A DISCRIMINATION METHOD OF MEASUREMENT DATA OF THE RIVERBED LANDFORM BY USING 3D LASER SCANNER*

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In this study, 3D laser scanner, which can scan the 3-dimensional shape of the landform automatically, was applied for measurement of 3-dimensional shape of the landform of the riverbed. Measurement result includes data of various objects. Discrimination of them is very important in the use of the data. In this study, streamline, shoal, soil, vegetation and concrete were discriminated by using intensity and the standard deviation value of it. By this algorithm, not only the measurement data provide more information in detail but also the data treatment algorithm was simplified. The measurement result by using the discrimination algorithm could provide distribution of streamline, shoal, soil, vegetation and concrete area clearly.

1. Guideline

Many trials to catch shapes of measured objects in the plane with the laser profiler technology have been tried. Although the technology about catching the reflection of the laser and discriminating it has developed progressively, in terms of the actual application, many researchers have been trying various examinations at present. Researchers including Mito have used 3D laser scanner to acquire shapes of the slope and the precipice ground and examined the utilization to the applied geology field. Thus the challenges regarding forest measurement with the aircraft laser scanner by Mita show the high attention of it in the field of remote sensing. Yasuda tried to make river channel shape information based on numerical altitude information in the field of river engineering, in addition, there is recently the trial which measures surface velocity and surface slope of actual rivers with tracking the float flowing by Okada except for the original purpose which acquires landform shapes.

Authors have tried to grasp 3-dimensional landform shapes of river channel landform by analyzing measurement results with 3D laser scanner, made by Riegl, with original data analysis system, developed by Mathematical Assist Design laboratory, since a few years ago.

In the case of applying the measurement technology with 3D laser scanner to river channel landform, the handling of water area is the most important. When 3D laser scanner is applied to river channel landform, grasping the complicated shape such as the water route and the bar in the place is expected very much. This is a problem that is not solved with a eventual cross-sectional surveying, therefore it is the effective application field for technology such as 3D laser scanner which is good for acquiring surface data.

However one problem occurs. Although existences of some objects are recognised by receiving light of the reflection laser, information about what their measurement objects are can’t be acquired. In this study, as a part of an efficiency improvement by the automatic handling of measurement results with 3D laser scanner, we tried automatic discrimination of measurement objects. That’s why we examined characteristics of measurement data on water area, shoal, grits, concrete, and vegetation in a river channel, and aimed to make the algorithm for discrimination of measurement objects with them.

2. Consideration of measurement results

Fig.1 is an example of the measurement result.

Figure 1. Measurement distance image

Fig.1 is the measurement distance image of the object landform where the distance from the measurement instrument is from 0.056m to 347.776m, showed by gray scale. It is showed darker as it is closer, and lighter as it is farer. The measurement object is the measurement result for the river (around Kotetsu Bridge at the upper Kanna River in Ueno village in Gunma prefecture), which is the measured result, looking down the river channel from one end of the bridge in the left bank side. Fig.2 is the ituation of it, but measurement point and angle are different a little.

Figure 2. Upper side of Kotetsu Bridge at Kanna River

Flow from the upstream (right side of Fig.2) is separated to right and left in the upstream of the bridge the area near right under the bridge is the shoal, and the bar is formed between them. Thus overgrowth of vegetations is observed. We can't discriminate that the aspect of the object landform is like Fig.2 from Fig.1.

Fig.1 is the image figure of the measurement distance, therefore it is not for discriminating aspect of the circumstance. However when 3D laser scanner is utilized actually, required data have to be selected to carry out the required data processing after changing the measurement result to the three-dimensional coordinate system. Although there is no problem when the measurement object is a single material, there are many cases that various objects such as grits, vegetation, water, and river structures are intermingled when measurement of river landform is carried out. For example, the landform eliminating the vegetation of the surface has to be grasped to calculate fluctuation quantity of the river bed, in addition, water area has to be grasped accurately to grasp the water route landform.

Among numbers from 1to 5 in Fig.1. 1 and 2 are the area where data was not acquired. However the reason why the data was not acquired at 1 is different from at 2. The reason at 1 is that the reflection light of the laser could not be received because of water surface, and the reason at 2 results that the laser could not be reached because it exceeded the effective range. 3 is the bridge. The dark landform that show the bridge of 3 is extending from the end of left bank to the right bank, the river channel landform around 1 is shielded. 4 is the river channel landform, the bar between river routes in the lower section of the bridge. 5 is the part of vegetations in the distance. It seems like it is difficult to discriminate the landform and vegetation. Although color images can be acquired, it is still difficult to discriminate with them accurately.

Fig.3 is the image figure of the light reception intensity corresponding to Fig.1 numbers from 1 to 5 are corresponding to Fig.1.

Figure 3. Light reception intensity image

In the measurement with 3D laser scanner the light reception intensity at the same time the coordinate of the measurement objects is measured. The light reception intensity is expressed by integer value from 0 to 255, and the value will change depending on not only material, color, and surface structure but also a weather condition when measurement is carried out.

We can find more information in Fig.3 than in Fig.1. For example, the difference between the riverbed of 4 and the vegetation of 5, which is not clear in Fig.1 can be discriminated clearly in Fig 3. When data processing, to save it from discriminating the measurement landform with pictures taken separately, we tried to examine the method for discriminating measurement objects automatically with adding ancillary information by the light reception intensity image.

3. Object discrimination algorithm by data characteristics

3.1. Relationship between distance and light reception intensity

Fig. 4 is the relationship between the distance and the light reception intensity extracted for ground data. The vertical line is light reception intensity and the horizontal line is the distance. From Fig 5, we can find that the light reception intensity increase as the distance increases until about 12~15m, and it keeps almost constant value. We couldn't expect the result that the light reception intensity increased with the increase of the distance within 15m because it is generally considered that the laser intensity decrease with distance. A tendency same to Fig.4 was confirmed in the examination with other measurement results.

The light reception intensity is calculated as some functions of the reflected light intensity and the distance, and has the characteristics that it keeps the peak value in the fixed distance, which is not accuracy because the detail of the method for calculating the light reception intensity inside the measurement instrument is uncertain. We focus on how we should discriminate measurement objects, base on these characteristics, without discussing the detail although various factors such as the effect by the changes of degree of the vertical angle and the laser spots shape can be considered. Fig. 5 is the relationship between the distance and the light reception intensity regarding grits, concrete, and vegetation. These were extracted from each same measurement figure, and measurement condition is also same.

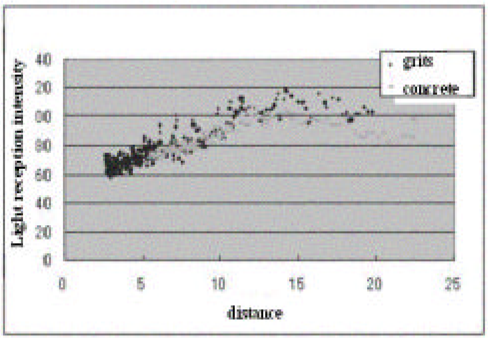

Figure 4. Relationship between distance and light reception intensity

Grits here is used as a generic name of land parts in river channel, therefore the gravel diameter and material is not distinguished. Vegetation data is showed in Fig. 6 because it is difficult to distinguish it in the same picture

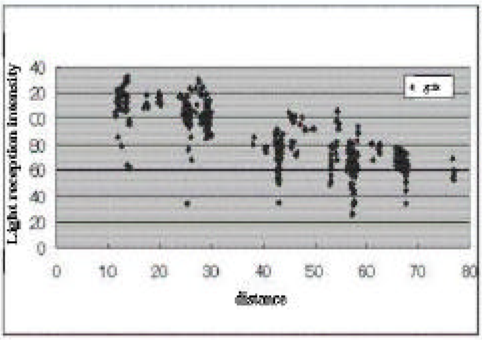

Figure 5. Relationship between distance and light reception intensity (grits and concrete)

Regarding grits and concrete, they increase with the distance until about 10m and keep constant same to Fig. 4 or look decrease gradually. In comparison with both, relationship between the distance and the light reception intensity shows a similar tendency, and this means that it is difficult to discriminate the grits and the concrete from the relationship between the distance and the light reception intensity. Regarding the vegetation, the vegetation here is herbaceous plants flourishing from a few 10m to a few m but not under growth such as grass. The distribution of the vegetation shows the tendency differ from grits and concrete clearly. It is considered that the light reception intensity is influenced by the direction, shape, and color of the leaf strongly in the vegetation area when the laser is reflected by flourishing vegetations.

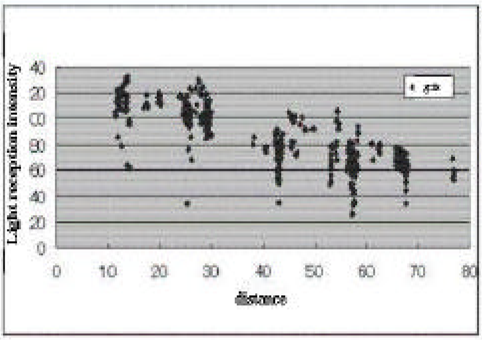

Figure 6. Relationship between distance and light reception intensity (vegetation)

The vegetation is not distributed successively therefore it is an intermittent data. That the distribution of the light reception intensity in the identical distance is uneven is confirmed although it seems because various vegetation data intermingles. This big fluctuation of the light reception intensity in the identical distance is one of specific characteristics of vegetation areas in the measurement with 3D laser scanner.

3.2. Relationship between distance and standard deviation of light reception intensity

Next we tried to examine the standard deviation of the light reception intensity. In terms of sampling, we aimed that the big distance deviation didn't occur by extracting data in the measurement figure transversally to remove the range dependence. In fact, on the vegetation transversal extracting data doesn't necessary remove the effect of the distance because there is a case in which the passage route of the laser is greatly different depending on places. Therefore we deliberated extracted data whose calculated standard deviation of the distance is under 1. Fig. 7 is the relationship between the distance and the standard deviation of the light reception intensity regarding the grits, concrete, and vegetation. About 100~500 of sampling data were used depending on the conditions of measurement figures to calculate the standard deviations. The difference between the grits and the concrete, which is not clear in Fig. 5, is found in Fig. 7. That's why the standard deviation of grits is bigger than the one of concrete, and it is considered that data characteristics based on the existence of the corrugation of the surface shape were extracted. The standard deviation of the vegetations showed the big fluctuation as well as the light reception intensity of it. According to Fig. 7, it is considered to be able to discriminate various phases representing landforms in the river channels such as grits, concrete and vegetation with standard deviations of their light reception intensity to some extents.

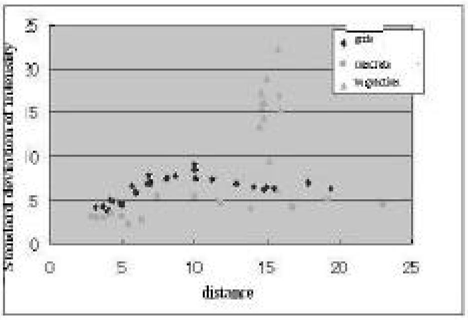

Figure 7. Relationship between distance and standard deviation of light reception intensity (grits, concrete, vegetation)

3.3. *Discrimination of measurement objects*

We showed the discrimination example of the measurement result. Fig. 8 is the measurement result around Kotetsu Bridge on Kinu River. That is the figure synthesized with the multiple measurement results after changing to rectangular coordinates, and the black point group shows the coordinate that data acquired.

The horizontal axis is the direction of the flow, the right side of Fig. 8 is the upstream, and the left side is the downstream. The grid line is conducted in the 50m interval and Kotetsu Bridge exits at 0 in the horizontal line in Fig. 8. It is possible to discriminate that the area without data is about the water route if the aspect of the field is confirmed, however it is not useful.

We showed the result discriminated with the discrimination algorithm for each kind of objects to Fig .9.

At first, we made the shape of the grits band rise and set the area without data between them to the water surface. The shape of Kotetsu Bridge is raised by extracting the concrete data. There is a region with data under the Kotetsu Bridge although the region is in water region. That region is shoal although it seems ground. There is the vegetation area surrounding the part of the grits. According to Fig. 9 the aspect of the river channel landform instinctively. Fig. 9 is expressed in the plane from upper part, however this is the three-dimensional landform aspect with the altitude information and it can be the beneficial information with various uses if we can provide the data proceeded to this condition.

However there are still many problems such as the discrimination of the gravel diameter of grits and the vegetation, acquisition of the landform information in bottom of water where there are still many problems, and establishment of the system that provides the stable measurement and data.

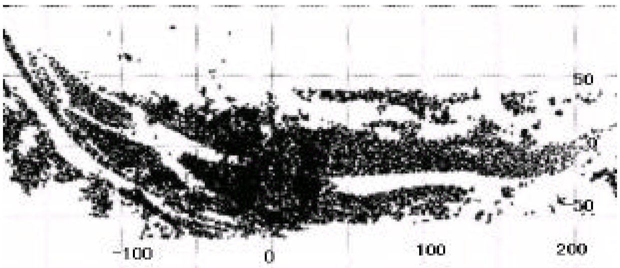

Figure 8. Measurement distribution data around Kotetsu Bridge on Kanna River (without discrimination handling)

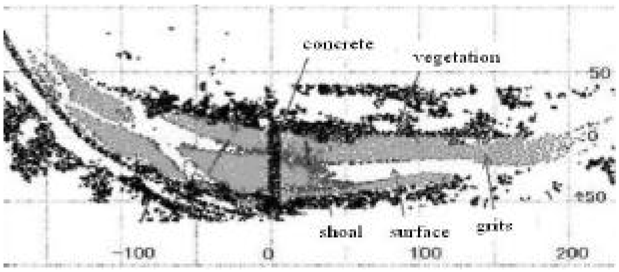

Figure 9. Measurement distribution data around Kotetsu Bridge on Kanna River (with discrimination handling)

4. Conclusion

As we mentioned above, in this study we tried to change the measurement results to the beneficial information for various uses by using the object discrimination algorithm with each kinds of data characteristics to measurement results. This algorithm can make discriminated information attach without the increase of human labor. Thus it is very beneficial to utilize 3D laser scanner in the field of the river engineering in the future. However there are various grits and vegetation in river, therefore we have to examine more detail and convenient discrimination method in the future.

References

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