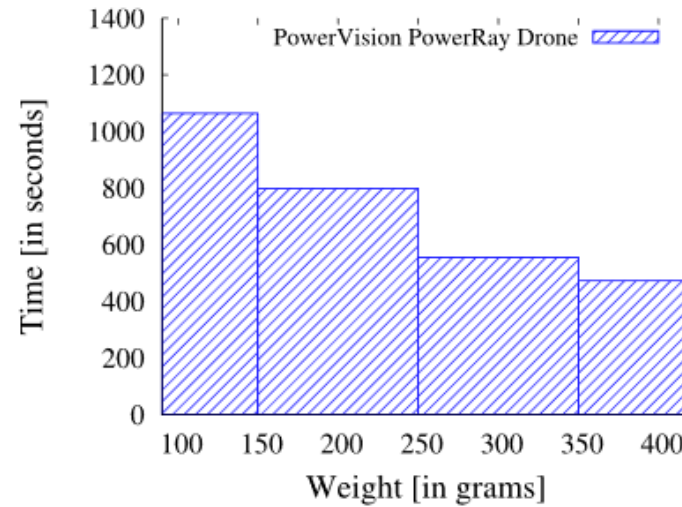
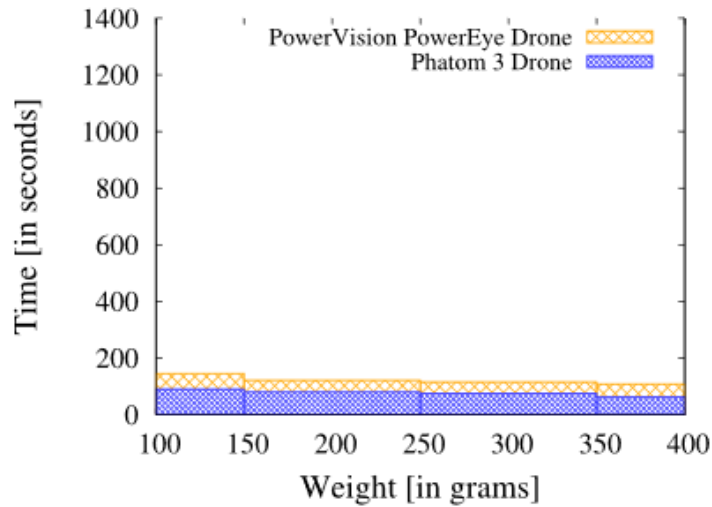
Additional  
processing units  
(cloudlets)



**Drones that can execute  
machine and deep  
learning**

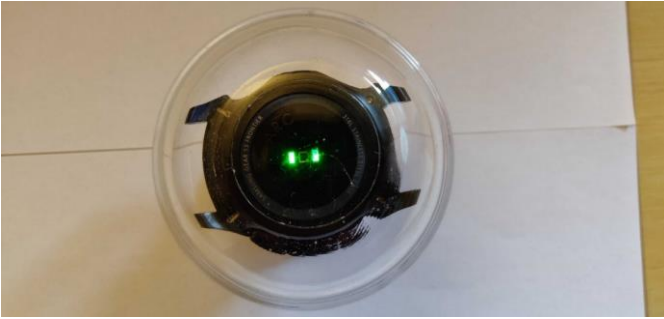
**Vision: Enabling city-scale operations of autonomous vehicles**

# Performance of autonomous vehicles

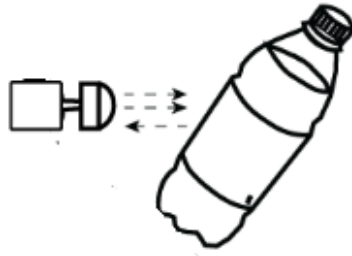


[PMC] Liyanage, M., Dar, F., Sharma, R., & Flores, H. (2021). ***GEESE: Edge computing enabled by Unmanned Autonomous Vehicles***. *Pervasive and Mobile Computing Journal*, 72, 101340.

# Autonomous Underwater Vehicles (AUV)



Light sensor through  
glass waterproof  
encasing



Identification of  
objects with light

Other applications:

- Water quality
- Marine biodiversity monitoring
- Health of synthetic habitats, e.g., aquaculture

Ocean-scale aquatic  
pollution monitoring



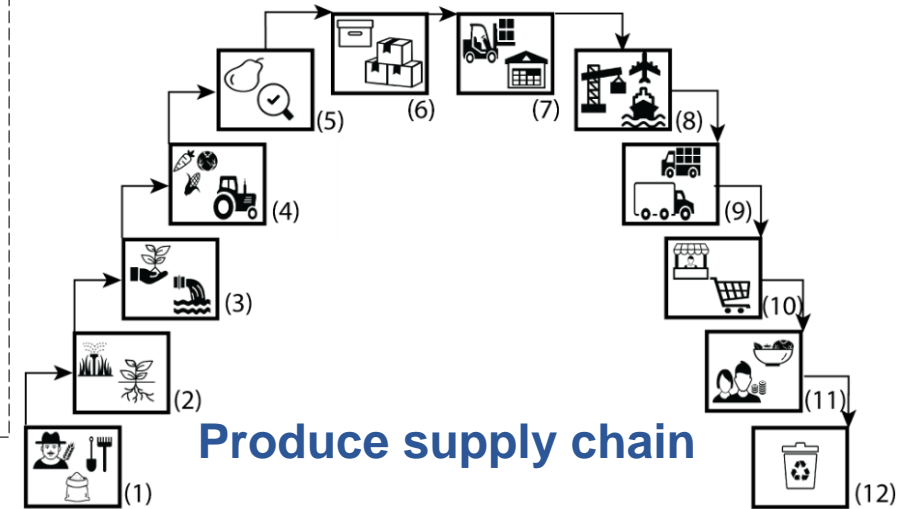
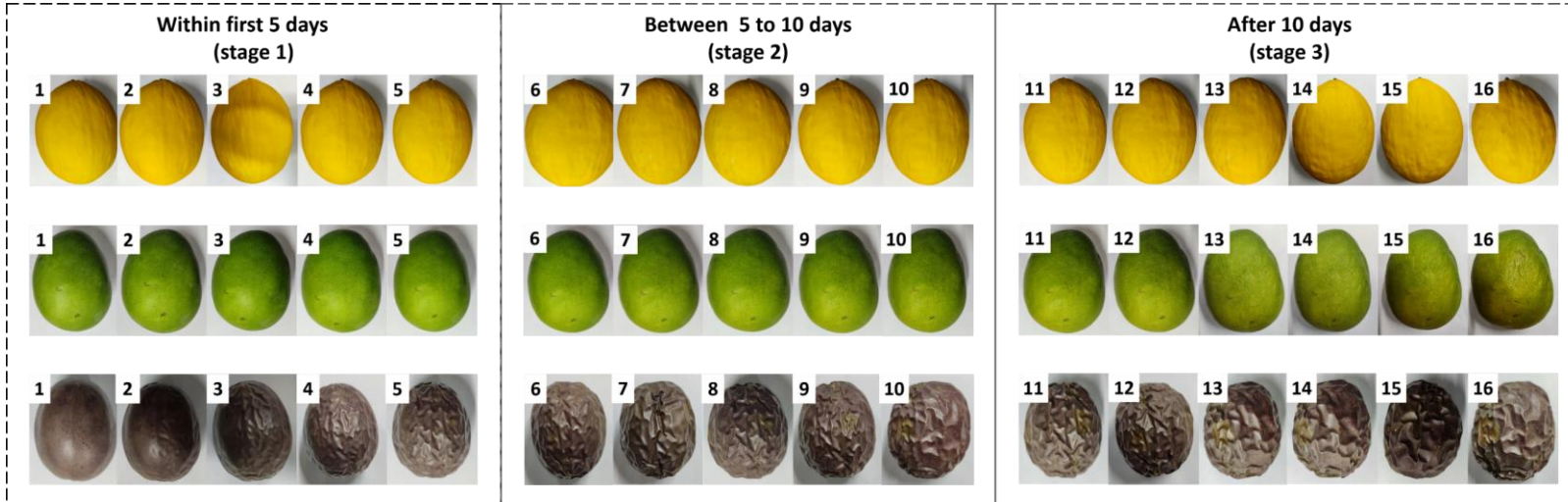
[IEEE-IoT] Flores, H., Motlagh, N. H., Zuniga, A., Liyanage, M., ... & Nurmi, P. (2021). ***Toward large-scale autonomous marine pollution monitoring.*** *IEEE Internet of Things Magazine*, 4(1).

Tulevikus saab merereostust seirata vetikarüü droonidega -

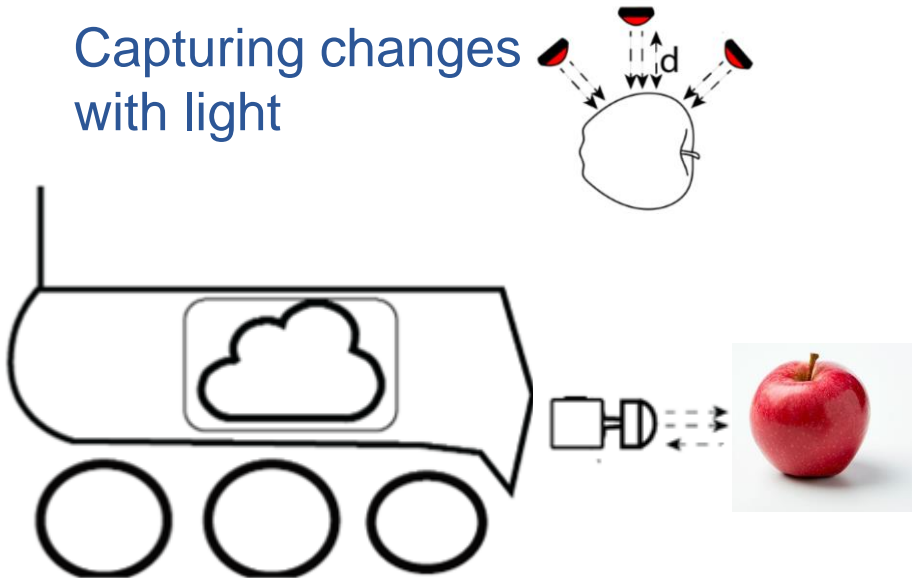
<https://novaator.err.ee/1608175690/tulevikus-saab-merereostust-seirata-vetikaruus-droonidega>



# Autonomous Ground Vehicles (AGV)



Capturing changes  
with light



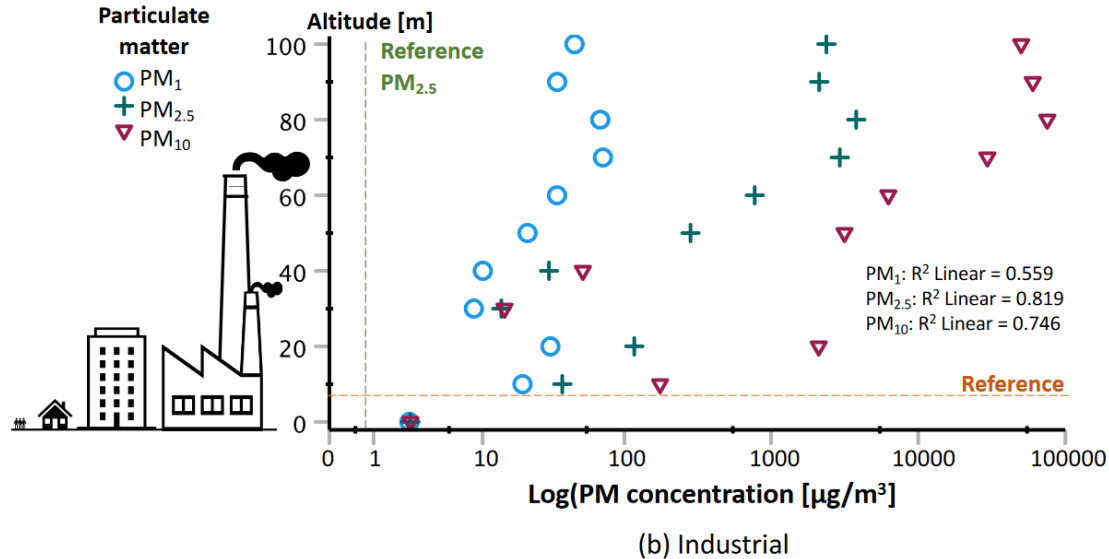
Other applications:

- Planting, growing, harvesting
- Packing, distribution

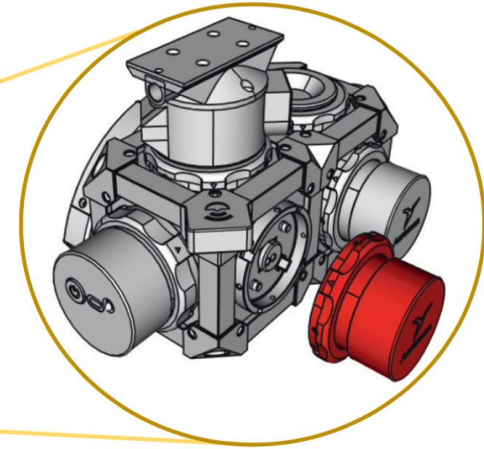
[IEEE Pervasive] Zuniga, A., Nurmi, P., & Flores, H. (2021). **Ripe or Rotten? Low-Cost Produce Quality Estimation Using Reflective Green Light Sensing.** *IEEE Pervasive Computing*.



# Unmanned Aerial Vehicles (UAV)



X4S-UAV model



Emission measuring device, BH-12

Other applications:

- Industry regulations
- Automobile pollution control

## City-scale air quality monitoring

[IEEE Network] Mothlagh, N. ., Flores, H.,... and Nurmi, P.. (under review).  
Towards Blue Skies: City-scale pollution monitoring using UAVs. 9

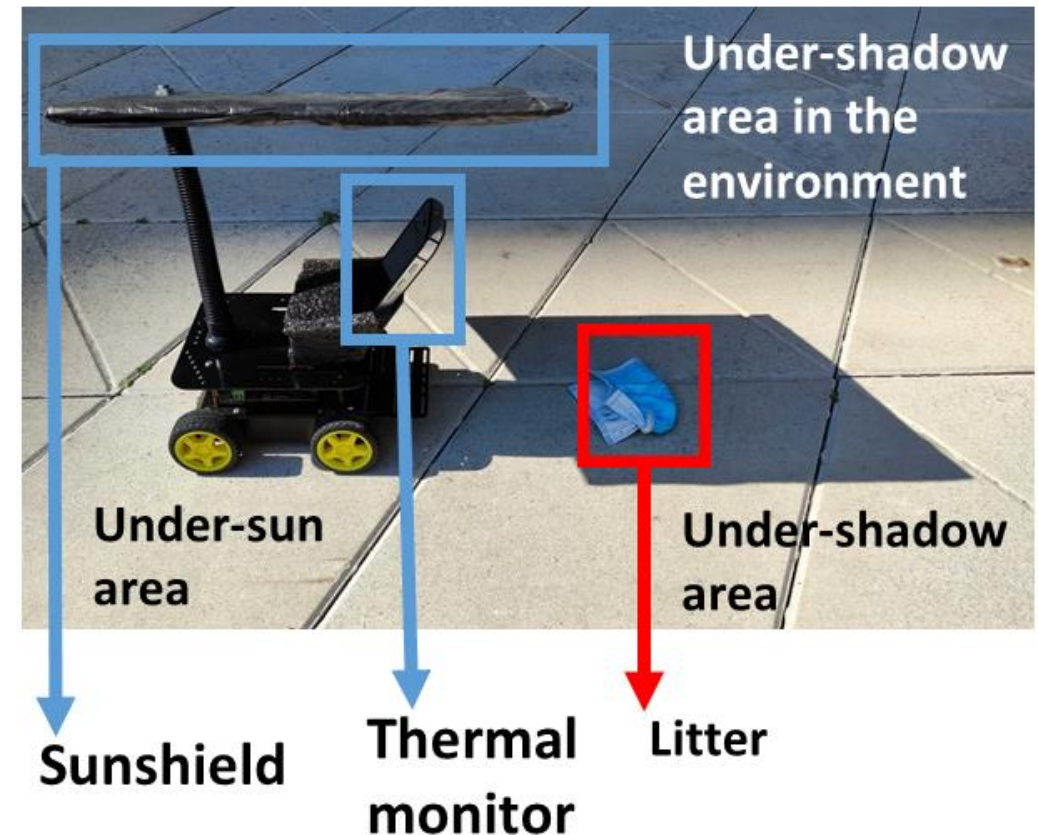
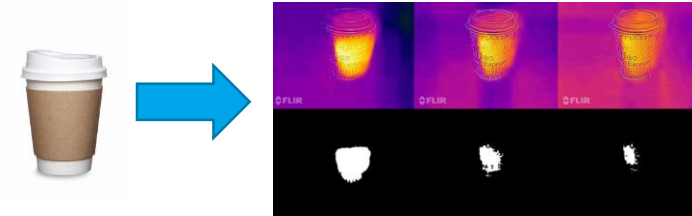
# Exploiting environmental support for sensing



[source] <https://es.dreamstime.com>

[IEEE PerCom] Emenike, H., Dar, F., Liyanage, M., Sharma, R., Zuniga, A., Hoque, M. A., ... & Flores, H. (2021). ***Characterizing Everyday Objects using Human Touch: Thermal Dissipation as a Sensing Modality.*** In *IEEE PerCom 2021*

## Sensing with sunlight



# Foundations of Autonomous Pervasive Sensing

## Long/short term applicability?

- Solutions can be used by several industries
- Opportunities for start-ups focus on sustainability
  - Europe wants to become climate neutral by 2050 and sustainability regulations should be checked periodically
  - Estonia has over 1500 aquatic areas and surrounded by the Baltic sea



# Research renewal

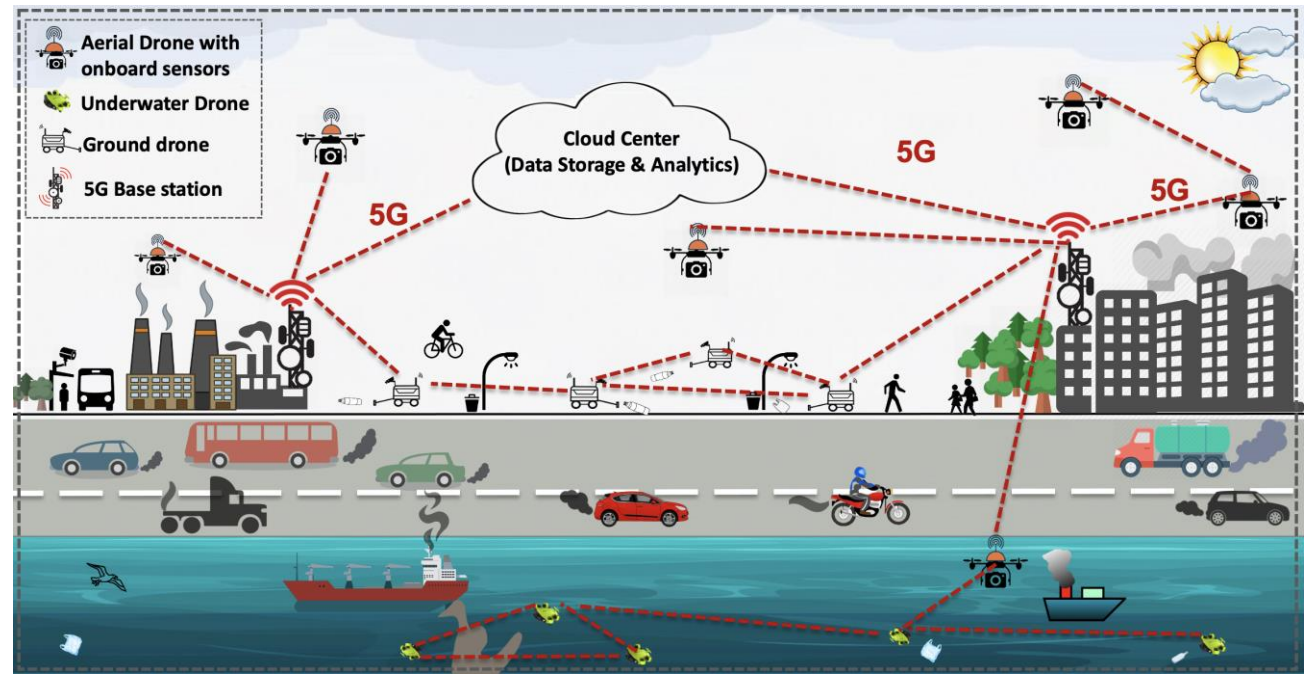
Integration of autonomous technologies in urban areas



# Foundations of Autonomous Pervasive Sensing

Autonomous = AI-based models (Deep and machine learning)

- Federated learning
- Distribute machine learning
- Collaborative processing



# Foundations of Autonomous Pervasive Sensing

Explainability of AI for autonomous pervasive technologies (Drones, IoT devices, sensors, etc.)



[source] <http://www.iretron.com/blog/posts/where-are-the-delivery-drones/drone-accident/>



[source] <https://gbagenlaw.com/drone-related-injuries-are-becoming-more-common/>



# Thank you!

<http://huberflores.com>

<https://dps.cs.ut.ee>

