EE/GP140-The Earth From Space- Winter 2008 **Handout #33**
Lab Exercise #7

Image Processing and Noise

We'll begin with mathematical definitions that we'll need later.

Definition: Mean: the average of a set of numbers. Given the following set of measurements (1, 3, 2, 1), the *mean* is defined as (1+3+2+1) ÷ 4 = 7 ÷ 4 = 1 3/4.

Definition: Median: the center value of an ordered list of numbers. Given (1, 3, 2, 1, 5), the ordered list is (1, 1, 2, 3, 5), so the *median* is 2.

Example: Mean value filter of length 3: Given a set of numbers (1, 3, 2, 4, 0, 8, 1, 3, 5), the *mean value filter of length 3* finds the mean of the first 3 numbers (mean of 1, 3, 2 is 2), then the mean of the 2nd through 4th numbers (mean of 3, 2, 4 is 3), then the mean of the 3rd through 5th numbers (mean of 2, 4, 0 is 2), etc. So the sequence produced by a mean value filter of length 3 is (2, 3, 2, 4, 3, 4, 3)

Example: Median value filter of same data, length 3: Given (1, 3, 2, 4, 0, 8, 1, 3, 5), the *median value filter of length 3* finds the median of the first 3 numbers (median of 1, 3, 2 is 2), then the median of the 2nd through 4th numbers (median of 3, 2, 4 is 3), etc. So in this case, the sequence produced by the median value filter of length 3 is (2, 3, 2, 4, 1, 3, 3). Generally this sequence is different from the mean filter sequence.

1. i) Plot the following input data below on the graph:
   Input data: 3, 1, 2, 2, 1, 5, 2, 10, 2, 1, 1, 2
   Time→

(At time=1, the value is 3, at time = 2, the value is 1…) Plot each value as a dot at the proper time, and connect the dots.

Here is the input sequence again:

3 1 2 2 1 5 2 10 2 1 1 2

ii) Calculate the length 3 mean value filtered sequence, list it here, and then those values as *'s on the previous graph. Connect the *'s with a light line.

Filtered sequence:

iii) Calculate the length 3 median value sequence and plot as x's, connected with a light line.

Filtered sequence:

iv) How do the plotted lines differ?

Now let's extend this to two dimensions on the computer. We'll look at two different types of noise, distributed (Gaussian) noise, and shot noise. These will be described on the board.

2. Download the Ex. 7 zip file, and unzip to the desktop as usual. Open Scion Image.

3. Open the file SAT-SHOT.TIF in the Ex. 7 folder. You should see a noisy (like a TV with static) B&W image of Saturn. Examine the details of the ring structure.

4. Under Process, select "Convolve". Look in the Kernels folder and find "Mean3x3.txt". This applies a mean value filter of size 3 by 3 to the image. The noise is reduced, but is still apparent.

5. Note also that the image has lost some sharpness (look at the rings). To further reduce the noise, select Process, Convolve, Mean11x11.txt. Now the noise is mostly averaged away, but the details in the rings are smoothed away also.

6. Close the image without saving changes, and re-open it.

7. Under Process, select Rank Filters. Pick Median and click OK.

8. Pretty neat, huh? Note that in this case, the noise is removed with little loss of detail. This is typical of shot-noise-corrupted data.

9. Repeat steps 5 to 10 with the image SAT-DIST.TIF. Does the Mean filter work any better? Does the Median filter work as well?

10. Open SATURNB.TIF. What does color add to your ability to see detail in the image?

Now let's see what filtering means for other types of analyses. Suppose we want to identify individual ringlets of Saturn. We might use an edge detection algorithm…

11. Re-open SAT-SHOT.TIF. Under Process, select "Find Edges". This will highlight all grayscale variations, showing the edges of the ringlets.

12. Note the all the background noise makes identification of individual ringlets difficult. We must filter first. To get back to the original image, Undo Filtering (in the Edit menu). (If this does not work, just close without saving, and re-open the image.)

13. Re-do the Median "Rank Filter" under Process, and click OK.

14. Now "Find Edges" again. This worked a bit better, did it not? You can see many very fine structures in the rings of Saturn. These are caused by gravitational interactions with Saturn's other moons.

15. Open the image entitled starcityrussia1200.tif.

16. Filter this image with a mean value filter using the kernel Mean3x3.txt. Under Process, select "Convolve". Look in the Kernels folder and find "Mean3x3.txt".

17. Open another copy of the same file, and filter this with a median value filter. Under Process, select Rank Filters. Pick Median and click OK.

18. Compare these two filtered versions of the image. Which produces an image that better defines fields of slightly differing brightness? Which better preserves detail? You might want to compare different amounts of filtering (for example, averaging kernel size or median size) to optimize the appearance of the data.

19. Close Scion Image and log out of your computer.