SCHOOL OF DATA SCIENCE AND FORECASTING

DAVV, INDORE

SESSION: 2020-2021

FORECASTING METHODS

ASSIGNMENT: PREDICTING AIR QUALITY INDEX (AQI) USING SINGLE EXPONENTIAL SMOOTHING METHOD.

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ABSTRACT

Air is one of the key elements without which survival is not possible. Air plays a key role in various environmental processes. Despite being such a crucial aspect of life, the air is getting polluted as rapid industrialization has patched in almost every part of the world. This increase in air pollutants can adversely affect an individual's health. Therefore, Air Quality Index (AQI) plays a crucial role in determining the quality of air in our surroundings. Knowing the air quality in places of living, working, and traveling may help individuals adopt measures to reduce the impact of such polluted air on their health. The main objective of this report is to focus on AQI measurement and predict the value of major air pollutants in Indore, based on historical data using exponential smoothing method.

INTRODUCTION

Air Quality Index (AQI) is a measure to determine the quality of air in our surroundings. It measures how air pollution can affect an individual's health within a specified period of time. The common air pollutants are Particulate Matter (PM2.5, PM10), Ozone (O3), Nitrogen Dioxide (NO2), Sulphur Dioxide (SO2), and Carbon Monoxide (CO). India recorded the highest annual average PM 2.5 concentration exposure in the world last year, according to the State of Global Air 2020 (SOGA 2020) report. There are 87 health risk factors based on the total number of deaths caused in 2019, polluted air has the fourth-highest risk globally preceded by high blood pressure, tobacco, and dietary risks. But in India, air pollution has become the highest risk factor because it largely contributes to premature deaths. More than 90% of people worldwide live in areas exceeding the World Health Organization (WHO) Guideline for healthy air. More than half live in areas that do not even meet WHO's least-stringent air quality target. India was also among the top ten countries with the highest ozone (O3) exposure in 2019. India records the highest increase (17%) in ozone (O3) concentrations in the past ten years. New data from WHO shows that 9 out of 10 people breathe air containing high levels of pollutants. WHO estimates that around 7 million people die every year from exposure to polluted air. Therefore, it is an essential task to monitor the air quality in the city area and alert the people on a timely basis.

REVIEW OF LITERATURE

The report can be divided into two tasks, an air pollutant monitoring unit, and an efficient forecasting model to determine the green zones.

Abdullah Kadri, Khaled Bashir Shaban, Elias Yaacoub, Adnan A. Abu-Dayya:
Air Quality Monitoring and Prediction System Using Machine-to-Machine Platform. ICONIP (4) 2012: 508-517, designed an air quality monitoring and prediction system using wireless connectivity among different monitoring centers and used artificial neural networks to predict air pollutant data before one hour to eight hours.

AIRNOW: A one-stop source for air quality data, monitors daily air quality data, and specifies a set of air pollutants across all cities in the United States.

David C. Roberts, Jaesung Choi, Eunsun Lee:
Forecast of CO2 Emissions from the U.S. Transportation Sector: Estimation from a Double Exponential Smoothing Model, January 2014Journal of the Transportation Research Forum 53(3):63-81, DOI: 10.5399/osu/jtrf.53.3.4246,
designed a double exponential smoothing forecasting model to determine CO2 emissions caused by the transportation sector in the states of USA.

Junjie Zhanga, Quan Mub
Air pollution and defensive expenditures: Evidence from particulate-filtering facemasks, Journal of Environmental Economics and Management, Volume 92, November 2018, Pages 517-536,
explains how preventive measures can be taken against ambient air pollution using particulate filtering facemasks.

MATHEMATICAL FORMULATION

For this report, daily data of past 1 month was recorded on a real time basis, from the official website of Central Pollution Control Board (CPCB), India. The data was collected on an hourly basis and averaged for daily recording purposes.

The formula for single exponential smoothing used in this calculation is as follows –

$$F_t = \alpha C_t + (1 - \alpha) F_{t-1}$$

F_t is called smoothed value; C_t is called current observation and α is called smoothing constant. The value of α is $0 < \alpha < 1$ and $t \geq 3$.

RESULT ANALYSIS

For this report, the forecasting result is developed on three values of α, i.e., α = 0.1, α = 0.5, and α = 0.9.

		FORECAST					FORECAST					FORECAST				
DATE	PM2.5	Alpha = 0.1	Error	Abs. Error	% Error	Sq. Error	Alpha = 0.5	Error	Abs. Error	% Error	Sq. Error	Alpha = 0.9	Error	Abs. Error	% Error	Sq. Error
01-12-2020	110	#N/A					#N/A					#N/A				
02-12-2020	136	110	26	26	19.1176	676	110	26	26	19.11765	676	110	26	26	19.117647	676
03-12-2020	137	112.6	24.4	24.4	17.8102	595.36	123	14	14	10.21898	196	133.4	3.6	3.6	2.6277372	12.96
04-12-2020	144	115.04	28.96	28.96	20.1111	838.682	130	14	14	9.722222	196	136.64	7.36	7.36	5.1111111	54.1696
05-12-2020	142	117.936	24.064	24.064	16.9465	579.076	137	5	5	3.521127	25	143.264	-1.264	1.264	-0.890141	1.597696
06-12-2020	134	120.3424	13.6576	13.6576	10.1922	186.53	139.5	-5.5	5.5	-4.104478	30.25	142.1264	-8.1264	8.1264	-6.064478	66.038377
07-12-2020	140	121.70816	18.29184	18.29184	13.0656	334.591	136.75	3.25	3.25	2.321429	10.5625	134.81264	5.18736	5.18736	3.7052571	26.908704
08-12-2020	144	123.53734	20.462656	20.462656	14.2102	418.72	138.375	5.625	5.625	3.90625	31.640625	139.48126	4.51874	4.518736	3.1380111	20.418975
09-12-2020	157	125.58361	31.4163904	31.4163904	20.0104	986.99	141.1875	15.8125	15.8125	10.07166	250.03516	143.54813	13.4519	13.451874	8.5680724	180.9529
12-12-2020	155	128.72525	26.2747514	26.2747514	16.9515	690.363	149.09375	5.90625	5.90625	3.810484	34.883789	155.65481	-0.6548	0.6548126	-0.42246	0.4287796
11-12-2020	147	131.35272	15.6472762	15.6472762	10.6444	244.837	152.04688	-5.0469	5.046875	-3.433248	25.470947	155.06548	-8.0655	8.0654813	-5.486722	65.051988
12-12-2020	138	132.91745	5.0825486	5.0825486	3.68301	25.8323	149.52344	-11.523	11.523438	-8.350317	132.78961	147.80655	-9.8065	9.8065481	-7.106194	96.168386
13-12-2020	139	133.42571	5.57429374	5.57429374	4.01028	31.0728	143.76172	-4.7617	4.7617188	-3.425697	22.673965	138.98065	0.01935	0.0193452	0.0139174	0.0003742
14-12-2020	134	133.98314	0.01686437	0.01686437	0.01259	0.00028	141.38086	-7.3809	7.3808594	-5.508104	54.477085	138.99807	-4.9981	4.9980655	-3.7299	24.980659
15-12-2020	172	133.98482	38.0151779	38.0151779	22.1018	1445.15	137.69043	34.3096	34.30957	19.94742	1177.1466	134.49981	37.5002	37.500193	21.802438	1406.2645
16-12-2020	170	137.78634	32.2136601	32.2136601	18.9492	1037.72	154.84521	15.1548	15.154785	8.91458	229.66751	168.24998	1.75002	1.7500193	1.0294231	3.0625677
17-12-2020	174	141.00771	32.9922941	32.9922941	18.9611	1088.49	162.42261	11.5774	11.577393	6.653674	134.03602	169.825	4.175	4.1750019	2.3994264	17.430641
18-12-2020	161	144.30694	16.6930647	16.6930647	10.3684	278.658	168.2113	-7.2113	7.2113037	-4.479071	52.002901	173.5825	-12.582	12.5825	-7.815217	158.3193
19-12-2020	133	145.97624	-12.976242	12.9762418	-9.7566	168.383	164.60565	-31.606	31.605652	-23.76365	998.91723	162.25825	-29.258	29.25825	-21.99868	856.04519
20-12-2020	105	144.67862	-39.678618	39.6786176	-37.789	1574.39	148.80283	-43.803	43.802826	-41.71698	1918.6876	135.92582	-30.926	30.925825	-29.45317	956.40665
21-12-2020	116	140.71076	-24.710756	24.7107558	-21.302	610.621	126.90141	-10.901	10.901413	-9.39777	118.8408	108.09258	7.90742	7.9074175	6.8167392	62.527252
22-12-2020	134	138.23968	-4.2396802	4.23968024	-3.1639	17.9749	121.45071	12.5493	12.549294	9.365144	157.48477	115.20926	18.7907	18.790742	14.022942	353.09198
23-12-2020	159	137.81571	21.1842878	21.1842878	13.3235	448.774	127.72535	31.2746	31.274647	19.66959	978.10353	132.12093	26.8791	26.879074	16.905078	722.48463
24-12-2020	152	139.93414	12.065859	12.065859	7.93807	145.585	143.36268	8.63732	8.6373234	5.68245	74.603355	156.31209	-4.3121	4.3120926	-2.836903	18.594142
25-12-2020	145	141.14073	3.8592731	3.8592731	2.66157	14.894	147.68134	-2.6813	2.6813383	-1.849199	7.1895751	152.43121	-7.4312	7.4312093	-5.124972	55.222871
26-12-2020	159	141.52665	17.4733458	17.4733458	10.9895	305.318	146.34067	12.6593	12.659331	7.961843	160.25866	145.74312	13.2569	13.256879	8.3376598	175.74484
27-12-2020	158	143.27399	14.7260112	14.7260112	9.32026	216.855	152.67033	5.32967	5.3296654	3.373206	28.405334	157.67431	0.32569	0.3256879	0.2061316	0.1060726
28-12-2020	127	144.74659	-17.74659	17.7465899	-13.974	314.941	155.33517	-28.335	28.335167	-22.31116	802.88171	157.96743	-30.967	30.967431	-24.3838	958.9818
29-12-2020	135	142.97193	-7.9719309	7.97193092	-5.9051	63.5517	141.16758	-6.1676	6.1675836	-4.56858	38.039088	130.09674	4.90326	4.9032569	3.6320421	24.041928
30-12-2020	165	142.17474	22.8252622	22.8252622	13.8335	520.993	138.08379	26.9162	26.916208	16.31285	724.48226	134.50967	30.4903	30.490326	18.478985	929.65996
31-12-2020	171	144.45726	26.542736	26.542736	15.5221	704.517	151.5419	19.4581	19.458104	11.37901	378.61781	161.95097	9.04903	9.0490326	5.2918319	81.88499
01-01-2021	178	147.11154	30.8884624	30.8884624	17.3531	954.097	161.27095	16.7291	16.729052	9.398344	279.86118	170.0951	7.9049	7.9049033	4.4409569	62.487496
02-01-2021	172	150.20038	21.7996161	21.7996161	12.6742	475.223	169.63547	2.36453	2.364526	1.374724	5.5909833	177.20951	-5.2095	5.2095097	-3.028785	27.138991
		MEAN	13.243858	19.9515965	7.77722	499.819		3.80111	14.108494	1.5567	310.95627		2.17087	11.770999	0.8532494	252.97413

Lowest error results at alpha = 0.9

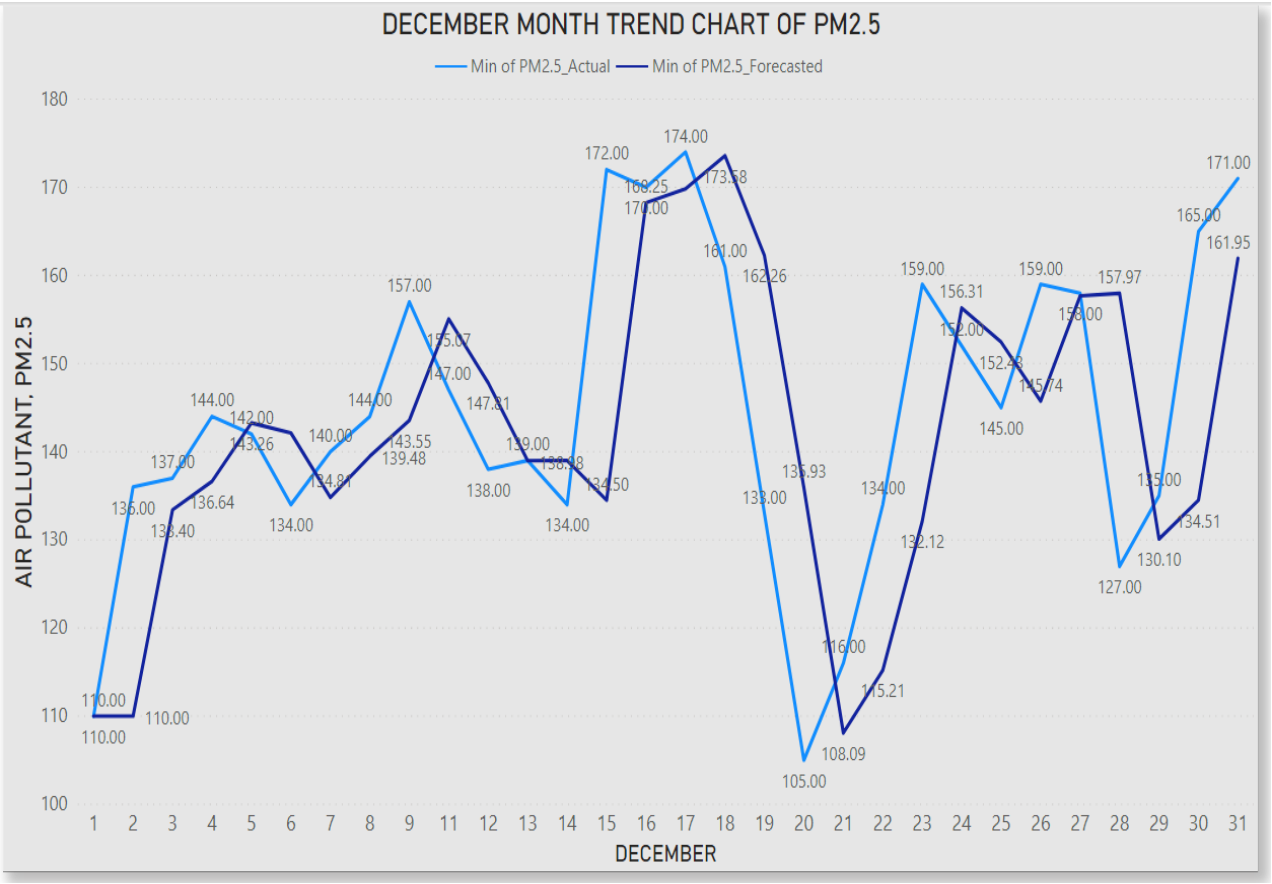
Results at Alpha = 0.9

Mean Error	2.1708
Mean Absolute Error (MAE)	11.7709
Mean Absolute Percent Error (MAPE)	0.8532
Mean Square Error (MSE)	252.9741

FORECASTS

		FORECAST					FORECAST					FORECAST				
DATE	PM2.5	Alpha = 0.1	Error	Abs. Error	% Error	Sq. Error	Alpha = 0.5	Error	Abs. Error	% Error	Sq. Error	Alpha = 0.9	Error	Abs. Error	% Error	Sq. Error
01-12-2020	110	#N/A					#N/A					#N/A				
02-12-2020	136	110	26	26	19.1176	676	110	26	26	19.11765	676	110	26	26	19.117647	676
03-12-2020	137	112.6	24.4	24.4	17.8102	595.36	123	14	14	10.21898	196	133.4	3.6	3.6	2.6277372	12.96
04-12-2020	144	115.04	28.96	28.96	20.1111	838.682	130	14	14	9.722222	196	136.64	7.36	7.36	5.1111111	54.1696
05-12-2020	142	117.936	24.064	24.064	16.9465	579.076	137	5	5	3.521127	25	143.264	-1.264	1.264	-0.890141	1.597696
06-12-2020	134	120.3424	13.6576	13.6576	10.1922	186.53	139.5	-5.5	5.5	-4.104478	30.25	142.1264	-8.1264	8.1264	-6.064478	66.038377
07-12-2020	140	121.70816	18.29184	18.29184	13.0656	334.591	136.75	3.25	3.25	2.321429	10.5625	134.81264	5.18736	5.18736	3.7052571	26.908704
08-12-2020	144	123.53734	20.462656	20.462656	14.2102	418.72	138.375	5.625	5.625	3.90625	31.640625	139.48126	4.51874	4.518736	3.1380111	20.418975
09-12-2020	157	125.58361	31.4163904	31.4163904	20.0104	986.99	141.1875	15.8125	15.8125	10.07166	250.03516	143.54813	13.4519	13.451874	8.5680724	180.9529
12-12-2020	155	128.72525	26.2747514	26.2747514	16.9515	690.363	149.09375	5.90625	5.90625	3.810484	34.883789	155.65481	-0.6548	0.6548126	-0.42246	0.4287796
11-12-2020	147	131.35272	15.6472762	15.6472762	10.6444	244.837	152.04688	-5.0469	5.046875	-3.433248	25.470947	155.06548	-8.0655	8.0654813	-5.486722	65.051988
12-12-2020	138	132.91745	5.0825486	5.0825486	3.68301	25.8323	149.52344	-11.523	11.523438	-8.350317	132.78961	147.80655	-9.8065	9.8065481	-7.106194	96.168386
13-12-2020	139	133.42571	5.57429374	5.57429374	4.01028	31.0728	143.76172	-4.7617	4.7617188	-3.425697	22.673965	138.98065	0.01935	0.0193452	0.0139174	0.0003742
14-12-2020	134	133.98314	0.01686437	0.01686437	0.01259	0.00028	141.38086	-7.3809	7.3808594	-5.508104	54.477085	138.99807	-4.9981	4.9980655	-3.7299	24.980659
15-12-2020	172	133.98482	38.0151779	38.0151779	22.1018	1445.15	137.69043	34.3096	34.30957	19.94742	1177.1466	134.49981	37.5002	37.500193	21.802438	1406.2645
16-12-2020	170	137.78634	32.2136601	32.2136601	18.9492	1037.72	154.84521	15.1548	15.154785	8.91458	229.66751	168.24998	1.75002	1.7500193	1.0294231	3.0625677
17-12-2020	174	141.00771	32.9922941	32.9922941	18.9611	1088.49	162.42261	11.5774	11.577393	6.653674	134.03602	169.825	4.175	4.1750019	2.3994264	17.430641
18-12-2020	161	144.30694	16.6930647	16.6930647	10.3684	278.658	168.2113	-7.2113	7.2113037	-4.479071	52.002901	173.5825	-12.582	12.5825	-7.815217	158.3193
19-12-2020	133	145.97624	-12.976242	12.9762418	-9.7566	168.383	164.60565	-31.606	31.605652	-23.76365	998.91723	162.25825	-29.258	29.25825	-21.99868	856.04519
20-12-2020	105	144.67862	-39.678618	39.6786176	-37.789	1574.39	148.80283	-43.803	43.802826	-41.71698	1918.6876	135.92582	-30.926	30.925825	-29.45317	956.40665
21-12-2020	116	140.71076	-24.710756	24.7107558	-21.302	610.621	126.90141	-10.901	10.901413	-9.39777	118.8408	108.09258	7.90742	7.9074175	6.8167392	62.527252
22-12-2020	134	138.23968	-4.2396802	4.23968024	-3.1639	17.9749	121.45071	12.5493	12.549294	9.365144	157.48477	115.20926	18.7907	18.790742	14.022942	353.09198
23-12-2020	159	137.81571	21.1842878	21.1842878	13.3235	448.774	127.72535	31.2746	31.274647	19.66959	978.10353	132.12093	26.8791	26.879074	16.905078	722.48463
24-12-2020	152	139.93414	12.065859	12.065859	7.93807	145.585	143.36268	8.63732	8.6373234	5.68245	74.603355	156.31209	-4.3121	4.3120926	-2.836903	18.594142
25-12-2020	145	141.14073	3.8592731	3.8592731	2.66157	14.894	147.68134	-2.6813	2.6813383	-1.849199	7.1895751	152.43121	-7.4312	7.4312093	-5.124972	55.222871
26-12-2020	159	141.52665	17.4733458	17.4733458	10.9895	305.318	146.34067	12.6593	12.659331	7.961843	160.25866	145.74312	13.2569	13.256879	8.3376598	175.74484
27-12-2020	158	143.27399	14.7260112	14.7260112	9.32026	216.855	152.67033	5.32967	5.3296654	3.373206	28.405334	157.67431	0.32569	0.3256879	0.2061316	0.1060726
28-12-2020	127	144.74659	-17.74659	17.7465899	-13.974	314.941	155.33517	-28.335	28.335167	-22.31116	802.88171	157.96743	-30.967	30.967431	-24.3838	958.9818
29-12-2020	135	142.97193	-7.9719309	7.97193092	-5.9051	63.5517	141.16758	-6.1676	6.1675836	-4.56858	38.039088	130.09674	4.90326	4.9032569	3.6320421	24.041928
30-12-2020	165	142.17474	22.8252622	22.8252622	13.8335	520.993	138.08379	26.9162	26.916208	16.31285	724.48226	134.50967	30.4903	30.490326	18.478985	929.65996
31-12-2020	171	144.45726	26.542736	26.542736	15.5221	704.517	151.5419	19.4581	19.458104	11.37901	378.61781	161.95097	9.04903	9.0490326	5.2918319	81.88499
01-01-2021	178	147.11154	30.8884624	30.8884624	17.3531	954.097	161.27095	16.7291	16.729052	9.398344	279.86118	170.0951	7.9049	7.9049033	4.4409569	62.487496
02-01-2021	172	150.20038	21.7996161	21.7996161	12.6742	475.223	169.63547	2.36453	2.364526	1.374724	5.5909833	177.20951	-5.2095	5.2095097	-3.028785	27.138991
03-01-2021		152.38035					169.87193					176.68856				
		MEAN	13.243858	19.9515965	7.77722	499.819		3.80111	14.108494	1.5567	310.95627		2.17087	11.770999	0.8532494	252.97413

Forecasts for the next day are shown above



Line chart representing actual and forecasted values of PM2.5.

COMPARISON OF FORECAST DATA AND ACTUAL DATA

Date	Forecasted Value	Actual Value
03-01-2021	176.68856	173

The actual value has been sourced from official website of Central Pollution Control Board (CPCB), India.

CONCLUSION

The actual value has an approximate error as calculated in the above sheet. Thus, the forecasted value can be taken into consideration for future forecasting of Air Quality Index (AQI).

Furthermore, double and triple exponential smoothing methods can be used on the data to minimize errors and improve accuracy of the forecasts.

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