Assignment 4 Determining and removing drawbacks of exponential and running mean Task 2

Table of Contents

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Part II 3D surface filtration using forward-backward smoothing

```
clc
clear
close all
```

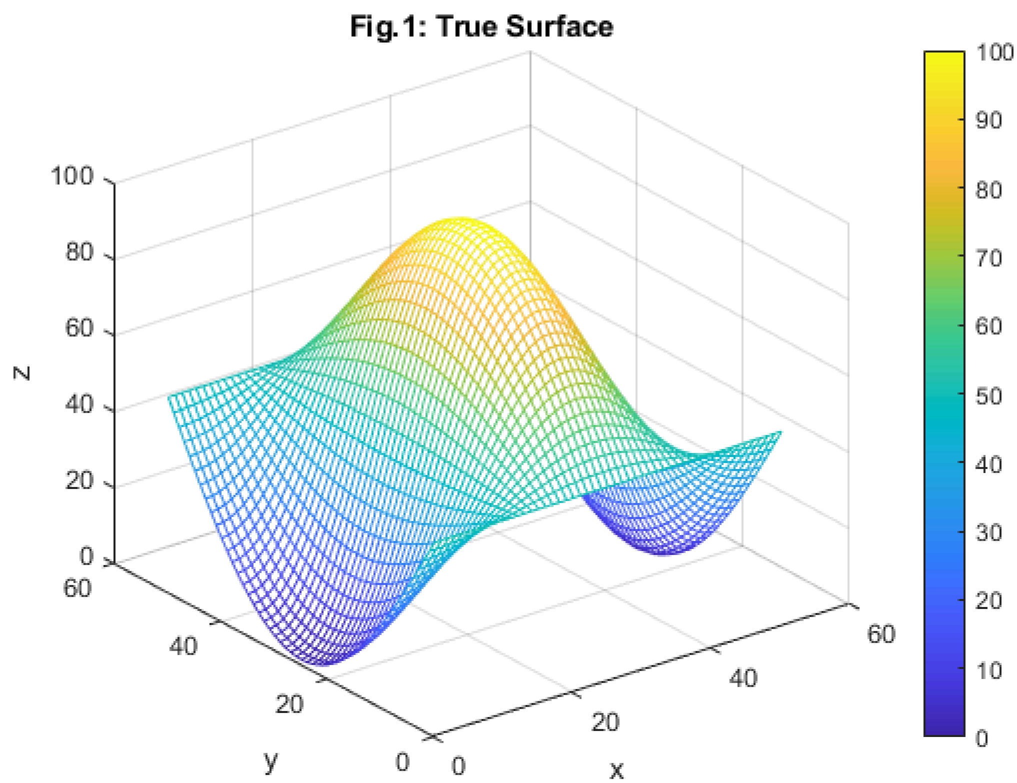
Task 1: Download surface data

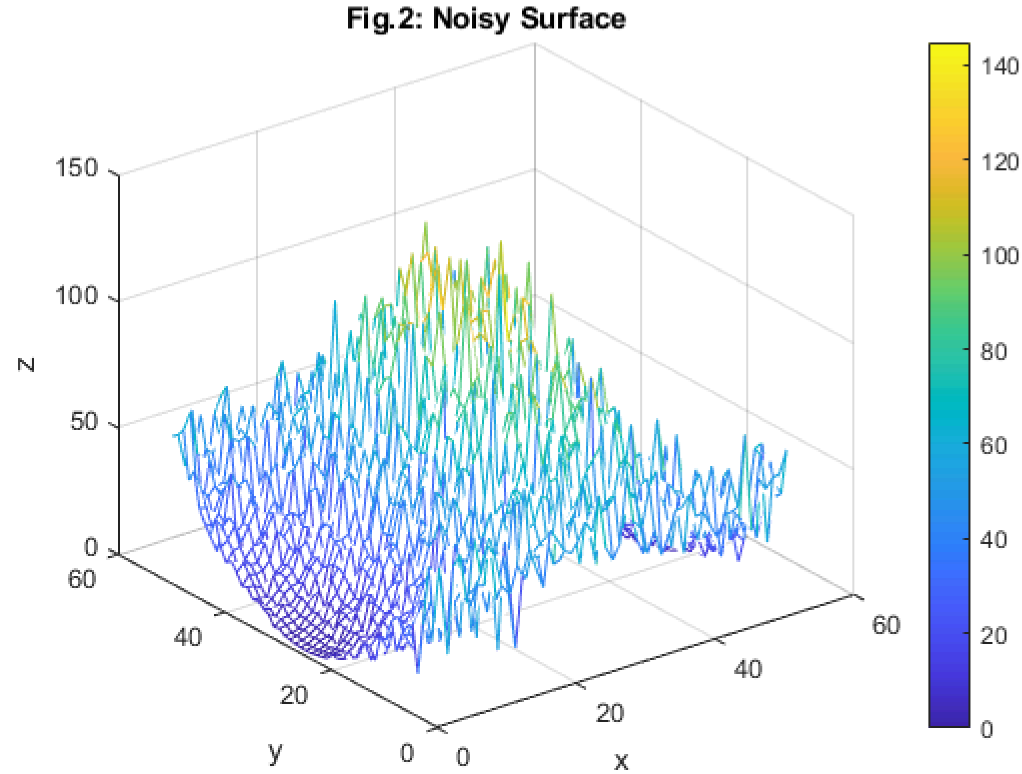
```
load('noisy_surface.mat', 'noisy_surface')
```

```
load('true_surface.mat')
```

Task 2: Plot noisy and true surface

```
figure
mesh(true_surface)
title('Fig.1: True Surface')
colorbar
xlabel('x')
ylabel('y')
zlabel('z')

figure
mesh(noisy_surface)
title('Fig.2: Noisy Surface')
xlabel('x')
ylabel('y')
zlabel('z')
colorbar
```





Task 3: Determine the variance of deviation of noisy surface from the true one

```
dev = reshape(true_surface-noisy_surface,[],1);
n = length(dev);
var = sum(dev.^2)/(n-1)-(sum(dev)/n)^2*n/(n-1);
```

Task 4: Apply forward-backward exponential smoothing to filter noisy surface measurements

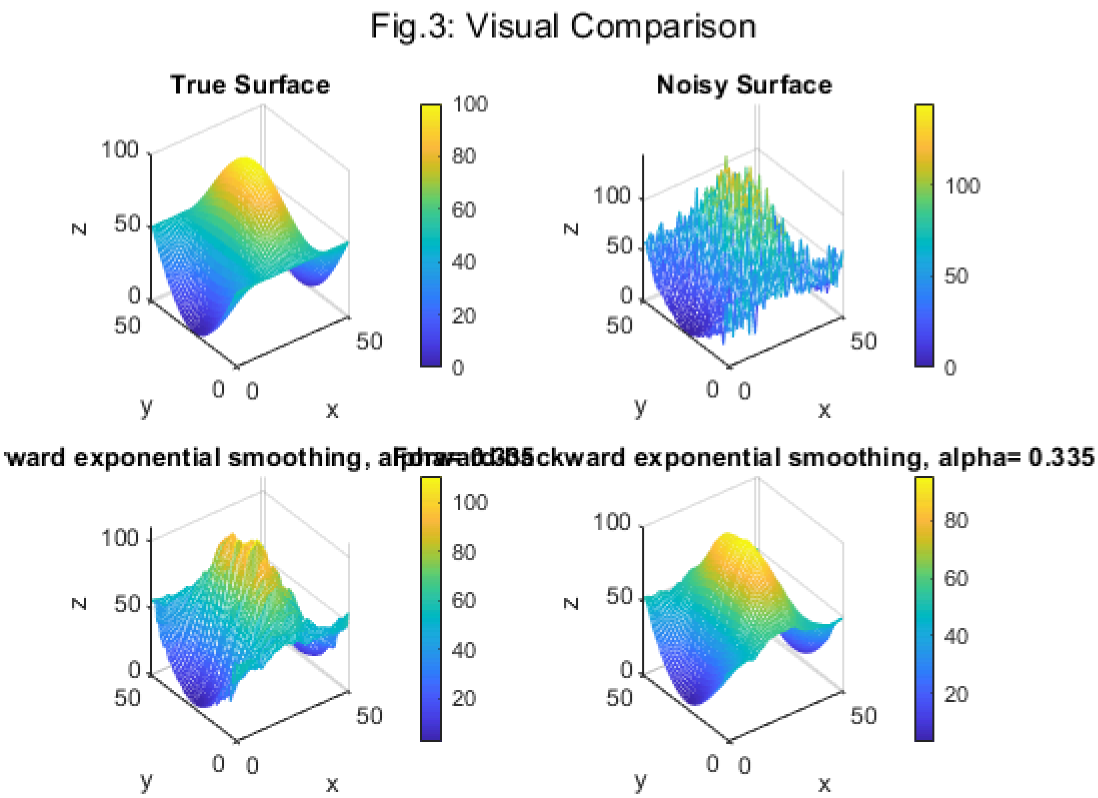
```
alpha = 0.335;

N = size(noisy_surface,1); %number of rows
M = size(noisy_surface,2); %number of columns

% Forward-backward exponential smoothing of rows
X_fr = noisy_surface;
X_br = zeros(N,M);

for j = 1:N
    for i = 2:M
```

```
        X_fr(j,i) = X_fr(j,i-1)+alpha*(noisy_surface(j,i)-
X_fr(j,i-1));
    end

    X_br(j,end) = X_fr(j,end);
    for i = M-1:-1:1
        X_br(j,i) = X_br(j,i+1)+alpha*(X_fr(j,i)-X_br(j,i+1));
    end
end

X_fc = X_br;
for i = 1:M
    for j = N-1:-1:1
        X_fc(j,i) = X_fc(j+1,i)+alpha*(X_br(j,i)-X_fc(j+1,i));
    end

    X_bc(1,i) = X_fc(1,i);
    for j = 2:N
        X_bc(j,i) = X_bc(j-1,i)+alpha*(X_fc(j,i)-X_bc(j-1,i));
    end
end
```

Task 5: Compare visually the obtained estimation results and true surface

```
figure
subplot(2,2,1)
mesh(true_surface)
sgtitle('Fig.3: Visual Comparison')
title('True Surface')
colorbar
xlabel('x')
ylabel('y')
zlabel('z')

subplot(2,2,2)
mesh(noisy_surface)
title('Noisy Surface')
xlabel('x')
ylabel('y')
zlabel('z')
colorbar

subplot(2,2,3)
mesh(X_br)
title(['Forward exponential smoothing, alpha= ',num2str(alpha)])
xlabel('x')
ylabel('y')
zlabel('z')
colorbar

subplot(2,2,4)
```

```
mesh(X_bc)
title(['Forward-backward exponential smoothing, alpha=
 ',num2str(alpha)])
xlabel('x')
ylabel('y')
zlabel('z')
colorbar
```



Task 6: Determine the variance of deviation of smoothed surface from the true one

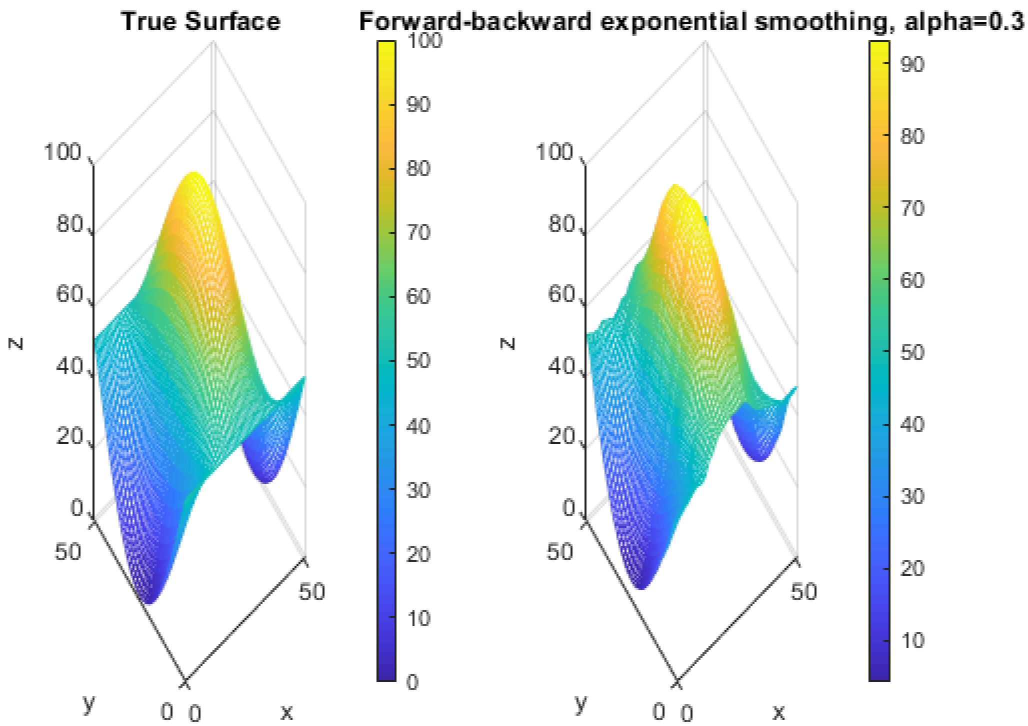
```
dev_s = reshape(true_surface-X_bc,[],1);
var_s = sum(dev_s.^2)/(n-1)-(sum(dev_s)/n)^2*n/(n-1);
```

Task 7: Try greater and smaller values of smoothing coefficient alpha

```
alpha = 0.3;
N = size(noisy_surface,1); %number of rows
M = size(noisy_surface,2); %number of columns

% Forward-backward exponential smoothing of rows
X_fr = noisy_surface;
```

```
X_br = zeros(N,M);

for j = 1:N
    for i = 2:M
        X_fr(j,i) = X_fr(j,i-1)+alpha*(noisy_surface(j,i)-
X_fr(j,i-1));
    end

    X_br(j,end) = X_fr(j,end);
    for i = M-1:-1:1
        X_br(j,i) = X_br(j,i+1)+alpha*(X_fr(j,i)-X_br(j,i+1));
    end
end

X_fc = X_br;
for i = 1:M
    for j = N-1:-1:1
        X_fc(j,i) = X_fc(j+1,i)+alpha*(X_br(j,i)-X_fc(j+1,i));
    end

    X_bc(1,i) = X_fc(1,i);
    for j = 2:N
        X_bc(j,i) = X_bc(j-1,i)+alpha*(X_fc(j,i)-X_bc(j-1,i));
    end
end

figure
subplot(1,2,1)
sgtitle('Fig.4: Effects of alpha on estimation results')
mesh(true_surface)
title('True Surface')
colorbar
xlabel('x')
ylabel('y')
zlabel('z')
subplot(1,2,2)
mesh(X_bc)
title(['Forward-backward exponential smoothing,
 alpha=',num2str(alpha)])
xlabel('x')
ylabel('y')
zlabel('z')
colorbar
```

Fig.4: Effects of alpha on estimation results



Conclusions:

- Smoothing coefficent from 0.1 - 0.2 gives less sensibility in changes of sharp
- Smoothing coefficent from 0.4 - 1 the surface is bad with noise.
- When smoothing coefficent is less than ~0.2, the resulted surface does not change visually in significant way. When smoothing coefficent is more than ~0.4, the smoothening doesn't remove noise from the measured data.
- Forward - backward exponential smoothing leads to the result which is quite close to the real surface. Though it leaves some roughness in the most noisy parts of measured data.
- We've learnt that it is possible to use exponential smoothing to smoothen 3d data

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