Lidar Filters

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Problem: Write filters to reduce noise in the data coming from a LIDAR sensor attached to your robot. The LIDAR generates scans at a certain rate. Each scan is an array of length N of float values representing distance measurements. N is typically in a range of ~[200, 1000] measurements, and it is fixed. Measured distances are typically in a range of [0.03, 50] meters. Each time a scan is received, it will be passed on to the filters. Each filter object should have an update method, that takes a length-N array of ranges and returns a filtered length-N array of ranges.

Solution: the UML class diagram is shown below. Basically, a pure abstract base class *LidarFilter* is defined first and then two class *RangeFilter* and *TempMedianFilter* are derived based on *LidarFilter*.

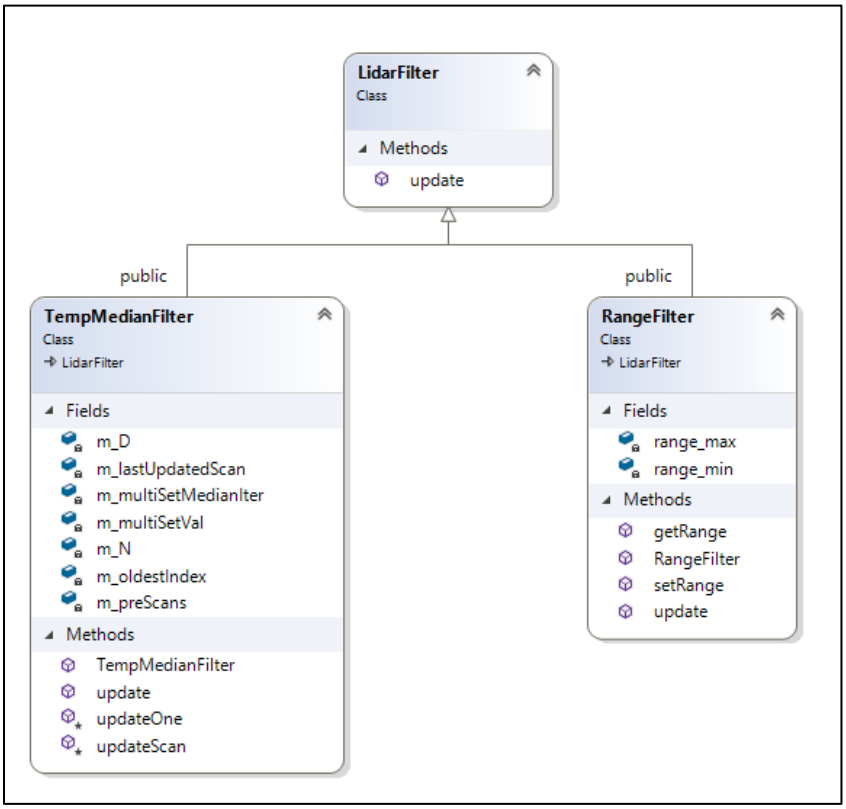

Figure 1. UML class diagram generated from Visual Studio 2017.

The *RangeFilter* class is used to crop all the values that are below *range_min* (or above *range_max*), and replaces them with the *range_min* value (or *range_max*) respectively.

The *TempMedianFilter* class is utilized to the median of the current and the previous D-1 scans:

$$y_i(t) = median(x_i(t), x_i(t-1), x_i(t-2), \dots, x_i(t-D+1))$$

where x and y are input and output length-1scans and i ranges from 0 to N-1.

One particular thing I want to mention is that I use C++ multiset container to facilitate the calculation of the median of previous scans in the *TempMedianFilter* class. The time complexity is O(N*logD) and space complexity is O(N*D).

The test result of these two class is shown below:

```
Starting the test:
Test Range Filter:
min_range: 2   maxRange: 4
 Org: 0 1 2 1 3  Updated: 2 2 2 2 3
 Org: 1 5 7 1 3  Updated: 2 4 4 2 3
 Org: 2 3 4 1 0  Updated: 2 3 4 2 2
 Org: 3 3 3 1 3  Updated: 3 3 3 2 3
 Org: 10 2 4 0 0  Updated: 4 2 4 2 2
 Org: 8 3 5 1 2  Updated: 4 3 4 2 2
 Org: 1 4 3 1 6  Updated: 2 4 3 2 4
 Org: 5 3 9 8 7  Updated: 4 3 4 4 4

Test Temporary Median Filter:
 Array size N: 5 , Number D: 4
 Org: 0 1 2 1 3  Updated: 0 1 2 1 3
 Org: 1 5 7 1 3  Updated: 0.5 3 4.5 1 3
 Org: 2 3 4 1 0  Updated: 1 3 4 1 3
 Org: 3 3 3 1 3  Updated: 1.5 3 3.5 1 3
 Org: 10 2 4 0 0  Updated: 2.5 3 4 1 1.5
 Org: 8 3 5 1 2  Updated: 5.5 3 4 1 1
 Org: 1 4 3 1 6  Updated: 5.5 3 3.5 1 2.5
 Org: 5 3 9 8 7  Updated: 6.5 3 4.5 1 4

Invalid input in update function in TempMedianFilter: size doesn't match N!
```