Evaluate accuracy of the Microlith package.

Comparison of simulated and analytical images of two points seperated by various distances under a bright-field microscope with matched illumination.

Contents

Define the simulation grid and parameters of imaging system.

```
L=5; % Support over which we want to calculate the image.

xs=0.05; % Sampling rate in the specimen plane.
% To avoid aliasing, specimen should be sampled at 0.2 lambda/NA
% atleast.
% Sampling rate in the specimen plane determines extent in frequency
% domain.  xs=0.1 should suffice as the transfer function fits into the square with
% side 2 or (1+S)/sqrt(2) and sampling at 0.1 defines support of [-5 5].

v=-L:xs:L; % Transeverse extent of simulation.
u=0; % Analytical expression for two point image is available only in focus.

params.NAo=1;
params.NAc=1;
params.lambda=1;
params.nImm=1;
params.nEmbb=1;
sep=0.1:0.1:1.2;
twopointsimulated=zeros(length(v),length(v),length(sep));
```

Set up the microscope.

```
brightfield=microlith(v,u);
computesys(brightfield,'Brightfield',params);
```

Compute images at different seperations.

```
[xx, yy]=meshgrid(v);

parfor idx=1:length(sep)
    specimen=(abs(abs(xx)-0.5*sep(idx))<10*eps ...
        & abs(yy)<10*eps );
    computeimage(brightfield,specimen,'CPU');
    twopointsimulated(:,:,idx)=brightfield.img;
end
```

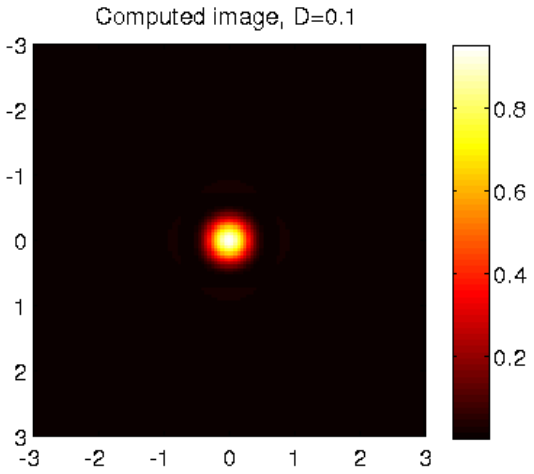
Analytical image of two points separated by D lambda/NA.

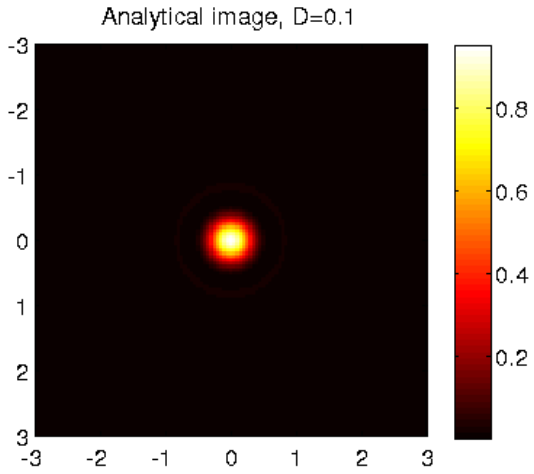
The expression can be found in Born & Wolf inside the section on 'two-point resolution.'

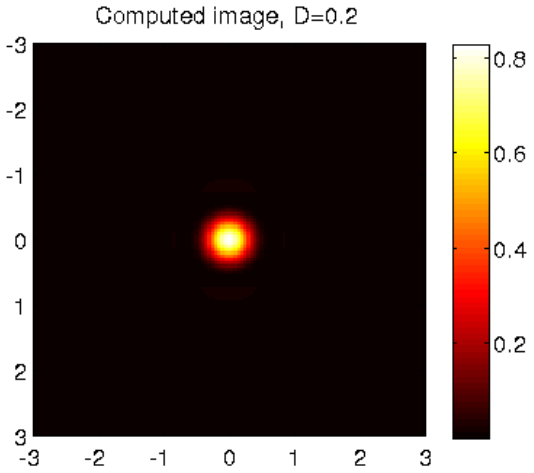
```
S=params.NAc/params.NAo;
twopointanalytical=zeros(size(twopointsimulated));
parfor idx=1:length(sep)
    point1=abs(xx-0.5*sep(idx))<10*eps & abs(yy)<10*eps;
    point2=abs(xx+0.5*sep(idx))<10*eps & abs(yy)<10*eps;
    dist1=bwdist(point1)*xs; %Distance in lambda/NA from point-1.
    dist2=bwdist(point2)*xs; %Distance in lambda/NA from point-2.
    twopointanalytical(:,:,idx)=jinc(dist1).^2+jinc(dist2).^2+2*jinc(S*sep(idx))*(jinc(dist1).*jinc(dist2));
end

% Apply the radiometric factor so that analytical and simulated images can
% be compared.
RadiometricFactor=params.NAo^2*params.NAc^2*(xs/0.1)^2;
twopointanalytical=RadiometricFactor*twopointanalytical;
```

Compare the analytical and computed two point images.

```
figure(1); clf;
set(1,'defaultaxesfontsize',14,'Position',[50 50 1000 600],'Color','white'); colormap hot;
for idx=1:length(sep)

    subplot(121);
    imagesc(v,v,twopointsimulated(:,:,idx)); axis equal; colorbar;
        xlim([-3 3]); ylim([-3 3]); title(['Computed image, D=' num2str(sep(idx))]);
    subplot(122);
    imagesc(v,v,twopointanalytical(:,:,idx)); axis equal; colorbar;
    xlim([-3 3]); ylim([-3 3]); title(['Analytical image, D=' num2str(sep(idx))]);

    snapnow;
    pause(0.5);
end
```


Computed image, D=0.1
-3
-2
-1
0
1
2
3
0.8
0.6
0.4
0.2


Analytical image, D=0.1
-3
-2
-1
0
1
2
3
0.8
0.6
0.4
0.2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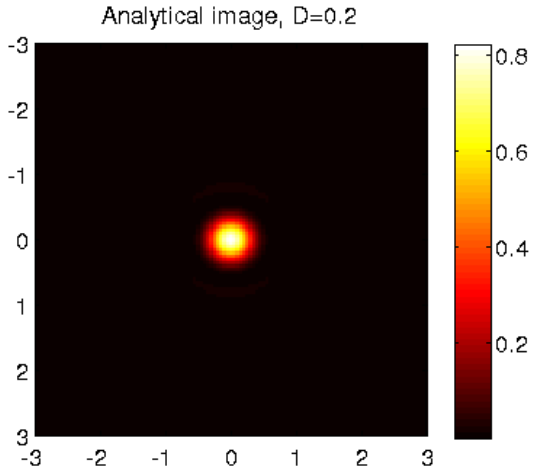
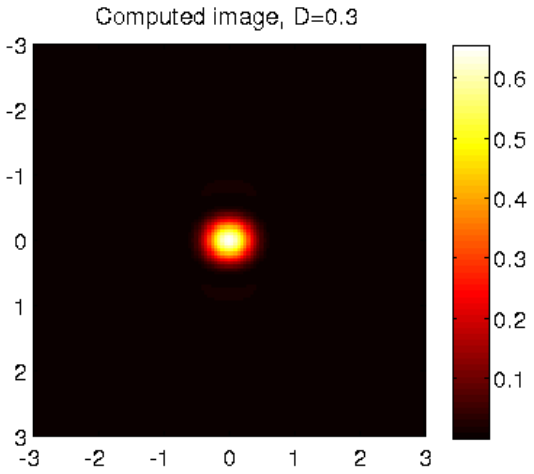
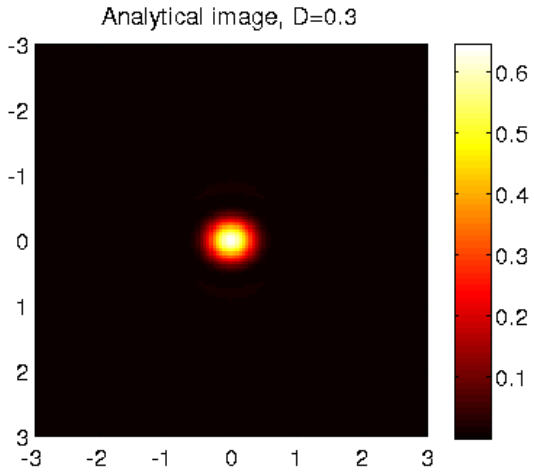
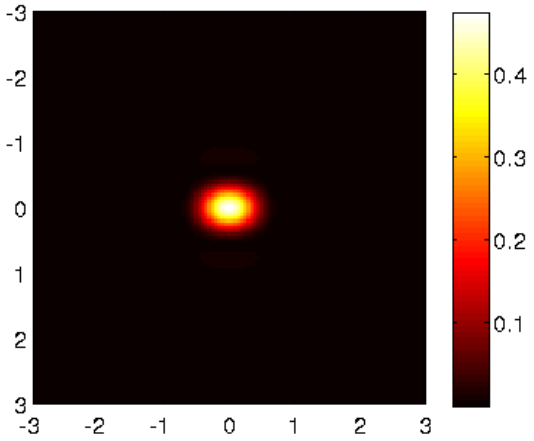
-3
-2
-1
0
1
2
3
0.8
0.6
0.4
0.2


Analytical image, D=0.2
-3
-2
-1
0
1
2
3
0.8
0.6
0.4
0.2


Computed image, D=0.3
-3
-2
-1
0
1
2
3
0.6
0.5
0.4
0.3
0.2
0.1


Analytical image, D=0.3
-3
-2
-1
0
1
2
3
0.6
0.5
0.4
0.3
0.2
0.1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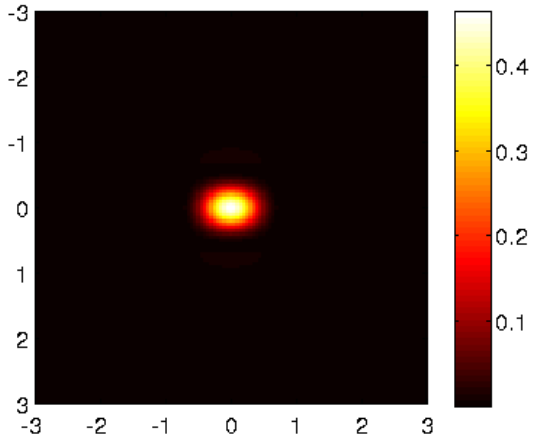
-3
-2
-1
0
1
2
3
0.4
0.3
0.2
0.1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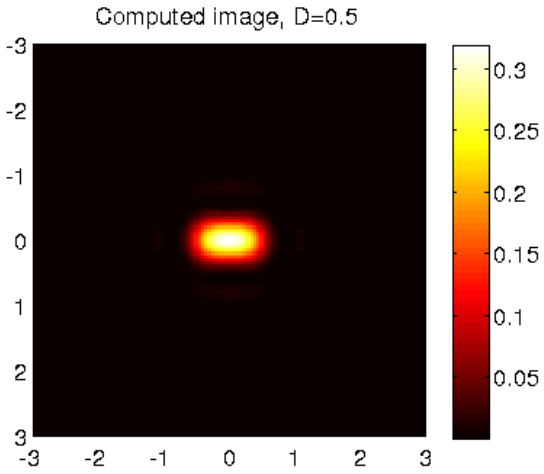
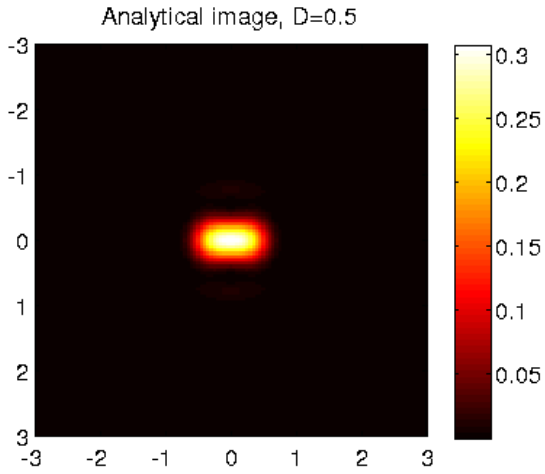
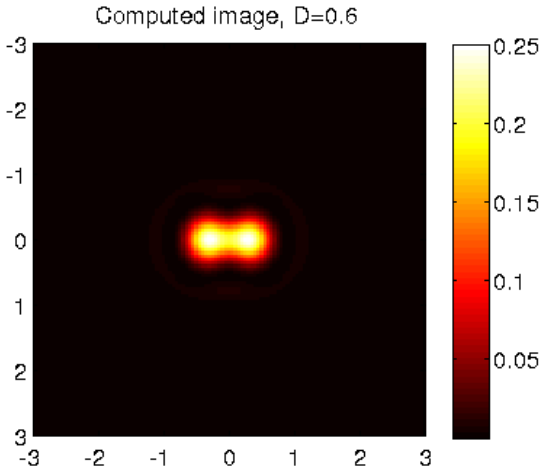
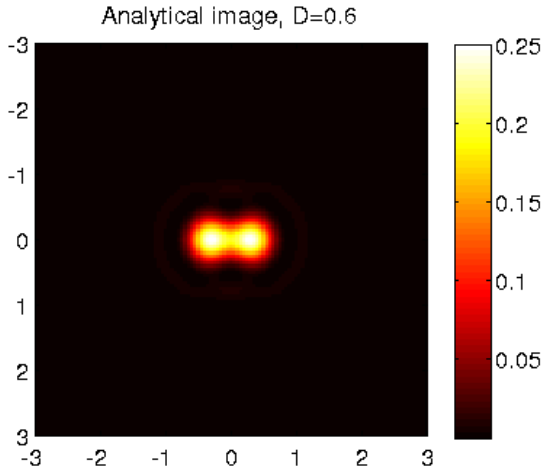
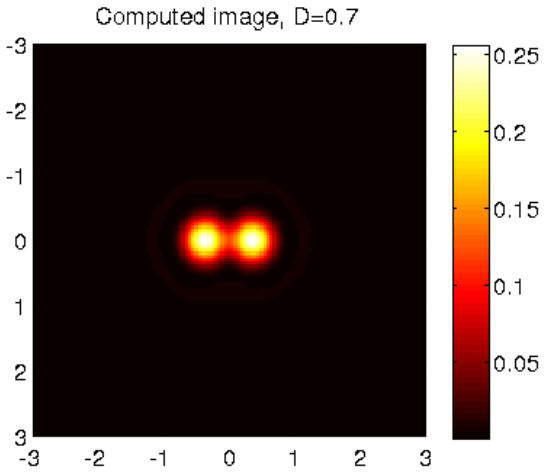
-3
-2
-1
0
1
2
3
0.4
0.3
0.2
0.1

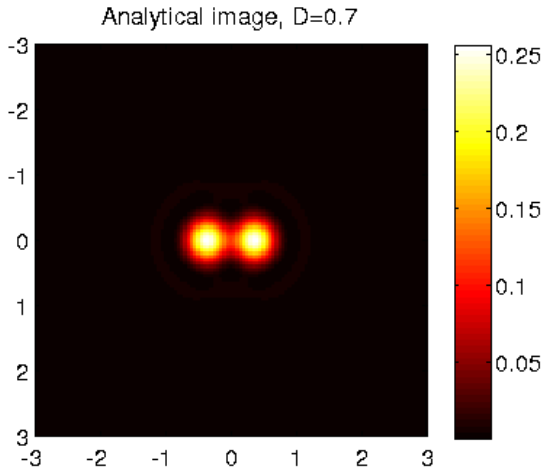

Computed image, D=0.5
-3
-2
-1
0
1
2
3
0.3
0.25
0.2
0.15
0.1
0.05

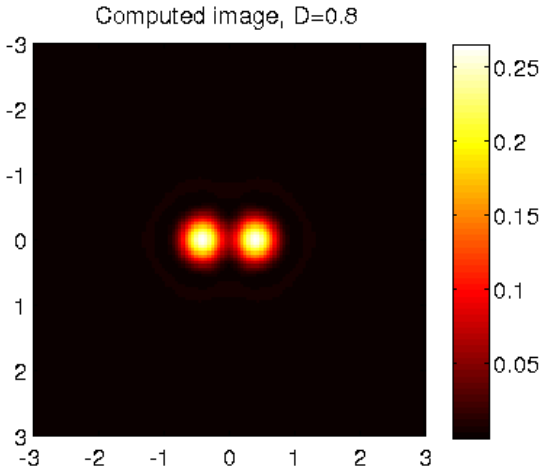

Analytical image, D=0.5
-3
-2
-1
0
1
2
3
0.3
0.25
0.2
0.15
0.1
0.05

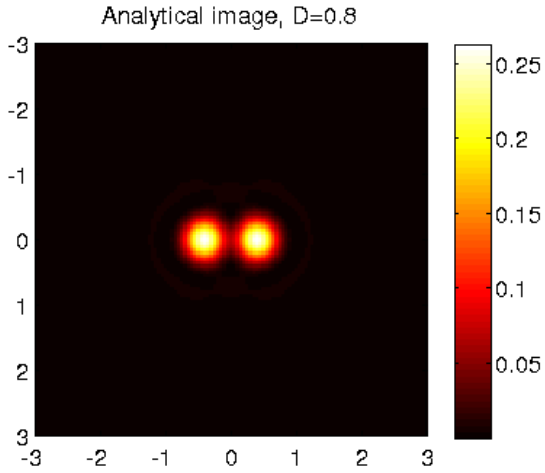

Computed image, D=0.6
-3
-2
-1
0
1
2
3
0.25
0.2
0.15
0.1
0.05

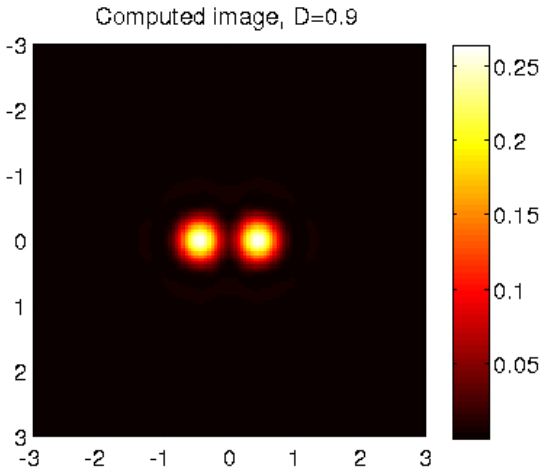

Analytical image, D=0.6
-3
-2
-1
0
1
2
3
0.25
0.2
0.15
0.1
0.05


Computed image, D=0.7
-3
-2
-1
0
1
2
3
0.25
0.2
0.15
0.1
0.05


Analytical image, D=0.7
-3
-2
-1
0
1
2
3
0.25
0.2
0.15
0.1
0.05


Computed image, D=0.8
-3
-2
-1
0
1
2
3
0.25
0.2
0.15
0.1
0.05


Analytical image, D=0.8
-3
-2
-1
0
1
2
3
0.25
0.2
0.15
0.1
0.05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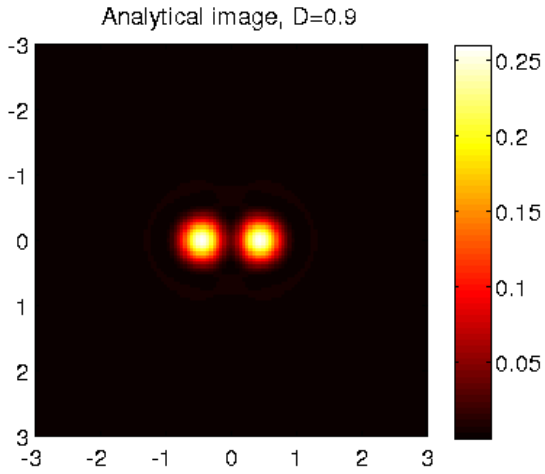
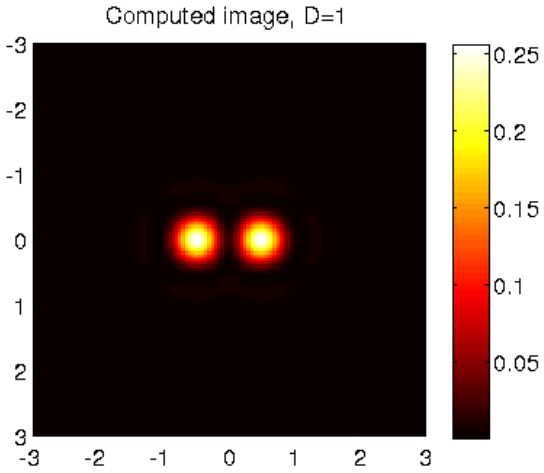
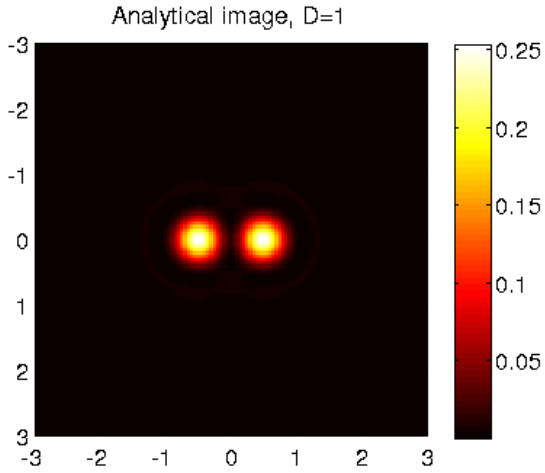
-3
-2
-1
0
1
2
3
0.25
0.2
0.15
0.1
0.05


Analytical image, D=0.9
-3
-2
-1
0
1
2
3
0.25
0.2
0.15
0.1
0.05


Computed image, D=1
-3
-2
-1
0
1
2
3
0.25
0.2
0.15
0.1
0.05


Analytical image, D=1
-3
-2
-1
0
1
2
3
0.25
0.2
0.15
0.1
0.05