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THE RECOGNITION OF SINGLE HIGH OBJECTS ON TERRAIN ACCORDING TO THE LASER SCANNING DATA

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Introduction

There are many software products for points cloud [1]. The algorithms that are used in such programs are diverse, but not universal and work ambiguously for objects of different types.

Many researches are devoted to development and modification of algorithms aimed to classification of points and recognition of objects in the cloud. Many works consider algorithms based on neural networks, on triangulation. A lot of algorithms are based on Hough Transform [2, 3].

1. The proposed approach

The Hough Transform structure is partially used in the implementation of the proposed algorithms.

The phases of proposed approach:

1) initial processing of points;

2) cellular dividing of the initial points cloud [4];

3) recognition of single high objects.

Let's consider in detail the last stage. Before applying this procedure, it is recommended to recognize and remove points belonging to the «underlying» surface.

In the resulting structure, we look for the global maximum — the cell in which the point with the maximum height is located, and check for the absence of unfilled voxels.

For a voxel containing a maximum, its neighbors are traversed at the same level and form a single layer. Similarly, the group of voxels of the layer below is highlighted, etc. For each layer in the (horizontal plane) it is possible to build a convex hull to determine the boundaries of the object in the layer.

2. Recognition of cylindrical objects by method of convex hull

For the identified single high object, assuming that the object is a vertical cylinder, one can determine the center and diameter of each part of the object located in a certain layer. For an ideal cylindrical object, after constructing a convex hull for the coordinates in X and Y the differences between the maximum and minimum values are calculated:

$$\Delta x = X_{\max} - X_{\min},\ \Delta y = Y_{\max} - Y_{\min},$$

after which the average diameter D is calculated:

$$D = (\Delta x + \Delta y)/2.$$

Most often, in practice, none of the objects is an ideal cylinder entirely, but appears as a complex object, in which only a certain part forms a cylinder. Therefore, this approach will not always give accurate results.

3. Hough Transform for section cylinder in a plane *xOy*

An alternative option that gives the best estimates of the parameters. The section of the cylinder in the *xOy* plane is a circle that can be specified in the form:

$$(x - x_c)^2 + (y - y_c)^2 = R^2,$$

(x_c, y_c) – coordinates of the center of the circle, R– its radius.

We define the radius R as the maximum possible radius for objects of a given type.

Of all the cells in the selected object, it is proposed to find the cell with the largest number of points in it, that is, for all voxels. We outline this cell with a 5x5 area, and the cell itself is located in the center of the region. Let the radius of a cylindrical object be limited to the size of a single cell, so the circle can be located in a 3x3 area, as shown in fig. 1.

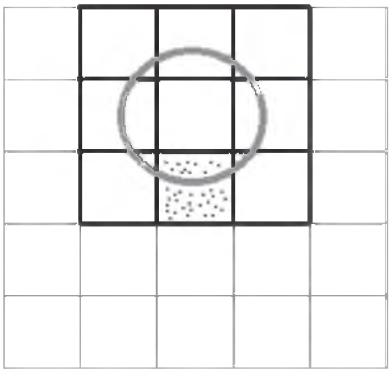

Fig. 1. Viewing of the area 3x3

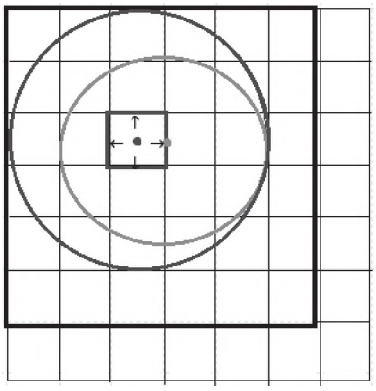

Fig. 2. Displacement of the centre

Among all 9 possible 3x3 positions within the 5x5 area, a global maximum is searched, which contains the greatest number of points. Further in this area you need to find the center of the circle, each cell is divided into smaller cells, so that the results are more accurate. Each point of the 3x3 area votes for one or another center of a circle with a maximum radius. Further, the radius decreases with a given step and the vote is again held, while the center of the circle may remain the same or shift, as shown in fig. 2.

4. Construction of the circle on three points

Another alternative option search for the center and diameter of the desired cylindrical object is based on the principle of constructing a circle by three points that define the circle passing through them. The center of the circle is the point of intersection of the mid-perpendiculars to two segments, constructed from the points P_1, P_2, P_3.

As in the previous version, use the area of 5x5 and 3x3 with the highest number of points. The 3x3 area is divided by a fine grid and we hold a vote, going through all the three points.

The center of the required circle (x_0, y_0) is calculated by the formulas [5]:

$$\begin{cases} (x_2 - x_1)x_0 + (y_2 - y_1)y_0 = A, \\ (x_3 - x_2)x_0 + (y_3 - y_2)y_0 = B, \end{cases}$$

$$A = (x_2 - x_1)(x_1 + x_2)/2 + (y_2 - y_1)(y_1 + y_2)/2,$$

$$B = (y_3 - y_2)(y_2 + y_3)/2 + (x_3 - x_2)(x_2 + x_3)/2.$$

Next is the global maximum - the largest number of points that voted for a certain center of the circle (x_0, y_0). Mean square of radius for the found circle:

$$R_m^2 = \frac{1}{k}\sum_i \left[(x_i - x_0)^2 + (y_i - y_0)^2 \right],$$

k – the amount of points which voted for given center (x_0, y_0), (x_i, y_i) – coordinates of current looked through point.

In fig. 3, the marker 'o' denotes points of the surface of a cylindrical object. The marker 'x' indicates noises. Fig. 4 shows an example of layering a single high cylindrical object. The centers of the layers are found using the convex hull algorithm.

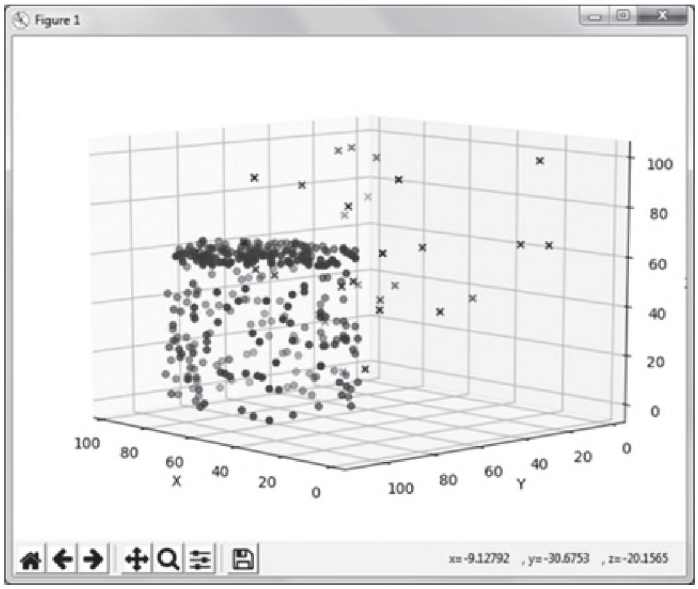

Fig. 3. Surface points cylindrical object and noise

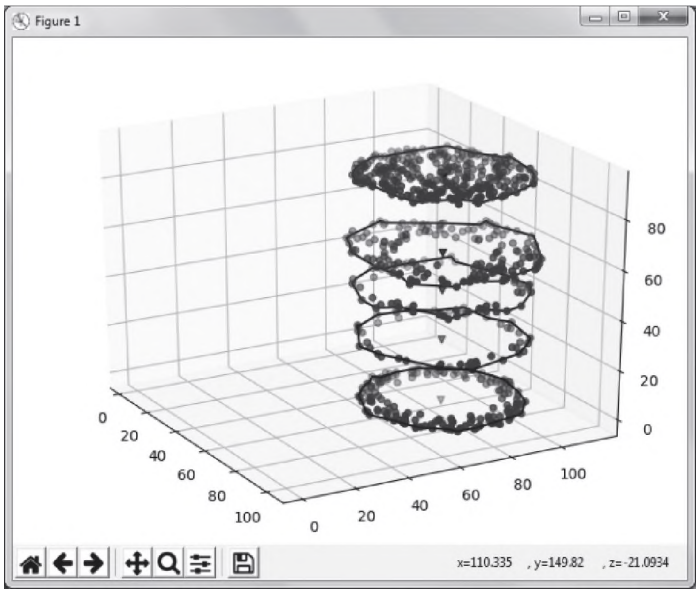

Fig. 4. Recognized vertical object of cylindrical form

Conclusion

The proposed approach is aimed at minimizing the time spent by typical objects, from which the vertical cylinder can be fully or partially distinguished.

In this paper, three methods were considered for detecting the centers and diameters of high single objects, after the convex hull was built for each layer.

The first method is simple, but it is suitable for ideal cylindrical objects, and for the rest it will produce results with a large error that do not correspond to the actual parameters of the object.

The second and third methods are fairly accurate, but lose on runtime to the first method.

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CURRENT PROBLEMS IN UX-DESIGN SPHERE

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Introduction

The field of UX-design is an actively developing and changing field in science, it is also noted in scientific research [1]. Analysis of the scientific literature allows us to study the problems of UX design and their solutions, which are presented in the latest modern studies of 2016-2019. According to research, you can trace new directions in the study of UX-design.

1. Theoretical issues of UX research

Starting to talk about UX design, it is impossible not to consider human-computer interaction as well HCI initially focused on the work of a person with a computer interface, but now this concept has become much broader and includes all types of devices with displays (fig. 1).

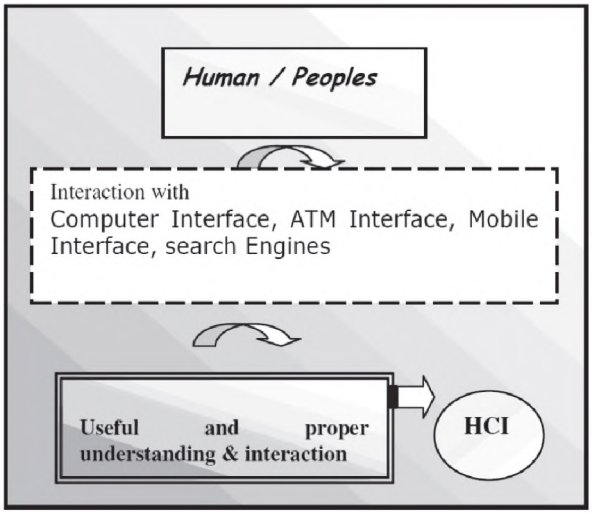

Fig. 1. Human interaction with computer and other devices

The main tasks of HCI are the creation of: more convenient interfaces, methodologies and interface design processes, an attractive interface, methods of using interfaces, a convenient information environment that allows you to process information faster [2]

Thus, UX-design can be considered a subsection of HCI, which focuses on creating efficient and user-friendly interfaces.Literature review by Tomasz Nedzielka [3] identified about 100 UX-methods of research. But despite this, the most common are the following: observa-