Dr. Matthias Locherer
Director Sales & Marketing

CUBERT HYPERSPECTRAL

Spectral Snapshot Imaging Solutions

cubert

HI, THIS IS US...

Cubert was founded back in 2012, and is still the only manufacturer of hyperspectral video cameras using snapshot technology for real time solutions.

We're excited about the enormous potential and untapped markets and applications our technology has and are committed to exploring them together with our customers.

What we offer:

- Off-the-shelf hyperspectral light field cameras
- Off-the-shelf spectral imaging software
- Full software development kit (SDK) for system builders
- Product customization
- Application and integration support

OEM APPLICATION FIELDS

There is a tremendous untapped potential growth for the application of the snapshot advantage of our video spectrometers. We offer a unique set of competences to support you in solving your application or help developing your next product line.

RESEARCH AND DEVELOPMENT

REMOTE SENSING

Cubert's state-of-the-art cameras are suited to any mobile applications such as UAV-based mapping. The snapshot nature of our cameras allows you to analyze the images within minutes following touchdown, or even in real-time

INDUSTRIAL IMAGING

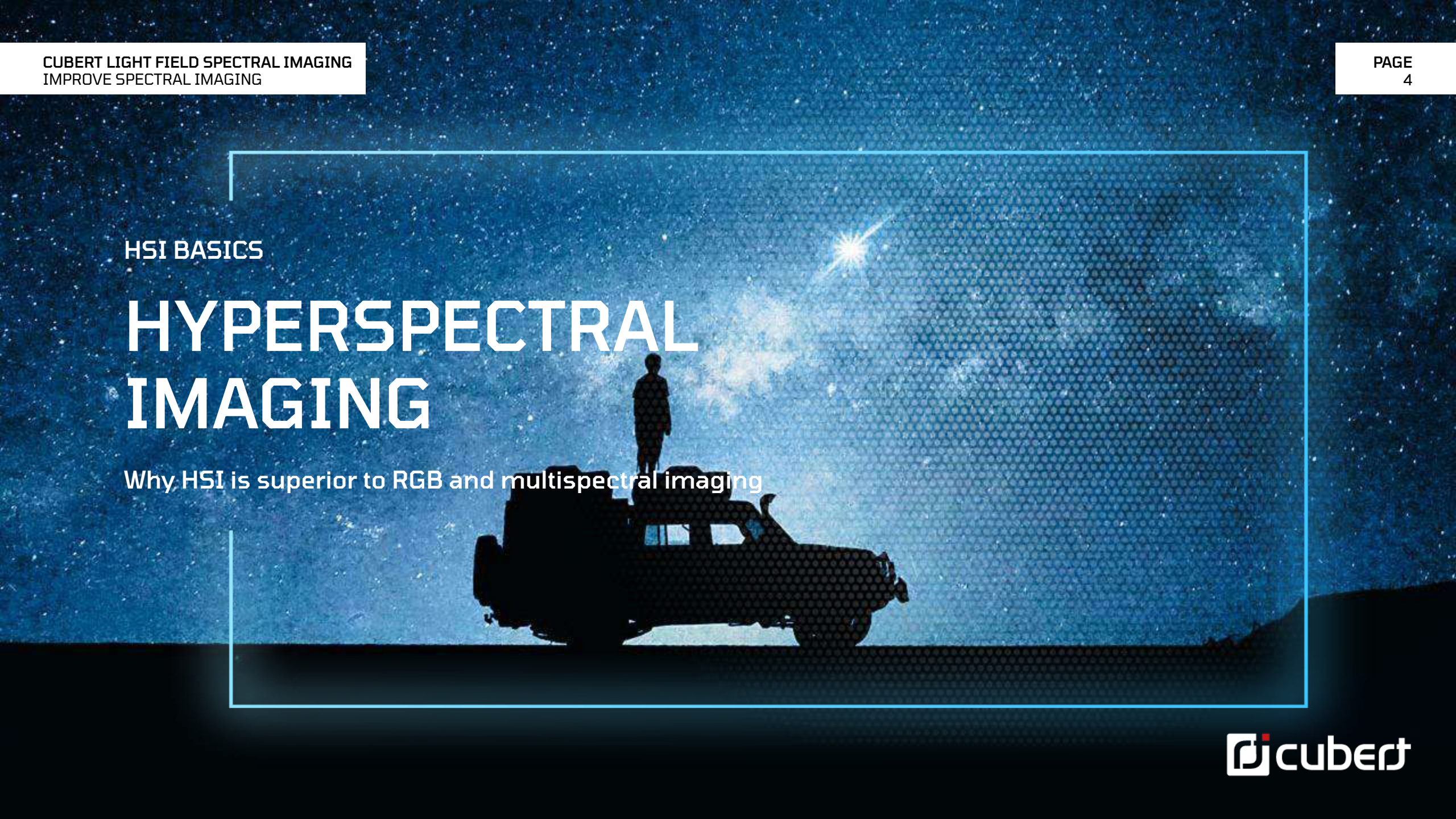
QUALITY CONTROL

Hyperspectral imaging enables contact free analysis of goods on the processing line. The ULTRIS X20 is our top of the line product for the most complicated analysis tasks.

LIFE SCIENCES

BIOMEDICAL IMAGING

Biomedical imaging aims to support physicians in their work with the best available imaging information. With hyperspectral measurement methods, the industry can use a multiple of image dimensions for analysis to open up new fields.



HSI BASICS

HYPERSPECTRAL IMAGING

Why HSI is superior to RGB and multispectral imaging

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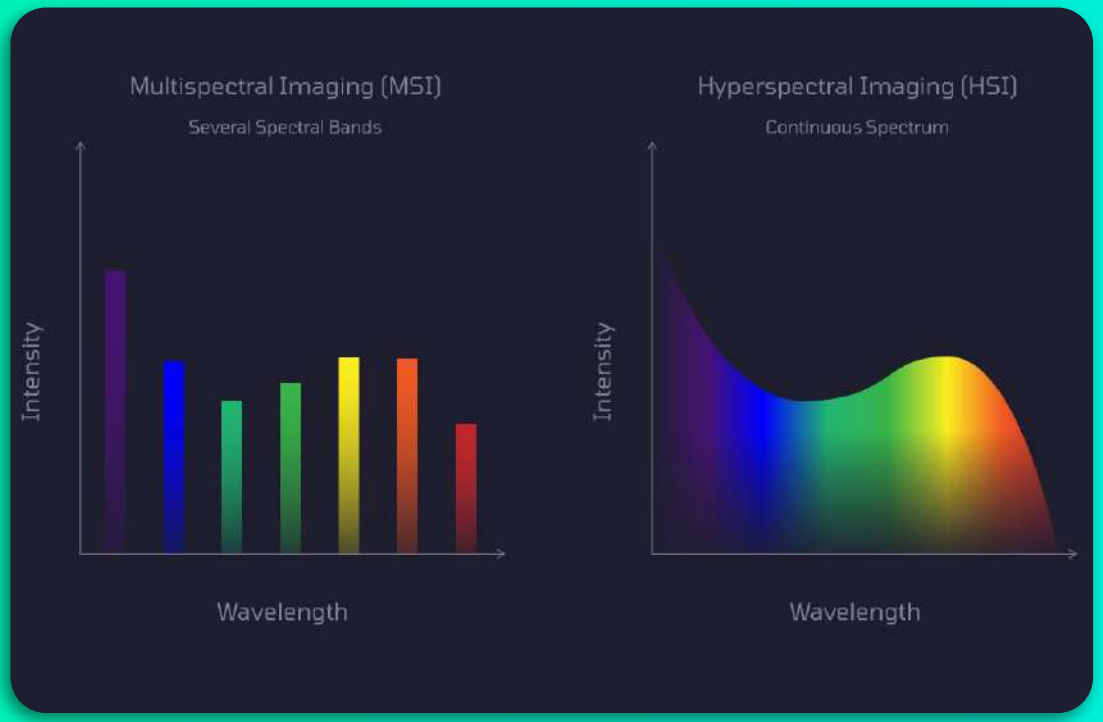
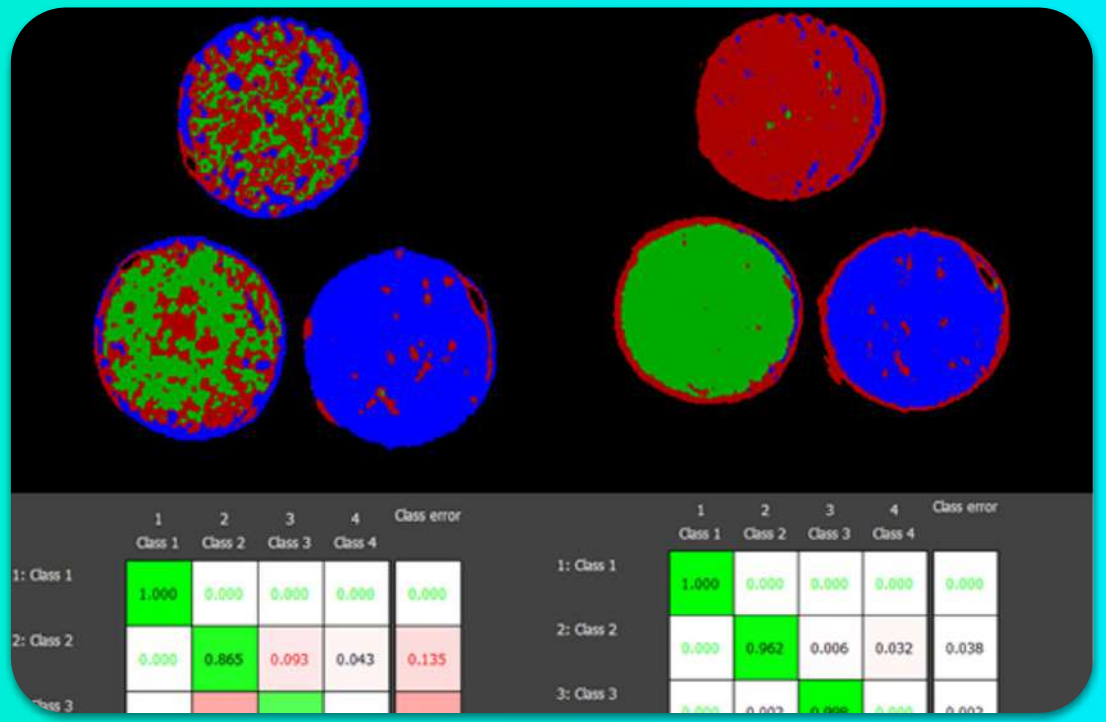


What is the difference between HSI and multispectral imaging

Comparison of multispectral imaging (left) to hyperspectral imaging (right). Multispectral imaging captures a limited number of discrete wavelengths, whereas hyperspectral imaging captures a continuous spectrum.

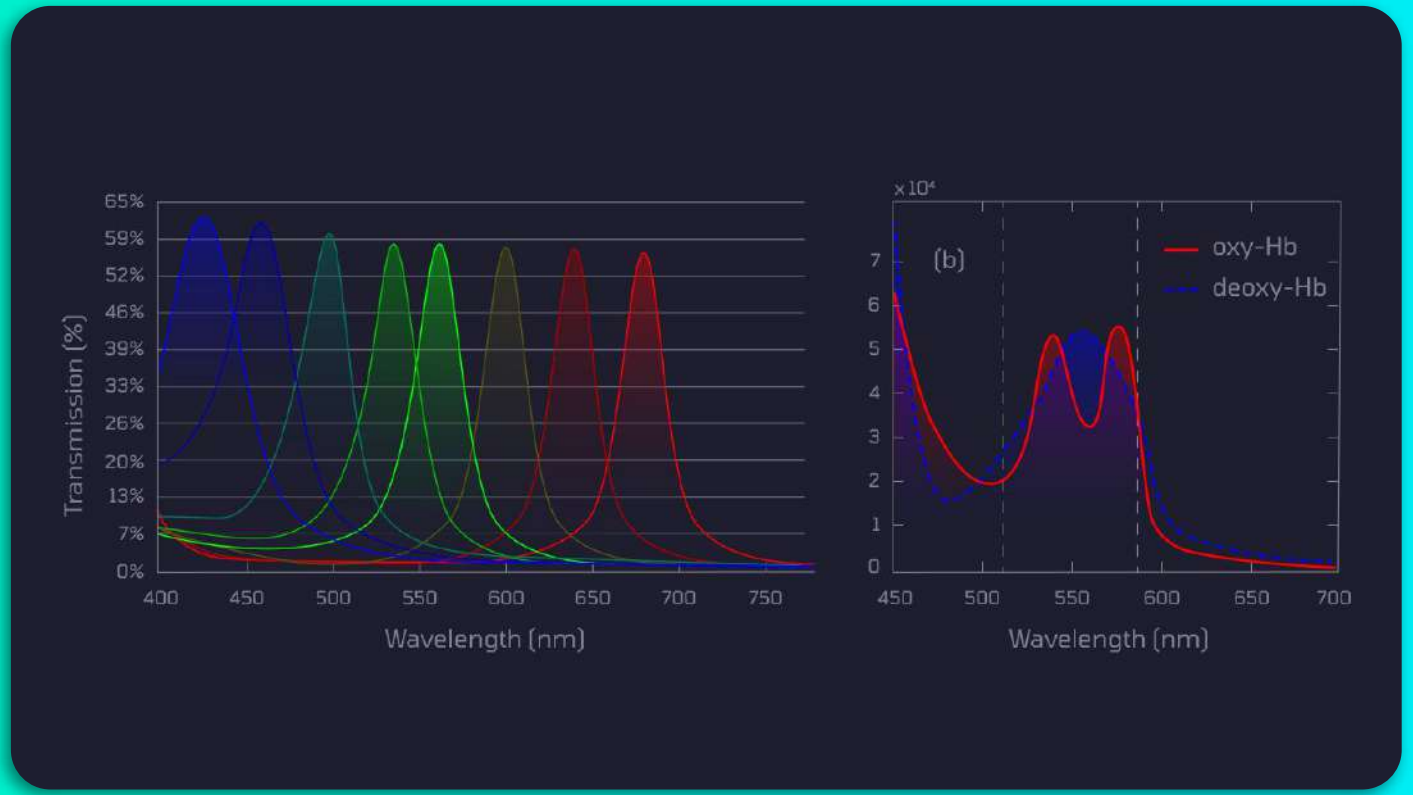


Why HSI is superior to RGB and multispectral imaging

Comparison between 12-band multispectral imaging (left) and 120-band hyperspectral Imaging (right). The cross-correlation matrix shows a maximum error of 33% for the multispectral imager, whereas the hyperspectral imager has a maximum error of 4.3%.

Derive the precise position of the critical channels

Example of a multispectral imaging system. These channels cannot discriminate the spectral difference between oxygenated blood and deoxygenated blood, which is a simple task with a hyperspectral camera (see spectral comparison on the right). However, with Light Field Hyperspectral Imaging, it is possible to derive the precise position of the critical channels and provide them in a customized system, which will fit the needs of spatial and spectral resolution and price of the application.



Learn more about true Video Spectroscopy

THE SNAPSHOT ADVANTAGE

A fundamentally new snapshot technology that enables high spatial and spectral resolution on the same time.

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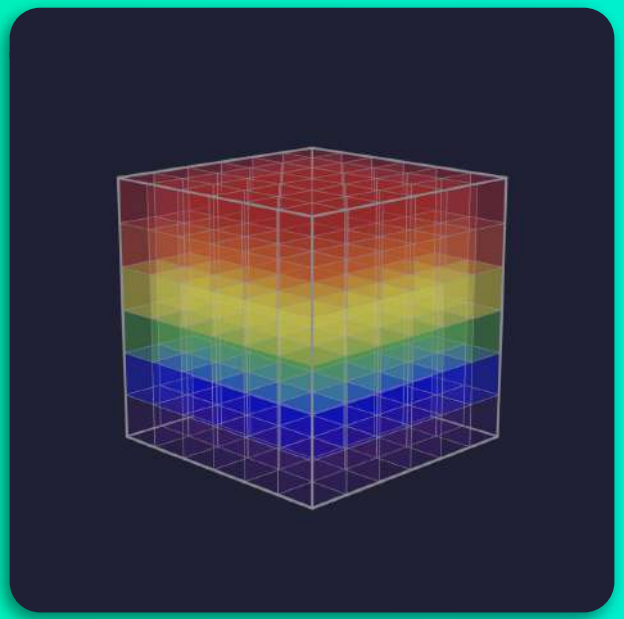
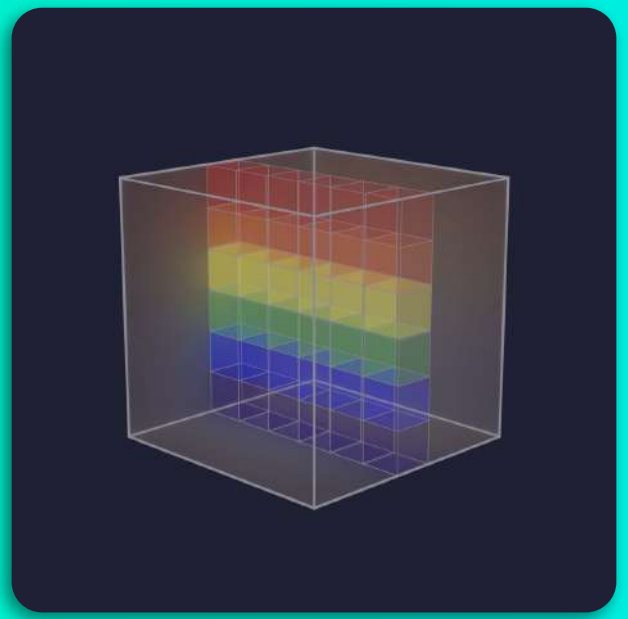
TRUE SNAPSHOT IMAGING



Cubert Light Field HSI

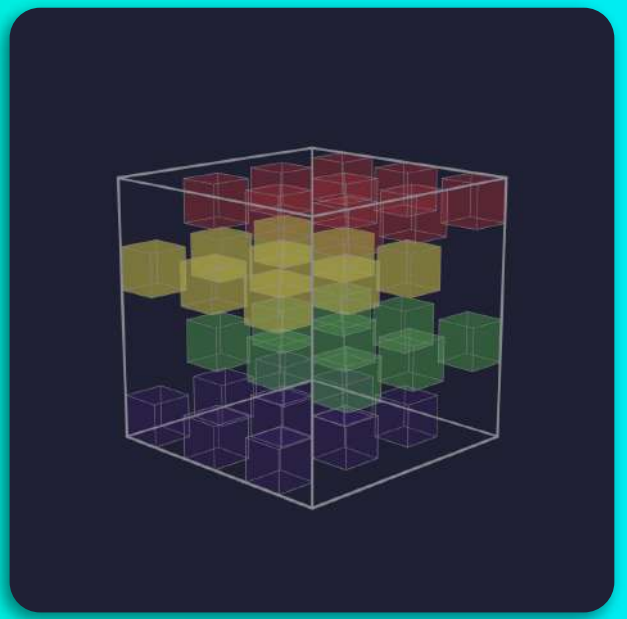
Advantages
- True video spectroscopy
- High spatial resolution
- High spectral resolution
- High light throughput / SNR
- High data throughout
- Time-saving



Push-broom HSI

Advantages
- High spatial resolution
- High spectral resolution
- High SNR

Disadvantages
- Non-simultaneous acquisition (temporal offset)
- data preprocessing required
- Line-scan



Filter-on-chip HSI

Advantages
- Snapshot Imaging
- Compact

Disadvantages
- Not hyperspectral, only multispectral
- Low spectral resolution
- Bad SNR
- Variable band position

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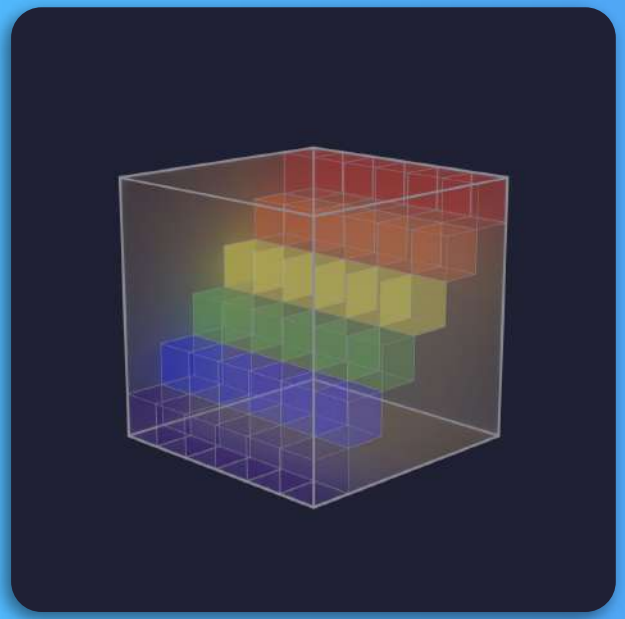
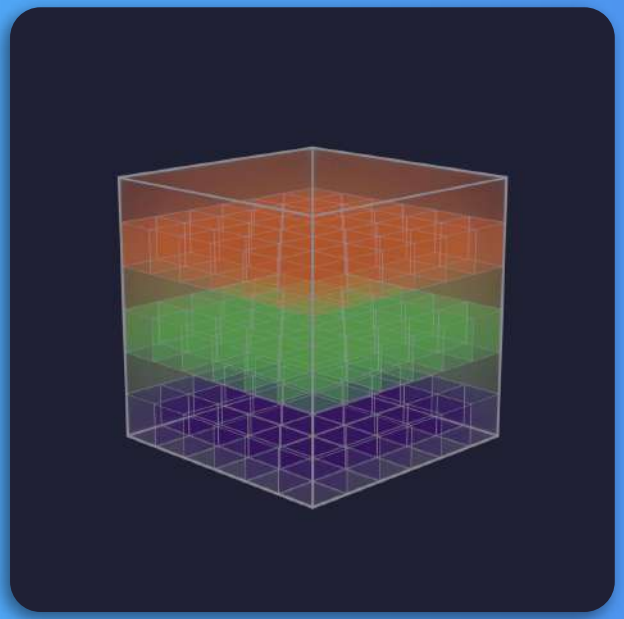
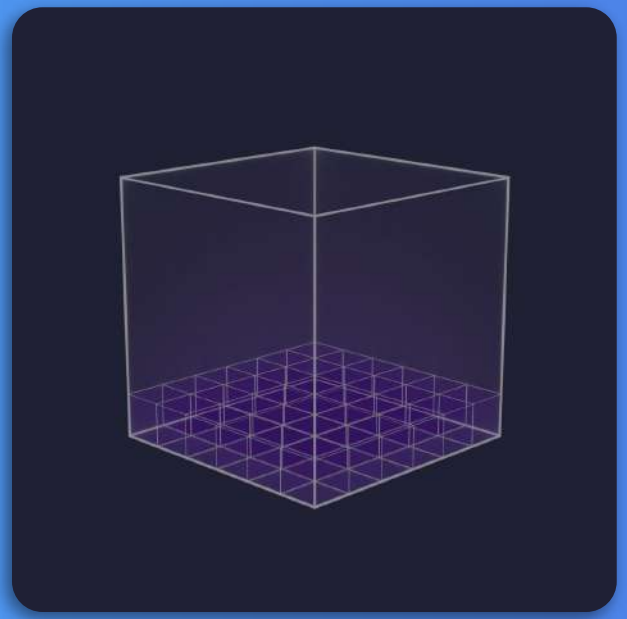
FURTHER TECHNOLOGIES



Spatiospectral Scanning HSI



3D Tunable Filter HSI



2D Tunable Filter HSI

What is Light Field HSI

LIGHT FIELD TECHNOLOGY

The working principles of Light Field HSI

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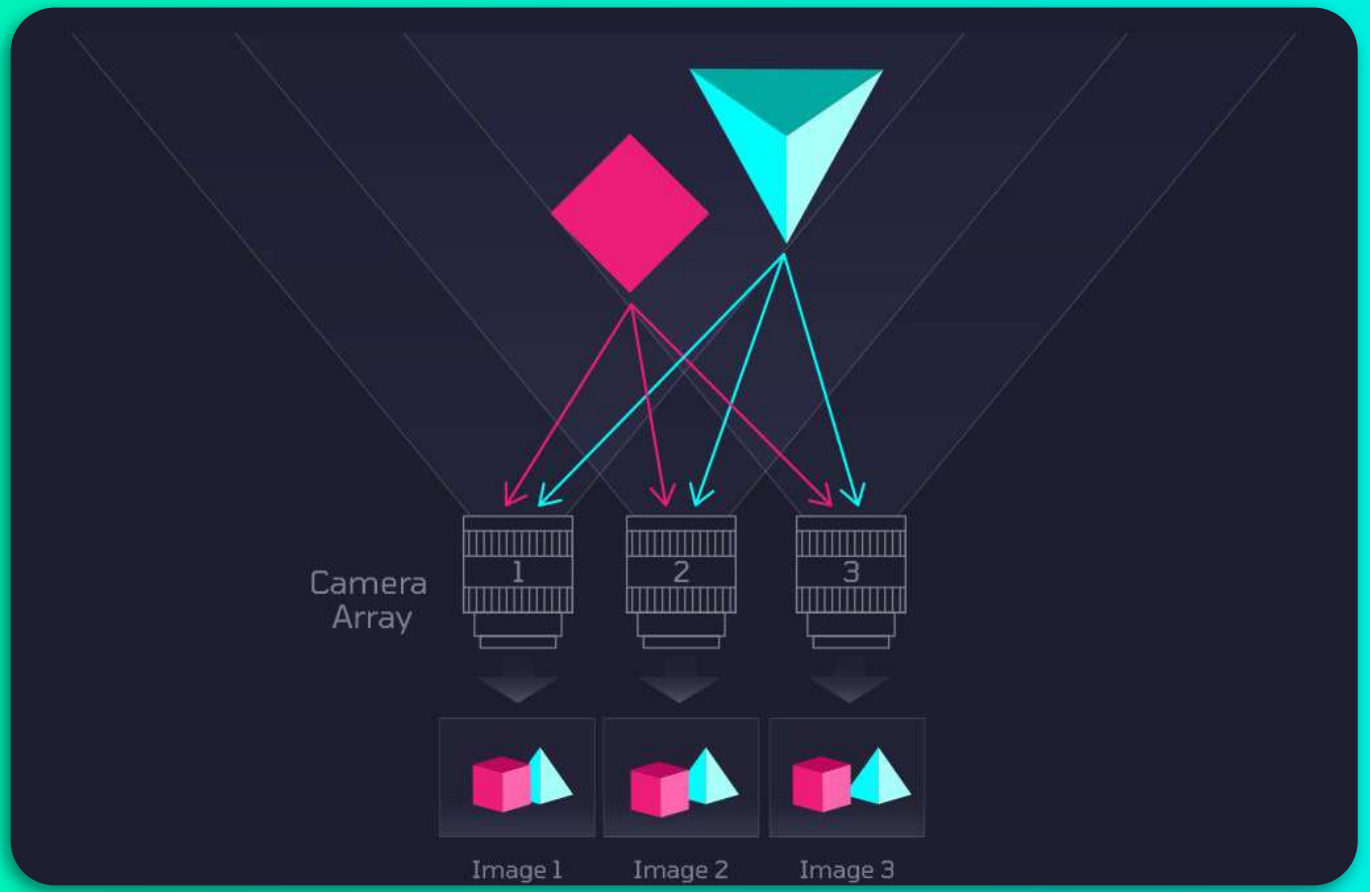
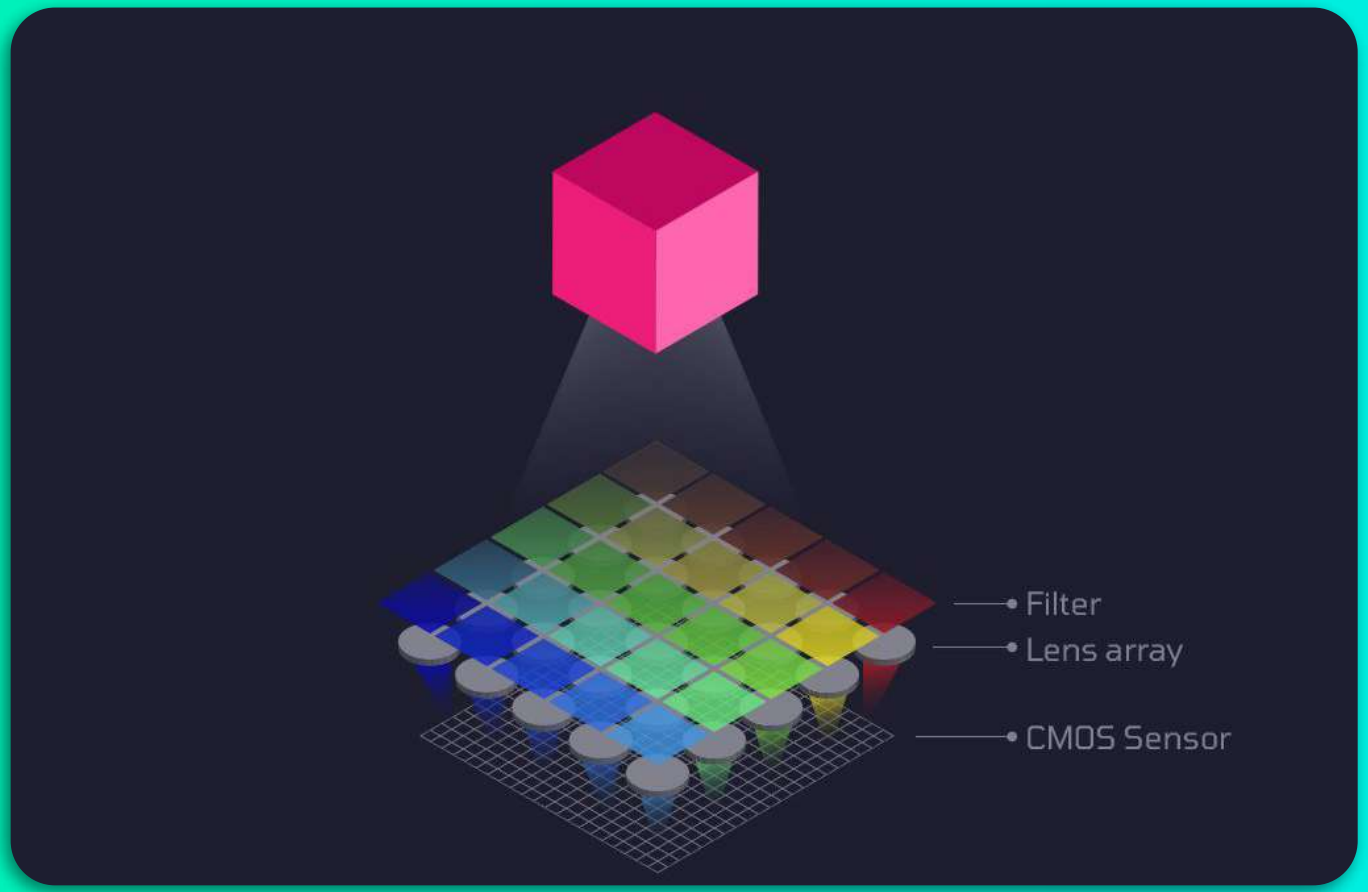


What is Light Field Imaging

A photographic camera captures the radiant intensity of light in a plane. A light field camera captures the entire light field in a plane. The light field consists of the radiant intensity and the direction of the light. Thus, if you know the radiant intensity and direction of the light in one plane, you can also calculate the intensity and direction of this light in other planes.

This principle enables light field cameras to reconstruct the 3D information of a scene or to refocus the image onto other planes. These advantages come with one drawback: the resulting image from a light field sensor has less resolution compared to the resolution of the photo image sensor.



Adding Hyperspectral to Light Field

Working Principle of a hyperspectral light field camera. The camera array captures a scene from different angles. Thus, the wavelength and radiant intensity, as well as the position and direction of the light, is captured..

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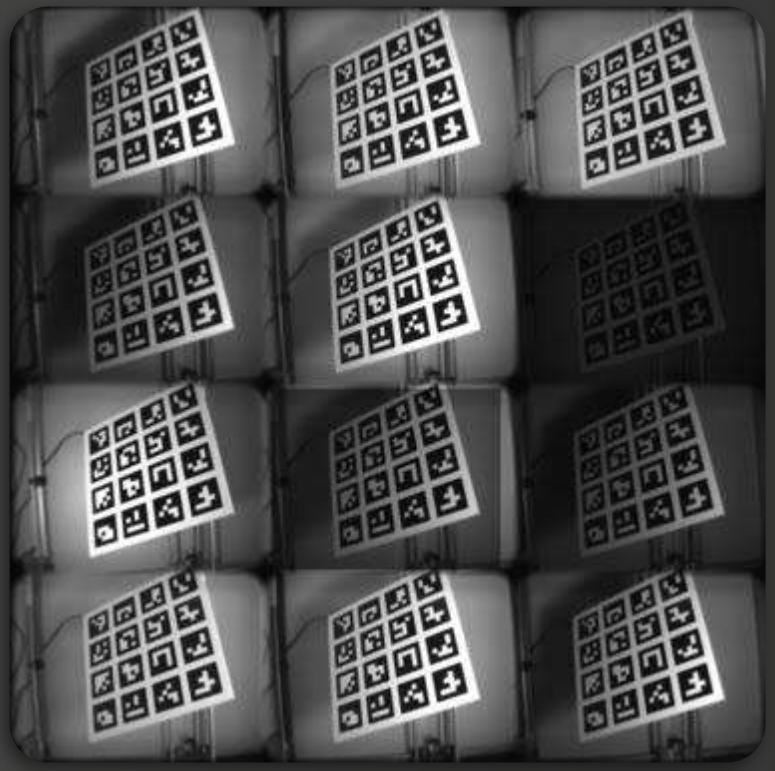
* Cubert patents: Kamerasystem 10 2019 101 324.0; Parallaxe 10 2019 133 515.9; Dispersion 10 2019 133 516.7; ect.

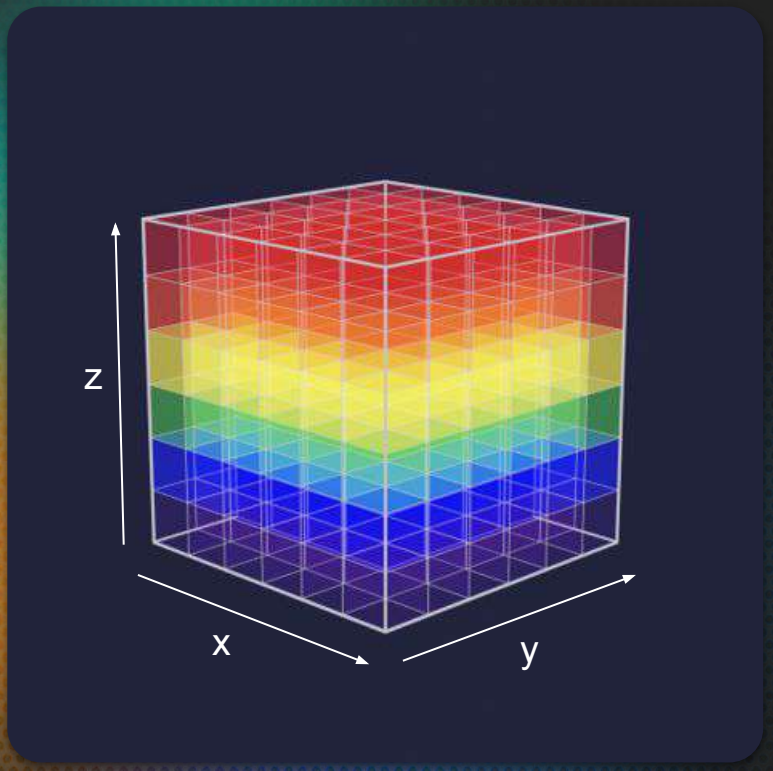


Sensor readout

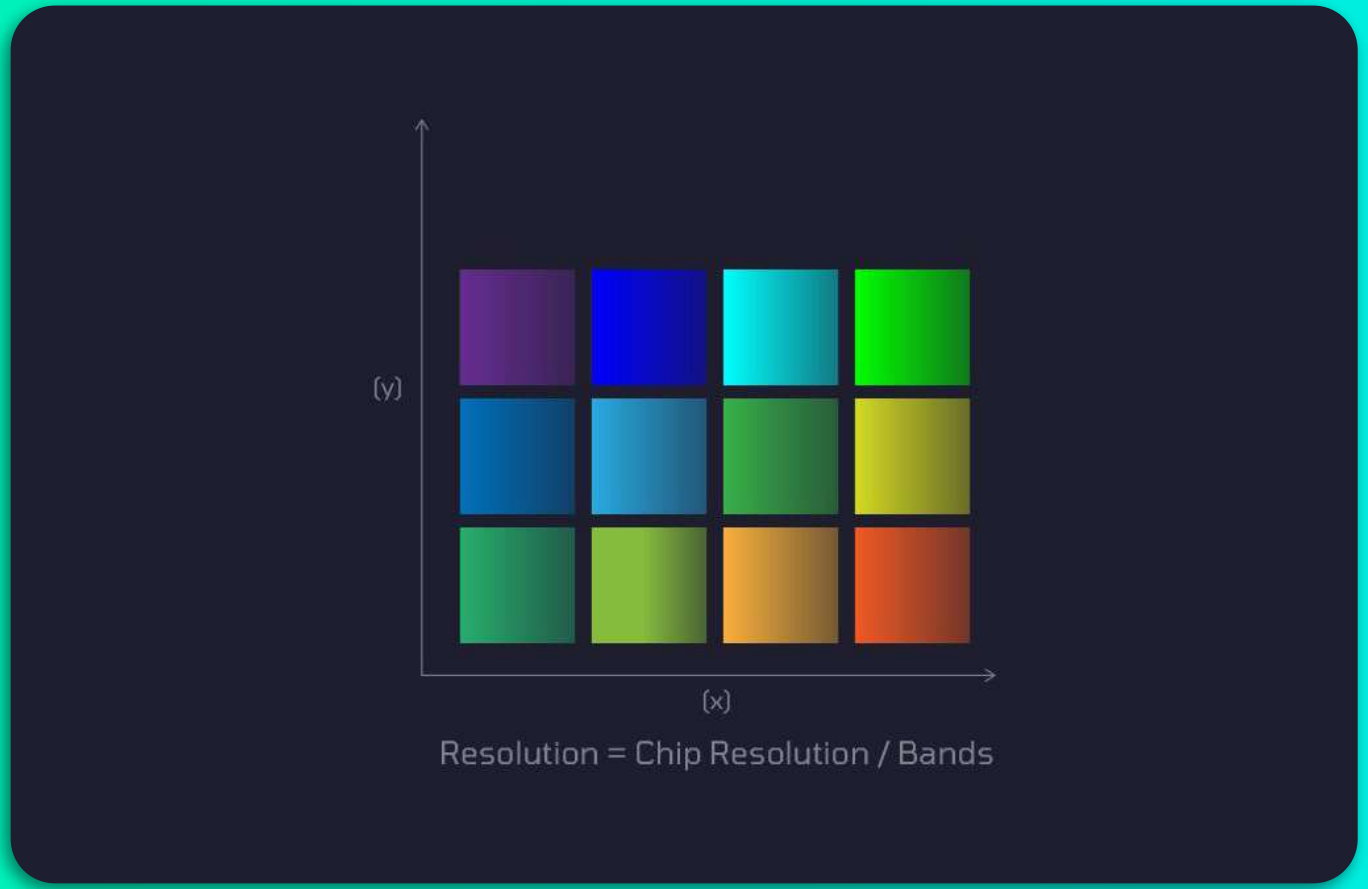
The pure sensor readout is not yet a HSI datacube. A sophisticated algorithm calculates the 3D image in near-real-time.

Correction routines

parallax*
lens error*
channel overlay*
dispersion*
white / dark / ambient light
radiometric correction



3D HSI Datacube



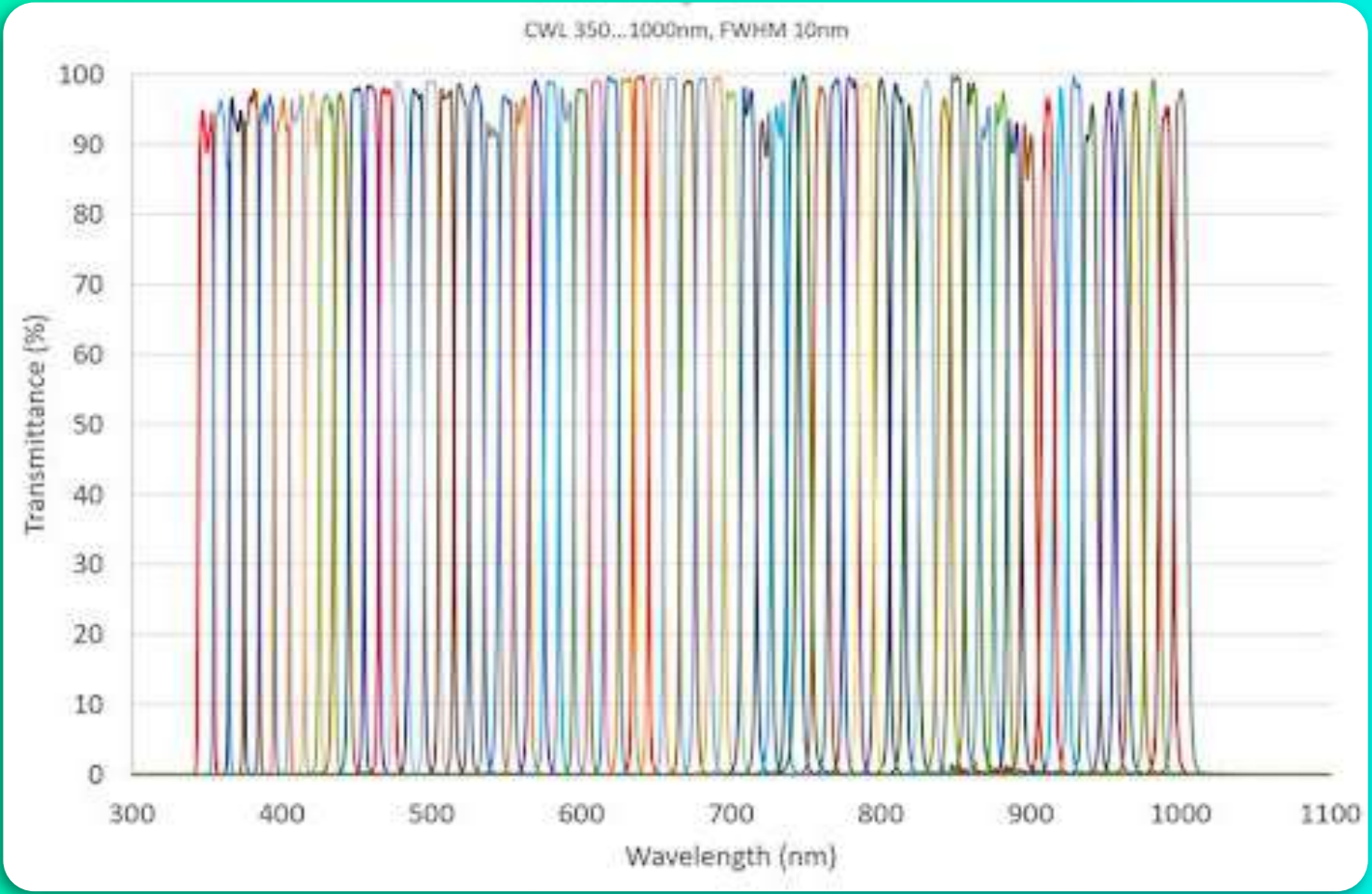
High adaptability

The complete dataset is captured within milliseconds and can be read out with video frame rates.

Instead of losing sensor pixels (as with light field cameras) we transform this sensor data into the wavelength dimension. Thus, the cameras do not lose the resolution of the underlying sensor. The resolution of each band can be chosen by the simple formulation:

spatial resolution =
sensor resolution / number of bands

This setup is highly adaptable and, in addition to our off-the-shelf products, we offer solutions with customizable specifications to match your requirements.

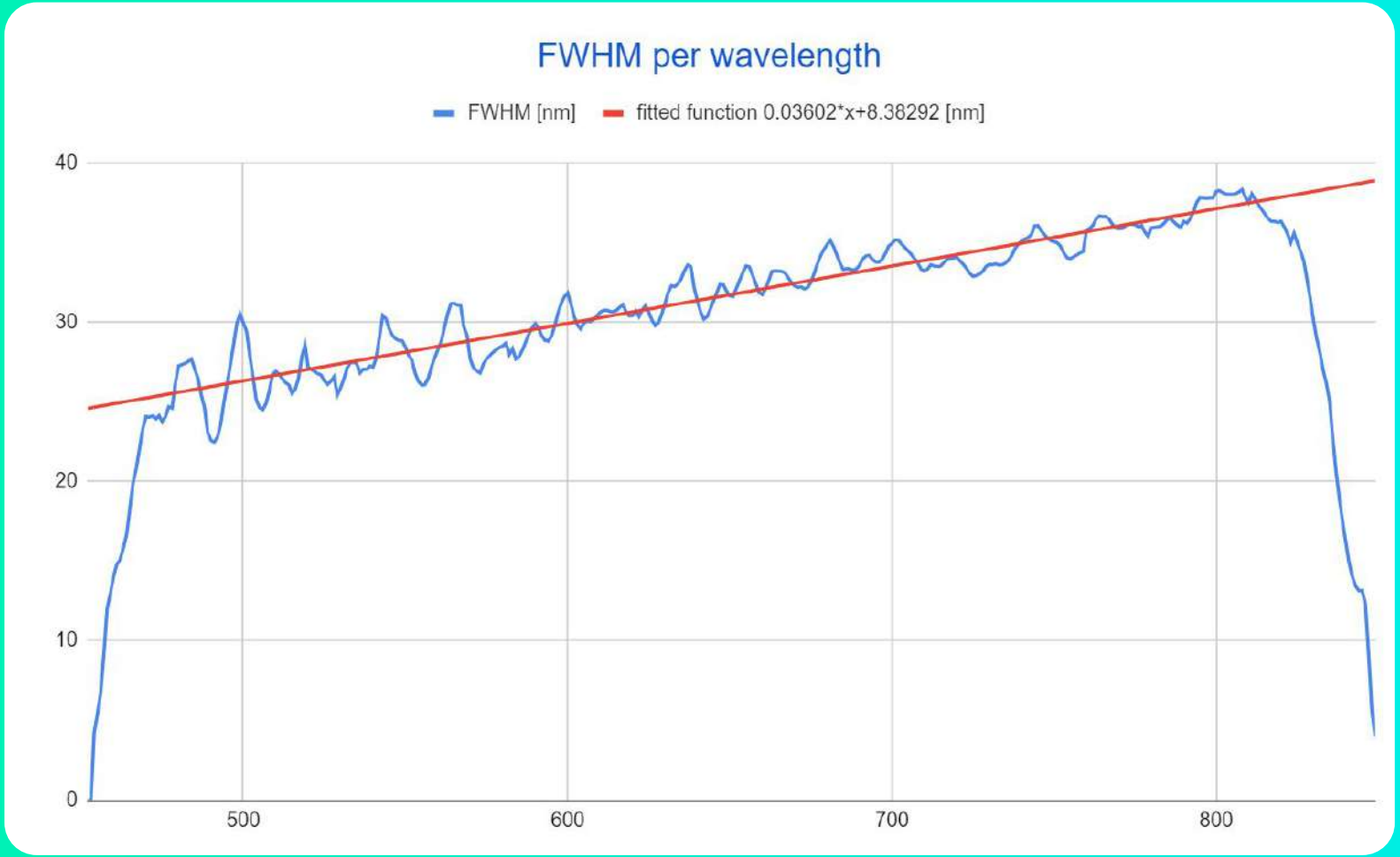


Why our filters offer superior quality

ULTRIS X20 / X20P / X50

10 nm Mosaic Filter

Filter specifications of the Ultris X20. The filters have a transmission >90% and feature a blocking of OD4. The resulting spectra are equidistant and equally broad for every wavelength.



ULTRIS 5 Linear Variable Filter (LVF)

Typical FWHM specification of the ULTRIS 5 .

MEET OUR PRODUCTS

OUR CAMERAS

The future of Hyperspectral Imaging is Video Spectroscopy

Hyperspectral Light Field Camera Product Portfolio

	ULTRIS 5	ULTRIS X20 / X20 Plus	ULTRIS XMR	ULTRIS SWIR 1
	Entry / OEM Camera	**Premium UV-VIS-NIR Camera**	**Next-Gen HR Camera**	**Hyperspectral SWIR Camera**
Price Range	Entry-level	Premium	Mid-range	Mid-range
Wavelength Range	450 - 850 nm	350 - 1000 nm	430 - 910 nm	980 - 1650 nm
Spectral Bands	51	164	61	38
Spectral Sampling	8 nm	4 nm	8 nm	18 nm
FWHM	26 nm @ 532 nm	Constant 10 nm	Constant 25 nm	Avg. 80 nm
Bandpass Filter	LVF	Mosaic	Mosaic	LVF
Spatial Resolution	290 x 275 pixel	410 x 410 pixel, 1886 x 1886 pixel (Pan X20 Plus)	1000 x 1000 pixel	200 x 200 pixel
Total Data Points	51 x 79 750 (4M)	164 x 168 100 (24.5M)	61 x 1 000 000 (61M)	38 x 40 000 (1.5M)
Lens / Optics	C-mount 2/3"	-	C-mount 4/3"	C-mount 2/3", 1"
FOV (Field of View)	15° (w/o lens) / lens-dependent	35°	lens-dependent	lens-dependent
Max Frame Rate	15 Hz / 75 Hz (HFR)	max 4 Hz	17 Hz (8 bit) / 12 Hz (12 bit)	80 Hz
Data Link	GigE / 10 GigE (HFR)	GigE	USB 3.0	USB 3.0
Integration Time	0.1 – 1000 ms	0.1 – 1000 ms	0.1 – 1000 ms	0.1 – 1000 ms
Data Depth	12 bit	12 bit	12 bit	12 bit
Technology	Light Field	Light Field, Dual Sensor (X20P)	Light Field	Light Field
Readout	Global Shutter	Global Shutter	Global Shutter	Global Shutter
Sensor	Sony IMX264	CMOSIS CMV20000, Sony IMX264 (X20P)	Sony IMX540	Sony IMX990
File size processed	< 8 MB	< 55 MB	~300 MB	3 MB
Weight	126 g	350 g / 630 g (X20P)	700 g	140 g (w/o lens)
Dimensions	29 x 29 x 65 mm	60 x 60 x 57 mm / 86 x 121 x 105 mm (X20P)	40 x 40 x 217 mm	30 x 30 x 85 mm (w/o lens)
Options	C-mount adapter High Frame Rate (HFR) Industrial Housing (IP66)	only X20: Industrial Housing (IP66) Underwater Housing (IP68)	Wavelength range customizable	-

ULTRIS 5 Relay Lens (SR5)

ULTRIS 5 Relay Lens Adapter

With the new ULTRIS Relay Lens adapter, you can mount any C-Mount objective on the ULTRIS 5 (HFR). The adapter can be attached plug-and-play, allowing to attach any lens including macro optics or fish eye lenses on the camera instantly. You can even attach the camera on more complex optical systems, such as microscopes, endoscopes, or fundus cameras. The Relay Lens is a huge step forward bringing hyperspectral light field technology to biomedical applications.

Size	29 x 42 mm
Weight	50 g
Optical Standard	C-Mount
Recommended lens size	supporting 2/3 inch sensors
Lens Compatibility	2/3 Inch or bigger
Camera	ULTRIS 5, ULTRIS 5 HFR
Status	Pre Series Production

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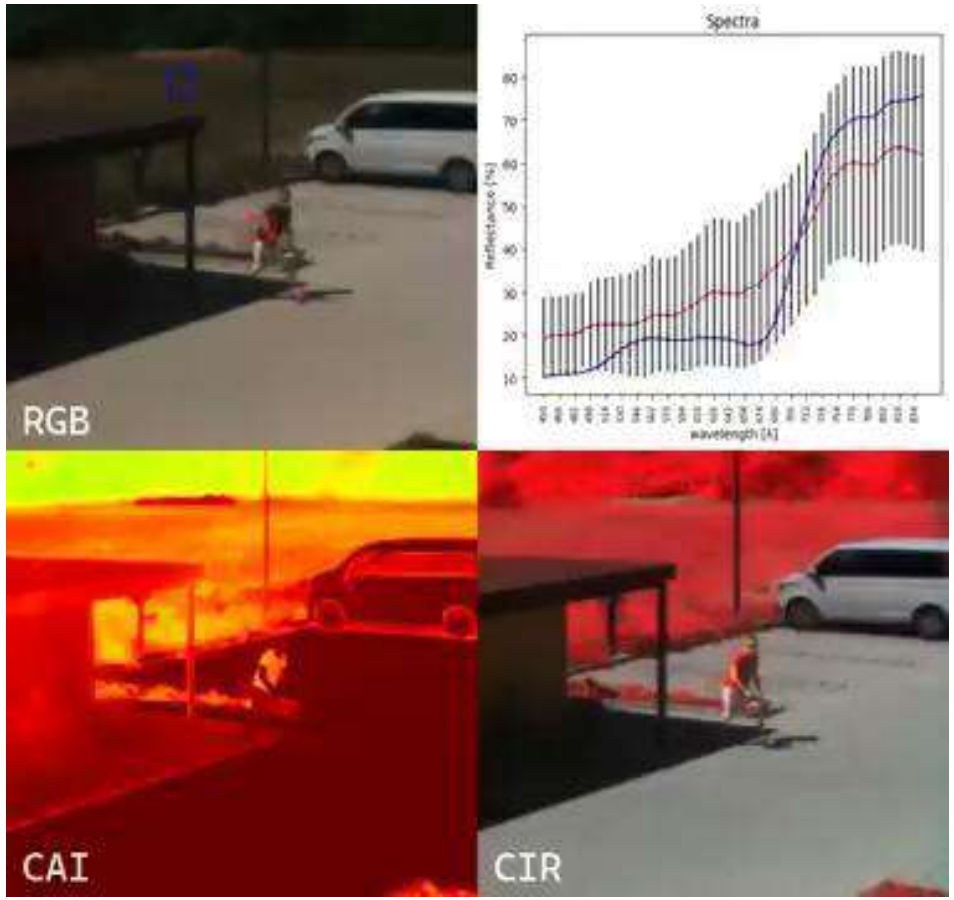
ULTRIS 5 HFR - High Frame Rate (H5)



- Frame rate (recording): up to 75 Hz
- Frame rate (live processing): up to 32 Hz
- Dimensions: 60 x 60 x 99.7 mm
- Weight: 495g
- Wavelength range: 450-850 (modifiable)
- Spectral bands: 51
- Spatial resolution: 290 x 275 pixel

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ULTRIS XMR

Next-Gen Spectral Video Camera

Our first 1MP (1000 x 1000 pixels) resolution spectral video camera comes with full integrated relay lens optics, allowing you to mount different lenses any time.

The ULTRIS XMR comes with USB3 connection, making it easy to integrate in any environment.

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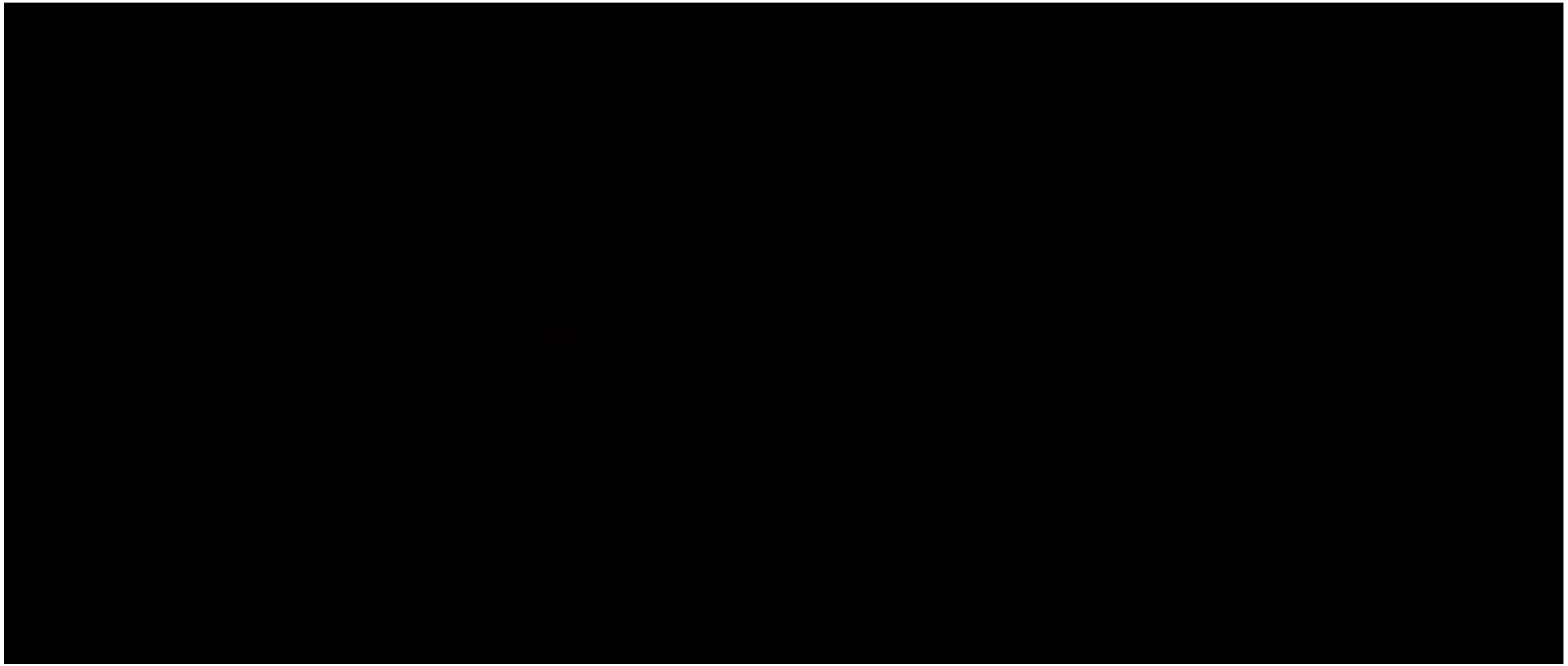
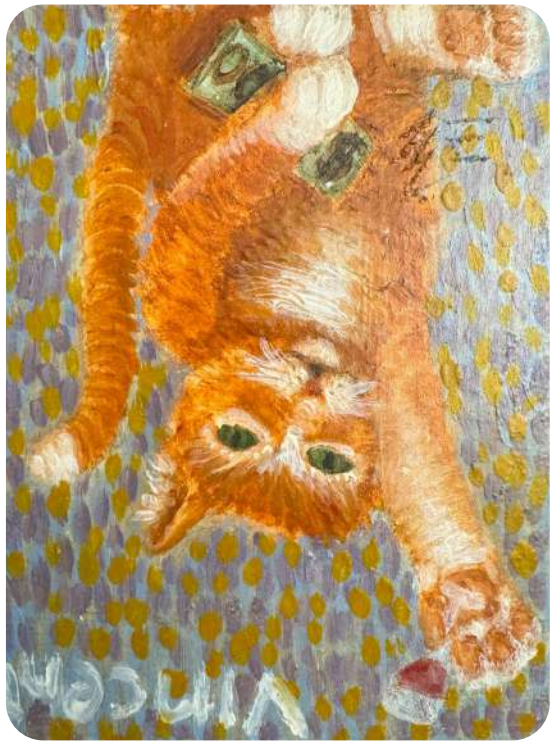
ULTRIS XMR

ULTRIS XMR



ULTRIS SWIR 1

Unveiling the Hidden



VIS

SWIR

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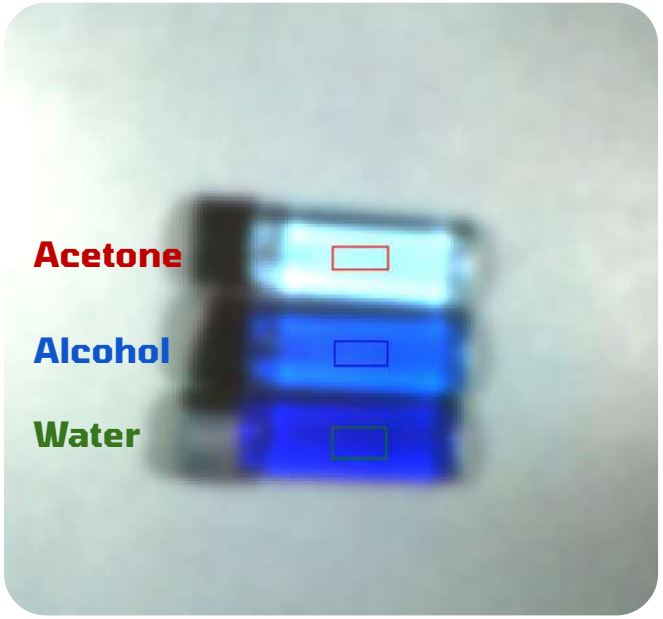
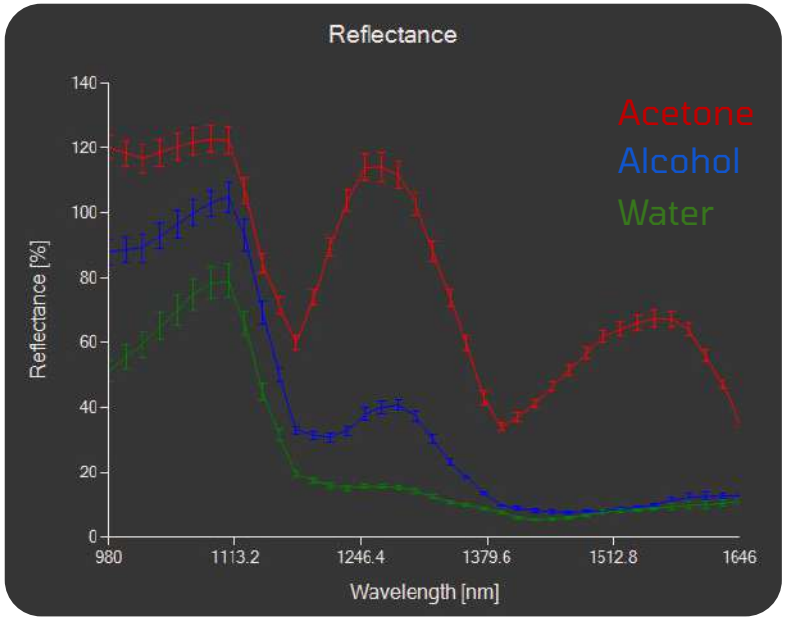
ULTRIS SWIR 1

Liquids differentiation

RGB True Color (Photo)



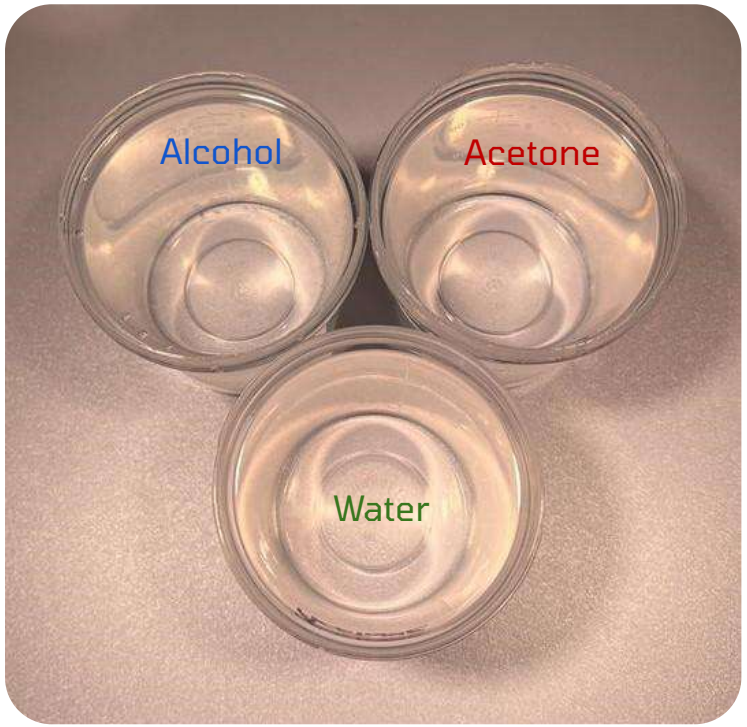
False Color image



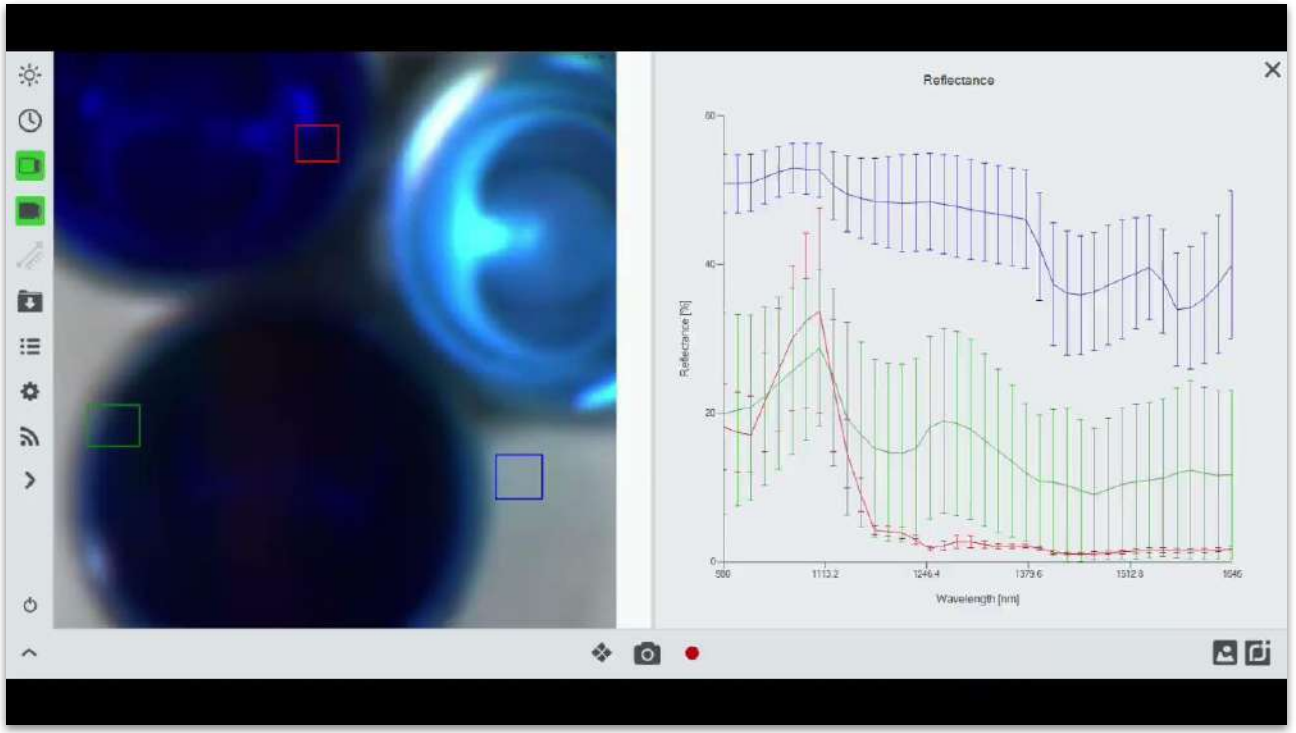
Spectral information of liquids
(Acetone, Alcohol, Water)

ULTRIS SWIR 1

Liquids differentiation



RGB True Color (Photo)



ULTRIS SWIR 1 - Spectral information of liquids

Gimbal Flight Solution

ULTRIS Aviator

Full Integration for
DJI M300/350

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ULTRIS X20 Plus - Gimbal

ULTRIS gimbal for DJI M300 RTK

The new gimbal designed exclusively for the **DJI M300 RTK**. Our gimbal seamlessly integrates the **X20 Plus**, the major model for UAV acquisitions, onto the M300, making it the perfect choice for your next mission.

Our gimbal connects seamlessly via the **DJI Skyport**, making it easy to set up and use. With a built-in Mini PC, you record image data and GPS data gathered from the M300, giving you valuable insights into your flight data.

The gimbal also comes with the **Cubert Touch** software accessible in the **DJI Controller**, allowing you to control the camera and adjust the settings with ease. And, with the camera triggered by the drone, you can be sure that you're capturing exactly what you need to make informed decisions.

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ULTRIS X20 | X20 Plus

X20
SPECTRAL
SENSOR

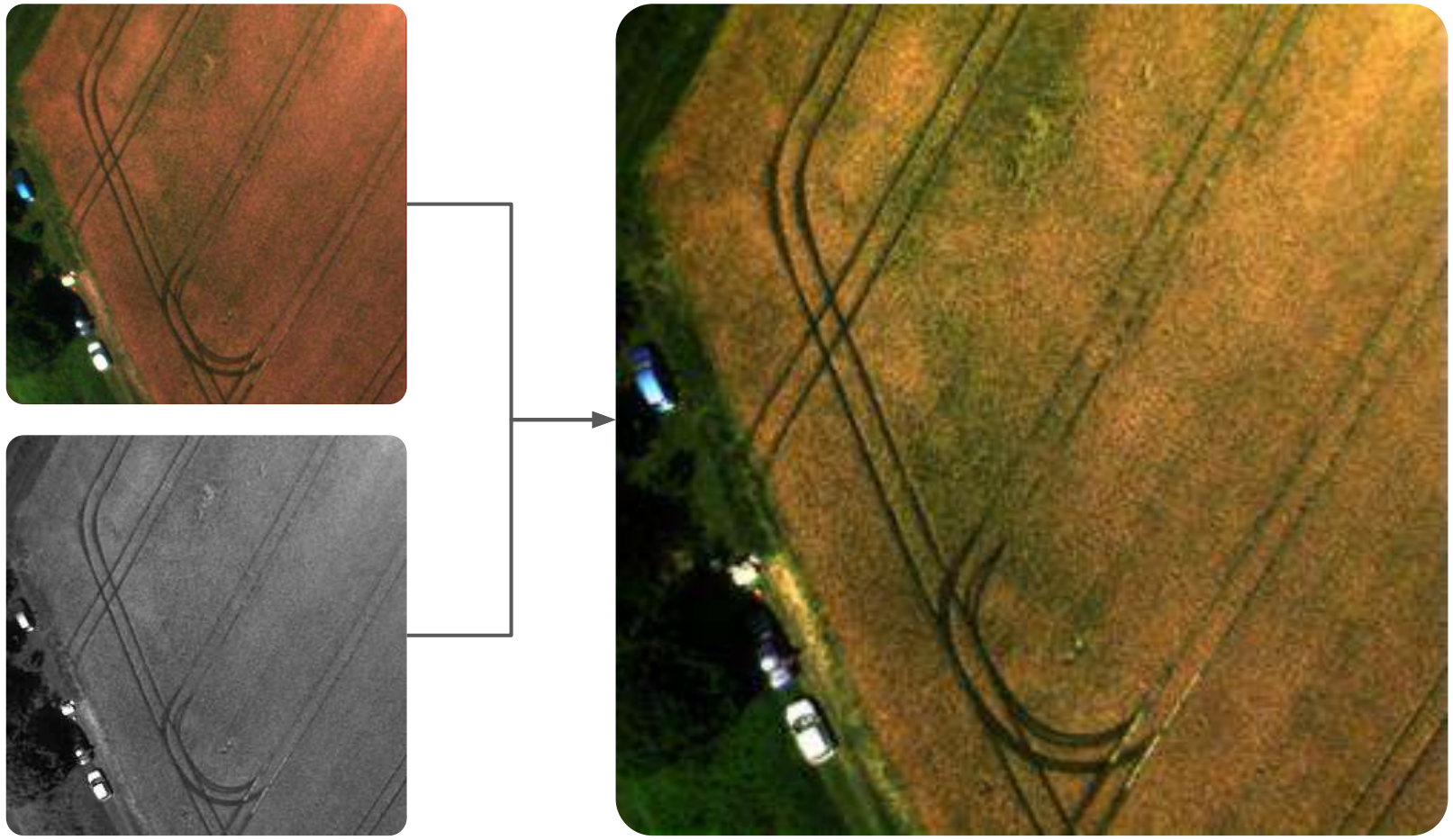
True Color (RGB)
164 bands
native 410 x 410 pixel
GSD: 14 cm / pixel

X20 Plus
PANCHROMATIC
SENSOR
Greyscale Image
1 band
native 1880 x 1880 pixel
GSD: 3 cm / pixel

ULTRIS X20 Plus - Pansharpening

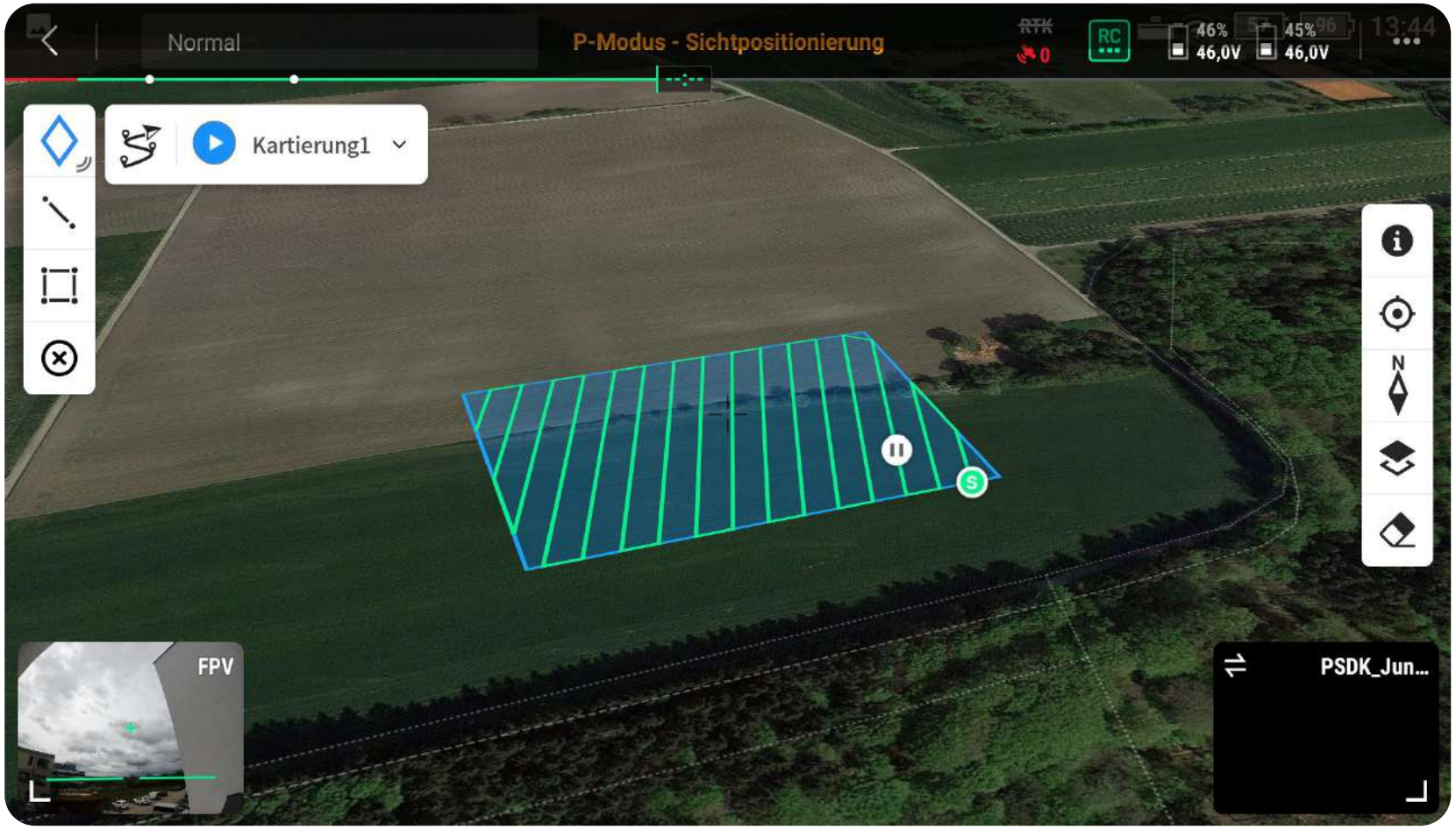
Pansharpening, or image fusion, is a well-known image enhancement technique in satellite remote sensing or earth observation. At Cubert we developed our own image fusion technique to increase the spatial resolution of our hyperspectral images.

PANSHARPENED PRODUCT
True Color (RGB)
164 bands
pansharpened 1880 x 1880 pixel
Pixel size: 3 cm / pixel



DJI software (DJI Pilot 2)

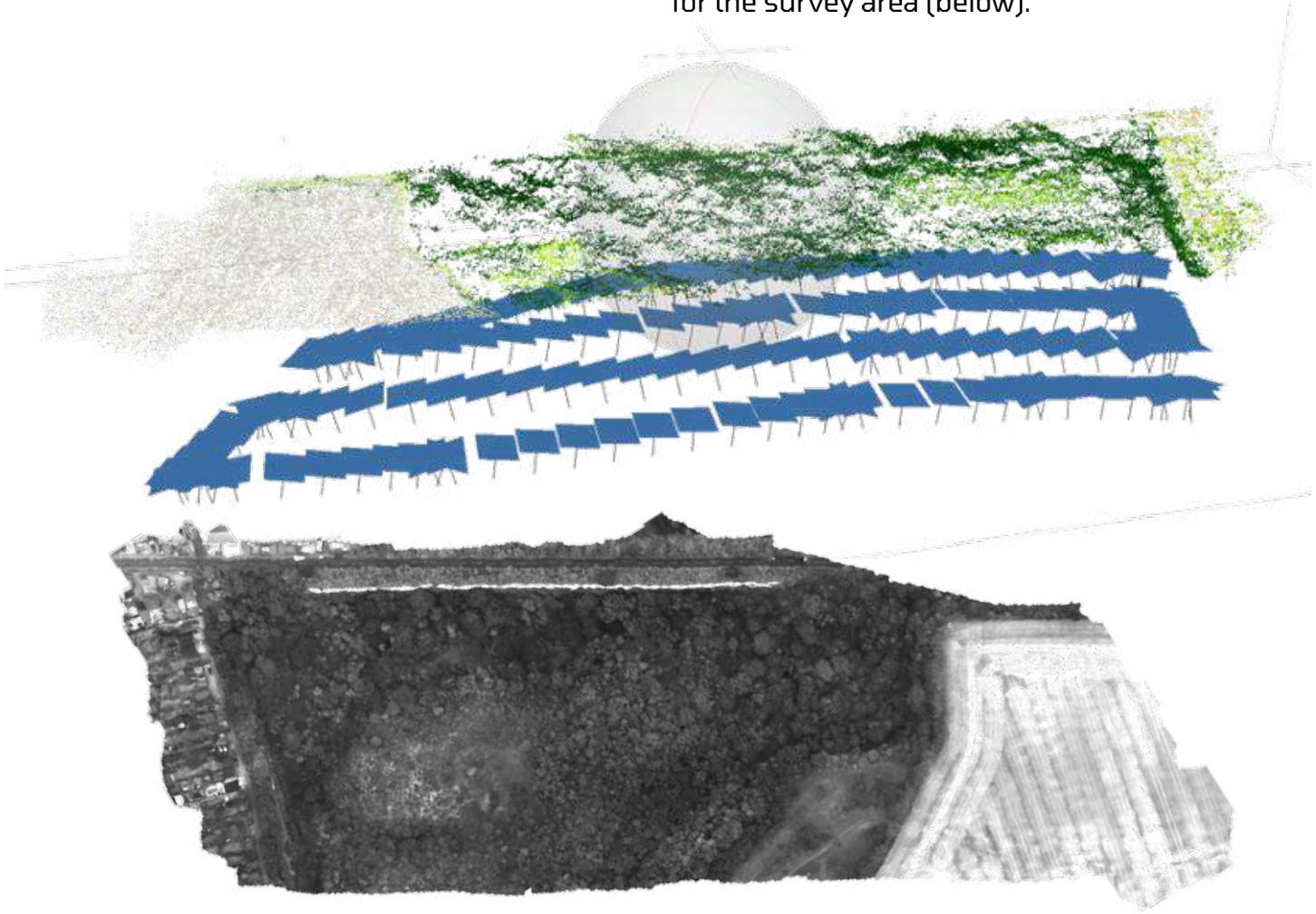
- Flight route planned using DJI Pilot 2 software.
- Automates data collection during flight.
- Captures hyperspectral images with GPS data.
- Ensures overlap and directionality of flight strips.



Stitching of hyperspectral images

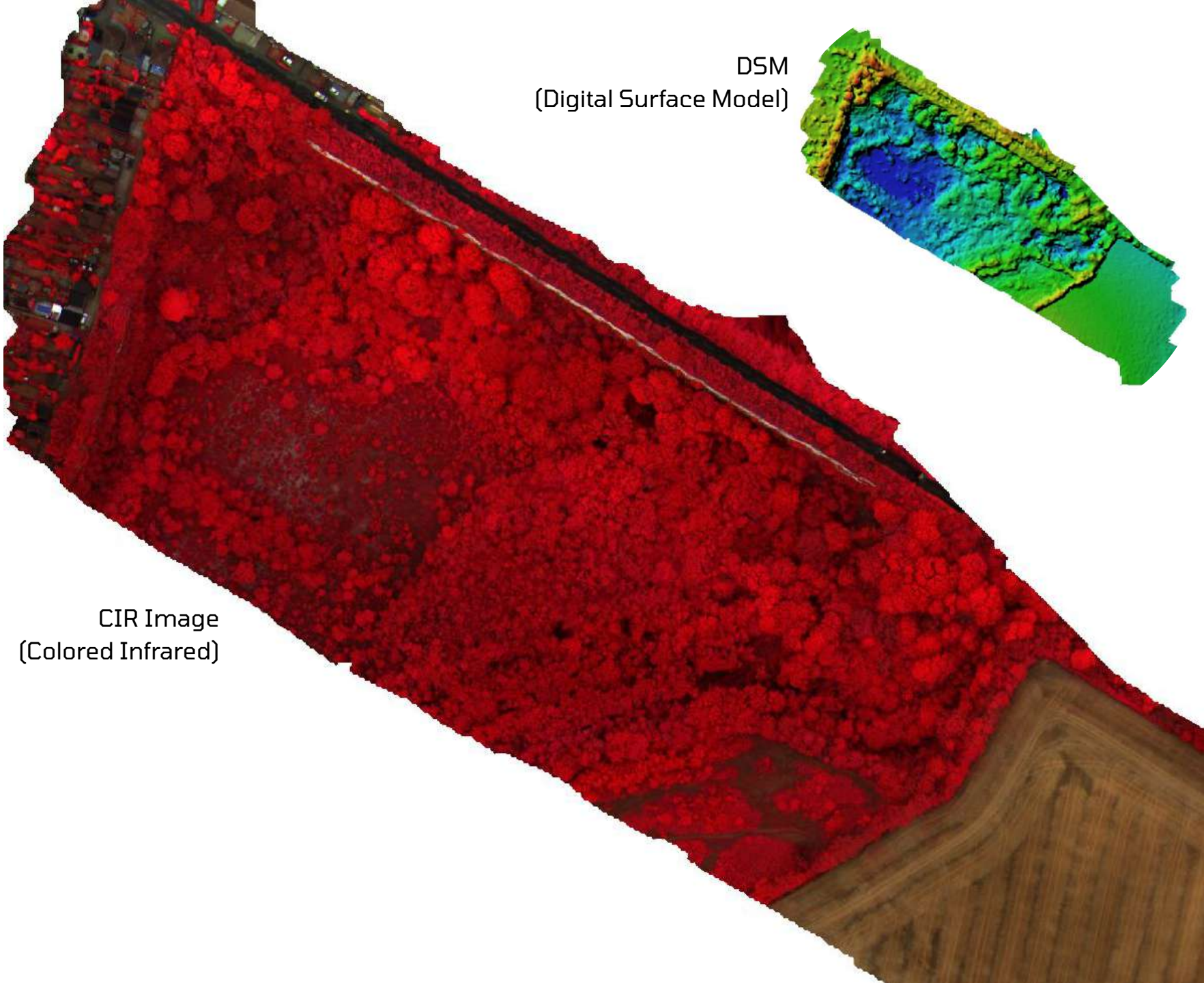
- Orthomosaic is generated from single hyperspectral image tiles.
- Image cubes are stitched using photogrammetric software, such as **AgiSoft Metashape**.
- Coordinates and common pixels among images help correct distortions and create an orthomosaic file.
- The hyperspectral dataset is enriched with elevation and positional data, integrated into the orthomosaic.

Point cloud from the common intersection points of the individual images with the corresponding individual images (top). Orthomosaic for the survey area (below).



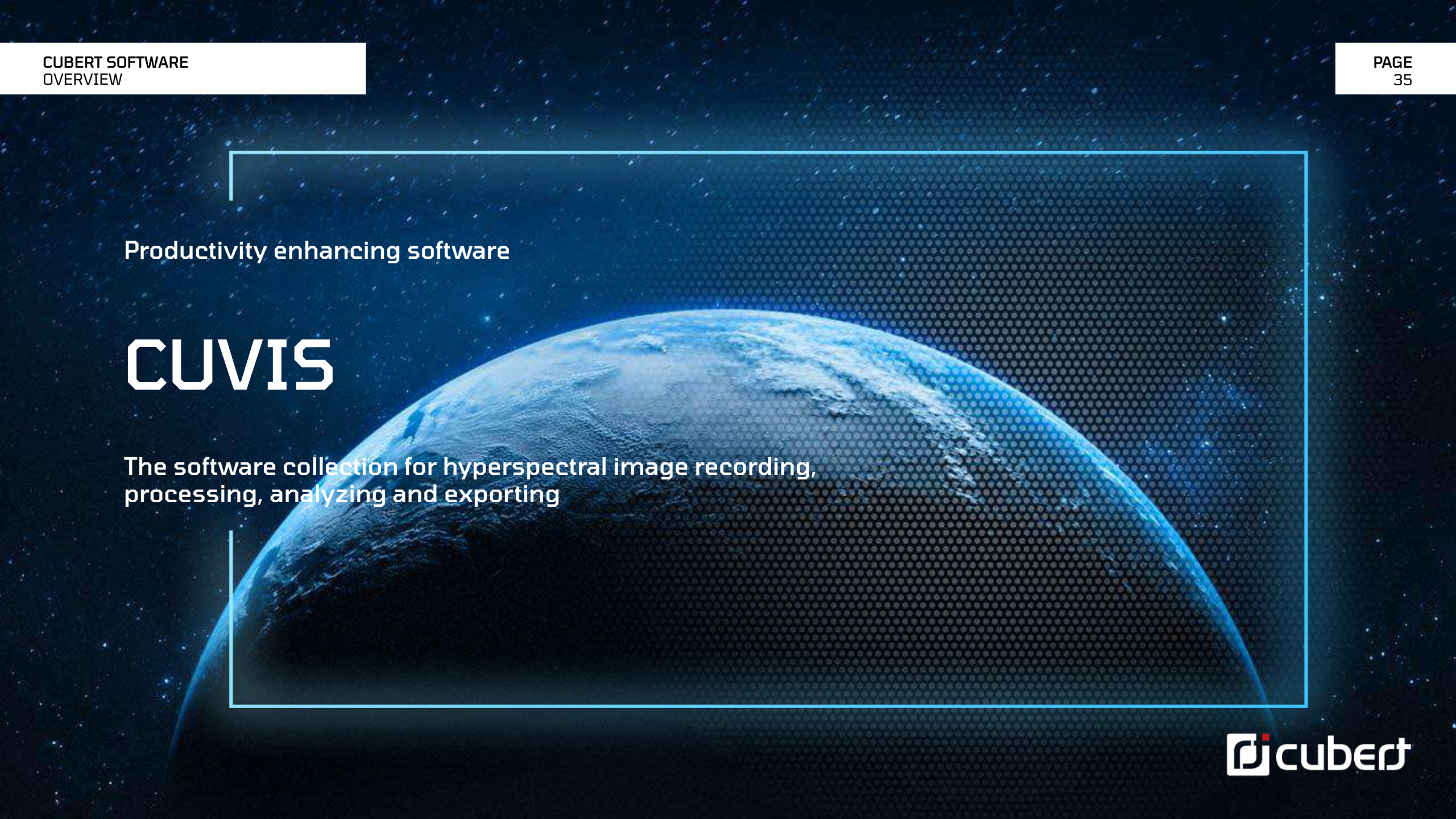
Stitched products

- Hyperspectral orthomosaic incorporates height and location data.
- Allows creation of precise georeferenced products like channel combinations, indices, and classifications.



DSM
(Digital Surface Model)

CIR Image
(Colored Infrared)



Productivity enhancing software

CUVIS

The software collection for hyperspectral image recording, processing, analyzing and exporting

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Cubert CUVIS HSI Software

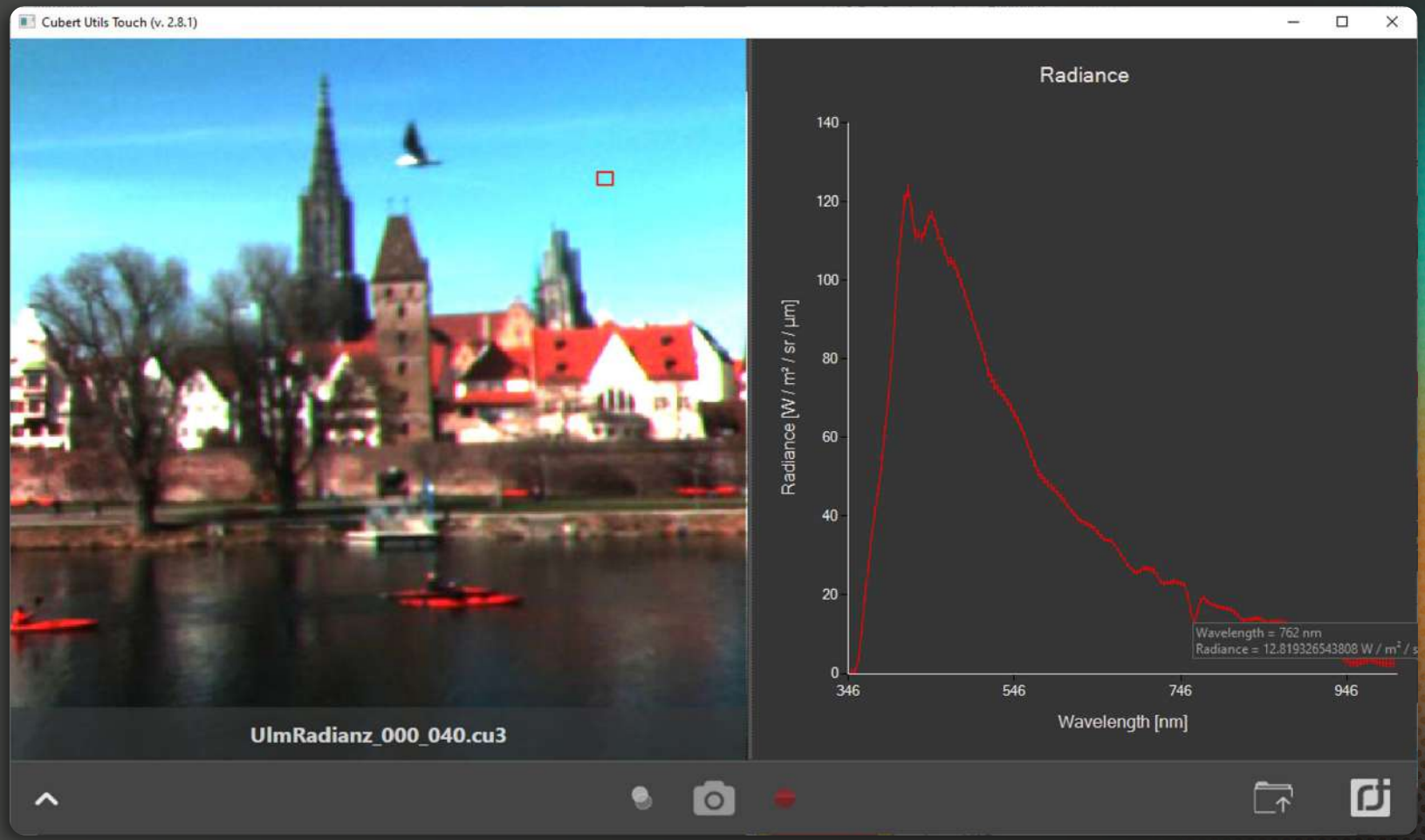
The CUVIS software suite includes:

Touch (GUI) and **Core** (backend) for Windows

- Enables camera control & calibration, live data stream and analyses (video mode), data recording, User plug-Ins
- Full export functionality, current formats are **ENVI** and **TIFF**

SDK

- based on C, with wrappers for **Python (3.9)** and **C++**
- SDK available for **Windows 10**, **11**, and **Ubuntu 20.04**
- Doxygen documentation



CUVIS TOUCH

- Camera Setup
- Image Capturing
- Online image Correction
- Online index Calculation
- Online Classification
- Online Processing
- Data Management
- Data Export Manager (TIFF, ENVI)
- Remote Operation
- Windows / Linux

cuvis.hub

Open source community hub for the development of hyperspectral applications using the latest tool chains and modern state of the art hyperspectral video cameras.

- Open source Repositories for **all SDK** wrappers including:
  - Windows 10/11, Ubuntu 20.04, X86/ARM64*
  - Intuitive **examples**
  - Doxygen **documentation**
- Comprehensive approach to develop hyperspectral **AI pipelines**.
- Labeling GUI + Automated labeling with Segment Anything
- Robot integration with ROS

Repositories:

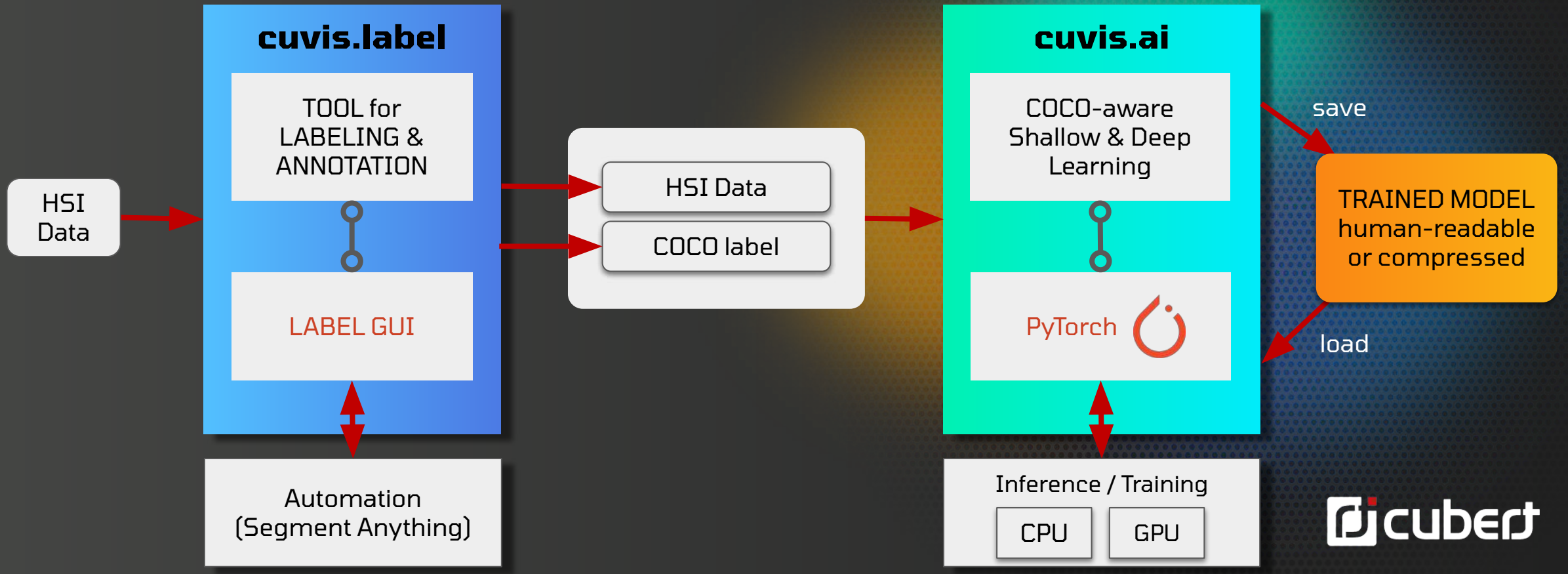
- cuvis.sdk
- cuvis.ai
- cuvis.label*
- cuvis.docker
- cuvis.ros
- cuvis.data*
- ...

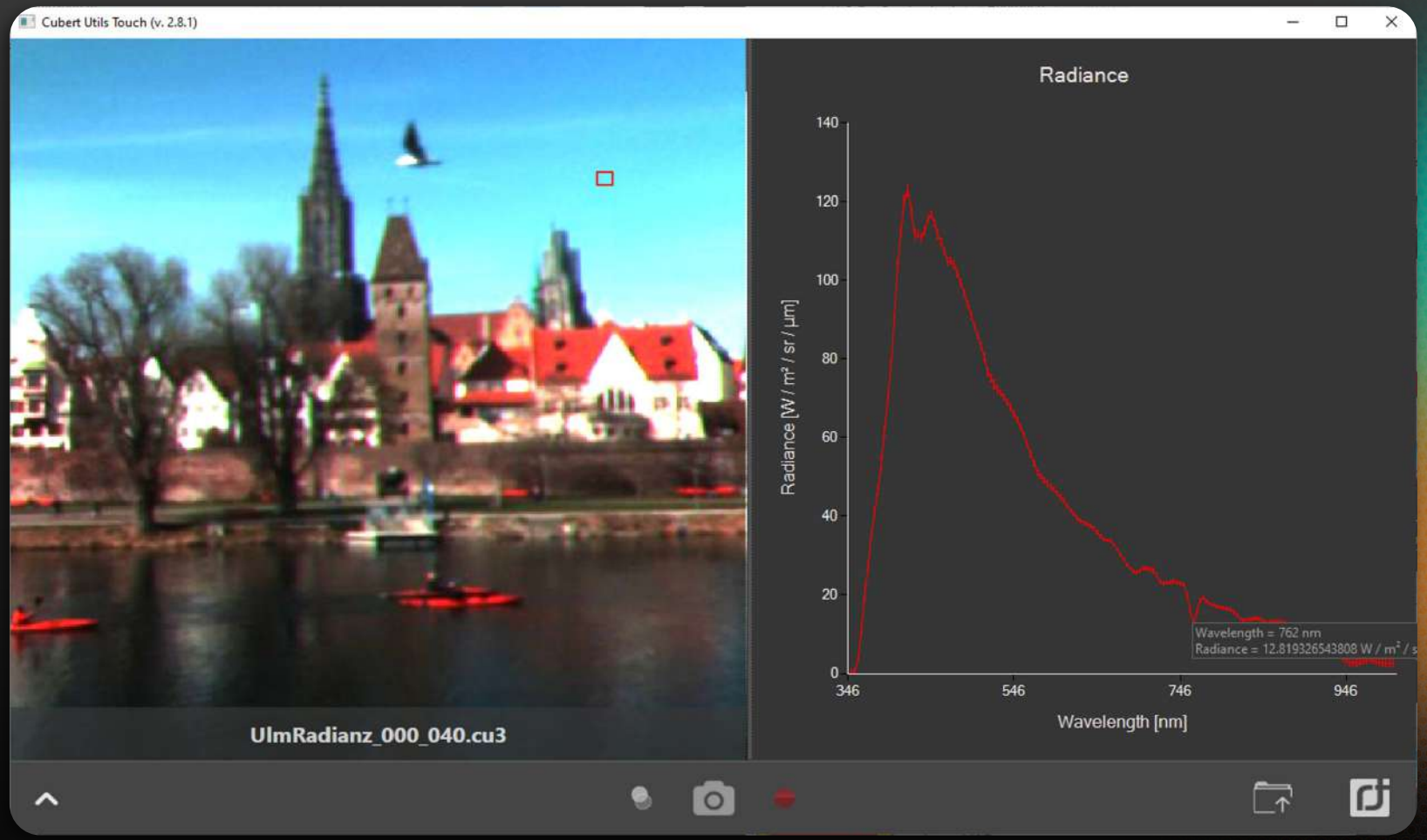
**going public soon*

https://github.com/cubert-hyperspectral

cuvis.ai

Framework for HSI machine learning

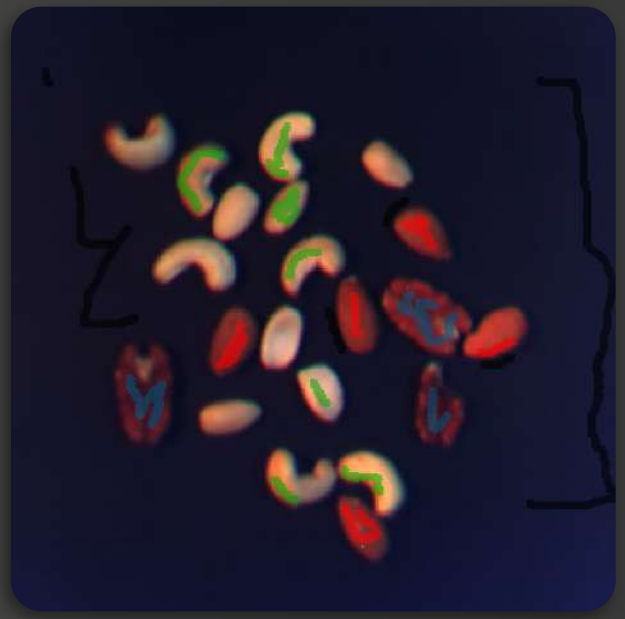




MAIN FEATURES

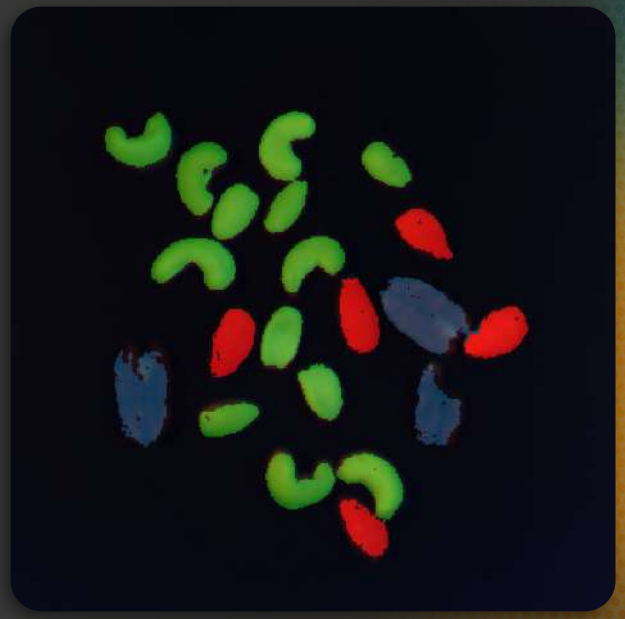
- Camera Setup
- Image Capturing
- Online image Correction
- Online index Calculation
- Online Classification
- Online Processing
- Data Management
- Data Export Manager
- Remote Operation
- Windows / Linux
- SDK

Video Spectroscopy meets Artificial Intelligence



Training the model

- Define multiple classes for samples
- Label those classes in the image



Pixel classification

- Composition of samples is gathered fully automatically
- Validate the result of the trained classifier and fine-tune the model interactively

Object segmentation

- Set a threshold for the size
- Classify the pixels within an object

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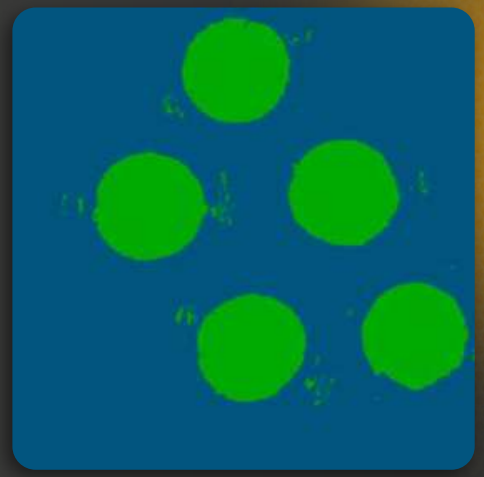
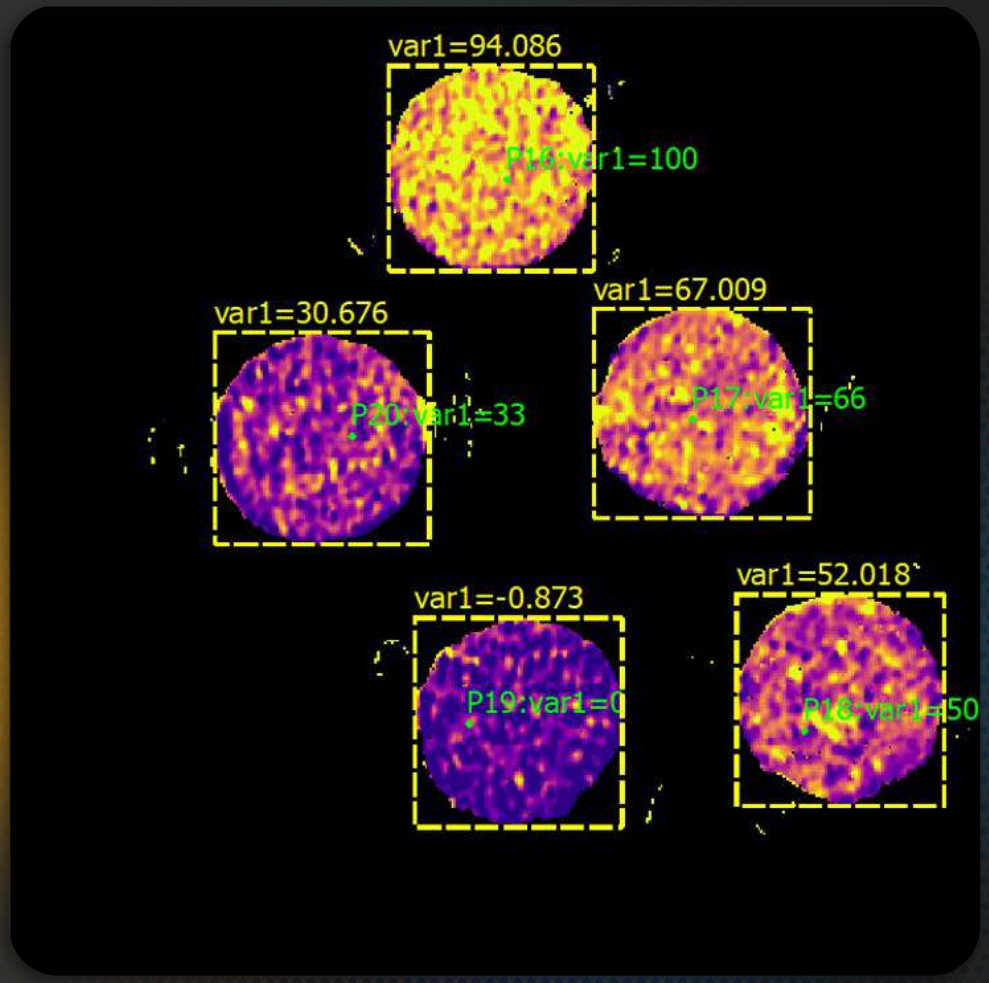
Regression analysis

The samples are segmented to provide only-needed information to the model. Regression analysis is performed.

Machine learning is used to identify the different mix concentrations of black and green tea completely automatically.

The model is applied to data and is able to detect different concentrations.





THANK YOU VERY MUCH

Get in Contact with our Sales Team

Dr. Viktoriya Tsyganskaya
Project Manager
+49 731 708156 - 78
tsyganskaya@cubert-gmbh.de

Dr. Marie-Theres Heine
Key Account Manager
+49 731 708156 - 70
marie-theres.heine@cubert-gmbh.de

Barbara Darnell
Sales Manager USA & Canada
M: 1.617.586.5952
darnell@cubert-gmbh.de

Dr. Matthias Locherer
Director Sales & Marketing
+49 731 708156 - 70
locherer@cubert-gmbh.de