

**Principles of Biomedical Ultrasound and
Photoacoustics
hw02: Speckle Statistics**

Due on Thursday, Nov 16, 2017

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1 Introduction

In this homework, we will use Matlab tool **Field2** to simulate speckle scattering.

2 Part I

In this part, we need to create a complex array with 10000 dimension, which magnitude is uniform distribution $[0, 1]$ and phase $[0, 2\pi]$. We name this array as **origin array**.

2.a Histogram of the Amplitude and Intensity

Figure 1 shows the histogram of amplitude and intensity of origin array.

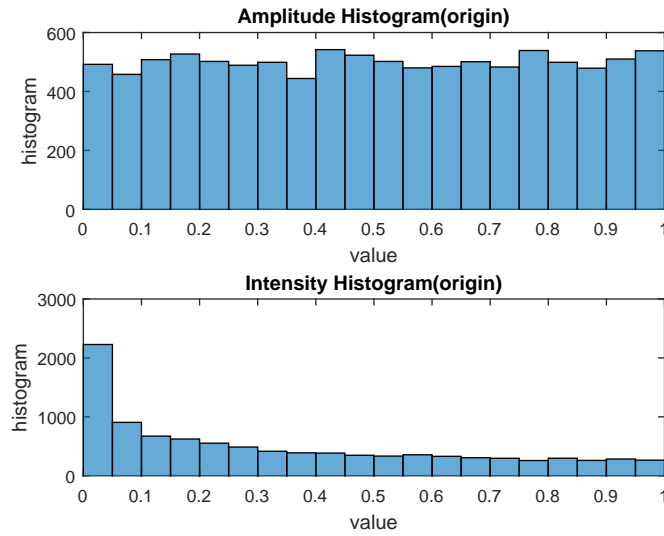


Figure 1: Histogram of amplitude (top) and intensity (bottom) of origin array

In Figure 1, we can see the distribution of amplitude is exactly uniform distribution. Because intensity is $amplitude^2$ and value between $[0, 1]$ will decay exponentially, so the distribution will move left.

2.b Histogram and Ratio of new array

Now we create a new array with size N ($= 10000, 5000, 2000, 1000, 500$), which value is the sum of M ($= 1, 2, 5, 10, 20$) consecutive data:

$$val(i) = \sum_{k=(i-1)*M}^{i*M} origin(k)$$

And then plot their histogram and calculate ratio of mean and standard deviation as a function of M .

Figure [2, 3, 4, 5, 6, 7, 8, 9, 10, 11] show the histogram result and Figure [12, 13, 14, 15, 16] show the ratio as a function of M .

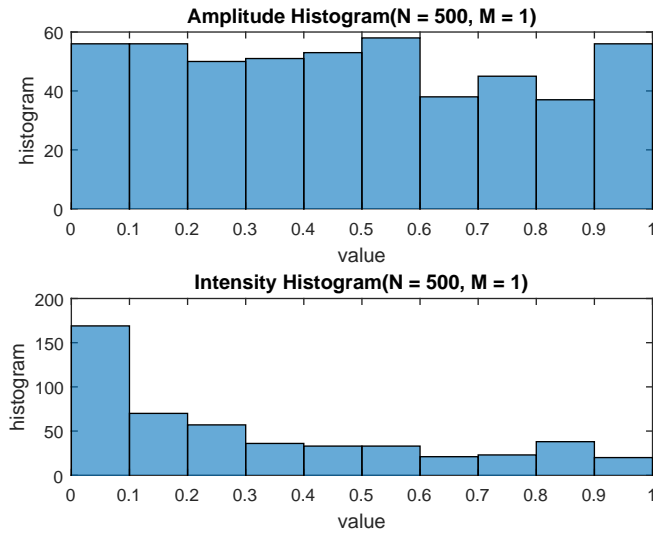


Figure 2: Histogram of amplitude (top) and intensity (bottom) of new array ($N = 500$, $M = 1$)

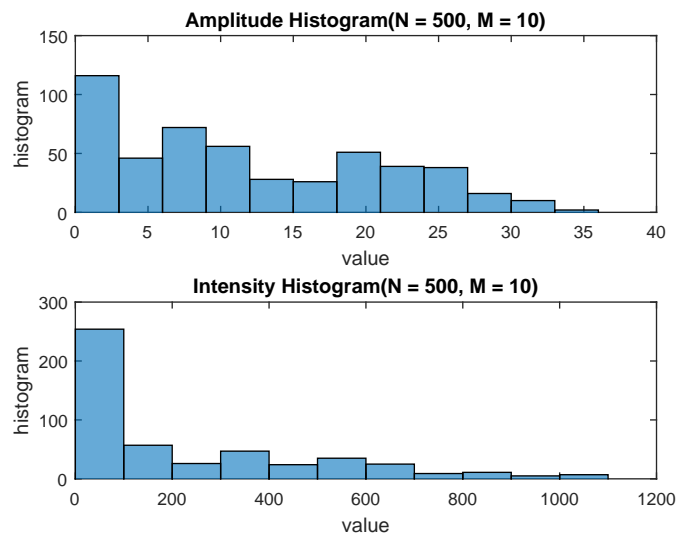


Figure 3: Histogram of amplitude (top) and intensity (bottom) of new array ($N = 500$, $M = 10$)

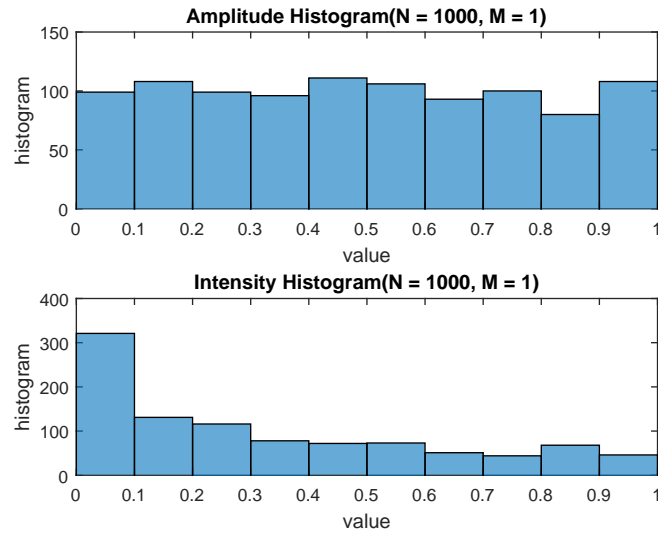


Figure 4: Histogram of amplitude (top) and intensity (bottom) of new array ($N = 1000$, $M = 1$)

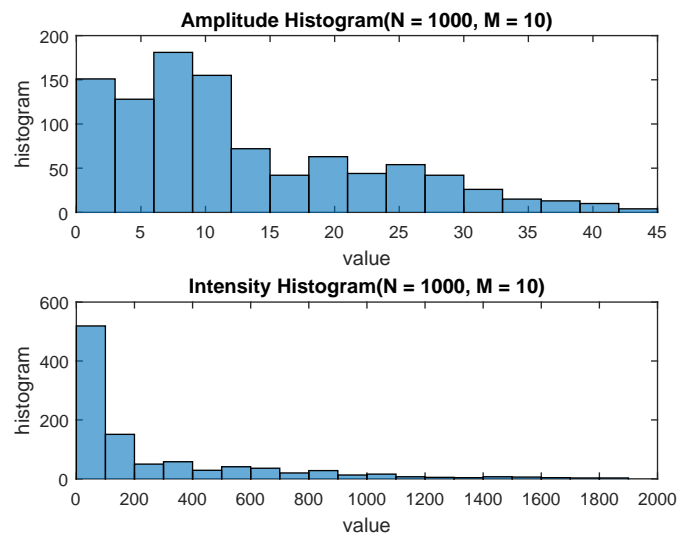


Figure 5: Histogram of amplitude (top) and intensity (bottom) of new array ($N = 1000$, $M = 10$)

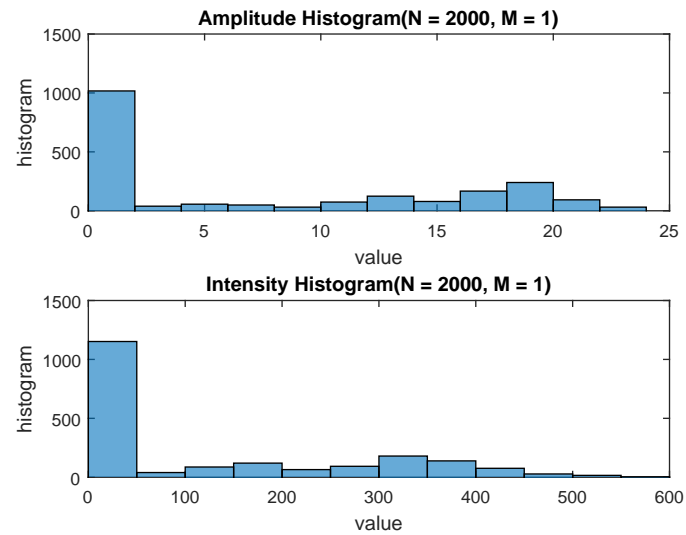


Figure 6: Histogram of amplitude (top) and intensity (bottom) of new array ($N = 2000$, $M = 1$)

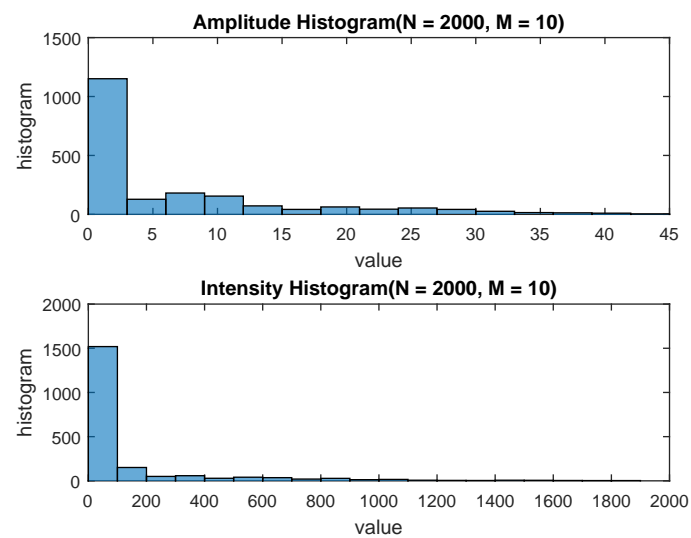


Figure 7: Histogram of amplitude (top) and intensity (bottom) of new array ($N = 2000$, $M = 10$)

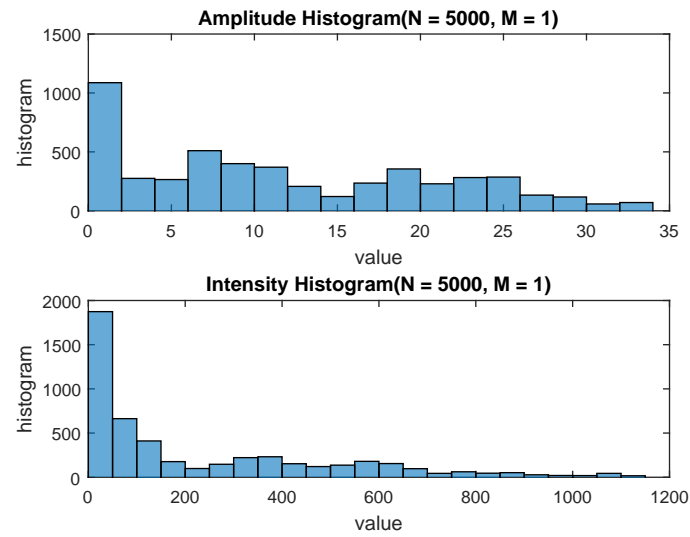


Figure 8: Histogram of amplitude (top) and intensity (bottom) of new array ($N = 5000$, $M = 1$)

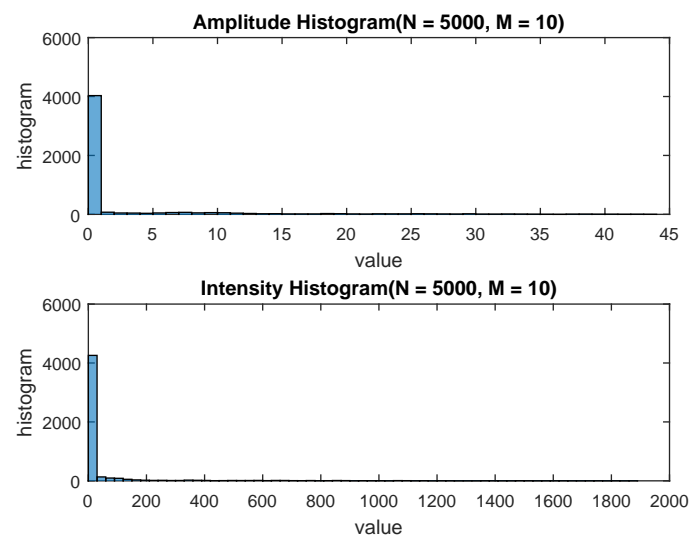


Figure 9: Histogram of amplitude (top) and intensity (bottom) of new array ($N = 5000$, $M = 10$)

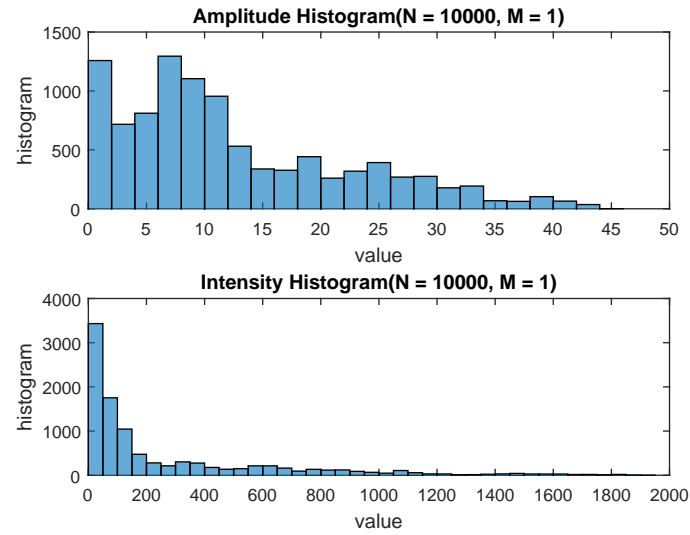


Figure 10: Histogram of amplitude (top) and intensity (bottom) of new array ($N = 10000$, $M = 1$)

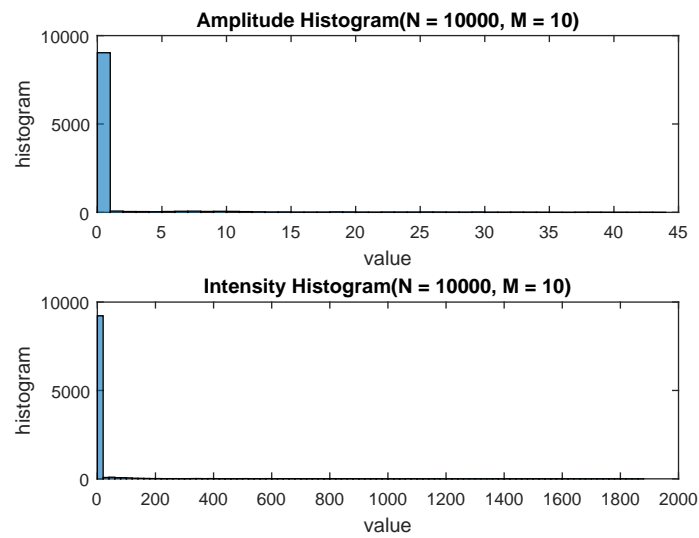
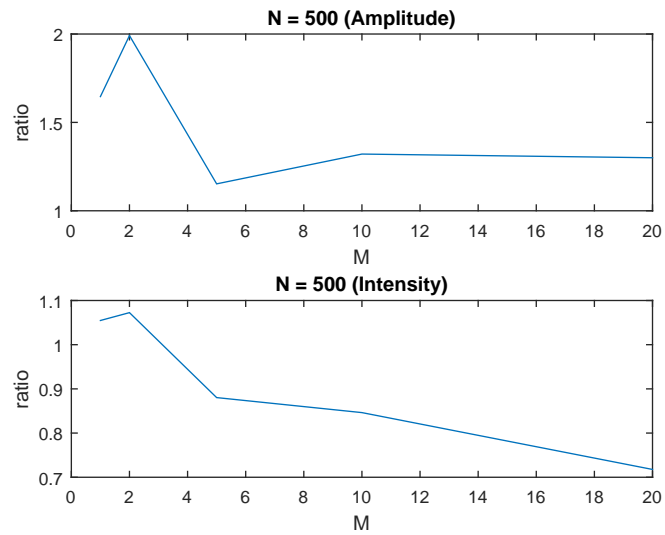
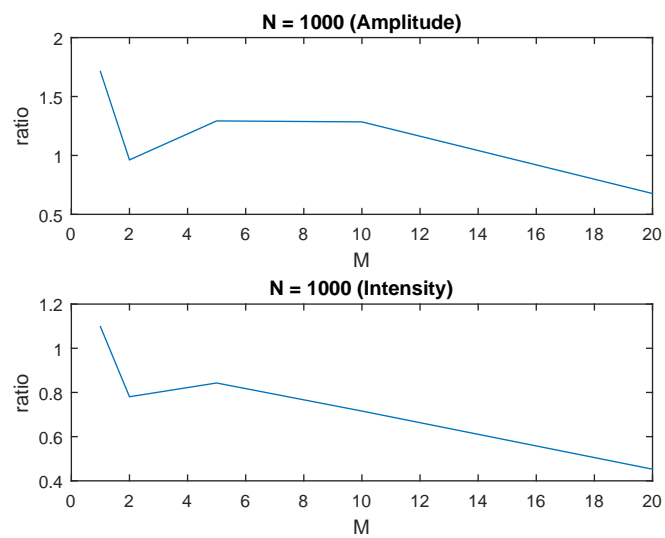
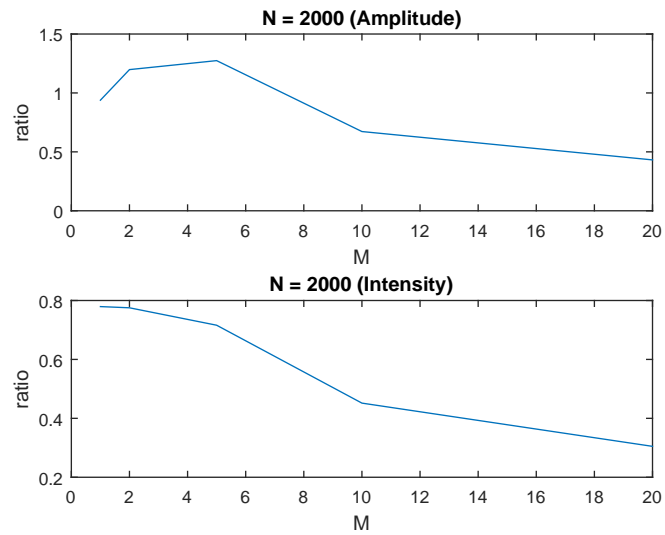
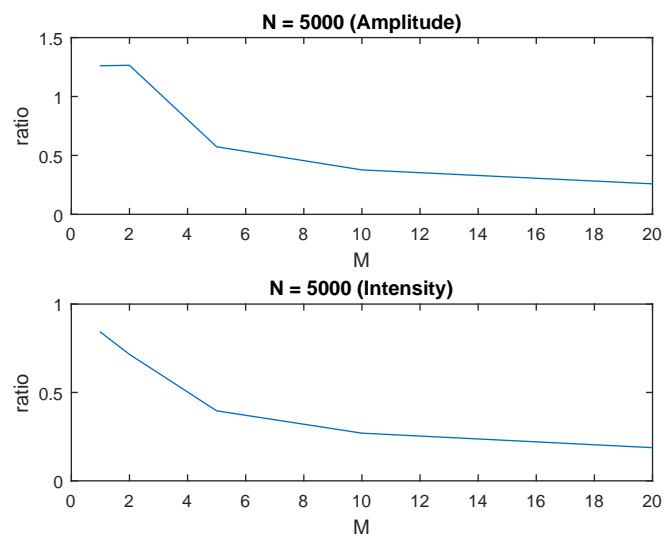
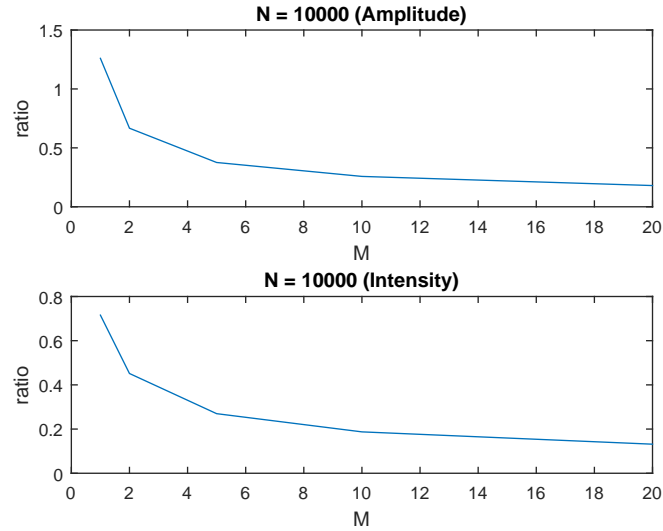


Figure 11: Histogram of amplitude (top) and intensity (bottom) of new array ($N = 10000$, $M = 10$)

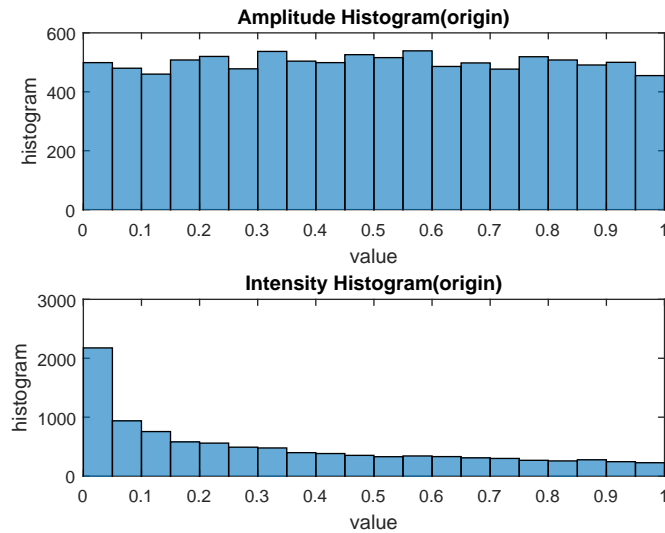
Figure 12: Ratio of mean and standard deviation ($N = 500$)Figure 13: Ratio of mean and standard deviation ($N = 1000$)

Figure 14: Ratio of mean and standard deviation ($N = 2000$)Figure 15: Ratio of mean and standard deviation ($N = 5000$)

Figure 16: Ratio of mean and standard deviation ($N = 10000$)

2.c Repeat (a) and (b) with phase distribution $[0, \pi]$

Now we change the phase distribution of origin array from $[0, 2\pi]$ to $[0, \pi]$. Figure 17 shows the histogram of amplitude and intensity of origin array with phase distribution $[0, \pi]$. Figure [18, 19, 20, 21, 22, 23, 24, 25, 26, 27] show histogram for different N and M . Figure [28, 29, 30, 31, 34] show the ratio.

Figure 17: Histogram of amplitude (top) and intensity (bottom) of origin array (phase = $[0, \pi]$)

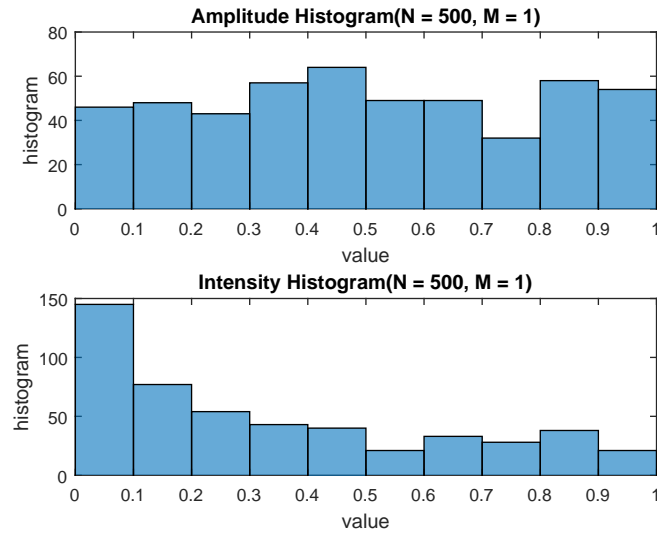


Figure 18: Histogram of amplitude (top) and intensity (bottom) of array ($N = 500$, $M = 1$, $\text{phase}[0, \pi]$)

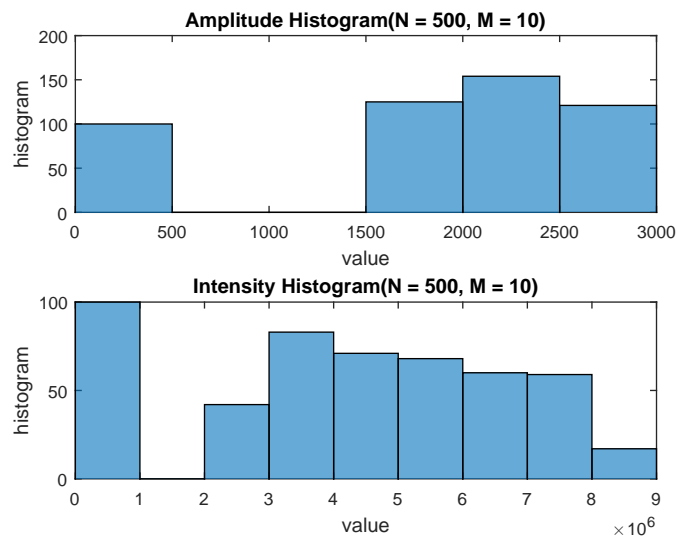


Figure 19: Histogram of amplitude (top) and intensity (bottom) of array ($N = 500$, $M = 10$, $\text{phase}[0, \pi]$)

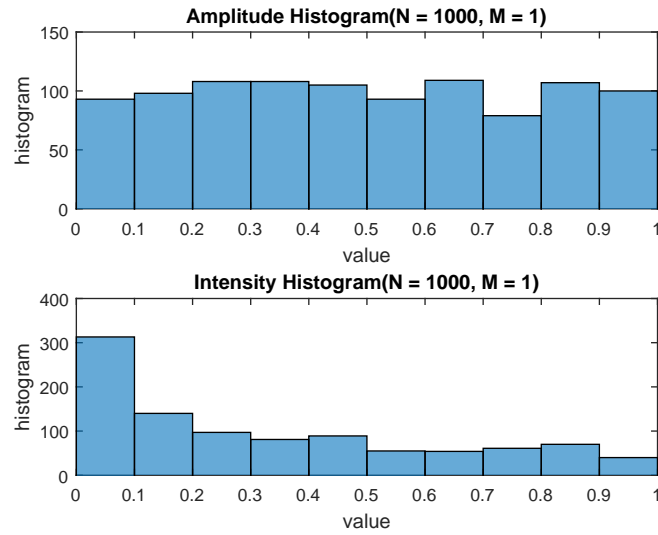


Figure 20: Histogram of amplitude (top) and intensity (bottom) of array ($N = 1000$, $M = 1$, $\text{phase}[0, \pi]$)

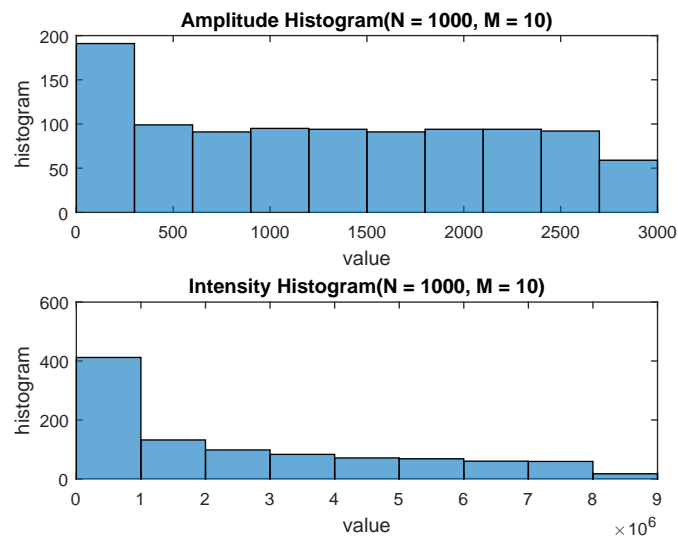


Figure 21: Histogram of amplitude (top) and intensity (bottom) of array ($N = 1000$, $M = 10$, $\text{phase}[0, \pi]$)

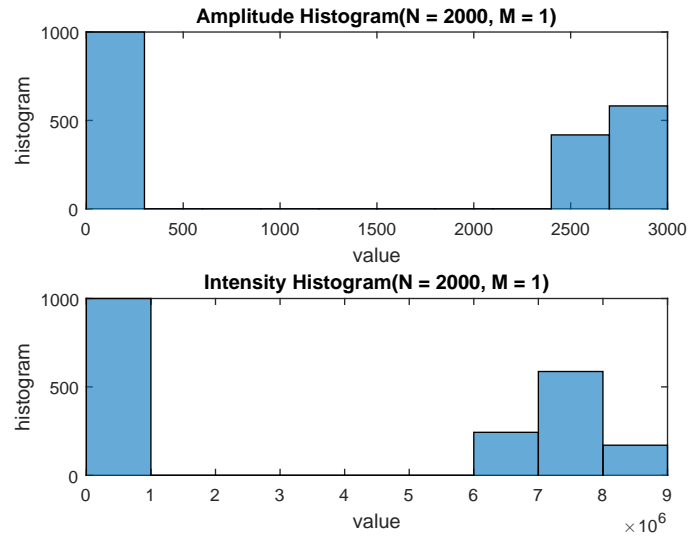


Figure 22: Histogram of amplitude (top) and intensity (bottom) of array ($N = 2000$, $M = 1$, $\text{phase}[0, \pi]$)

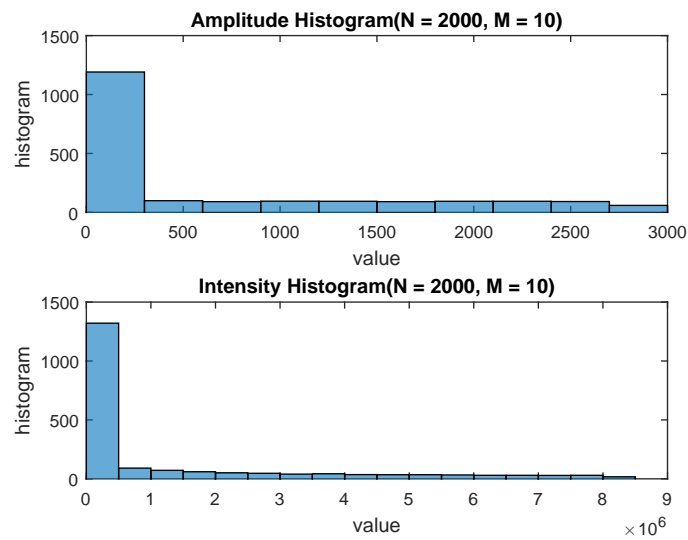


Figure 23: Histogram of amplitude (top) and intensity (bottom) of array ($N = 2000$, $M = 10$, $\text{phase}[0, \pi]$)

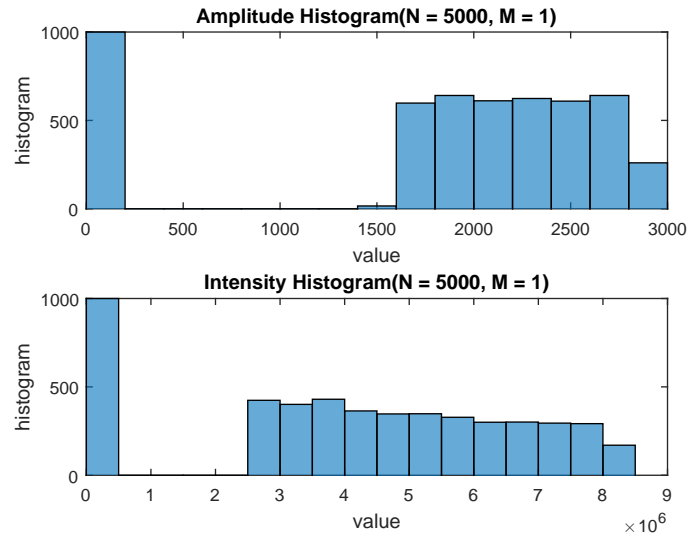


Figure 24: Histogram of amplitude (top) and intensity (bottom) of array ($N = 5000$, $M = 1$, $\text{phase}[0, \pi]$)

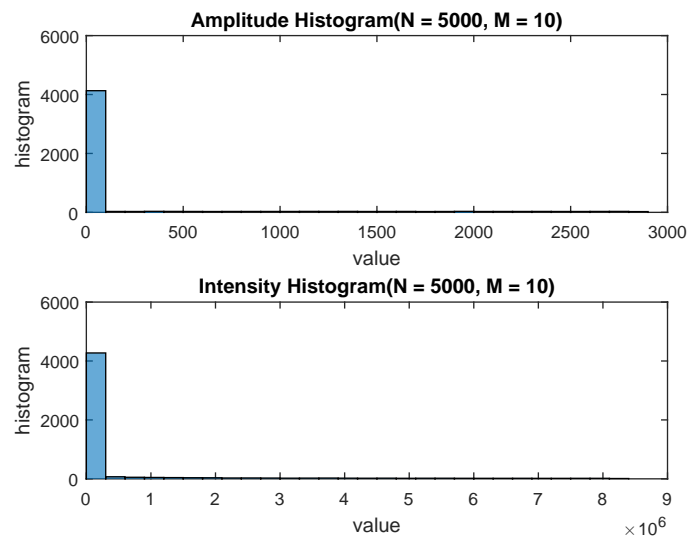


Figure 25: Histogram of amplitude (top) and intensity (bottom) of array ($N = 5000$, $M = 10$, $\text{phase}[0, \pi]$)

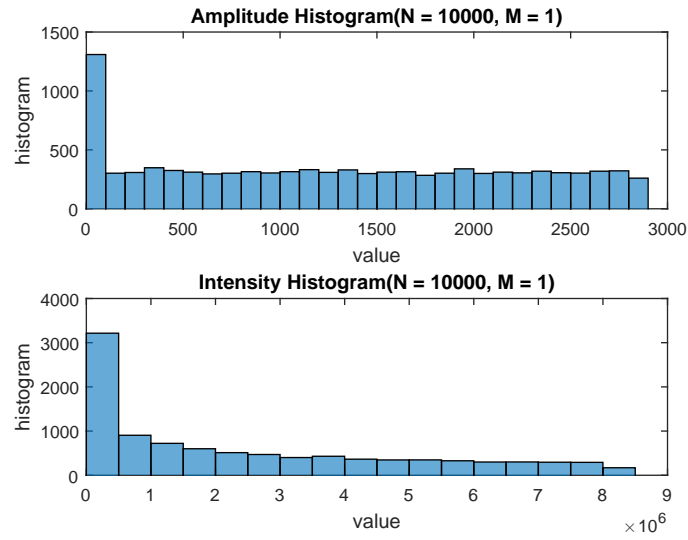


Figure 26: Histogram of amplitude (top) and intensity (bottom) of array ($N = 10000$, $M = 1$, $\text{phase}[0, \pi]$)

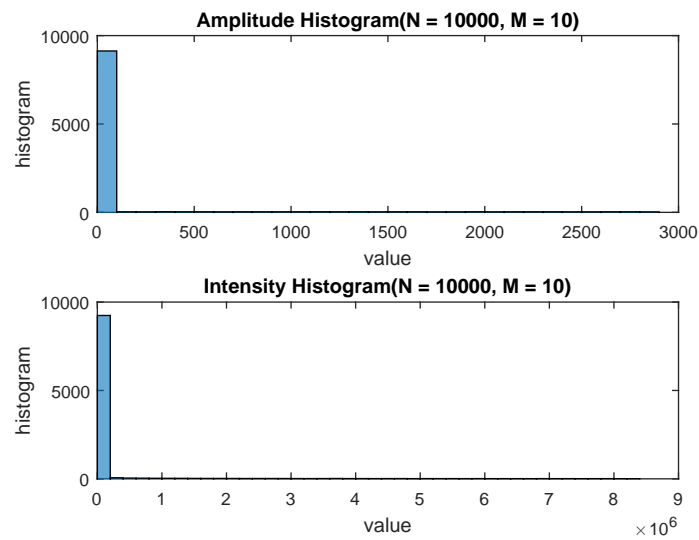
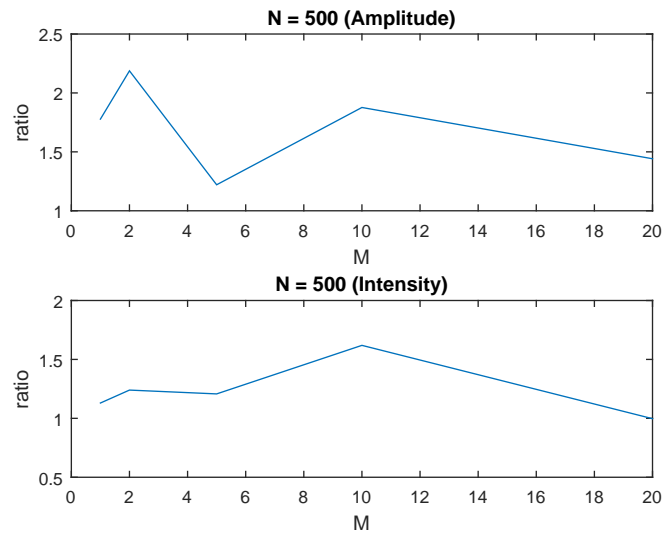
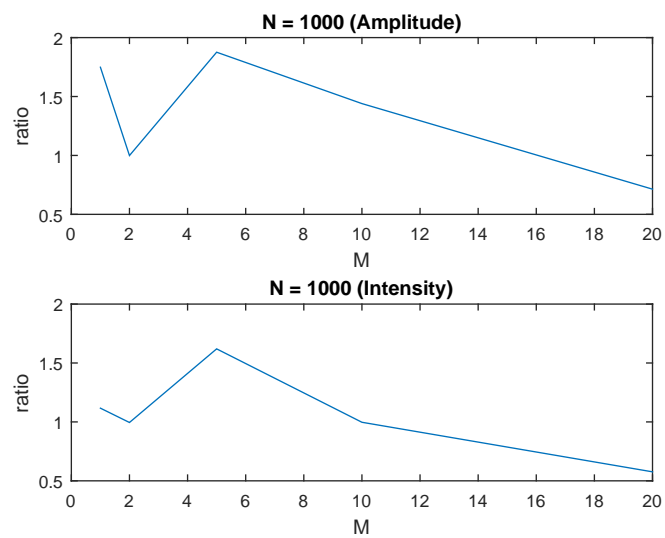
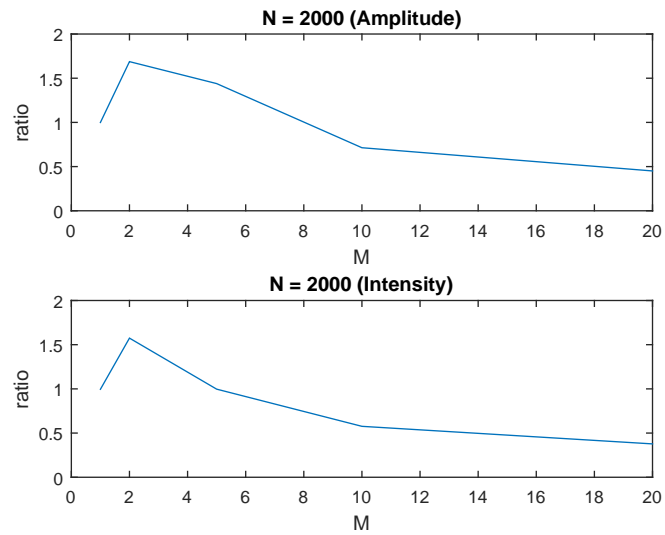
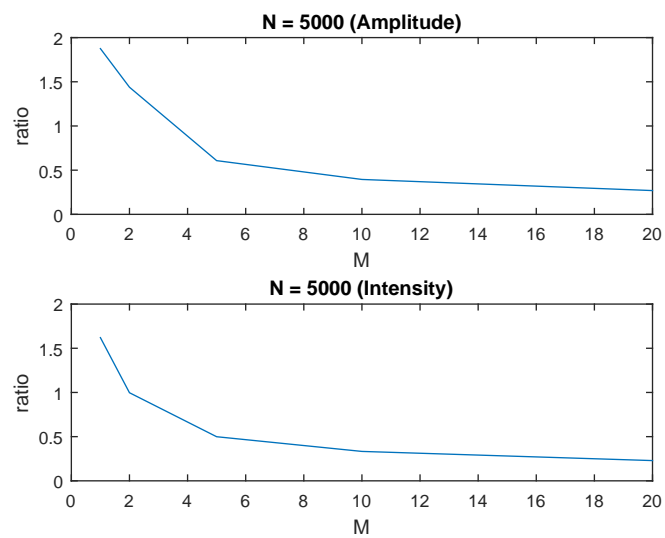


Figure 27: Histogram of amplitude (top) and intensity (bottom) of array ($N = 10000$, $M = 10$, $\text{phase}[0, \pi]$)

Figure 28: Ratio of mean and standard deviation ($N = 500$, phase $[0, \pi]$)Figure 29: Ratio of mean and standard deviation ($N = 1000$, phase $[0, \pi]$)

Figure 30: Ratio of mean and standard deviation ($N = 2000$, $\text{phase}[0, \pi]$)Figure 31: Ratio of mean and standard deviation ($N = 5000$, $\text{phase}[0, \pi]$)

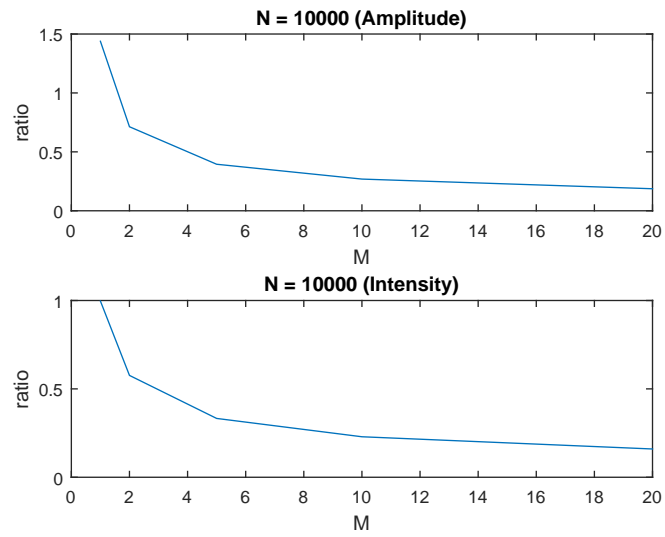
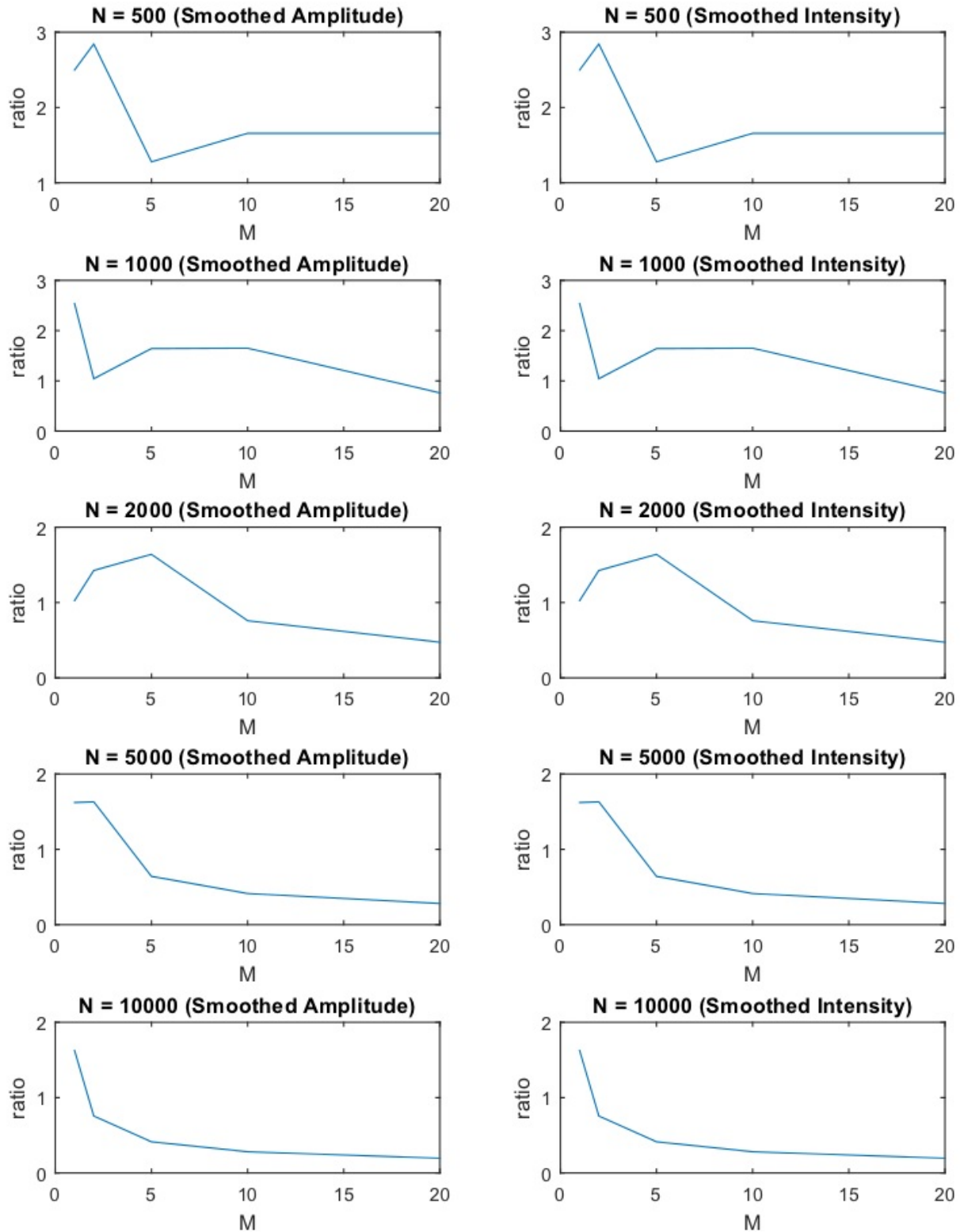
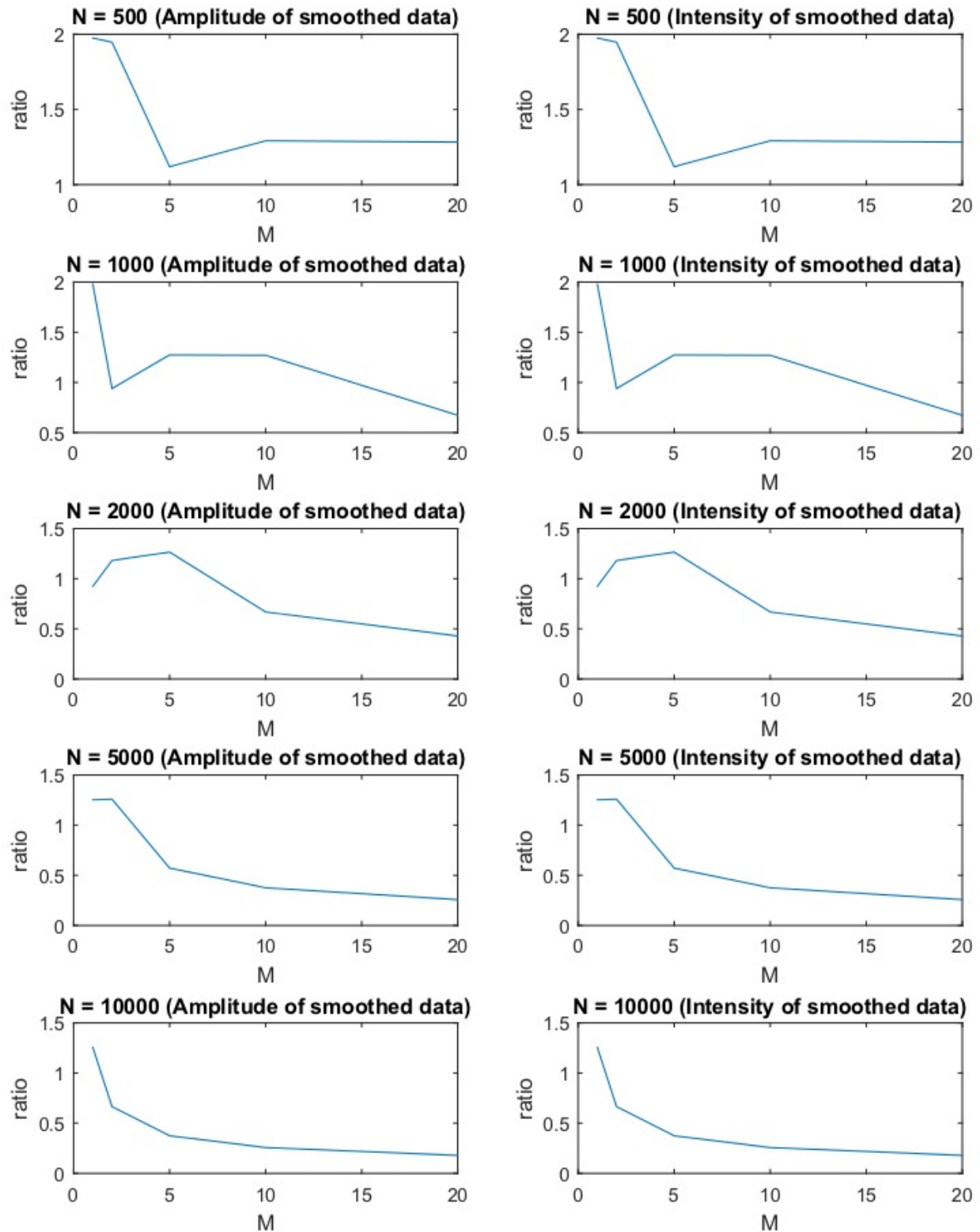


Figure 32: Ratio of mean and standard deviation ($N = 10000$, $\text{phase}[0, \pi]$)

Figure 33: Ratio of mean and standard deviation ($N = 10000$, $\text{phase}[0, \pi]$)

Figure 34: Ratio of mean and standard deviation ($N = 10000$, $\text{phase}[0, \pi]$)