COMPARISON OF TREE EXTRACTION FROM INTENSITY DROP AND FROM MULTIPLE RETURNS IN ALS DATA

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ABSTRACT:

LIDAR is an application widely open as an area of study for modelling detailed topographic maps. It is generally used in airborne applications. In this study, the aim is tree extraction from a data having the 3D coordinates of first and last returns, and intensity data. The data used is from the city center of Stuttgart/Germany and includes large and irregularly shaped buildings and road with a bridge and tunnel. Two methods were compared. In the first method, the algorithm searched for neighboring points with low intensities. The points with lower intensity than the treshold represented trees, as trees cause absorption. In the secon method, the algorithm searched for the points that had height difference between the first and last returns. These point clouds were effective on tree extraction, as trees cause multiple returns. The density of trees in the first method was poorer than in the second, while in the second method, balconies and corners of the buildings were seen as trees. As a result, the second method is better on tree extraction, however an additional edge-detecting filter is needed.

1. INTRODUCTION

LIDAR is acronym for Light Detection and Ranging and is used to gain high resolution topograghic maps more accurate than traditional methods. It has the same working principle as radar, except using laser light instead of radio waves. A typical Lidar consists of transmitter (one laser or more), transmitter optics, receiver optics, detector and electronic system. Lidars may be classified according to process (range finders, DIAL, Doppler Lidar), platform (terrestrial, airborne, spaceborne), wavelength (infrared, visible, ultraviolet), scattering type (Backscattering Lidar, Rayleigh Lidar, Raman Lidar, Fluorescence Lidar) (Weitkamp, 2005). Airborne Laser System is one type which the Earth is scanned from an airplane or a helicopter and the surface elevation is estimated by return time. A small telescope (detector) and a mirror (receiver optics) is used to collect the light back. The position of the plane is determined by a differential Global Positioning System (dGPS). The orientation of the plane is measured by an Inertial Navigation System (INS) (Figure 1).

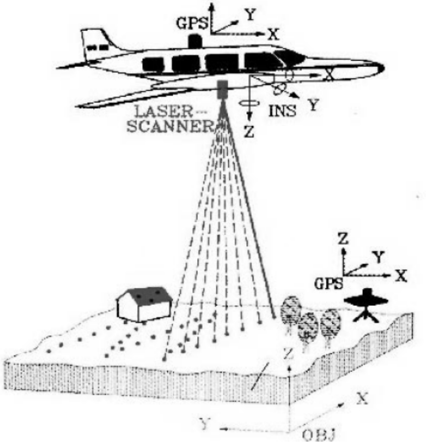

Figure 1. ALS and its components [2]

All these information is collected to have a “geolocated laser return” (Harding, 2000). The ground that is to be scanned can be rocky mountains or urban city or densely forested area. The produced data consists of dense point clouds and until now, several filters have been developed to interprete bare Earth, buildings and vegetations; morphological, or segment-based, or slope-based, or iterative and or point to point (Sithole, 2004).
In this paper, two methods were used for tree extraction. The raw data used is test site 2 in the ISPRS Working Group III/3 and belongs to Stuttgart city center (Figure 2).

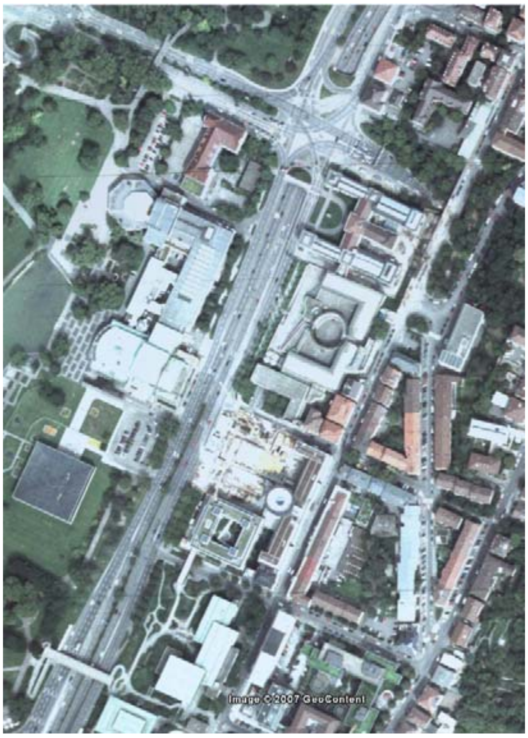

Figure 2. Stuttgart city center. (Google Earth Application Image Copyright 2007 GeoContent All Rights Reserved)

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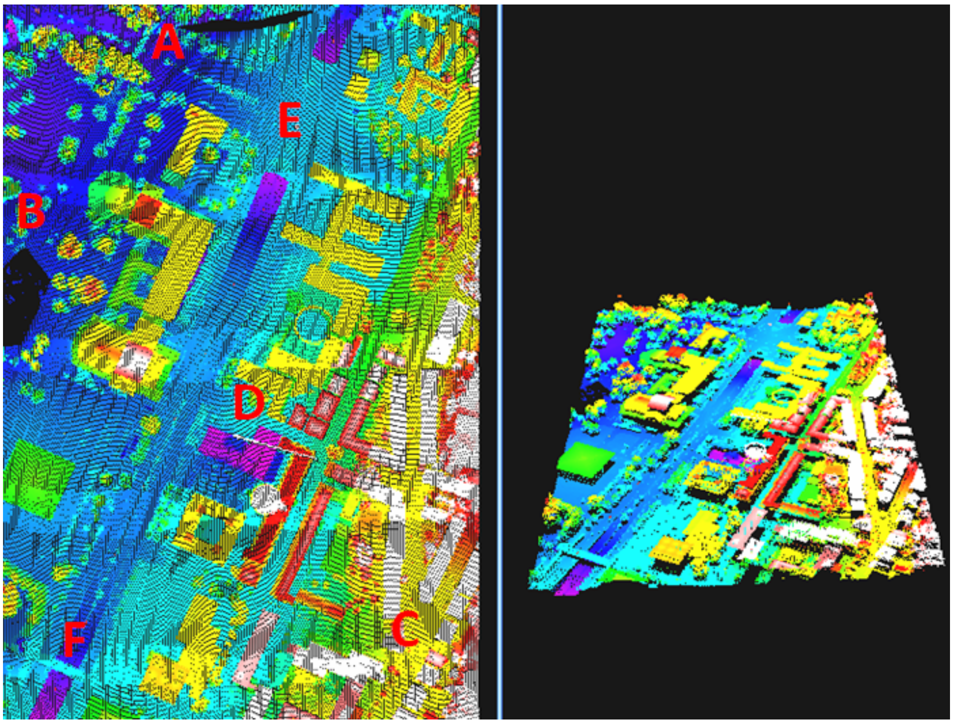

Figure 3. A (right) data gap, (left) road with a bridge and trees, B pool, C and D large and irregularly shaped buildings, E a crossroad with small tunnel, F bridge. (Illustrated by Cloud Peak Software LASEdit Utility Copiright 2006 All Rights Reserved)

The test site has a crossroad with a tunnel, a bridge, a pool, irregular shaped buildings and trees.The planimetric resolution is 0,67 points per square; thus, the two points spacing is 1-1.5m (Figure 3).

2. M ETHODS

The methods presented here for tree extraction are related to mathematical algorithms:

1. Preprocessing of the raw laser data (true DSM)

2. Application of mathematical algorithms

3. Building of images.

The input file “cite.txt” has 8 collumns and 243.400 rows. The collumns are X, Y and Z coordinates (Easting, Northing and Height) and intensity of first returns and X, Y and Z coordinates (Easting, Northing and Height) and intensity of last returns in that form:

X1	Y1	Z1	I1	X2	Y2	Z2	I2
513450.03	5402650.22	296.38	3	513450.04	5402650.23	296.30	3
513450.04	5402651.74	295.44	146	513450.04	5402651.74	295.44	146
513449.85	5402653.04	301.16	0	513450.00	5402653.29	296.12	80

.....

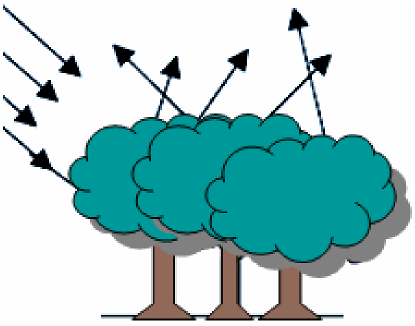

Figure 4. Due to diffusion in trees only one or two of the rays come back to detector, resulting intensity drop.

Intensity Drop Method: When the laser light hits trees, there is loss in intensity diffusion(Figure 4). The mathematical algorithm is based on intensity drop.

The condition to find trees is the three following intensities be less than treshold value. After tests the treshold value was chosen 35 (Figure 5).

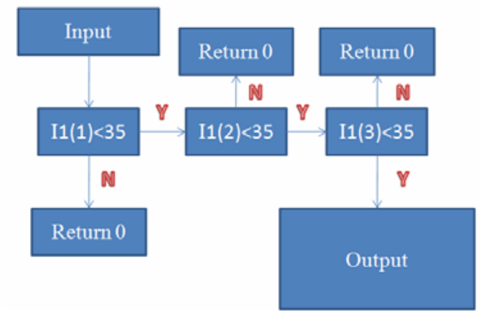

Figure 5. Algorithm for first method.

Algorithm for intensity drop:

```
main(){
FILE *fin,*fout;
fin = fopen ("cite2.txt","r");
fout = fopen ("inten2.txt","a");
int k;   /*N is defined as row number separately, i.e. 243.400*/
double Nor[N];
float Eas[N], Hei[N], Int[N], Easl[N], Norl[N], Heil[N], Intl[N];
if (fin==NULL){ printf("Cannot open the input file"); return 1;}
if (fout==NULL){ printf("Cannot open the output file"); return 1;}
for (k=1;k<N+1;k++) {
fscanf(fin,"%f %lf %f %f %f %f %f %f\n",&Eas[k], &Nor[k],&Hei[k],&Int[k],& Easl[k], &Norl[k], &Heil[k], &Intl[k]);}
for (k=1;k<N;k++) { if (Int[k]<35) { if (Int[k+1]<35) { if (Int[k+2]<35)
fprintf (fout, "%.2f %.2lf %.2f %+.2f %d \n", Eas[k],Nor[k],Hei[k],Int[k],k); } } }
fclose (fin);
fclose(fout);
getchar();
return 0; }
```

The output is txt file and was imported to las format and displayed via LASEdit software.

Intensity Drop Method: When laser light hits vegetation multiple returns used was due to multiple return in trees.

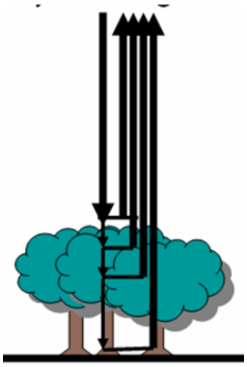

Figure 6. Due to multiple returns in trees the first and last return must have different heights.

According to algorithm the difference between first and last returns must be bigger than a treshold. After tests the treshold was chosen 5 (Figure 7).

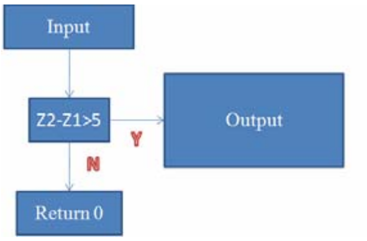

Figure 7. Algorithm for second method.

Algorithm for height difference:

```
main(){
FILE *fin,*fout;
fin = fopen ("cite2.txt","r");
fout = fopen ("heights2.txt","a");
int k; /*N is defined as row number separately, i.e. 243.400*/
float Eas[N], Nor[N], Hei[N], Int[N], Easl[N], Norl[N], Heil[N], Intl[N], df[N];
if (fin==NULL){printf("Cannot open the input file");return 1;}
if (fout==NULL){printf("Cannot open the output file"); return 1;}
for (k=0;k<N;k++) {
fscanf(fin,"%f %f %f %f %f %f %f %f\n", &Eas[k],&Nor[k],&Hei[k],&Int[k],& Easl[k],&Norl[k],&Heil[k],&Intl[k]);
df[k]=Heil[k]-Hei[k];
if (5<fabs(df[k])) {
fprintf(fout,"%.2f %.2f %.2f %.2f %.2f %d\n",Eas[k],Nor[k],Hei[k],Heil[k],df[k],k+1); } }
fclose (fin);
fclose(fout);
getchar();
return 0; }
```

3. RESULTS

The first method returned tree points quite satisfactory and the second method returned tree points with errors due to balcony and bulding corners (Figure 10 and 11)

4. CONCLUSION

Even though there are some errors in the second method the density of the trees is more satisfied (Figure 12 and 13).

REFERENCES

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Sithole, G., Vosselman, G., 2004. Experimental comparison of filter algorithms for bare-Earth extraction from airborne

laser scanning point clouds.ISPRS Journal of Photogrametry & Remote Sensing 59, pp. 85-101.

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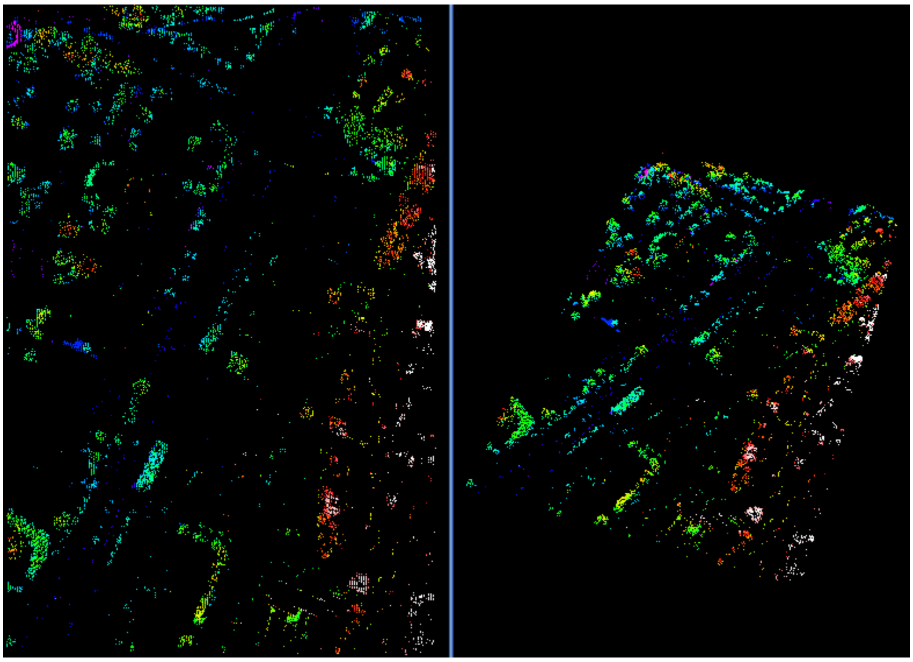

Figure 8 The output for the first method

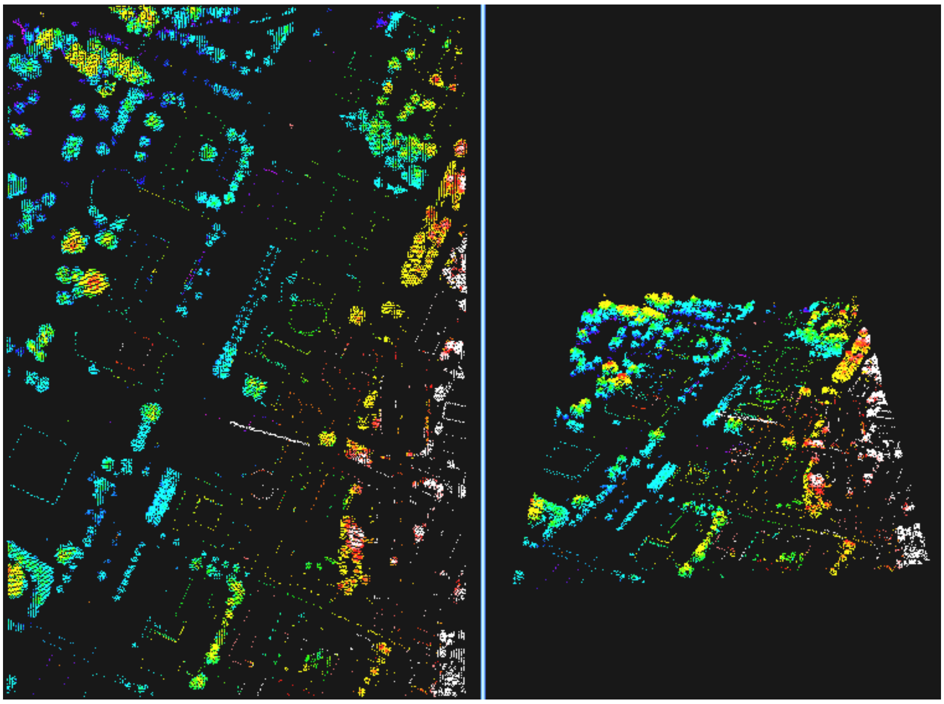

Figure 9. The output for the second method.

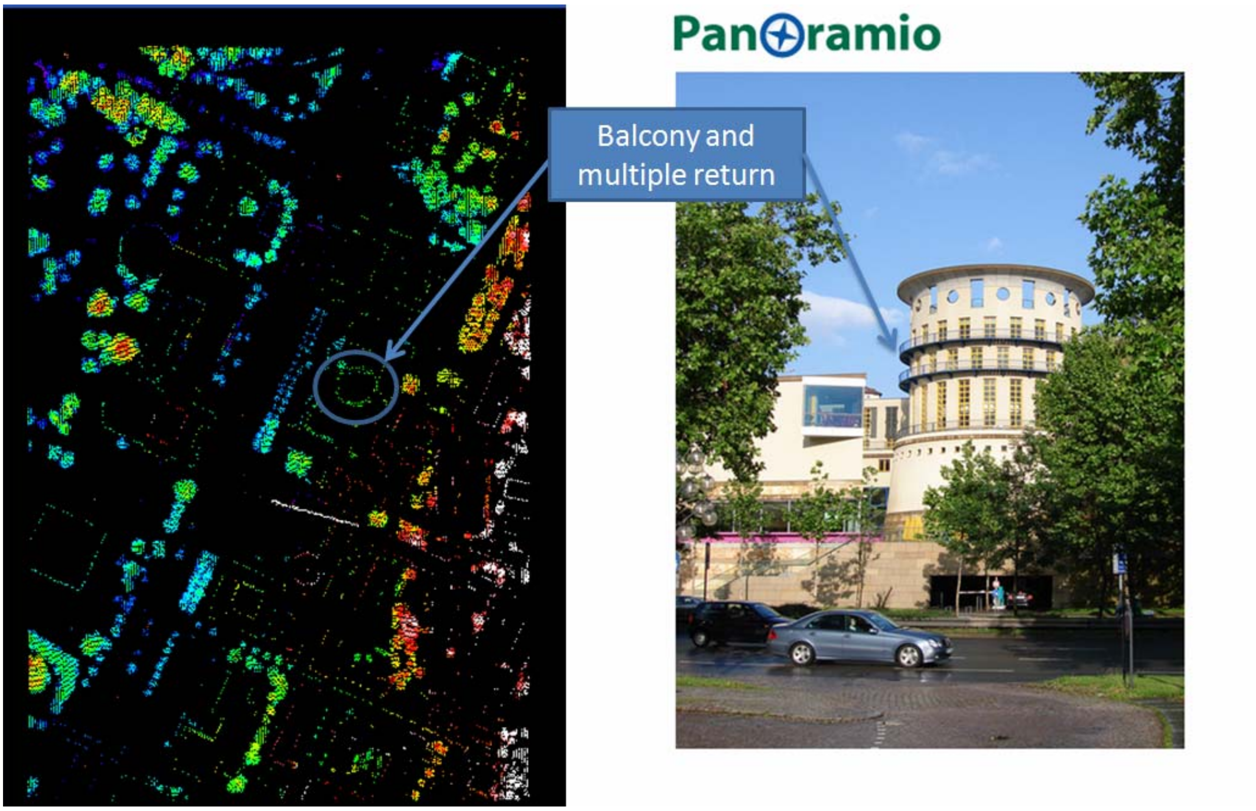

Figure 10. The errors in the second methods are due to balcony.

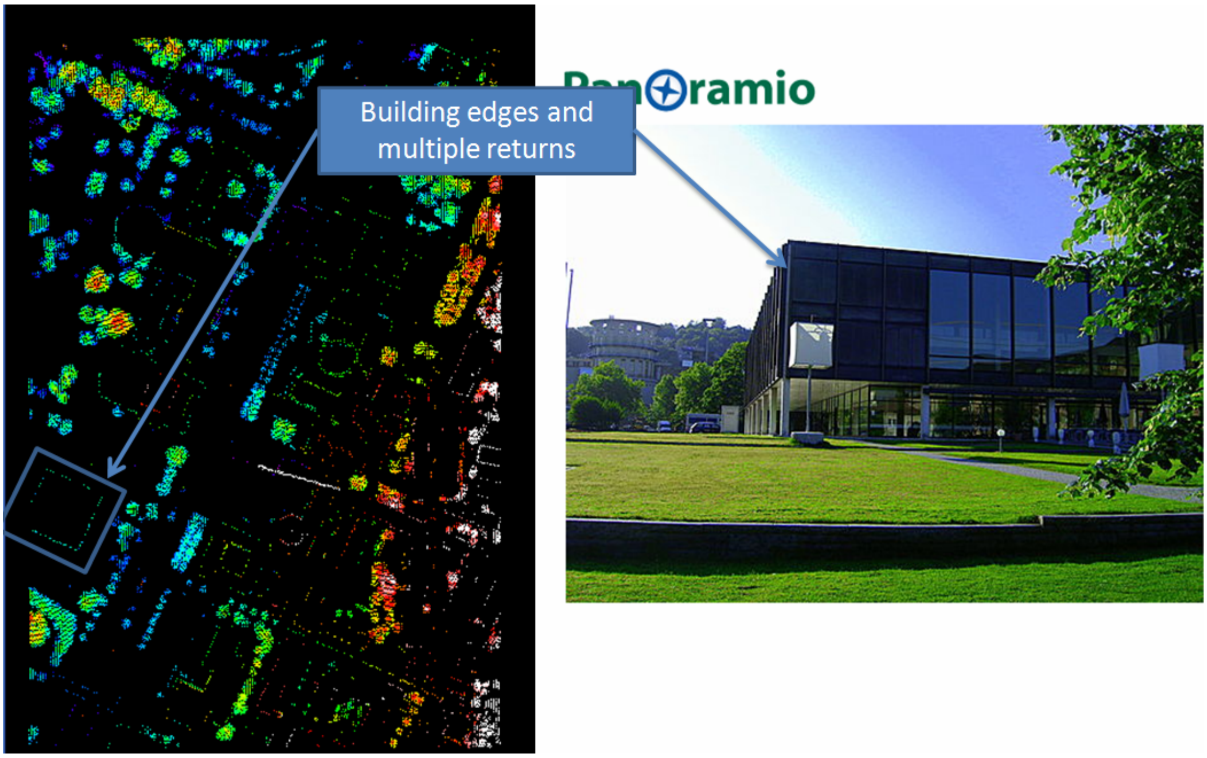

Figure 11. The errors in the second methods are due to building corners.

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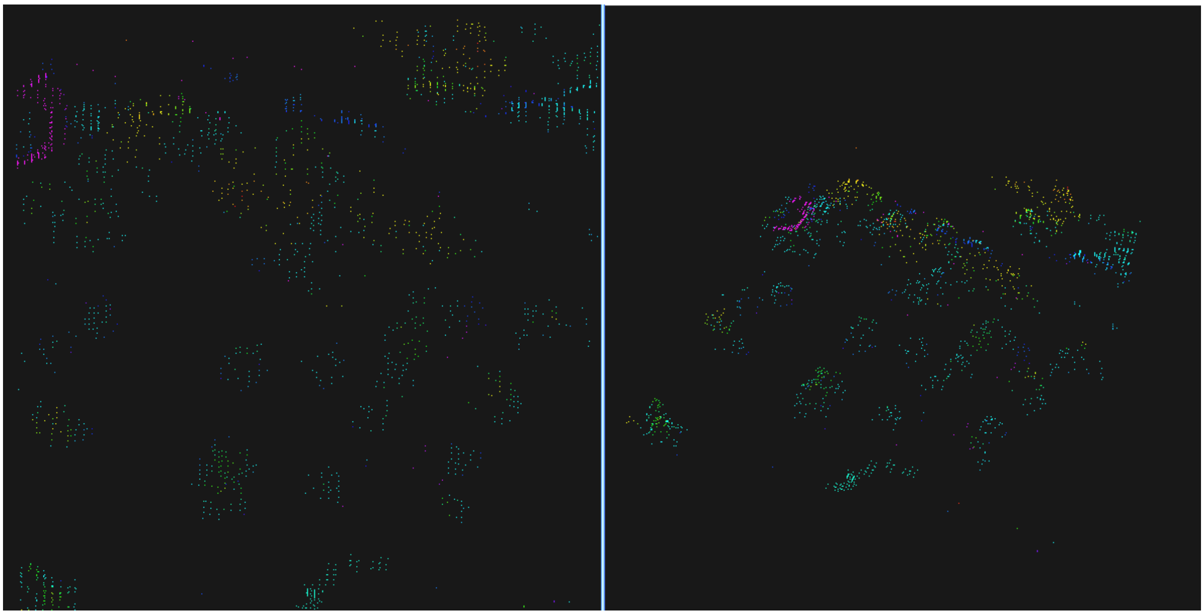

Figure 12. The upper left part of the output data of the first method.

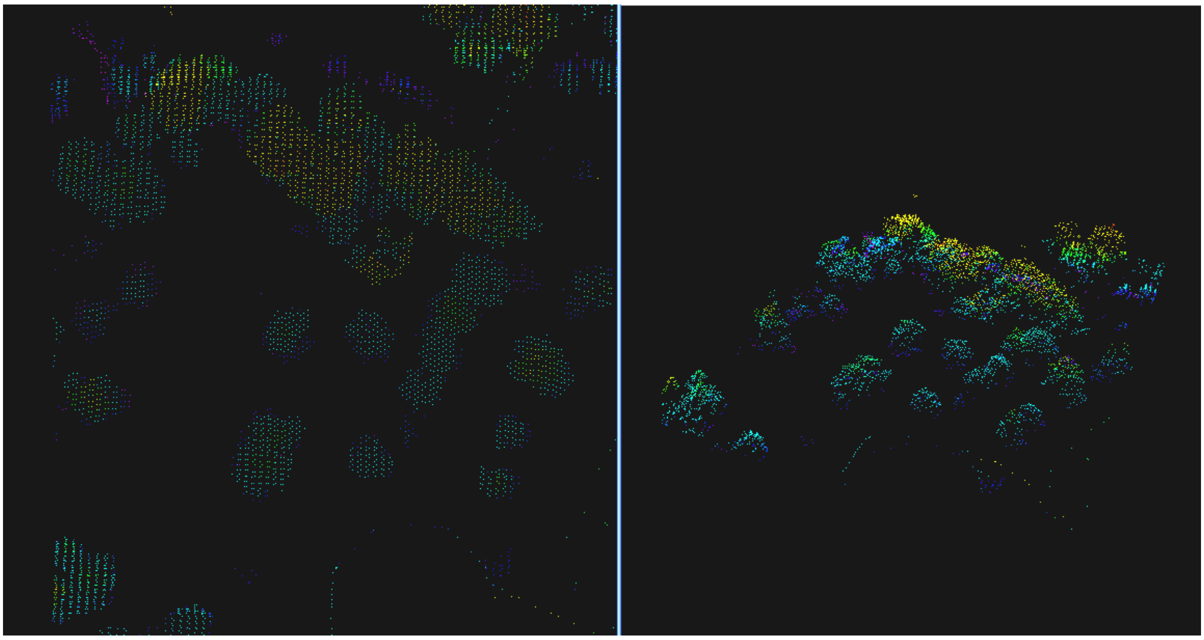

Figure 13. The upper left part of the output data of the second method.