



D2000S

One-stop high-precision work platform based on high-performance rotor UAS

Shenzhen Feima Robotics Technology Co.,Ltd.

Feima Intelligent Aerial Photogrammetry, Remote Sensing,
Patrol Inspection and Eergency System



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Overview



D2000S is a small-sized and long-endurance four-rotor UAV platform newly developed by Feima Robotics, which can meet the civilian needs of high-precision mapping, remote sensing and video surveillance applications.

D2000S can be equipped with photogrammetric ortho module, oblique module, LiDAR module, visible light video module, thermal infrared video module, thermal infrared remote sensing module, lidar module and so on, thus has the ability to acquire multi-source data. As for the photogrammetric and remote sensing modules, photogrammetry and remote sensing applications can be fulfilled, while the video modules equipped with long-distance high-definition image transmission can realize functions such as target recognition, target positioning, target real-time tracking, and target position and speed estimation.

The standard take-off weight of the UAV platform is 2.8 kilograms, the standard payload is 200 grams, and the endurance time is 74 minutes.

D2000S is equipped with a high-precision differential GNSS board and two dual-differential antennas. Through the optional physical base station with RTK and PPK fusion solution, it can support high-precision POS-assisted aerial triangulation and realize image control-free applications. Also, with the software named UAVManager Professional Edition, it has various route modes for different application requirements. The software supports accurate three-dimensional route planning, three-dimensional real-time flight monitoring, GNSS fusion solution, control point measurement, aerial triangulation, one-key to output and browse multiple data results such as TDOM, DOM, DEM, DSM, LIDAR point cloud and so on.

System characteristics

Image control-free topographic mapping

With 20 Hz high-precision differential GNSS, D2000S is able to accomplish topographic mapping without image control points for various application scenarios.

Long endurance, high efficiency and high reliability

The hovering time at sea level for a single flight is 60 minutes. The modules such as IMU, barometer, magnetometer, and GNSS module adopt redundant design. The components such as ultrasonic wave, optical flow module and double differential antennas are utilized to provide multiple guarantees. A number of components and the whole UAV platform have passed the reliability test to ensure product safety and reliability.

Dual-differential antenna

Double dual-differential antennas are the standard configurations of the D2000S, which enhance the anti-interference ability and help to operate in complex environments such as mining areas, bridges, and ship-borne take-off and landing platforms.

Module payload design and multi-source data acquisition

D2000S can be equipped with single-head photogrammetric module, penta-head oblique module, LiDAR module, thermal infrared remote sensing module, visible light video module, thermal infrared video module and related software solutions.

Precise terrain following flight

Combined with the software of UAVManager Professional Edition, the D2000S can achieve accurate terrain following flight, improving the image acquisition resolution and ensuring the consistency of image resolution.

Automatic obstacle avoidance

D2000S is equipped with a front-mounted milliwave radar obstacle avoidance module, which can automatically detect obstacles ahead and improve the safety level.

One-stop software solution and advanced data processing workstation

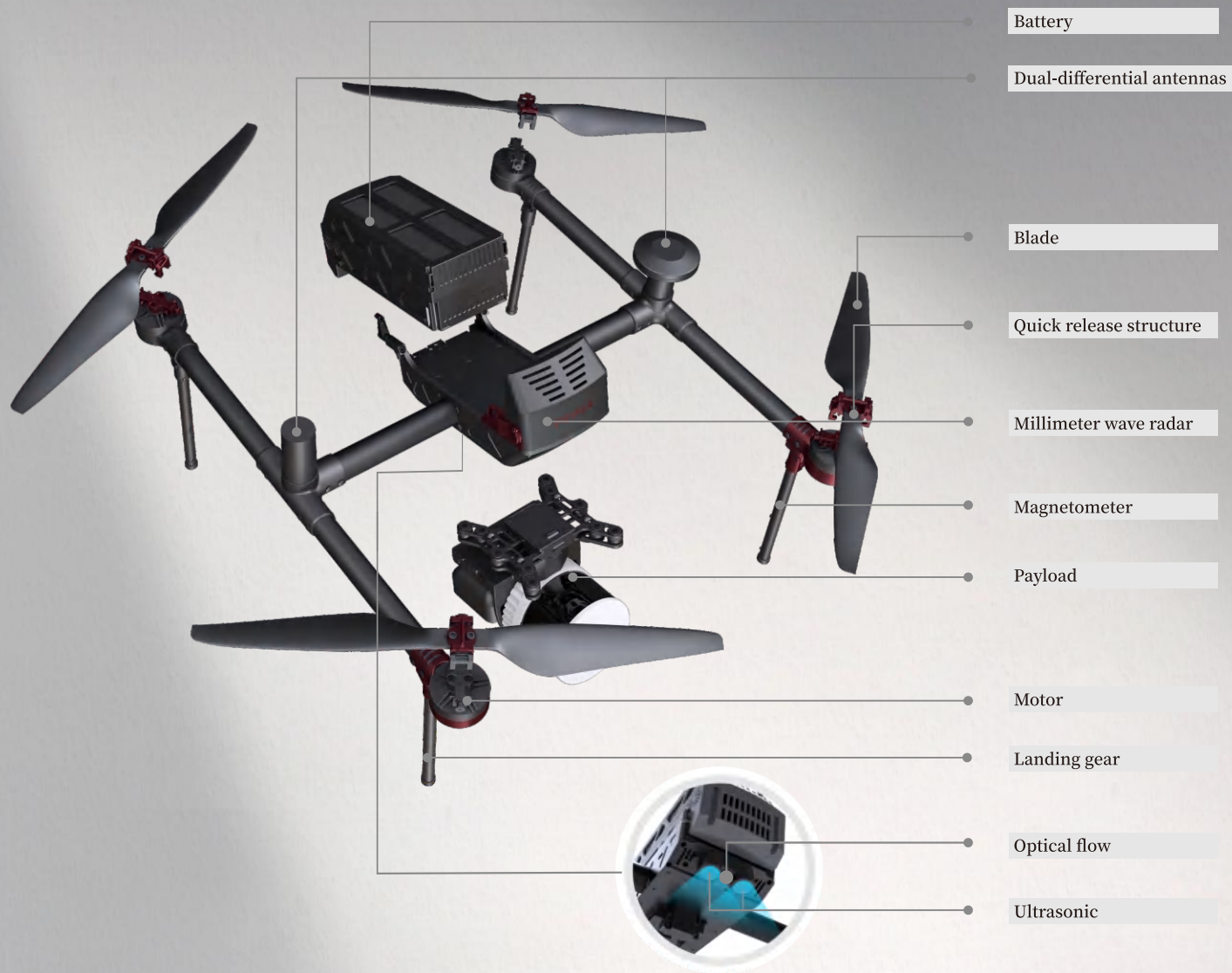
The software of UAVManager Professional Edition supports the whole process from accurate 3D flight route planning, 3D real-time flight monitoring, control point measurement, aerial triangulation to providing and browsing a variety of data results such as DOM, DEM, DSM, TDOM, LiDAR point cloud and so on.

Cloud-based active service

Based on cloud services, the system supports information push, project synchronization, flight data sharing, active UAV maintenance, flight real-time display and playback afterwards. Also, remote monitoring and video streaming can be accomplished based on 4G/5G networks.

Net weight	2.6 kg
Maximum/Standard takeoff weight	3.8 kg / 2.8 kg
Maximum payload capacity	1.2 kg
Symmetrical motor wheelbase	598 mm
Dimensions (without paddles)	Unfold 495 mm × 442 mm × 279 mm Fold 495 mm × 442 mm × 143 mm
Navigation satellite	GPS, BeiDou, GLONASS
Power mode	Electric
Maximum speed	20 m/s(when the UAV platform is tilted 25 degrees)
Cruising speed of the longest flight	13.5 m/s(maximum voyage of 50 kilometers)
Cruising speed of the longest flight	7.0 m/s(maximum flight duration of 74 minutes)
Hovering time	60 min (hovering at sea level with a single camera as payload)
Maximum climb speed	8.0 m/s (manual), 5.0 m/s (automatic)
Maximum descent speed	5.0 m/s (manual), 3.0 m/s (automatic)
Hovering accuracy in RTK mode	Horizontal 1cm+1ppm Vertical 2cm+1ppm
Differential GNSS update frequency	20 Hz
Maximum take-off altitude	6000 m
Wind resistance capability	Level 6 (10.8~13.8 m/s)
Task response time	Unfold ≤10 mins, Withdraw ≤15 mins
Measurement and control radius	Image transmission distance < 10 kilometers Data transmission distance < 20 kilometers
Take-off and landing mode	Vertical take-off and landing without remote control
Working temperature	-20°C~45°C

System characteristics



Battery disassembly



Gimbal disassembly



Propeller disassembly



System characteristics

Carbon fiber structure

The fuselage of D2000S can be folded quickly, and the whole body can be stored in a transport box for easy transportation.



Motor

High efficiency, high reliability, low vibration, low noise motor



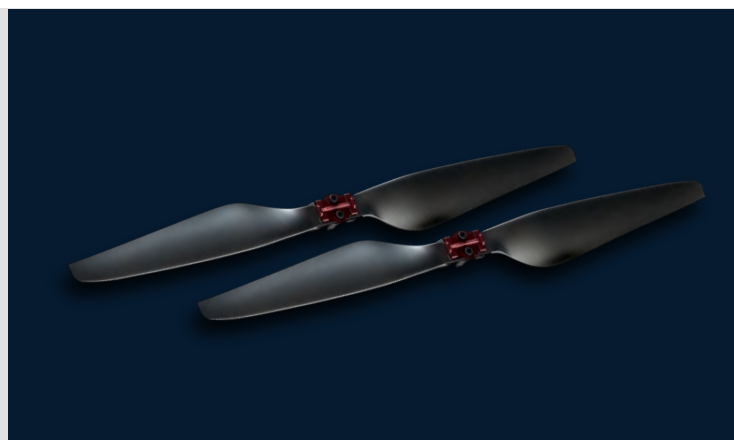
Intelligent battery

With an innovative battery protection scheme, it is easy to view parameters such as battery power and battery working status. Moreover, a complete safety protection logistic is developed to reasonably and comprehensively ensure the safety of battery use.



Quick release propeller

Professional pneumatic shape design and exquisite processing technology ensure the performance and quality of the propellers. The propellers of D2000S can be quickly disassembled and assembled without tools, which is convenient and reliable.



Key components



RTK100 GNSS base station (optional)

RTK100 is an independently developed GNSS reference stations by Feima Robotics, supporting RTK and PPK fusion solution via the software of UAVManager Professional Edition.

HGS2000 handheld ground station (Optional)

Portable ground station; compatible with D2000S; built-in tablet computer and digital radio; supporting route planning; flight monitoring and flight control



Screen size	8 inches (with touch)
Screen Resolution	1920 x 1200@60 Hz
Built-in battery capacity	13000 mAh
operating system	Linux
Adapter parameters	19 V/4.4 A
Storage	Built-in 32 GEMMC + external MicroSD card holder
Built-in video frequency	1427 MHz~1447 MHz
Built-in data transmission frequency	840 M~845 M
Front camera	500 million pixels
Microphone	Built-in and external headset
USB interface	TYPE A+TYPE C(Compatible with USB2.0)
Wireless network	5G network Wi-Fi (optional)
Wired network	RJ45 interface supporting Gigabit Ethernet
Power bank charging	Supported (requiring a power bank that supports PD)
HDMI output	Supported
Total Weight	1700 g
Dimensions	305 mm × 175 mm × 70 mm
Total power consumption	13 W
Battery life	≥6 H
Operating temperature	-10°-50°
Storage temperature	-20°-60°

Key components

Platform Configurations

Order	Component name	Unit	Quantities
1	D2000S UAV platform	set	1
2	D2000S ground data transmission module	set	1
3	UAVManager Professional Edition	set	1
4	D2000S intelligent battery	groups	2
5	D2000S intelligent battery charger	piece	1
6	D2000S transport box	piece	1



Whole packaging

Modular design, easy to carry and transport

Dimensions: 55 cm × 29.5 cm × 67.5 cm

Total weight: 12.34 kg(including standard modules and accessories)

Platform configurations

D-CAM2000



Photogrammetric module

D-CAM3000



Photogrammetric module

D-OP3000



Oblique photographing module

D-OP4000



Oblique photographing module

D-EOV2000



Dual visible light video module

D-TIRV1000



Thermal infrared and visible light video module

D-MSPC2000



Multispectral remote sensing module

D-LiDAR2000



LiDAR module

D-LiDAR3000



LiDAR module

D-LiDAR500



LiDAR module



Photogrammetric module

D-CAM2000 (optional)

Flight efficiency table (orthophoto photographing)

speed	GSD	relative flight height	area of each sortie	daily area	flight range
(m/s)	(cm)	(m)	(km ²)	(km ²)	(km)
13.5	2	128	2.09	16.72	45
	3	192	3.12	24.92	
	5	321	5.13	41.04	
	8	513	8.10	64.80	

supposing 8 sorties per day, 80%×60% overlap degree, conventional route design

Flight Efficiency Table (oblique photographing)

speed	GSD	relative flight height	area of single sortie		daily area		flight range
			for best texture	routine work	for best texture	routine work	
(m/s)	(cm)	(m)	(km ²)	(km ²)	(km ²)	(km ²)	(km)
8	1.5	74	0.08	0.12	1.45	1.63	30
						3.48	
13.5	2	98	0.20	0.29	3.13	3.48	45
	2.5	123	0.24	0.37	3.90	4.39	
	3	147	0.28	0.45	4.64	5.28	

supposing 8 sorties per day, one block, 80%×80% overlap degree, cross-route design



D-CAM3000 (optional)

Flight efficiency table (orthophoto photographing)

speed	GSD	relative flight height	area of each sortie	daily area	flight range
(m/s)	(cm)	(m)	(km ²)	(km ²)	(km)
13.5	2	213	3.28	26.28	45
	3	319	4.88	39.00	
	5	532	8.02	64.15	
	8	851	12.63	101.06	

supposing 8 sorties per day, 80%×60% overlap degree, conventional route design

Flight Efficiency Table (oblique photographing)

speed	GSD	relative flight height	area of single sortie		daily area		flight range
			for best texture	routine work	for best texture	routine work	
(m/s)	(cm)	(m)	(km ²)	(km ²)	(km ²)	(km ²)	(km)
13.5	1.5	122	0.23	0.35	3.71	4.16	45
	2	163	0.29	0.48	4.89	5.58	
	2.5	204	0.34	0.60	6.02	6.99	
	3	244	0.39	0.72	7.12	8.39	

supposing 8 sorties per day, One block, 80%×80% overlap degree, cross-route design

Payloads

Oblique photographing module

D-OP3000(optional)

Payload parameters	
Camera model	SONY ILCE-6000
Sensor size	23.5 mm × 15.6 mm (aps-c)
Effective pixels	about 120 million (24.3 million for each)
Lens	25 mm fixed focus (nadir) 35 mm fixed focus (oblique)



D-OP4000(optional)

Payload parameters	
Camera model	SONY ILCE-7RM4A
Resolution	9504 × 6336 pixels
Effective pixels	about 305 million (61 million for each)
pixel size	3.76 μm
Sensor size	35.7 mm × 23.8 mm
Lens	40 mm fixed focus (nadir) 56 mm fixed focus (oblique)
Oblique angle	45°

Flight Efficiency Table (oblique photographing)

speed	GSD	relative flight height	area of single sortie		daily area		flight range
			for best texture	routine work	for best texture	routine work	
(m/s)	(cm)	(m)	(km ²)	(km ²)	(km ²)	(km ²)	(km)
8	1.5	96	0.42	0.68	3.63	4.34	24
	2	128	0.93	1.44	7.81	9.19	
13.5	2.5	160	1.08	1.78	9.51	11.44	38
	3	192	1.21	2.12	11.15	13.66	

supposing 8 sorties per day, one block, 80% × 80% overlap degree, conventional route design

Flight Efficiency Table (oblique photographing)

speed	GSD	relative flight height	area of single sortie		daily area		flight range
			for best texture	routine work	for best texture	routine work	
(m/s)	(cm)	(m)	(km ²)	(km ²)	(km ²)	(km ²)	(km)
	1.5	160	1.09	1.76	9.24	11.04	
	2	213	1.32	2.32	11.91	14.66	
13.5	2.5	266	1.50	2.87	14.44	18.25	38
	3	319	1.65	3.42	16.85	21.81	

supposing 8 sorties per day, one block 80% × 80% overlap degree, conventional route design

Payloads

Dual visible light video module D-EOV2000 (optional)



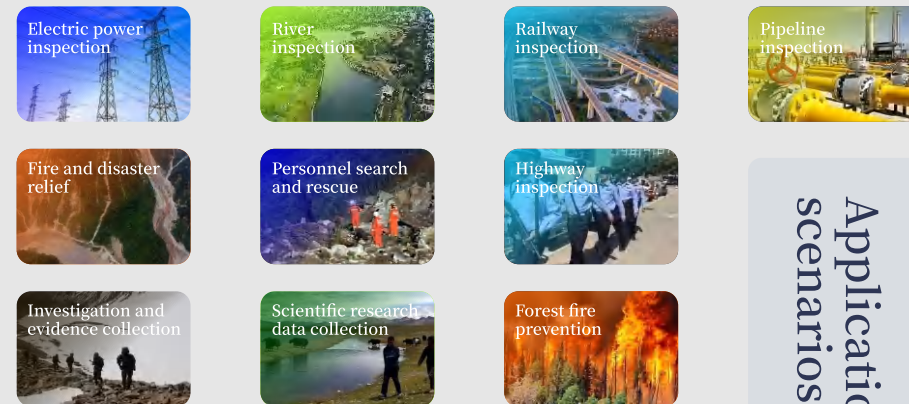
- Continuous zoom
- Local image transmission
- Photo and video recording
- PIP
- Pointing and positioning
- Remote transmission
- Visual tracking
- Visual surrounding



- Dual one-inch, 20.3 megapixel sensors
- Dual constant aperture lens (fixed & zoom)
- Up to 12X lossless zoom
- Up to 4K @ 60 fps mode
- Three-axis gimbal stabilization and electronic image stabilization
- Supporting PIP mode
- With pointing and positioning, visual surrounding function
- With intelligent tracking function (automatic zoom during tracking)
- Supporting both high-definition video and high-resolution image acquisition
- Supporting extended 4G/5G networking (need to purchase additional extended communication module)

Pyaload parameters

Video movement gimbal	Sensor size	1 inch
	Sensor effective pixels	20.3 million+2030
	Video resolution	3840 × 2160, 2376 × 1536, 1920 × 1080, 1280 × 720
	Image transmission resolution	1920 × 1080, 1280 × 720
	Real-time video frame rate	30 fps
	Zoom factor	12X(720p) 8.3X(1080p)
	Lens focal length	12 mm+35 mm
	Lens aperture	F/4.0+F/4.0
	Onboard video storage	supported
	Storage format	mp4
Parameter image transmission	Video encoding	H.265 (default), H.264 (optional)
	Storage method	built-in 32 Gigabyte TF card
	Number of axes	three axes
	Gimbal stabilization accuracy	relative stabilization accuracy ±0.005°; absolute stabilization accuracy ±0.1°
Parameter vision	Controllable rotation range	Tilt: -20° to +120°; Pan: ±270°
	Structural designed rotation range	Tilt: -60° to +160°; Pan: ±300°; Roll: -65° to +65
	Working frequency	1427 MHz~1447 MHz
Tracking	Transmit power	24±2 dBm
	Transfer Protocol	Proprietary protocol (extensible to support AES256 and AES128 encryption)
	Channel bandwidth	supporting 1.4, 3, 5, 10, and 20MHz
	Image transmission distance	10 kilometers (no interference, no occlusion)
Tracking	Target size	15 to 510 pixels
	Automatic target detection	supported
	Target turn and U-turn tracking	supported
	One-time tracking	supported
	Tracking target dynamic switching	supported



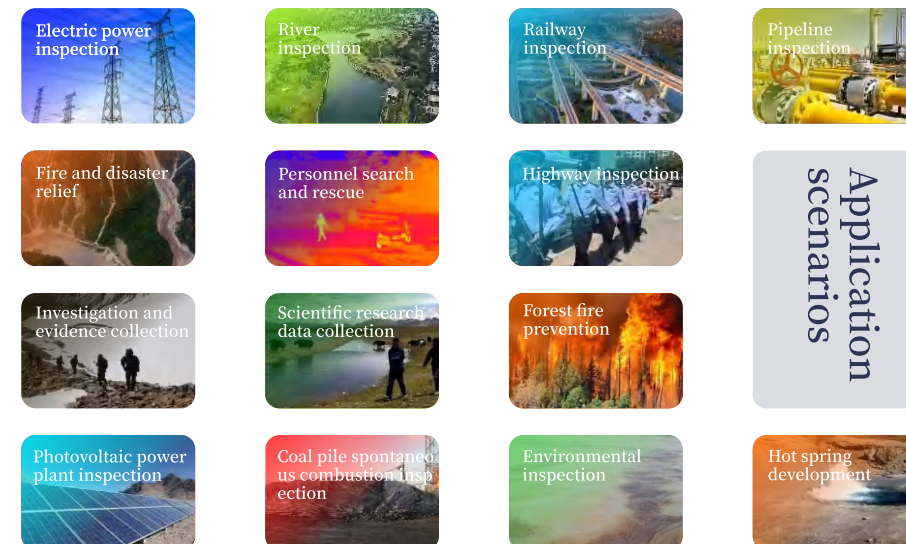
Application scenarios

Payloads

Video module

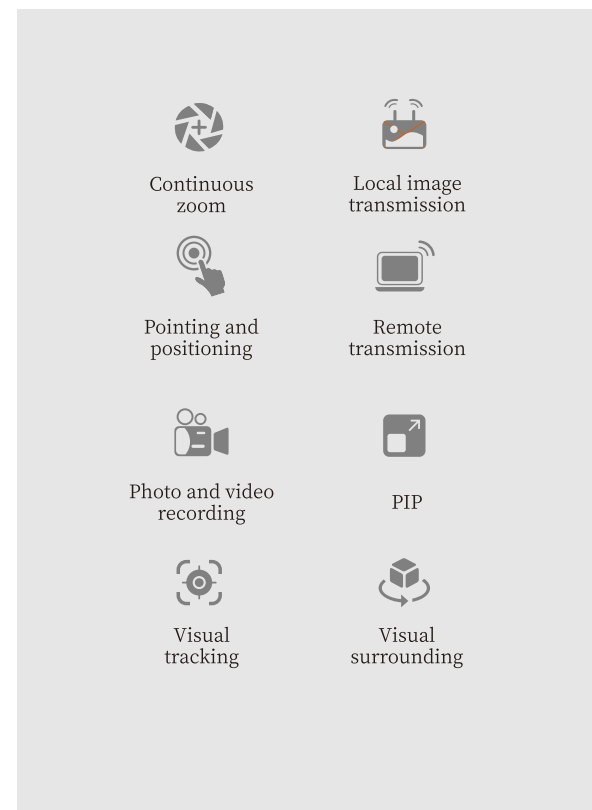
D-TIRV1000 (optional)

Integrated thermal infrared and visible light video



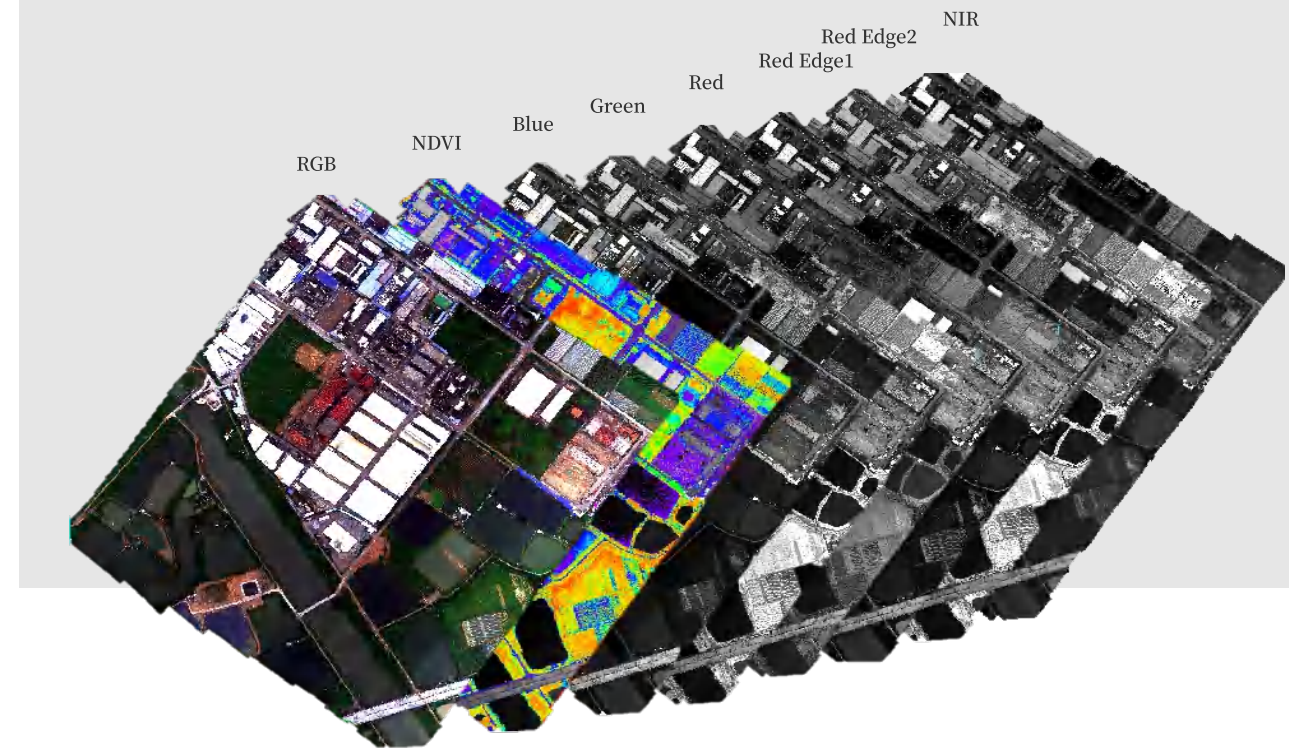
Pyaload parameters

Thermal infrared movement	Detector type	Vanadium Oxide Uncooled Infrared Focal Plane Detector
	Video resolution	640 × 512 (thermal infrared)
	Detector frame rate	50 Hz/30 Hz
	Response band	8~14 μm
	Lens focal length	13 mm (equivalent focal length 57mm)
	Digital zoom	1.0~8.0×Continuous zoom (step of 0.1)
	Pixel size	12 μm
visible light sensor	NETD	≤50 mK@25 °C,F#1.0
	Stabilization gimbal	Three-axis stabilization gimbal
	Temperature measurement range	-20 °C~+150 °C, 0~+550 °C
	Sensor size	1 inch
image transmission parameters	Effective pixels	20.3 million
	Lens focal length	12 mm
	Stabilization gimbal	Three-axis stabilization gimbal
image transmission parameters	Working frequency	1427 MHz~1447 MHz
	Transmission power	24±2 dBm
	Channel bandwidth	Supporting 1.4, 3, 5, 10, and 20MHz
	Image transmission distance	10 km (no interference, no blockage)



Payloads

Multispectral module D-MSPC2000 (optional)



Pyaload parameters

Adapted UAV platform	D2000/D2000S/D500/D20	Ground Resolution	GSD:8.65 cm/pix, AGL:120 m
Sensor parameters	CMOS:1/3" global shutter	Storage	128 GB (Maximum)
Effective pixels	1.2 million	Number of bands	6
Resolution	1280 × 960		450 nm(35 nm)
Sensor size	4.8 mm × 3.6 mm		555 nm(25 nm)
Focal length	5.2 mm	Band configuration (standard)	660 nm(22.5 nm)
Field of View	HFOV:49.6°, VFOV:38°		720 nm(10 nm)
Aperture	F/2.2		750 nm(10 nm)
Shooting speed	one time per second		840 nm(30 nm)



Land feature classification



Forestry survey



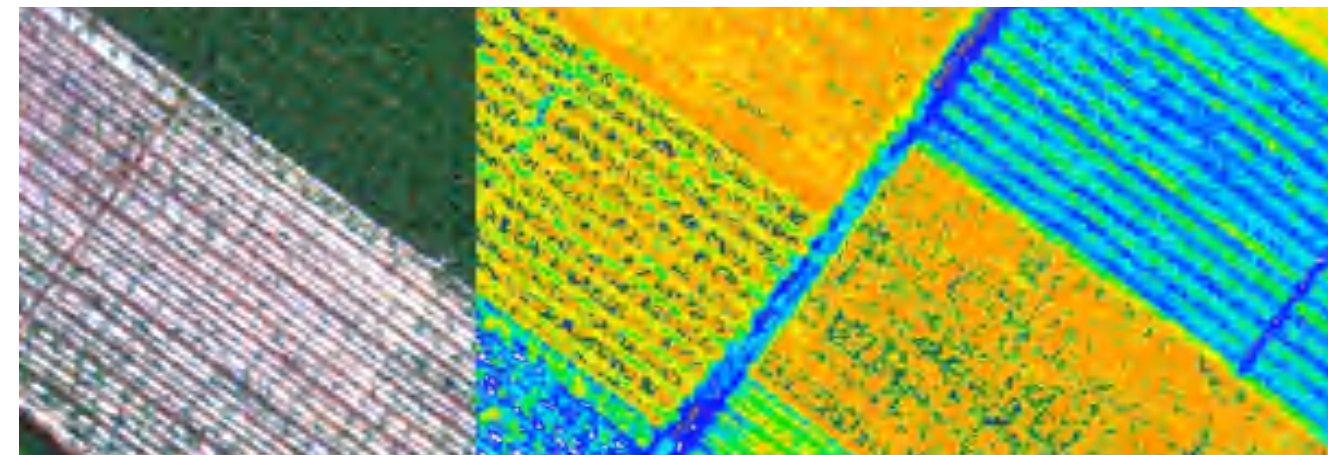
Vegetation statistics



Growth assessment



River monitoring



Payloads

Lidar Module D-LiDAR2000 (optional)

Pyaload parameters

Model	D-LiDAR2000
Adapted UAV platforms	D2000/D2000S/D500/D20
Horizontal field of view	70.4°
Vertical field of view	4.5°/77.2°
Accuracy	5 cm @ 50 m
Measuring range	190 m @ 10% ρ @ 100klx 450 m @ 80% ρ @ 0klx



Laser	Ranging mode	TOF	POS	Horizontal positioning accuracy	0.01 m
	Laser class	Class 1		Height difference positioning accuracy	0.02 m
	Wavelength	905 nm		Roll & Pitch Accuracy	0.006°
	Laser pulse repetition rate	240 kpts/s		Heading angular accuracy	0.03°
	Echoes	3		GNSS data update frequency	20 Hz
	Echo signal intensity	8 bits		Inertial navigation data update frequency	200 Hz
	Ranging accuracy	±2 cm			

Flight Efficiency Table

relative flight height (m)	point cloud density (pts/m ²)	area of each sortie (km ²)	daily area (km ²)	flight range (km)
70	259	2.61	15.65	38
100	181	3.73	22.35	
150	121	5.59	33.53	
200	91	7.45	44.70	
300	60	11.18	67.05	

Supposing 6 sorties per day with a side overlap of 30% and a cruising speed of 13.5 meters per second

Applicable scenarios



Topographic mapping



Vegetation statistics



Power line patrol



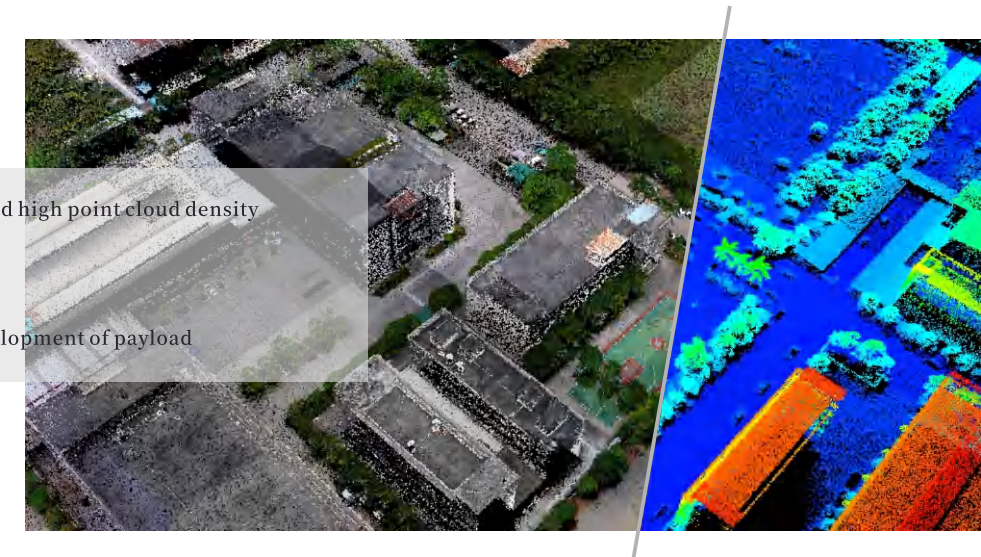
Volume calculation



3D modeling

Advantages

- Low cost, high precision and high point cloud density
- 24/7
- Automatic data acquisition
- Raw data compression
- Supporting secondary development of payload



Payloads

Lidar module

D-LiDAR500(optional)

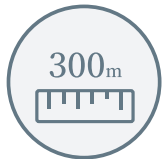
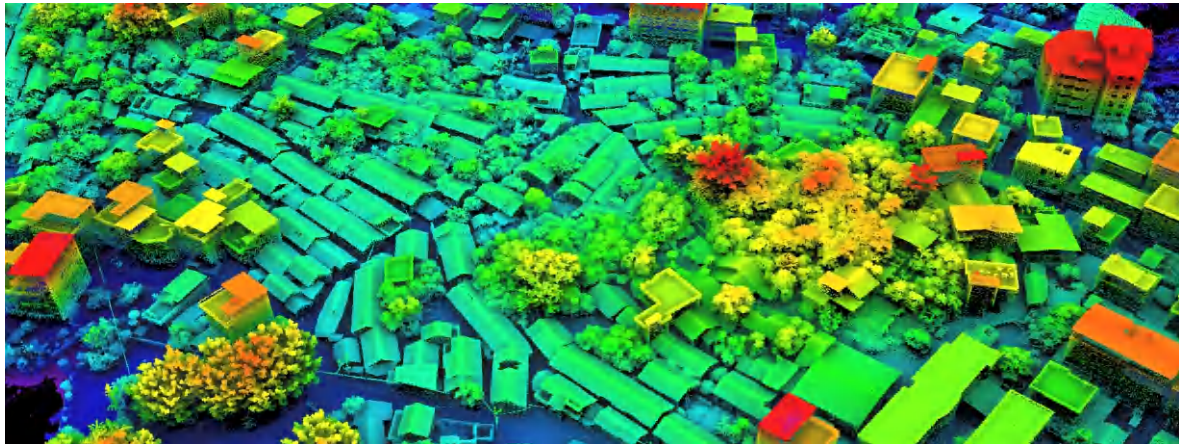
D-LiDAR500 adopts a small Chinese domestic high-precision LiDAR and equipped with a 20 mm focal length APS-C frame camera, with the characteristics of high laser pulse repetition rate, long measuring range, and three echoes, and can perform high-precision terrain mapping, power line inspection and other three-dimensional point clouds acquisition.



Payload parameters

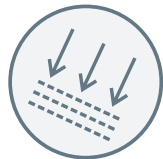
Adapted UAV platforms	D2000/D2000S/D500/D20
Weight	1060 g
Dimensions	145.3 mm × 110 mm × 137.2 mm

Laser	Ranging mode	TOF	POS	Horizontal positioning accuracy	0.01 m
	Laser class	Class 1		Height difference positioning accuracy	0.02 m
	Wavelength	905 nm		Roll & pitch accuracy	0.006°
	Laser pulse repetition rate	640 kpts/s		Heading angular accuracy	0.03°
	Echoes	3		GNSS data update frequency	20 Hz
	Echo signal intensity	8 bits	Camera	Inertial navigation data update frequency	300 Hz
	Ranging accuracy	±2 cm		Effective pixels	2.43 million
	Horizontal field of view	360°		Sensor size	23.5 mm x 15.6 mm
	Vertical field of view	40.3°		Focal length	20 mm
	Measuring range	300 m		Field of view	61°



300m Measuring range

Longer ranging, high operational efficiency, and more flexible flight plans



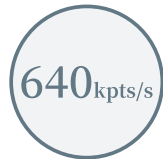
Three echoes

Longer ranging, high operational efficiency, and more flexible flight plans



360° x 40.3° field of view

Combined with the intelligent laser cutting algorithm integrated in SmartLiDAR, the side data is easier to protect



High laser pulse repetition rate

32 channels and a single echo contains 640,000 points per second, suitable for high-density demand scenarios

Flight Efficiency Table

relative flight height	point cloud density	area of each sortie	daily area	flight range
(m)	(pts/m ²)	(km ²)	(km ²)	(km)
60	146	2.34	14.04	30
80	110	3.12	18.72	
100	88	3.90	23.40	
120	74	4.68	28.08	
150	58	5.85	35.10	

Supposing 6 sorties per day with a side overlap of 35% and a conventional route

Safety mechanism

Autopilot

Autopilot of D2000S

Model-based flying control logistics

Advanced multi-sensor data fusion algorithm

Redundant sensor design for increased operational security

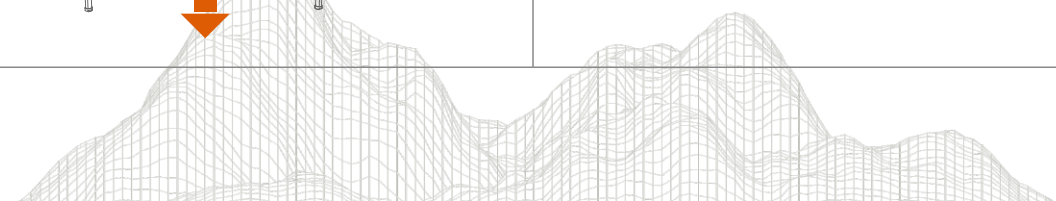
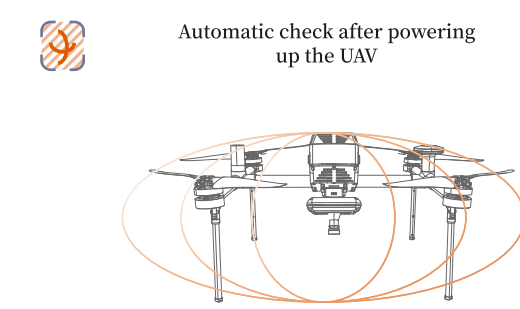
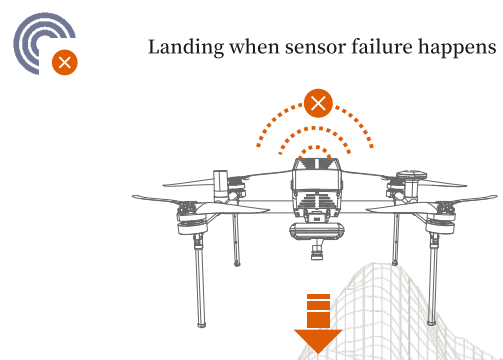
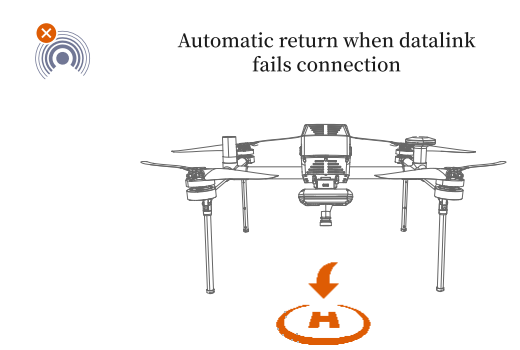
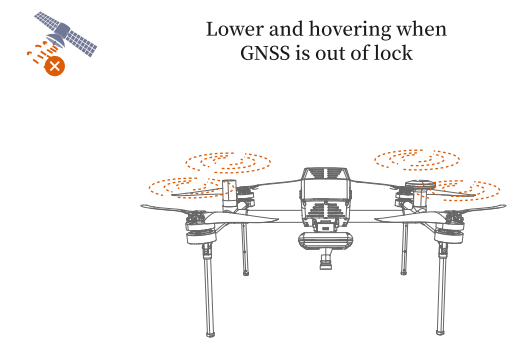
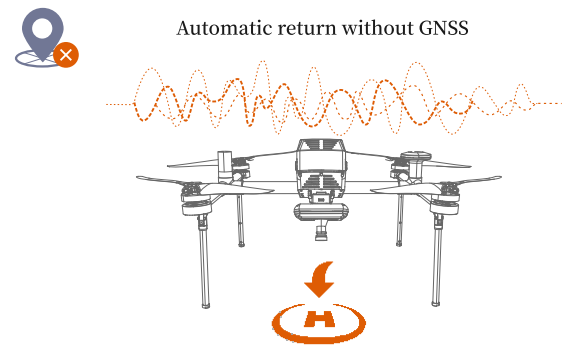
Real-time fault detection and fault isolation algorithms

High-precision heading and attitude measurement system

Fully automatic task mode

Efficient embedded software system and modular design, Supporting multiple payloads

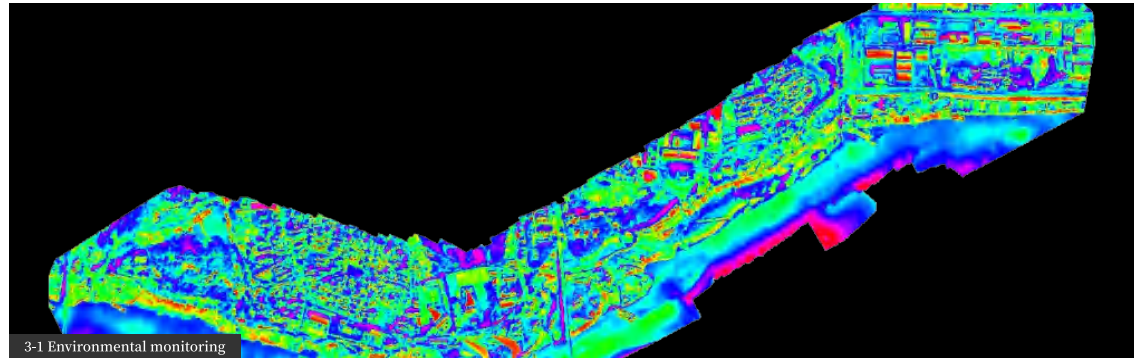
Supporting RTK, PPK and their fusion solution to provide centimeter-level positioning accuracy



Applications scenarios

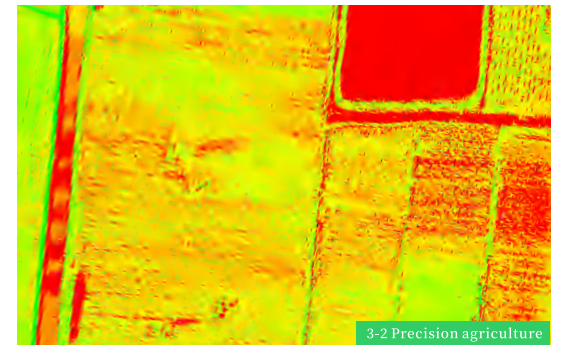
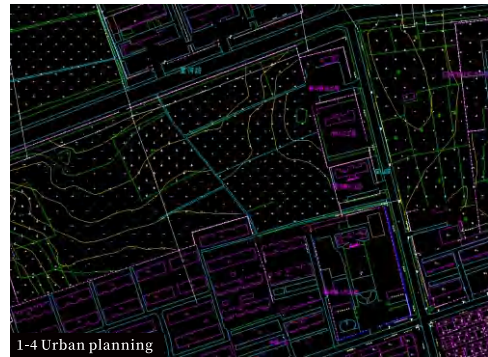
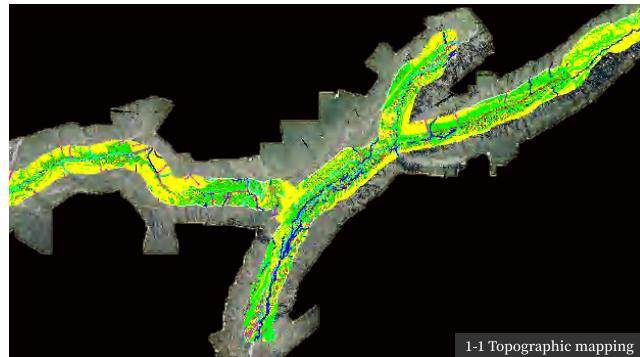
High-precision topographic mapping

- 1-1 Topographic mapping
- 1-2 Engineering survey (water conservancy)
- 1-3 Land survey
- 1-4 Urban planning



High-precision 3D modeling

- 2-1 Digital city
- 2-2 Cultural relics protection
- 2-3 BIM application
- 2-4 Emergency monitoring



Remote sensing monitoring

- 3-1 Environmental monitoring
- 3-2 Precision agriculture



Application cases

Large-scale image-control free mapping test

The D2000S is equipped with a single camera for data acquisition in a certain area. The route is designed as a control strip mode. The relative altitude is 255 meters with the corresponding ground resolution being 5 centimeters. And the forward overlap and side overlap are 80% and 65% respectively. Besides, RTK and PPK fusion differential solution is adopted to acquire high-precision GNSS data.



First perform PPK/RTK fusion differential calculation on the base station data and rover GNSS data in the SmartProcess module of UAVManager Professional Edition to obtain differential POS data. Next, perform correction for centering based on the flight attitude and placement angle of the payload to obtain the high-precision POS data of camera projection center.

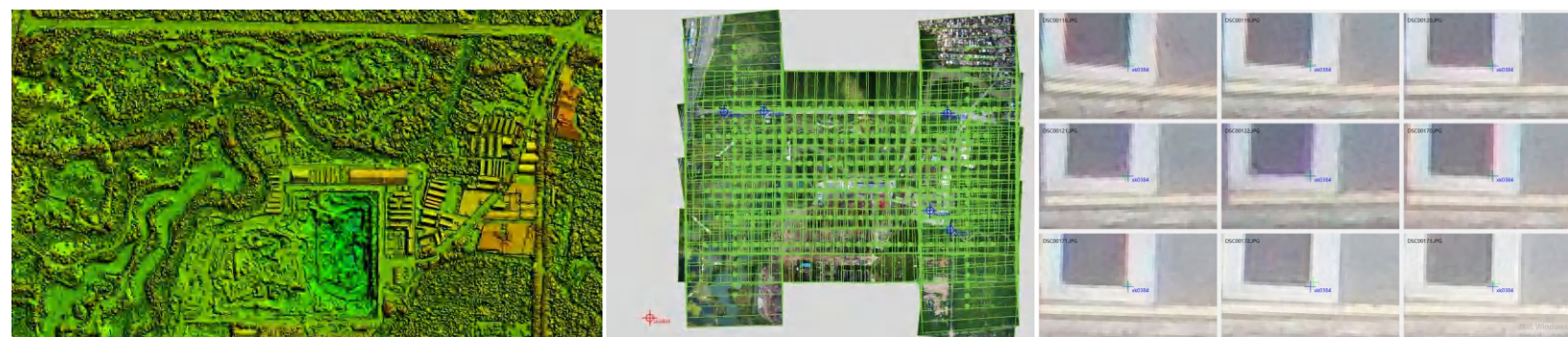
Use the high-precision GNSS data of the camera center to create a new project in SmartMap Module of UAVManager Professional Edition. Then, based on the additional parameters of RTK and PPK fused GNSS data, the additional parameters-aided orientation algorithm without control points is utilized to perform aerotriangulation processing. Import the control point file of the survey area to complete the measuring points work, and set all the control points as check points. It can be seen from the statistics on the upper right that only an average deviation of one to two pixels exists between the actual point positions to the corresponding software predicted point positions.

Aerotriangulation accuracy statistics

Predicted point positions relative to actual point positions				
ID	TYPE	DX(m)	DY(m)	DZ(m)
xk0184	CHK	0.164	-0.03	-0.115
xk0284	CHK	-0.011	-0.042	-0.027
xk0384	CHK	0.002	-0.027	-0.041
xk0584	CHK	-0.006	-0.062	-0.019
xk0684	CHK	0.056	-0.013	-0.009
RMSE of plane				0.087
RMSE of height				0.057

Output DOM and DEM accuracy statistics

Measuring positions relative to actual positions of check points			
ID	TYPE	DXY(m)	DZ(m)
xk0184	CHK	0.12	-0.12
xk0284	CHK	-0.052	0.08
xk0384	CHK	0.081	-0.043
xk0584	CHK	0.076	0.052
xk0684	CHK	0.085	-0.12
RMSE of height		0.085	0.089

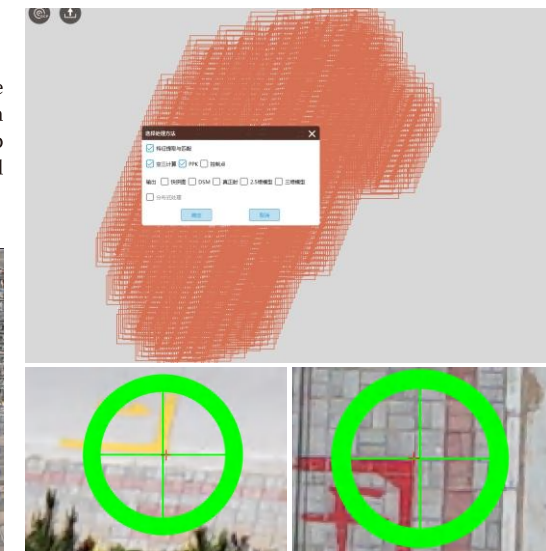


Application cases



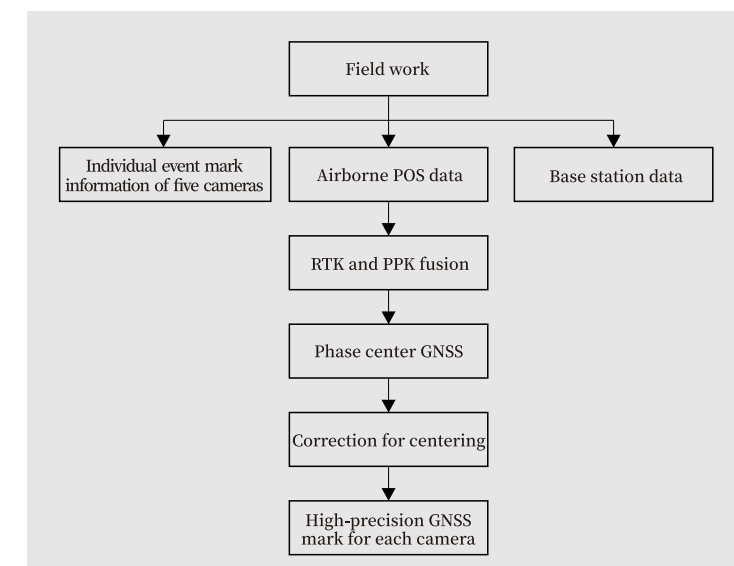
Cadastral mapping

The D2000S is equipped with penta-head oblique module for oblique image acquisition in a certain area. The designed relative height is 96 meters with the corresponding ground resolution is 1.5 centimeters. The forward overlap is 80% and the side overlap is 70%. Besides, RTK and PPK fusion differential solution is adopted to acquire high-precision GNSS data.



Accuracy inspection of in situ check points

ID	DX(m)	DY(m)	DZ(m)
Coners1	-0.009	0.017	—
Coners2	0.037	-0.018	—
Coners3	0.016	0.012	—
Coners4	0.005	-0.003	—
Coners5	-0.023	-0.053	—
Coners6	-0.004	-0.036	—
Coners7	-0.066	0.003	—
Coners8	0.028	0.023	—
Coners9	0.006	-0.004	—
Height I	—	—	0.031
Height II	—	—	-0.03
Height III	—	—	-0.026
Height IV	—	—	0.002
Height V	—	—	0.03
Height VI	—	—	0.04
Height VII	—	—	-0.003
RMSE of plane	0.038		
RMSE of height	0.028		



Application cases

Thermal infrared remote sensing solution

The thermal infrared remote sensing module mounted on D2000S adopts a high-sensitivity thermal infrared sensor from FLIR. The thermal radiation value of each pixel in the original thermal infrared image has been accurately corrected, and an accurate temperature inversion model is used to achieve non-contact accurate temperature measurement capability.

The thermal infrared data processing function in the SmartMap module of the UAVManager Professional Edition can realize one-key thermal infrared mapping to generate orthophoto image and thermal radiation image at the same time. Also, real surface temperature distribution map can be output to accomplish the accuracy inspection of temperature control points, of which the software operation is simple.

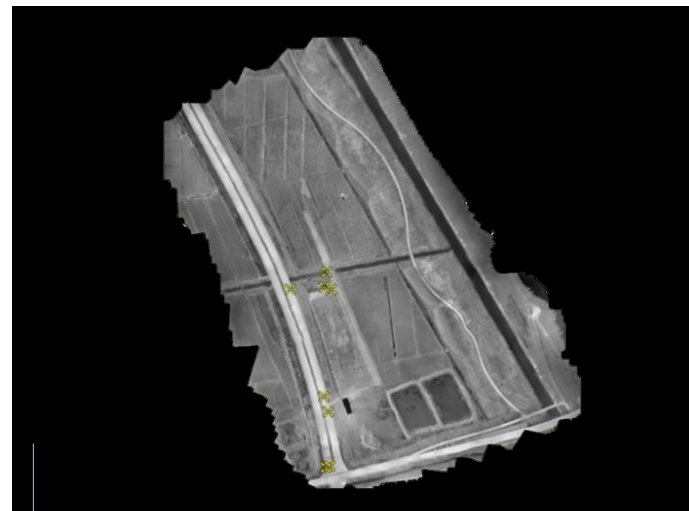
Flight design parameters

GSD	17 cm
Relative altitude	120 m
Forward overlap	80%
Side overlap	60%
One sortie	

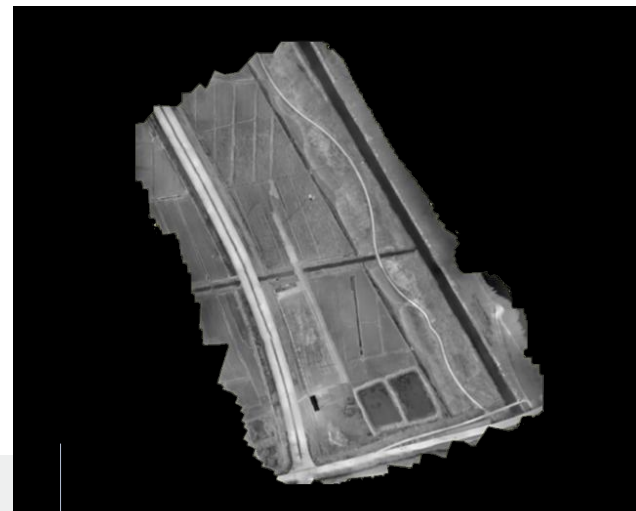
Temperature measurement accuracy of thermal infrared remote sensing module;
 Temperature inversion accuracy: better than 2 degrees

Temperature inversion results

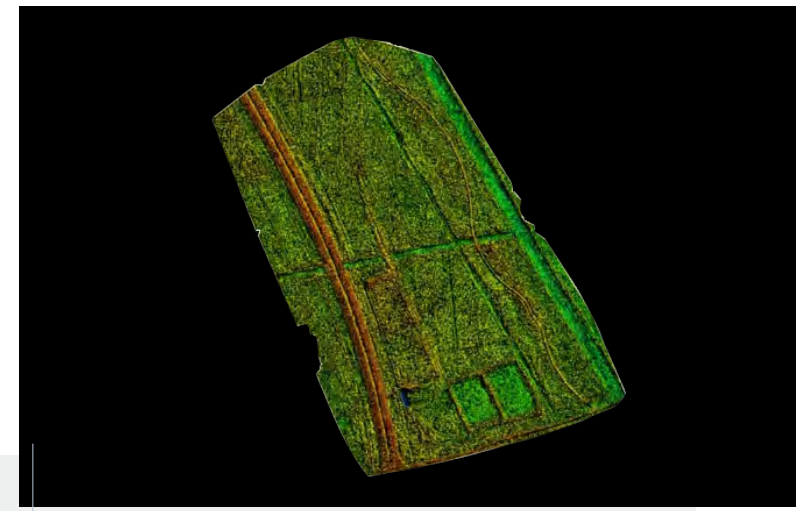
Point ID	Latitude	Longitude	Height	Gray value	In situ measured temperature (°C)	Inversion result	Deviation
Dirt road 1#	39:33:12.84205	117:24:12.92391	-4.7356	7351.04	17.72	18.892	-1.1720
Plastic green belt	39:33:27.644254	117:24:12.728714	-2.81648	7323.152	18.14	19.776	-1.6360
Cement road 2#	39:33:26.283450	117:24:13.125973	-2.90608	7339.966	19.30	20.449	-1.1490
Asphalt road 2#	39:33:18.174569	117:24:12.336875	-2.48054	7394.865	22.20	22.645	-0.4450
Brick road 2#	39:33:26.317183	117:24:9.143035	-2.25588	7364.417	22.30	21.427	0.8730
Brick road 1#	39:33:16.996839	117:24:12.790675	-2.30236	7397.923	24.12	22.767	1.3530
Asphalt road 1#	39:33:12.76086	117:24:12.56192	-3.83254	7314.01	21.94	20.41	1.5300
Container house 1#	39:33:26.46077	117:24:12.50234	-2.2678	7257.574	17.72	17.153	0.5670
RMSE							1.2434



Temperature measurement point distribution



Thermal infrared image results



Temperature inversion results

Application fields

Thermal infrared remote sensing can distinguish any object with differences in temperature or radiation characteristics, and can be used in the following applications.

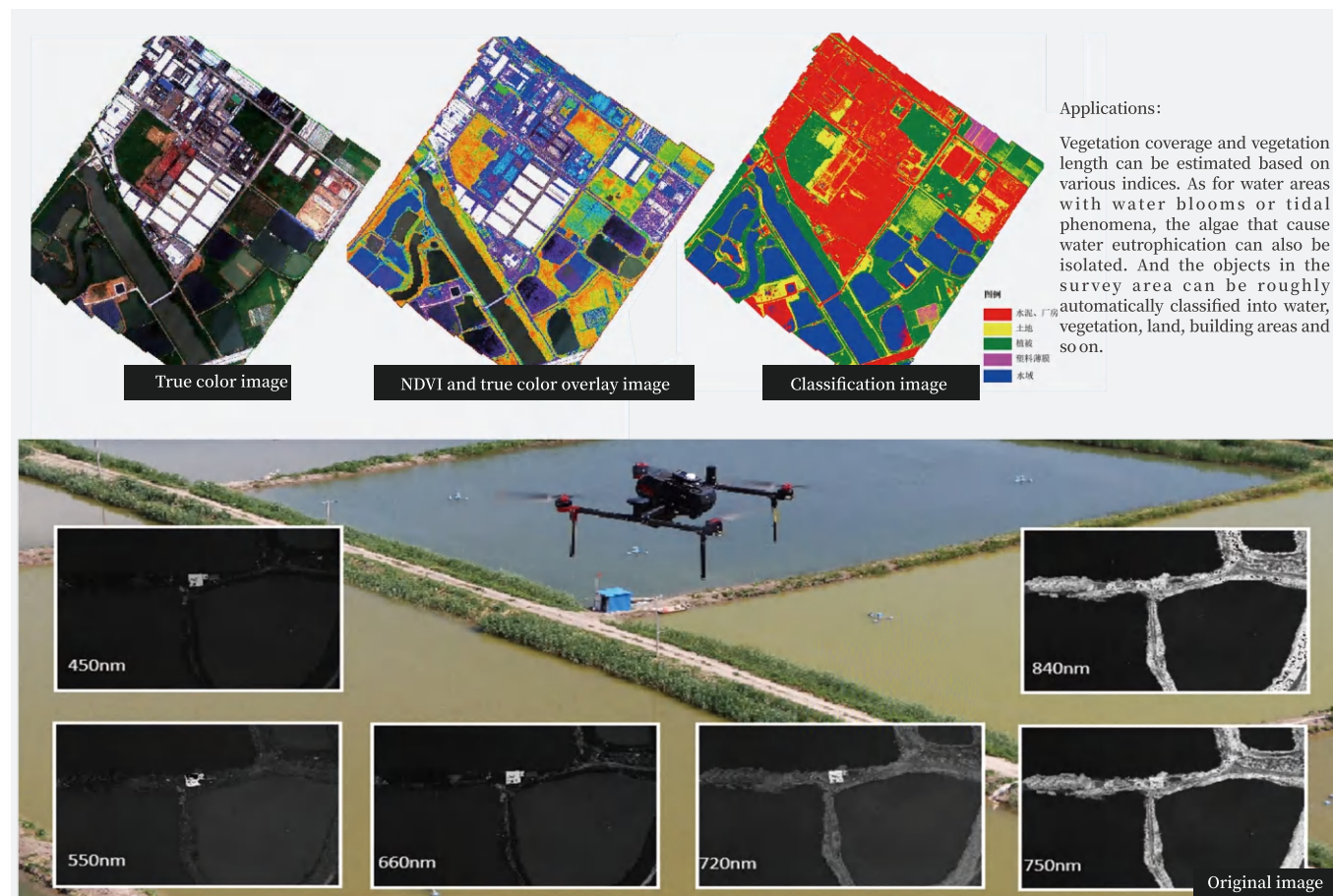
- Regional geological survey
- Geothermal survey
- Fire and coverage surveys
- Environmental pollution survey
- Industrial heat flow and heat loss monitoring
- Various natural disaster investigations

Application cases

Multispectral remote sensing solution

D-MSPC2000

A typical regional multispectral data collection was conducted in the suburbs of a Chinese city, with a 25 minutes flight covering a total area of 0.8 square kilometers and obtaining a total of 563×6 multispectral images. There are typical scenes such as factories, ponds, banana orchard, and vegetable gardens in the area.

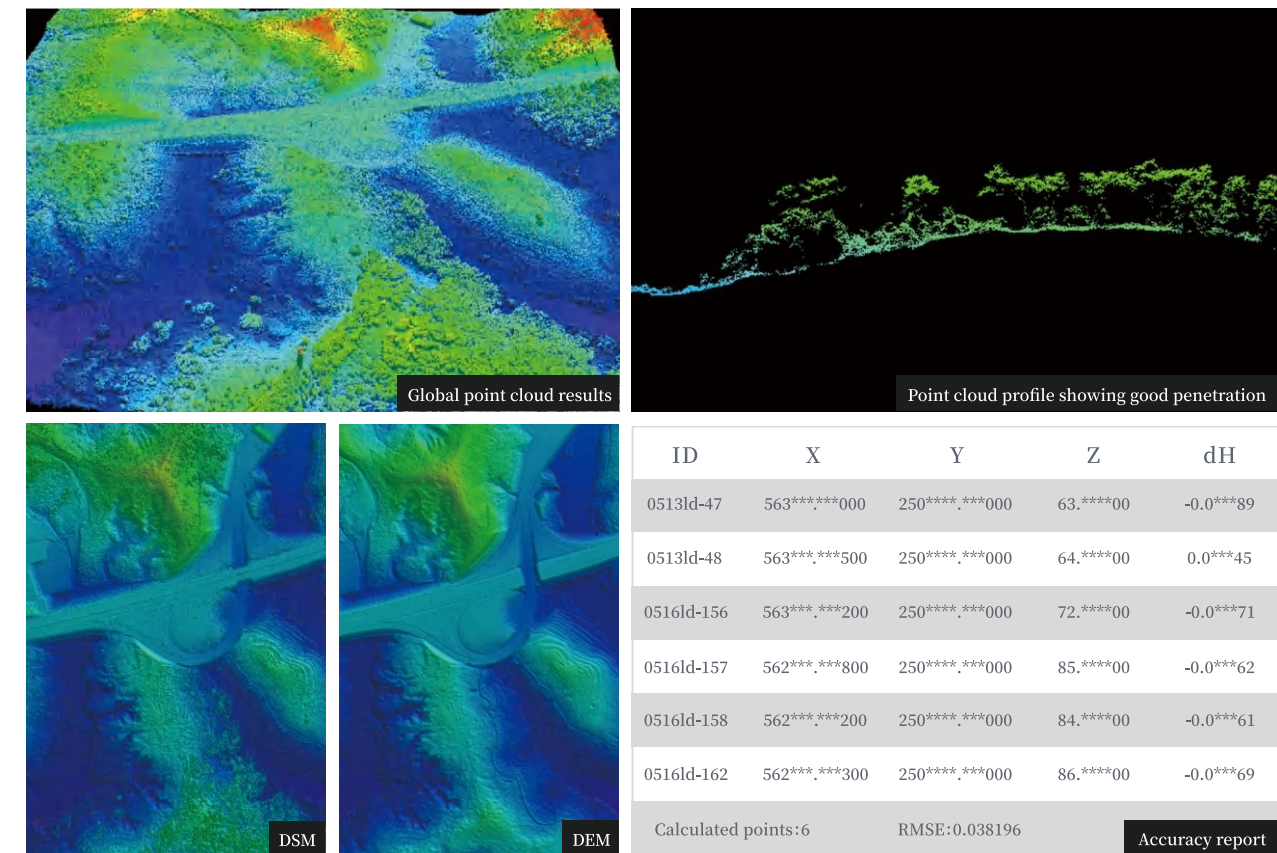


Light and small LiDAR solution

D-LiDAR2000

A high-precision terrain data acquisition project has been accomplished in a certain densely wooded area of Guangdong province, China. The D2000S equipped with D-LiDAR2000 was utilized to acquire point cloud data. The vegetation coverage area basically has ground point penetration, which can better fit the terrain. Through point cloud filtering and editing, the final obtained point cloud accuracy is 3.8 centimeters.

Relative altitude:120 m
Flight area:0.502 km²
Flight duration:27 minutes
Speed:8 meters per second



Supporting software



UAVManager Professional Edition supports both Windows and iPad clients.

UAVManager



Professional Edition

UAVManager Professional Edition is a one-stop intelligent GIS system for UAV flight plan and manipulation, data acquisition, data processing, display and management, and UAV maintenance.

According to different kinds of application purposes, automatic and accurate flight planning based on real scene 3D terrain data are integrated to UAVManager Professional Edition for both fixed-wing UAVs and rotorcrafts. Moreover, 3D real-time monitoring, fast quality inspection for flights, pre-processing tool box, robust accuracy control and automatic stitching, 4D outputs, visual monitoring center, and cloud services (e.g., system update, intelligent maintenance, and information pushing) are provided by UAVManager.



SmartPlan
Simple and reliable 3D route design

SmartPlan is a route planning software for fixed-wing and rotor UAVs. It can automatically generate the best flight plan and route for post-processing based on high-precision real 3D terrain according to the terrain fluctuations and image requirements of the mission area. The task area can be automatically divided at any angle and the route angle can be adjusted to meet the needs of post-processing. Adapting to the requirements of sensor application mode, the terrain fitting automatic route algorithm based on high-precision 3D model generates accurate terrain following flight plans and routes to ensure the consistency of the acquired data throughout the flight.



SmartFly
Real-time 3D display of flight status

SmartFLY is a UAV flight monitoring software, which can visually monitor the flight status and parameters in real-time 3D scenes, modify certain flight control parameters, and provide intelligent early warning to ensure the safe execution of flight missions. By regarding the pending project as a virtual sortie, it helps to obtain the data of a single sortie according to the actual field conditions, and automatically continue the flight through the software to complete the coverage of the whole area and improve the work efficiency.

Software features

1.Scene-adaptive high-precision automatic 3D route

According to the aerial photography parameters such as the area scope, terrain fluctuations, image resolution, payload, and overlap requirements, the optimal flight route that adapts to different terrains is automatically generated based on the 3D terrain data. A variety of strip routes are supported such as block route, strip route, control strip route, cross route, facade route and surrounding route.

2.Precise terrain following route based on high-precision 3D terrain

It adapts to the requirements of payload operation and application over complex ground scenes. Combined with the generic or self-imported high-precision 3D terrain data and self-developed automatic routing algorithm, it can automatically generate accurate terrain-fitting routes to ensure the consistency of obtained image resolution and LiDAR point cloud density.

3.Easy mapping

It is easy to outline an area for aerial photography by drawing polygons, rectangles or arbitrary lines. Moreover, the KML format file import, manual coordinates input, and map data caching are supported as well.

4.Intelligent flight block division

As for super large survey areas, the automatic block partition algorithm pioneered by Feima Robotics is used to achieve one-key division, edge matching and overlap, and mission assignment and management. It can also support block splitting at any angle for optimizing the route generation which is closer to the ideal planning of aerial photography in the survey area.

Software features

1.It provides a unified monitoring interface for both the fixed-wing and rotor UAVs. It supports different monitoring modes with aerial photography videos and supports operations using multiple sensors for different applications.

2.Visualizaion of 3D scenes, sorties, and status is supported, which enriches the information content for flight monitoring and improves monitoring quality for users.

3.It furnishes real-time visulizaion of flight track, UAV contition, wind speed, ground velocity, battery condition, onboard temperature, GPS positioning status, and other parameters.

4.Smart alert of flight abnormality and one-key return

5.Visualization playback of flight process

6.Guided interface design helps the beginners to fulfill take-off preparatory work with ease.



Operations before takeoff

1.Mission setting

HOME point position

Latitude	40.252342
Longitude	116.256878
GNSS altitude	100

Mission range

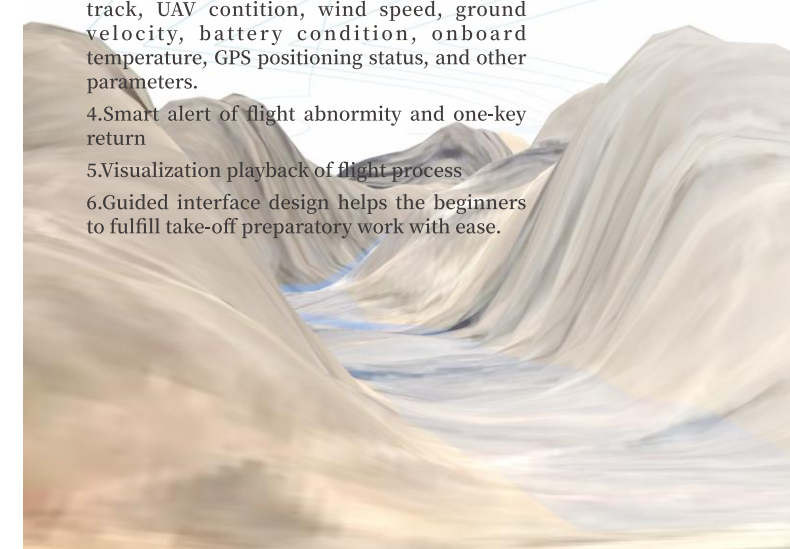
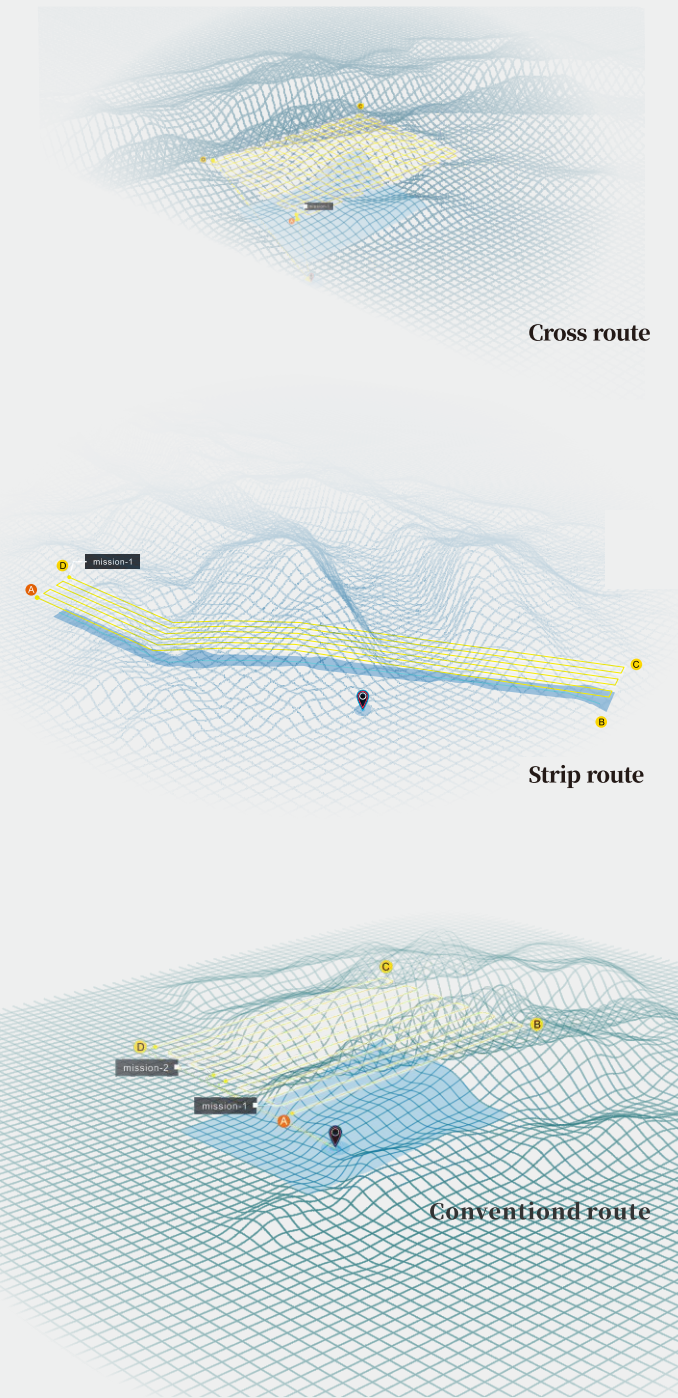
- Full flight
- Continue last flight
- Custom flight

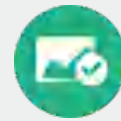
2.Camera inspection

3.UAV inspection

4.Task upload

5.Summary of pre-flight situation





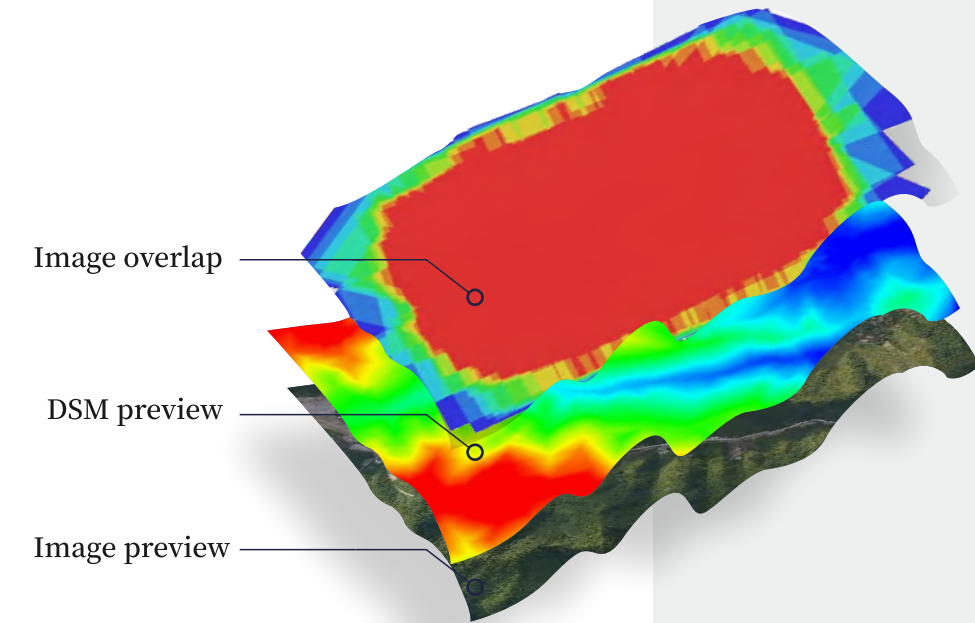
SmartCheck

Clearly displayed Flight date and quality report

SmartCheck is a professional and automatic software system for on-spot flight quality inspections and assessments. It helps to quickly generate quality reports and to improve the efficiency of data quality review and the reliability of subsequent image processings.

Software features

1. The highly automatic software system can complete data quality inspection for aerial photography with one click. It is easy to use with simple training even for beginner users.
2. Based on GPU parallel computing, it only takes 5 to 10 minutes from image input to quality report output. It is convenient for aerial photography operators to identify problems and take counter-measures in a timely manner.
3. It provides professional UAV data quality reports by means of graphical results and summary statistics for certain indices.
4. It supplies a variety of information, e.g., exposure stations, footprint, attitude over-run, and image connectedness for users to inspect data quality from multiple aspects.



Software interface

Exposure stations
 Footprint map
 Image ID
 Connection strength
 Image
 Route strips
 IMU over-run
 Roll > 4°
 Pitch > 4°
 Strip adjustment
 Strip

Mapping scale: 1:1000
 Mapping resolution: 0.10
 Forward overlap: 60%
 Side overlap: 30%
 Reset POS
 View result
 Run

Refresh route
 Refresh image

Quality inspection report
 Thumbnails
 POS data

UAV data quality inspection report

project overview	
project name	Test_area2
operation time	2016-11-04 10:37:04
survey area	6.9 square kilometers
camera type	DSC-RX1
average ground resolution	0.04 meters
coordinate system	UTM zone 49N
processing time	10'27"

project overview	
calculated images	1086
Adjustment situation	1086 successful
Matching pixels	40009
Number of matched pixels per image	42
Overlap distribution of matching points	2degrees:7623 3degrees:7755 4degrees:6548 5degrees:6117 5+degrees:11966
Mean Elevation of matched points	-3.26 Mean Elevation of matched points

Quality inspection conclusion

flight requirements	
mapping scale	1:1000
mapping resolution	0.10 meters
forward overlap	60%
side overlap	30%

Quality inspection conclusion

The average resolution of the survey area is 0.04 meters, the forward overlap is 78%, and the side overlap is 55%.

UAVManager

Professional Edition

Report number:
 calibration date:
 Feima Robotics Digital camera calibration report

camera body number:
 camera lens number:

serial number	Calibration content	Calibration value
1	image width × height (unit: pixel)	
2	pixel size (unit: micron)	
3	principal point: (unit: pixel)	
4	principal point: (unit: pixel)	
5	focal length f (unit: pixel)	
6	radial distortion coefficient k_1	
7	radial distortion coefficient k_2	
8	radial distortion coefficient k_3	
9	eccentricity distortion coefficient p_1	
10	eccentricity distortion coefficient p_2	
11	non-square scale coefficient α	
12	non-square scale coefficient β	

Distortion model:

$$\begin{cases} \Delta x = (x-x_0)(k_1r^2+k_2r^4+k_3r^6+L) + p_1[r^2+2(x-x_0)y] + 2p_2(x-x_0)(y-y_0) + \alpha(x-x_0) + \beta(y-y_0) \\ \Delta y = (y-y_0)(k_1r^2+k_2r^4+k_3r^6+L) + p_1[r^2+2(y-y_0)x] + 2p_2(x-x_0)(y-y_0) \end{cases}$$

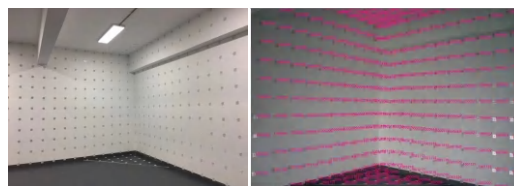
the collinear condition equation introduced into the distortion model is:

$$\begin{cases} x - x_0 + \Delta x = -f \frac{a_0(x-x_0) + b_0(y-y_0) + c_0(Z-Z_0)}{a_0(x-x_0) + b_0(y-y_0) + c_0(Z-Z_0)} = -f \frac{x}{Z} \\ y - y_0 + \Delta y = -f \frac{a_0(x-x_0) + b_0(y-y_0) + c_0(Z-Z_0)}{a_0(x-x_0) + b_0(y-y_0) + c_0(Z-Z_0)} = -f \frac{y}{Z} \end{cases}$$

principal point coordinate system:

$$r = \sqrt{(x-x_0)^2 + (y-y_0)^2}$$

Camera calibration report



Camera calibration



SmartProcess

Abundant UAV data processing toolbox

SmartProcess is UAV data preprocessing software, which provides advanced camera model self-calibration algorithm based on calibration field model constraints, distortion removal tools, RTK/PPK fusion solution tools, etc, to meet the high quality of UAVs , High-precision surveying and mapping requirements.

In addition, it also provides preprocessing functions such as image homogenization, enhancement, pyramid creation, format conversion, and result accuracy checking.

GNSS calculation

Calculation mode: Single point positioning Differential calculation

GPS antenna height:
 D 0.147 m
 L 0.052 m
 P 0.037 m
 S 1.504 m

Vertical height of GPS antenna:
 H 0 m

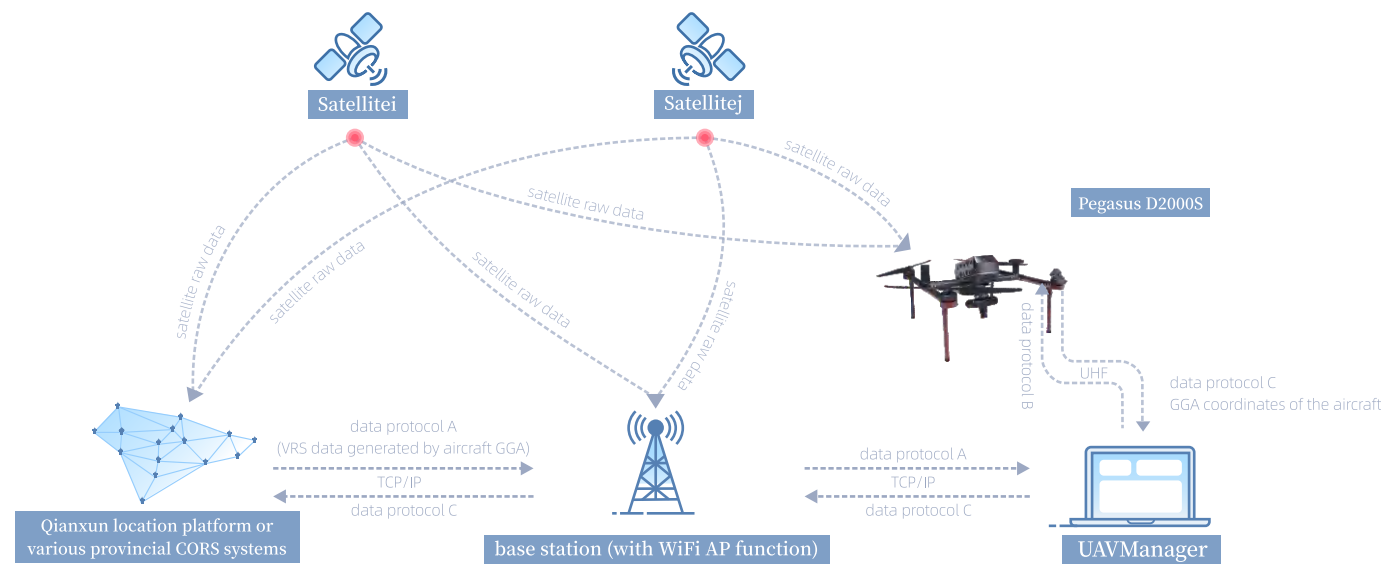
Sampling interval: 0.1 (S)

GNSS systems: GPS BeiDou
 GLONASS SBNS

Reference POS:

Output direction:

GNSS calculation



CORS mode Data protocol A: RTCM2.3, RTCM3.0, RTCM3.2, CRM, CRM+;
 Data protocol B: repackaged RTCM2.3, RTCM3.0, RTCM3.2, CRM, CRM+;
 Data protocol C: NMEA-0183

Software features

1. Advanced camera calibration and distortion removal

It supports flight data self-checking and calibration of camera models to meet general use. Also, it provides a camera self-checking and calibration method based on the constraints of the ground calibration field model, outputs a more robust and accurate optimal camera model, and ensures large-scale mapping accuracy requirements. It supports the functions of non-destructive precision import of common domestic camera calibration models, image distortion removal, etc., to ensure the seamless connection between aerotriangulation and stereo mapping.

2. RTK/PPK fusion solution

It supports one-click differential data calculation based on PPK mode, supports GPS, Beidou, GLONASS and Galileo data, and outputs high-precision POS. It supports fusion and differential calculation based on RTK/PPK mode, supports single base station and CORS operation modes, and automatic collection of known point coordinates. It directly incorporates the POS data of flight exposure points into the final target coordinate system.



Cluster processing

UAVManager Professional Edition cluster processing, i.e., multiple computers running at the same time, supporting cluster processing of quick mapping, DSM, TDOM, 2.5D and 3D meshes and so on.

The survey version and full version of UAVManager Professional Edition supports 3 computing nodes, and its efficiency will be increased by 3 times compared with the stand-alone version, which can meet the rapid production needs of regular customers.

In addition, for large data, it also supports users to customize and expand more computing nodes, which can improve the efficiency by N times (basically proportional to the nodes).

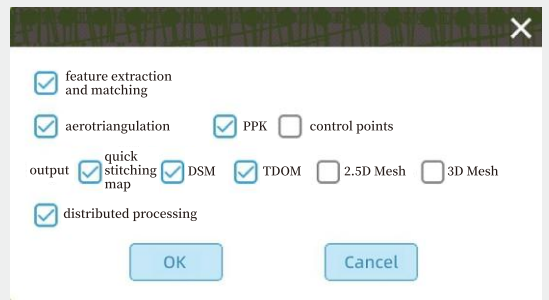
Software features

1. The cluster setting is simple, and the cluster operation can be performed by connecting to the local area network, sharing between groups, and opening the service. One host can be configured with multiple computing nodes (the number of nodes depends on the number of concurrent software licenses).

2.Using the data distribution method for data block processing can greatly reduce the dependence of data processing on the host storage space, reduce the frequent transmission of data, and improve data processing efficiency.

3.It supports the needs of data segmentation and merging, and meets the cutting needs of large data volumes.

4.It supports multi-project and multi-mission queuing processing to make full use of cluster resources.



Software features

1.Powerful core algorithms

Powerful core algorithms of image matching and aerotriangulation, for both ortho and oblique photography, enable users to handle issues, such as irregular image arrangements, large swing angles, irregular overlaps and so on. In addition, it is compatible with image data acquired from different cameras, over differing terrains, and in different weathers and surroundings.

2.Strong processing performance and rich types of results

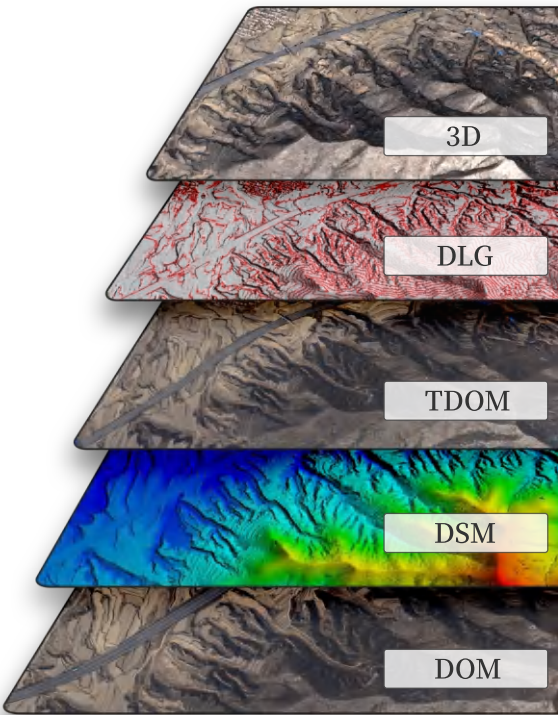
UAVManager Professional Edition is powerful for data processing and can generate various output types. More than 10,000 image frames can be handled simultaneously. Dense point clouds, TDOMs, and out door scene 3D models are supported as well.

3.Intelligent control point measurement and POS auxiliary aerotriangulation

Intelligent control points measurement and GNSS-aided aerotriangulation remarkably reduce field workload. Both manual and automatic measurements are supported in the control point measuring module of UAVManager. The robust GNSS-aided aerotriangulation can guarantee mapping accuracy even with very few control points, thus improving the efficiency of large-scale mapping with UAV platforms.

4.Based on RTK and PPK high-precision GNSS additional parameter control-free orientation algorithm, to achieve control-free mapping

An orientation algorithm with additional parameters, based on RTK and PPK fusion high-precision GNSS, supports mapping without ground control. With RTK and PPK fusion calculation of the more accurate GNSS positions of exposure stations, optimized camera calibration model fitting based on 3D calibration fields, and lever arm correction based on additional parameter aerotriangulation, high-precision direct orientation without ground control is accomplished, thus greatly decreasing field work in UAV-based aerial photography and making data acquisitions in dangerous areas possible.



UAVManager

Professional Edition



SmartMap

High-precision, fast, and total outputs processing software system

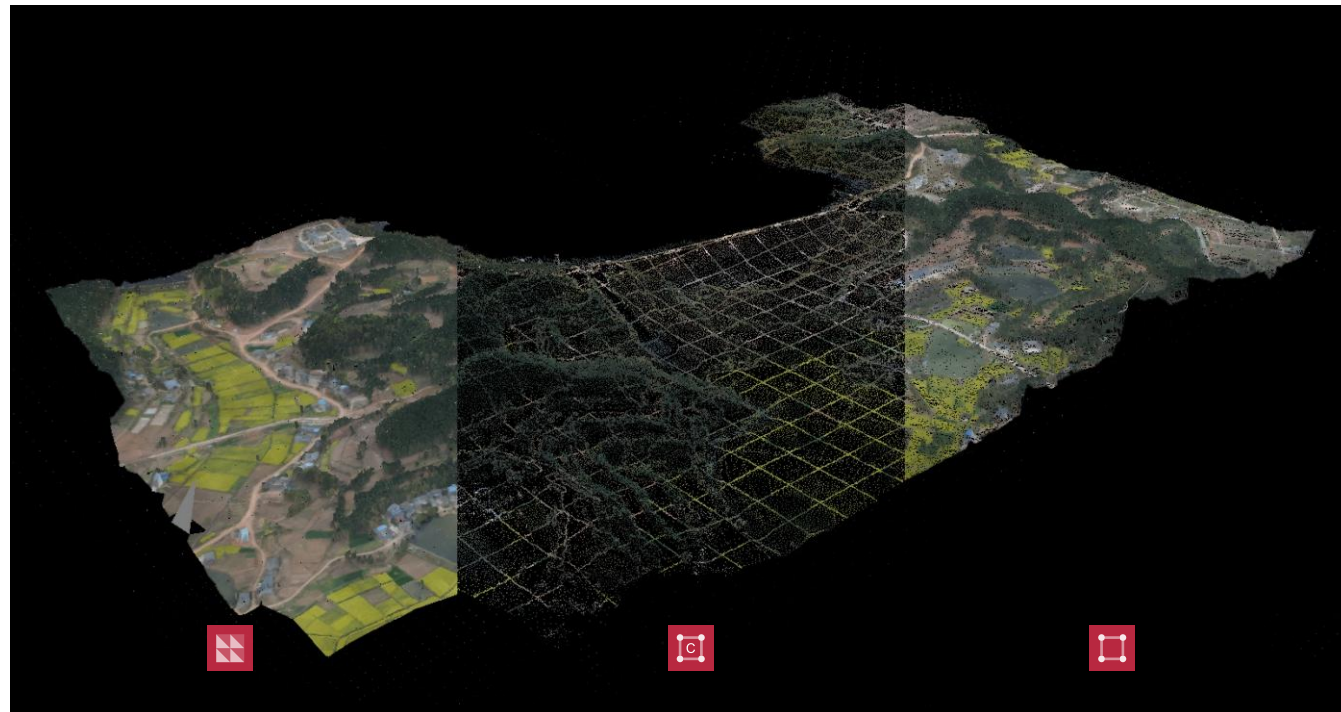
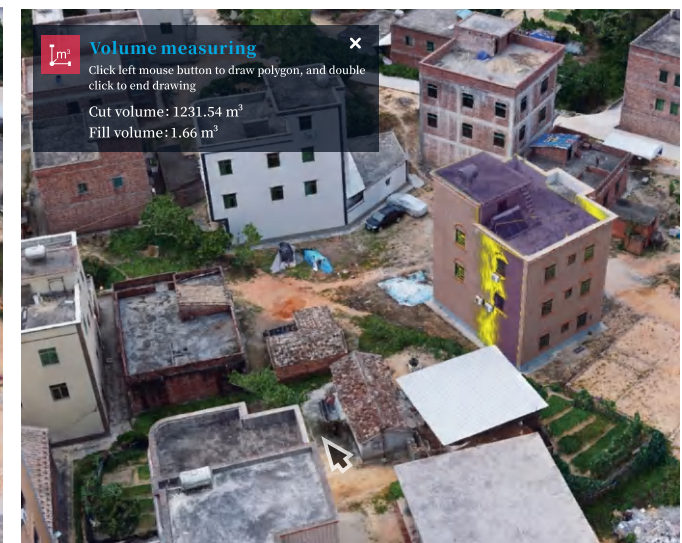
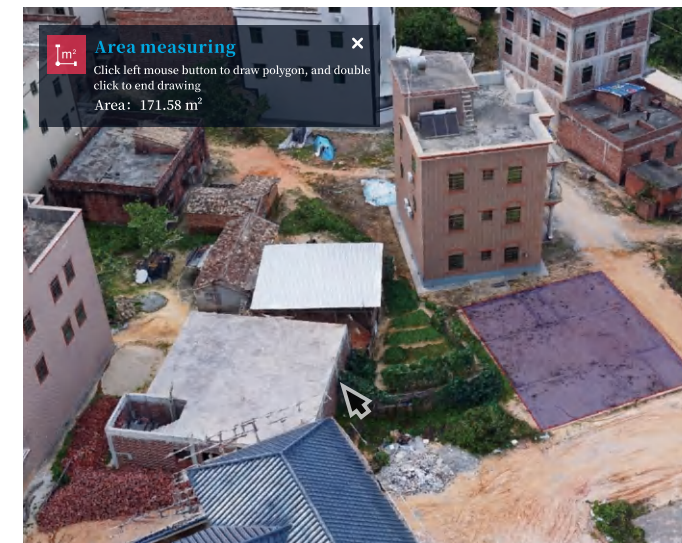
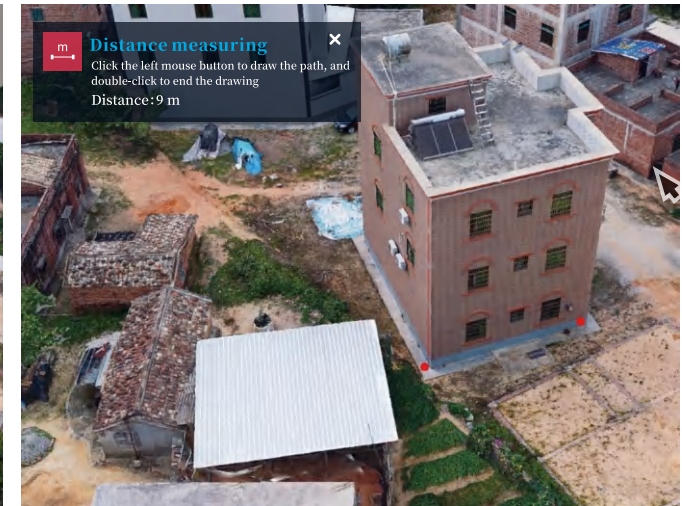
SmartMap is a one-key UAV data processing software system with its processing chain covering orthophoto and oblique-photo aerial triangulation, adaptive feature points matching, control points measurement, ortho-rectificaion, color balancing, stitching, full-pixel and high-density point cloud matching, TDOM and 3D reconstruction. Traditional DEMs and DOMs, high-precision and high-quality DSMs and TDOMs, and realscene 3D models can be generated and output by SmartMap. Intelligent control points measurement, GPS-supported aerotriangulation, PPK mode image mosaic, and fast 3D data viewing are also supported.

UAVManager

Professional Edition

3D 3D Viewer

Feima 3D Viewer is an application software system for 3D data generation from oblique photography. It supports the import of current popular OSGB 3D products to 3D digital earth and provides versatile functions, such as roaming, distance measuring, area measuring, volume measuring, and model import. Feima 3D Viewer provides a unified display platform for existing 3D terrain models, oblique high-resolution 3D terrain models, and fine 3D models.



UAVManager

Professional Edition



SmartMonitor UAV flights under control

SmartMonitor is a characteristic module of UAVManager Professional Edition, providing functions such as visualization and review of flights, flight records analysis, and summary display.



mission1
✕

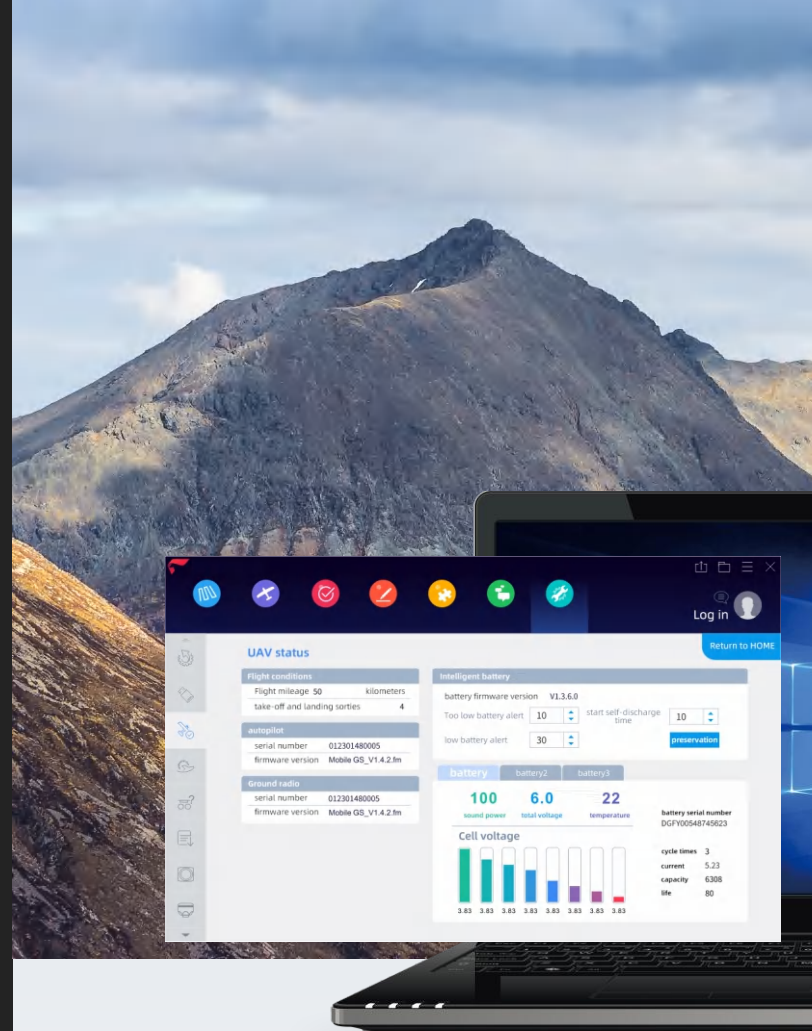
Project name – survey area name

D2000S
Drone Model

Camera type	D-OP3000		
Scale	1:500	Average altitude of the survey area	43 m
Resolution	4 cm/px		
Course overlap	80%	The peak	
Side overlap	60%	Resolution	4 cm/px
Route spacing	96 m	Altitude	47 m
Baseline	32 m	Forward overlap	80%
Default airspeed	10 m/s	Side overlap	59%
Relative height	205 m	Lowest ground point	
Estimated area	1.133 km ²	Resolution	4 cm/px
Estimated time	33 min	Altitude	40 m
Estimated mileage	20.226 km		

Flight record

2017/09/23	09:36:23	▶
2017/09/25	14:12:56	▶
2017/10/13	12:56:20	▶
2017/10/26	15:25:53	▶



Maintenance UAV health status assistant

It can realize online upgrade of UAVManager Professional Edition, online health analysis, UAV fault diagnosis and fir- mware upgrade of all Feima's UAV platforms.



Firmware upgrade

Autopilot Ground radio Camera Ground base station



Dongle information

Authorization Serial number of dongle Validity period Mileage Active date UAV serial number



UAV condition

UAV condition Autopilot Ground radio Parachute Intelligent battery



Flight settings

Radio loss protection time



Troubleshooting

Software version Operating system Fault category Problem description Uploading onboard logs



Data download

GNSS Base station Camera POS



Camera settings

Camera parameters Test shot Clear all data



Base station settings

High-precision operation mode Known point acquisition

UAVManager

Professional Edition



SmartPointCloud

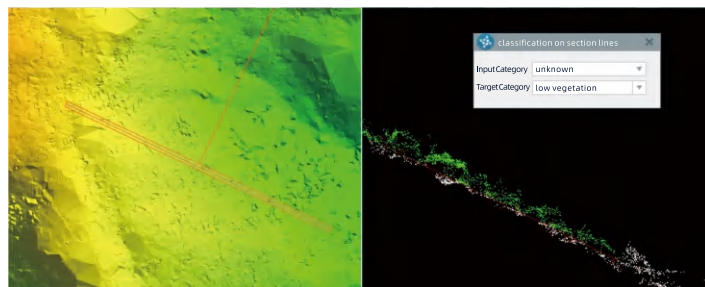
Integrated laser point cloud preprocessing software

SmartPointCloud is a point cloud data post-processing software that supports various data sources. It can browse, display, process and edit point cloud data. It includes automate point cloud classification algorithms and comprehensive interactive editing tools, and can produce standard terrain results and other thematic results.

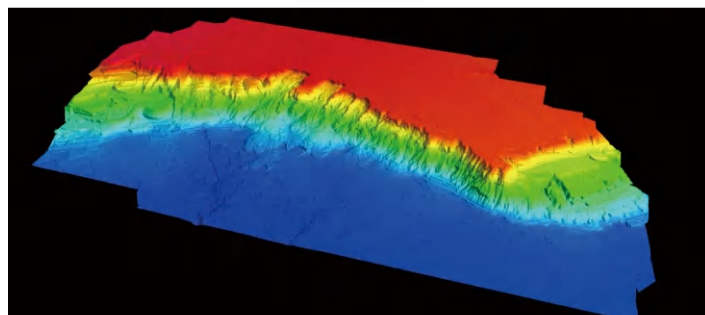
Software features

- 1.Supporting point cloud data processing such as dense matching point cloud, airborne LiDAR, and ground scanning
- 2.Browsing and displaying large amount of point cloud and supporting renderings of elevation, texture, section and so on
- 3.Providing automatic point cloud filtering, vegetation extraction and building filtering and classification algorithms
- 4.Providing various interactive editing tools for point cloud classification
- 5.Supporting section display and editing, real-time update and display of point cloud triangulation, convenient for assisting point cloud classification and judgment
- 6.Supporting the output of elevation points, DEM, contour lines and other results
- 7.Supporting import and automatic generation of mileage points, and one-click road section extraction and visual display based on point cloud
- 8.Supporting output of road section files in vector and latitudinal formats

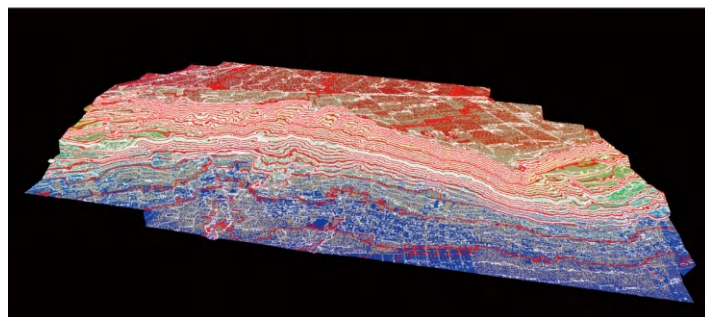
Interactive editing



DEM



Contour lines



Interactive editing

Ground points Vegetation points Buildings Transform

Triangulation TINs Delete triangulation Hide triangulation

Manual classification

Data editing

Breaking lines

Automatic processing algorithms

batch processing

input path

function list

- redundancy removal
- data framing
- data denoising
- data resampling
- point cloud coloring
- ground filtering
- vegetation classification
- building classification
- data merge
- DEM output
- contour extraction

delete intermediate process data

Run Cancel

ground point classification

basic settings

data category: 0 represents unknown

target category: 2 represents ground

filtering method: TIN filtering

parameter filtering

maximum building size: 30 meters

maximum slope adjustment value: 88.00 degrees

maximum iteration angle: 6.00 degrees

maximum iteration distance: 0.80 meters

options

reduce iteration angle when the side length is less than 5.00 meters

stop triangulation when side length is less than 2.00 meters

Confirm Cancel

Before point cloud filtering

After point cloud filtering

UAVManager

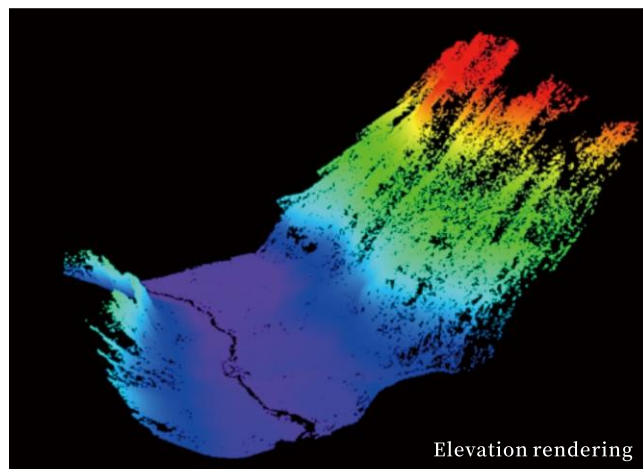
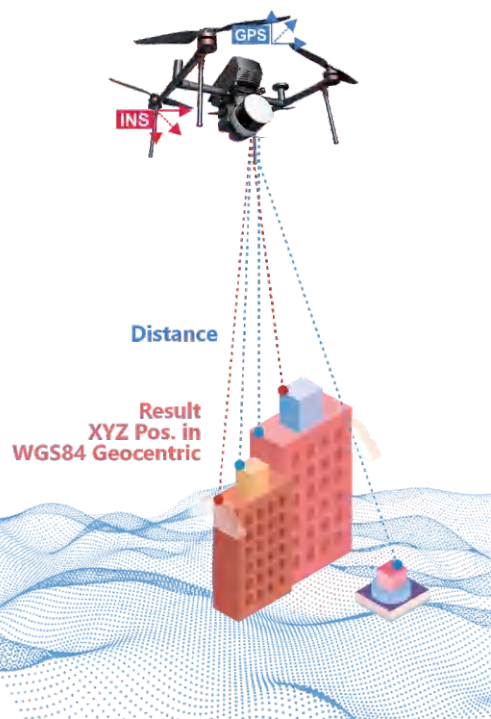
Professional Edition



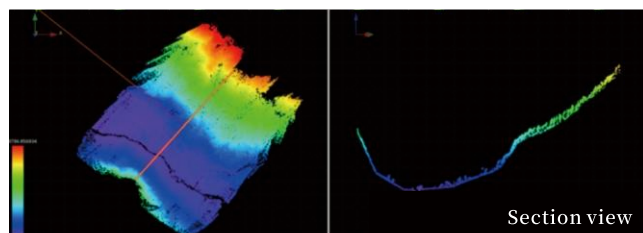
SmartLiDAR

Integrated laser point cloud preprocessing software

SmartLiDAR can generate accurate point cloud data based on the original data such as distances, positions, and attitudes obtained by UAV's LiDAR module. Cloud data calculation, LiDAR module calibration, strip adjustment, massive point cloud visualization, standard point cloud output and other functions are integrated in this software.



Elevation rendering



Section view



Texture rendering

point cloud solution split strips feature extraction strip adjustment elevation adjustment projection management coordinate transformation

one-click point cloud solution

one-click point cloud solution

L R

-45° 45°

use absolute FOV

select	files	status
<input checked="" type="checkbox"/>	20210803-...ar20_0001	unresolved
<input checked="" type="checkbox"/>	20210803-...ar20_0002	unresolved
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<input checked="" type="checkbox"/>	20210803-...ar20_0009	unresolved
<input checked="" type="checkbox"/>	20210803-...ar20_0010	unresolved

using the strip adjustment results raw data calculation

Start Close

Point cloud trajectory

Point cloud trajectory



Point cloud profile

Software features

- 1.Supporting strip inspection and calibration, and supporting multi-sortie adjustment
- 2.Massive data point cloud browsing and viewing

UAVManager

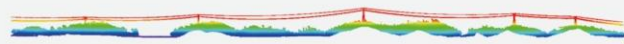
Professional Edition



SmartPowerLine

Overhead transmission line inspection system, making line inspection simple, efficient and reliable

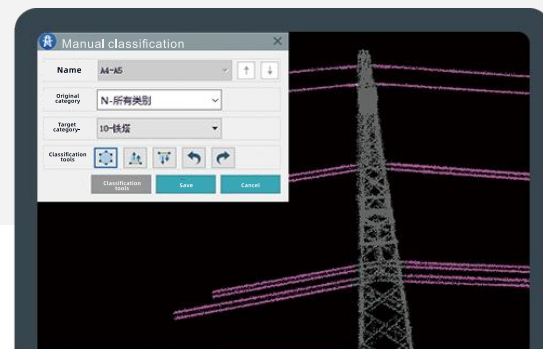
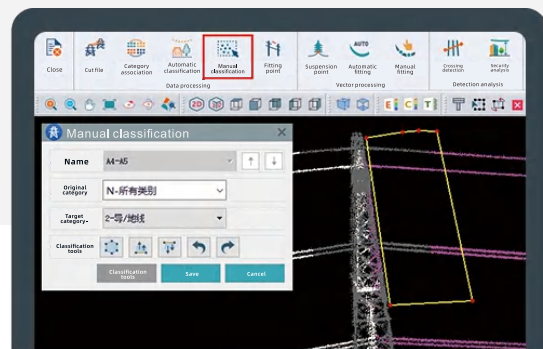
SmartPowerline is a software specially designed for patrol inspection and analysis of overhead transmission line channels. It can perform tower calibration, channel cutting, point cloud classification, and wire vectorization processing for massive airborne, ground, densely matched and other multi-source point cloud data. It is able to establish a three-dimensional point cloud visualization ledger of powerlines, conduct spatial three-dimensional information analysis on the point cloud data according to the relevant operation specifications of the overhead transmission lines, efficiently and accurately discover the hidden dangers of the line channel and output the real-time working condition and crossover report, which helps to efficiently solve the problems of slow efficiency and poor accuracy of traditional manual inspection.



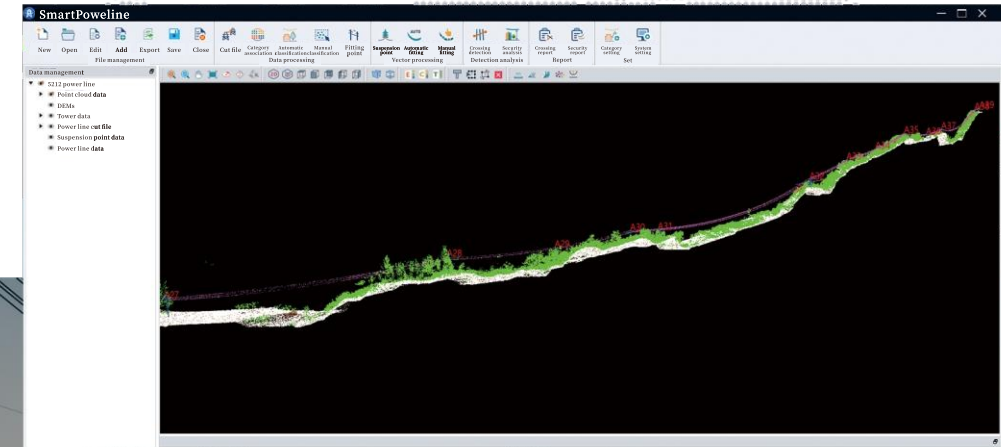
Original point cloud



Automatic classification effect



Manual interactive editing



Software features

1. Massive point cloud carrying capacity

Supporting loading a single point cloud data set larger than 40 Gigabytes, and enabling fast browsing of massive point cloud data

2. Powerful point cloud classification capability

The GPU-based automatic point cloud classification algorithm can quickly and efficiently extract point clouds of ground, vegetation, towers, wires, buildings, etc., and can adjust adaptive parameters to deal with different terrain scenarios. The classification accuracy is over 90%.

3. Guided interface and user-friendly interaction design to improve user experience

The guided interface design from point cloud data loading, file cutting, classification, detection to report output makes the data processing more intuitive and easier. Plentiful humanized interactive tools improve the processing speed of manual editing.

4. One-key detection analysis and output channel inspection report, supporting fast inspection based on classified point cloud and conductor vector lines

It can help to quickly find vegetation, buildings, ground, railways, graded highways, etc., and related hidden dangers. Also, it can output real-time operating conditions and cross-span reports with one click.

5. Customized service

The channel hidden danger detection template can be set according to different project requirements, and the function can be customized and developed according to user needs.

Cloud Monitor

Platform Features

1. Cloud-specific interaction and flying situation being perceived

- Completely recording the life cycle of the drone, and managing the whole process of data cloud management
- Real-time data link based on cloud architecture for live cloud broadcasting process
- Cloud data history traceability, visualized playback of the history flying process and surveying area operation parameters
- Statistics of cloud data global for auxiliary decision-making including global statistics, custom statistics, regional statistics, comparative statistics

2. Real-time information sharing for active and instant service

- Real-time information push mechanism, such as drone and battery warranty and maintenance reminders automatic delivery
- Supporting custom information push and one-click to achieve multi-platform, i.e. SMS, email, UAVManager Professional Edition (software), delivery to target users

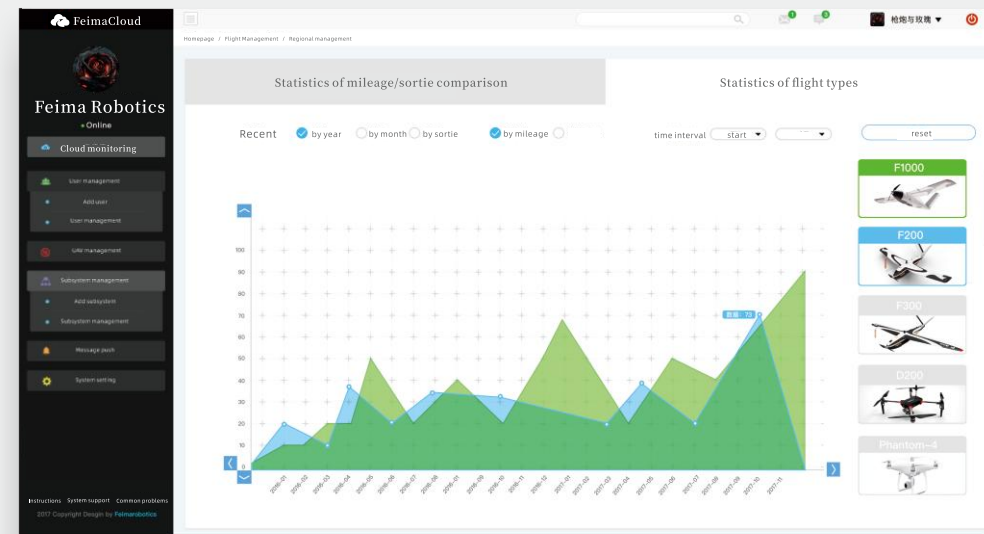
3. Multi-terminal push of tasks for easy cooperation of management

- Supporting unified planning and assignment of aerial photography tasks by means of centralized assignment by one person, and collaborative operation of multiple people and multiple terminals
- Following up the progress of tasks in a timely manner, and centrally perceiving the progress of multi-person and multi-end operations

4. Open extension interface for customized requirements

- Supporting custom cloud subsystem to create an exclusive management platform for industry customers
- Supporting the integration of third-party drone interfaces and business display platforms

Cloud Monitor



User management	Flight management	Dongle management	Realtime broadcasting
History playback	Data statistics	Task push	Message push

