

## Robotic Engineer - Entry/Mid Level

You have been assigned to 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  $\sim[200, 1000]$  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.

We want you to write two different filter objects:

- A range filter

The range filter crops all the values that are below `range_min` (resp. above `range_max`), and replaces them with the `range_min` value (resp. `range_max`)

- A temporal median filter

The temporal median filter returns the median of the current and the previous  $D$  scans:

$$y_i(t) = \text{median}(x_i(t), x_i(t-1), \dots, x_i(t-D))$$

where  $x$  and  $y$  are input and output length- $N$  scans and  $i$  ranges from 0 to  $N-1$ . The number of previous scans  $D$  is a parameter that should be given when creating a new temporal median filter. Note that, although the **update** method will receive a single scan, the returned array depends on the values of previous scans. Note also that for the first  $D$  scans, the filter is expected to return the median of all the scans so far.

Here is a short example of the result ( $Y$ ) of a temporal median filter object with  $D=3$  for an input ( $X$ ) of dimension  $N=5$ , for the first five updates:

T (time)	X (input scan)	Y (return of the update)
0	[0., 1., 2., 1., 3.]	[0., 1., 2., 1., 3.]
1	[1., 5., 7., 1., 3.]	[0.5, 3., 4.5, 1., 3.]
2	[2., 3., 4., 1., 0.]	[1., 3., 4., 1., 3.]
3	[3., 3., 3., 1., 3.]	[1.5, 3., 3.5, 1., 3.]
4	[10., 2., 4., 0., 0.]	[2.5, 3., 4., 1., 1.5]

You are expected to write documentation and test correctness for your code.

You can either use Python 2.7 and/or C++. For Python, Numpy library may be used. For C++, boost and stl libraries may be used.