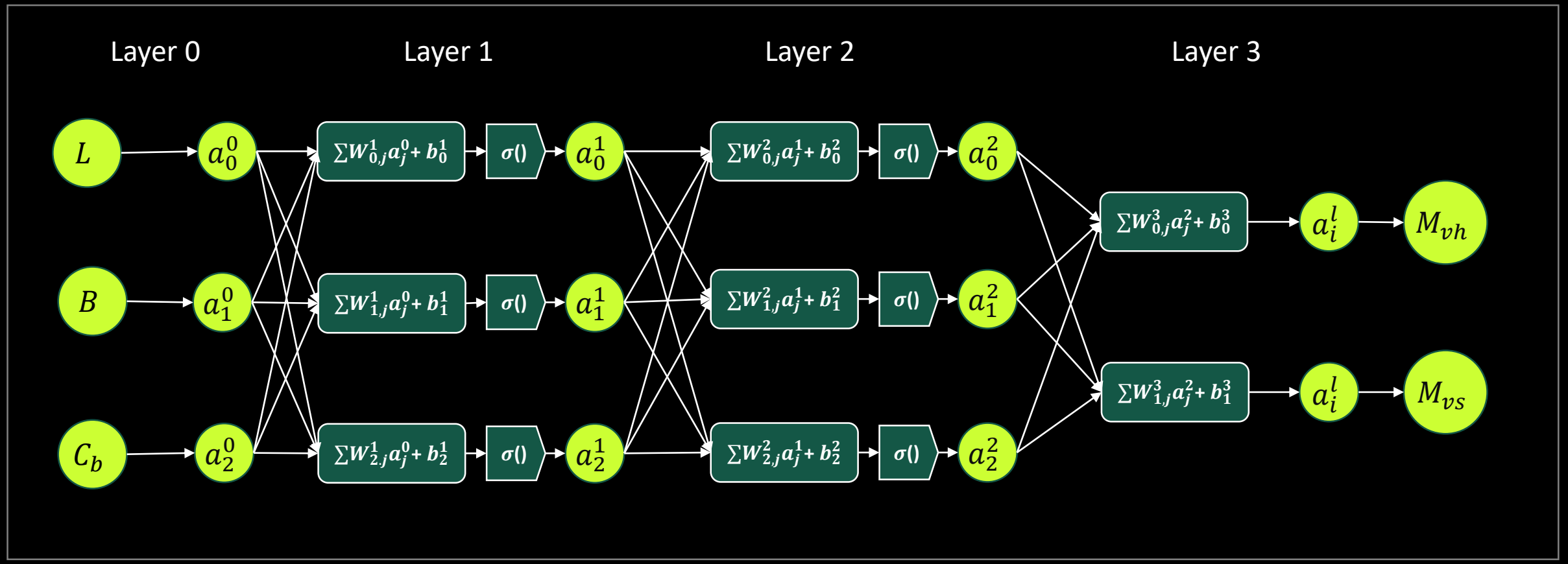
A Neural Net Model built from Scratch

Human-Typed · No GPT · First principles · Only Numpy

- Scripting Language : Python
- Libraries used : Numpy, (Pandas, Matplotlib for reading and plotting data)
- Network Architecture : Feed Forward Network
- Activation Function : Sigmoid
- Loss Function : Mean Squared Error (MSE)
- Sample Data Generated from Vertical Wave Bending Moment Formula given in Common Structural Rules for Bulk Carriers and Oil Tankers
  [Ref 3.1, Section 4, Chapter 4, Part 1, CSR for Bulk Carriers and Oil Tankers]
- This Script can be improved / adapted for other applications by:
  - Training with other Sample Data sets
  - Changing No of Input / Outputs, No of Layers and No of Neurons in each layer
  - Introducing a suitable activation function
  - Introducing better Loss function

Network Architecture



Note:

- Input Layer (0) is not Weighted
- Output Layer (3) has no activation function
- There are options to easily modify this Architecture

$W_{i,j}^l \rightarrow j^{th}$ *column of weigth vector corresponding to* i^{th} *neuron in* l^{th} *layer*

$b_i^l \rightarrow$ *bias of* i^{th} *neuron in* l^{th} *layer*

$a_i^l \rightarrow$ *output of* i^{th} *neuron in* l^{th} *Layer*

$\sigma(x) \rightarrow$ *Sigmoid Activation Function*

Sample Data Generation

- Sample Data Generated from **Vertical Wave Bending Moment** Formula given in Common Structural Rules for Bulk Carriers and Oil Tankers

Hogging condition:

$$M_{wv-h} = 0{,}19\, f_{nl-vh}\, f_m\, f_p\, C_w\, L^2\, BC_B$$

Sagging condition:

$$M_{wv-s} = -0{,}19\, f_{nl-vs}\, f_m\, f_p\, C_w\, L^2\, BC_B$$

[Ref : 3.1.1, Section 4, Chapter 4, Part 1, CSR for Bulk Carriers and Oil Tankers]

All units in SI

L	B	CB	fnl-vh	fnl-vs	fm	fp	Cw	Mv-h	Mv-s
90	18.00	0.6	1	1.26	1	1	7.71	128096.45	-160974.53
105	19.09	0.6	1	1.26	1	1	8.03	192602.48	-242037.11
120	20.00	0.6	1	1.26	1	1	8.34	273656.25	-343894.69
135	20.77	0.6	1	1.26	1	1	8.63	372417.95	-468005.22
150	21.43	0.6	1	1.26	1	1	8.91	489890.23	-615628.72
165	22.00	0.6	1	1.26	1	1	9.18	626911.60	-787818.91
180	36.00	0.7	1	1.16	1	1	9.44	1463735.14	-1697932.76
195	35.45	0.7	1	1.16	1	1	9.67	1734610.69	-2012148.40
210	35.00	0.7	1	1.16	1	1	9.90	2031543.29	-2356590.22
225	34.62	0.7	1	1.16	1	1	10.10	2354116.18	-2730774.77
240	34.29	0.7	1	1.16	1	1	10.29	2701480.52	-3133717.41
255	34.00	0.7	1	1.16	1	1	10.45	3072200.25	-3563752.29
270	54.00	0.8	1	1.09	1	1	10.59	6334083.29	-6888315.58
285	51.82	0.8	1	1.09	1	1	10.69	6840228.03	-7438747.98
300	50.00	0.8	1	1.09	1	1	10.75	7353000.00	-7996387.50

Inputs (Independent Variables)

L → Length of Ship

B → Breadth of Ship

C_B → Block Coefficients

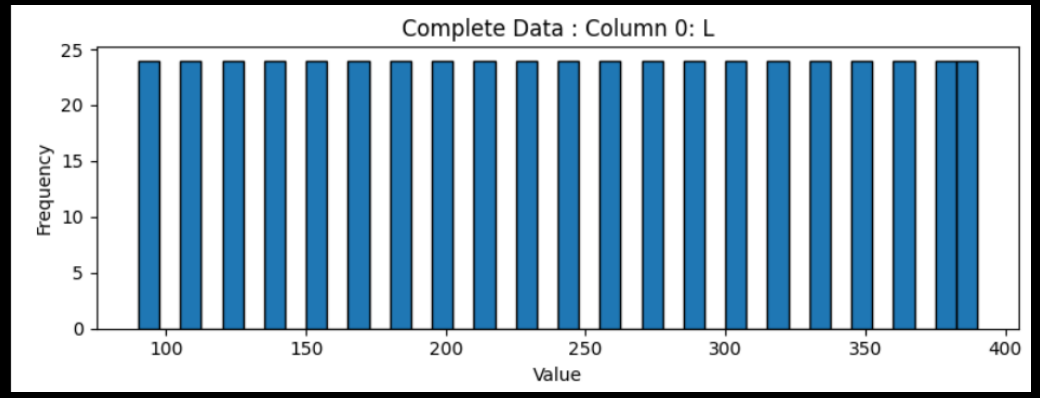
Outputs (Dependent Variables)

M_{wv-h} → Hog Vertical Wave Bending moment at Mid Ship

M_{wv-s} → Sag Vertical Wave Bending moment at Mid Ship

Sample Data Stats

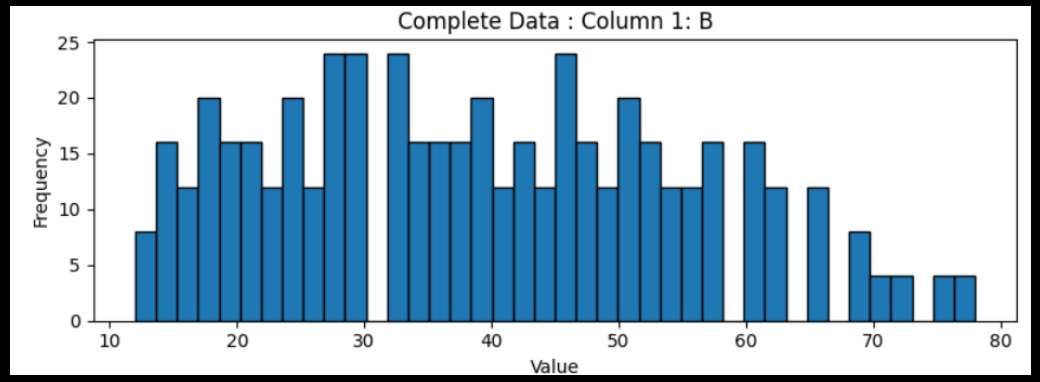
All units in SI

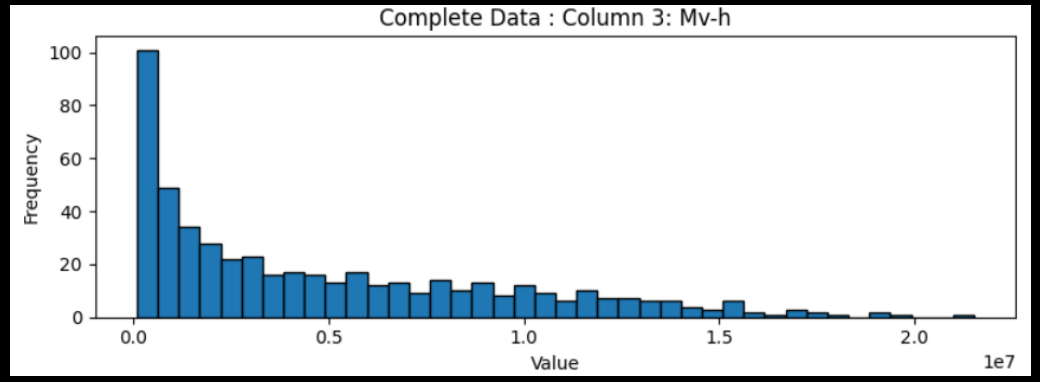


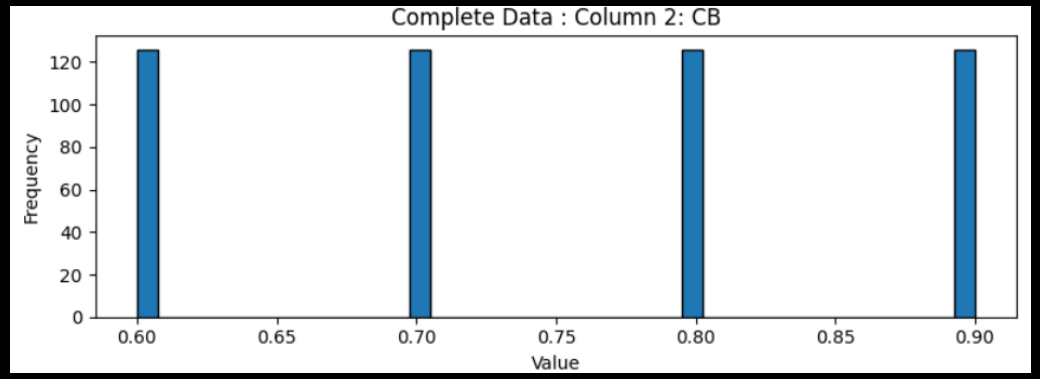
Data Characteristics (All Data)

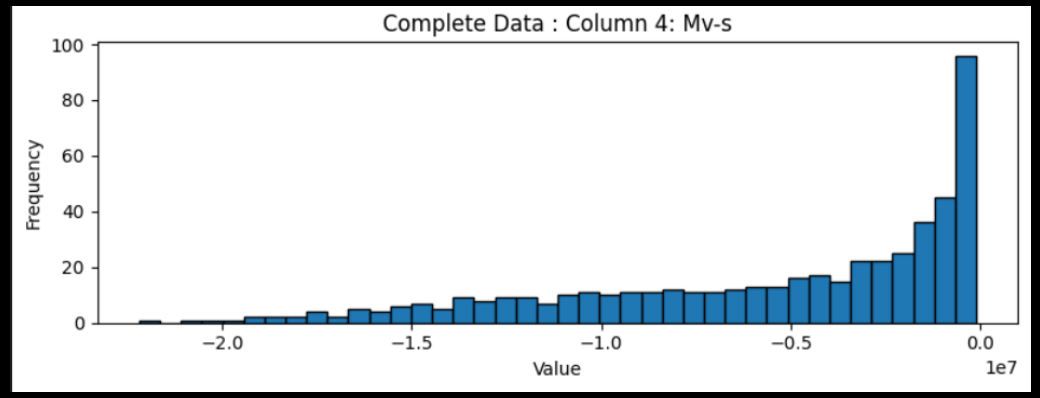
Data Frame Shape : (504, 5)

		Min	Max	Mean	Std Dev
Column	0 : L	90.00	390.00	240.00	90.92
Column	1 : B	12.00	78.00	39.14	15.94
Column	2 : CB	0.60	0.90	0.75	0.11
Column	3 : Mv-h	85397.63	21529264.69	4840756.46	4690944.51
Column	4 : Mv-s	-22199064.03	-107316.36	-5428101.58	5172824.78

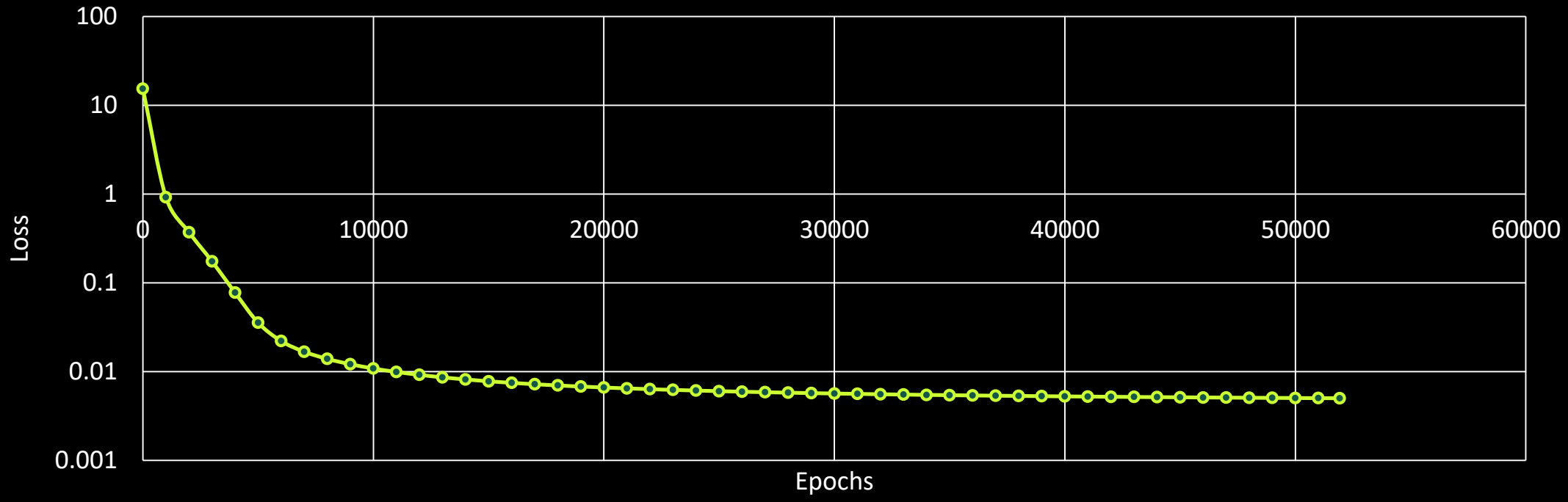








Training : Decay of Loss



Note:

- Decaying of Loss can be improved by,
  - Larger and Diverse Data Set
  - Use Better Loss Function
  - Better Activation Function
  - Adapt Learning Rate
  - Tweak Architecture

Application of Trained Model

Variation of Vertical Wave Bending Moment with L/B ratio

Assuming following are Constants:

- Volume Displacement = 100000
- Draft = 20
- Block Coefficient = 0.75

L/B	L	B	Cb	Mv-h	Mv-s
5.00	182.57	36.51	0.75	1710735.97	-1976970.57
5.28	187.58	35.54	0.75	1747149.53	-2017159.67
5.56	192.45	34.64	0.75	1785801.65	-2059819.43
5.83	197.20	33.81	0.75	1826457.01	-2104690.13
6.11	201.84	33.03	0.75	1868925.36	-2151561.80
6.39	206.38	32.30	0.75	1913051.45	-2200263.09
6.67	210.82	31.62	0.75	1958707.45	-2250652.92
6.94	215.17	30.98	0.75	2005787.34	-2302614.28
7.22	219.43	30.38	0.75	2054202.58	-2356049.44
7.50	223.61	29.81	0.75	2103878.71	-2410876.23

All units in SI