THE MEASUREMENT OF THE TREE ASSEMBLAGE'S COVERAGE IN RIVER CHANNEL BY LIDAR

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ABSTRACT:

The purpose of this project is the flood disaster prevention. Recently it has been happened frequent floods in the small and middle size rivers caused of the local heavy rainfalls in Japan. The Japanese River Bureau had decided to the achievement project what the terrain of river channel and flood plain terrain would be gotten by Airborne Laser terrain mapping (Lidar). Next consideration, we would try the measurement of the tree assemblage's coverage in river channel. The tree assemblages sometimes prevent water from flowing and some flood disasters happen. We would consider about "the woodiness rate" the relative correlation between the field plant survey data and the laser point cloud data. This paper is introduced how to calculate the woodiness rate using the laser point clouds.

1. INSTRUCTIONS

Global warming causes to the abnormal climate (ie the concentrated heavy rain). Ten typhoons had hit to Japan in Japan, and had happen some flood at small and medium rivers. Japanese National River Bureau should do maintenances for the first grade river, but they had not grasped the flow volumes of upper reaches and tributaries. In addition, the planar terrain of river channel had never surveyed.

It is one factor of flood what trees and vegetations grow thick and wild to increase the dead water zone.

On the other hand, the remote sensing technology used by Laser has developed in survey issues like the terrain mapping and vegetation survey since 1998. It has also applied to energy industry (gas and oil, mining, etc.), city modelling, and forest monitoring. It is the most popular for Japanese utilization to protect the disaster.

We have provided to our client the proposal that has described as using the Lidar for the measurement of tree assemblage in river channels.

Figure.1 Tree assemblages in river channel

2. AIRBORNE LASER SCANNING SURVEY

River survey project by LiDAR had been done from 2004 to 2007. This project was a big enterprise (survey area approximately 88,000 square km). Asia Air Survey (AAS) had installed three Airborne scanning systems including new ALS50II (Leica Geosystems) which purchased in October 2006. AAS has another two Optech systems (ALTM 2033EDC and 3100DC).

This project's guideline has been formulated and issued since 2004. The specification of this LiDAR survey is described as table1.

Parameter Items	Remarks
Laser points density	One point per 1 – 2.5square meters (interval:1m-1.5m)
Side lap rate	30-50%
Pulse data	Over two pulses
Height accuracy	30cm (1 sigma)
Image resolution	0.5-1m per pixel

Table 1. Specification of LiDAR survey

2.1 Workflow of Lidar measurement and data processing

The proceeding of LiDAR survey should conform to the guideline by Japanese Geographical Survey Institute. This guideline's name is "Manual of making DEM by Airborne Laser Scanning survey".

This manual provides flight planning, GPS/IMU measurement, bore site calibration, operating, remove of noise (dusts, clouds and birds etc.), adjustments between flight course, accuracy inspection, filtering (eliminating surface objects), interpolation to grid data, and generation contours.

1) Flight planning

Survey planning depends on the topography of a survey area and laser point density which clients require.

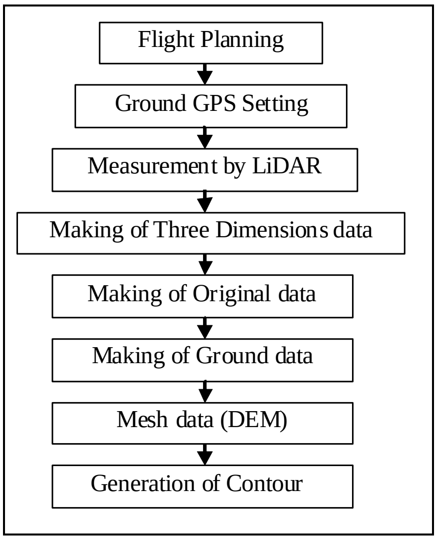

Figure.2 Flow chart of "Manual of making DEM by Airborne Laser Scanning survey"

2) Ground GPS setting
At present, Japanese surveyors of Lidar don't set any ground GPS stations. Because there are approximately 1200 GPS based control stations in Japan. Their main purpose is an observing any earthquake and delivering public electric information of control point for 24 hours.

We usually get and download data from some GPS data suppliers.

Figure.3 GPS based control station (GSI)

3) Measurement by LiDAR
In this project, LiDAR system loaded on some fixed planes. Because it was very vast flight area and we should have to complete fast. We should have to survey over 100 square km per day. In general, airborne LiDAR survey by helicopter is efficient for small area less than a few square km or line survey like powerline and rails. Because chopper cost is expensive and flight time is shorter than fixed plane.

4) Making of Three Dimensions data (3D)
This proceeding is next below works.

a) Each sensor data combines to geodetic data.
Binary data output from sensors convert to text data (XYZ). We calculate a geoid model and BLXY.
b) Delete noise from 3D data
Noises include dusts in air, clouds, birds etc.
c) Light Orthophoto Image

We usually use some LiDAR systems with a digital camera. It is made by Applanix DSS, and has 1600 mega pixel resolutions. We give outer orientations photographs, and make light-orthophoto images without adjusting and colour control. They use for filtering verification and draw "water polygons"; rivers, lakes and marine etc.

5) Original data
Original data also call "all data", because they have terrain data including surface objects on earth. This proceeding includes both check of interval courses, and absolute accuracy check.
Original data were made about the whole survey area.

6) Ground data
Ground data extract surface objects (buildings, trees, bridges, artificial things etc.) from original data. A filtering area is defined river channels as project's guideline (see Fig. 4).
At first, we had done the automatic filtering method by "Terrascan". This software is made of Terrasolid. Therefore, we have achieved perfect filtering by operator's manual removing.

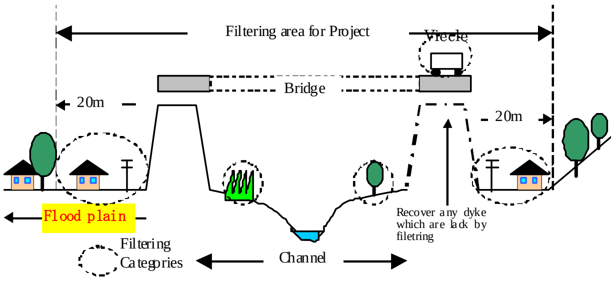

Figure.4 Filtering categories of river survey by LiDAR

7) Interpolation
Original data and Ground data are built as random points. It is difficult for end users to apply them to various calculation and analysis. We convert to grid that also called "mesh data". At last, End users can acquire DSM (Digital Surface Model) and DEM (Digital Elevation Model) through TIN. Triangular group generated from the randomly distributed laser points. It is called Triangulated Irregular Network (TIN), and the elevation of the arbitrary point is interpolated from the triangular plane.

2.2 Accuracy Assessment of LiDAR

Accuracy check of Laser points clouds are done below proceedings.
1) Check of conformity between flight courses
At least three places are set about 100m2 in side-lap between two courses. The place is called "Tie point" like photogrammetry. Some tie points have to be selected at flat space as car-parking, roof terrace, and gland etc. Elevation

differences between courses are asked for RMSE (1 sigma). RMSE must be less than 25cm. If RMSE is over 25cm, surveyors must recalculate or take off another flight.

2) Comparison with control points

This verification is absolute accuracy check. The results show clients an understandable proof. The elevation of control points are acquired by levelling from bench mark, and horizontal position of control point is measured by Total station or GPS static survey. The circumstances of control point should be flat place and near any existing BM or triangular point. If there is never existing BM, GPS static survey may be used in place of levelling.

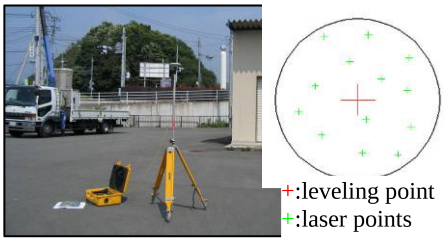

Figure.5 Accuracy check at flat place

3. CALCULATION OF WOODINESS RATE

LiDAR data are usually used as contour line of topographic map, and 3D map like shade map of topographic analysis.

We have developed particularly environmental method by first and last pulses, DSM, and DTM.

3.1 Definition of "Woodiness rate"

In this examination, "Woodiness rate" was set as an index that showed the density of tree assemblage in river channel. Ordinary method how to ask "Woodiness rate" is mainly the counting trees in quadrat (ex.10m × 10m). This method is accurate, but it is impossible to understand tree assembles upon the whole.

We have tried to ask for the distribution of tree assemblages by laser point clouds. The concept image is shown in Fig. 6.

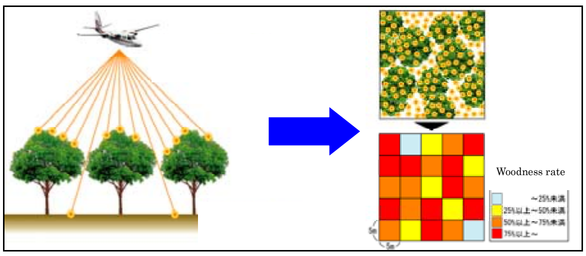

Figure.6 Image of the computation of "Woodiness rate"

3.2 Calculation

The procedure is shown below.

1) We divide two data from all laser point clouds. One cloud is returned from the canopy of trees (first pulse), the other is returned from the reached earth surface through canopy space (last pulse).
2) In this method, we use "Original data" and "Ground data". Original data is merged from first pulse data and ground pulse data. Ground data is extracted the surface objects from last pulse data.
3) 5.0m×5.0m meshes are set in river channel.
4) We calculate "woodiness rate" used by both data in every meshes. The formula is shown below. Woodiness rate (%) = (Original data – Ground data)/(Original data) This parameter shows a density of tree assemblage.

3.3 Problem and improvement

The defect of this calculation is including of herbaceous species and bushy trees. These vegetations are levelled to the ground while flood time, because it is weak for them to plant. Trees with thick stem are remained, dead water zones are formed like indicated Fig.7.

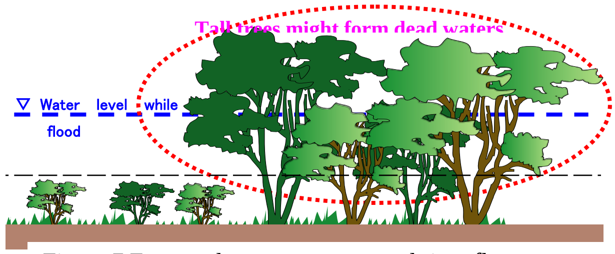

Figure.7 Extracted any trees prevented river flow

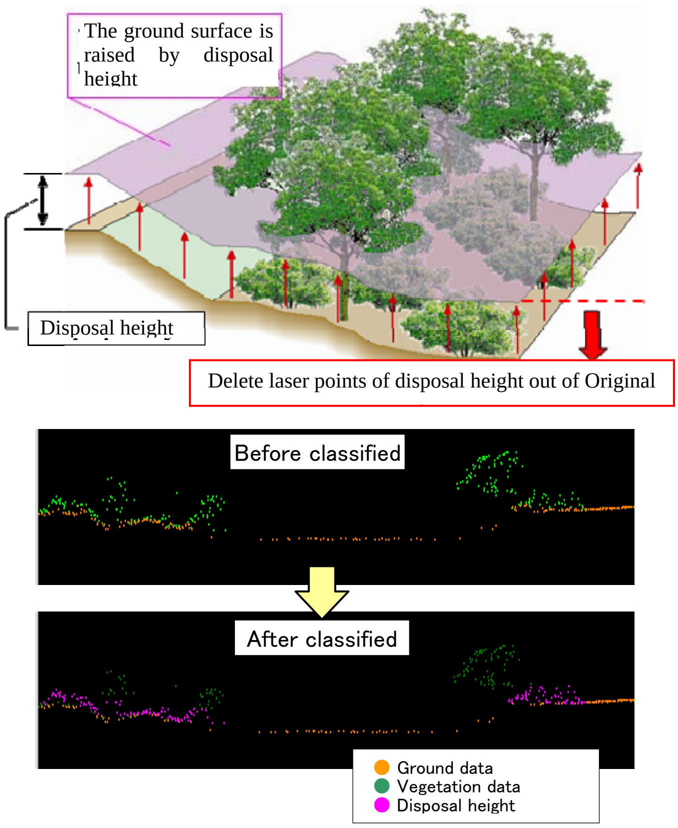

Figure.8 Method how to be extracted tall trees

Therefore, the result of this calculation might affect for the discharge capacity. The means is that the discharge capacity over counts. So, we have improved the method to extract any tree assemblages.

At first, if we have set the height of herbaceous species and bushy trees (ie. disposal height), the level of ground data raises up to disposal height. Furthermore, we have eliminated the original data below the level; we should extract only tall trees that affect discharge capacity.

Profiles of Fig.8 are indicated laser point clouds. Upper profile has not been extracted tall tree assemblages yet. Some pink points in below profile indicate classified as "disposal height".

3.4 Ver]ification

In order to check the right of woodiness rate, we have done field survey. We have confirmed good result about coefficient of trees transmissibility, after we have compared both data.

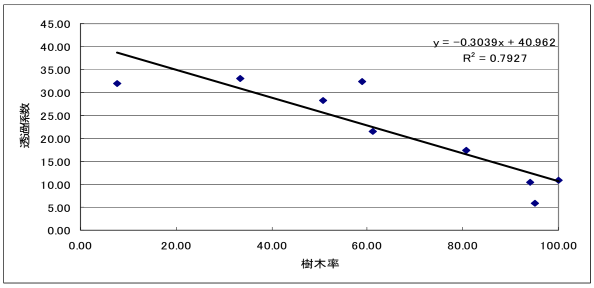

Figure.9 Correlation between woodiness rate by LiDAR data and transmissibility by field survey

4. RESULTS

At last, we have made the distribution map of woodiness rate after computed laser data. Mesh size of this map is 5m x 5m.

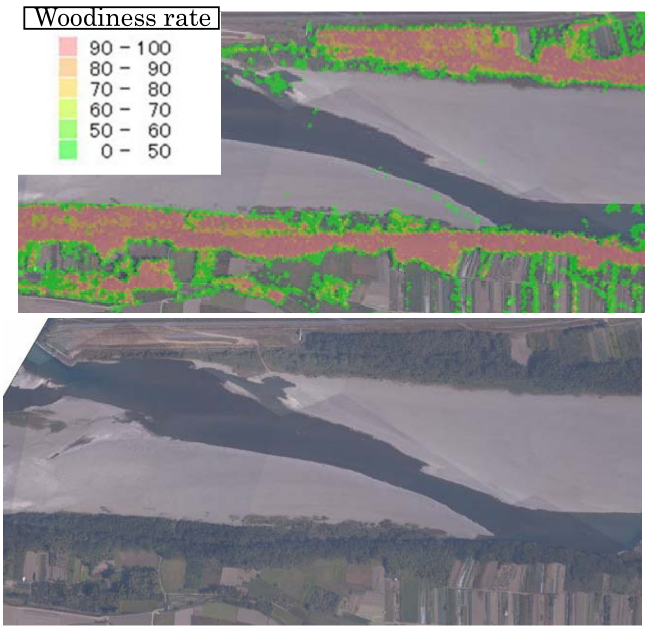

Figure.10 Distribution map of Woodiness rate (below image is orthophoto)

Additionally, we have made the DHM distribution map. DHM means tree heights, are acquired by subtracted from DSM to DEM. As tree heights are visualized (Fig.11), we are able to make any polygons of tall tree assemblages.

If DHM are combined with woodiness rate, it is possible to evaluate 3D assembles of river trees. If canopy scale are given each trees, we might be able to recognize the correlation between HWL and tree heights.

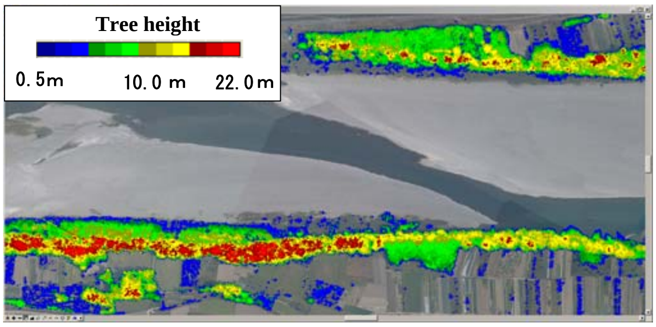

Figure.11

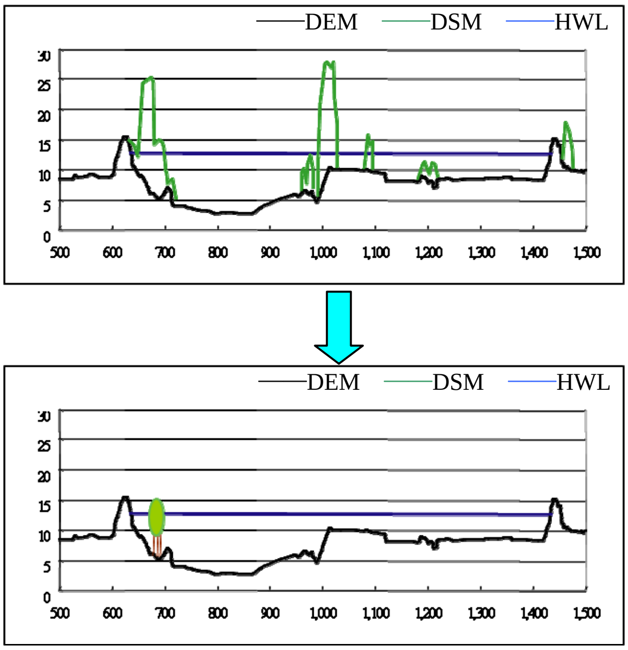

Figure.12 A profile in river channel (Upper: DSM and DEM, below: canopy of tree)

5. CONCLUSION

According to this research, "woodiness rate" by LiDAR is efficient for recognizing the growth of river tress widely and effectively. In future, we will consider that the coefficient of trees transmissibility.

New method described in this paper will be applied quantification of tree assemblage for any various rivers, and we will analyze the correlation between discharge capacity and laser point clouds.

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