

# TECHNICAL AND ANALYTICAL CHALLENGES INVOLVED IN DRONE-BASED LASER-INDUCED BREAKDOWN SPECTROSCOPY MEASUREMENTS FOR SECURITY APPLICATIONS



Our system integrates a GigaRotor6 hexacopter

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## Introduction

Laser-Induced Breakdown Spectroscopy (LIBS) is a versatile technique for chemical analysis. With the advent of compact drones, integrating LIBS into UAVs offers unique opportunities for security applications such as the detection of explosives, biological aerosols, and nuclear materials. Our pilot research projects financed by NKFIH (Hungary) aiming at demonstrating the potential of LIBS spectroscopy in chemical, biological, radiological, and nuclear (CBRN) security applications also belong to these efforts.

## Results and Discussion

- Precise positioning and stability of the drone (mm accuracy required)
- Optical interferences from dust, humidity, and turbulence
- Safety concerns related to laser operation and drone reliability

An overview of some of the most important challenges concerning drone-based LIBS systems.

### Analytical challenges

- increasing operational distance decreases sensitivity
- dust particles, humidity, gases and turbulence in the optical path can have an influence on the performance
- the higher the resolution of the spectrometer, the lower is the sensitivity
- the broader is the spectral coverage, the lower is the resolution and sensitivity
- aiming should have a high positional accuracy (mm-range)
- laser wavelength should be not interfering with spectrometer
- tilted target surfaces will decrease sensitivity

### Technical challenges

- sufficient load-carrying capacity
- sufficient electrical power to subsystems
- high maneuvering accuracy (positional control) is needed in the x-y plane
- a continuous, high accuracy (mm) monitoring of drone-target distance is required
- a continuous feed of imaging data is necessary to the operator
- rotors generate dust and wind (turbulence) which dictates longer operational distances
- on-board evaluation capability or high-speed streaming for measurement data (spectra + images) is needed
- communication range

### Safety issues

- danger of laser-inflicted eye or skin injuries to persons in the measurement path or caused by tilted, reflective targets
- danger of laser-induced fire, explosions or release of CBRN materials
- danger of rotor-inflicted damages to installations or injuries of persons in the measurement path
- fall-inflicted damages to installations or injuries of persons in the measurement path, caused by drone failure/out-of-communication/out-of-power/EMI situations

### Construction

The LIBS measurement module was built inside a plastic box (600'600'200 mm) attached to the bottom of the drone (in between the legs propping up the drone when standing on the ground). Fiber optic cables and a combination of reflective and transmissive optical elements were employed in the focusing and light collection optics. A compact, 532 nm laser was chosen as the excitation source, and the spectrometer was configured to measure in the 380-470 nm spectral range. The target distance is continuously monitored by a laser distance sensor which is aiming at the same spot as the excitation laser beam.

### Measurements

The operational sequence of the system is the following. The operator steers the system over the target (suspicious object), at a height which is larger than the measurement distance. The target is locked by the operator and the drone enters a hovering mode, with no (intentional) lateral movements. The drone is then slowly lowered while the target distance is continuously monitored. At the moment when the target distance is equal to the measurement distance (set by the LIBS optics), the laser is fired, and the target's emission atomic spectrum is captured.

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### Conclusion

A functional pilot LIBS drone system was developed, addressing key analytical, technical, and safety challenges. Demonstrative field experiments confirmed its potential in security applications.

