3D Road Shape Production Technique by Fusion of Laser Data and CCD Image

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ABSTRACT: For road research such as road safety analysis 3D information is very useful. Using a laser scanner, 3D road information can be obtained. However laser scanner data are not close to real scenery. To complement laser data, we take optical images by CCD cameras. If we fuse optical images with laser scanner data, we can make true 3D road images. Here, the fusion of laser data and CCD image means finding RGB pixel values of the points in the CCD image which correspond to the laser data and applying the pixel values to the laser data. For applying this method, we need to set up a model between laser data and CCD images. We used a DLT model in this study. Firstly, we transformed the laser data to a DEM image. Next, we found corresponded points in the DEM and CCD images. Finally, we set up the DLT model and applied fusion. Result showed that these images after fusion show color closer to the reality and we can make a more realistic 3D road images with interpolation.

KEY WORDS: Fusion, 3D Laser Scanner, CCD

1. INTRODUCTION

Laser scanner is useful for obtain 3D information of roads. Laser scanner can calculate the distance between the scanner and the ground by sending laser pulses and receiving the reflected laser signals. Then it can make 3D coordinates of roads in combination with GPS receivers on INU (Inertial Navigation Unit).

However if we visualize Laser data, the laser imagery is not close to real scenery like CCD Images. Because these images are not from spectral response. Although we can make images from intensity of laser signals, it is not close to real scenery either.

To overcome this problem, we take the optical images by CCD cameras. If we fuse optical images with laser scanner data, we can make true 3D road images. In this Paper, we will report this fusion.

2. DATA SET & METHOD

We used a laser scanner The HDS2500 produced from the Leica. The contents of laser data are shown in Figure 1. First line of this data means the numbers of recording points. Then the data contain TM coordinates of a laser point (the first to third fields), digitized laser intensity(the forth field) and RGB intensity values taken by a CCD camera(the fifth to seventh fields). This CCD sensor synchronized with the laser canner. But resolution of this CCD images are not good enough to make scenery like real world. For this reason, we need fusion of laser data with high resolution CCD images. The high resolution CCD images used in this experiment were taken by personal digital camera, FUJI FinePix F700 (See figure 3(A)).

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769735
233363.849709 407917.650009 113.273139 462 74 71 101
233300.790875 407847.858930 112.802885 -453 57 60 87
233300.820126 407847.852270 112.631092 -457 56 59 86
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Figure 1. Structure of laser scan data (.PTS file)

In this paper, the fusion of laser data and CCD images means finding RGB pixel values of the points in CCD images which correspond to the laser data and applying the pixel values to the laser data. Figure 2 shows the flowchart of this method.

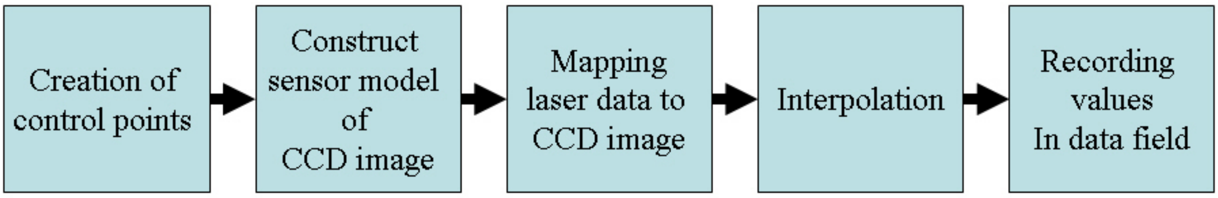


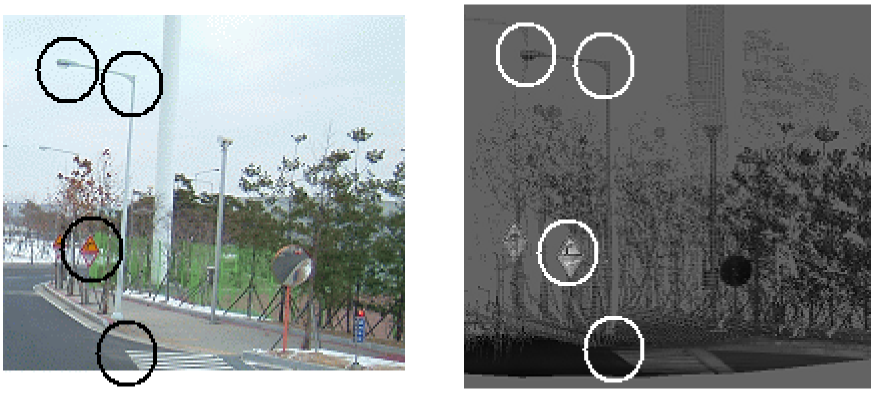
Figure 2. Flowchart for fusion of laser data and CCD images

To make control points, we made a DEM image from laser data. Then we found corresponding points in the DEM and CCD images manually. Among these points, we selected some control points that had low RMSE(in this experiment, we selected 6 points) . Figure 3 is example of corresponded points

To construct a sensor model at CCD images, we use a DLT model, and the numerical formula of a DLT model is shown below.

$$\begin{bmatrix} u\omega \\ v\omega \\ \omega \end{bmatrix} = M \begin{bmatrix} x \\ y \\ z \\ l \end{bmatrix}$$

In this formula, *(x,y,z)* is the coordinates of 3D object points, *(u,v)* is coordinates of 2D image points, *w* is a scale factor, and *M* is a matrix that defines the relation between object points and image points. A DLT model needs more control points than a collinearity model. On the other side, it can obtain coefficients of *M* matrix easily without consideration of physical camera parameters. A DLT model needs 6 control points at least.



(A) CCD image (B) Laser intensity image

Figure 3. position of corresponded points

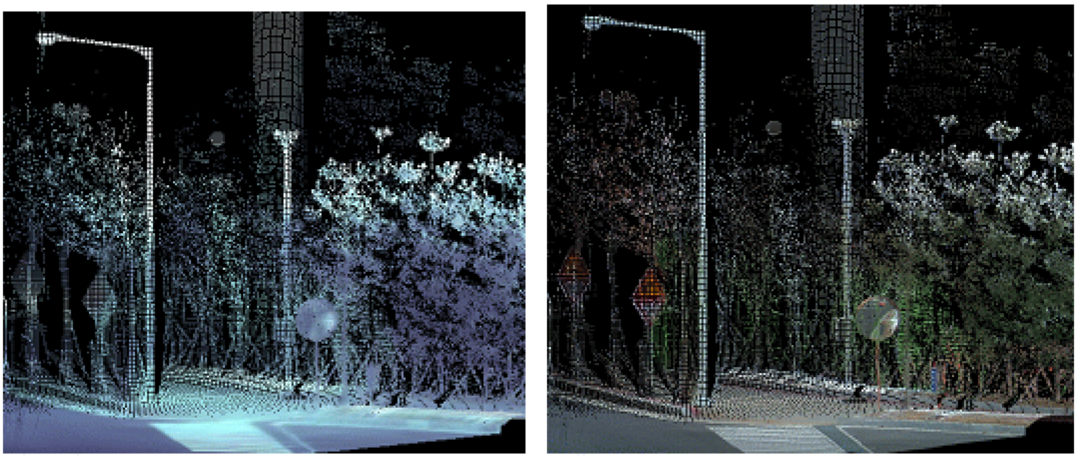
Once a sensor model of a CCD image is constructed, we can obtain the image coordinate *(u,v)* for laser point easily by substituting the coordinates of the laser point *(X,Y,Z)* into the DLT formula.

Generally, calculated image coordinates are not integer numbers and to find RGB intensity values on the calculated image coordinates we need interpolation. In this experiment, we use 'Nearest Neighbor Interpolation'. If we obtained new RGB pixel values, we replaced the original RGB fields of laser data with new ones.

3. RESULT

Figure 4 is the CCD image taken by FUJI FinePix F700. This image was fused with laser data acquired from the HDS 2500. Figure 5 shows two RGB images for comparison. The left image is a RGB image from the original low resolution CCD camera synchronized with the laser scanner. The right image is a RGB image obtained by fusion method proposed here.

Figure 4. CCD image



(A) before fusion (B) after fusion

Figure 5. RGB image

We can confirm that in the fused image the shape of crosswalk, the road mirror and road signs are similar to the original high resolution CCD image as shown in Figure 4 and 5(B). And it was also confirmed that the image after fusion show color closer to the reality than laser data. However, when we could not observe precise control points due to resolution difference of DEM image and CCD image fusion could not be performed successfully.

4. CONCLUSION

It was confirmed that fusion of laser data and CCD images could be accomplished through the procedures described here. As a result, fused image shows color closer to the reality more than before. Our method requires to select precise control points manually, Sometimes this task was not done properly because the resolutions of a DEM from laser data and CCD images are different. It needs to interpolation because there are many blanks in the laser data which used in this test.

5. REFERENCES

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