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Learning Outcomes

With this assignment, we learned how the shape-from-shading problem, though ill-posed, can be computationally solved using the fundamental concepts of computer vision. We also learned the effect of noise, regularizer constraint, alpha, and the epsilon on the solutions.

Effect of noise:
We have taken Gaussian/Normal noise. The noise adds randomness, and the results deteriorate as the noise levels increase. Still, the shape was more or less recognizable.

Effect of lambda:
The regularization constraint parameter (lambda) increases the smoothness of the solution, resulting in a more natural-looking output for higher lambda. Lower lambda even seems to amplify the effect of noise.

Effect of alpha:
Alpha seems to affect the contrast of the image. High alpha values seem to reduce the difference in apparent depth, leading to underestimation. In the case of noise, higher alpha amplifies noise.

Epsilon:
The change in epsilon distorts the direction of apparent depth as the light is not coming from the same direction as of viewer, giving a misleading result.

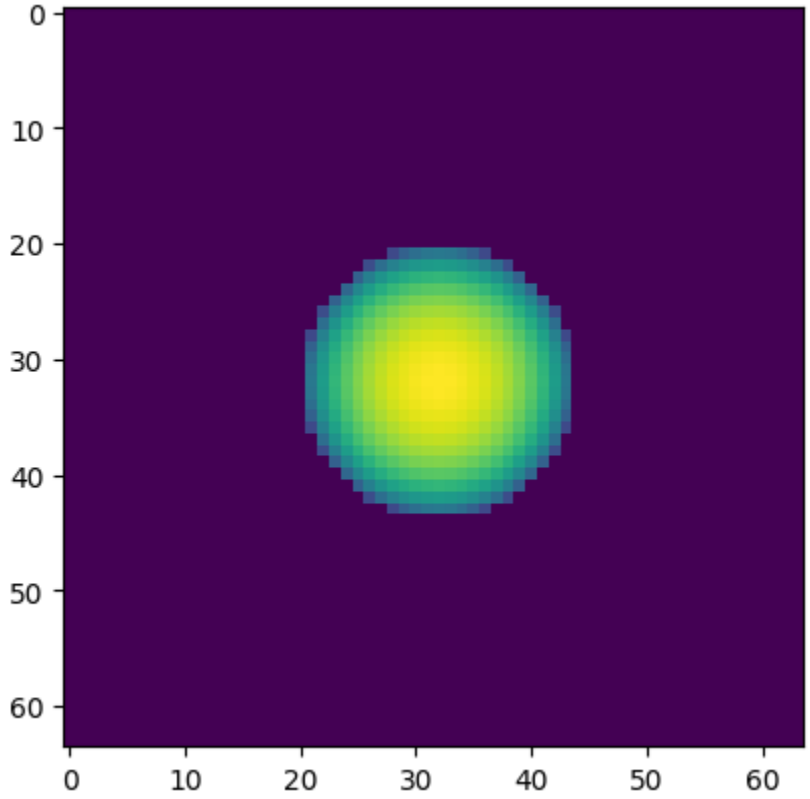
Image size:
Using parallel matrix computations, we were able to compute for images larger than 64x64

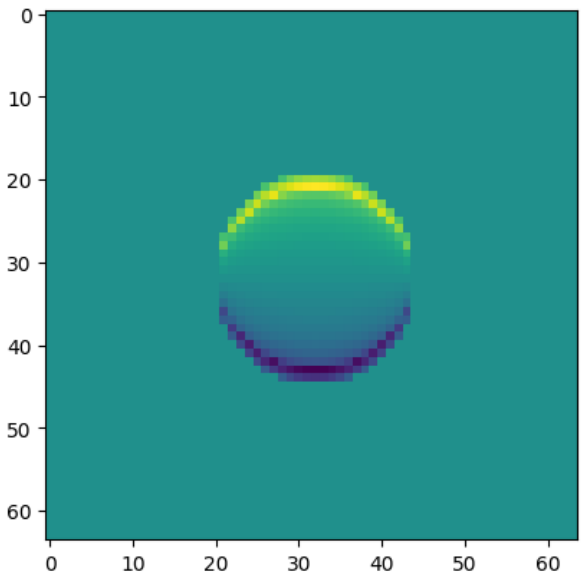
See the next pages for outputs

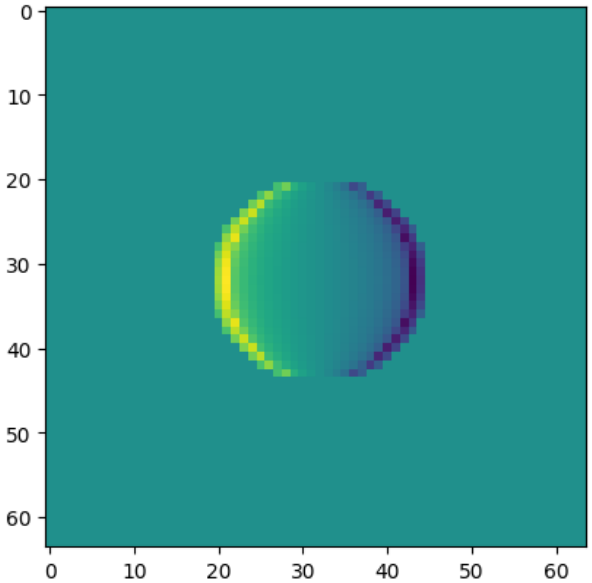
Outputs

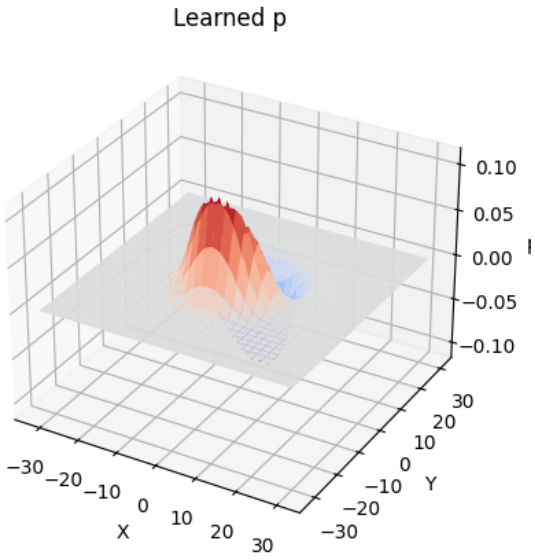
(a) Without Noise:

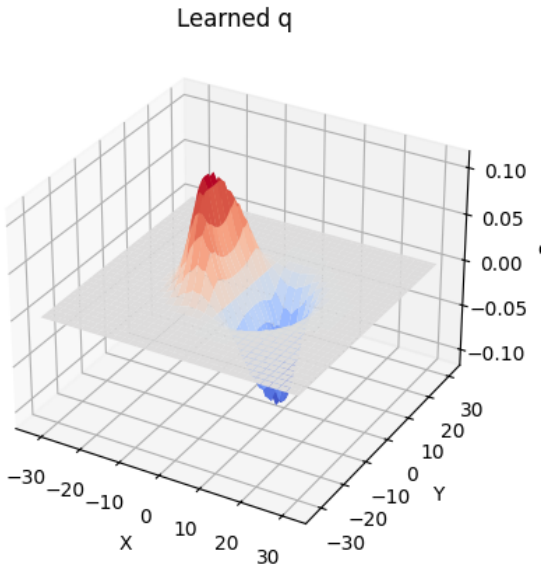
Generated E(x,y):



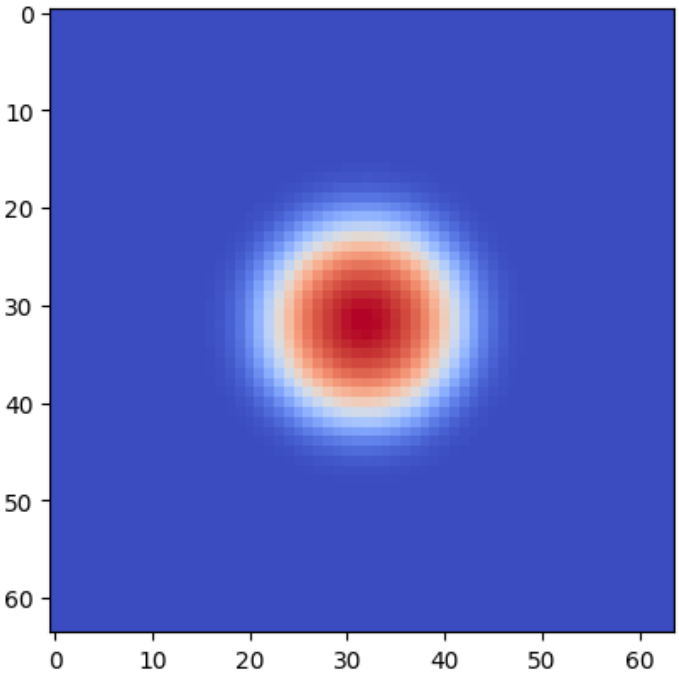


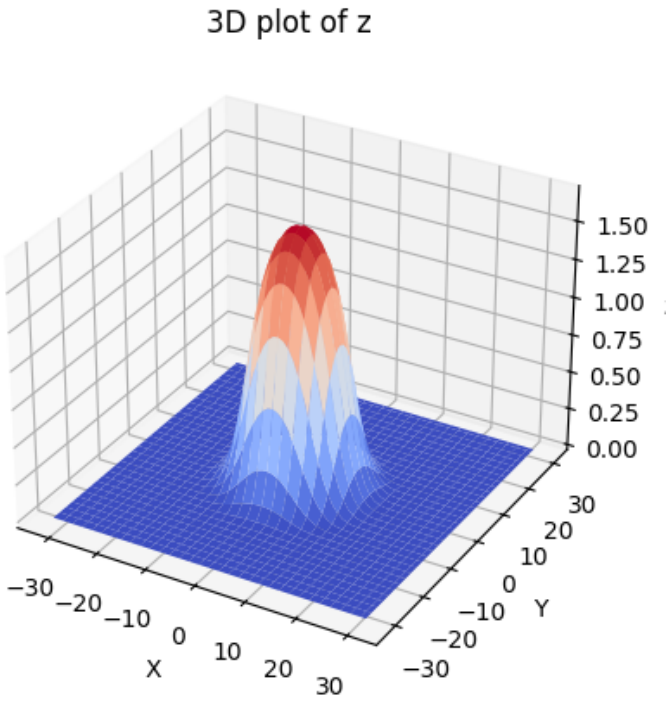






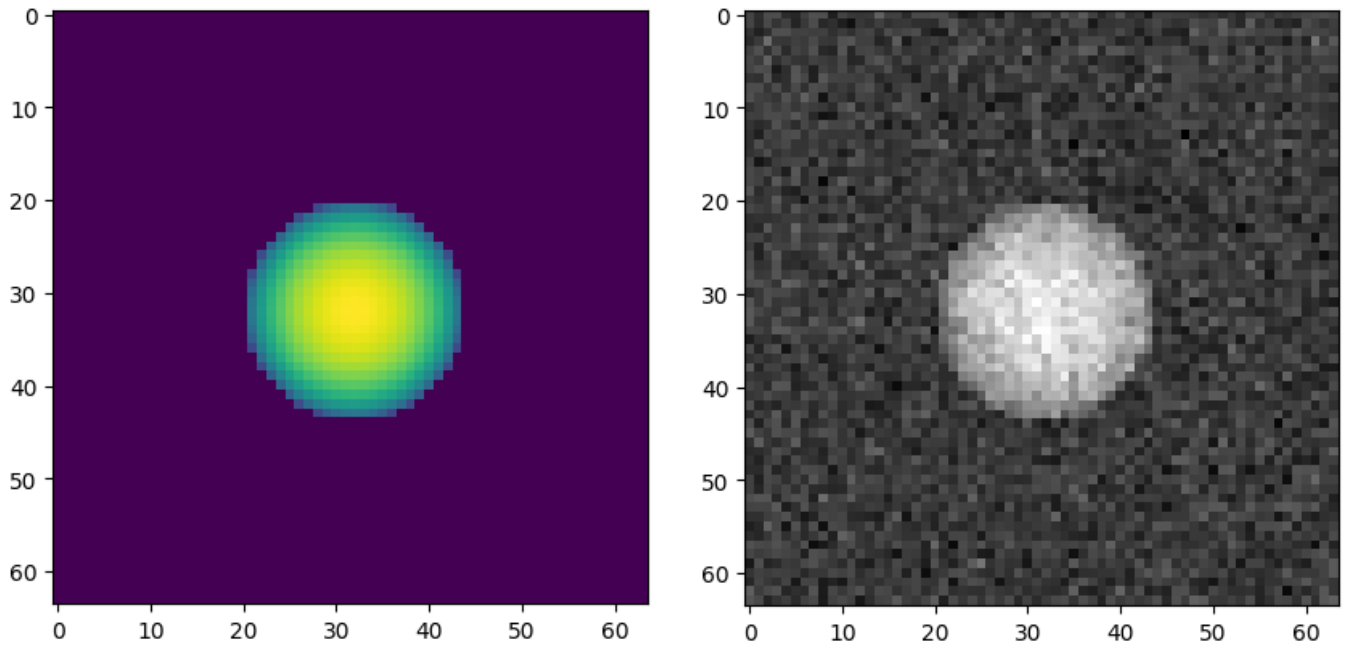
Lambda = 1
Alpha = 1

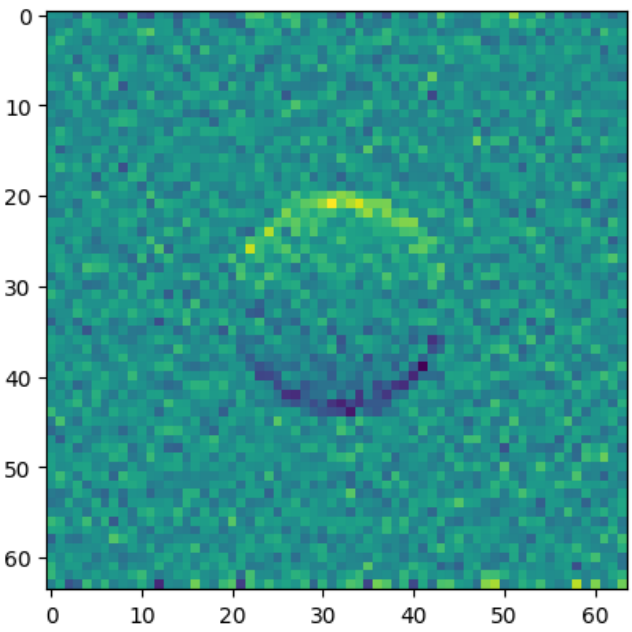


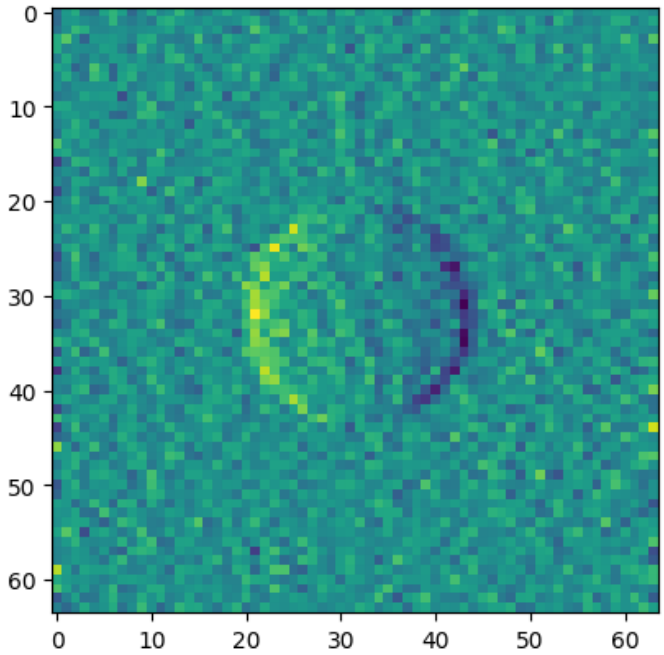


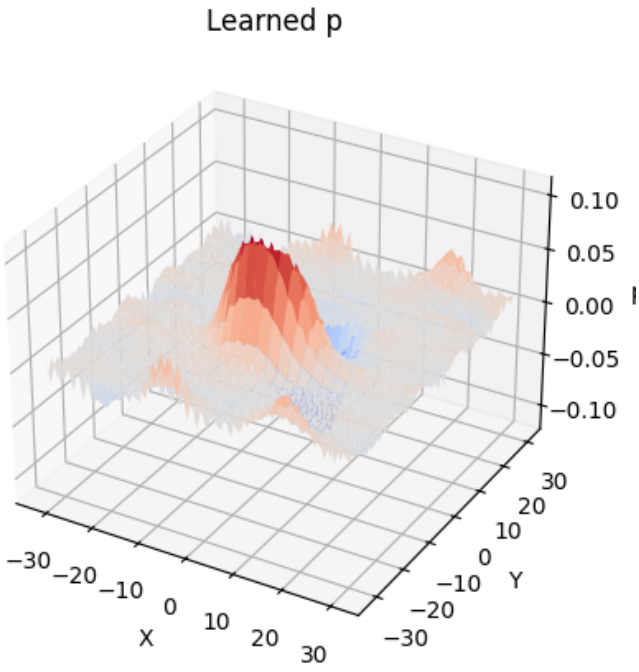
(b) With Noise:

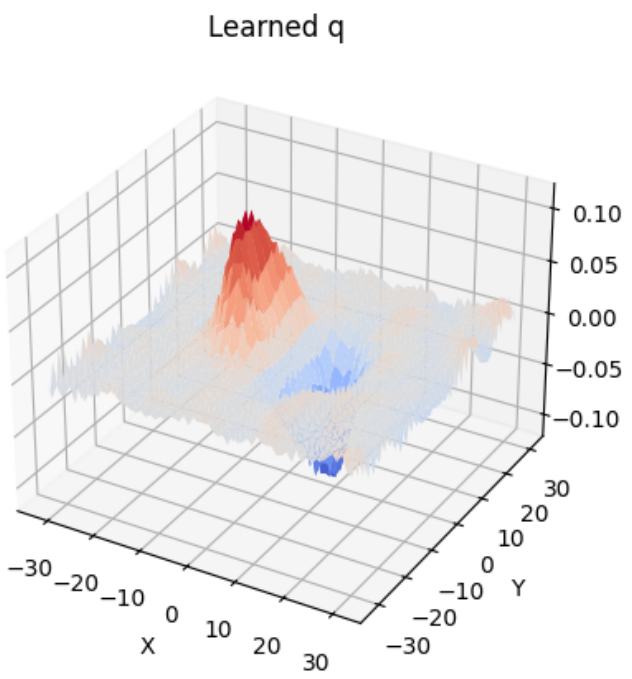
Noise factor = 0.1

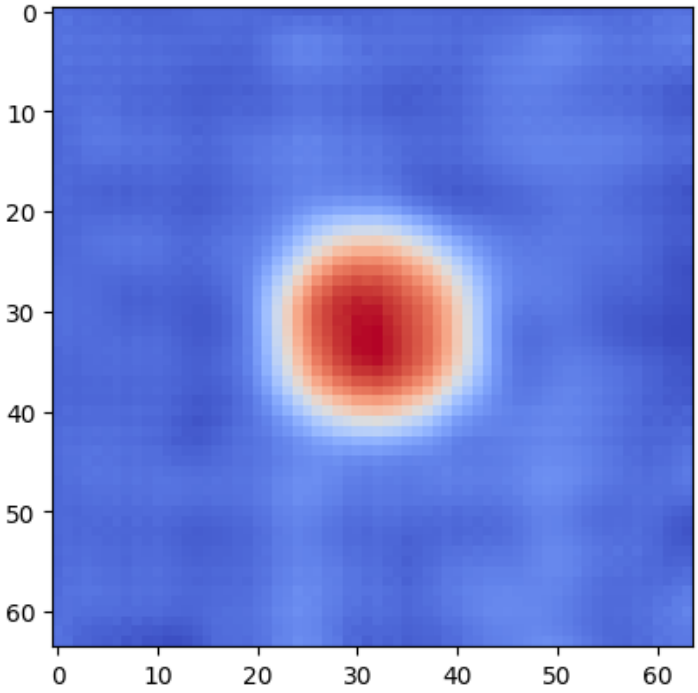


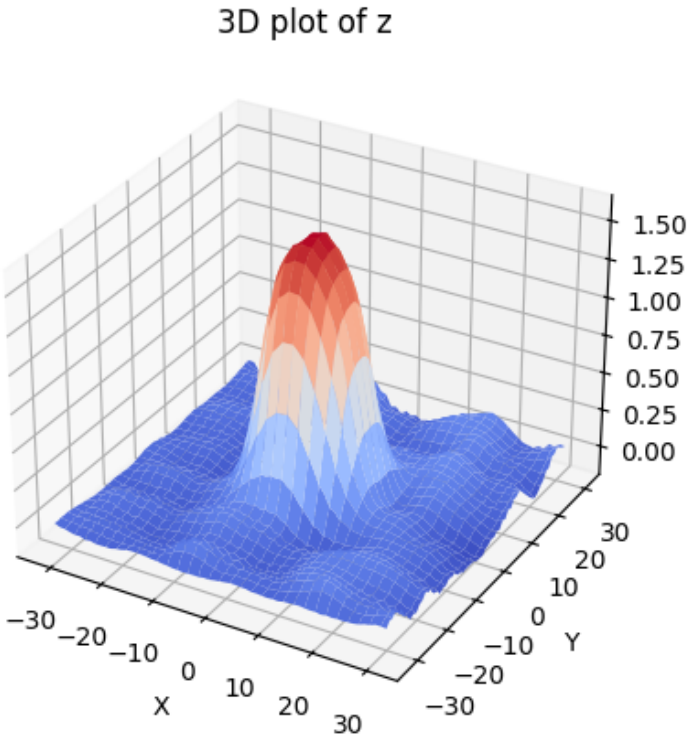

0
10
20
30
40
50
60


0
10
20
30
40
50
60

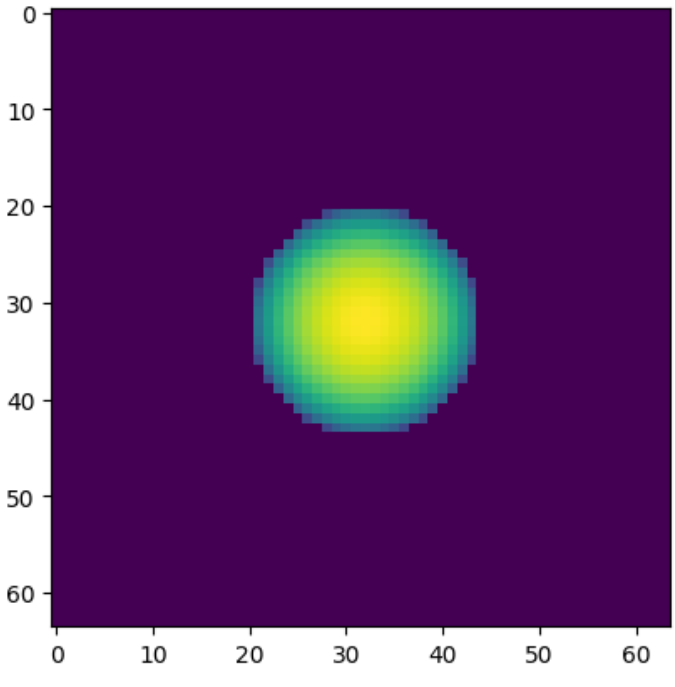

Learned p
0.10
0.05
0.00
−0.05
−0.10
−30
−20
−10
0
10
20
30
X
Y

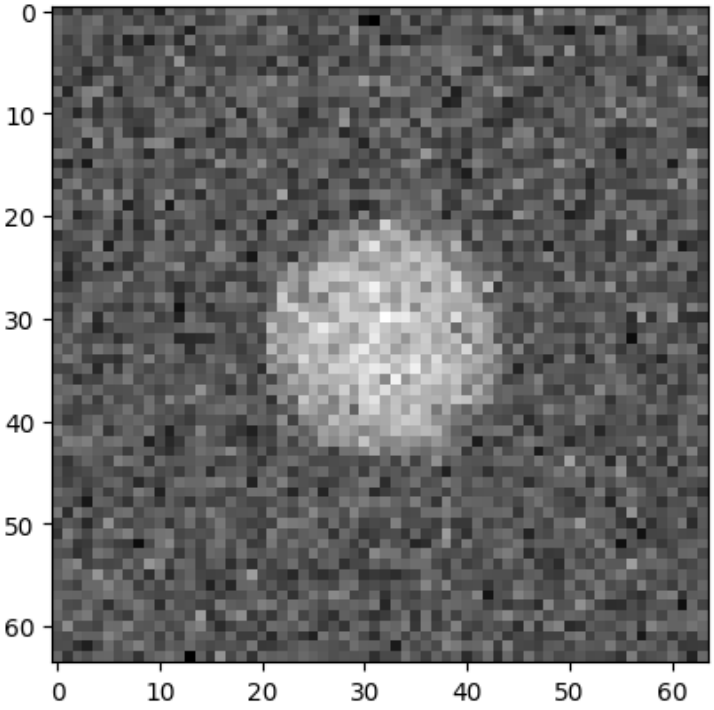

Learned q
0.10
0.05
0.00
−0.05
−0.10
−30
−20
−10
0
10
20
30
X
Y

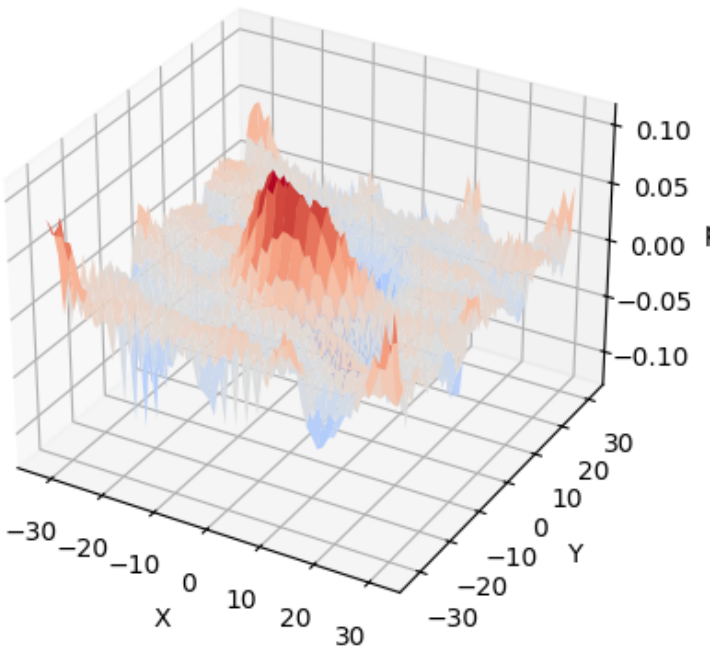


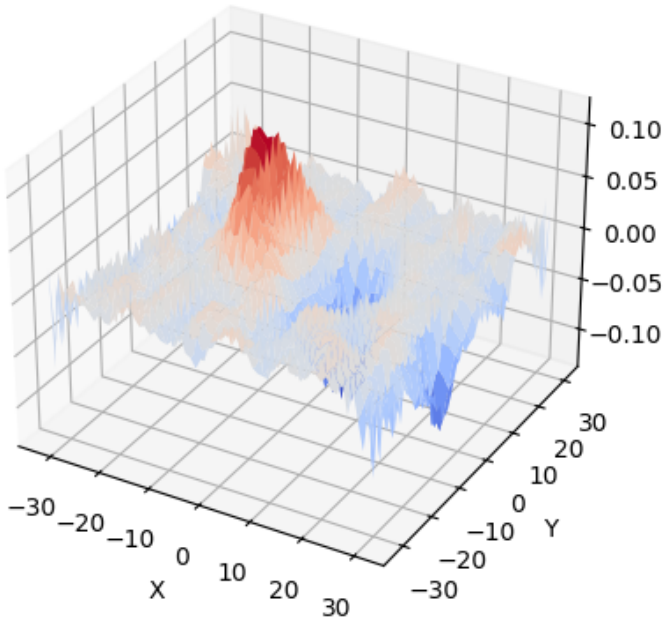


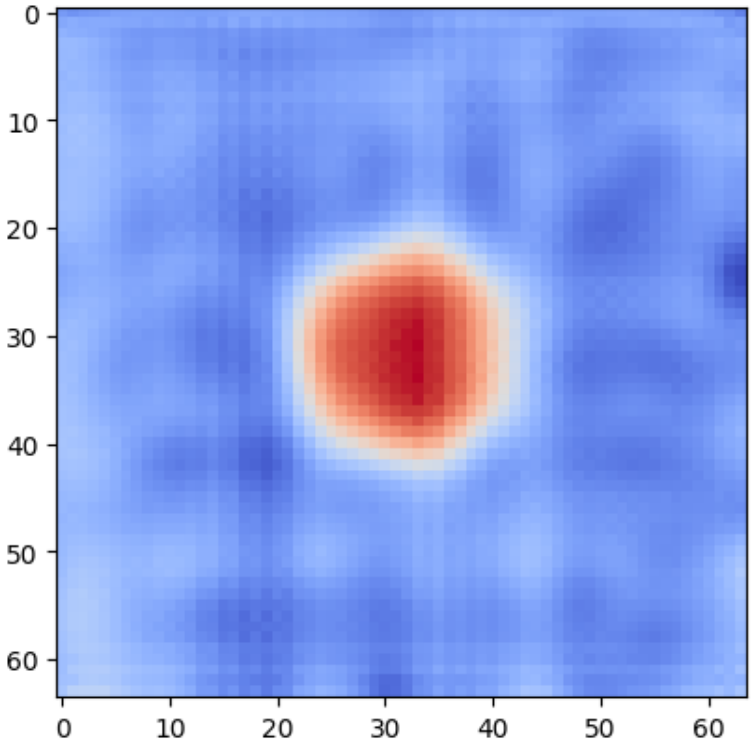
Noise Level = 0.2






Learned p
0.10
0.05
0.00
−0.05
−0.10
−30 −20 −10 0 10 20 30
X
−30 −20 −10 0 10 20 30
Y


Learned q
0.10
0.05
0.00
−0.05
−0.10
−30 −20 −10 0 10 20 30
X
−30 −20 −10 0 10 20 30
Y


0
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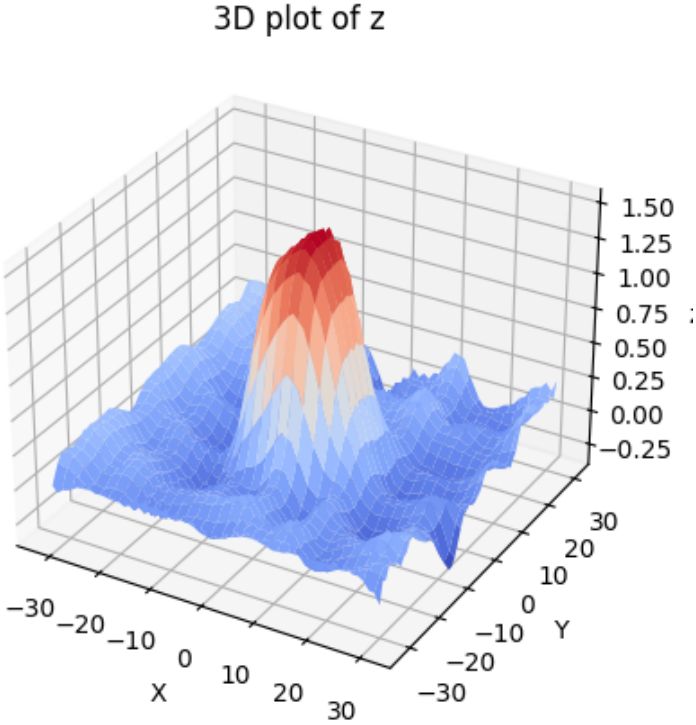
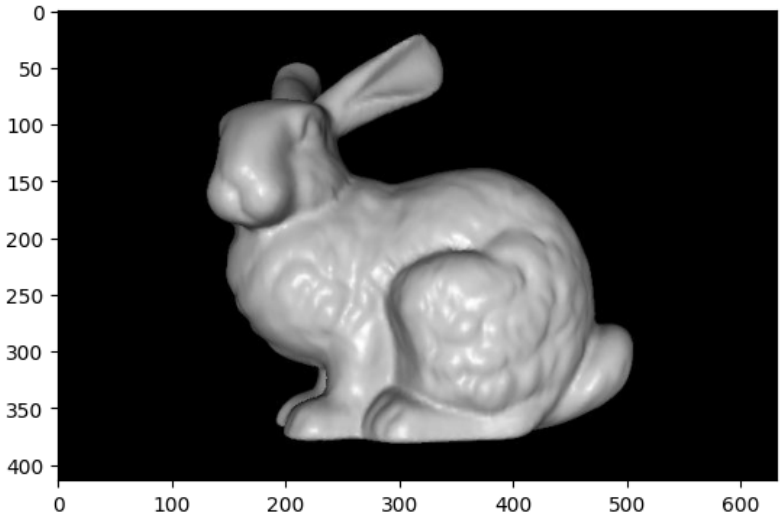
0 10 20 30 40 50 60


3D plot of z
1.50
1.25
1.00
0.75
0.50
0.25
0.00
−0.25
−30 −20 −10 0 10 20 30
X
−30 −20 −10 0 10 20 30
Y


0
50
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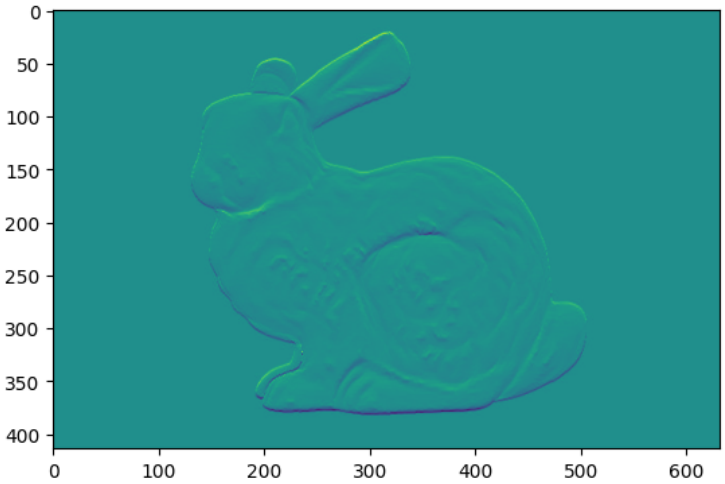
150
200
250
300
350
400
0
100
200
300
400
500
600


0
50
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350
400
0
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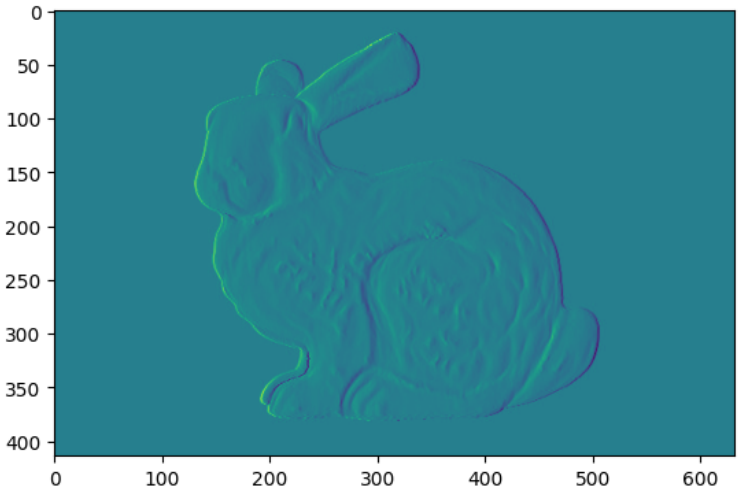
400
500
600


0
50
100
150
200
250
300
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400
0
100
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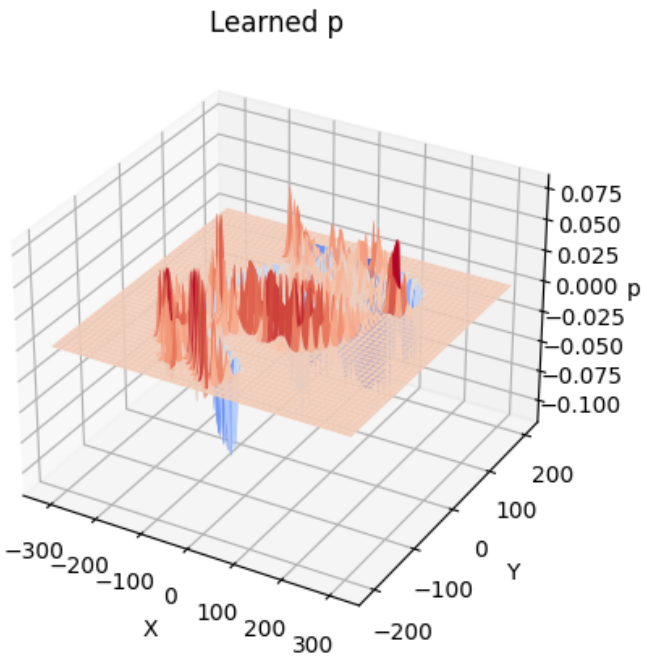
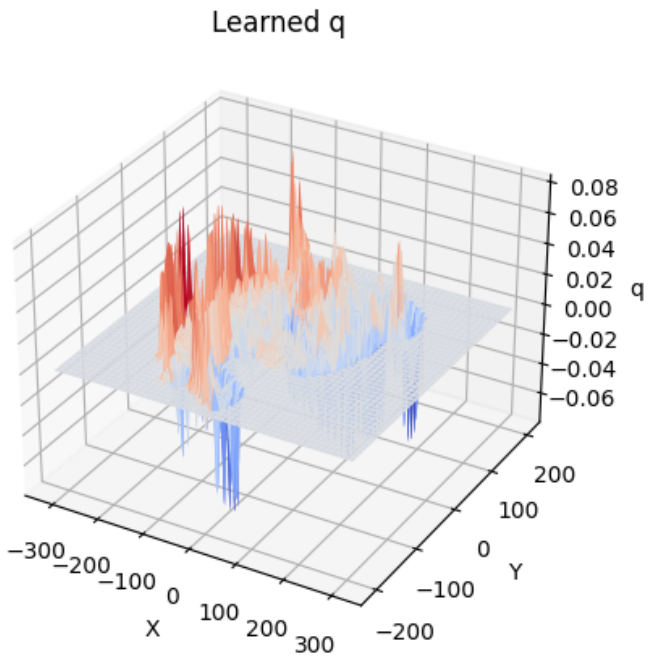
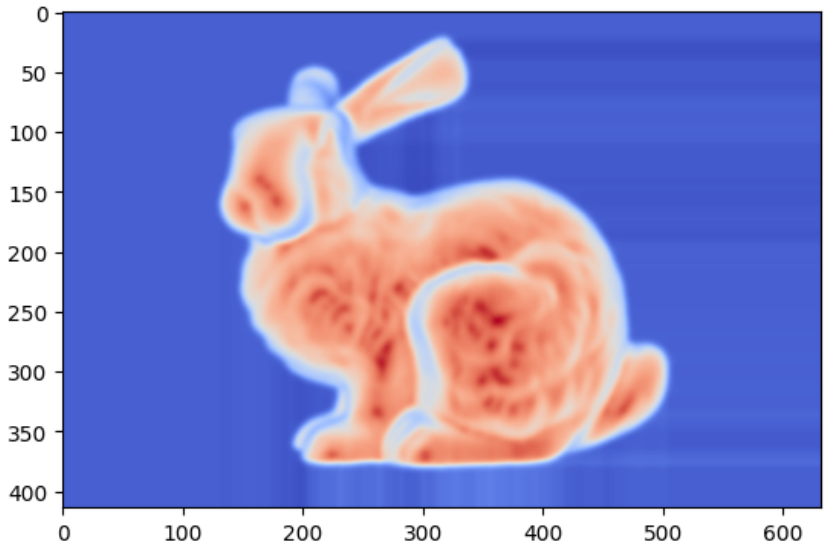
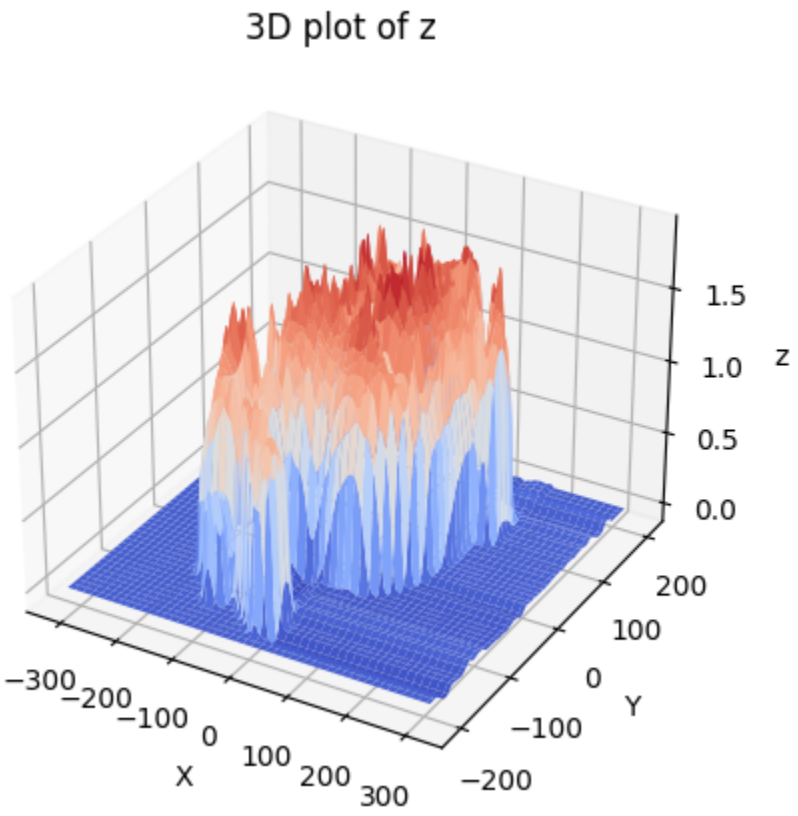
300
400
500
600


Learned p
0.075
0.050
0.025
0.000
−0.025
−0.050
−0.075
−0.100
p
−300
−200
−100
0
100
200
300
X
200
100
0
−100
−200
Y


Learned q
0.08
0.06
0.04
0.02
0.00
−0.02
−0.04
−0.06
q
−300
−200
−100
0
100
200
300
X
200
100
0
−100
−200
Y


0
50
100
150
200
250
300
350
400
0
100
200
300
400
500
600


3D plot of z
1.5
1.0
0.5
0.0
z
200
100
0
−100
−200
Y
−300
−200
−100
0
100
200
300
X