Eurographics Conference on Visualization (EuroVis) (2014)
R. Borgo, R. Maciejewski, and I. Viola (Editors)

STAR – State of The Art Report

Bridge and terrain reconstruction in LiDAR point clouds

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Abstract

When LiDAR data of the terrain is being acquired some object might interfere with the surroundings in such a way that a lot of detail is lost. One type of these examples are bridges. Details of them are lost and they have a large impact on the terrain bellow which is also lost. In this paper we propose an algorithm to reconstruct the lost terrain and basic bridge geometry using additional data about bridges and the terrain found in SHP files. We discuss the results that this kind of an approach brings and what can be done to further improve it.

1. Introduction

In this paper we discuss an implementation of an algrorithm to reconstruct bridges and terrain under them in LAZ files in which point clouds are stored. We also discuss how the additional data in the form of SHP files which were available to us from the e-Geodetski podatki web site proved effective in our algorithm. **??**. These contain geometries and some basic information about infrastructure such as bridges and natural resources such as rivers. We also show the results that we produced using some simple approaches, our own approach and the final result of the reconstruction process.

2. Terrain reconstruction

The majority of our effort was aimed towards reconstructing the surface underneath the bridge. At the start we tried some basic approaches towards terrain reconstruction and got some insight into problems that we will have to solve. These were:

- how to obtain the area of the terrain under the bridge,
- how to generate points on this area to best reconstruct the terrain and
- how to deal with outliers, vegetation, power lines and object that are adjecent to bridges and don't represent the terrain.

Our first attempt at solving this issue can be seen as the red part of the figure 1.

Here we used a simple approach of a weighted nearest neigbour interpolation. As it can be seen reconstructed points do not follow the reality of the terrain well. The majority of points are interpolated to roughly the right height but the transitions between them are very harsh.

After some examination of the issues we have come to an algorhitm which proved very effective in reconstruction terrain under a bridge and can be seen as blue in the figure 1. We have also chosen a very complex bridge example in order to make our approach as robust as possible. Our example consisted of two adjecent bridges that extended over a mov-

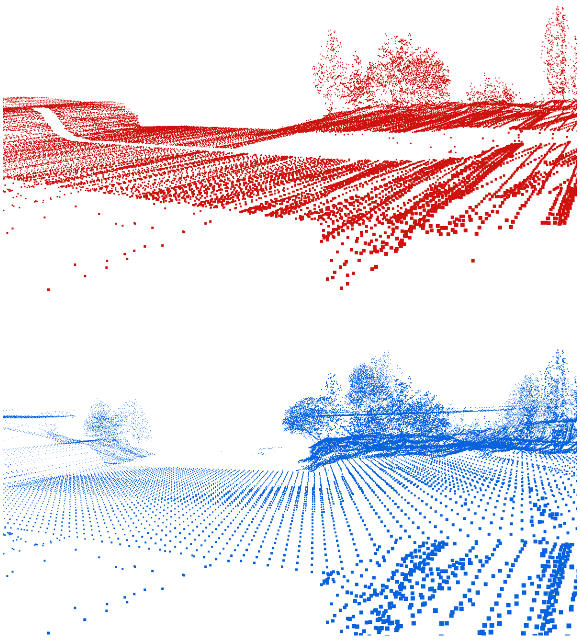

Figure 1: *Results of terrain reconstruction. Image in red shows the closest neighbour interpolation while the blue image shows selected group interpolation.*

ing body of water at an angle that wasn't perpendicular to it. Both also extended over a large portion of the terrain.

Our approach can be seen on figure 2 and is described bellow.

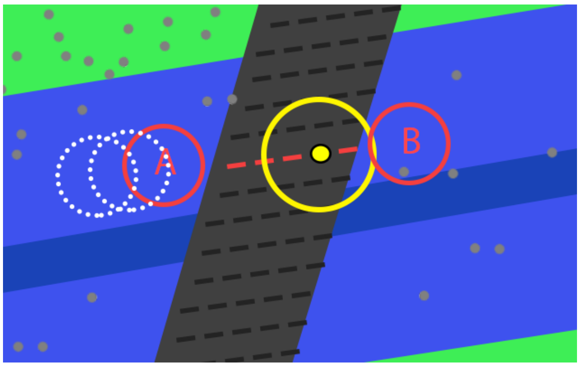

Figure 2:

- 1. Define the bridge polygon from the SHP file and temporary remove every point that is determined to belong to a bridge.
- 2. Generate values x and y along the bridge in such a way that they run parallel to the valley bellow the bridge.
- 3. Sample points from both sides of this line (terrain adjecent to the bridge marked with A and B). If there are too few points sampled then continue searching in the same direction until some threshold (white dotted circle). If there are still not enough points to be found sample the surrounging area of the terrain that has already been completed (yellow circle).
- 4. Process the sampled points to remove any objects that aren't terrain.
- 5. Interpolate the z coordinate with distance as a weight on sampled points.

An important thing to note is also that bridges werent always saved as a simple rectangle but were made of many bridge sections that together formed a bridge. Because of this and given that the orientation of each bridge section could have a slightly diffferent angle so this process had to be repeated on each one independently.

3. Bridge reconstruction

Because of the nature of how the LiDAR data is gathered the surface bellow the bridge was missing. This was then reconstructed using a similar traversing approach as the one described in the previous section. The main difference being the direction in which lines were being generated. Here they were generated perpendicular to the bridge orientation. Instead of using all of the points only four key points were used for interpolation, these being the four edges of the bridge section. Like for the terrain generation here this interpolation had to be made to each of the bridge sections that formed a single bridge.

4. Results

The whole reconstruction process of the bridge and terrain on an example of two highway bridges produced the results in under a minute, but this may vary based on the system performance. The cloud points before and after the reconstruction process can be seen in figures 3 and 4.

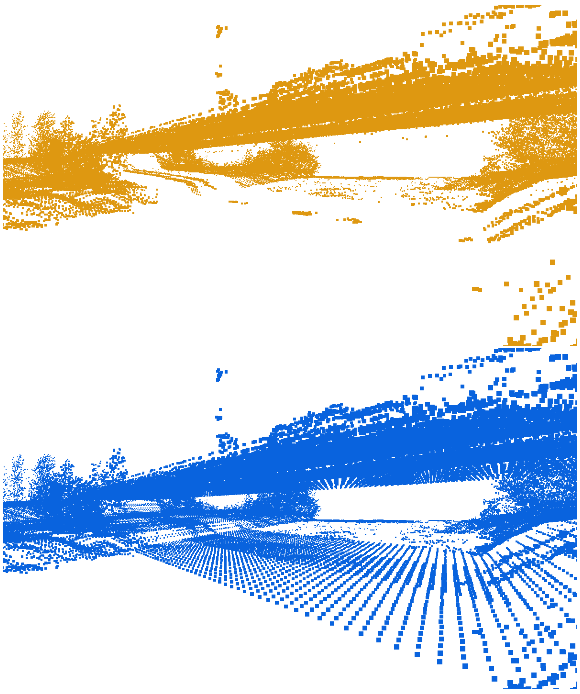

Figure 3: *Results of terrain and bridge reconstruction. Image in yellow shows the original data while the blue image shows the added reconstructed data.*

5. Further work

One of the issues we didn't solve is that of saving the reconstructed data in LAZ format. We weren't sucessful in finding any free library that we could use to save the reconstructed data in the same LAZ format as the input file. That is why the system outputs a simple OBJ file which contains the reconstructed bridge points alongside with the original points inside of a certain circumference of the bridge.

More of the infrastructure of terrain bellow the bridge could also be supported. For now only rivers have been supported but also roads, railways or any other kind of infrastructure could be supported as well with the right SHP files and filtering attributes.

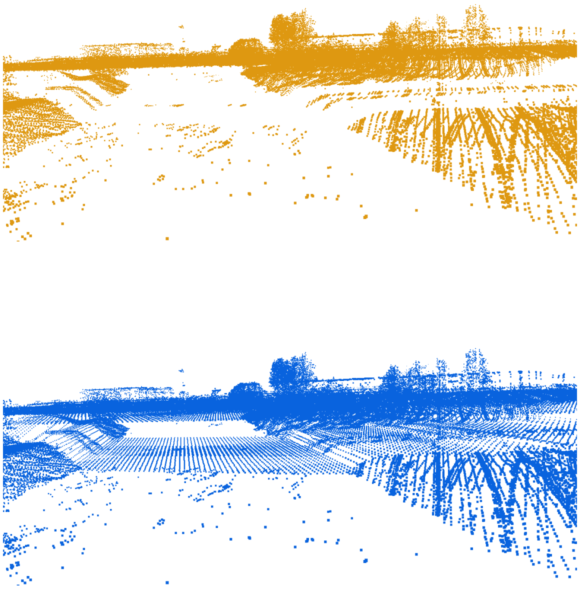

Figure 4: *Results of terrain and bridge reconstruction. Image in yellow shows the original data while the blue image shows the added reconstructed data.*

6. Conclusion

We were sucessful in implementing a rather robust approach for reconstructing bridges and terrain underneath. The reconstruction algorhitm is aware of the natural flow of the terrain and the points that are important for interpolation. Compared to simple interpolation methods our approach provided better results while still giving the result in an acceptable amount of time. Further work could be done improving this approach especially on reconstructing the bridge.