17 R&D of the crack detection system for runways with a 3D camera and all direction-moving robot

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R&D Objectives and Subjects

Objectives

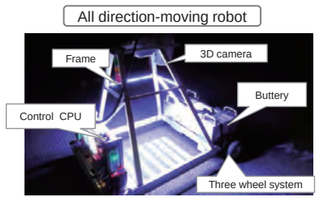
Cracks appearing on the surface of runways bring degradation of asphalt and causes surface peeling. The large-scale surface peeling affects the operation of aircraft. The large parts of the actual crack detection are manual operation so that the detection performance depends on the human skill of inspectors.

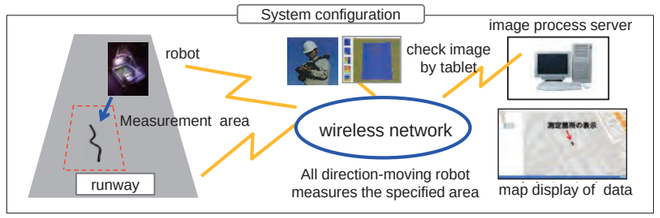
We must improve this situation in the ordinal routine work of crack detection. Our object is to develop a high-performance crack detection system by using 3D cameras mounted on an all direction-moving robot.

Source: MLIT "Variation of asphalt pavement and curren status of airport paving inspection technology"

Subjects

The crack detection system for runways with a 3D camera and all direction-moving robot is able to quickly detect the many types of cracks on runways by analyzing 3D data automatically captured by 3D cameras mounted on an all direction-moving robot.



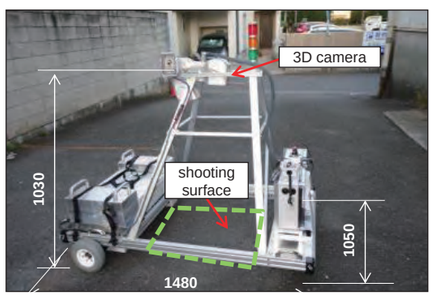


Current Accomplishments (1/2)

All direction-moving robot

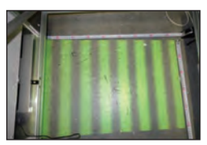
We have developed the all direction-moving robot with a low-positioned center of gravity, three-wheel moving configuration, and spring dumper for suspension in order to suppress the affection for the 3D data due to unevenness of the road surface and due to wandering when moving and stopping. We have realized the automated crack detection system for runways by the fact that our system can capture 3D data automatically without moving conditions and send to the data server.

Specification of all direction-moving robot



All direction-moving robot（side view）

（front view）



Projection surface of the 3D camera projector

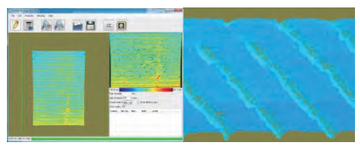


Image process (color mapping)

Zoomed in on grooving

Specification

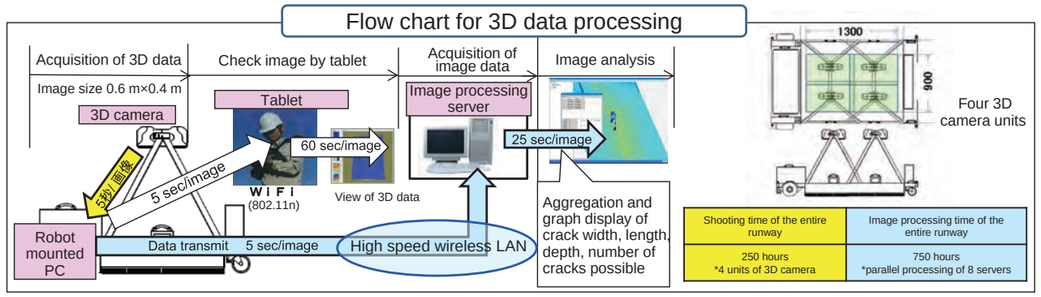
Item	Contents
Configuration	3-wheel configuration Drive wheel: 2, auxiliary wheel: 1
External dimensions	1050 W×1480 L×1030 H
Weight	total weight: 80 kg body: 60 kg battery:11.5 kg×2
On-board camera	Seiko Wave's 3D camera
Move control	Movement control by rotation control of two driving wheels
Control PC	Micro PC two configuration
Position accuracy	GPS: position accuracy ±1m
Movement control technology	・SLAM ・gyro ・Odometry
Power supply	Lithium, ferrite battery 24Ah×2 ・Detachable ・Continuous operation time: 2 hours or more
Camera control	Shooting control of dimensional camera
Vibration control	Spring damper for auxiliary wheel, ｅｔｃ.

Current Accomplishments (2/2)

Reduction of wasted time in analyzing data

Typical 3D data requires much processing time due to the shooting process, data transfer, and data analysis. We can obtain a total processing time of 30 seconds for 3D data corresponding to a 70 MB data file (70 cm x 50 cm square area) compared with our prototype processing system. With one 3D camera system, it takes one thousand hours to execute crack detection for the whole runway of a typical airport. To reduce the processing time, we can show the demonstration of our system in cases of operating four 3D cameras simultaneously, as below.

Flow chart for 3D data processing



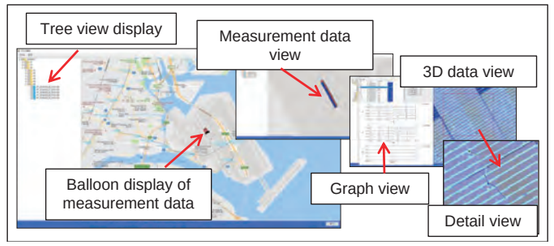
Shooting time of the entire runway	Image processing time of the entire runway
250 hours *4 units of 3D camera	750 hours *parallel processing of 8 servers

Data mapping

We can manage the measuring 3D data and show the resulting cracks on the map. The main features of our system are as follows:

(1) Tree view display and data storing
(2) Balloon display of data
(3) Measuring data display in detail
(4) Graphically display the measured data

It is easy to identify the cracks with collaboration in the mapping system, which can improve the performance of crack inspection in the field.

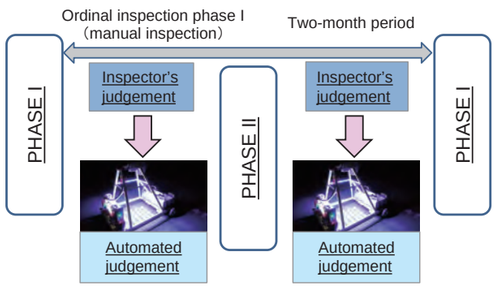


Goals

Achievement of Goals

Items	Achievement of items
3D data capturing	・250 hours sweeping time for runway area（Width 60 m × Distance 3,000m) with a four camera configuration. ・750 hours aata analyzing time with 8 server multi-operation system
Detection of cracks	・ linear cracks with more than 1 mm width can be detected automatically ・alligator cracks can be detected with a manual assistance.
Visualization of monitoring data	・ monitoring data can be projected onto the map ・ 3D graphical representation

Support for ordinal inspection



・ High precision and effective inspection can be performed by using 3D data analyzing with our programed robots.

Concrete product concepts

① Alternative inspection method for ordinal inspection operation
  ・ support and assistance of ordinal inspection work for runways

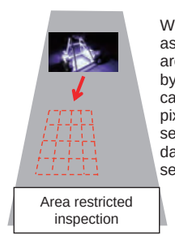
② Crack detection system business for promotion
  ・ automated crack detection system
  ・ 3D surface analyzing system

③ Technical consulting
  ・ system support and consulting for different fields

④ New Business
  ・ New Monitoring services for building and other structures

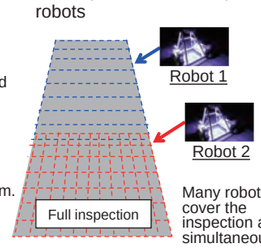
New concept of crack monitoring system

①Area assigned inspection



We capture assigned areas divided by a 3D camera's pixels and send their data to the server system.

②Full inspection with many robots



Many robots cover the inspection area simultaneously.