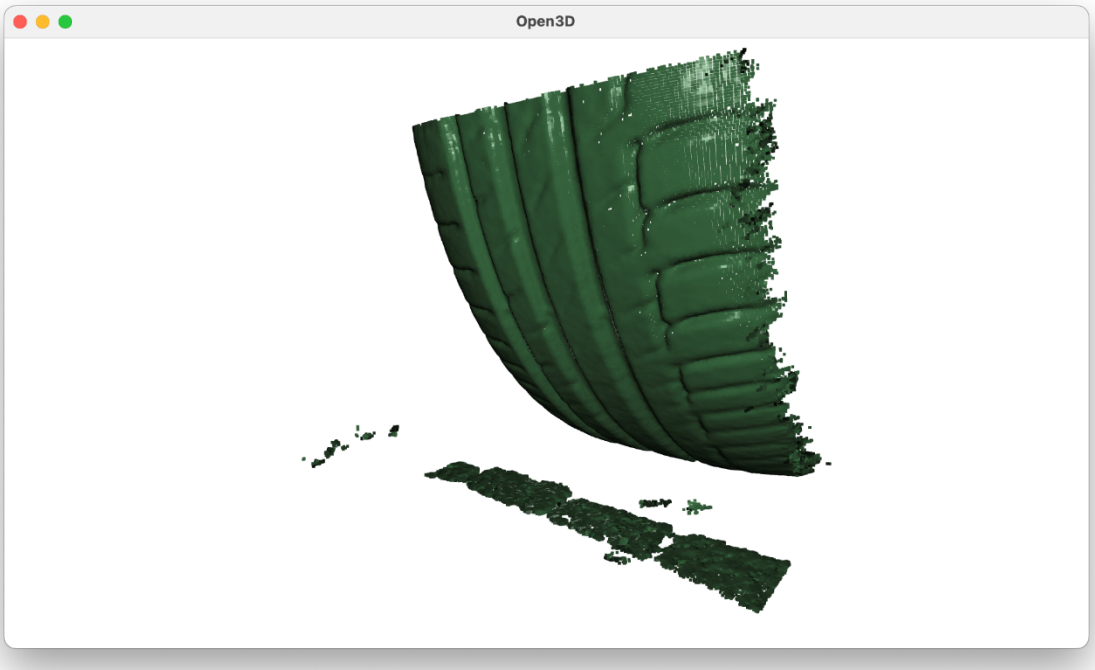
Thread Depth Estimation

Description:

One of Continental's customers major interests is knowing what the tread depth of their tires is. This is partly due to fleet maintenance operations and partly for legal reasons, e. g. a minimum tread depth of 1.6 mm must be kept. Even before reaching this critical threshold, once the thread depth falls below 3 mm there are growing issues with respect to the tire's performance.

Among other, one of the methods to derive such information is to capture a point cloud of the tire directly at the vehicle with a scanner device. The collected data is typically a point cloud containing part of the tire but can contain also other unwanted artifacts such as other parts of the vehicle or parts the ground underneath the vehicle, like shown in the picture below. To turn this technology into a product it is fundamental to collect several scans of different tires (e. g. with different patterns, differently worn out, etc.) and verify that the estimation works consistently in all cases.



Data sources:

A Field Engineer provides you with the scan of a tire and asks you to perform an analysis to prove the viability of this method for assessing the thread depth. Although the above-mentioned unwanted artifacts have already been removed, both the vertices and the depth data are still noisy.

Below you can find an explanation of the provided files.

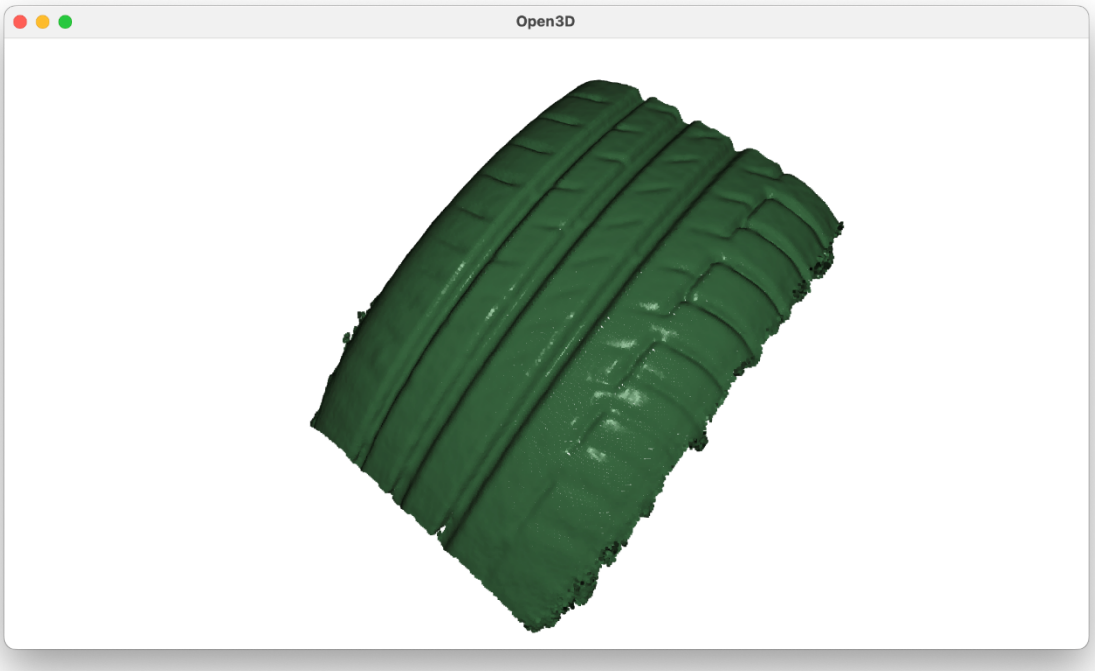
- **Depth-mono.xyz:** a plain file with the coordinates of a point of the point cloud per line with unit in mm. Coordinate centre is the point of scanning device viewing along z direction.
- **Depth.txt**: a plain text file with the associated depth information, also one value per line with unit in mm.
- **Groove-{4,5,6}.xyz** are the files of the point clouds filtered for the individual grooves.
- **Groove-{4,5,6}.txt** are the associated depth information per point.

Tasks:

Work with the data provided to solve the tasks below. Choose your tools, e.g., numpy and some 3D frameworks like open3d, PCL, or other… Sketch a solution and feel free to code.
Note that the groove data sets have been provided in case you have trouble to derive them programmatically. Note also that the tasks are not order by level of difficulty and can be mostly tackled in any order since they are loosely coupled to each other.

Task 1: Get a high-level view of the data

To understand this complex data is crucial to find a meaningful way to visualize it - for example by choosing a nice colouring of the point cloud to better understand its characteristics. The initial dataset painted just uniformly looks like this:



Can you find a more informative way to display it?

Task 2: Detect the areas in point cloud with a depth > 3mm and cluster connected points in space

Divide the point cloud into parts which belongs to the tread, and which belong to grooves. To do so you should think about clustering the points that belong to the different grooves segments to get the different grooves.
Hint: for presentation colour each cluster with different colour, filter out clusters with too few points, and focus on large clusters.

Task 3: Get a "nice" value representing the depth of such an area

Think about what the tread depth is and how would you physically measure it with a gauge. And now think about could the tread depth be derived from the data set. You should target to get the tread depth value of the bottom of each groove. How could you derive such a value?

Hint: You may have to further reduce the data set of points you have identified in Task 2 to focus on the meaningful points at the bottom of the groove - take a close look at the groove you have isolated in Task 2.

Hint: You could also take a close look at the data sets provided for the groove and compare them with the ones you have created - look at the cross section of the groove - is yours shaped like a U?

Task 4: Visualize a representative point of the "nice" value depth in the point cloud

If you have the nice tread depth value per groove calculated in Task 3 - could you show point(s) in the groove matching this value?

Task 5: Statistics & Depth and Grooves

Data is noisy and someway distributed. What can you tell about the groove data?

Task 6: Tell me the depth of the 3 major grooves

Connect the points/depths of the grooves from Task 4 with a value - table/tag/label/…