Table of Contents

Demo 05: noise test

A demo script to check the noise statitics. Not all spectral seperation modes and processing steps gives a proper SNR metric. This script is to verify the standard normal distribution of data, image and metabolite amplitudes after every processing step. Download noise data (800 MB "phantom-DMI-noise.tar.gz") from zenodo.org (DOI: 10.5281/zenodo.14652737) to follow this excercise.

FISP CSI dataset with acquistion weighting

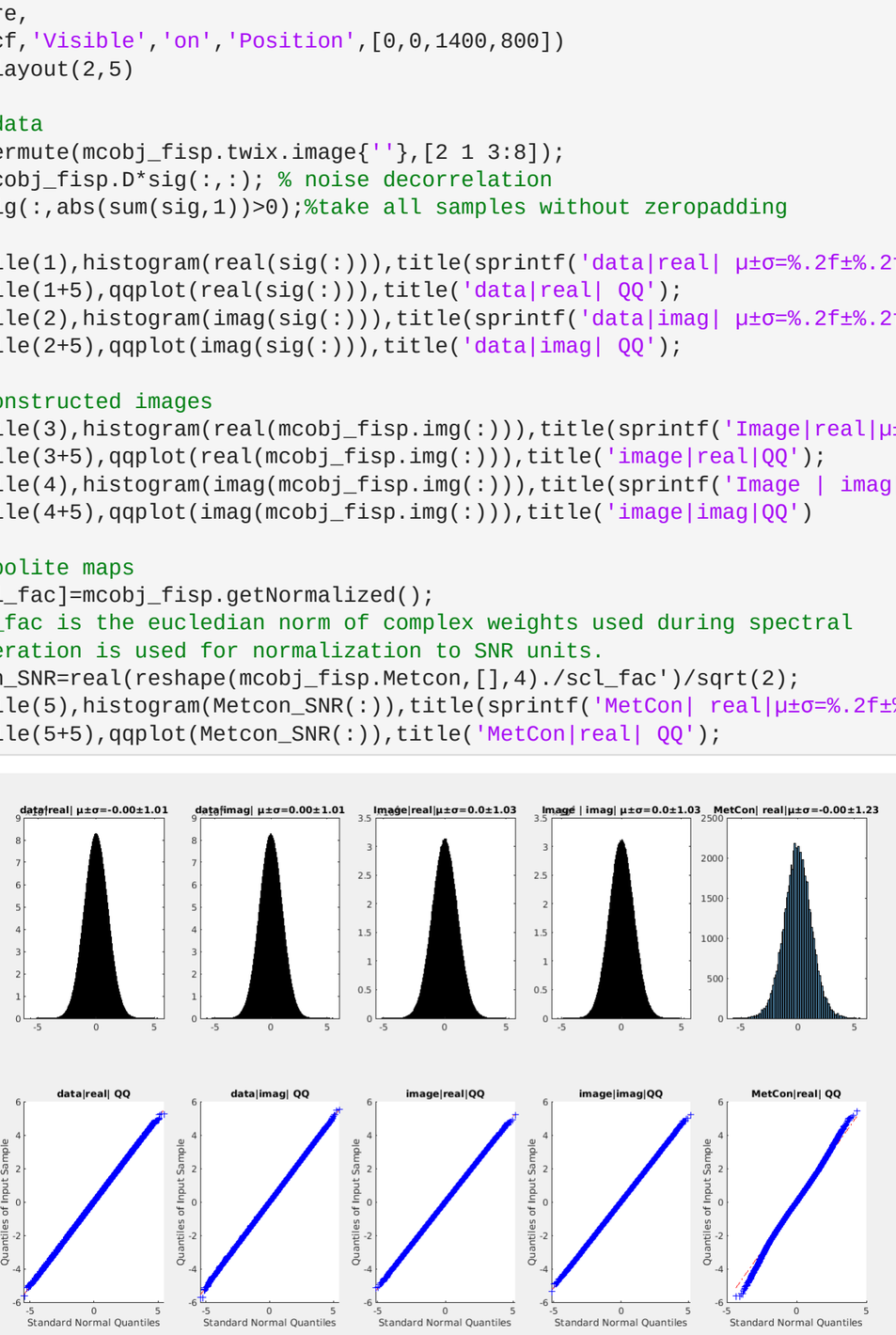
```
% add all dependencies
addpath(genpath('/ptmp/pvalsala/Packages/mapVBVD'))
addpath(genpath('/ptmp/pvalsala/Packages/DeuteMetCon'))
addpath(genpath('/ptmp/pvalsala/Packages/OXSA'))

%data path
sn='/ptmp/pvalsala/deuterium/dataForPublication/phantom-DMI-Noise';

fn=fullfile(sn,'meas_MID00750_FID11717_rpcsi_fid_Stan_res15_6_TR36_5min_0FA.dat');
metabolites=getMetaboliteStruct('phantom',0);
CSI_setting={'metabolites',metabolites,'parfor',true,...
    'doCoilCombine','adapt1','doZeropad',[0.5 0.5 0.5 0]*0,'mask',[],'Solver','IDEAL'};
mcobj_fisp=MetCon_CSI(fn,CSI_setting{:});
```

```
Software version: VD (!?)
Reader version: 1660732089 (UTC: 17-Aug-2022 10:28:09)
Scan 1/1, read all mdhs:
   324.1 MB read in   18 s
Using T2* =20 ms
starting reco
initial CSI data size:           10   25   25   25  256
final CSI data size:           10   25   25   25  256
reco  time =    4.9 s
estimating field map(1/2)
estimating metabolities(2/2)
Metabolite mapping time =    8.0 s
```

Plot FISP noise characteristics

verify noise is uniformly distributed

```
 figure,
set(gcf,'Visible','on','Position',[0,0,1400,800])
tiledlayout(2,5)

%raw data
sig=permute(mcobj_fisp.twix.image{''},[2 1 3:8]);
sig=mcobj_fisp.D*sig(:,:); % noise decorrelation
sig=sig(:,abs(sum(sig,1))>0);%take all samples without zeropadding

nexttile(1),histogram(real(sig(:))),title(sprintf('data|real| μ±σ=%.2f±%.2f',mean(real(sig(:))),std(real(sig(:)))));
nexttile(1+5),qqplot(real(sig(:))),title('data|real| QQ');
nexttile(2),histogram(imag(sig(:))),title(sprintf('data|imag| μ±σ=%.2f±%.2f',mean(imag(sig(:))),std(imag(sig(:)))));
nexttile(2+5),qqplot(imag(sig(:))),title('data|imag| QQ');

% reconstructed images
nexttile(3),histogram(real(mcobj_fisp.img(:))),title(sprintf('Image|real|μ±σ=%.1f±%.2f',mean(real(mcobj_fisp.img(:))),std(real(mcobj_fisp.img(:)))));
nexttile(3+5),qqplot(real(mcobj_fisp.img(:))),title('image|real|QQ');
nexttile(4),histogram(imag(mcobj_fisp.img(:))),title(sprintf('Image | imag| μ±σ=%.1f±%.2f',mean(real(mcobj_fisp.img(:))),std(real(mcobj_fisp.img(:)))));
nexttile(4+5),qqplot(imag(mcobj_fisp.img(:))),title('image|imag|QQ')

%Metabolite maps
[~,scl_fac]=mcobj_fisp.getNormalized();
% scl_fac is the eucledian norm of complex weights used during spectral
% seperation is used for normalization to SNR units.
Metcon_SNR=real(reshape(mcobj_fisp.Metcon,[],4)./scl_fac')/sqrt(2);
nexttile(5),histogram(Metcon_SNR(:)),title(sprintf('MetCon| real|μ±σ=%.2f±%.2f',mean(Metcon_SNR(:)),std(Metcon_SNR(:))));
nexttile(5+5),qqplot(Metcon_SNR(:)),title('MetCon|real| QQ');
```



CSI-bSSFP dataset with acquistion weighting

```
%data path
sn='/ptmp/pvalsala/deuterium/dataForPublication/phantom-DMI-Noise';

fn=fullfile(sn,'meas_MID00749_FID11716_rpcsi_ssfp_Stan25_15_6mm_5mins_0FA.dat');
metabolites=getMetaboliteStruct('phantom',0);
CSI_setting={'metabolites',metabolites,'parfor',true,...
    'doCoilCombine','adapt1','doZeropad',[0.5 0.5 0.5 0]*0,'mask',[],'Solver','IDEAL-modes'};
mcobj_ssfp=MetCon_CSI(fn,CSI_setting{:});
```

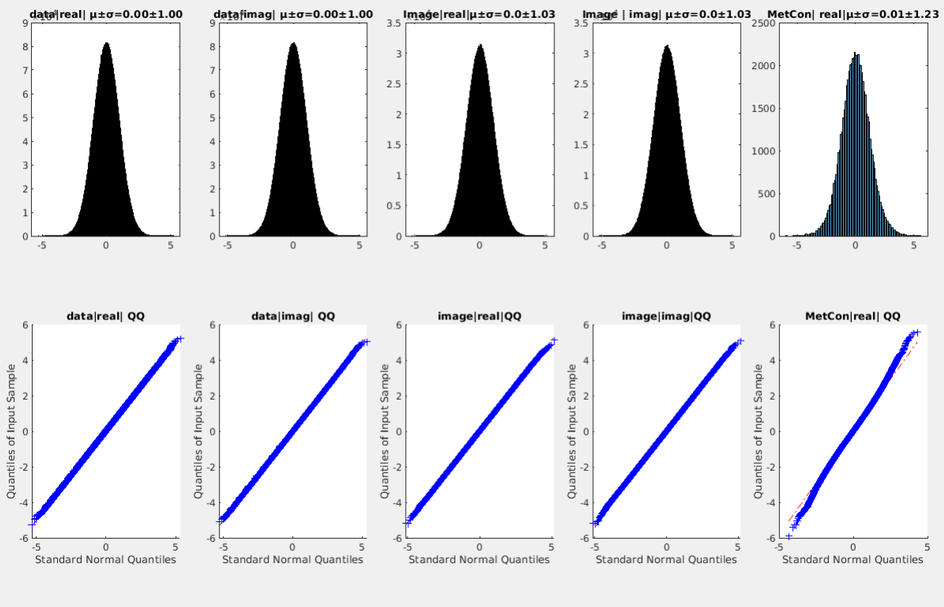
```
Software version: VD (!?)
Reader version: 1660732089 (UTC: 17-Aug-2022 10:28:09)
Scan 1/1, read all mdhs:
   163.8 MB read in   20 s
Using T2* =20 ms
starting reco
initial CSI data size:           10  25  25  25  64   4
final CSI data size:           10  25  25  25  64   4
reco  time =    3.7 s
estimating field map(1/2)
estimating metabolities(2/2)
Metabolite mapping time =    5.9 s
```

Plot CSI-bSSFP noise characteristics

verify noise is uniformly distributed

```
 figure,
set(gcf,'Visible','on','Position',[0,0,1400,800])
tiledlayout(2,5)

%raw data
sig=permute(mcobj_ssfp.twix.image{''},[2 1 3:8]);
sig=mcobj_ssfp.D*sig(:,:); % noise decorrelation
sig=sig(:,abs(sum(sig,1))>0);%take all samples without zeropadding

nexttile(1),histogram(real(sig(:))),title(sprintf('data|real| μ±σ=%.2f±%.2f',mean(real(sig(:))),std(real(sig(:)))));
nexttile(1+5),qqplot(real(sig(:))),title('data|real| QQ');
nexttile(2),histogram(imag(sig(:))),title(sprintf('data|imag| μ±σ=%.2f±%.2f',mean(imag(sig(:))),std(imag(sig(:)))));
nexttile(2+5),qqplot(imag(sig(:))),title('data|imag| QQ');

% reconstructed images
```

```
nexttile(3),histogram(real(mcobj_ssfp.img(:))),title(sprintf('Image|real|μ±σ=%.1f±%.2f',mean(real(mcobj_ssfp.img(:))),std(real(mcobj_ssfp.img(:)))));
nexttile(3+5),qqplot(real(mcobj_ssfp.img(:))),title('image|real|QQ');
nexttile(4),histogram(imag(mcobj_ssfp.img(:))),title(sprintf('Image | imag| μ±σ=%.1f±%.2f',mean(real(mcobj_ssfp.img(:))),std(real(mcobj_ssfp.img(:)))));
nexttile(4+5),qqplot(imag(mcobj_ssfp.img(:))),title('image|imag|QQ')

%Metabolite maps
[~,scl_fac]=mcobj_ssfp.getNormalized();
% scl_fac is the eucledian norm of complex weights used during spectral
% seperation is used for normalization to SNR units.
Metcon_SNR=real(reshape(mcobj_ssfp.Metcon,[],4)./scl_fac')/sqrt(2);
nexttile(5),histogram(Metcon_SNR(:)),title(sprintf('MetCon| real|μ±σ=%.2f±%.2f',mean(Metcon_SNR(:)),std(Metcon_SNR(:))));
nexttile(5+5),qqplot(Metcon_SNR(:)),title('MetCon|real| QQ');
```



multiecho-bSSFP dataset with acquistion weighting

```
%data path
sn='/ptmp/pvalsala/deuterium/dataForPublication/phantom-DMI-Noise';
% trufi sequence acquire noise data only when parallel imaging is enabled. Therefore, we acquire noise scan with 0 flip angle seperately.
twix_noise=mapVBVD(fullfile(sn,'meas_MID00735_FID11702_pvrh_trufi_5E_noise_12P5mm.dat'),'rmos');
```

```
Software version: VD (!?)
Reader version: 1660732089 (UTC: 17-Aug-2022 10:28:09)
Scan 1/1, read all mdhs:
    40.4 MB read in   17 s
```

```
[D_noise,D_image,noise_info]=CalcNoiseDecorrMat(twix_noise);
%D_image is the noise correlation from image data measured with 0 FA
```

assemble inputs and processing flags

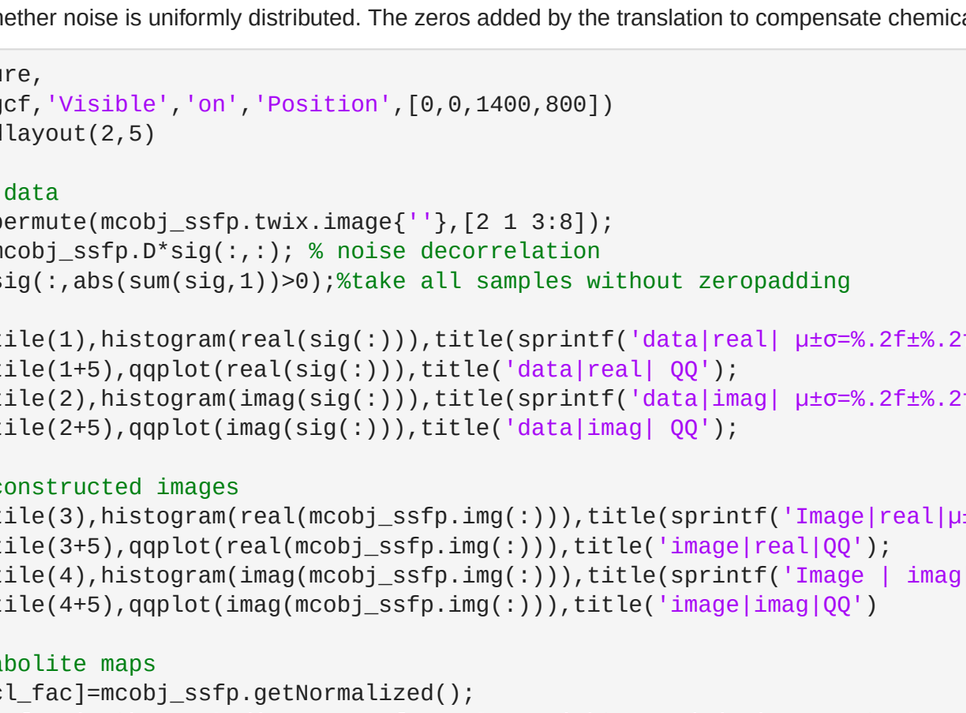
```
ME_setting={'NoiseDecorr',D_image,'mask',[],'metabolites',metabolites,...
            'doPhaseCorr',true,'doZeropad',[1 1 1]*0.5,'parfor',true,'fm','IDEAL','Solver','IDEAL-modes'};
fn=fullfile(sn,'meas_MID00752_FID11719_pvrh_trufi_5E_18PC_12P5mm_FA50_s4_r180_0FA.dat');
metabolites=getMetaboliteStruct('phantom',0);
mcobj_me=MetCon_ME(fn,ME_setting{:});
```

```
Software version: VD (!?)
Reader version: 1660732089 (UTC: 17-Aug-2022 10:28:09)
Scan 1/1, read all mdhs:
   428.6 MB read in   19 s
Warning: applied Phase cycle correction for data before 20.Sep.24
starting reco
reco  time =   14.1 s
estimating field map(1/2)
estimating metabolities(2/2)
Performed pixel shift along read: (0.0,-2.2,-5.2 ,-7.2) mm
Metabolite mapping time =   22.4 s
```

Plot CSI-bSSFP noise characteristics

verify whether noise is uniformly distributed. The zeros added by the translation to compensate chemical shifts along read is visible in the metcon histogram

```
 figure,
set(gcf,'Visible','on','Position',[0,0,1400,800])
tiledlayout(2,5)

%raw data
sig=permute(mcobj_ssfp.twix.image{''},[2 1 3:8]);
sig=mcobj_ssfp.D*sig(:,:); % noise decorrelation
sig=sig(:,abs(sum(sig,1))>0);%take all samples without zeropadding

nexttile(1),histogram(real(sig(:))),title(sprintf('data|real| μ±σ=%.2f±%.2f',mean(real(sig(:))),std(real(sig(:)))));
nexttile(1+5),qqplot(real(sig(:))),title('data|real| QQ');
nexttile(2),histogram(imag(sig(:))),title(sprintf('data|imag| μ±σ=%.2f±%.2f',mean(imag(sig(:))),std(imag(sig(:)))));
nexttile(2+5),qqplot(imag(sig(:))),title('data|imag| QQ');

% reconstructed images
nexttile(3),histogram(real(mcobj_ssfp.img(:))),title(sprintf('Image|real|μ±σ=%.1f±%.2f',mean(real(mcobj_ssfp.img(:))),std(real(mcobj_ssfp.img(:)))));
nexttile(3+5),qqplot(real(mcobj_ssfp.img(:))),title('image|real|QQ');
nexttile(4),histogram(imag(mcobj_ssfp.img(:))),title(sprintf('Image | imag| μ±σ=%.1f±%.2f',mean(real(mcobj_ssfp.img(:))),std(real(mcobj_ssfp.img(:)))));
nexttile(4+5),qqplot(imag(mcobj_ssfp.img(:))),title('image|imag|QQ')

%Metabolite maps
[~,scl_fac]=mcobj_ssfp.getNormalized();
% scl_fac is the eucledian norm of complex weights used during spectral
% seperation is used for normalization to SNR units.
Metcon_SNR=real(reshape(mcobj_ssfp.Metcon,[],4)./scl_fac')/sqrt(2);
nexttile(5),histogram(Metcon_SNR(:)),title(sprintf('MetCon| real|μ±σ=%.2f±%.2f',mean(Metcon_SNR(:)),std(Metcon_SNR(:))));
nexttile(5+5),qqplot(Metcon_SNR(:)),title('MetCon|real| QQ');
```



PDF export 17 inch x 28 inch 600 dpi