

The logo for the 2024 embedded VISION SUMMIT is centered within a white octagonal shape. The octagon is surrounded by a colorful, multi-layered geometric border composed of overlapping triangles in shades of purple, blue, green, yellow, and orange. The text inside the octagon reads "2024" in a small, black, sans-serif font at the top, "embedded" in a slightly larger, black, sans-serif font below it, "VISION" in a large, bold, black, sans-serif font with a blue-to-orange gradient, and "SUMMIT" in a smaller, black, sans-serif font at the bottom.

2024  
embedded  
**VISION**  
SUMMIT®

# Using Artificial Intelligence to Enhance the Well-Being of the Elderly

Dr. Harro Stokman

CEO

Kepler Vision Technologies

- **The problem**
- **Biggest challenges to solve:**
  1. From 100% cloud-based to an embedded solution
  2. Collecting patient data to train neural networks
  3. Processing fish-eye images
- **Key take-aways**
- **Questions?**

# The problem

- **Today:** Impossible to hire caregivers in current job market
  - 1,500,000 unfulfilled care job openings in US
  - 600,000 unfulfilled care job openings in Europe
  - 270,000 unfulfilled care job openings in Japan
- **Upcoming years:**
  - 25-30% of caregivers retire in next 5 years
  - 2-6% year over year increase in the demand for care

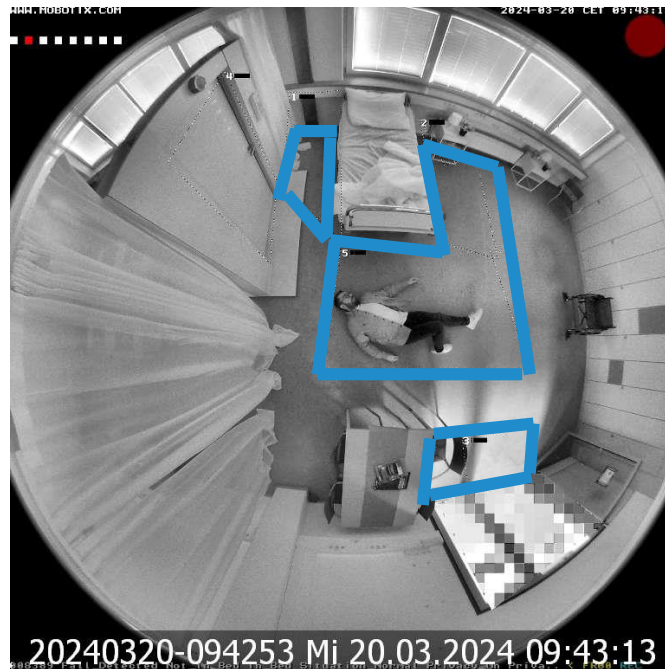
# How the problem gets solved: Old-fashioned approach

## Motion sensors or camera-based geo-fencing to look after patients



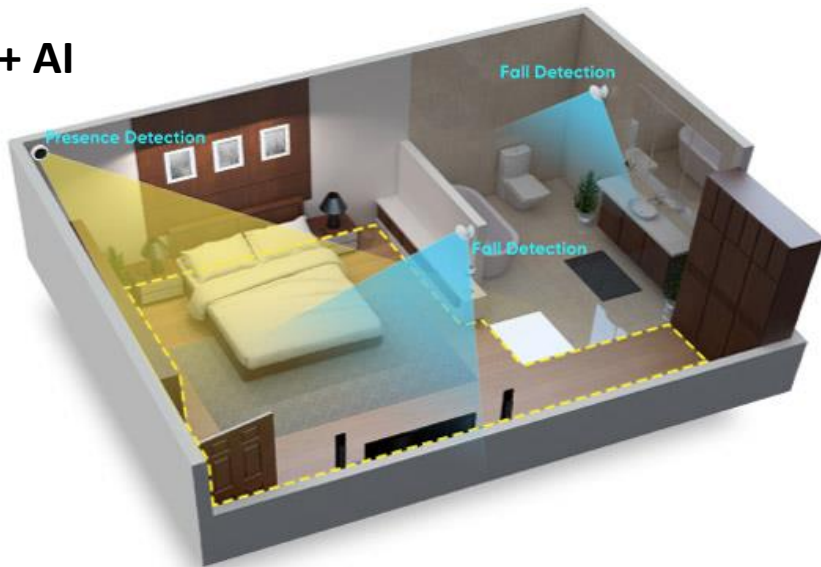
### Key shortcomings:

1. High false alarm rates
2. Does not work if bed is moved by cleaners



# How the problem gets solved: Competing solutions

## Radar + AI



### Key shortcomings:

1. Does not work if patient slowly collapses
2. Does not work if bed is moved by cleaners

# How the problem gets solved: Our solution

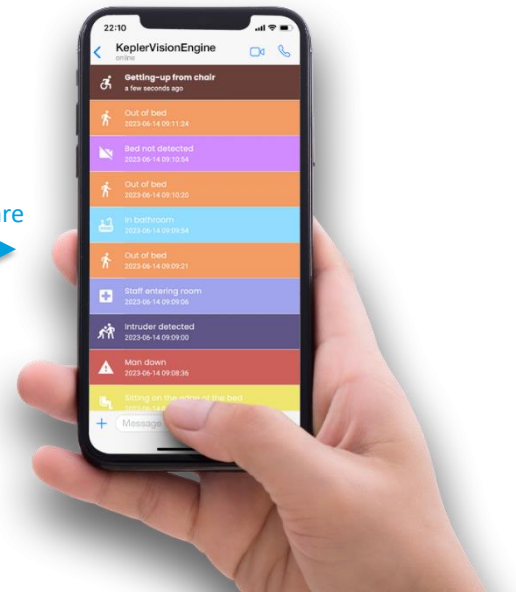


Kepler's software



|    |   |
|----|---|
| 🏠  | Out of room<br>a few seconds ago                      |
| 🚶  | Out of bed<br>2023-03-16 17:30:05                     |
| 👤  | Staff entering room<br>2023-03-16 17:30:05            |
| 🏠  | Out of room<br>2023-03-16 17:29:35                    |
| 🚽  | In bathroom<br>2023-03-16 17:29:05                    |
| 🚶  | Getting-up from chair<br>2023-03-16 17:28:41          |
| 🚶  | Out of bed<br>2023-03-16 17:28:23                     |
| ⚠️ | Man down<br>2023-03-16 17:28:08                       |
| 🪑  | Sitting on the edge of the bed<br>2023-03-16 17:27:38 |
| 🛡️ | All clear<br>2023-03-16 17:27:19                      |
| 🏠  | Out of room<br>2023-03-16 17:26:22                    |

Partner's software

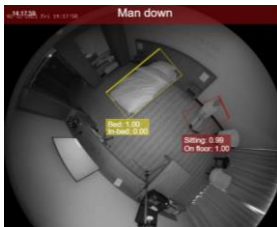
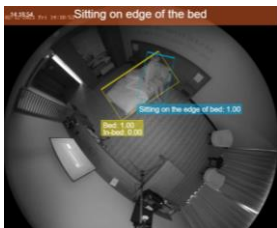


1 We develop and sell computer vision software. Our customers are care homes and hospitals.

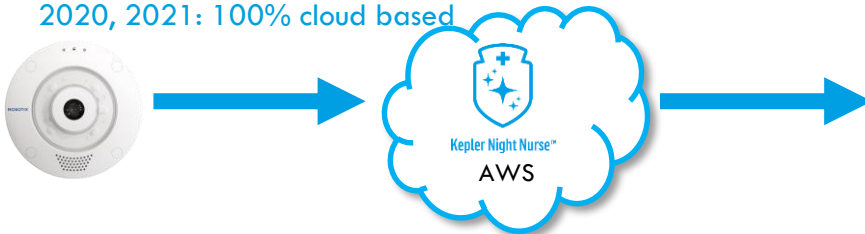
2 Our software translates the human activities it sees in video into text messages.

3 The text messages are sent to the nurses' phones. The nurses become more productive, and the well-being of patients improves.

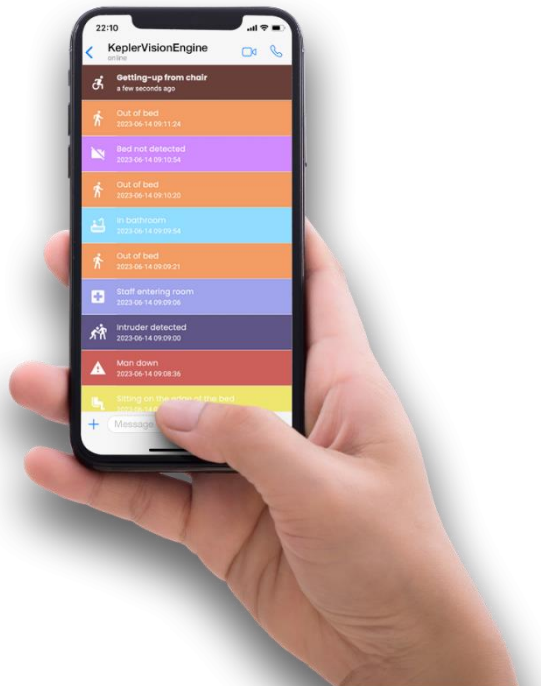
# Challenges to solve: Architecture



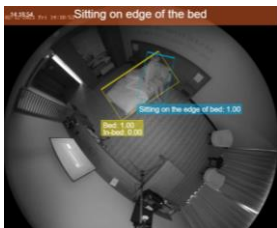
2020, 2021: 100% cloud based



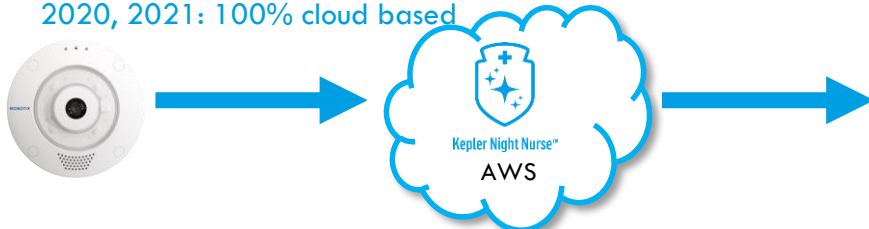
- **Pros:**
  - Easy to develop
  - AWS finances your growth
- **Cons:**
  - Care home operators find the cloud scary
  - AWS costs soar – only 25% of cost is GPU related
  - VPN and firewall requirements delay rollout



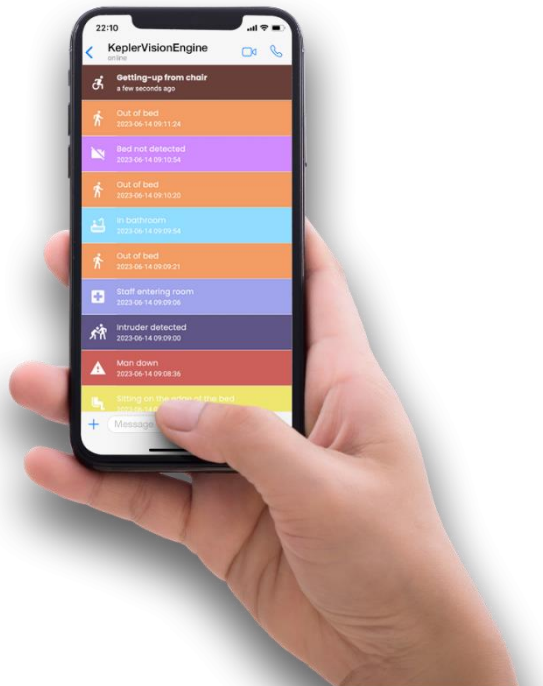
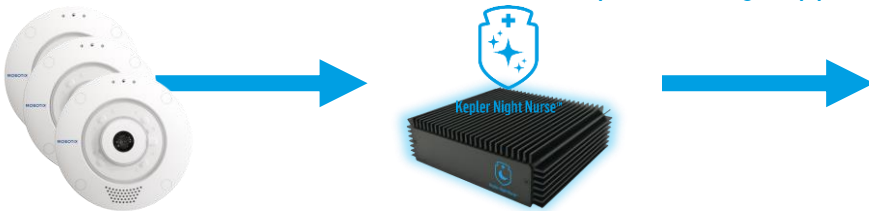
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2020, 2021: 100% cloud based

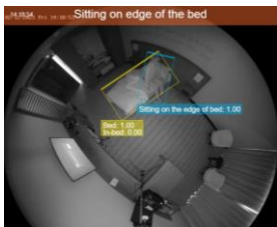


2022 and onwards for “dumb” cameras: on-premise edge appliance



- **Pro:** Customers like their data on-premise
- **Con:** Old-school system maintenance issues, machines crash. Most customers do not want to pay for redundancy.

# Challenges to solve: Architecture



2020, 2021: 100% cloud based



2022 and onwards for “dumb” cameras: on-premise edge appliance



2024 and onwards: embedded on Mobotix C71 camera

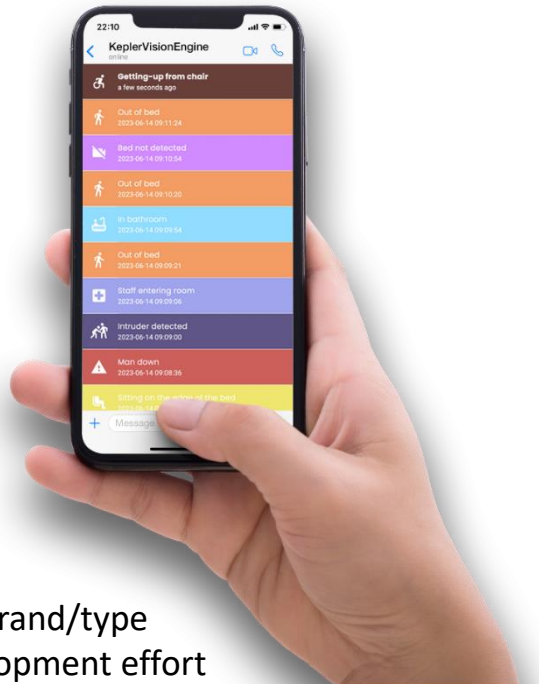


**Pros:**

- Ease of distribution
- CAPEX instead of OPEX
- “Redundancy” for free

**Cons:**

- Each camera brand/type requires development effort
- Camera manufacturers don’t provide access to compute resources



## CPU Part

- Quad-core ARM Cortex-A53 (up to 1,300 MHz)
- Mali-400 MP2 GPU (up to 667 MHz)
- 4 GB DDR4 memory connected with 64-bit interface

## FPGA Part

- 88000 CLB LUTs
- 4.5 Mbit Block RAM
- 1.5 GB DDR4 memory



# Porting to the C71 camera

## Main challenge: Running the neural network on the FPGA

- Could not program FPGA directly, vendor supplies a deep-learning processing unit (DPU) loaded onto the FPGA that abstracts the underlying hardware
- Model has to run quantized (INT8 computations); no floating point available on the DPU
- Model conversion tools had issues:
  1. Unsupported custom activation layers
  2. Splitting/chunking/concatenating of tensors
  3. A converted model doesn't necessarily produce sensible output.



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# Challenges to solve: Collecting patient data for training neural networks

Clients are vulnerable, is filming them in their most private moments necessary?

## Step 1

Collecting data requires data processing agreement, which in turn requires:

1. Kepler adheres to ISO certification
2. Care home gets consent from patient or family

## Outcome:

- We collected 2M+ frames from videos – the real thing
- We survived five ISO audits. Adhering to the P and C of PDCA (plan, do, check, act) is a pain for a startup

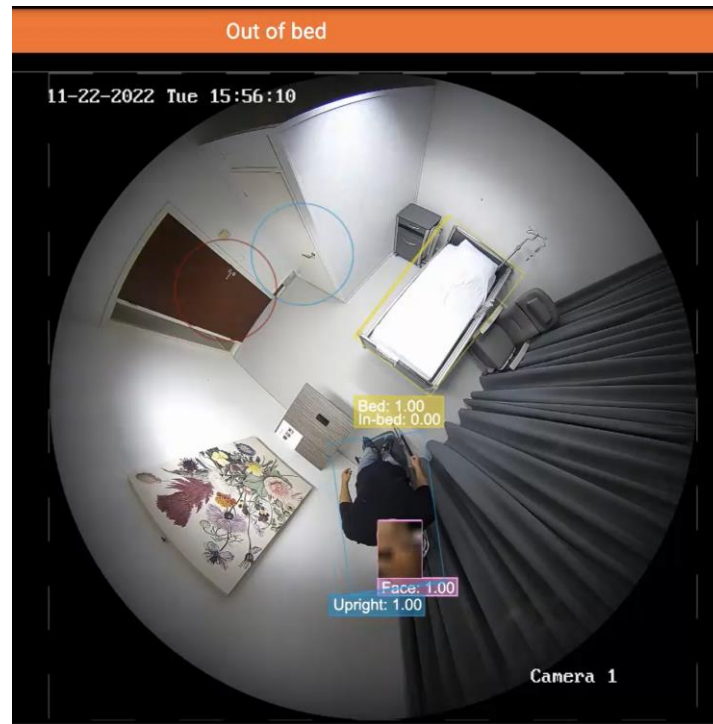


# Challenges to solve: Collecting patient data for training neural networks

## Step 2

- We always blur faces, also in our training data
- Just like Google Streetview

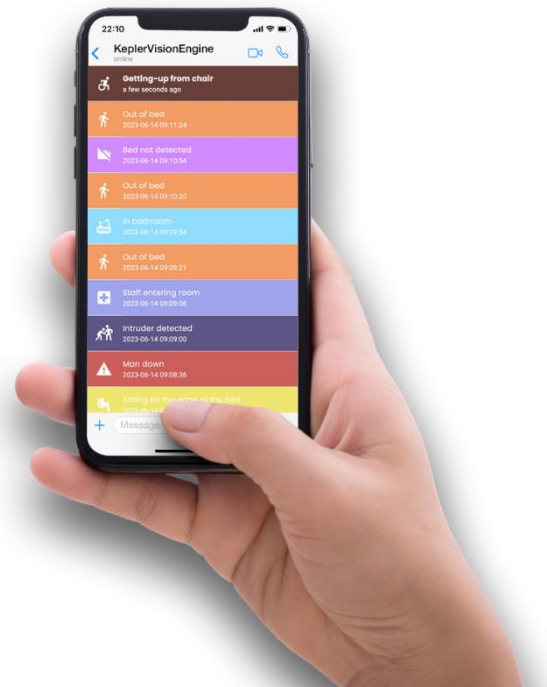
Challenge: Blurring the images in such a way that you can still train neural networks on them



# Challenges to solve: Collecting patient data for training neural networks

## Step 3

- We never show images to nurses. Our software is video-to-text

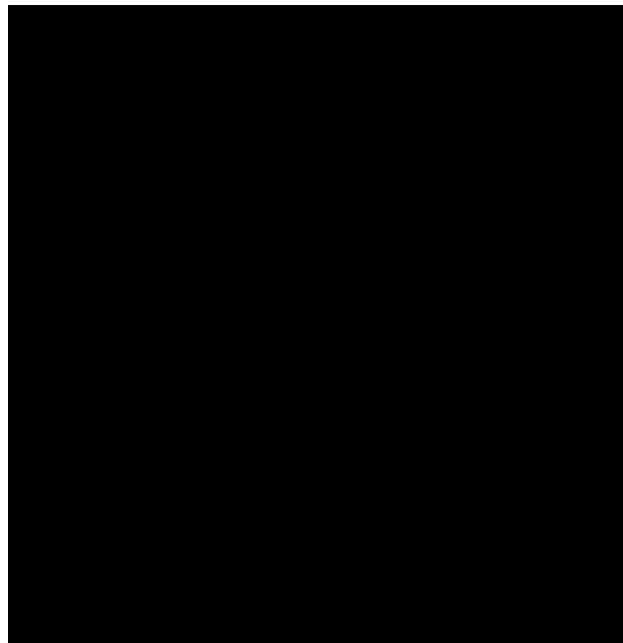


# Challenges to solve: Collecting patient data for training neural networks

## Step 4

Mobotix camera offers  
privacy mode:

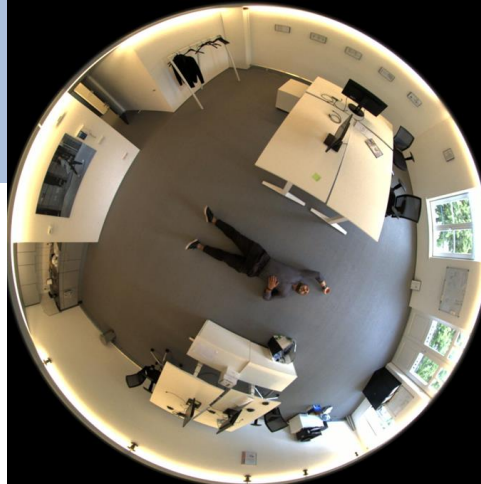
1. The software runs on  
the camera
2. The camera does not  
transmit video, just  
black pixels



**Camera output in privacy mode**

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# Image processing of fish-eye images



# Image processing on unwarped fish-eye images

- **Pros for image processing in unwarped image**
  - You can pretrain on ImageNet
- **Cons:**
  - Distortion due to unwarping makes object recognition difficult. We did not find an unwarping algorithm that does not distort.
  - You need to “cut” the image somewhere. Every now and then, you will cut a person in two. This leads to double counting – or very complex algorithms



# Image processing directly on the “raw” fish-eye image

- **Pros**
  - You eliminate the drawbacks of unwarping
- **Cons (requires lots of hard work):**
  - No ImageNet-like datasets available. We developed a fish-eye training data set from scratch.
  - No standard image annotation tooling known to us handles fish-eye images – we had to build it ourselves



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# Key take-aways for our embedded vision product

1. The embedded product created a new distribution channel where Mobotix and its global partner network sell our vision product.
2. The CAPEX payment schedule for the embedded product fuels our growth – compared to OPEX for the SaaS model
3. The care home operators love the privacy offered by the embedded product.

# Questions?

- Company website: <https://keplervision.eu/>
- Embedded product page: <https://www.mobotix.com/en/mobotix-c71-nurseassist>