Enabling Video Privacy Through Embedded Vision

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Presentation Overview

• Problems in long term care
• Live demo of solution
• What is difficult in getting this to work:
  • Computer vision problems
  • Infrastructure problems (focus of this presentation)
• How the technology works
• Clinical validation outcome
• Background of the Kepler Vision company
• Summary
Problems in Long Term Care

Issues

• Aging population:
  • Diminishing ‘supply’ of care (25% of caregivers to retire in next 5 years)
  • Increasing demand for care (6% growth YoY)
• Hardly any innovation:
  • Motion sensors generating too many alarms
  • Caregivers check on patients just like they did 100 years ago

Resulting in

• Alarm fatigue
• Overstretched caregivers
• Patients not getting the care they need: 5 out of 6 patients remain on floor longer than 5 min when fallen
• Lack of privacy for patients: Three times at night a nurse enters room unnecessarily
Computer-Vision Specific Problems in Long Term Care

- High pixel resolution required to detect residents falling at end of hallway
- **Is deep learning the right technology?** No publicly available training datasets for
  - Infrared images
  - Human poses observed indoors as sitting, bending, lying, kneeling, crouching
  - Rare events such as falling
  - Fisheye images (see also next slide)
The Kepler Night Nurse – Unique Fisheye Approach

**Conventional Camera**

- For humans, fisheye images are hard to interpret due to lens distortion and the strange viewing angle. This is not an issue for KNN.
- Proprietary annotation studio able to label fisheye images.

**Kepler Night Nurse Fish Eye Camera**

- Unwarping unnecessary, therefore image distortion is prevented and better recognition accuracy is achieved.
- Unique AI solution to detect human behaviour from fish eye images.
- Recognizes a person standing upright even while the image shows the person upside down.
- Avoids blind spots which conventional cameras cannot.
Infrastructure and Hardware Specific Problems in Long Term Care
(Focus of This Presentation)

- Low tech environment: No rack space available on premise
- Processing in the cloud is challenging:
  - Network maintenance outsourced, setting up VPN connection takes months
  - Internet bandwidth costly, setting it up takes months
  - AWS does not charge for incoming traffic but charges for data transfer between availability zones
  - Perceived by non-technical stakeholders as insecure
The Kepler Night Nurse – How it Works

Helicopter surround view camera position

Edge Box (Located safely on site)
Nvidia Jetson GPU
Processes eight 12MP video streams simultaneously

1. Monitor
2. Process
3. Understand/Assess
4. Alert

Fisheye video option A

Fisheye video option B over VPN

Encrypted metadata over HTTPS

Encrypted text message

Amazon data center in Frankfurt

The Kepler Night Nurse

– How it Works

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Fisheye video option B
Deep Learning Model Training and Inference

Model training

Kepler Training Data → Kepler Labels → Train ensemble of deep convolutional neural networks → PyTorch Models

Model optimization

Kepler PyTorch → TensorRT convertors → TensorRT Models

Two options for model inference: Cloud only or on Edge

Fisheye camera

Frame preprocessing → Nvidia Triton Inference Server → Event detection

Notify nurse
Clinical Validation Outcomes

• Over 99% reliability
• 1 false alarm per video stream per 96 days
• Assistance takes more than 5 minutes to arrive after fall
  • Without the Kepler Night Nurse: 6 out of 7 cases
  • With Kepler Night Nurse: 1 out of 7 cases
Introduction to Kepler Vision Technologies

### Company Overview

- Founded in 2018
- Founded by a team of PhDs in computer vision with over 20 years of experience
- Spin-off from the Faculty of Science of the University of Amsterdam
- Headquarters in Amsterdam, the Netherlands
- 15 employees (11 FTE), of which 7 PhD’s

### Best in Class

- Source code quality rated by TÜV 4 out of 5-star two years in a row
- 3 patent families granted, and 11 patent families pending related to AI and computer vision
- Kepler Night Nurse (flagship product) is registered as a medical device in Europe
- Certified ISO 27001 and NEN 7510, to securely process personal and medical data

### Selected Awards

- **Microsoft Innovate AI Challenge Global Top 10** - 2018
- **Future of AI Innovate AI Competition First Prize** - Winner Europe 2019
- **The Big Score Top 50 Most Promising European Scale-up** - 2019
- **GIANT Health Event Winner Scale-up Competition** - 2020
Summary: How embedded vision enables video privacy in long-term care

<table>
<thead>
<tr>
<th>Challenges due to cloud-based vision solution</th>
<th>Advantages of embedded vision solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low tech environment, no rack space available on premise</td>
<td>Embedded vision on edge box does not need rack space</td>
</tr>
<tr>
<td>For security reasons, we connect from the cloud to the camera over VPN (outside in). However, setting up VPN connection takes months</td>
<td>Edge box connects to cloud (inside out) over HTTPS/TLS connection&lt;br&gt; Video stays on premise, only metadata needs to be encrypted</td>
</tr>
<tr>
<td>Bandwidth costly to connect to cloud (32 Mbit/s per 8 video streams of 6 MP)</td>
<td>Embedded vision on edge box outputs only fraction of data (1 Mbit/s per 8 video streams)</td>
</tr>
<tr>
<td>Cloud perceived by non-technical stakeholders as privacy issue</td>
<td>Video does not leave premise when using edge box</td>
</tr>
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Cloud-based or embedded:

Staff is alerted *only* when resident is in acute need, thus no unnecessary visits three times at night
Raising venture capital to expand to the UK