Next generation of the sub-millimetre wave security camera

**THz Videocam**

- Security body scanning: concept and actuality
- Realization of our camera(s)
  - Overview
  - Details of selected components
- Conclusion
basic concept of a „body scanner“

image of a person in a suitable wavelength band

conditions:
1. (partial) transparent clothing
2. contrast between hidden object (z.B. weapons, explosives etc.) and human body
3. best possible spatial resolution
4. avoid health and privacy issues
Actuality

L3 Provision ATD

Smith Detection Eqo

Braun Conpass

ASE SmartCheck

Prospects and limits of established solutions

- high image quality
- mature technology
- in operation at airport
- no health issues

Why cameras?

‘camera’ is synonymous with ‘flexible’:
- quasi-mobile operation (configurable)

perspective: thinking beyond
- detection prior endangering
- temporary installation

limited to near field (portal) because of insufficient spatial resolution and difficult illumination
Active or passive?

reflectivity of human skin


Indeed, a passive camera is a more simple approach

thermal radiation of 35°C black body
...in retrospect:

1st generation (2007):
- 1 sensor
- 25 seconds / frame
- liquid helium

2nd generation (2009):
- 7 sensors
- 1 seconds / frame
- liquid helium

3rd generation (2010):
- 20 sensors
- 10 frames / second
- cryogen-free
THz-Videocam TWO

integrated system concept with automated cryocooler TransMIT model PT4200 (air-cooled, 220V 4kW)

linear array of 64 superconducting detectors

Rohde & Schwarz

scanning apparatus for 25Hz utilising carbon fibre reinforced mirror

modular THz-optics
Modular optics

on-axis telescope as telephoto
off-axis telescope as wide-angle

- field of view $1 \text{ m} \times 2 \text{ m}$
- intended image resolution $128 \times 256$ pixel (1.5cm Nyquist sampling)
- image plane corrected for 25cm long receiver (tilted and curved)
Scanning scheme

@ 25Hz:
frame-time: 40 ms
dead-time: 2 ms
image: 38 ms
Scanning scheme

effect of time domain multiplexing (serial readout) on the scanning

scan movement $\Delta x = 0,75\ cm$

$\Delta T = 30\text{ms}/256\text{ rows}$
$(120\mu s \cong 8,5\ kHz)$
Achievable performance

- compromise between spatial resolution and transmission
- horn-coupled detector with bandwidth 0.8 – 0.91 mm
- coupling efficiency including filters about 40%

- solving Planck’s equation (200 pW @ 295K)
- background-limited NEP $1 \cdot 10^{-15} \text{ W/} \sqrt{\text{Hz}}$
- human body (310K) stands out with about 18pW ($\Delta T=15K$)
- bandwidth is limited by scanning approach to about 8.5kHz at 25Hz frame rate
- achievable thermal resolution (theoretical) $\Delta T=0.16K \leq 7\text{bit}$
Detector technology: TES

- superconducting bolometer based on 1µm thick siliconnitrid-membrane
- working temperature $\sim 0.5$ K
- absorption in impedance matched dipole-antenna array ($\lambda/2$)
- bandpass-definition through a set of cryogenic filters
Linear array

- 8 sensor modules with 8 pixel each
- Cryogenic setup with vibration isolation
- Optimised magnetic shielding (superconducting + cryoperm)
- First milestone (6/2013): 64 pixel
- Final stage of completion: 128 pixel
THz footage (Click to view video in a separate window, return manually to slide No. 15)

- „first light“ 20.6.2013
- 25Hz, object distance 20m
- hidden money bag and plastic bottle (soft drink)
## Summary of progress

<table>
<thead>
<tr>
<th>Parameter</th>
<th>THz-Videocam’</th>
<th>THz-Videocam TWO’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working frequency (wavelength)</td>
<td>0.34THz (870µm)</td>
<td></td>
</tr>
<tr>
<td>Frame rate</td>
<td>10 Hz</td>
<td>25 Hz</td>
</tr>
<tr>
<td>Spatial resolution (diffraction limit)</td>
<td>1.7cm</td>
<td>1 cm</td>
</tr>
<tr>
<td>Object plane</td>
<td>∅1.2m (1.1m²)</td>
<td>2 m x 1 m (2m²)</td>
</tr>
<tr>
<td>Distance</td>
<td>(8.5±1.5)m</td>
<td>(4-20) m</td>
</tr>
<tr>
<td>Field of view (FOV max)</td>
<td>0.14 rad</td>
<td>max. 0.58rad x 0.32rad</td>
</tr>
<tr>
<td>Receiver</td>
<td>20 pixel circular array</td>
<td>64 pixel linear array</td>
</tr>
<tr>
<td>Scan</td>
<td>spiral (5 traces), effective about 100x100</td>
<td>linear, 256x64</td>
</tr>
<tr>
<td>Power supply</td>
<td>water-cooled compressor 380V/6kW</td>
<td>air-cooled compressor with 220V, power supply 4kW</td>
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</tbody>
</table>
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*and last but not least:*

to the audience for listening...