Subject: Roundoff error in SMOOTH
Posted by landsman on Wed, 26 May 1999 07:00:00 GMT
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I was recently surprised to discover that applying the SMOOTH function to a non-negative array could yield an array with negative numbers. I give an example below. This problem is evidently due to some sort of roundoff error, since it does not occur when using double precision. But it is not obvious to me how averaging 9 non-negative numbers (for a 3x3 box smooth) could yield a negative number, even allowing for roundoff error.

Although not obvious from my simple example, this has nothing to do with edge effects -- I originally found the problem when 3x3 smoothing a 1024 x 1024 array.

--Wayne Landsman landsman@mpb.gsfc.nasa.gov

```
d = fltarr(11,11)              ;Initialize array to zero
d[ [0,2,0,2],[2,3,4,5] ] = 0.48   ;Set a few values to a positive number
print,where(d lt 0)            ;Make sure there are really no negative values
;         -1

print,d[1:6,1:6]                    ;Print a block of numbers in array
;      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
;      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
;      0.00000     0.480000      0.00000      0.00000      0.00000      0.00000
;      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
;     0.480000      0.00000      0.00000      0.00000      0.00000      0.00000
;      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000


dd = smooth(d,3)       ;Smooth the array
print,dd[1:6,1:6]      ;After smooothing there are negative values!
;      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
;    0.0533333    0.0533333    0.0533333      0.00000      0.00000      0.00000
;     0.106667    0.0533333    0.0533333      0.00000      0.00000      0.00000
;     0.160000     0.106667    0.0533333 -6.62274e-09 -6.62274e-09 -6.62274e-09
;     0.106667    0.0533333      0.00000      0.00000      0.00000      0.00000
;    0.0533333    0.0533333      0.00000      0.00000      0.00000      0.00000

dd = smooth(double(d),3)   ;Negative values do not occur in double precision
print,float(dd[1:6,1:6])
;      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
;    0.0533333    0.0533333    0.0533333      0.00000      0.00000      0.00000
;     0.106667    0.0533333    0.0533333      0.00000      0.00000      0.00000
;     0.160000     0.106667    0.0533333      0.00000      0.00000      0.00000
;     0.106667    0.0533333      0.00000      0.00000      0.00000      0.00000
;    0.0533333    0.0533333      0.00000      0.00000      0.00000      0.00000
```

Subject: Re: Roundoff error in SMOOTH
Posted by Boyd Blackwell on Thu, 27 May 1999 07:00:00 GMT
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THe IDL smooth function scales well with the number of points in the average
(i.e. smooth(x,10) and smooth(x,1000) take the same time. It is very likely
that it uses an incremental algorithm, whereby result(i) = result(i-1) + x(i+n)
- x(i-1)
where n is the number of points in the average.
This is inherently subject to roundoff error, albeit relatively small.

I can be sure it doe not use FFTs, as it is way too fast for that.

Wayne Landsman wrote:
>
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> non-negative array could yield an array with negative numbers. I give an
> example below. This problem is evidently due to some sort of roundoff error,
> since it does not occur when using double precision. But it is not obvious to
> me how averaging 9 non-negative numbers (for a 3x3 box smooth) could yield a
> negative number, even allowing for roundoff error.
>
> Although not obvious from my simple example, this has nothing to do with edge
> effects -- I originally found the problem when 3x3 smoothing a 1024 x 1024
> array.
>
> --Wayne Landsman landsman@mpb.gsfc.nasa.gov
>
> d = fltarr(11,11) ;Initialize array to zero
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> ; -1
>
> print,d[1:6,1:6] ;Print a block of numbers in array
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> ; 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
> ; 0.00000 0.480000 0.00000 0.00000 0.00000 0.00000
> ; 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
> ; 0.480000 0.00000 0.00000 0.00000 0.00000 0.00000
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```
> ;     0.106667    0.0533333      0.00000      0.00000      0.00000      0.00000
> ;    0.0533333    0.0533333      0.00000      0.00000      0.00000      0.00000
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> ;      0.00000      0.00000      0.00000      0.00000      0.00000      0.00000
> ;    0.0533333    0.0533333    0.0533333      0.00000      0.00000      0.00000
> ;     0.106667    0.0533333    0.0533333      0.00000      0.00000      0.00000
> ;     0.160000     0.106667    0.0533333      0.00000      0.00000      0.00000
> ;     0.106667    0.0533333      0.00000      0.00000      0.00000      0.00000
> ;    0.0533333    0.0533333      0.00000      0.00000      0.00000      0.00000
```