Laser Based CBE Stand-off Detection

and

the new Cooperation of the German Aerospace Center (DLR) with the University of Rome Tor Vergata in CBRNe Research, Didactic, and Training

Prof. Dr. Thomas Dekorsy
Institute of Technical Physic
German Aerospace Center (DLR)

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DLR at a glance

- Research Institution
  - Space Administration
  - Project Management Agency
Locations and employees

More than 9000 employees work in 54 institutes and facilities at 30 sites across Germany.

International offices in Brussels, Paris, Tokyo and Washington D.C.

Institute of Technical Physics
National and international networking

Clients and partners: Governments and ministries, agencies and organisations, industry and business, science and research
Areas of research:

- Aeronautics
- Space research and technology
- Transport
- Energy
- Security (cross-sectoral area)
- Digitalisation (cross-sectoral area)
DLR Security cross-sectoral research area

- Coordination of the cross-focus defence and security-related research

- Development activities in consultation with partners in government, science, industry and international organisations

- Innovative organisational concepts for the development, testing and evaluation of technologies, as well as for the assessment of and consulting in connection with security-relevant applications
Structure / Organisation
DLR cross-sectoral area security

Security research programme

Defense technology research
- Airborne platforms
- Satellite technology and sensor technology
- Impact, protection and cyber
- Responsive space

Civil security research
- Security and dual use
- Maritime safety
- Corporate security

Operational safety

Total budget defense and security research approx. 80 Mio €/year
(institutional and third party funding)
Defence technology research

- Contributes to meeting the Bundeswehr’s needs and closing capability gaps
- Provides processes and facilities for the demonstration, testing and evaluation of defence-relevant technologies
- Serves to maintain and expand the analysis and evaluation capability for the Ministry of Defence and subordinate departments
Civilian security research

• Contributes to current and future capability profiles that are relevant to the protection and security of the...
  • population
  • borders
  • critical infrastructure
  • business enterprises
  • crisis and disaster management services

• Manages the activities and coordinates the research of the DLR research network ‘Maritime Security’
Institute of Technical Physics

80 Co-workers
Institute of Technical Physics

Laser technology and laser based systems for:

**Aviation**
Optical air data systems
Head: Oliver Kliebisch

**Space**
Detection, ranging and mitigation of space debris
Head: Wolfgang Riede

**Security**
Stand-off CBE detection
UAV carrier system
Head: Frank Duschek

**Defence**
Directed energy laser systems
Head: Jochen Speiser
Detection of chemical, biological hazards and explosives

Basic & applied research…

… on CBE detection in aerosols, bulk material and on surfaces…

… for applications in industry, public safety, food security and many others.
Chemicals and explosives
Laser based stand-off detection of chlorine gas

Chlorine
- Highly toxic
- IR-inactive
- Raman-active
- UV absorption

Environment
- Absorption ($O_2$, $O_3$, $H_2O$)
- Scattering (Aerosols)
- Light / Reflection
- Turbulence

Detection
- LIDAR / DIAL long range warning
- (UV-) Raman short / medium range identification

Modelling
Design & concept
From lab to test range
Proof of principle
Airport security
The PHYLAX-Project

Objective: Easy and reliable check of persons for explosives at entry points and/or security check points

Concept:
- Automated recognition of passengers between check-in and boarding
- Walk-by check at distances of 0.5 – 1 m during security check at airports
- Detection of explosives using laser spectroscopy

Advantages of laser spectroscopy:
- Contact-free measurements
- Fast measurements
- High sensitivity
- Substance-specific signals
PHYLAX system components

Recognition, pointing & tracking module
- Detection of targets and laser beam positioning on moving target

Laser spectroscopy systems
- Detection of explosive traces using different technologies

Evaluation
- Decision for alarm based on full, combined data

MIR reflection spectroscopy
UV Raman spectroscopy
IR gas phase spectroscopy
Tracking module
Data evaluation algorithm

Merging Raman & MIR spectral data

Absorbance vs. Raman shift for different substances (e.g., Aspirin, NaClO, NaClO₂).

Aspirin reference spectra at various wavelengths (μm) from 7 to 11 µm.
Bio-agents
Development of a drone-based CBE stand-off detection system

UAV aerial remote sensing of CBE agents by means of an laser-based stand-off detection system (LUCS)
Compact, mobile LUCS sensor

- Power connector
- GPS
- UHF Antenna
- Widefield camera
- Tele camera
- Outcoupling mirror
- Laser beam

[Images of powders 1, 2, and 3 with corresponding wavelength graphs]
Improved LIF technology: retrieving full process information

**Excitation and Detection Wavelengths:**
- **Excitation:** 266 nm (266 nm)
- **Detection:** 310 nm (310 nm)
- **Excitation:** 355 nm (355 nm)
- **Detection:** 460 nm (460 nm)
Compact, cost-efficient sensor design

1024 spectral channels

93% accuracy (from 1024 channels)

32 spectral channels
1 time-resolved channel

86% accuracy from 32 spectral channels
83% accuracy from 1 time-resolved channel

93% accuracy (from 33 channels)

How-to interprete data from mixtures?

Problem
• signals not linear, not additive

Machine learning aproach applying combined neural networks
• prediction model #1: Fluorophore present
• prediction model #2: Relative amount for each fluorophore

Results
• R2 >99 %
• Collaboration with University Tor Vergata
Thanks to the co-workers in the department of Dr. Frank Duschek

- Luca Cantu
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- Emanuela Gallo
- Karin Grünewald
- Jonas Grzesiak
- Anja Köhntopp
- Christoph Kölbl
- Marian Kraus
- Arne Walter
History, presence & future

- Initialization of MoU during visit at DLR
- MasterCBRN Dr. Lea Fellner
- Collaboration at DLR
  - Valentina Gabbarini
  - Riccardo Rossi
  - joined publications
- Multiple Lectures by Frank Duschek during 1st & 2nd level master courses

"Coming together is the beginning. 
Keeping together is progress. 
Working together is success."

Henry Ford