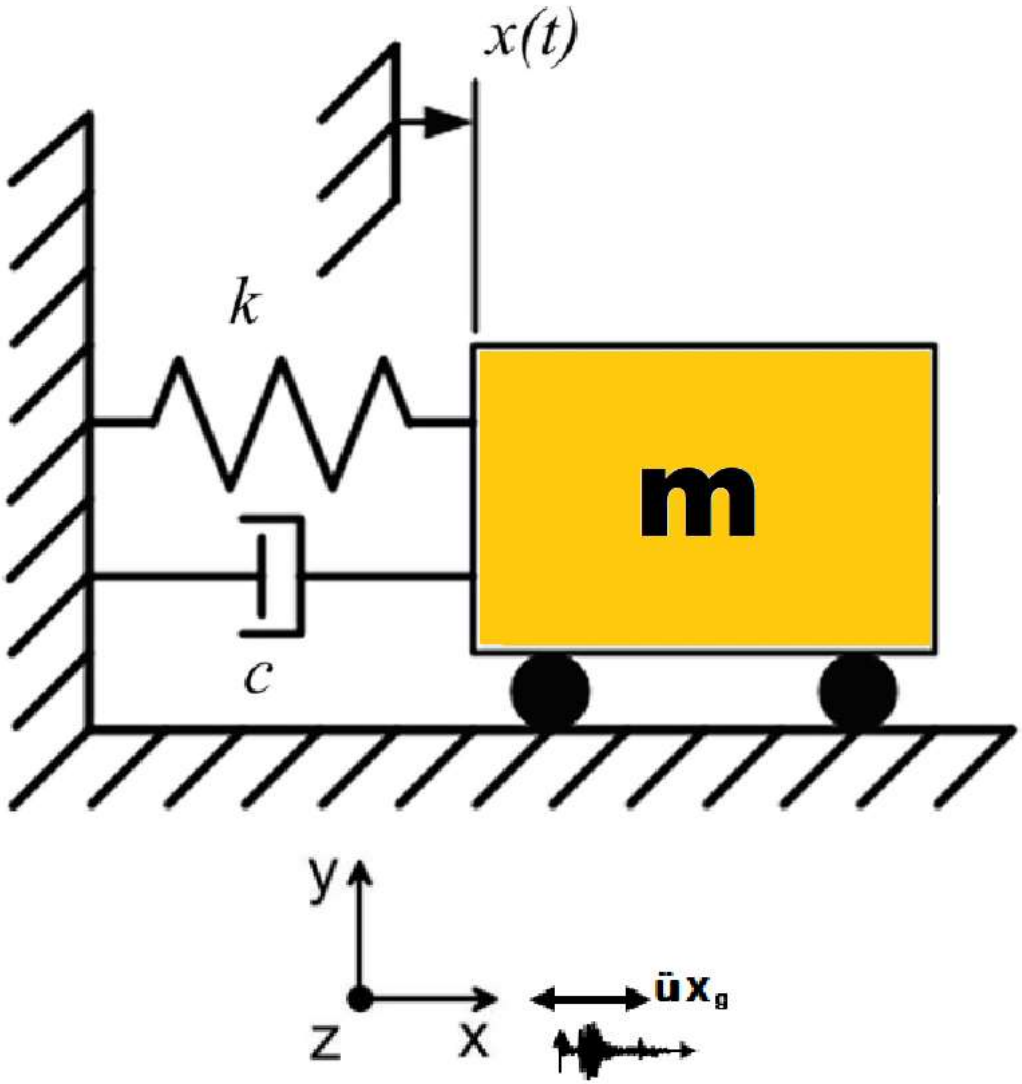
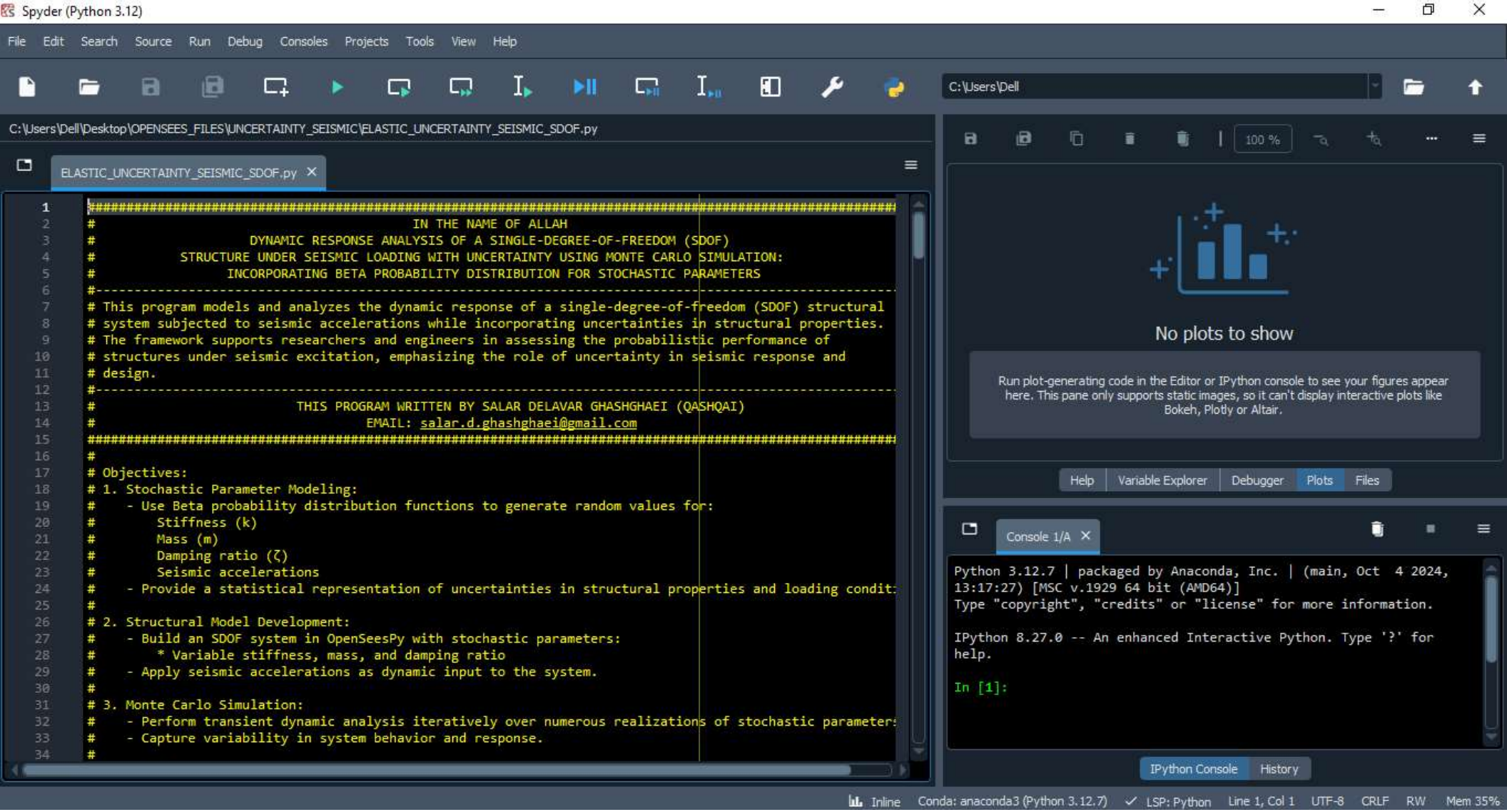
IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL

DYNAMIC RESPONSE ANALYSIS OF A SINGLE-DEGREE-OF-FREEDOM (SDOF) ELASTIC STRUCTURE UNDER SEISMIC LOADING WITH UNCERTAINTY USING MONTE CARLO SIMULATION: INCORPORATING BETA PROBABILITY DISTRIBUTION FOR STOCHASTIC PARAMETERS

WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)


x(t)
k
m
c
y
z
x
ü x g


Spyder (Python 3.12)
File Edit Search Source Run Debug Consoles Projects Tools View Help
C:\Users\Dell
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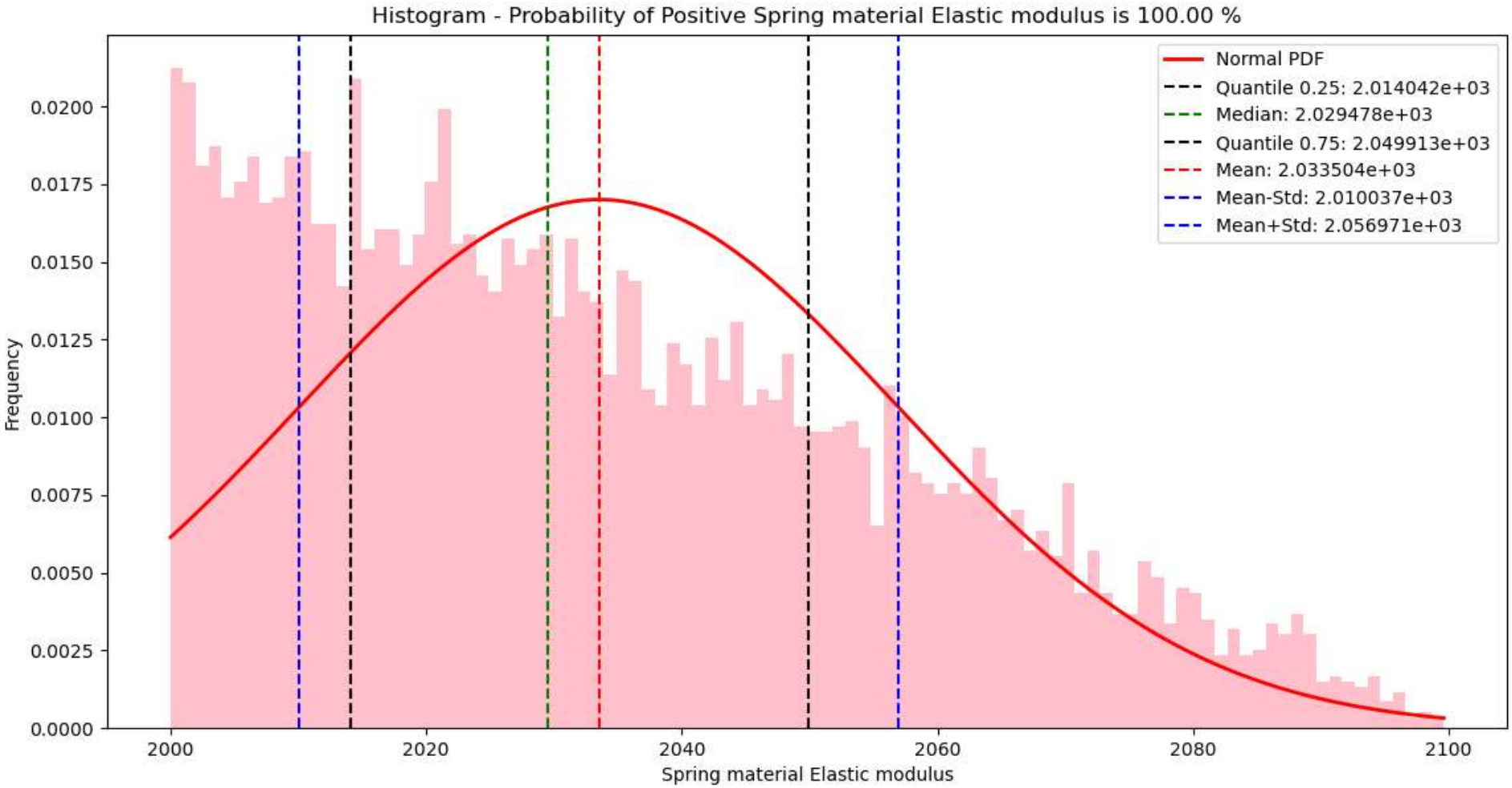
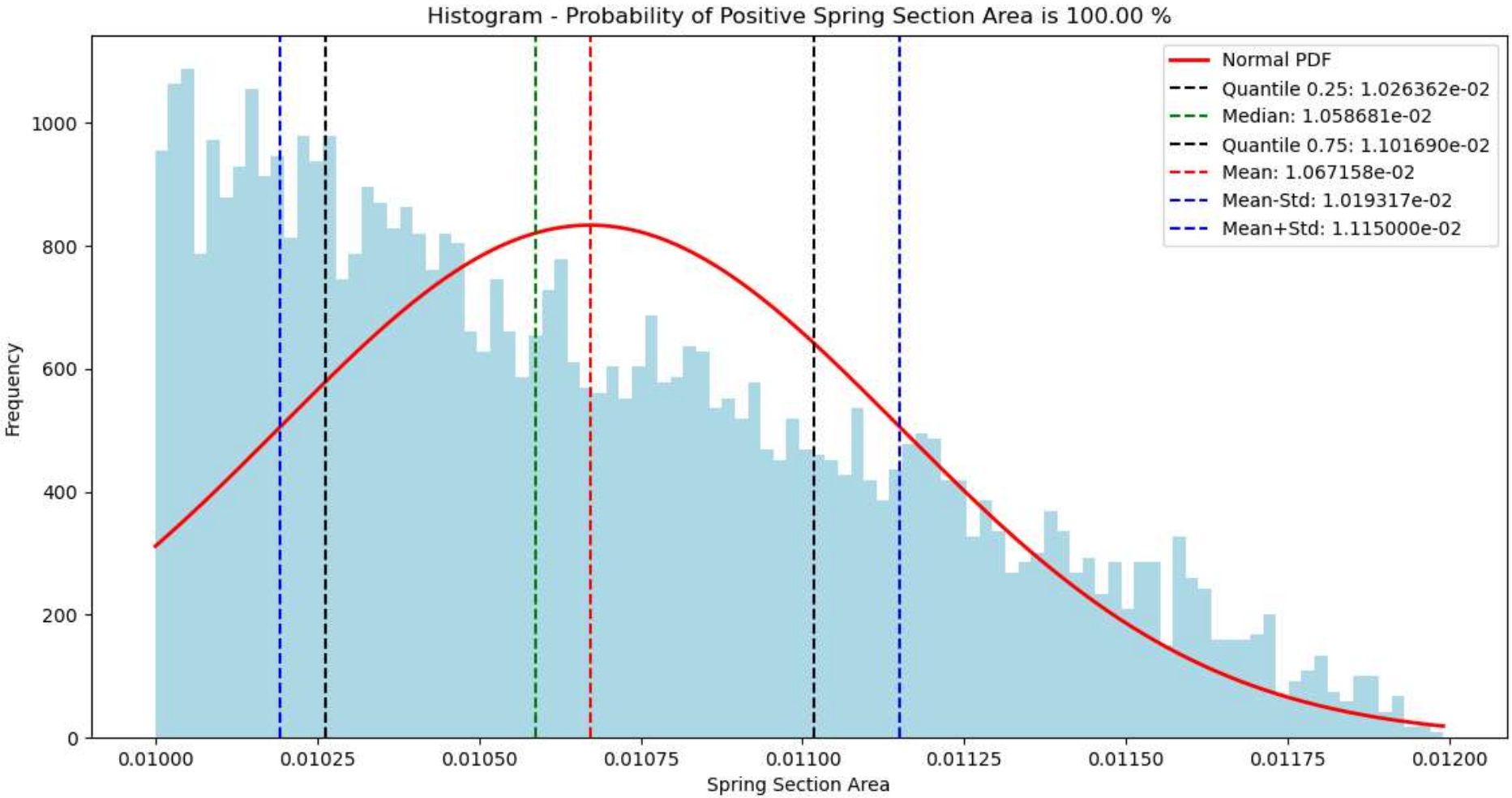
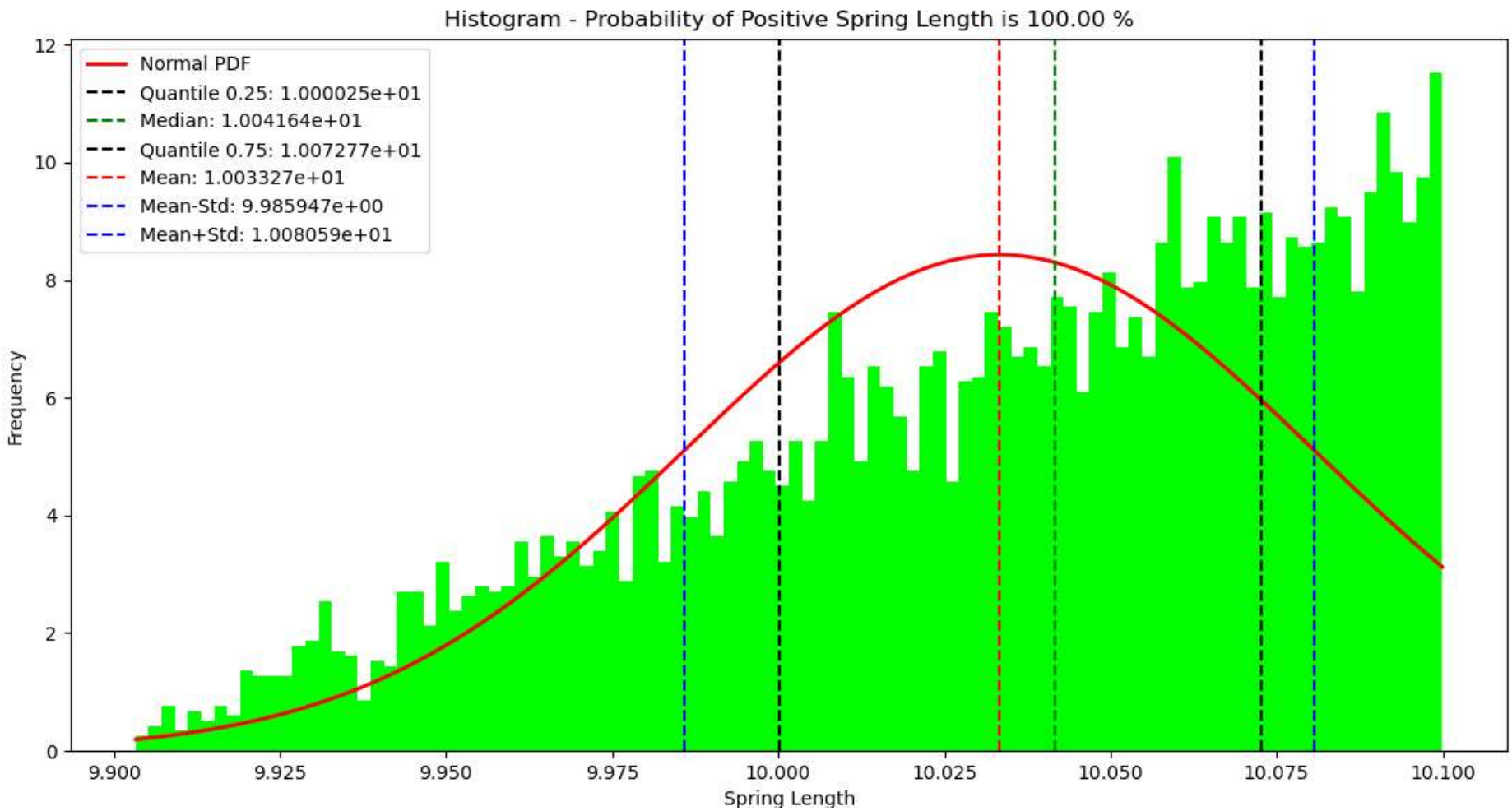
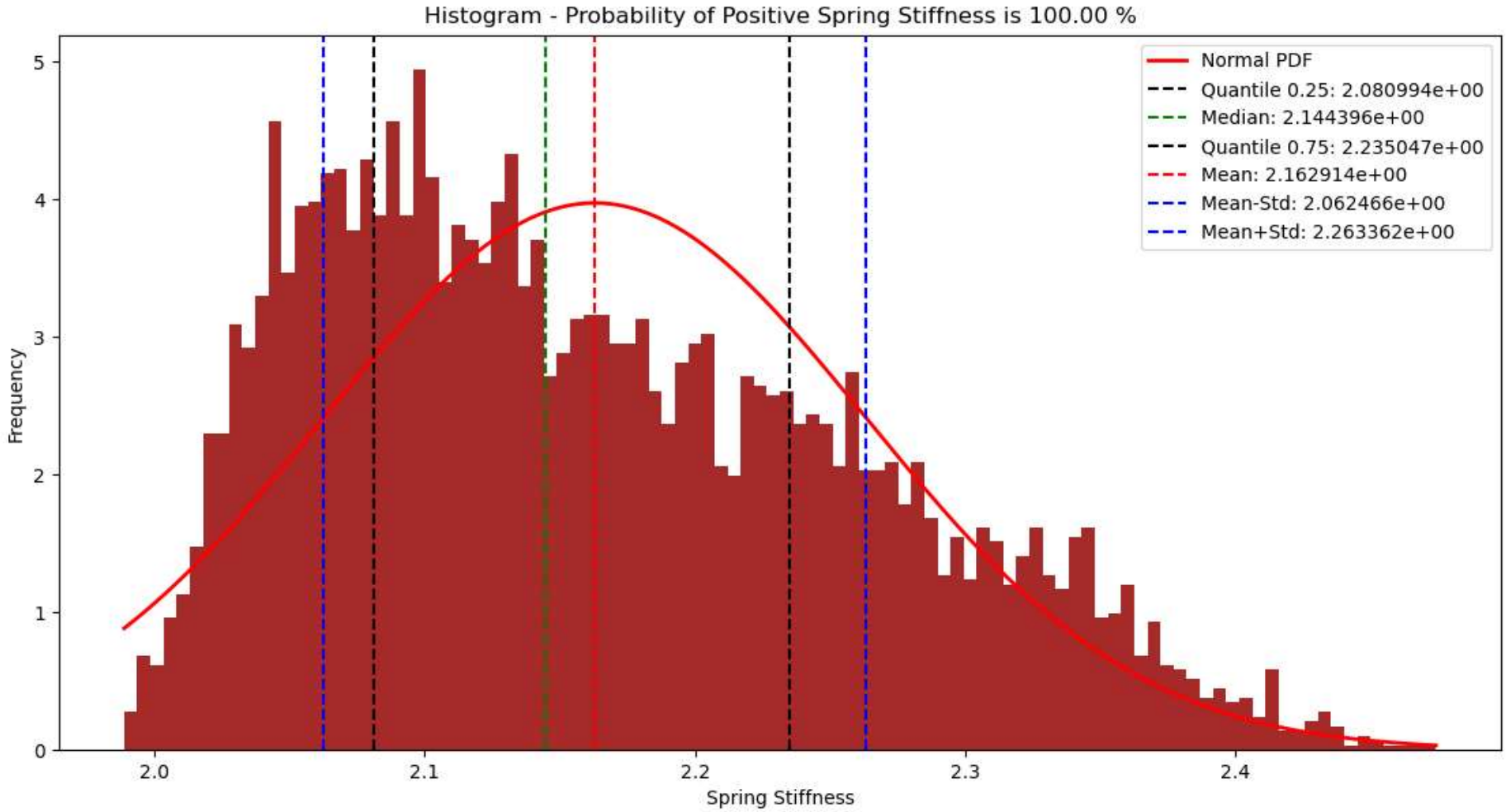
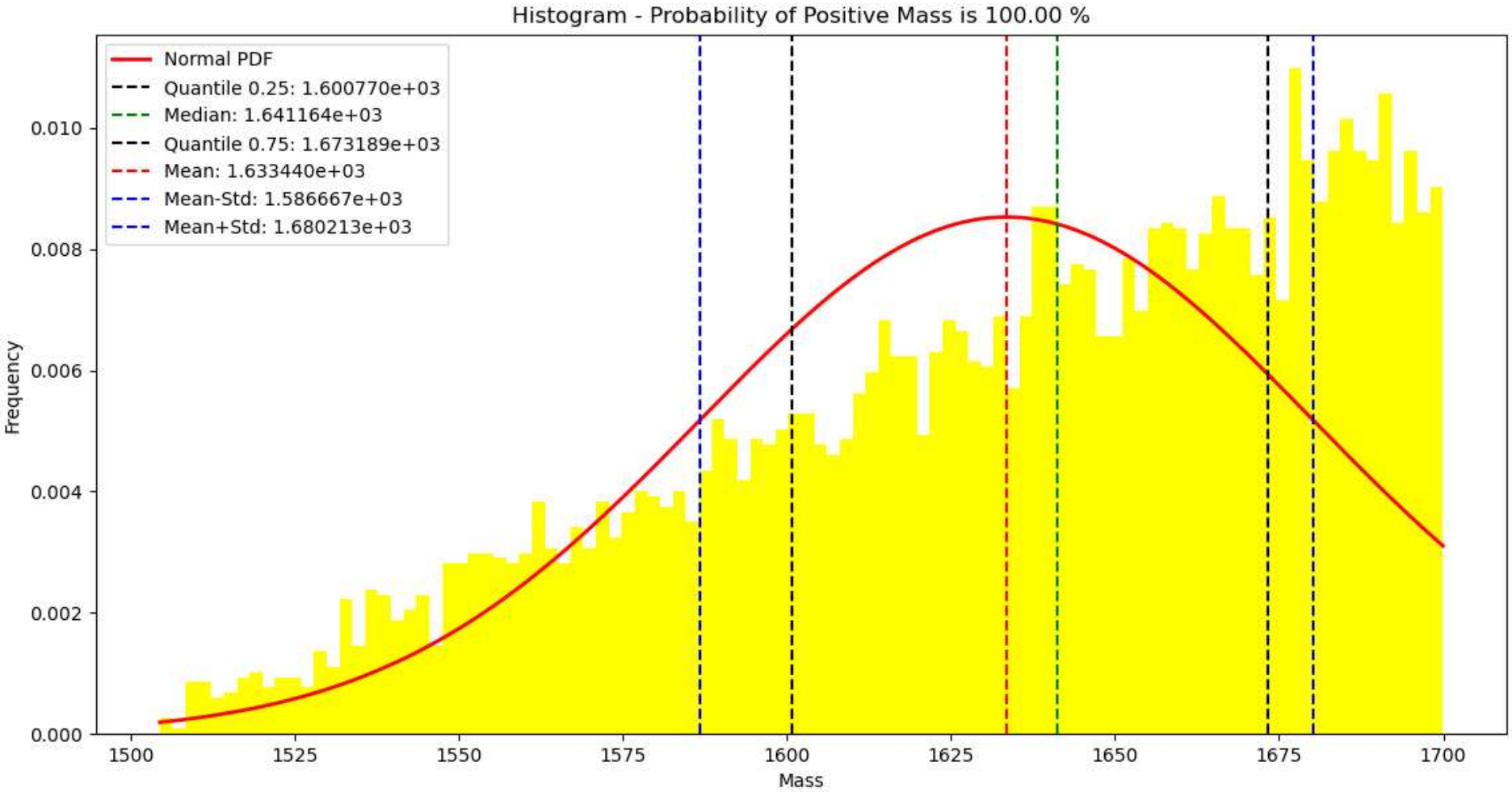
ELASTIC_UNCERTAINTY_SEISMIC_SDOF.py
IN THE NAME OF ALLAH
DYNAMIC RESPONSE ANALYSIS OF A SINGLE-DEGREE-OF-FREEDOM (SDOF)
STRUCTURE UNDER SEISMIC LOADING WITH UNCERTAINTY USING MONTE CARLO SIMULATION:
INCORPORATING BETA PROBABILITY DISTRIBUTION FOR STOCHASTIC PARAMETERS
This program models and analyzes the dynamic response of a single-degree-of-freedom (SDOF) structural
system subjected to seismic accelerations while incorporating uncertainties in structural properties.
The framework supports researchers and engineers in assessing the probabilistic performance of
structures under seismic excitation, emphasizing the role of uncertainty in seismic response and
design.
THIS PROGRAM WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)
EMAIL: salar.d.ghashghaei@gmail.com
Objectives:
1. Stochastic Parameter Modeling:
- Use Beta probability distribution functions to generate random values for:
Stiffness (k)
Mass (m)
Damping ratio (ζ)
Seismic accelerations
- Provide a statistical representation of uncertainties in structural properties and loading condit
2. Structural Model Development:
- Build an SDOF system in OpenSeesPy with stochastic parameters:
* Variable stiffness, mass, and damping ratio
- Apply seismic accelerations as dynamic input to the system.
3. Monte Carlo Simulation:
- Perform transient dynamic analysis iteratively over numerous realizations of stochastic parameter
- Capture variability in system behavior and response.
100 %
No plots to show
Run plot-generating code in the Editor or IPython console to see your figures appear here. This pane only supports static images, so it can't display interactive plots like Bokeh, Plotly or Altair.
Help Variable Explorer Debugger Plots Files
Console 1/A
Python 3.12.7 | packaged by Anaconda, Inc. | (main, Oct 4 2024, 13:17:27) [MSC v.1929 64 bit (AMD64)]
Type "copyright", "credits" or "license" for more information.
IPython 8.27.0 -- An enhanced Interactive Python. Type '?' for help.
In [1]:
IPython Console History
Inline Conda: anaconda3 (Python 3.12.7) LSP: Python Line 1, Col 1 UTF-8 CRLF RW Mem 35%

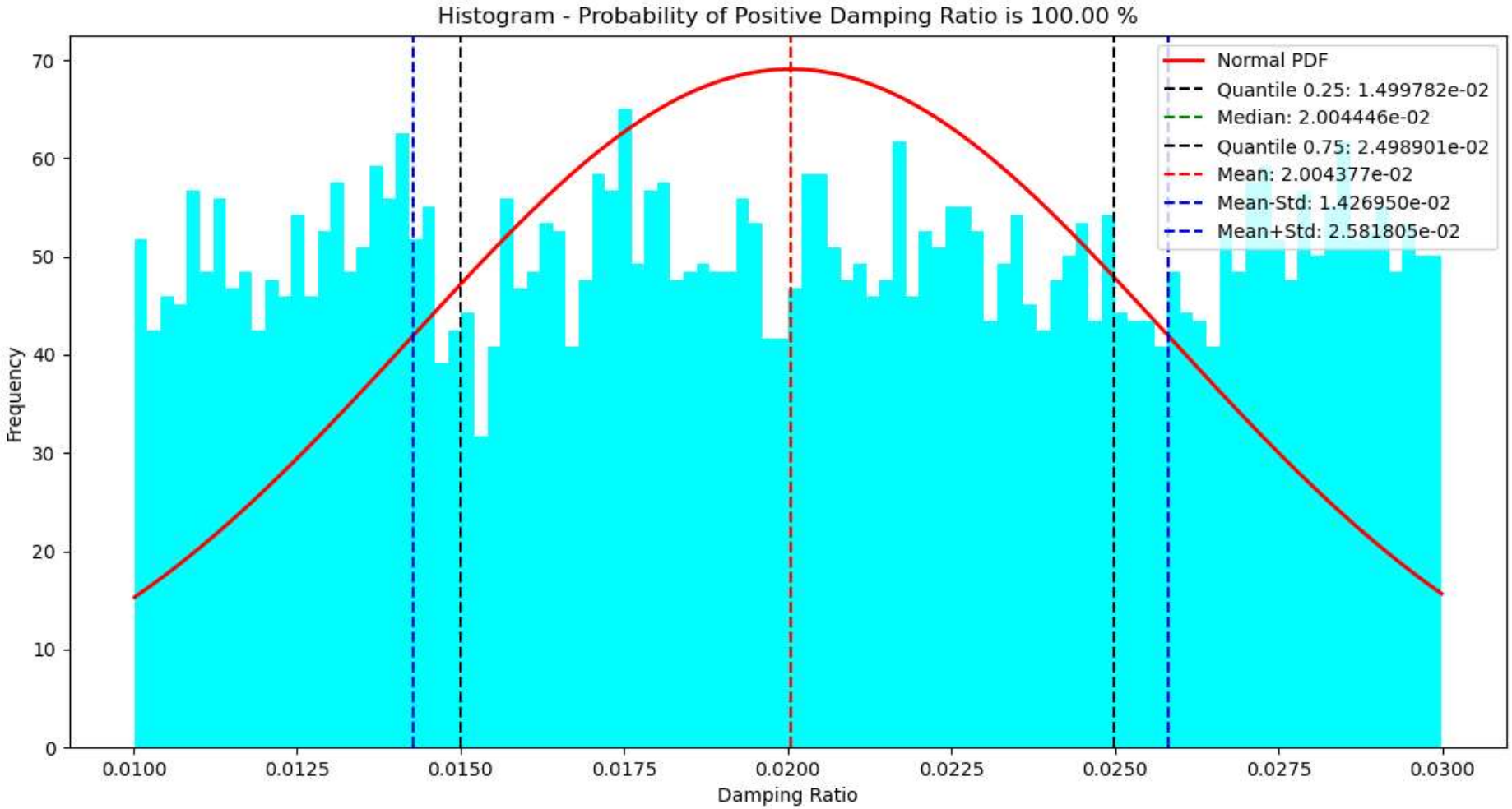

Histogram - Probability of Positive Spring material Elastic modulus is 100.00 %
Normal PDF
Quantile 0.25: 2.014042e+03
Median: 2.029478e+03
Quantile 0.75: 2.049913e+03
Mean: 2.033504e+03
Mean-Std: 2.010037e+03
Mean+Std: 2.056971e+03
Frequency
0.0200
0.0175
0.0150
0.0125
0.0100
0.0075
0.0050
0.0025
0.0000
2000
2020
2040
2060
2080
2100
Spring material Elastic modulus

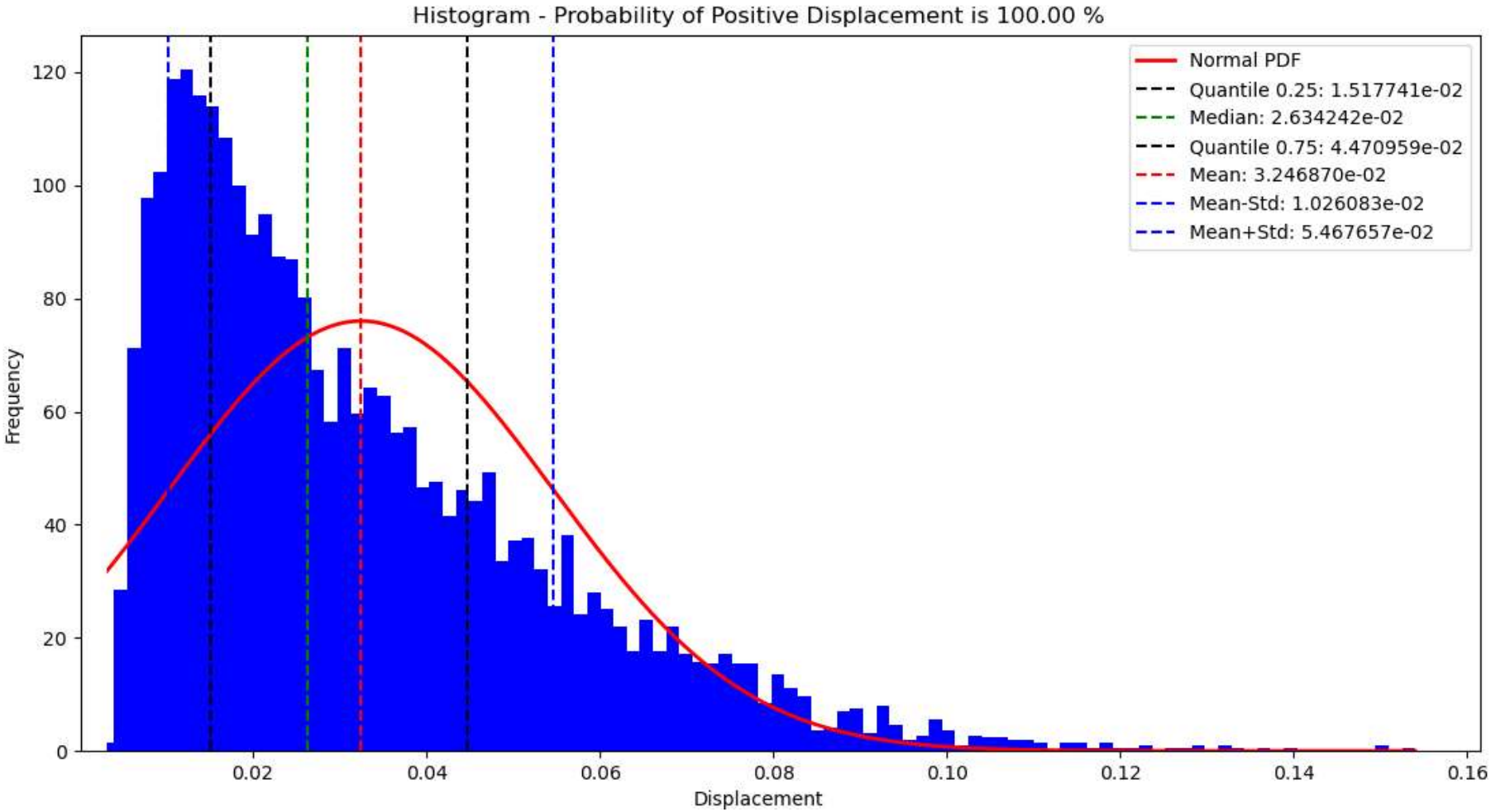

Histogram - Probability of Positive Spring Section Area is 100.00 %
Normal PDF
Quantile 0.25: 1.026362e-02
Median: 1.058681e-02
Quantile 0.75: 1.101690e-02
Mean: 1.067158e-02
Mean-Std: 1.019317e-02
Mean+Std: 1.115000e-02
Frequency
0
200
400
600
800
1000
0.01000
0.01025
0.01050
0.01075
0.01100
0.01125
0.01150
0.01175
0.01200
Spring Section Area

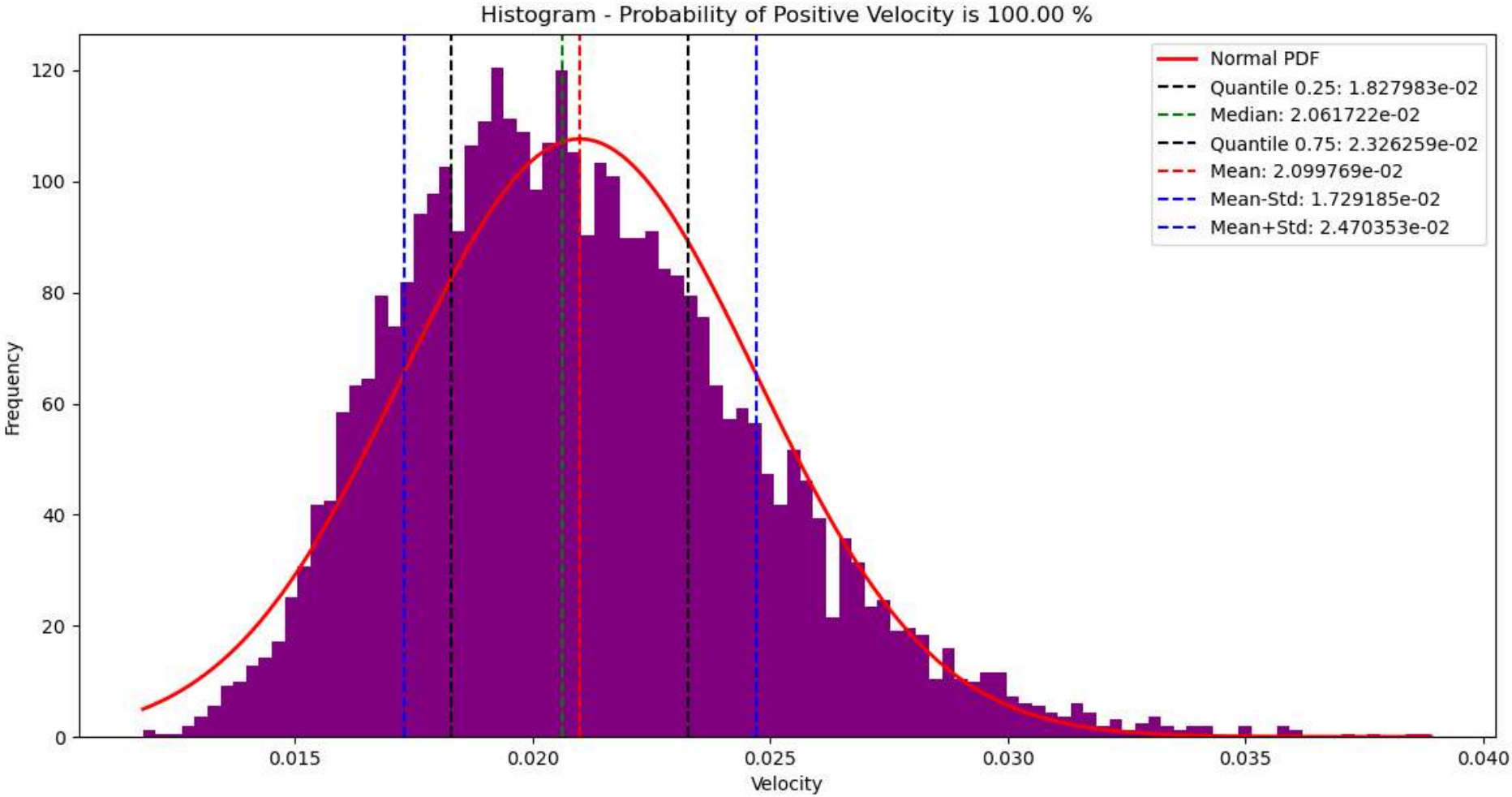

Histogram - Probability of Positive Spring Length is 100.00 %
Normal PDF
Quantile 0.25: 1.000025e+01
Median: 1.004164e+01
Quantile 0.75: 1.007277e+01
Mean: 1.003327e+01
Mean-Std: 9.985947e+00
Mean+Std: 1.008059e+01
Frequency
Spring Length
0
2
4
6
8
10
12
9.900
9.925
9.950
9.975
10.000
10.025
10.050
10.075
10.100

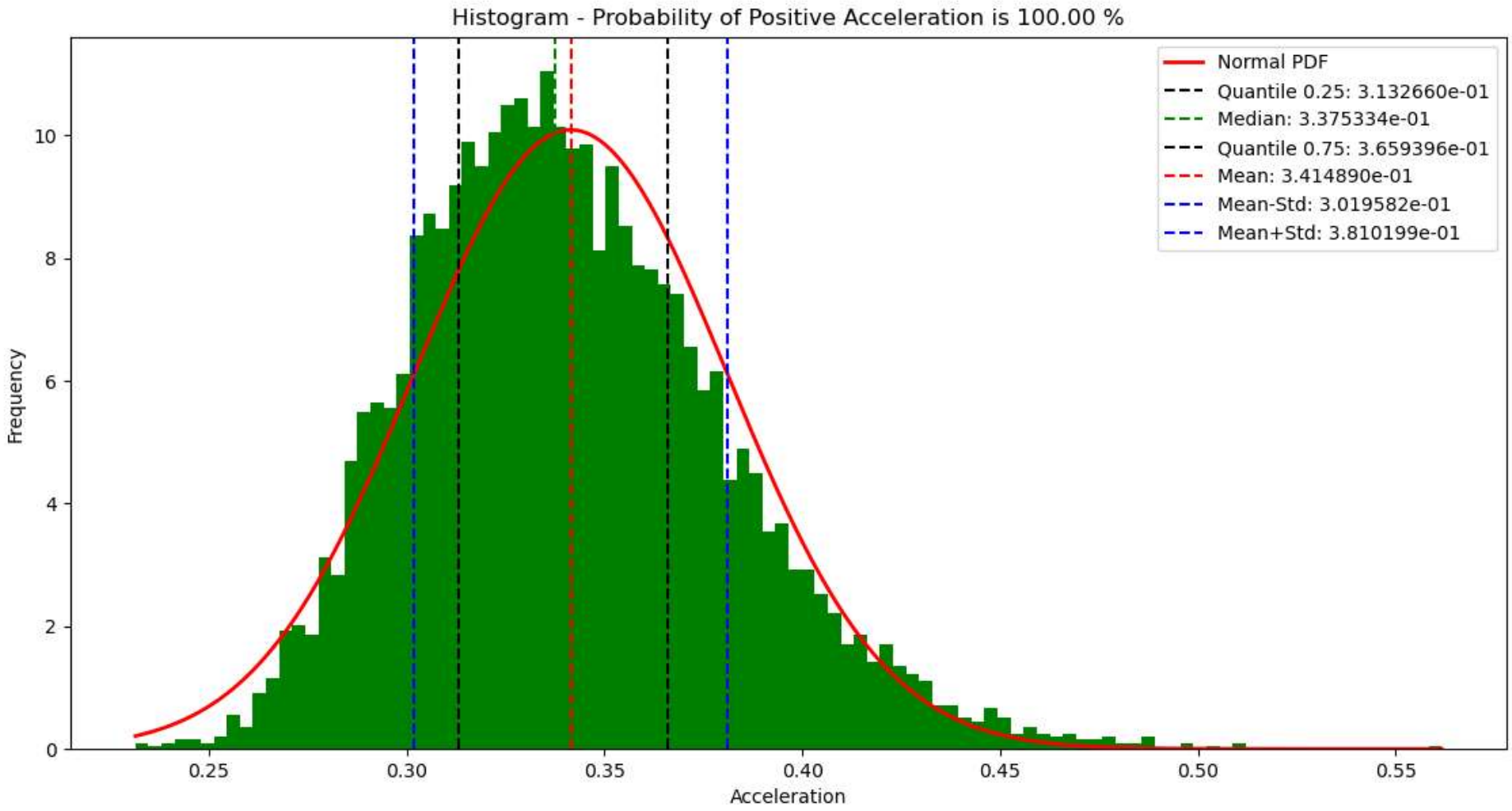

Histogram - Probability of Positive Spring Stiffness is 100.00 %
Normal PDF
Quantile 0.25: 2.080994e+00
Median: 2.144396e+00
Quantile 0.75: 2.235047e+00
Mean: 2.162914e+00
Mean-Std: 2.062466e+00
Mean+Std: 2.263362e+00
Frequency
Spring Stiffness
0
1
2
3
4
5
2.0
2.1
2.2
2.3
2.4

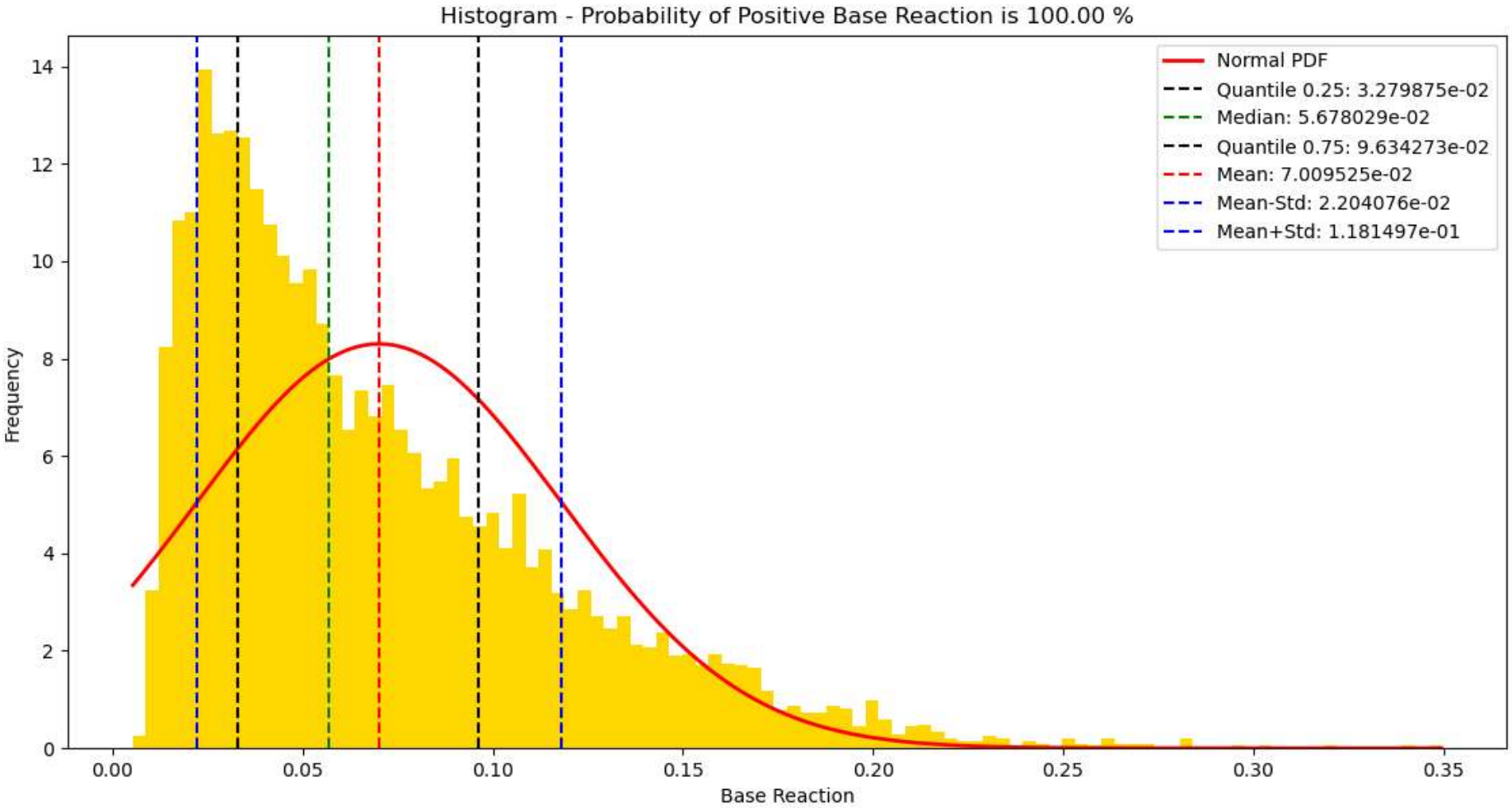

Histogram - Probability of Positive Mass is 100.00 %
Normal PDF
Quantile 0.25: 1.600770e+03
Median: 1.641164e+03
Quantile 0.75: 1.673189e+03
Mean: 1.633440e+03
Mean-Std: 1.586667e+03
Mean+Std: 1.680213e+03
Frequency
0.000
0.002
0.004
0.006
0.008
0.010
1500
1525
1550
1575
1600
1625
1650
1675
1700
Mass

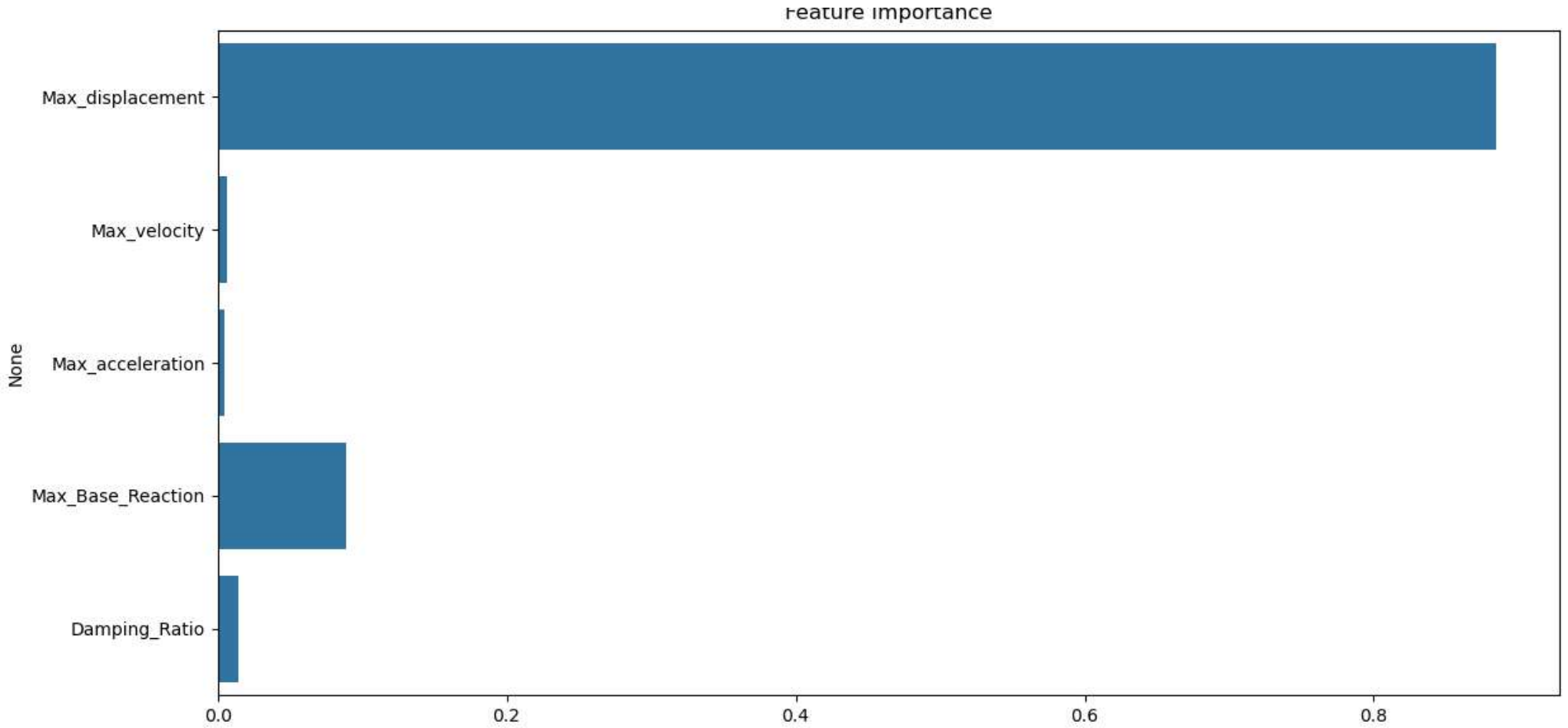

Histogram - Probability of Positive Damping Ratio is 100.00 %
Normal PDF
Quantile 0.25: 1.499782e-02
Median: 2.004446e-02
Quantile 0.75: 2.498901e-02
Mean: 2.004377e-02
Mean-Std: 1.426950e-02
Mean+Std: 2.581805e-02
Frequency
Damping Ratio
0
10
20
30
40
50
60
70
0.0100
0.0125
0.0150
0.0175
0.0200
0.0225
0.0250
0.0275
0.0300

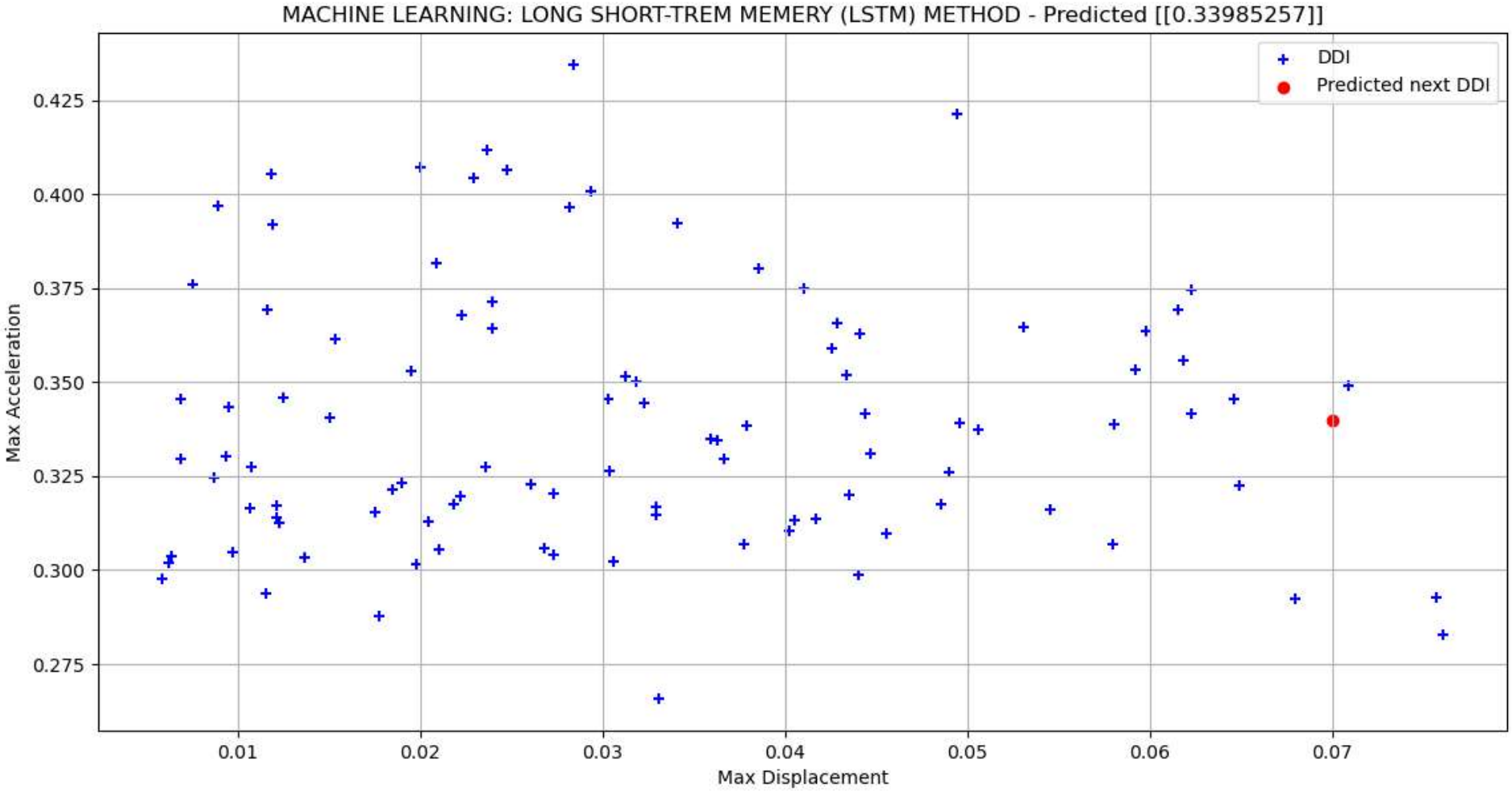

Histogram - Probability of Positive Displacement is 100.00 %
Normal PDF
Quantile 0.25: 1.517741e-02
Median: 2.634242e-02
Quantile 0.75: 4.470959e-02
Mean: 3.246870e-02
Mean-Std: 1.026083e-02
Mean+Std: 5.467657e-02
Frequency
Displacement
0
20
40
60
80
100
120
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16


Histogram - Probability of Positive Velocity is 100.00 %
Normal PDF
Quantile 0.25: 1.827983e-02
Median: 2.061722e-02
Quantile 0.75: 2.326259e-02
Mean: 2.099769e-02
Mean-Std: 1.729185e-02
Mean+Std: 2.470353e-02
Frequency
Velocity
0
20
40
60
80
100
120
0.015
0.020
0.025
0.030
0.035
0.040


Histogram - Probability of Positive Acceleration is 100.00 %
Normal PDF
Quantile 0.25: 3.132660e-01
Median: 3.375334e-01
Quantile 0.75: 3.659396e-01
Mean: 3.414890e-01
Mean-Std: 3.019582e-01
Mean+Std: 3.810199e-01
Frequency
Acceleration
0
2
4
6
8
10
0.25
0.30
0.35
0.40
0.45
0.50
0.55


Histogram - Probability of Positive Base Reaction is 100.00 %
Normal PDF
Quantile 0.25: 3.279875e-02
Median: 5.678029e-02
Quantile 0.75: 9.634273e-02
Mean: 7.009525e-02
Mean-Std: 2.204076e-02
Mean+Std: 1.181497e-01
Frequency
Base Reaction
0
2
4
6
8
10
12
14
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35


Feature Importance
Max_displacement
Max_velocity
Max_acceleration
Max_Base_Reaction
Damping_Ratio
None
0.0
0.2
0.4
0.6
0.8

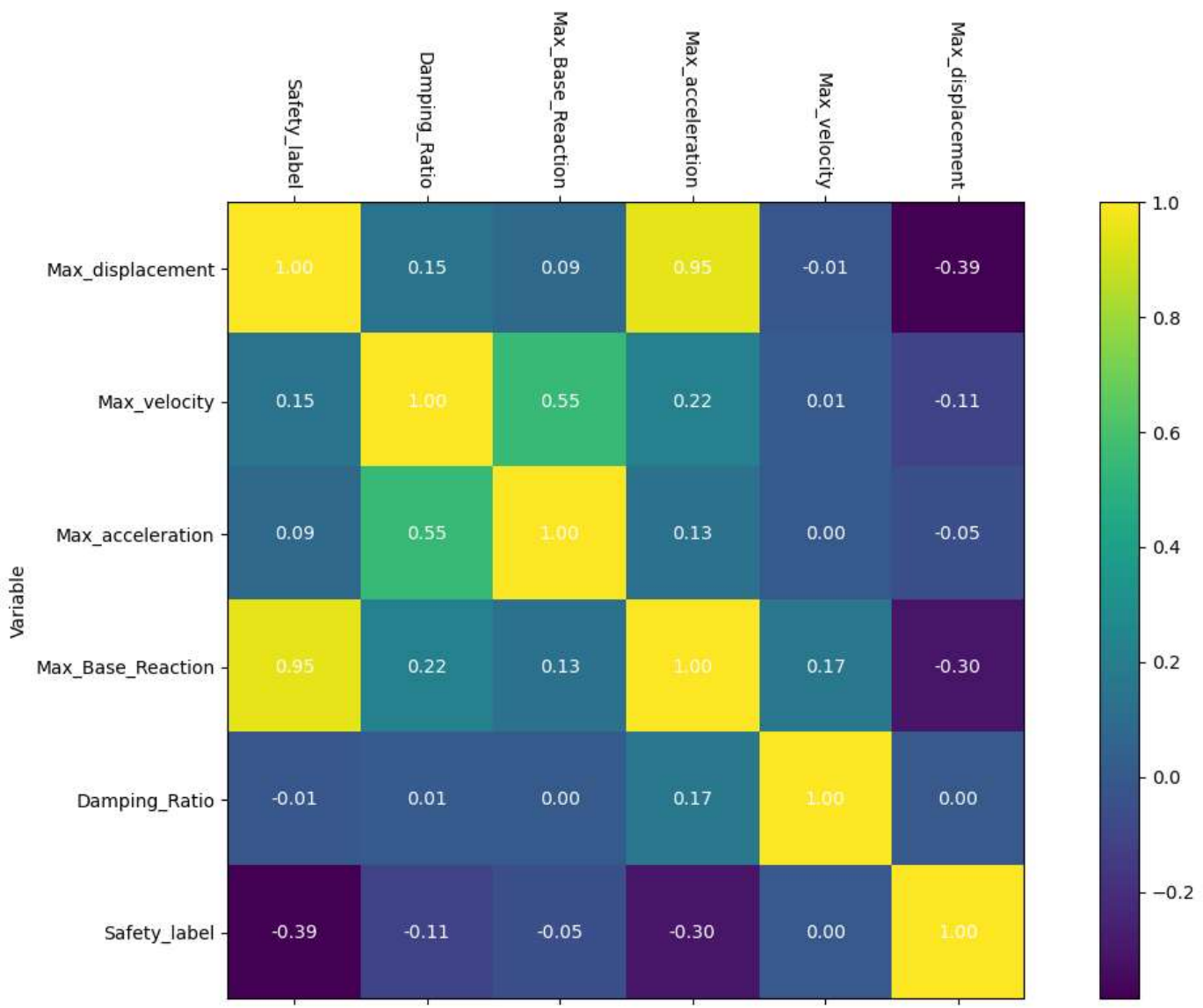

MACHINE LEARNING: LONG SHORT-TREM MEMERY (LSTM) METHOD - Predicted [[0.33985257]]
DDI
Predicted next DDI
Max Acceleration
Max Displacement
0.425
0.400
0.375
0.350
0.325
0.300
0.275
0.01
0.02
0.03
0.04
0.05
0.06
0.07

OLS Regression Results

Dep. Variable:	Max_displacement	R-squared:	0.939
Model:	OLS	Adj. R-squared:	0.939
Method:	Least Squares	F-statistic:	2.316e+04
Date:	Mon, 27 Jan 2025	Prob (F-statistic):	0.00
Time:	19:12:59	Log-Likelihood:	22732.
No. Observations:	6000	AIC:	-4.545e+04
Df Residuals:	5995	BIC:	-4.542e+04
Df Model:	4		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	0.0129	0.001	19.442	0.000	0.012	0.014
Max_velocity	-0.4383	0.023	-18.809	0.000	-0.484	-0.393
Max_acceleration	0.0004	0.002	0.193	0.847	-0.004	0.005
Max_Base_Reaction	0.4451	0.001	300.811	0.000	0.442	0.448
Damping_Ratio	-0.7020	0.012	-56.525	0.000	-0.726	-0.678

Omnibus:	120.702	Durbin-Watson:	1.989
Prob(Omnibus):	0.000	Jarque-Bera (JB):	127.808
Skew:	-0.357	Prob(JB):	1.77e-28
Kurtosis:	2.991	Cond. No.	350.


Safety_label
Damping_Ratio
Max_Base_Reaction
Max_acceleration
Max_velocity
Max_displacement
Variable
Max_displacement
Max_velocity
Max_acceleration
Max_Base_Reaction
Damping_Ratio
Safety_label
1.00 0.15 0.09 0.95 -0.01 -0.39
0.15 1.00 0.55 0.22 0.01 -0.11
0.09 0.55 1.00 0.13 0.00 -0.05
0.95 0.22 0.13 1.00 0.17 -0.30
-0.01 0.01 0.00 0.17 1.00 0.00
-0.39 -0.11 -0.05 -0.30 0.00 1.00
1.0
0.8
0.6
0.4
0.2
0.0
−0.2