

# Augmented Reality

## Applications at VTT

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# Introduction

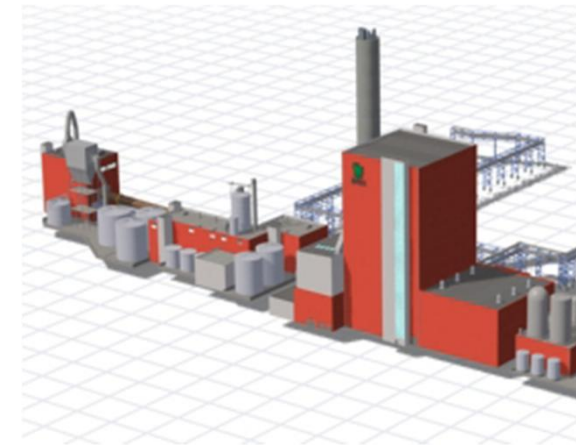
# Introduction – AR

## Augmented Reality (AR)

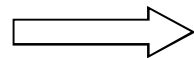
- § Adding of virtual objects in view of real world
- § C.f. Virtual Reality (completely virtual worlds)
- § Properties: real-time, interactive, 3D registration
- <-> Challenges: tracking, accuracy, speed, mobile

## Related technologies

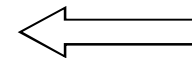
- § Augmented Virtuality
- § Mediated Reality
- § Diminished Reality, ...
- <-> *Mixed Reality (MR)*



Reality



Augmented  
Reality



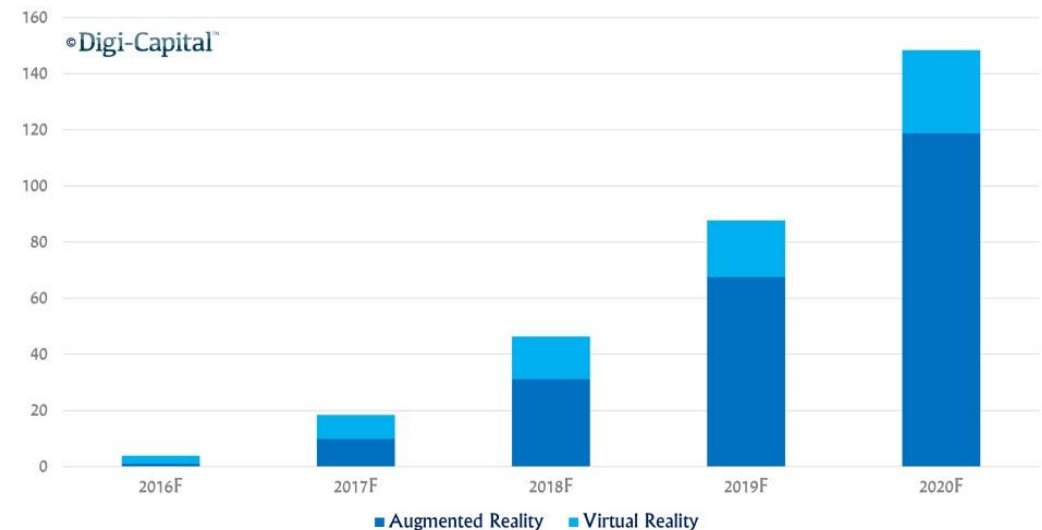
Virtual Reality

# AR/VR Markets

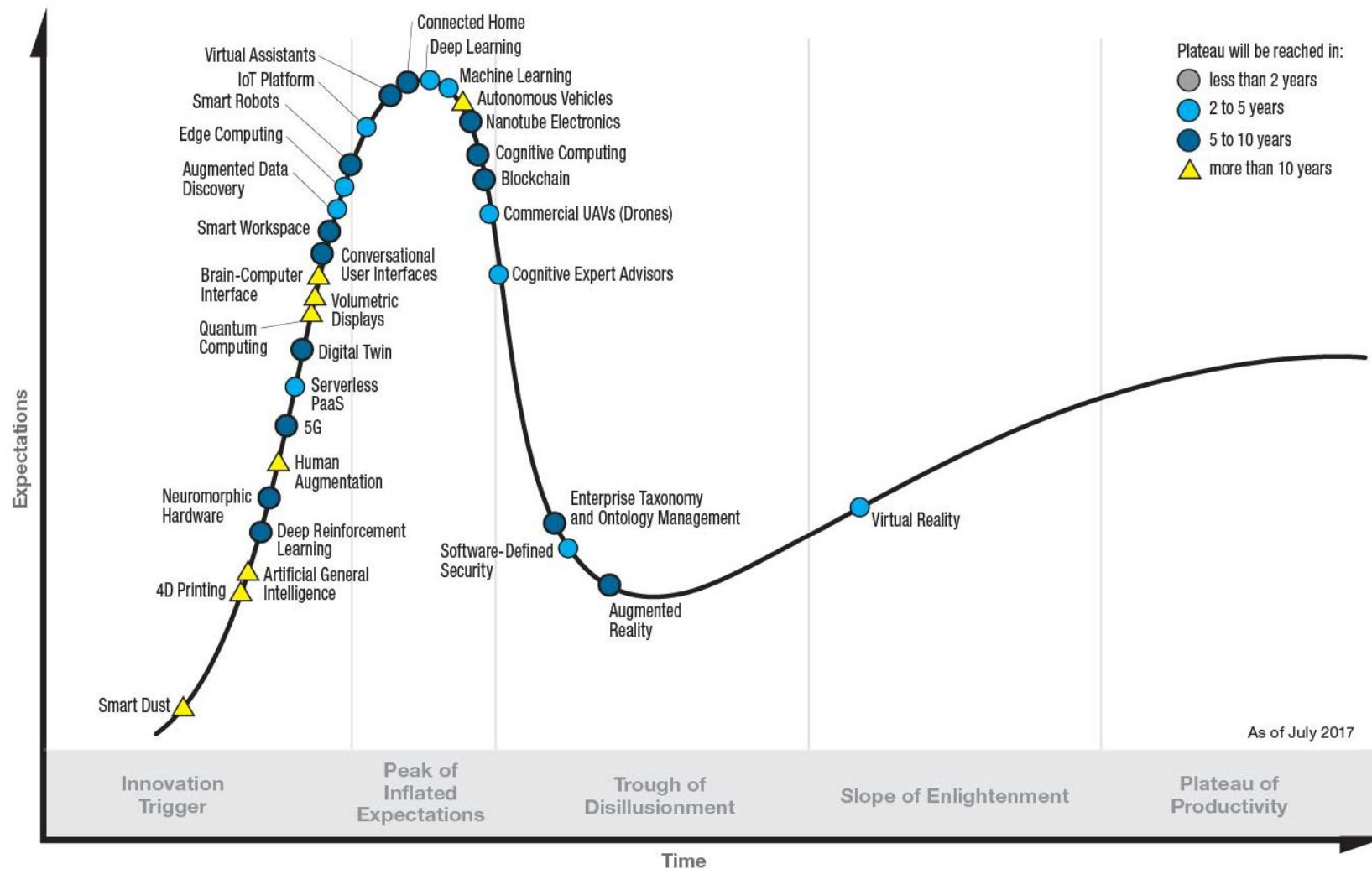
## Market predictions

- § According to Digi-Capital, VR and AR markets will reach 150 \$B revenue by 2020
- § AR taking the lion's share around 120 \$B and VR \$30 \$B
- § AR to become the 4th ICT revolution, after PC -> Internet -> Mobile
- § Part of our everyday lives in near future
- § Industrial adoption has already begun

Augmented/Virtual Reality Revenue Forecast (\$B)



# Gartner Hype Cycle for Emerging Technologies, 2017



[gartner.com/SmarterWithGartner](https://gartner.com/SmarterWithGartner)

Source: Gartner (July 2017)  
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**Gartner**

## Augmented Reality / 3D Tracking research at VTT

- § Research topic started in 2001
- § Today team of 25 people based in Espoo & Tampere
- § AR/MR core technology & high-end applications
- § Human factors, usability, user experience

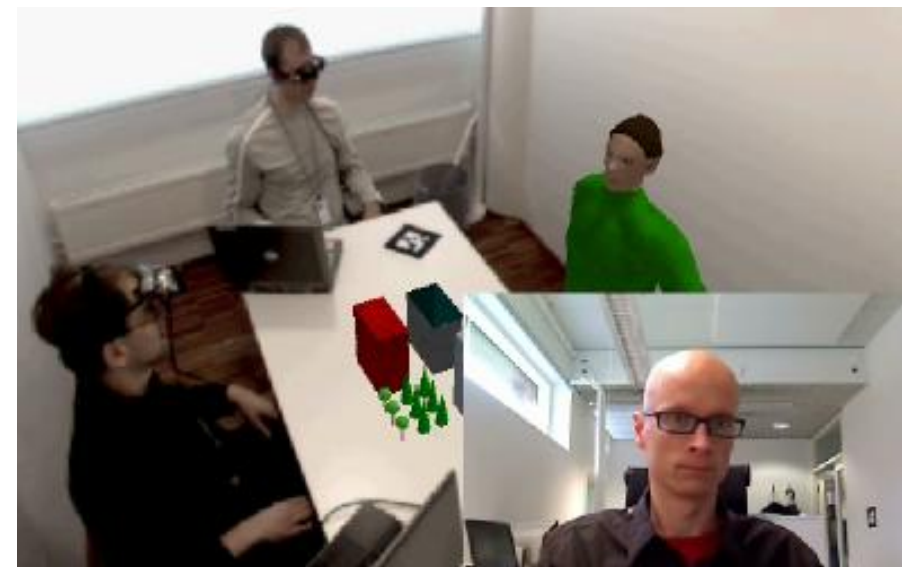


## Leading edge technology

- § First in the world with various AR applications
- § ALVAR SDK (A Library for Virtual and Augmented Reality)
- § Marker, multimarker, 2D template and 3D point cloud tracking
- § See [www.vtt.fi/multimedia](http://www.vtt.fi/multimedia)

## Applications, incl.

- § Games, Entertainment
- § Print media, Advertising
- § Interior design, Furniture, Rendering
- § Virtual Worlds Collaboration, Telepresence
- § Industrial Training, Maintenance, Assembly
- § Architecture, Engineering & Construction (AEC)



## **Some Early Applications**

# Augmented Reality Games

## AR table tennis (2001-2003)

- § Augmented two player games, PC / Symbian
- § Operation over Internet / Bluetooth
- § Mobile phone stereo version



**SymBall**



**StereoGames**



**CamBall**



**TelePet**

# Consumer Applications: Print & Advertising



Sparkly in Elle magazine



Augmented business cards (Painonet)



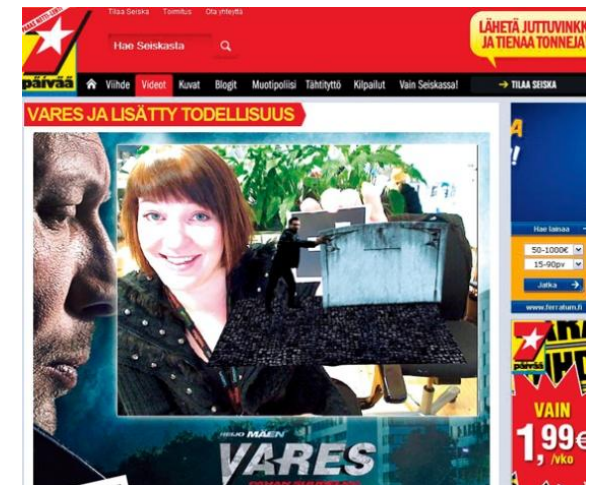
Dibidogs in Katso & AR children's book



Nestle bunny on cocoa package



DNV (Det Norske Veritas): Technology Outlook 2020



Veijarit & Vares movie trailers in Seiska magazine

# Interior Design

## VividAR

- § AR interior design system by VividWorks, based on VTT technology
- § Free download, various furniture retail companies around the world
- § Spearhead for international marketing



§ Incl. Diminished Reality

# Photorealistic Rendering

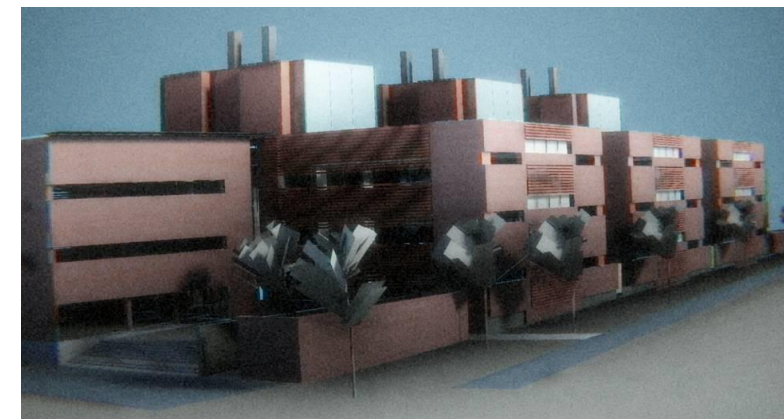
## Challenges, e.g.

- § Materials, incl. reflections, transparency
- § Accounting for real world lighting conditions
- § Incl. light direction, intensity, colors, shadows
- § Matching computer graphics with webcam video quality



## Comparisons

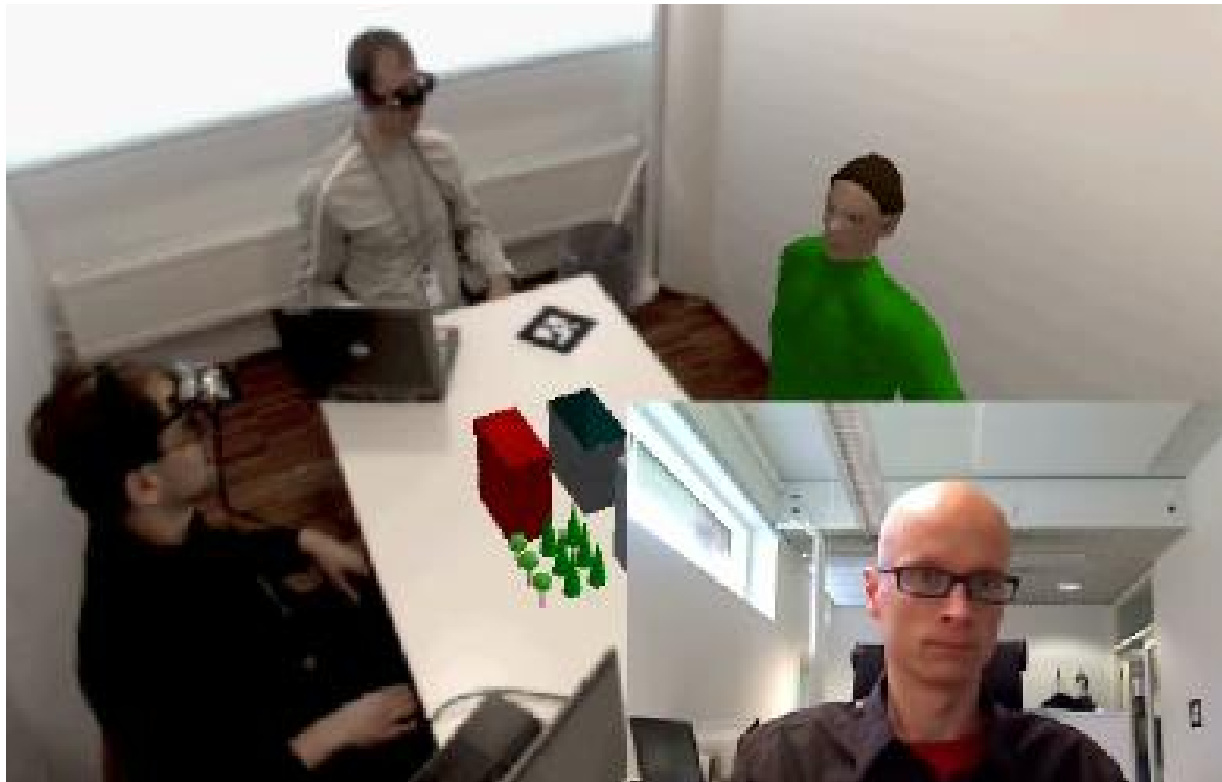
- § Left - standard 3D graphics
- § Right - using VTT methods



# Mixed Reality Telepresence

## Connecting Real and Virtual Worlds

- § Mixed Reality teleconferencing between real people and Second Life avatars
- § Avatars appear at meeting room with real people, following real people's gestures
- § Aiming at huge cost savings in travel and time
- § Implemented in co-operation with IBM Corp. (USA)



# **Industrial Applications**

# Maintenance, Operation

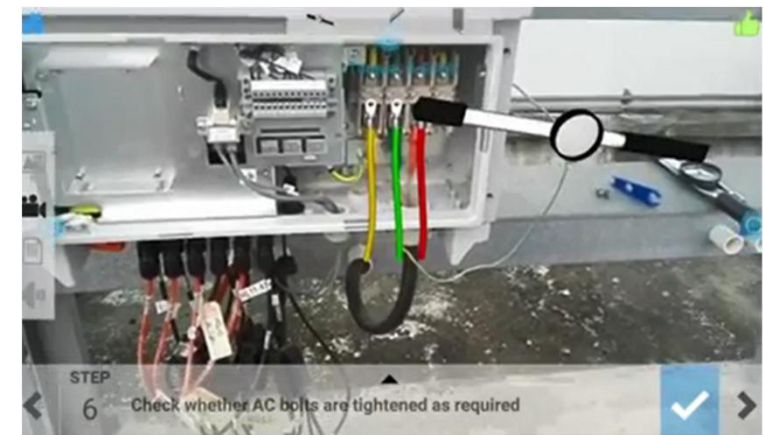
## Case ABB

- § AR visualization of IoT information
- § Maintenance tasks, safety elements
- § User interface on HoloLens & tablet



## Case Huawei

- § 3D visualization of maintenance tasks
- § Implementation by Inglobe Technologies
- § Point cloud based 3D tracking by VTT's ALVAR SDK



# Maintenance, Operation

## Case ESA – European Space Agency

- § Maintenance, Safety instructions, 3D manuals, IoT data
- § HoloLens data glasses, voice and gesture commands
- § User tests at International Space Station



# Assembly, Training

## Case Valtra

- § Finnish tractor company
- § Hydraulic block, 200 pcs, AR pipeline from STEP model
- § User interfaces for PC monitor, data glasses & mobile phone

## User study

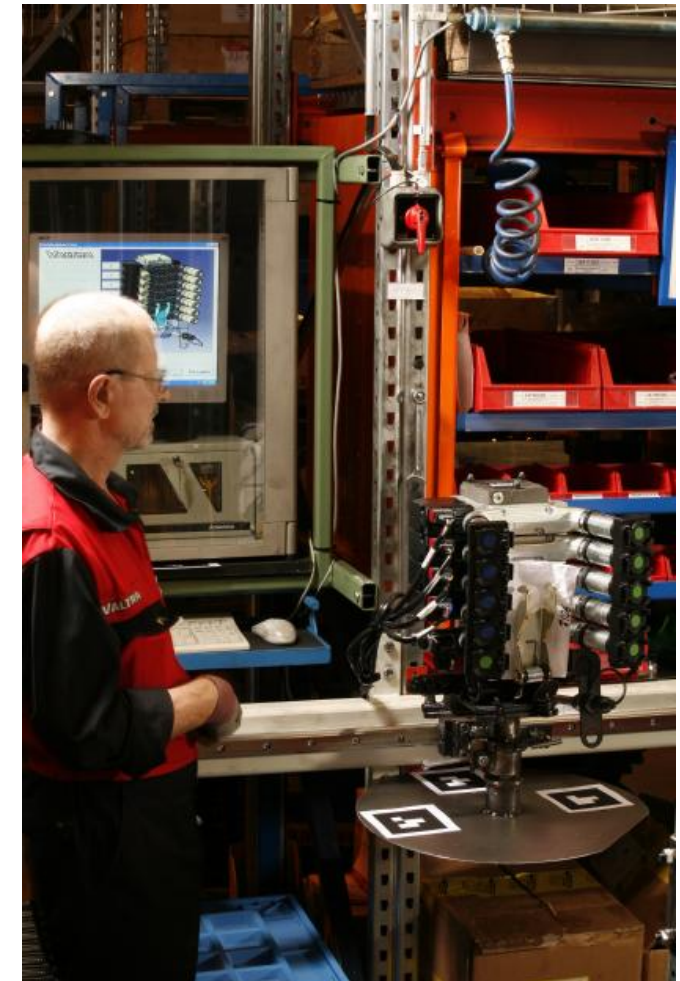
- § 60 students, 30 using AR, 30 paper manuals
- § Performance with AR was faster, and 6 times less errors

## Current system

- § Unity authoring tool
- § Markerless tracking
- § Assembly -> maintenance

## Strenghts

- § Straightforward 3D content
- § Range of applications
- § Tablet / screen display



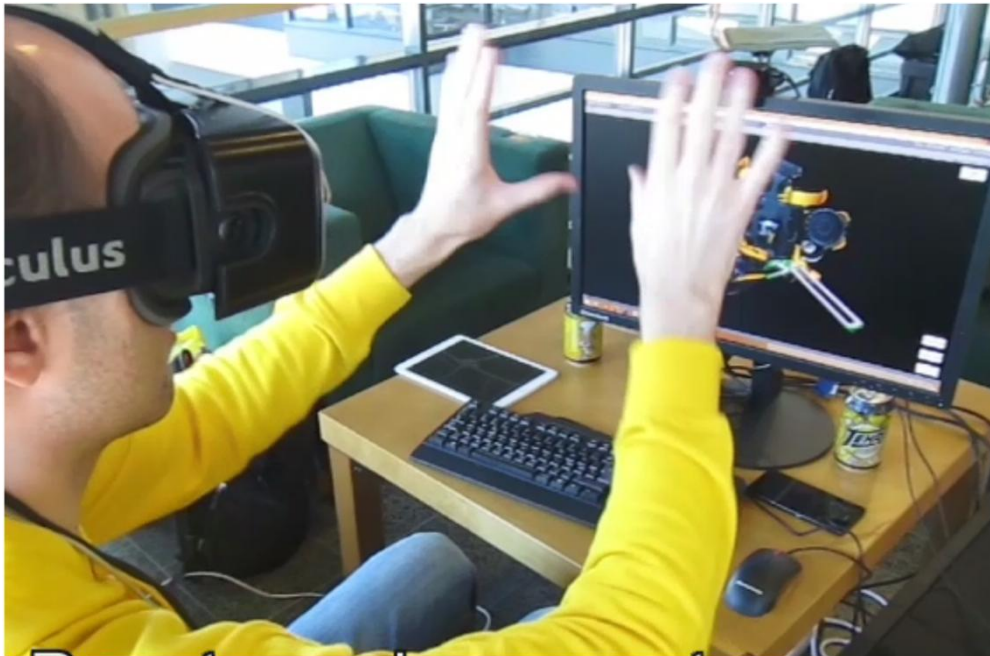
# Remote Assistance

## Case Ponsse

- § Finnish forest machinery manufacturer
- § AR instructions from expert to remote user (in woods)

## Features

- § Limited bandwidth – transmit only coordinates, annotations
- § No bandwidth – enable training at hotel room
- § Recording of training material for wider use



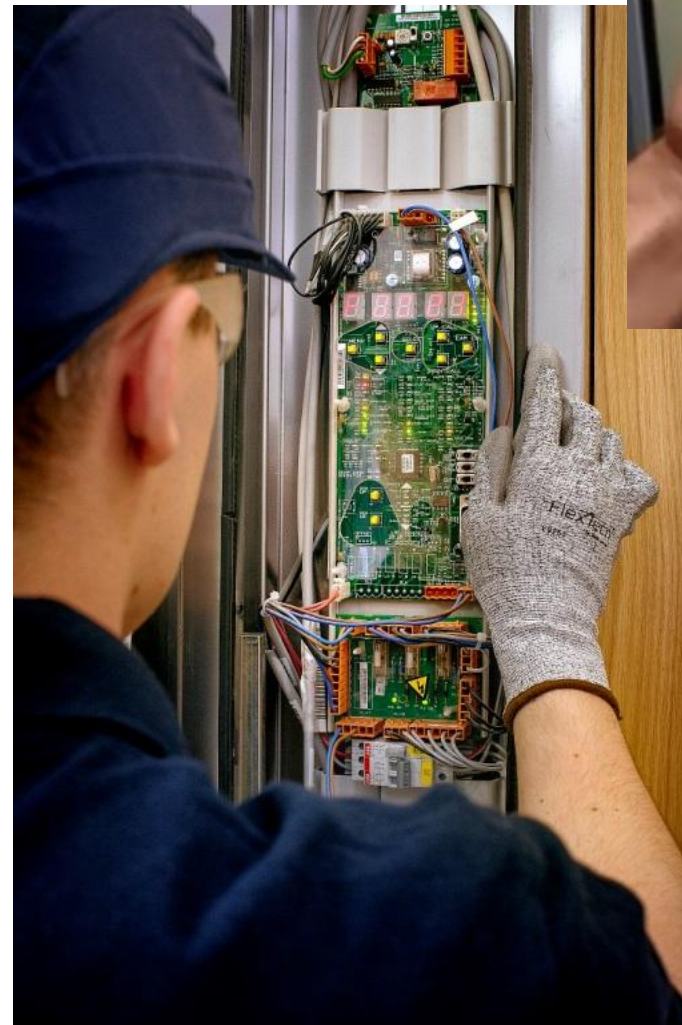
# Special Equipment

## Case KONE

- § Maintenance of elevator control unit, life cycle may be > 50 years
- § State of equipment shown as digits, LEDs on control unit
- § Interpretation must be sought from service manual
- § Cumbersome, potential source for errors

## Solution

- § Computer Vision methods to interpret state of equipment
- § Maintenance instructions obtained automatically from service manual & shown to user
- § Also, optional 3D AR instructions



# Augmented Reality Social Media

## Bringing real world objects to Social Media

- § Attach social media posts to real-world objects, in AR view
- § Add new target object by taking a reference image
- § Or, create a 3D target using several reference images
- § Target objects are automatically associated with a hashtag
- § Tweets are augmented on objects using ALVAR tracker
- § Works with Twitter, also Instagram, Facebook, ...
- § Possible to include photo content etc.



## Case Konecranes

- § Thousands of maintenance workers around the world
- § Majority of equipment by other manufacturers
- § Experienced workers retiring
- § Need to collect tacit knowledge
- § Solution: AR SoMe



# **Building Visualization**

# Mobile AR for AEC

Pioneering works by VTT

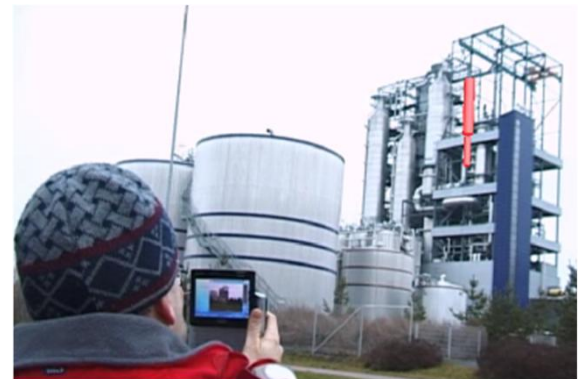
AR-PDA system (2003)

- § Client/server
- § Marker based



UMPC stand-alone system (2006)

- § Interactive placement of model
- § Optical flow / feature based tracking



“Google Earth on Earth” (2007)

- § Model placed in Google Earth
- § User's location provided by GPS
- § Interactive positioning

Markerless tracking (2010)

- § Model-based initialization
- § Real time feature based tracking



# City Planning

## Case Billnäs

- § New hotel being planned at historical Billnäs ironworks site, Finland
- § Mobile AR visualization was presented to group of 20 city council members
- § Devices: five N900 phones operated by audience
- § Feature based tracking, handling of occlusions etc.
- § User interviews, most positive feedback



# City Planning

## City development project in Helsinki Jätkäsaari

- § Clarion Hotel, tallest building planned in Helsinki (33 floors)
- § Mobile AR visualization presented to Helsinki city council members
- § Windows tablets, operated by architects & decision makers
- § Further visualizations to related interest groups



# Real Estate

## Property marketing

- § New housing area planned in Sarrvik, Finland
- § Property marketing by Westpro Oy
- § Presentations Aug – Sep 2014



# Citizen Participation

## AR visualization of wind generator park

- § Wind generator park being planned at Pörtom (Finland), project by VindIn (Sweden)
- § Tour around the site, to show AR plans for authorities & local people, farmers
- § Mobile phone, features incl. animations, lighting, masking by sky line etc.



# Citizen Participation

## Koskela hospital area

- § Four alternative plans, designed by Helsinki city planning office
- § Presentation to local residents Oct 2014



# Further Examples

## Case Rastila

- § New buildings planned in urban environment
- § Presentations spring 2014

## Conclusions

- § Technology is ready for mainstream
- § Content adaptation may need some work
- § Good tracking accuracy required



# **Building Life Cycle**

# Building and Construction

## Mobile AR visualization of construction plans

- § Pilot / Skanska offices 2009-2011
- § Devices: laptop PC, UMPC, data glasses
- § Photorealistic visualization of architectural model
- § Augmenting 4D plans during construction work
- § Comparison with partially ready building
- § Client/server solution -> mobile phones



# Navigation

## Tracking solutions

- § Point clouds obtained from photos
- § Using several point clouds
- § Dynamic loading of point clouds
- § Updating of point clouds, edge computing
- § Autonomous robot to collect & update point clouds

## Functionality

- § Navigation to vending machines, find food items
- § Operating instructions, showing which buttons to press



# Facility Maintenance

## Project DigiSpaces

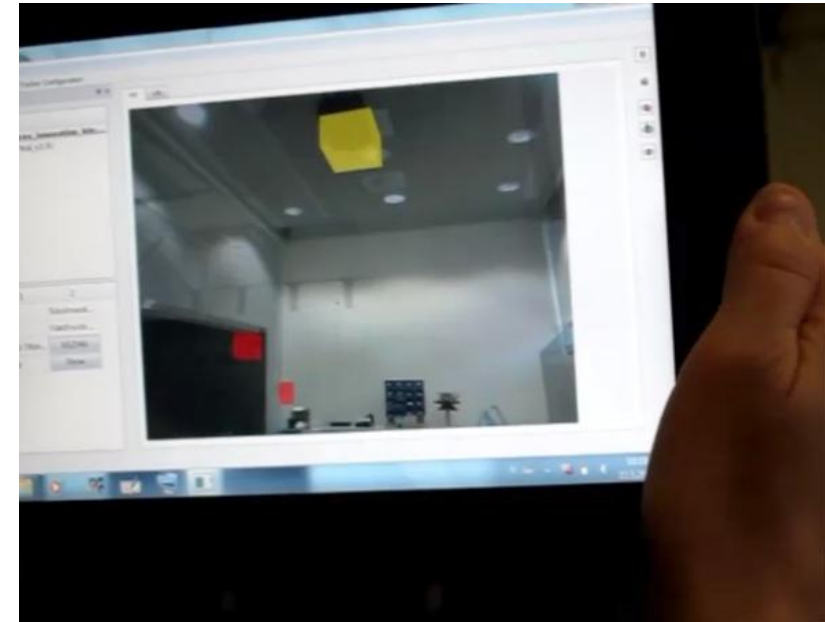
- § Mobile AR visualization and interaction with Building Information Models (BIM) & service book
- § Applications: building's life cycle services, e.g. maintenance & repair

## Functionality

- § Navigation to service targets
- § Interacting with targets by clicking in camera view
- § “X-ray vision”, seeing targets behind walls etc.

## Tracking

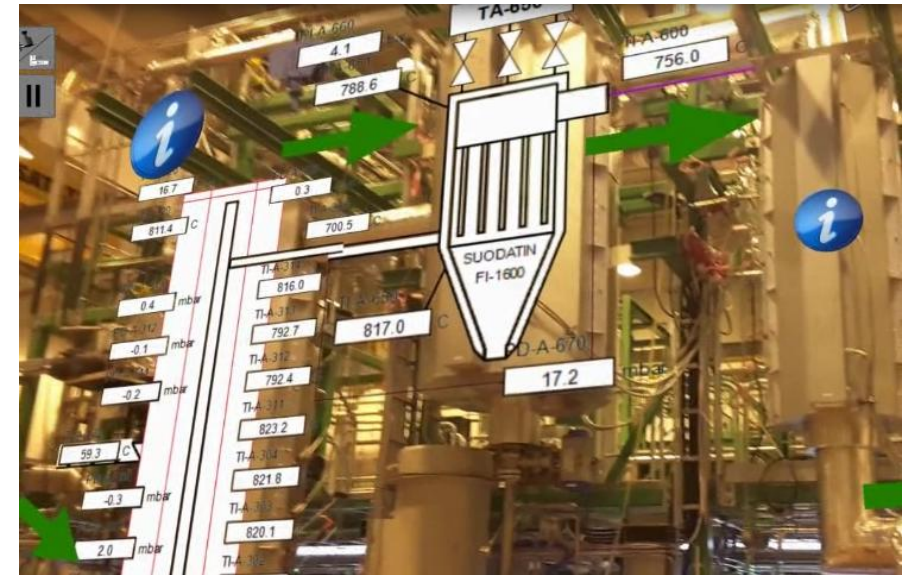
- § Based on 3D point clouds, obtained from photos
- § Supported by accelerometer, gyro-compass
- § Managing & updating of multiple point clouds



# Facility Asset Management

## Case Bioruukki

- § AR visualization of factory asset information
- § IoT, process data, simulation data, alerts



## Case Granlund

- § Pilot at VTT Digitalo offices
- § AR visualization of BIM and IoT data
- § Integration with Granlund Manager (Facility Management System, FMS)
- § Two-way interaction, feedback to FMS

## Challenges

- § Covering the whole factory/building
- § Several floors, hundreds of rooms
- § Handling and updating of point clouds
- § Moving elements, difficult areas
- § Varying lighting conditions etc.



# Construction & Renovation

## Project VisiLean

- § In co-operation with Aalto University
- § Combining lean production methods with BIM and mobile AR
- § Point clouds derived from panoramic images, coupled with photogrammetry data
- § Web based, device independent user interface, AR mode for all functionality



## Case Fira

- § Plumbing renovation (bathroom, kitchen)
- § Relaxed requirements and easier scale
- § 3D plans and 2D drawings associated to BIM
- § Also, photos for later as-built inspections
- § Piloting with workers at real renovation site, December 2017



## **Point-of-Interest**

# World Browsing



## Application

- § Technology licensing projects to Nokia
- § Pilot: Augmenting the camera view with point-of-interest (POI) information, tourist info, mobile advertising

## Challenges

- § World browser solutions based on GPS and compass are inaccurate, bad user experience
- § Accurate tracking of mobile device (both location and rotation), robustness under fast motion
- § Integration with existing point clouds, Navteq True

## Solution

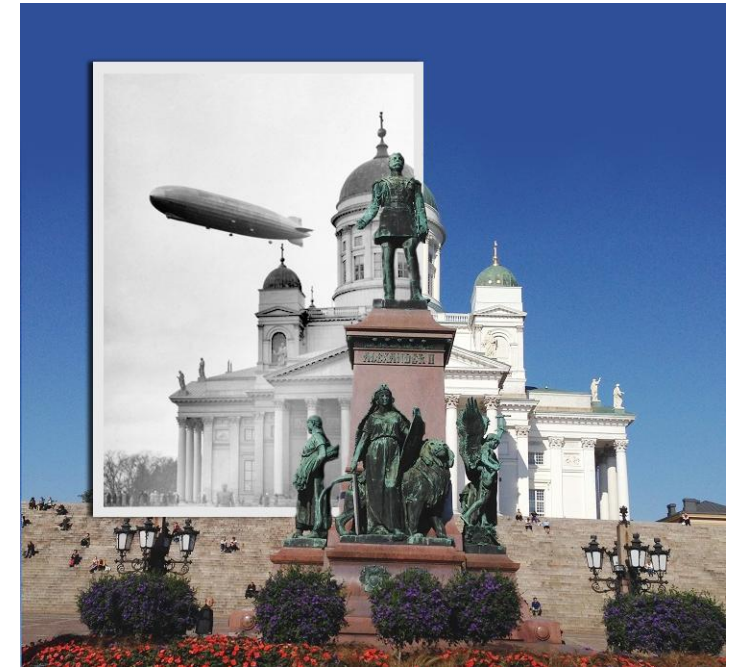
- § 3D point cloud based tracking + sensor fusion
- § Implementation optimized for mobile phones
- § Providing extreme accuracy, robustness and speed



# Visualizing the Past

## Augmenting historical photos

- § Pilot cases in Turku, Helsinki and Lahti
- § Augmenting historical photos at real locations
- § Showing how the city looked in the good old times



# AR Storytelling

## Project Futuristic History (2015)

- § In co-operation with VTT and Turku University
- § AR storytelling, bringing historical places to life
- § Including 40 minute tour around site
- § Several AR scenes and interactions
- § Based on point cloud tracking



## **3D Tracking Technology**

# ALVAR SDK



## A Library for Virtual and Augmented Reality

§ Computer vision based camera tracking for AR

## ALVAR Desktop

§ Windows / Linux – marker based – *Open Sourced*

§ Users incl. Google, NASA, MIT, Vuzix, ROS etc.

## ALVAR Mobile

§ Marker, multimarker, 2D image and 3D point cloud tracking

§ Generality, works from close range to wide areas

§ ALVAR for Unity, enabling easy content authoring

§ Point Cloud Tool for optimizing performance

§ HoloLens and ARCore support, tracking of predefined targets

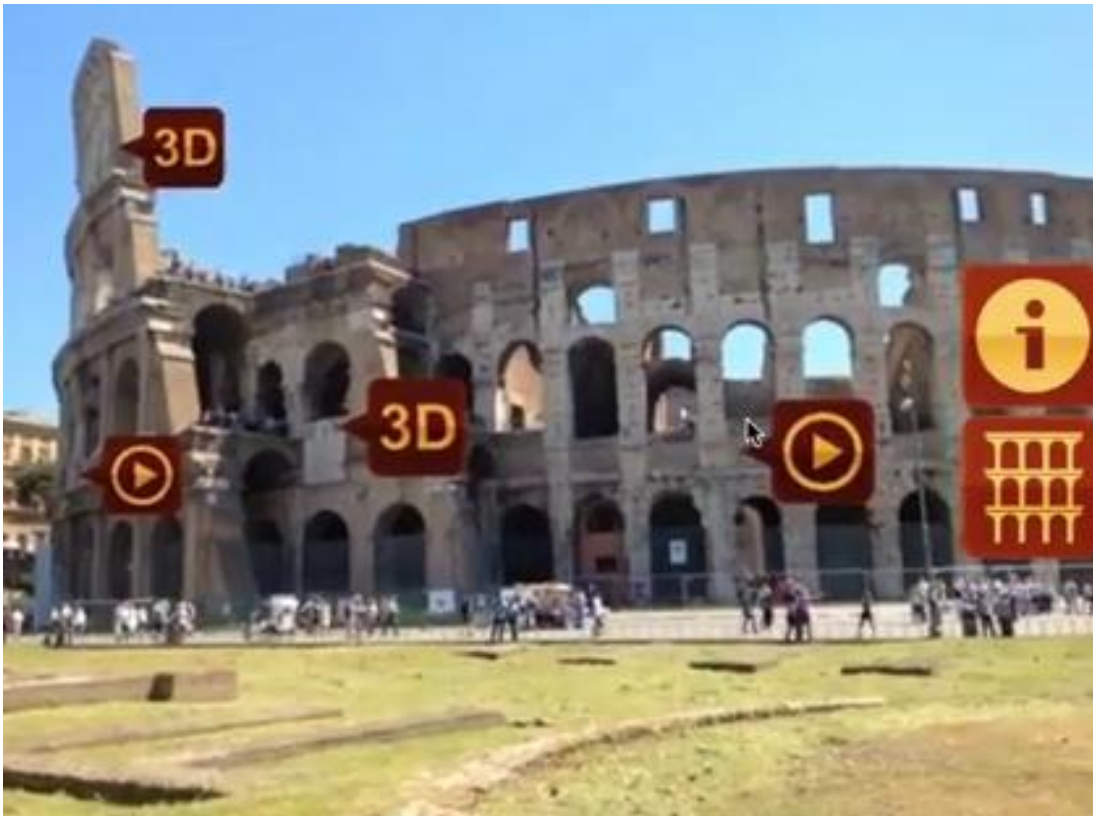
§ Platforms: iOS, Android, UWP, Windows, Mac



# Markerless 3D Tracking

## Point cloud based tracking

- § 3D point clouds obtained from photos
- § Properties: automatic, accurate, fast, robust
- § Single solution to handle wide range of applications
- § International licensing: Inglobe (Italy) / AR-Media



# ALVAR Tracking in Space, by NASA, Google, ...



## NASA Spheres robots in zero-gravity

- § Co-operation with NASA and Google
- § ALVAR multimarkers used for evaluating ground truth of Project Tango tracking
- § See Google video <https://www.youtube.com/watch?v=Vc5YyLI1Ksg&t=130>
- § See NASA video: <https://www.youtube.com/watch?v=psZ6UAFUOT4&t=305>



## NASA Hedgehog robot in micro-gravity

- § Co-operation between NASA, Stanford and CalTech
- § ALVAR multimarkers used for orientation tracking of robot, under fast movement
- § See news & videos: <http://www.dailymail.co.uk/sciencetech/article-3222992/Nasa-reveals-bizarre-hedgehog-robot-roll-fall-alien-planets.html>



## Contact:

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<http://www.vtt.fi/multimedia>

[www.youtube.com/user/VTTAugmentedReality](http://www.youtube.com/user/VTTAugmentedReality)

[www.youtube.com/user/VirtualAndAugmented/videos](http://www.youtube.com/user/VirtualAndAugmented/videos)