

# CleanAI Analysis Report

## Model Informations

The table below shows general information about the 'ResNet' model.

	Model name	Total params	Number of layers
Informations	ResNet	60192808	423

## Coverage Values of Layers (For Only One Input)

The table below shows coverage values about the 'ResNet' model's all layers. The 'mean of layer' value shows the average of neurons in that layer. When calculating the number of covered neurons, this value is accepted as the threshold value for that layer. NOTE: The coverage value of a layer is the ratio of the number of covered neurons to the total number of neurons in that layer. The values in the table below, it was formed as a result of giving the 'n01496331\n01496331\_14320.JPEG' input in the data set to the model.

Layer Index	Activation Function	Number of Covered Neurons	Number of Total Neurons	Coverage Value	Mean of Layer
Layer 3	ReLU	289854	802816	36.10%	0.23
Layer 13	ReLU	295048	802816	36.75%	0.11
Layer 24	ReLU	308830	802816	38.47%	0.13
Layer 32	ReLU	324610	802816	40.43%	0.15
Layer 41	ReLU	135513	401408	33.76%	0.11
Layer 52	ReLU	146614	401408	36.52%	0.12
Layer 60	ReLU	155703	401408	38.79%	0.14
Layer 68	ReLU	156856	401408	39.08%	0.14
Layer 76	ReLU	156256	401408	38.93%	0.15
Layer 84	ReLU	157077	401408	39.13%	0.15
Layer 92	ReLU	157239	401408	39.17%	0.15
Layer 100	ReLU	157203	401408	39.16%	0.15
Layer 109	ReLU	61263	200704	30.52%	0.09
Layer 120	ReLU	63615	200704	31.70%	0.10
Layer 128	ReLU	64850	200704	32.31%	0.10
Layer 136	ReLU	66902	200704	33.33%	0.11
Layer 144	ReLU	66173	200704	32.97%	0.11
Layer 152	ReLU	65836	200704	32.80%	0.11
Layer 160	ReLU	65974	200704	32.87%	0.11
Layer 168	ReLU	66469	200704	33.12%	0.11
Layer 176	ReLU	66380	200704	33.07%	0.11

Layer 184	ReLU	66033	200704	32.90%	0.11
Layer 192	ReLU	66866	200704	33.32%	0.11
Layer 200	ReLU	67112	200704	33.44%	0.11
Layer 208	ReLU	66619	200704	33.19%	0.11
Layer 216	ReLU	65302	200704	32.54%	0.11
Layer 224	ReLU	64655	200704	32.21%	0.11
Layer 232	ReLU	64813	200704	32.29%	0.11
Layer 240	ReLU	65149	200704	32.46%	0.12
Layer 248	ReLU	65329	200704	32.55%	0.12
Layer 256	ReLU	65634	200704	32.70%	0.12
Layer 264	ReLU	65412	200704	32.59%	0.12
Layer 272	ReLU	65095	200704	32.43%	0.12
Layer 280	ReLU	64838	200704	32.31%	0.12
Layer 288	ReLU	64468	200704	32.12%	0.12
Layer 296	ReLU	63877	200704	31.83%	0.12
Layer 304	ReLU	63584	200704	31.68%	0.11
Layer 312	ReLU	63320	200704	31.55%	0.12
Layer 320	ReLU	62554	200704	31.17%	0.11
Layer 328	ReLU	61346	200704	30.57%	0.11
Layer 336	ReLU	60790	200704	30.29%	0.11
Layer 344	ReLU	59881	200704	29.84%	0.11
Layer 352	ReLU	58783	200704	29.29%	0.10
Layer 360	ReLU	57767	200704	28.78%	0.10
Layer 368	ReLU	57013	200704	28.41%	0.10
Layer 376	ReLU	55471	200704	27.64%	0.09
Layer 384	ReLU	55555	200704	27.68%	0.09
Layer 392	ReLU	55510	200704	27.66%	0.09
Layer 401	ReLU	30196	100352	30.09%	0.20
Layer 412	ReLU	31172	100352	31.06%	0.30
Layer 420	ReLU	30872	100352	30.76%	0.42
All model	-	4813281	13948928	34.51%	

## Coverage Values of Layers (For Multiple Inputs) 50 Inputs

The table below shows coverage values for multiple inputs about the 'ResNet' model. The values in the table below, it was formed as a result of giving the '50' inputs in the data set to the model.

Layer index	Number of covered neurons	Number of total neurons	Coverage value
All model	241045702	697446400	34.56%

## Threshold Coverage Values of Layers (TH = 0.75)

The table below shows threshold coverage values about the 'ResNet' model's all layers. NOTE: The threshold coverage value of a layer is the ratio of the number of covered neurons (number of neurons greater than the threshold value) to the total number of neurons in that layer. The values in the table below, it was formed as a result of giving the 'n01496331\n01496331\_14320.JPEG' input in the data set to the model.

Layer index	Activation function	Number of covered neurons	Number of total neurons	Coverage value
Layer 3	ReLU	67751	802816	8.44%
Layer 13	ReLU	2895	802816	0.36%
Layer 24	ReLU	3184	802816	0.40%
Layer 32	ReLU	4123	802816	0.51%
Layer 41	ReLU	3706	401408	0.92%
Layer 52	ReLU	1951	401408	0.49%
Layer 60	ReLU	1884	401408	0.47%
Layer 68	ReLU	2340	401408	0.58%
Layer 76	ReLU	2621	401408	0.65%
Layer 84	ReLU	2903	401408	0.72%
Layer 92	ReLU	3105	401408	0.77%
Layer 100	ReLU	3028	401408	0.75%
Layer 109	ReLU	1482	200704	0.74%
Layer 120	ReLU	1422	200704	0.71%
Layer 128	ReLU	1444	200704	0.72%
Layer 136	ReLU	1293	200704	0.64%
Layer 144	ReLU	1417	200704	0.71%
Layer 152	ReLU	1471	200704	0.73%
Layer 160	ReLU	1582	200704	0.79%
Layer 168	ReLU	1455	200704	0.72%
Layer 176	ReLU	1453	200704	0.72%
Layer 184	ReLU	1473	200704	0.73%
Layer 192	ReLU	1448	200704	0.72%
Layer 200	ReLU	1544	200704	0.77%

Layer 208	ReLU	1648	200704	0.82%
Layer 216	ReLU	1663	200704	0.83%
Layer 224	ReLU	1710	200704	0.85%
Layer 232	ReLU	1786	200704	0.89%
Layer 240	ReLU	1875	200704	0.93%
Layer 248	ReLU	1964	200704	0.98%
Layer 256	ReLU	2035	200704	1.01%
Layer 264	ReLU	2074	200704	1.03%
Layer 272	ReLU	2034	200704	1.01%
Layer 280	ReLU	2055	200704	1.02%
Layer 288	ReLU	2077	200704	1.03%
Layer 296	ReLU	2042	200704	1.02%
Layer 304	ReLU	2030	200704	1.01%
Layer 312	ReLU	2181	200704	1.09%
Layer 320	ReLU	2160	200704	1.08%
Layer 328	ReLU	2132	200704	1.06%
Layer 336	ReLU	2169	200704	1.08%
Layer 344	ReLU	2212	200704	1.10%
Layer 352	ReLU	2102	200704	1.05%
Layer 360	ReLU	2095	200704	1.04%
Layer 368	ReLU	2011	200704	1.00%
Layer 376	ReLU	1961	200704	0.98%
Layer 384	ReLU	1920	200704	0.96%
Layer 392	ReLU	1693	200704	0.84%
Layer 401	ReLU	8145	100352	8.12%
Layer 412	ReLU	13265	100352	13.22%
Layer 420	ReLU	19403	100352	19.33%
All model	-	205417	13948928	1.47%

## Sign Coverage and Value Coverage (TH = 0.75) Values of Model

The table below shows Sign Coverage and Value Coverage values of the 'ResNet' model. Sign Coverage: When given two different test inputs, it checks whether the signs of a specific neuron's value after the activation function are the same. If the signs are not the same, the counter is incremented. Value Coverage: When given two different test inputs, it checks whether the difference between the values of a specific neuron after the activation function is greater than the given threshold value. If the

difference is greater than the threshold value, the counter is incremented. The values in the table below, it was formed as a result of giving the 'n01496331\n01496331\_14320.JPEG' and 'n01496331\n01496331\_28855.JPEG' input in the data set to the model.

Coverage Metric	Number of covered neurons	Number of total neurons	Coverage value
Sign Coverage	6609216	13948928	47.38%
Value Coverage	129227	13948928	0.93%

## Top-K Neuron Coverage (K = 3) Value of Model

The table below shows Top-K Neuron Coverage value of the 'ResNet' model. Top-K Neuron Coverage (TKNC) is a metric used to evaluate the activation patterns and coverage of neurons in a deep neural network (DNN). It measures the percentage of neurons that are activated for a given set of input samples. The idea behind TKNC is to assess how well a set of input samples can activate different neurons in the network. How is it calculated? TKNC travels through all layers on a model one by one and ranks the neuron values of each layer in order from largest to smallest. Then it takes k neurons in each layer and adds it to a list. It then creates a value called 'TKNC Sum', which represents the sum of neurons in this list. The 'Number of Selected Neurons' value shows how many neurons were selected on the whole model as a result of k neurons from each layer. The 'Mean of Top-K Neurons' value shows the ratio of the 'TKNC Sum' value to the 'Number of Selected Neurons' value. The values in the table below, it was formed as a result of giving the 'n01496331\n01496331\_14320.JPEG' input in the data set to the model.

Coverage Metric	TKNC Sum	Number of Selected Neurons	Mean of Top-K Neurons
Top-K Neuron Coverage	466.37	153	3.05

## Neuron Boundary Coverage Value of Model (For 50 Inputs)

The table below shows Neuron Boundary Coverage value of the 'ResNet' model. Neuron Boundary Coverage (NBC) is a metric used to evaluate the coverage of decision boundaries in a deep neural network (DNN). It measures the percentage of decision boundaries in the network that have been activated or crossed by the input samples. How is it calculated? NBC receives a random set of inputs from the user, and as a result of these inputs, it determines the maximum and minimum interval value for each layer. Then, for the input data to be checked, it is checked whether each neuron belonging to each layer is within the maximum and minimum range of this layer. If it is within this range, the 'NBC Counter' value is increased by one. The values in the table below, it was formed as a result of giving the 'n01496331\n01496331\_14320.JPEG' input in the data set to the model.

Coverage Metric	NBC Counter	Number of Total Neurons	Neuron Boundary Coverage
Neuron Boundary Coverage	0	13948928	0.00%

## Multisection Neuron Coverage Value of Model

The table below shows Multisection Neuron Coverage value of the 'ResNet' model. Multisection Neuron Coverage (MNC) specifically focuses on assessing the coverage of individual neurons within the

model. The goal of MNC is to evaluate the degree to which the decisions made by individual neurons have been exercised by the test cases. It helps identify potential shortcomings in the model's behavior and reveal areas that may require further testing. It provides the user with the information of how many neurons are found according to the threshold value ranges given by the user. How is it calculated? The MNC receives threshold ranges from the user. Then, it evaluates all the neurons on the model and checks whether each neuron is within these threshold ranges. If the corresponding neuron is within this threshold value, it increases the 'MNC Counter' value found for the relevant range by one. The 'Multisection Neuron Coverage' value is the ratio of the 'MNC Counter' value to the number of all neurons on the model. The values in the table below, it was formed as a result of giving the 'n01496331\n01496331\_14320.JPG' input in the data set to the model.

Threshold Intervals	MNC Counter	Number of Total Neurons	Multisection Neuron Coverage
0 - 0.1	8492250	13948928	60.88%
0.1 - 0.2	1967291	13948928	14.10%
0.2 - 0.3	1356514	13948928	9.72%
0.3 - 0.4	884184	13948928	6.34%
0.4 - 0.5	534387	13948928	3.83%