

## iSCAN<sub>HR</sub> Intelligent Scanning System for high standards highways

iSCAN (intelligent System for 3D Surface Condition Scanning), a unique system currently existing in the world, is developed to validate the 3DLS multifunctional sensor units and demonstrate their performance for technique transfer to assets managing industries of all forms of transport infrastructures, including high standards highways, railways, low-standards roads and airport runways.

The iSCAN<sub>HR</sub> is designed for demonstrations of function, repeatability, accuracy and reliability of the 3DLS<sub>HR</sub> for trunk highways.

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## A Features of the System

The iSCAN<sub>HR</sub> (Figure-1) is able to, automatically measure three dimensional (3D) conditions of pavement surfaces with 100km/h maximum running speed, process intelligently all kinds of data collected, and calculate all parameters required by both domestic and international assets managing standards as listed.

- 1) Highway Performance Assessment Standard, JTG 5210-2018, Ministry of Transport, PRC
- 2) Specification of Automated Pavement Condition Survey, JTG/T E61-2014, Ministry of Transport, PRC;
- 3) Multifunctional High-speed Highway Condition Monitor, GB/T 26764-2011, National Standards Management Committee, PRC;
- 4) SCANNER Surveys for Local Roads, User Guide and Specification, 2009, UK Roads Board



Figure-1 iSCAN<sub>HR</sub> intelligent scanning system

The iSCAN<sub>HR</sub> is much intelligent, small, simple, multifunctional and high-accurate

### 01 Multifunction and Contracted

The iSCAN<sub>HR</sub> integrates as many as possible complex measuring missions such as measurement of surface distress, roughness, rutting depth, texture, geometry and GNSS into one 3DLS<sub>HR</sub> sensor unit. The whole system includes only a 3DLS<sub>HR</sub>, a RView (environment camera), a DMI and a set of IPC. The minimal components enables the iSCAN<sub>HR</sub> both simple and contracted.

The iSCAN<sub>HR</sub> has an ability to measure 7 different kinds of surface data including 3D depth image, 2D picture and 3D surface map, longitudinal profiles, transverse profiles, texture profiles, geometry, GNSS and environment images. The highly compacted 3DLS<sub>HR</sub> has significantly promoted its measuring capacity.

### 02 High Accurate and Intelligent

The 3DLS<sub>HR</sub>, that integrated into the iSCAN<sub>HR</sub> system, is a highly accurate multifunctional sensor unit with a resolution of 1.0×1.0×0.25 mm separately for longitudinal, transverse and vertical dimensions, and a crack recognition width of 1.0 mm.

The 3DiP (3D data intelligent processing software), that responsible for the iSCAN<sub>HR</sub> collected data auto-processing, is able to intelligently auto-identify and calculate all sorts of distresses including four types of cracks, potholes, depression, shoving and waves, raveling and patching, with a 90% accuracy level of auto-recognition.

Figure-2 is the iSCAN<sub>HR</sub>, that reconstructed based on a local made small size vehicle, presents a simple and contracted engineering design.



Figure-2 iSCAN<sub>HR</sub> (Simple Style and Small Size)

## B Real-time Display of Measuring Results

The 3DSS software (3D Surface Scanning software), which controls the scanning processes of the iSCAN<sub>HR</sub> (Figure-3), can produce and display images, profiles and parameters including 3D images, 2D pictures, longitudinal profiles, transverse profiles, texture profiles, geometry parameters, distance and GNSS information in real-time, meanwhile be able to download and save necessary data for further detailed analysis.

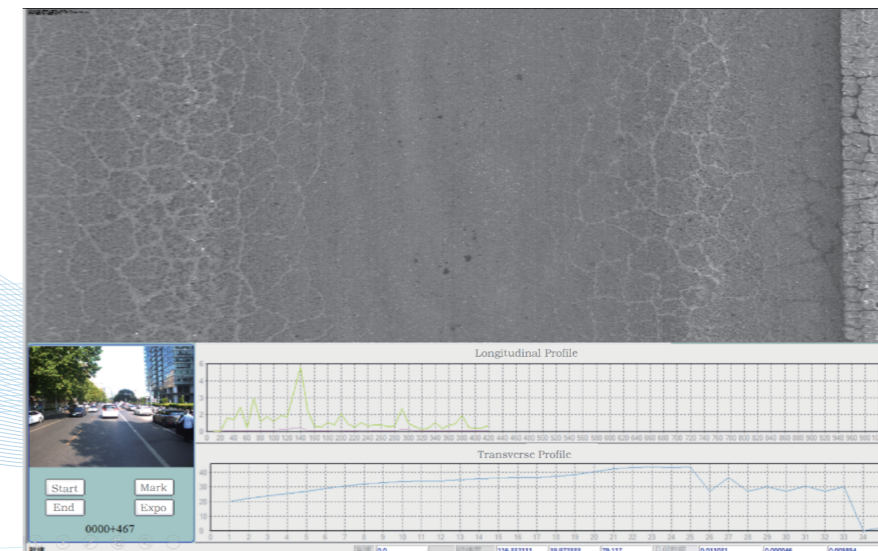


Figure-3 3DSS (3D Surface Scanning Software)

## Intelligent Recognition of Surface Distress

The 3DiP software (Figure-4) can intelligently recognize and pick up various types of distresses including cracks (longitudinal, transverse, block and alligator), potholes, depression, shoving and waves, raveling, patching, bridge joint and manhole cover etc., from the iSCAN<sub>HR</sub> measured 3D depth images, 2D pictures and 3D surface map as showing in Figure-5~Figure-8. The 3DiP software will automatically trace the trends of all cracks and mark them up in line charts.

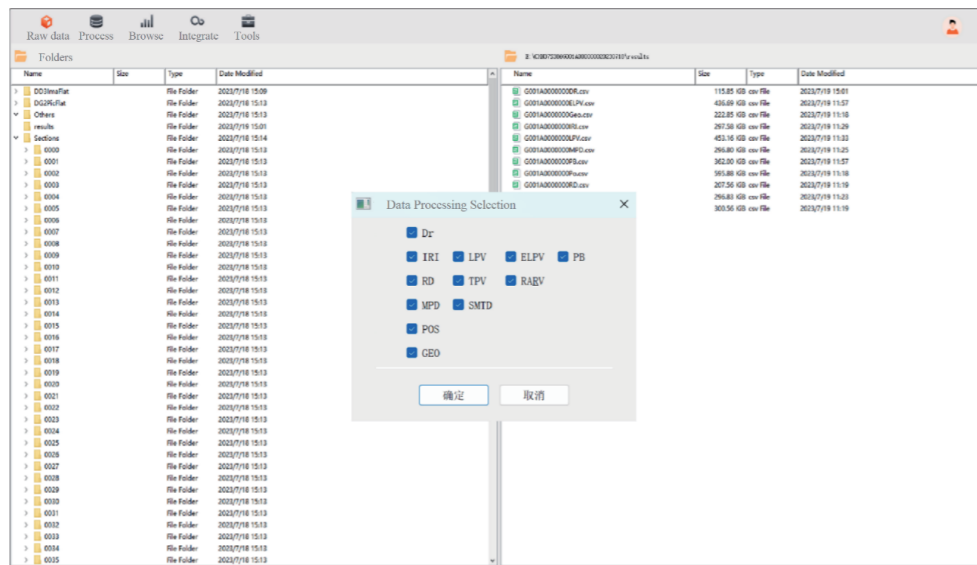


Figure-4 3DiP (3D Data intelligent Processing Software)

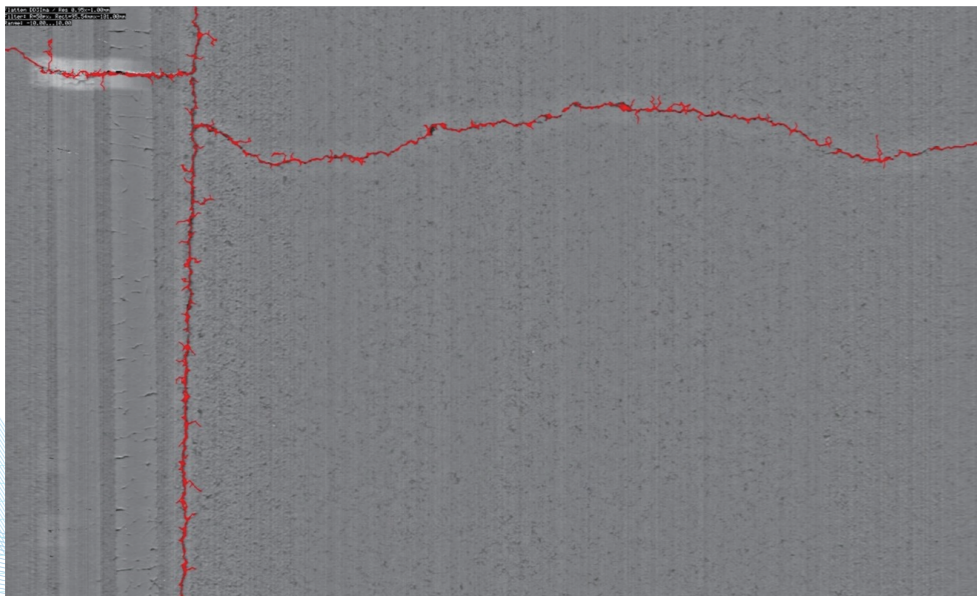


Figure-5 Cracks Marked-up in Read Line Charts

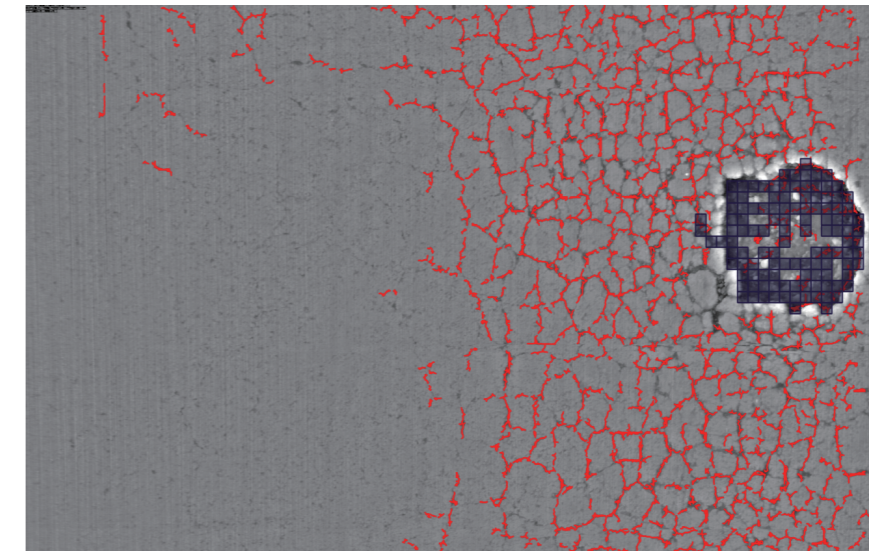


Figure-6 Pothole Marked-up in Mini-blue Squares

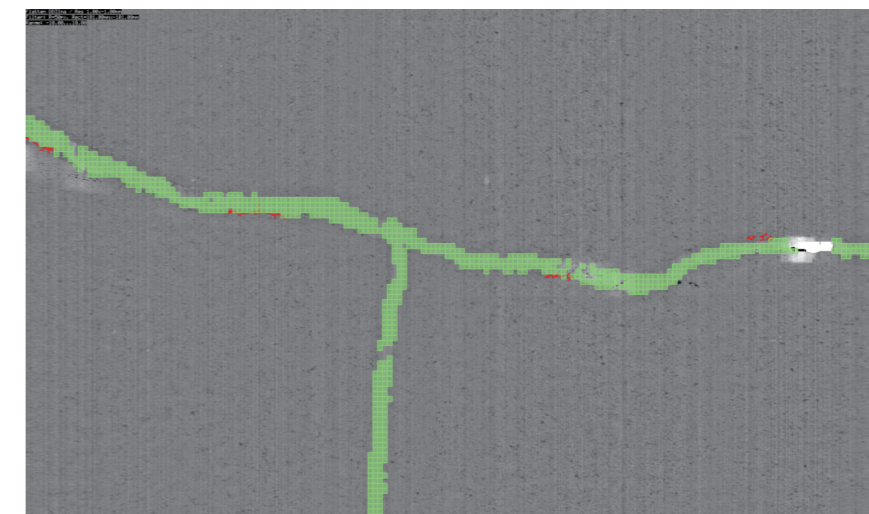


Figure-7 Patching Marked-up in Mini-green Squares

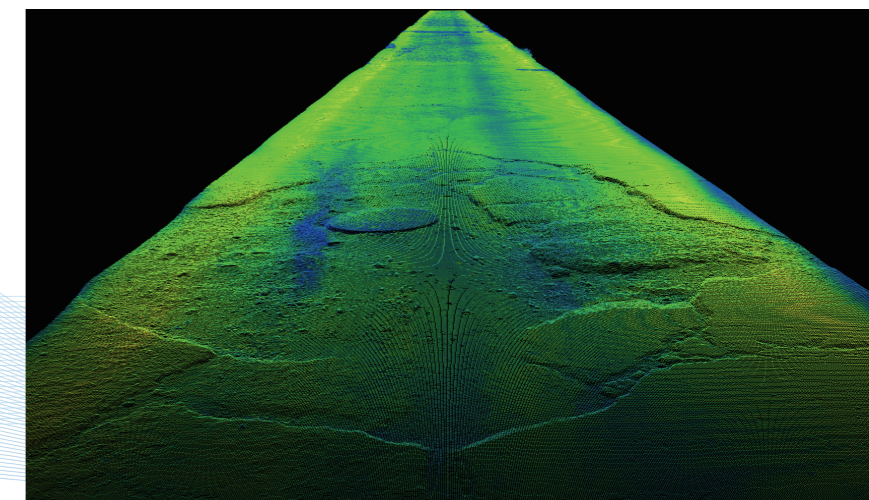


Figure-8 Raveling (in 3D view)

## D Auto-calculation of Profile Parameters

The 3DiP software can calculate and display various types of parameters such as IRI/VP3/PB from longitudinal profiles, RD/TPV from transverse profiles, MPD/WR from texture profiles, and GR/SP/CR from geometry data etc. in line charts as presented in Figure-9 and Figure-10.



Figure-9 Longitudinal Profile Parameters



Figure-10 Transverse Profile Parameters

Table-1 is a summary of data measured by iSCAN<sub>HR</sub> and parameters that can be processed by 3DiP software. The 3DiP software can process 6 types of iSCAN<sub>HR</sub> measured data and produce more than 10 kinds of major parameters and 10 sorts of subdivide parameters.

No.	Types of Data	Major Parameters	Subdivide Parameter	Accuracy Description
1	3D Surface	3D depth image 2D picture 3D surface map  Surface distress DR	+ Cracks: Alligator Block Longitudinal Transverse + Deformation: Depression Shoving and waves Pothole + Patching + Raveling	3D resolutions: 1.0×1.0×0.25 mm in 3D (longitudinal×transverse× vertical/depth) directions  1) Measuring width 3.50~3.75m 2) Cracks visual recognition 1.0mm in width 3) Distress auto-recognition accuracy >90%
2	Longitudinal Profiles	Roughness index IRI Longitudinal profile variance LPV <sub>3</sub> Pavement bumping PB		Variable coefficient of repeatability CV<5%
3	Transverse Profiles	Pavement bumping PB Transverse profile variance TPV	Left rutting depth RD <sub>L</sub> Right rutting depth RD <sub>R</sub>	Variable coefficient of repeatability CV<5%
4	Texture Profile	Mean profile depth MPD Surface wearing ratio WR	Left wheel path MPD <sub>L</sub> Mid wheel path MPD <sub>M</sub> Right wheel path MPD <sub>R</sub>	Variable coefficient of repeatability CV<5%
5	Geometry	Gradient GR Transverse slope SP Horizontal curvature CR		1) 95% GR absolute errors <1.5% 2) 95% SP absolute errors <1.5% 3) 95% CR absolute errors <0.003m-1
6	Position	Coordinate (X, Y, Z)		GNSS and distance

# E Auto-integration of Data

The 3DiP software can automatically integrate all types of data measured by iSCAN<sub>HR</sub> and parameters calculated into one frame as shown in figure-11~Figure-15. The frames of the Figures can divide into four zones, two zones for displaying 3D images and environment images, one zone for parameters and the other for parameter line charts.

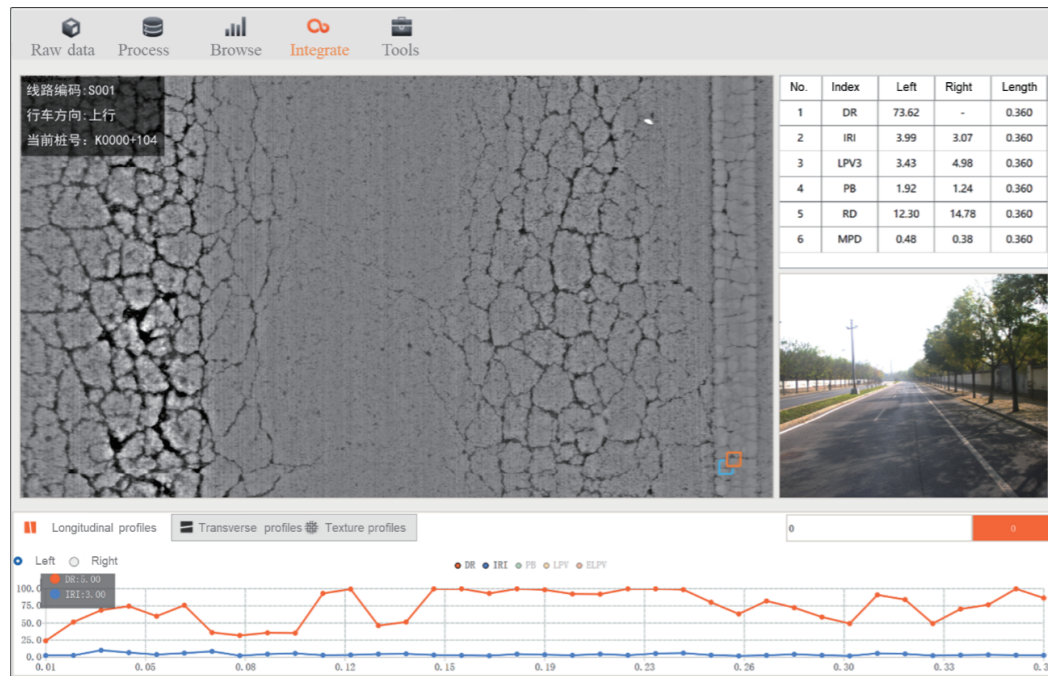


Figure-11 Data Integration (3D depth image)

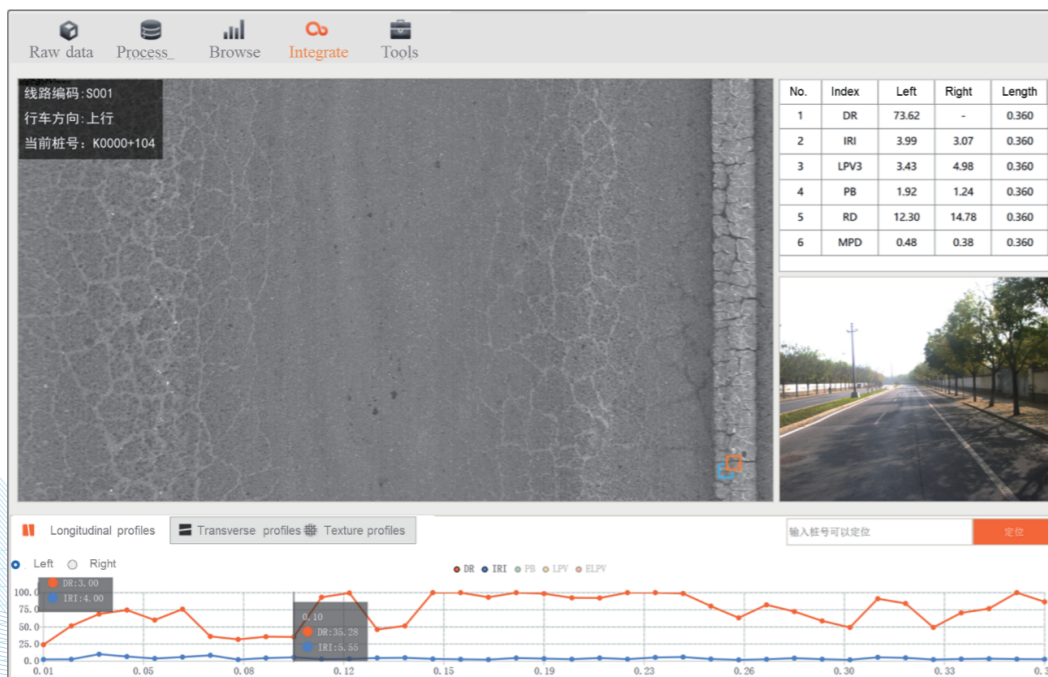


Figure-12 Data Integration (2D Picture)

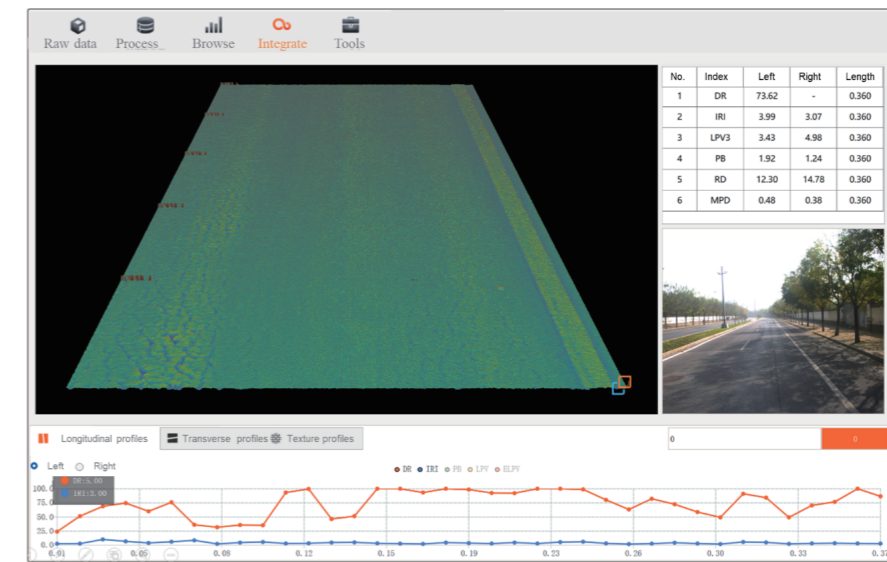


Figure-13 Data Integration (3D Surface Map)

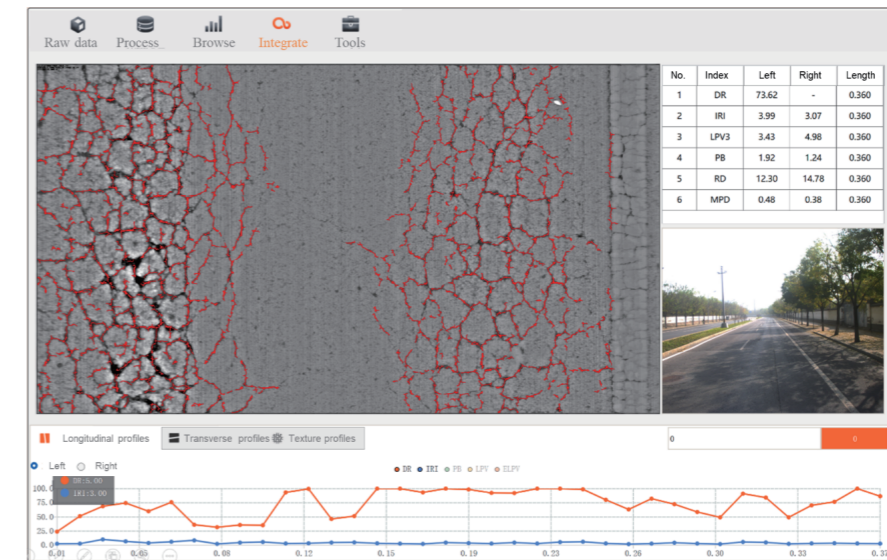


Figure-14 Data Integration (2D Marked-up Distress)

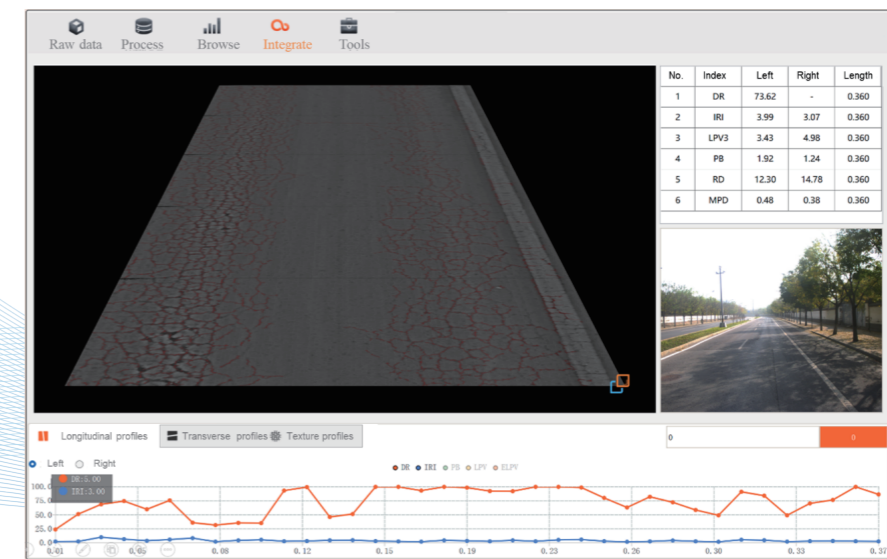


Figure-15 Data Integration (3D Marked-up Distress)

## Cloud Computing and Evaluation

The 3DiP software (cloud client service) can calculate and display all kinds of indices based on parameters uploaded into the cloud, including PCI, RQI, RDI, PBI and PWI etc. required by domestical standards (Figure-16) and other indices may specified by other international standards.

Road ID	RD Name	M-Start	Direction	Length	DR(%)	PCI	Alligator crack			Blocking crack		Longitudinal crack		Transverse crack		Depression		Rutting		Showing &
							Light	Medium	Heavy	Light	Heavy	Light	Heavy	Light	Heavy	Light	Heavy	Light	Heavy	
Y001	Y001	0.000	2.37	1000	7.42	65.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Y001	Y001	1.000	2.37	1000	4.53	72.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Y001	Y001	2.000	2.37	1000	8.59	63.62	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Y001	Y001	3.000	2.37	1000	31.4	37.94	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Y001	Y001	4.000	2.37	1000	18.87	49.68	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Y001	Y001	5.000	2.37	1000	13.83	55.73	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Y001	Y001	6.000	2.37	1000	17.77	50.91	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Y001	Y001	7.000	2.37	1000	7.85	64.94	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Y001	Y001	8.000	2.37	1000	4.89	71.15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Y001	Y001	9.000	2.37	1000	16.33	52.59	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Y001	Y001	30.000	2.37	1000	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Y001	Y001	31.000	2.37	1000	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Y001	Y001	32.000	2.37	1000	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Y001	Y001	33.000	2.37	1000	0	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure-16 3DiP (Cloud Computing of Indices)

## System Configuration

Table-2 is the system configuration of the iSCAN<sub>HR</sub>.

No.	Components	Item and Name	Description
1	Vehicle Platform	Type	BJ80
		Dimension	5015 × 2015 × 2160 mm (length width height)
		Computer	IPC, vehicle mounted
		Power	Battery
2	DMI Distance Measuring Unit	Encoder	5000 lines
		Resolution	0.125mm

Table-2 iSCAN<sub>HR</sub> System Configuration

No.	Components	Item and Name	Description
3	3DLS <sub>HR</sub> Multifunctional Sensor Unit	Types of data	+ 3D Surface Data - 3D depth image - 2D Picture - 3D Surface map + Position (GNSS and distance)  + Longitudinal profiles + Transverse profiles + Texture profiles + Geometry
		Image format	PNG, JPEG
		Resolutions	1.0×1.0×0.25 mm, in three directions
		Data process	Automatic
4	RView Environment Picture Unit	Camera	Progressive
		Resolution	500 pixel per frame
		Measuring interval	1f/5m ~1f/10m
		Type of data	Picture, real time collection, display and saving
		Picture format	JPEG
5	3DSS Data Collection Software	Process Control	+ Real time producing: 3D depth images, 2D pictures and profiles + Real time displaying: 3D depth images, 2D pictures line charts of profile parameters, environment pictures + Real time saving: 3D depth images, 2D pictures and profiles
6	3DiP Data Processing Software	Data Processing	+ Client software: Data processing + Server software: Indices calculation

## Metrological Certification

The iSCAN<sub>HR</sub> has passed various tests including laboratory tests, field tests and third-party metrological certification tests (by national metrological institution) in terms of repeatability, accuracy and reliability.