

GOVERNMENT OF THE REPUBLIC OF CROATIA
OFFICE FOR MINE ACTION

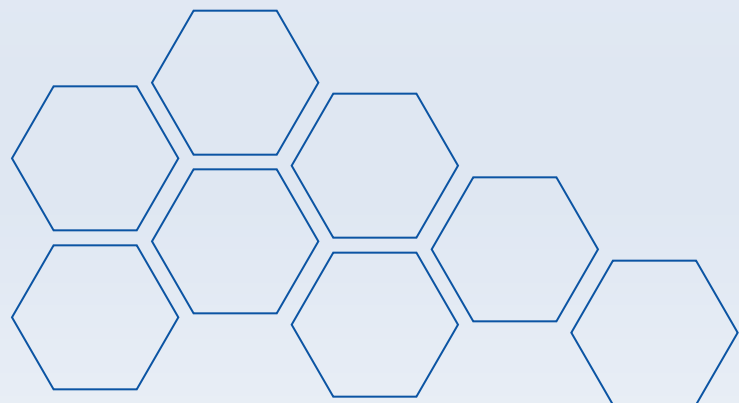


**13TH INTERNATIONAL SYMPOSIUM
AND EQUIPMENT EXHIBITION**

MINE ACTION 2016

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Detection of preconditioned honeybees on data in visible wavelengths range collected from RPAS



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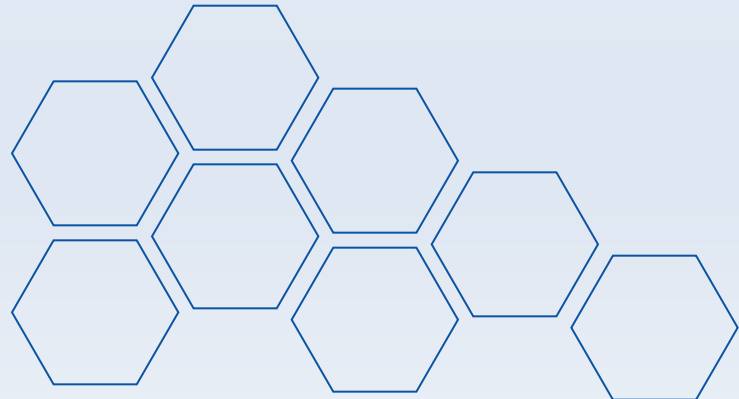
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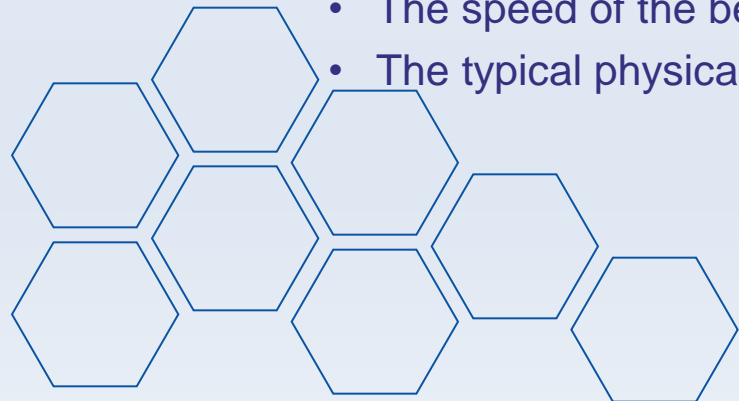
Introduction

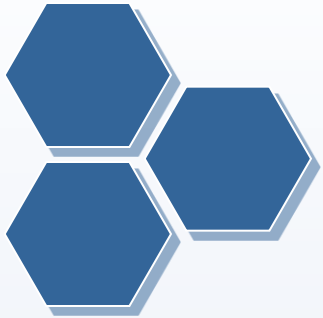
- Honeybees are approved as very sensitive biosensors of nuclear and chemical pollution. Approved in Croatia after Chernobyl disaster.
- Honeybees can also detect explosive among others pollutants (DARPA 1999, Controlled Biological and Biomimetic Systems).
- EU FP7 project TIRAMISU:
 - Bees sensitivity for DNT and TNT
 - Conditioning, training of bees - Bees can be trained using operant conditioning methods for detection of explosives and landmines. The reward is food, which is associated with the odour of the chemical of interest.
- **TASK:** Find an appropriate sensor, airborne platform and operational parameters for acquiring the data that enables detection and extracting spatial-temporal density information of the free flying honeybees above the area of interest!



Problem definition

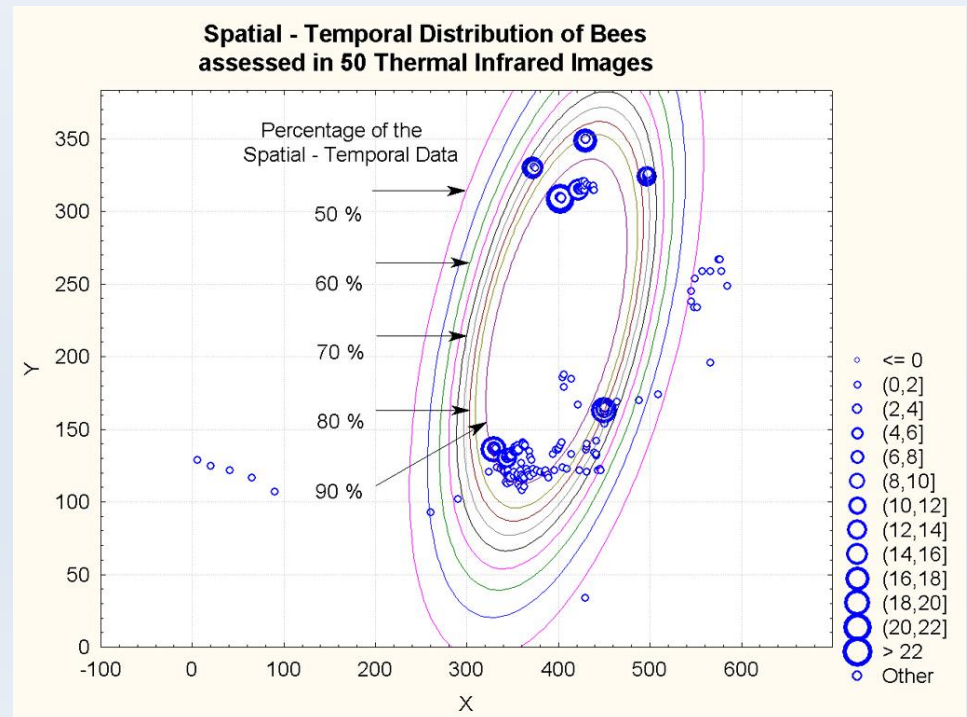
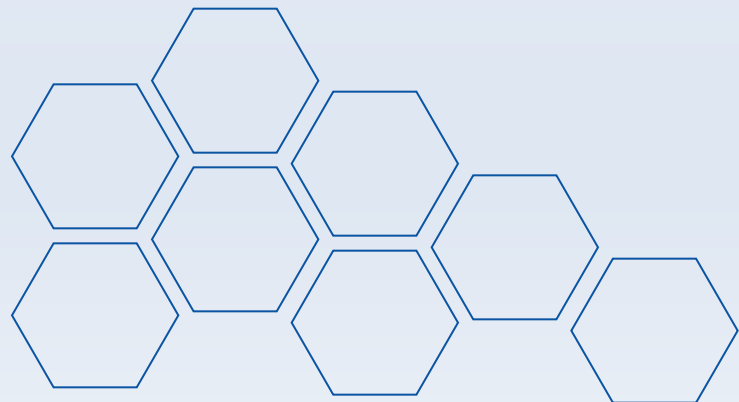
- **For this task it is necessary to take into account:**
 - Special characteristics and limitations of sensors (LWIR, RGB)
 - Image resolution
 - FOV
 - Contrast
 - Platform requirements
 - Stable/still
 - Good maneuverability performances
 - Physical characteristics of honeybees
 - The radius of the foraging is from 1 to 3km from the hive
 - The speed of the bees is around 5 m/s for foraging flights
 - The typical physical size of a honeybee is 0.375 cm²

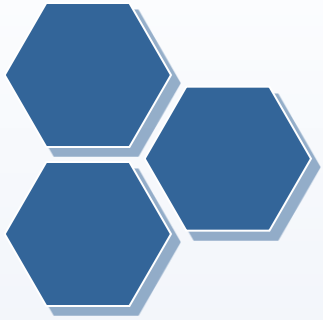




Development of the method

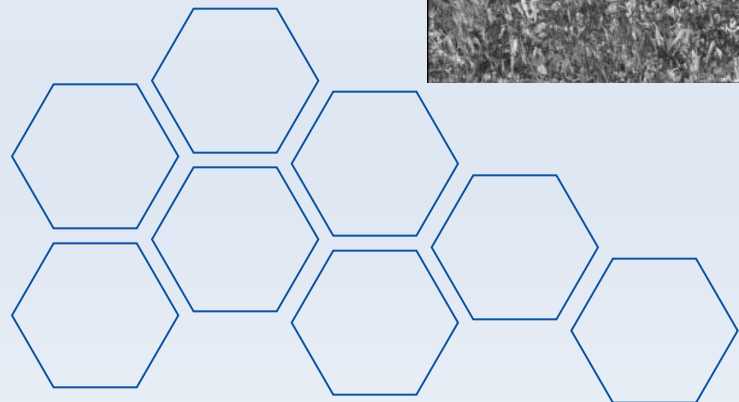
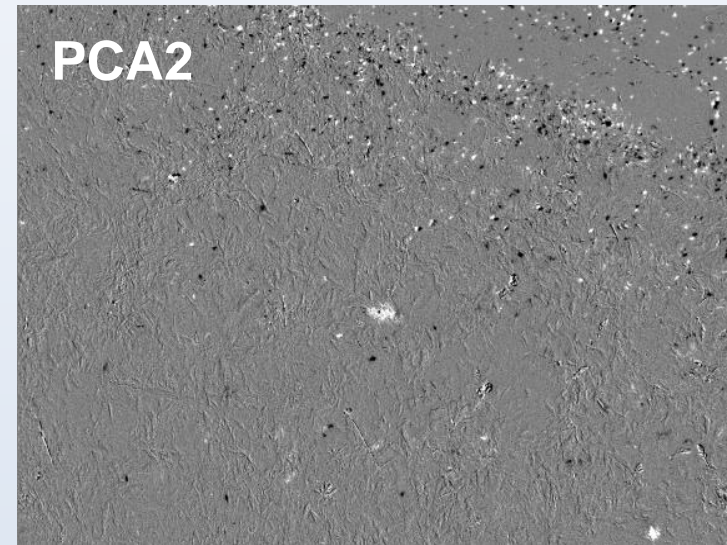
- Development of the method for the spatial-temporal distribution assessment of the honeybees started in 2003, while its operational application has started in 2013 within the framework of the TIRAMISU Project.
- The method is based on the principal components analysis (PCA) and filtering of the clutter.
- Result of the method is spatial-temporal distribution assessment of honeybees over area of the interest.





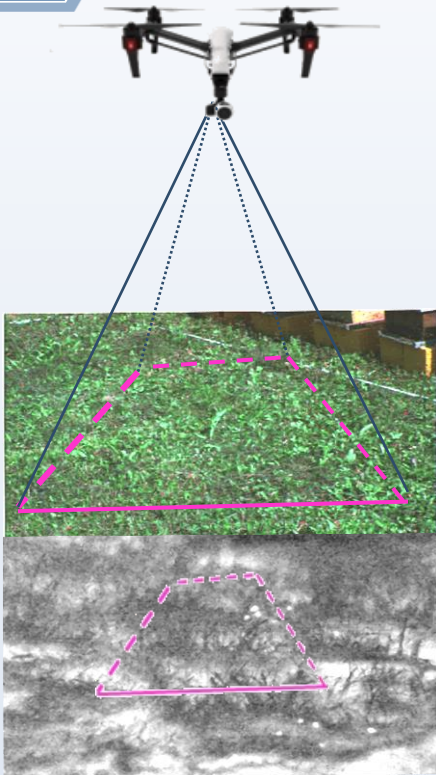
Development of the method

- It enables detection of the movement of bees even if the spatial resolution and signal to clutter ratio are low and direct detection of honeybees is not possible.



- Honeybees are **not visible** on the LWIR image (except several of them on the hive).
- Second principal component (PCA2), calculated by use of only two successive images, presents bees as dark and bright spots. Bees **are visible on the entire area**.

Data acquisition development



- **SENSOR “TRADE OFF”**

- Long-wave infrared imagery enables better contrast of the honeybees to ground surface but with coarse image resolution and limited field of view.
- Color cameras provide imagery with larger FOV and high resolution, but struggle with honeybees-ground contrast.

- **AIRBORNE PLATFORMS**

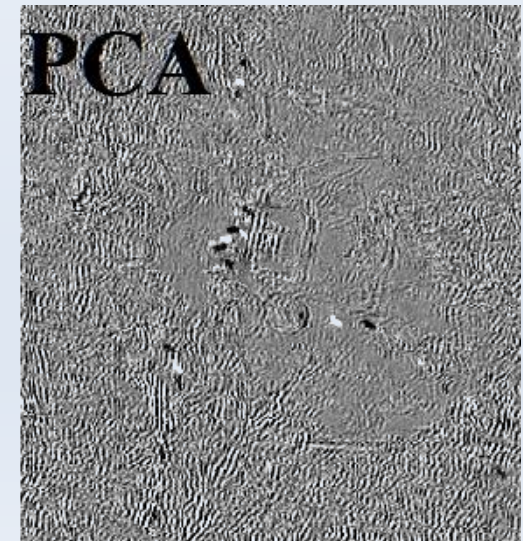
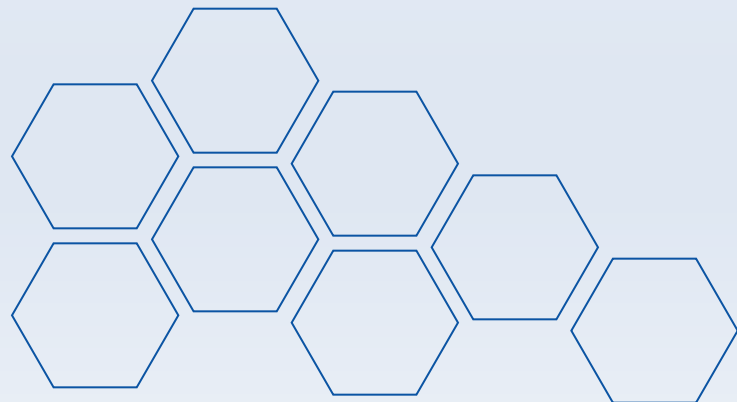
- **RPAS** was proven to be the most appropriate platform for such application, considering its **stability and maneuverability**.



Visible wavelength data collection from RPAS

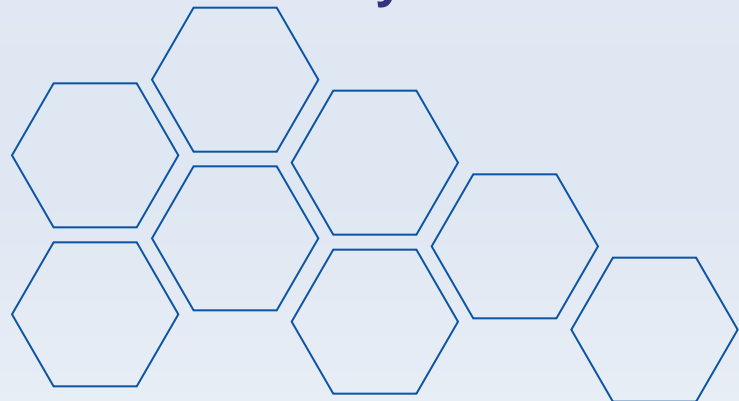
- In 2015 successful results were achieved!
- Tests and data acquisition were conducted in minefield Cerovac (14th, 15th and 16th of July) and large amount of data (168 GB) was collected.
- **Collecting of color images was done in hovering mode:**
 - in several time intervals taking into account parts of the day when bees are most active
 - on 3 - 4 m above the terrain
 - over references (clean) and test (mine contaminated) area

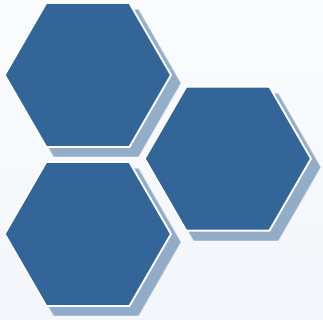
• Each image has 4096x2160 pixels, 24 bits, 25 frame/s,



Conclusion

- **On 3-4m hovering altitude bees are not disturbed by the RPAS and the optimal ground resolution is achieved.**
- **Color camera frame rate of 25 frames/s enables extraction of spatial-temporal honeybees distribution.**
- **This kind of platforms and cameras are evolving very fast and becoming more accessible so potential of this remote sensing method is even greater.**
- **One of the most valuable results of the research of honeybees by remote sensing methods is significant set of collected imagery available data for further research and analysis.**





THANK YOU!
Any Questions?

Acknowledgement

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