
Subject: Re: IDL 5.5, 2D FFT indexing confusion.
Posted by [Benjamin Hornberger](#) on Tue, 19 Jul 2005 14:29:46 GMT
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Pitufa wrote:

> Hi,
>
> I have been trying to generate an real even function in fourier space
> that I can INVERSE FFT in order to get a function which has no
> imaginary part. I have no problems when the function is a vector, but I
> get an imaginary part when it is a two dimensional array.
>
> Below is the test program that shows my problem. Am I defining wrong
> the variables 'centre' or 'nshift'?
>
> I would be really grateful if someone could let me know what I am doing
> wrong.
>
> Thanks!
>
> Pitufa.

I believe your TEST array is not even in the sense which is required for the FT to be real. I think it has to be even (symmetric) in each dimension separately, and not point-symmetric about the center. Please correct me if I'm wrong. E.g., the following TEST array gives a real FT:

```
test = sqrt((rebin(f, 100, 100))^2+$  
(rebin(reform(f, 1, 100), 100, 100))^2)
```

which is basically the same as a shifted DIST array.

With respect to centers and shifts, I prefer to shift everything by $n/2$ when going from real to Fourier space and $-n/2$ when going back:

```
fourier = shift(fft(real), n/2)  
real = fft(shift(fourier, -n/2), /inverse)
```

In this case, the zero frequency is right in the center for an odd number of pixels and just right/above the center for an even number of pixels, and the frequency array goes from $-Nyquist$ to $+(1 \text{ index below } Nyquist)$. For even number of pixels, you don't even have to worry about shifting plus or minus any more.

As a side note, you can easily vectorize the calculation of your PHI array:

```
nx2d = rebin(indgen(nx)-cx, nx, ny)
```

```
ny2d = rebin(reform(indgen(ny)-cy, 1, ny), nx, ny)
phi = atan(ny2d, nx2d)
```

where nx, ny are the numbers of pixels and cx, cy the centers.

Benjamin

```
>
> pro test_index
>
> npix = 100
> centre = npix/2.d - 1.d
> nshift = npix/2 + 1
>
> ;1d example:
>
> f = abs(findgen(npix) - centre)
> ifft = fft(shift(f,nshift),1,/double)
>
> print,'1D: Imaginary maximum:', Max(Abs(Imaginary(ifft)))
> print,'1D: Real maximum   ', Max(Abs(Double(ifft)))
>
> ;2d example:
>
> ;angle of position vector w.r.t x axis:
>
> phi = dblarr(NPIX,NPIX)
> FOR X = 0, NPIX-1 DO FOR Y = 0, NPIX-1 DO $
> PHI[X,Y] = ATAN(Y*1.D - centre,X*1.D - centre)
>
> TEST   = sin(2.d*phi)
> IFFTTEST = FFT(SHIFT(TEST,nshift,nshift),1,/DOUBLE)
>
> print,'2D: Imaginary maximum: ', $
> MAX(ABS(imaginary(IFFTTEST))),mean(ABS(imaginary(IFFTTEST)))
> print,'2D: Real maximum   ',MAX(ABS(double(IFFTTEST)))
>
> end
>
```

Subject: Re: IDL 5.5, 2D FFT indexing confusion.
Posted by [Pitufa](#) on Tue, 19 Jul 2005 16:44:50 GMT
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Thanks for your reply, I was wondering if there was a way to shrink the phi derivation!

About the symmetry in fft, here is why I thought it had to be point symmetric about the centre. The FFT of a function $f_{\{kj\}}$ is given by (for a square array of side dimension N):

$$F_{\{m,p\}} = (1/N^2) \sum_{\{k,j\}} f_{\{k,j\}} \exp[-2\pi i (km + jp)/N] \quad \text{eqn. [1]}$$

Now, if the array in fourier space has its origin at the centre of the array, then the point (m, p) is centrally opposite to (N-m, N-p). And the FFT for this point is:

$$\begin{aligned} F_{\{N-m,N-p\}} &= (1/N^2) \sum_{\{k,j\}} f_{\{k,j\}} \exp[-2\pi i (k(N-m) + j(N-p))/N] \\ &= (1/N^2) \sum_{\{k,j\}} f_{\{k,j\}} \exp[2\pi i (km + jp)/N] \exp[-2\pi i (k + j)] \\ &= (1/N^2) \sum_{\{k,j\}} f_{\{k,j\}} \exp[2\pi i (km + jp)/N] \quad \text{eqn. [2]} \end{aligned}$$

which is the complex conjugate of eqn [1] if $f_{\{k,j\}}$ is real.

Please let me know if you don't agree.

Thanks,

Pitufa.

Subject: Re: IDL 5.5, 2D FFT indexing confusion.
Posted by [R.G. Stockwell](#) on Tue, 19 Jul 2005 20:49:34 GMT
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"Pitufa" <c.c.calderon@gmail.com> wrote in message
news:1121772201.952005.96070@g43g2000cwa.googlegroups.com...

> Hi,

>

> I have been trying to generate an real even function in fourier space
> that I can INVERSE FFT in order to get a function which has no
> imaginary part. I have no problems when the function is a vector, but I
> get an imaginary part when it is a two dimensional array.

...

Hello Pitufa,

I shrunk the size of the array and took a look.

I think your nyquist rows and columns should all be positive (i.e. don't flip the signs).

(by nyquist rows/columns i mean the $npix/2+1$ column and the $npix/2+1$ row)

Here is a $npix=6$ example that i fixed

$f = [\$$
 $[0.00, 0.00, 0.00, 0.00, 0.00, 0.00], \$$

```
[0.00, 1.00, 0.80, 0.60, -0.80, -1.00],$
[0.00, 0.80, 1.00, 0.92, -1.00, -0.80],$
[0.00, 0.60, 0.92, 1.00, 0.92, 0.60],$
[0.00,-0.80, -1.00, 0.92, 1.00, 0.80],$
[0.00,-1.00, -0.80, 0.60, 0.80, 1.00] $
]
```

Cheers,
bob

PS

Note that if your "npix" is odd, you have both a positive and negative nyquist points and they are both complex.

Subject: Re: IDL 5.5, 2D FFT indexing confusion.
Posted by [Pitufa](#) on Thu, 21 Jul 2005 17:28:52 GMT
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Thanks Bob!

I tried what you told me and it seemed to work, although I am not totally sure why..

I agree, everything becomes much simpler if N is odd, since the range of frequencies is symmetric (taking centre as $(npix - 1)/2.d$ and nshift as $(npix - 1)/2 + 1$).

I tried to understand how it can work with an even N, and got the following conditions:

1. $F_{\{m,p\}} = F_{\{N-m,N-p\}}^*$
2. $F_{\{m,N\}} = F_{\{N-m,N\}}^*$
3. $F_{\{N,p\}} = F_{\{N,N-p\}}^*$
4. $F_{\{N,N\}} = F_{\{N/2-1,N/2-1\}}^*$
5. $F_{\{N,N/2-1\}} = F_{\{N/2-1,N\}}^*$

but then it only works if the fourier array is real, and 2-5 don't make any sense physically! My conclusion from this is that you are better off using an odd N if you are doing this sort of calculation.

Agree? Disagree?

Why the nyquist rows/columns need to be positive?

Thanks alot,

Pitufa.

R.G. Stockwell wrote:

> "Pitufa" <c.c.calderon@gmail.com> wrote in message
> news:1121772201.952005.96070@g43g2000cwa.googlegroups.com...
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> [0.00, 0.80, 1.00, 0.92, -1.00, -0.80],\$
> [0.00, 0.60, 0.92, 1.00, 0.92, 0.60],\$
> [0.00,-0.80, -1.00, 0.92, 1.00, 0.80],\$
> [0.00,-1.00, -0.80, 0.60, 0.80, 1.00] \$
>]
>
> Cheers,
> bob
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> PS
> Note that if your "npix" is odd, you have both a positive and negative
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> and they are both complex.
