

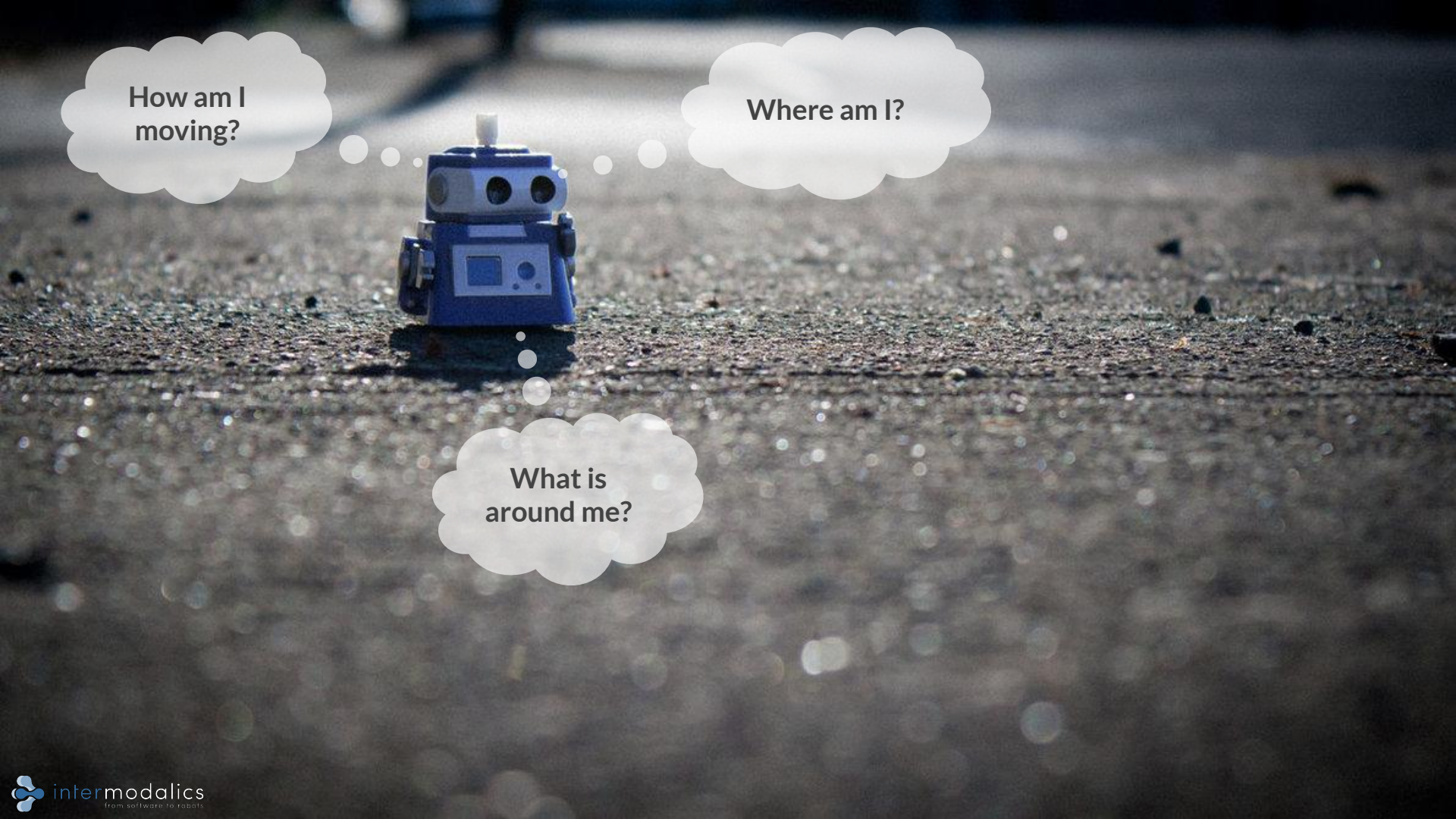


# Visual Positioning

Dominick Vanthienen, PhD  
Boston - June 6th, 2019



intermodalics  
from software to robots


A small, blue, boxy robot with two large black eyes and a small antenna is positioned in the center-left of the frame. It sits on a dark, granular surface like asphalt. Three white thought bubbles are connected to the robot by small circles. The top-left bubble contains the text 'How am I moving?'. The top-right bubble contains 'Where am I?'. The bottom bubble, directly below the robot, contains 'What is around me?'.

How am I  
moving?

Where am I?

What is  
around me?



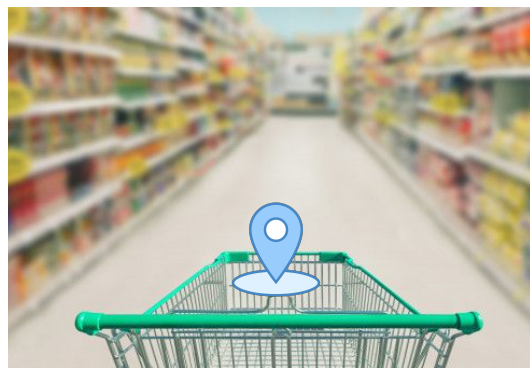
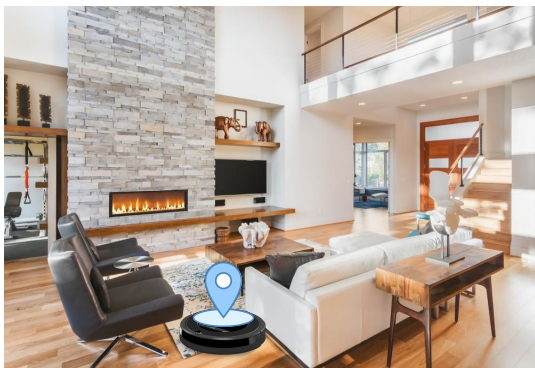


1. Which  
use cases?

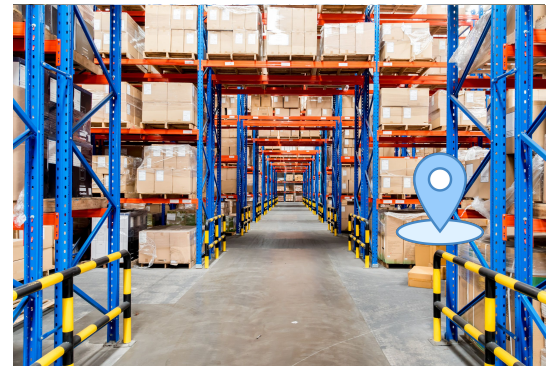
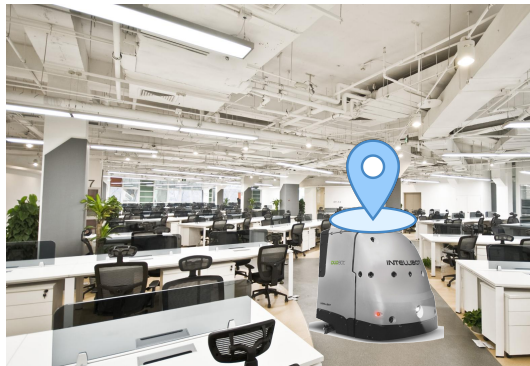
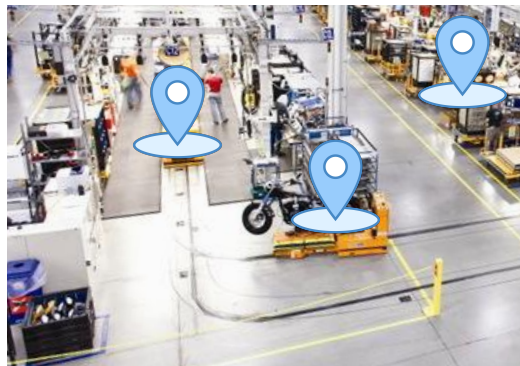
2. What  
technologies  
exist today?

4. Visual  
Positioning  
**PLUS**

3. Visual  
Positioning



# Indoor





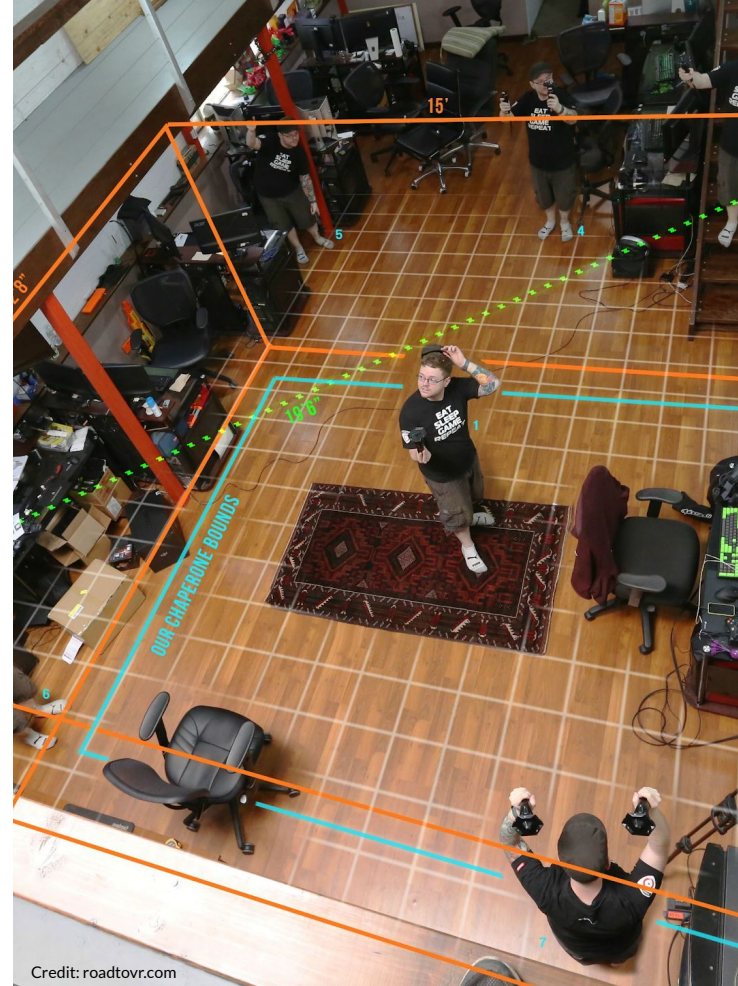
# Inventory



# AR-VR-MR apps



Credit: HTC



Credit: roadtovr.com





# Outdoor





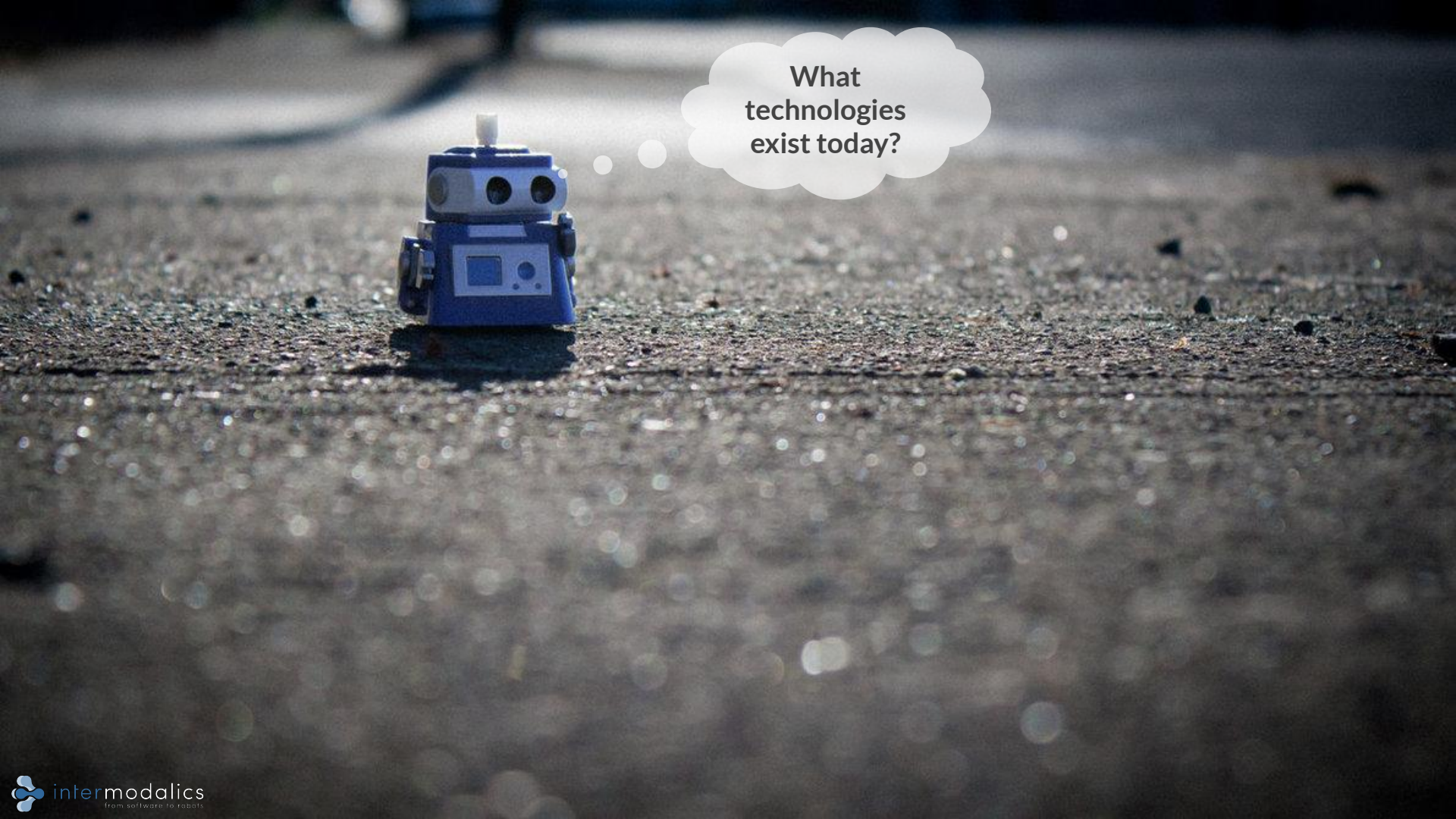
# GPS denied







Precise inspections

A small, blue and white robot with a square head and two large black eyes is positioned on a dark, textured surface. A thought bubble above the robot contains the text "What technologies exist today?".

What  
technologies  
exist today?



# Fiducials





Fiducials



# Time of Flight

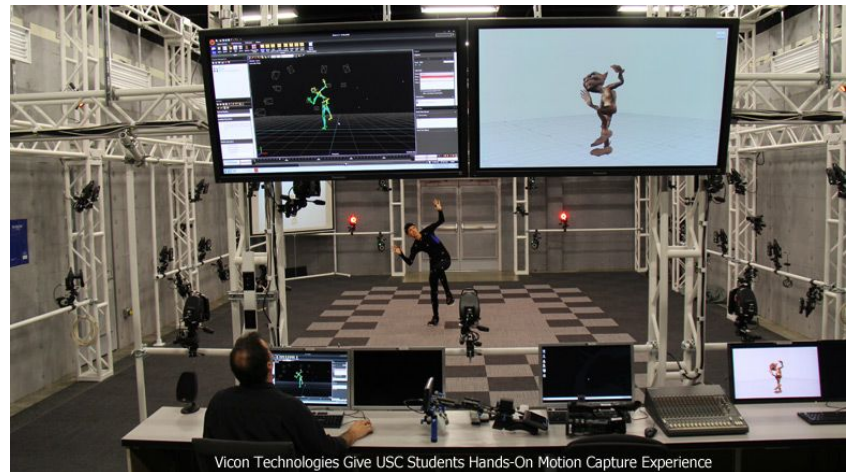


# Time of Flight



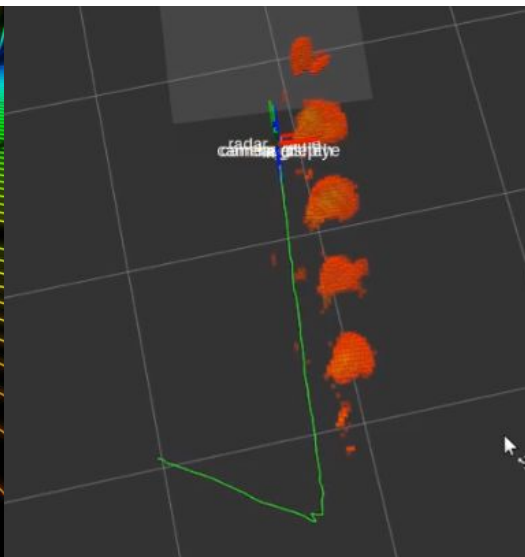
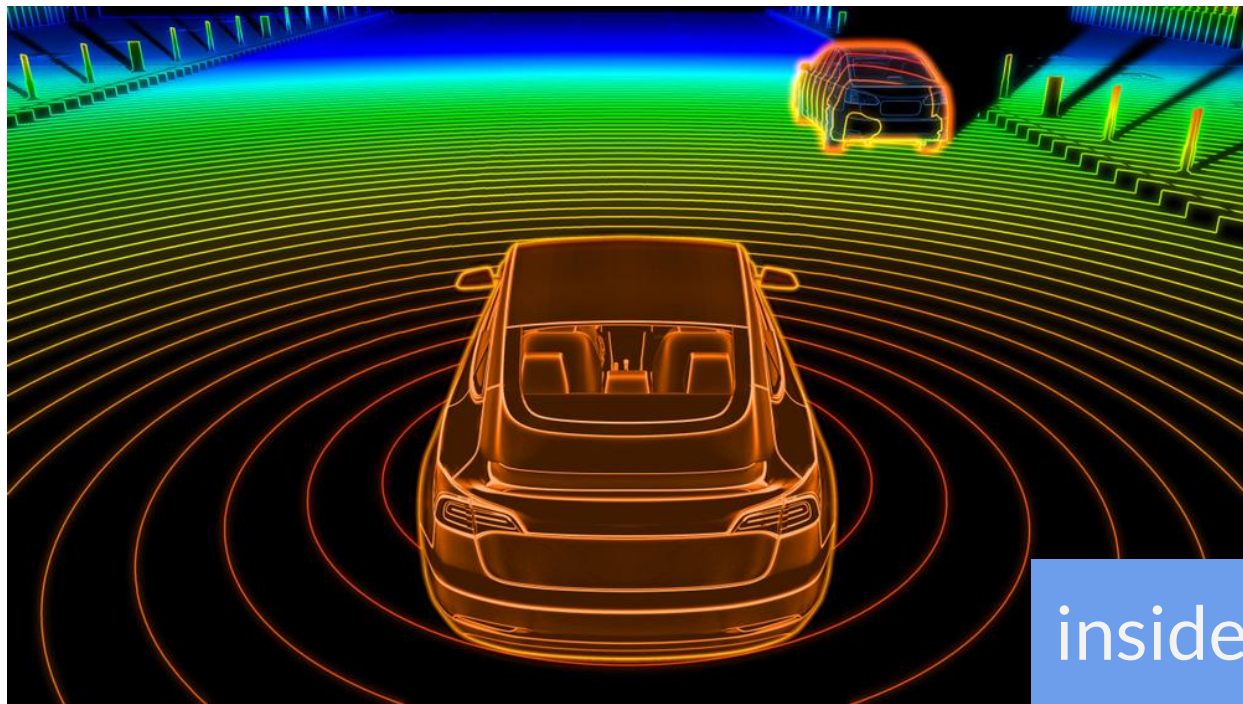


# Line of sight



outside-in

# Line of sight



inside-out



# Line of sight



Credit: MIT

*“**Lidar** is a fool’s errand. Anyone relying on lidar is doomed. Doomed! [They are] expensive sensors that are unnecessary. It’s like having a whole bunch of expensive appendices. Like, one appendix is bad, well now you have a whole bunch of them, it’s ridiculous, you’ll see.” - Elon Musk, CEO Tesla*

## inside-out

# Technologies

Need for infrastructure

Outside-in

Fiducials

GPS  
WiFi  
BLE  
bluetooth  
UWB  
ultra wide band  
Visual Light communication  
Active/Passive visual markers

RFID  
QR/AR tags

2D LiDAR with reflectors

3D LiDAR

2D LiDAR

Ultrasound

Expensive

Inside-out



# Technologies

Need for infrastructure

Outside-in

Fiducials

GPS  
WiFi  
BLE  
bluetooth  
UWB  
ultra wide band  
Visual Light communication  
Active/Passive visual markers

RFID  
QR/AR tags

2D LiDAR  
with  
reflectors

3D LiDAR


2D LiDAR

Ultrasound

Expensive

Inside-out

Accuracy >50cm



I want  
something  
that is  
**accurate**

I want  
something  
that **scales at**  
**no cost**

I want  
something  
that **works**  
**anywhere**



A small blue robot with a white antenna and two large black eyes stands on a dark, textured asphalt surface. Three thought bubbles are connected to the robot by small circles. The bubbles contain the words 'accurate', 'infrastructure less', and 'works anywhere\*'.

accurate

infrastructure  
less

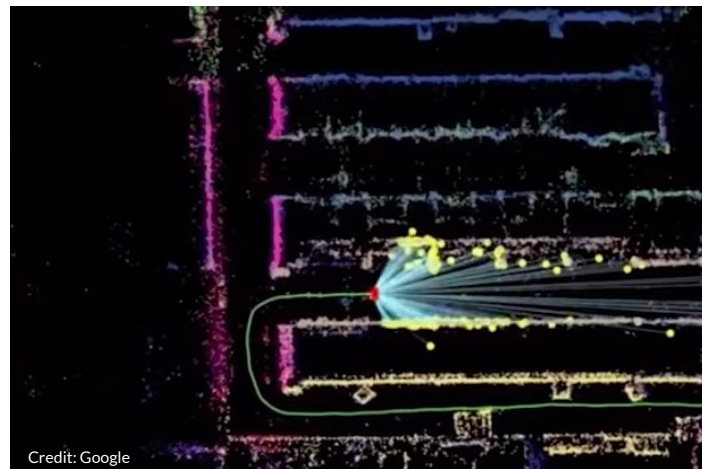
works  
anywhere\*

# Visual Positioning

# What is Visual Positioning?

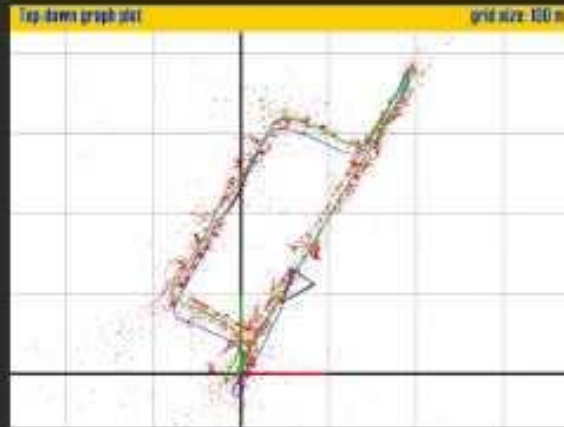
→ localization based on  
visual cues and IMU sensor  
data

- VIO      Visual Inertial Odometry
- (V)SLAM   Visual Simultaneous  
                 Localization and Mapping
- VPS      Visual Positioning System





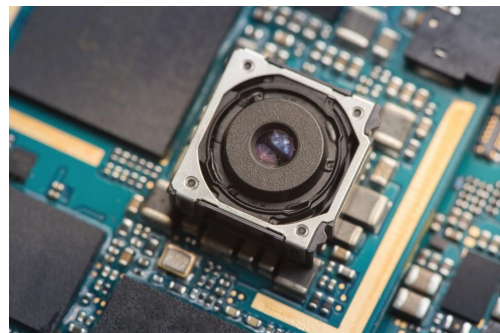
# What is Visual Positioning?



Google 2014

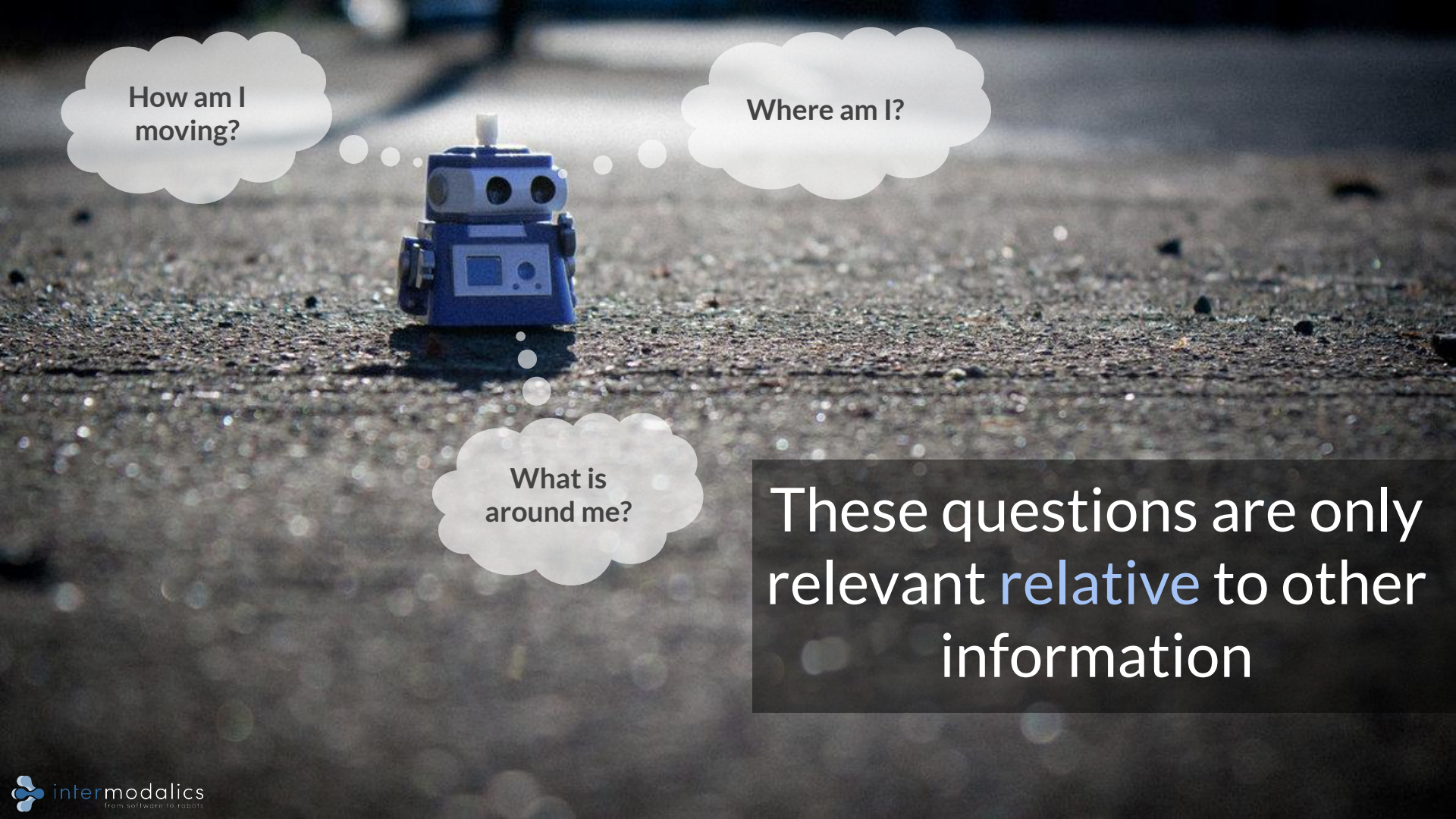
# Advantages of a Visual Positioning

- **Scalability** in cost and ownership
  - No infrastructure on site - no beacons
  - Ease of deployment or extension
  - Wholesale prices IMU and camera for few € each
- **Compact** and flexible hardware
  - Choose your form factor and device location
  - No hardware lock in !
- Full **3D** pose
  - Which direction are we looking at ?
  - Position and orientation
- **Accurate**
  - ~10cm in a map



Most scalable



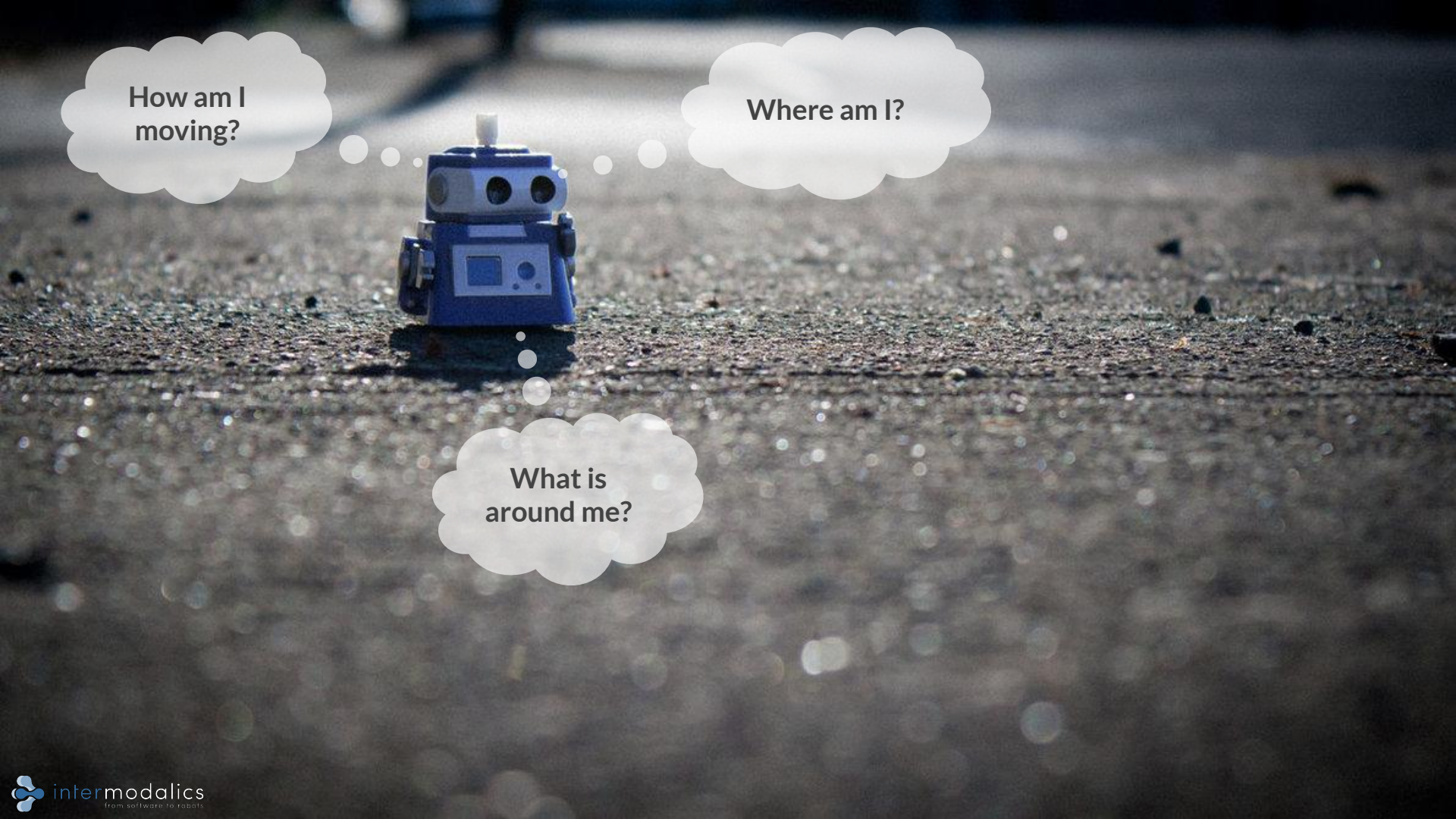
A small blue robot with two large black eyes and a small antenna is positioned in the center-left of the frame. It is standing on a dark, granular surface. Three thought bubbles are connected to the robot by small circles. The top-left bubble contains the text 'How am I moving?'. The top-right bubble contains the text 'Where am I?'. The bottom bubble contains the text 'What is around me?'.

How am I  
moving?

Where am I?

What is  
around me?

These questions are only  
relevant **relative** to other  
information

A small blue robot with two large black eyes and a small antenna is positioned in the center-left of the frame. It is standing on a dark, textured surface that looks like asphalt. Three thought bubbles are connected to the robot by small circles. The top-left bubble contains the text 'How am I moving?'. The top-right bubble contains the text 'Where am I?'. The bottom bubble contains the text 'What is around me?'.

How am I  
moving?

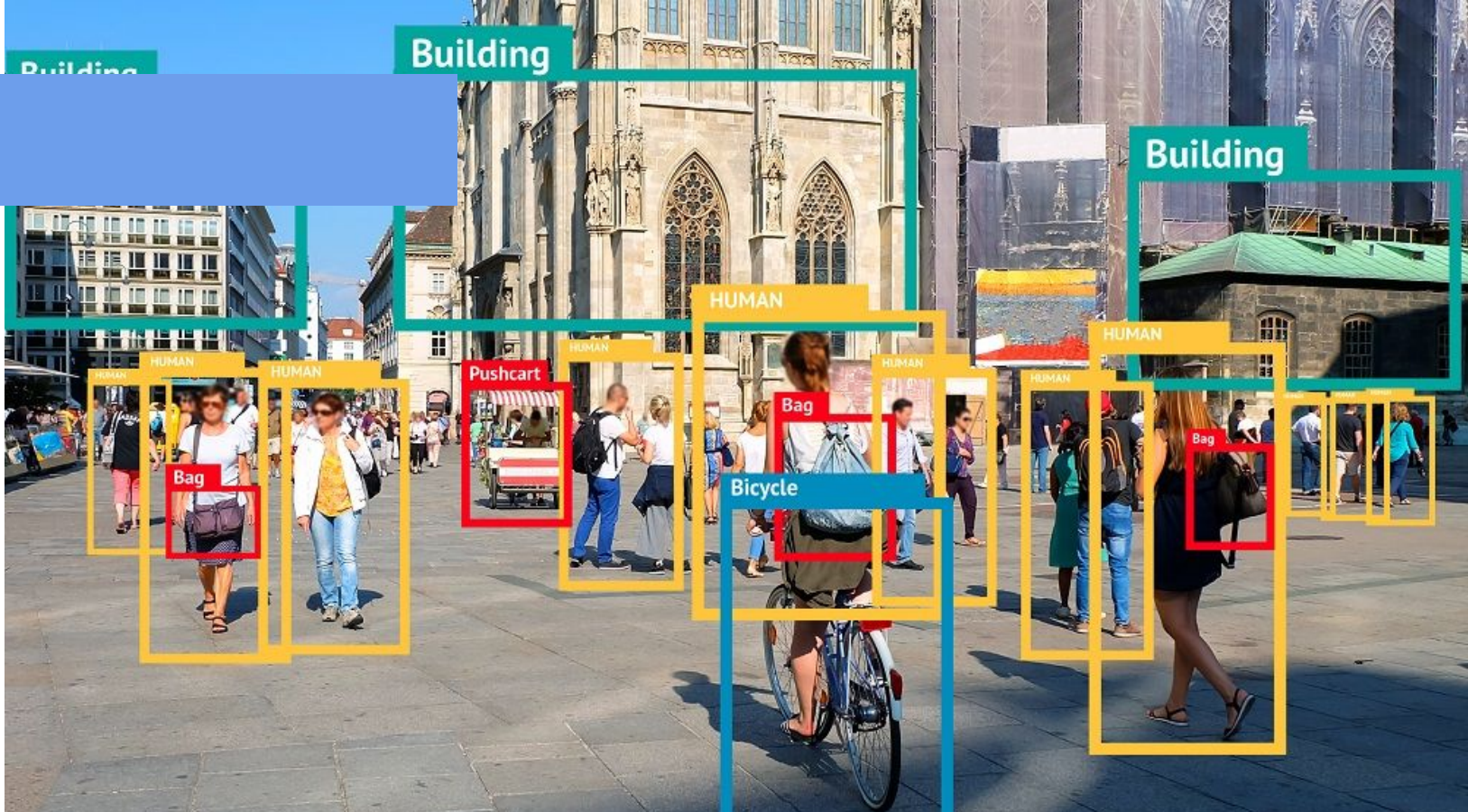
Where am I?

What is  
around me?

VPS+

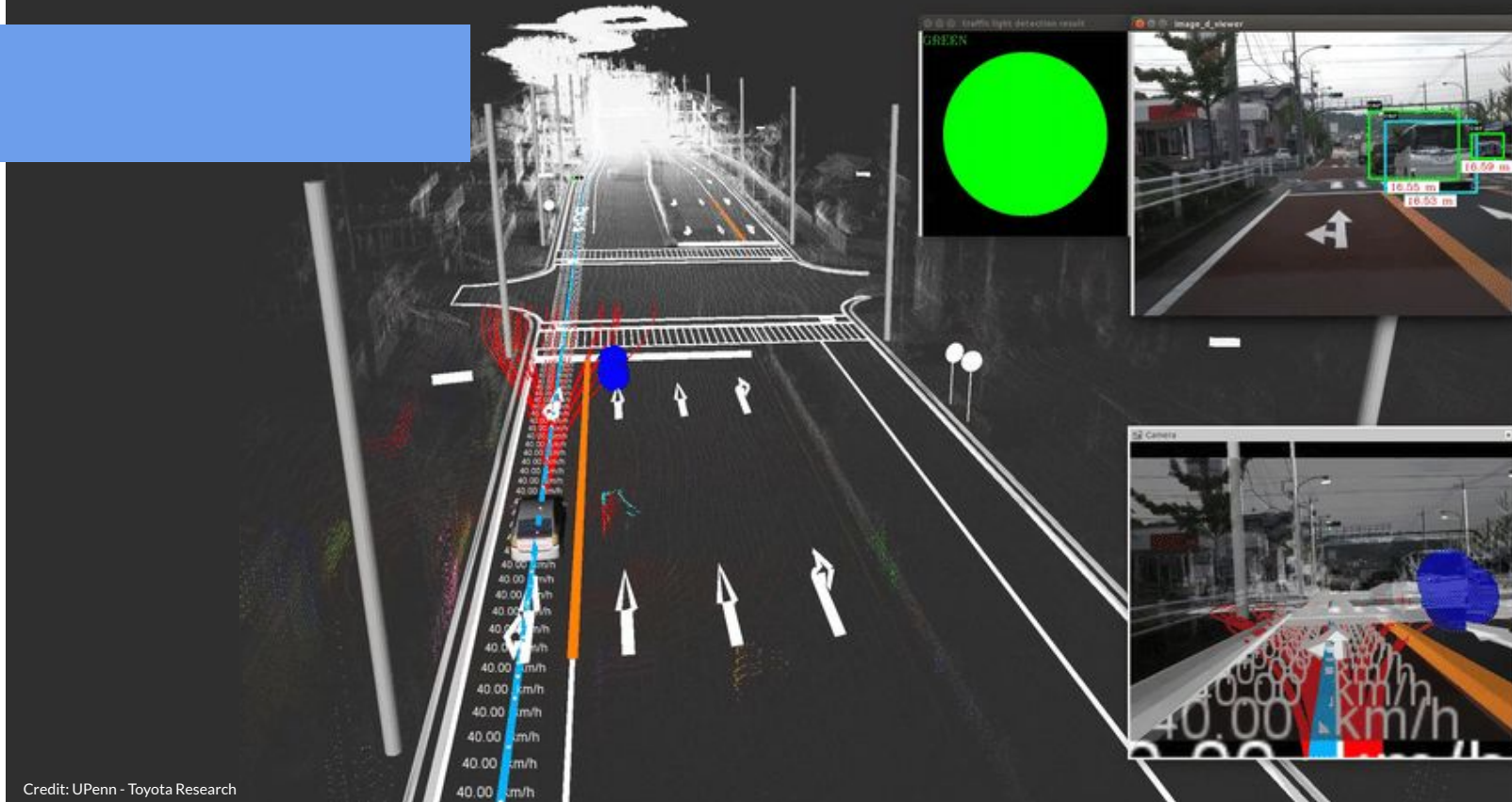


VPS+



Object detection

# VPS+



## Object localisation



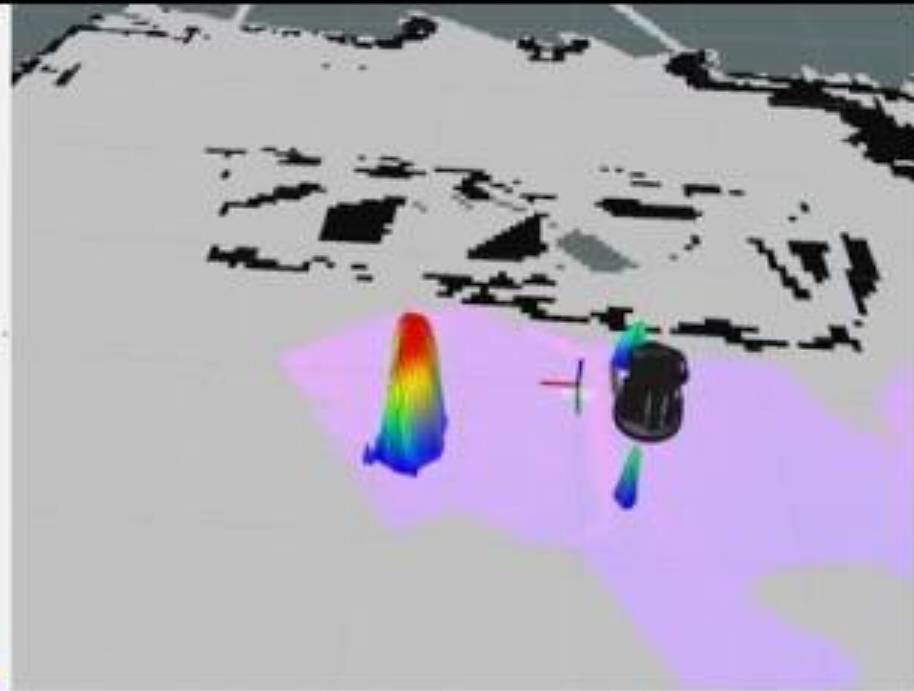
VPS+



Credit: Toyota

Obstacle avoidance

# VPS+



## Obstacle avoidance

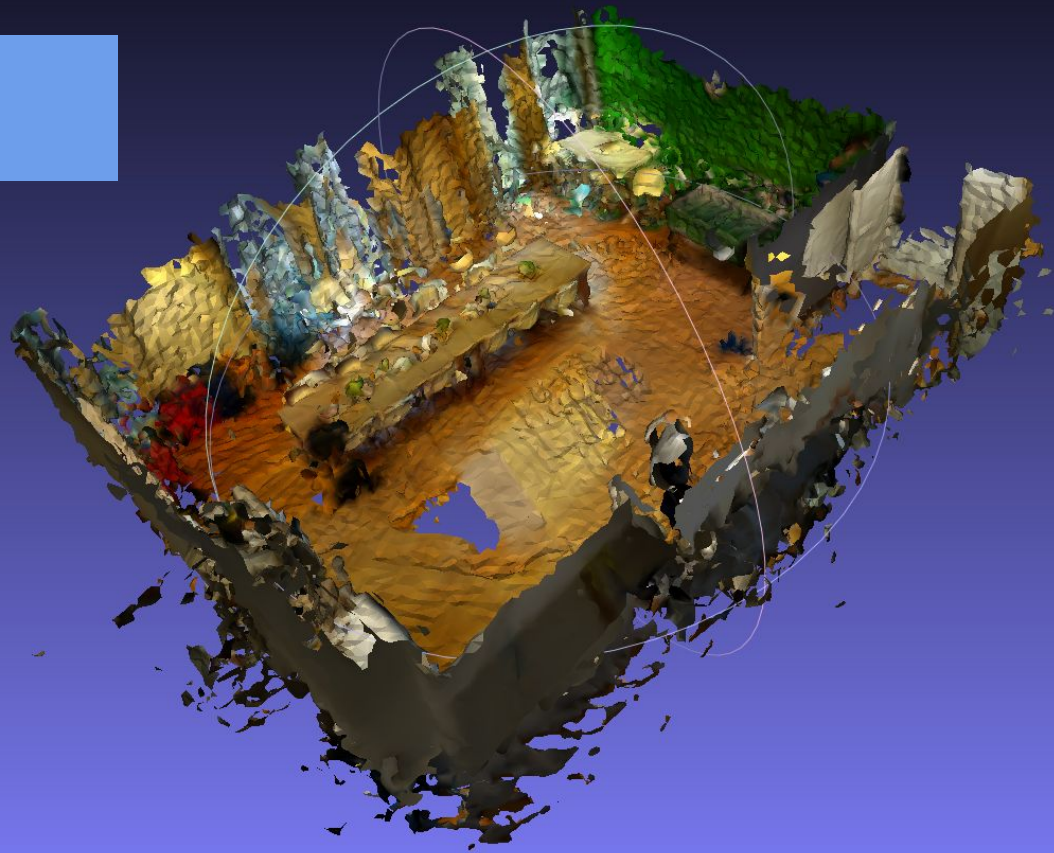


VPS+



Floorplan generation

VPS+



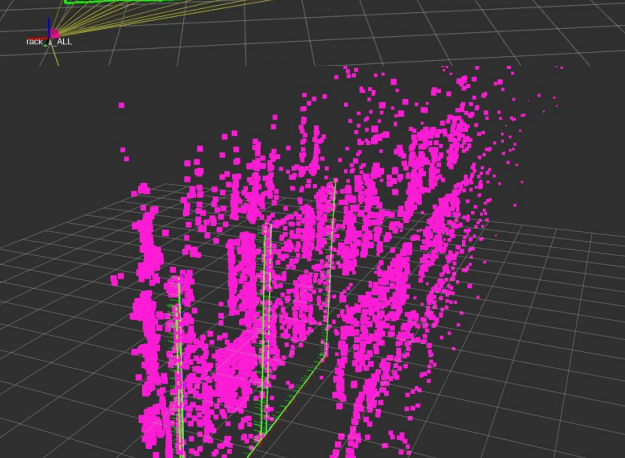
3D reconstruction



# VPS+

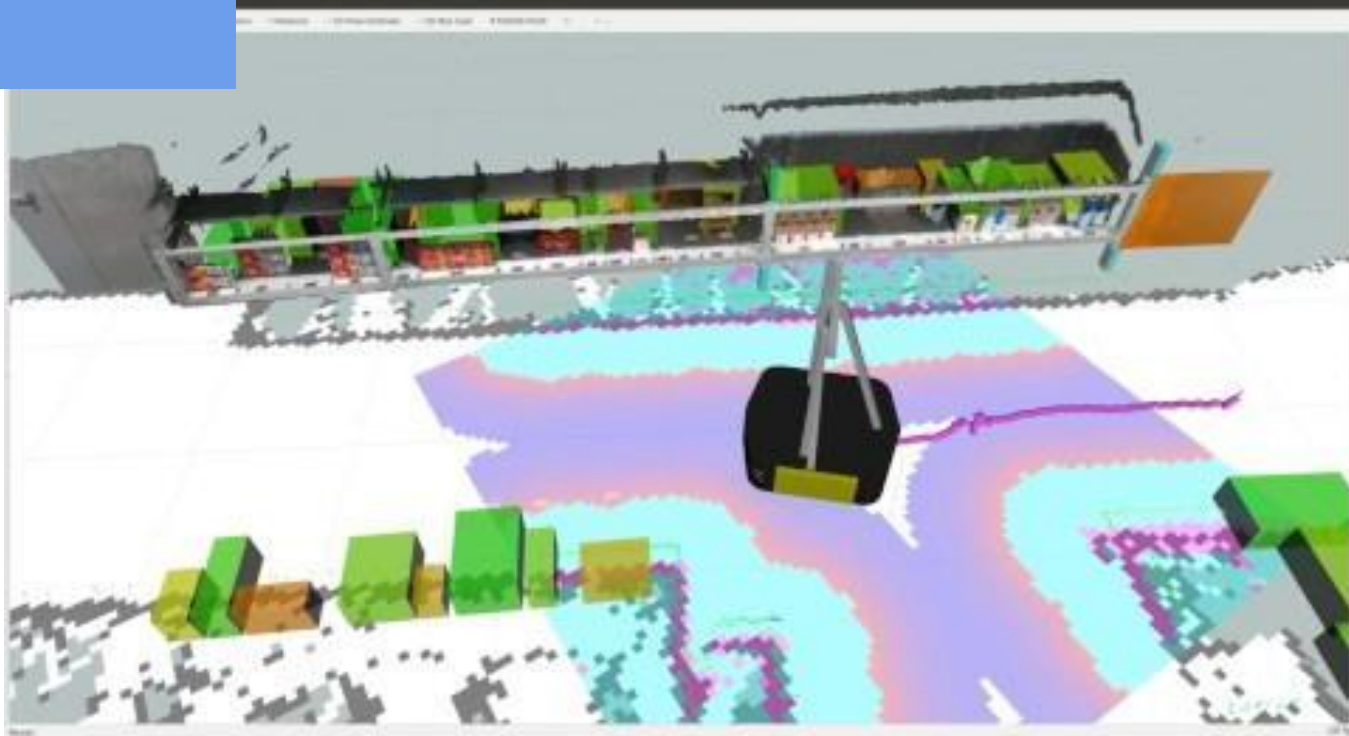


Shelf ID: 01ALL-011	Shelf ID: 01ALL-012	Shelf ID: 01ALL-013	Shelf ID: 01ALL-014	Shelf ID: 01ALL-015	Shelf ID: 01ALL-016
→ Actual codes:	→ Actual codes:	→ Actual codes:	→ Actual codes:	→ Actual codes:	→ Actual codes:
00000001111	00000001112	00000001113	00000001114	00000001115	00000001116
→ Expected codes:	→ Expected codes:	→ Expected codes:	→ Expected codes:	→ Expected codes:	→ Expected codes:
00000001111	00000001112	00000001113	00000001114	00000001115	00000001116
Status: 2	Status: 2	Status: 2	Status: 2	Status: 2	Status: 2



## Object Localisation

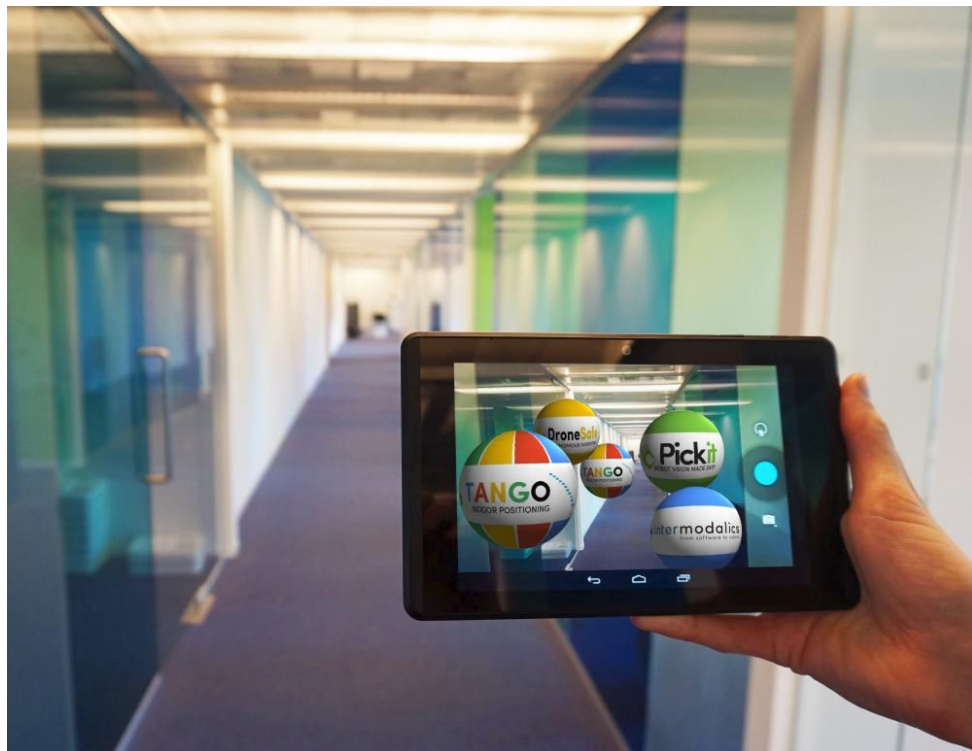
VPS+



3D Shelf Scanning



# VPS+



Credit: Magic Leap

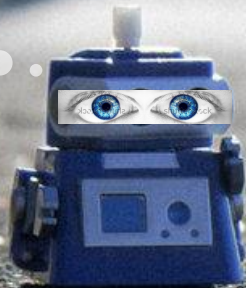
## VR / AR / MR

What will  
the future  
bring?





What will  
the future  
bring?



More than 500 million years ago, vision became the primary driving force of evolution's 'big bang', the Cambrian Explosion, which resulted in explosive speciation of the animal kingdom. 500 million years later, AI technology is at the verge of changing the landscape of how humans live, work, communicate, and shape our environment.  
*Prof. Fei-Fei Li - Stanford University*



**Elon Musk**  @elonmusk · 31 Oct 2018

Scientists uncover Sneaky move by GM

**InsideEVs** @InsideEVs

GM's National EV Proposal Hides Call To Roll Back Vehicle Efficiency  
[insideevs.com/gm-ev-proposal...](https://insideevs.com/gm-ev-proposal...)

636 1.9K 18K



**Pier Carlo Cadoppi** @vaipier · 31 Oct 2018

Are you planning on adding a radar heater? Autopilot and adaptive cruise control are not working in cold climates / with snow!

1 6 70



**Elon Musk** 

@elonmusk



Replying to @vaipier

Long-term, the car will work purely on vision, with radar just a plus, but maybe worth adding a radar heater anyway

3:55 AM - 1 Nov 2018

# Let's meet!

What is your VPS plus?

Where could you use localization?

What are your experiences  
with indoor localization?

Which RTLS did you consider or use?



[www.intermodalics.eu](http://www.intermodalics.eu)

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