EXPONENTIAL SMOOTHING FOR FORECASTING CAR ACCIDENTS IN KERALA

A Computer Aided Structural Engineering, SCMS School of Engineering and Technology,
Karukutty, Angamaly, Kerala, India.

SUBMITTED BY
PARVATHY RAMACHANDRAN
MTC/852/24

ABSTRACT

Exponential smoothing is a versatile statistical technique used in traffic or accident analysis to forecast future trends. This study explores the application of exponential smoothing in predicting infrastructure condition, traffic flows, accident frequency and road maintenance needs. It is a time series forecasting method widely applied due to its simplicity, adaptability and effectiveness in capturing trends in accident data. This technique assigns exponentially decreasing weights to past observation, making it particularly suited for data sets with short term fluctuations. This paper explores the application of exponential smoothing in forecasting occurrence and analyzing traffic patterns, with a focus on urban environments where accident rates are often volatile. This approach not only enhances understanding of car accidents dynamics but also serves as a valuable resource for policy makers and traffic management authorities in Kerala, enabling them to implement targeted safety measures and allocate resources more efficiently.

Key words: Exponential Smoothing, Traffic flow, Accident Analysis

INTRODUCTION

Forecasting plays a vital role in understanding and mitigating the risks associated with road accidents, particularly in regions like Kerala, where an increasing population and rapid urbanization contribute to a growing number of vehicles on the road. Accurate predictions of car accident trends are crucial for policymakers, transportation authorities, and public safety organizations to implement effective preventive measures.

Many states in India is having issues related to road traffic concerns such as slow moving traffic, higher accident rates for past several years etc. The situation is getting worsened year by year due to the increasing population. In India along with the population growth, other factors such as improved financial status resulted in the increased number of vehicles. This leads to increased number of road accidents and their resulting fatalities as a growing social and economic problem. The concerned authorities in Kerala are finding it difficult to address the issues such as monsoon maintenance works of the roads and drains. The absence of street lights on most roads has added to the difficulties faced by road users. Apart from the street conditions, other issues such as human errors, over speed, lack of knowledge about rules, violation of traffic rules, vehicle conditions/unauthorized extra fittings, etc. also contribute significantly to road accidents. The World Health Organization (WHO) has reported that traffic fatalities will be the third leading cause of deaths thus worldwide by 2020. Recent reports about road accidents in India by National Transportation Planning and Research Centre (NATPAC) indicate that after Maharashtra, Kerala positioned second among different states in country with respect to the road accident rate.

According to data in 2004, the total number of road accidents reported is 41219 in Kerala and in 2005 come across to near 43000. Later the state implemented strict laws in roads, installed speed control devices/ speed breaks in roads, and also extended the road safety campaigning activities. The reported number of accidents went down due to taking immediate actions. Still when we look at the data of past three years 2020 the figures were 27877 and, coming to 2023 it becomes 48091 so it moving towards to 50K again. The recent trend is also showing the upward trend in the road accidents in Kerala. It is in this direction that this paper is prepared to study the trends, patterns and forecast of road traffic accidents in Kerala.

Exponential smoothing, a widely used time series forecasting method, offers a robust approach to predicting future data trends by giving greater weight to recent observations. Its simplicity and adaptability make it an ideal tool for analyzing the temporal patterns of car accidents, where seasonal variations, policy changes, and behavioral factors may significantly influence outcomes.

This report explores the application of exponential smoothing for forecasting car accidents in Kerala. By analyzing historical accident data, the study aims to provide insights into emerging trends and offer reliable predictions to support strategic planning and interventions. The findings of this report have the potential to contribute to enhancing road safety measures and reducing accident-related fatalities in the region.

Fig 1. Car Accident due to over speeding

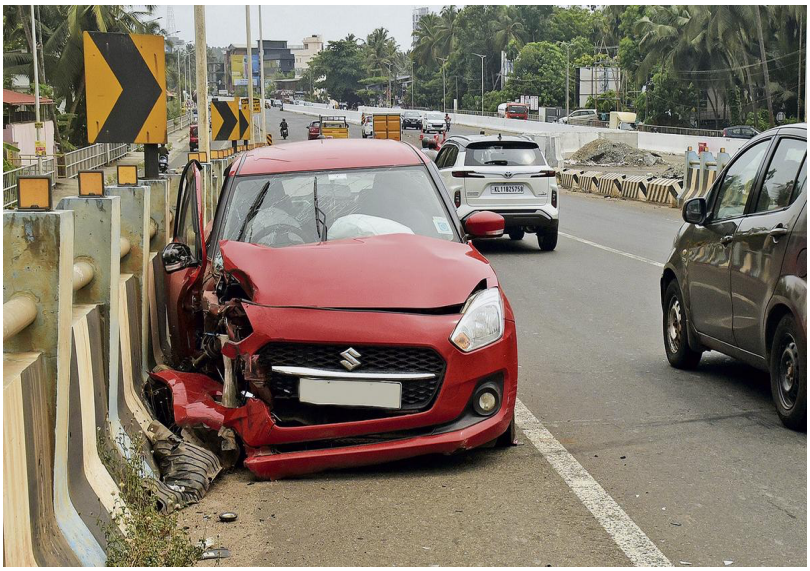


Fig 2. Car accidents due to overtaking

Fig 3. Car accidents due to rain

METHODOLOGY

Single Exponential Smoothing (SES)

The Moving Average (MA) forecasting method family includes Single Exponential Smoothing. Its other name, Exponentially Weighted Moving Average, originates from the research of Brown. Recent data will be given more weight than older data. As can be seen in Hansun and Subanar, Single Exponential Smoothing for a time series can be calculated as

$$A_1 = x_1$$

For t>1, $A_t = \alpha \times x_t + (1-\alpha) \times A_t\text{-}1$

Where,

x_t: data value at a time period t

A_t: Single Exponential Smoothing value at time t

α: a constant smoothing factor between 0 and 1

α can be calculated as mentioned:

$$\alpha = \frac{2}{n-1}$$

Error Measurements

Mean Square Error (MSE), a widely utilized forecast error measuring method by researchers that work in the time series domain. By averaging the square of the error sum, it may be found. The formula for Mean Square Error can be seen as

$$\text{MSE} = \frac{1}{n} \sum_{t=1}^{n} (A_t - x_t)$$

n : total data of time series

A_t : the real value of data

F_t : forecasted data

Data Collection

Here, we present the data gathered on car accidents in Kerala from the years 2018 to 2023, categorised by accident types and individuals involved. In this study, we try to predict the accidents intensity of Kerala a south Indian state. Therefore the data needed was collected from the Kerala Police Department which has detailed report of accidents that has occurred throughout the years in 14 districts.

Road accident details for the year 2018

	Accident Type					Persons Involved			
District	Fatal	Grevious	Minor	Non Injury	Total	Death	Grevious	Minor	Total
THIRUVANANTHAPURAM CITY	195	1880	178	53	**2306**	202	2033	714	**2949**
THIRUVANANTHAPURAM RURAL	332	2728	124	39	**3223**	342	3068	592	**4002**
KOLLAM CITY	226	1526	140	48	**1940**	241	1691	306	**2238**
KOLLAM RURAL	220	1179	110	29	**1538**	228	1299	289	**1816**
PATHANAMTHITTA	139	1190	197	1	**1527**	149	1320	456	**1925**
ALAPPUZHA	348	2571	546	24	**3489**	373	2840	1294	**4507**
KOTTAYAM	268	2023	467	166	**2924**	279	2289	915	**3483**
IDUKKI	82	808	241	51	**1182**	91	931	606	**1628**
ERNAKULAM CITY	131	1651	436	193	**2411**	141	1753	725	**2619**
ERNAKULAM RURAL	305	2650	617	13	**3585**	317	2800	1031	**4148**
THRISSUR CITY	207	1538	364	113	**2222**	218	1670	923	**2811**
THRISSUR RURAL	221	1554	338	72	**2185**	231	1695	807	**2733**
PALAKKAD	329	1456	537	89	**2411**	347	1574	1048	**2969**
MALAPPURAM	346	1677	217	183	**2423**	367	1911	690	**2968**
KOZHIKODE CITY	144	966	205	108	**1423**	154	1062	490	**1706**
KOZHIKODE RURAL	173	1210	183	108	**1674**	187	1372	549	**2108**
WAYANAD	67	404	123	40	**634**	74	445	336	**855**
KANNUR	217	1205	579	69	**2070**	233	1348	1243	**2824**
KASARAGOD	119	498	369	28	**1014**	129	571	772	**1472**
Total	**4069**	**28714**	**5971**	**1427**	**40181**	**4303**	**31672**	**13786**	**49761**

Table 1 – Collected Data

Road accident details for the year 2019									
	Accident Type					Persons Involved			
District	Fatal	Grevious	Minor	Non Injury	Total	Death	Grevious	Minor	Total
THIRUVANANTHAPURAM CITY	199	1602	154	40	**1995**	205	1762	422	**2389**
THIRUVANANTHAPURAM RURAL	325	2756	114	32	**3227**	342	3106	509	**3957**
KOLLAM CITY	216	1591	110	23	**1940**	225	1726	255	**2206**
KOLLAM RURAL	203	1221	121	33	**1578**	215	1360	323	**1898**
PATHANAMTHITTA	160	1253	208	0	**1621**	170	1384	506	**2060**
ALAPPUZHA	384	2719	517	12	**3632**	409	2956	1233	**4598**
KOTTAYAM	263	2104	431	153	**2951**	281	2391	788	**3460**
IDUKKI	100	743	234	41	**1118**	106	858	525	**1489**
ERNAKULAM CITY	144	1617	377	152	**2290**	155	1697	557	**2409**
ERNAKULAM RURAL	319	2948	718	7	**3992**	337	3078	1298	**4713**
THRISSUR CITY	203	1520	370	117	**2210**	213	1636	855	**2704**
THRISSUR RURAL	190	1597	378	87	**2252**	200	1759	968	**2927**
PALAKKAD	356	1435	539	89	**2419**	397	1568	1048	**3013**
MALAPPURAM	343	1816	229	174	**2562**	364	2055	771	**3190**
KOZHIKODE CITY	172	1062	236	127	**1597**	179	1152	445	**1776**
KOZHIKODE RURAL	193	1329	231	100	**1853**	202	1473	650	**2325**
WAYANAD	71	441	147	28	**687**	78	525	431	**1034**
KANNUR	228	1355	584	68	**2235**	243	1548	1265	**3056**
KASARAGOD	114	460	345	33	**952**	119	536	636	**1291**
Total	**4183**	**29569**	**6043**	**1316**	**41111**	**4440**	**32570**	**13485**	**50495**

Table 2 – Collected Data

Road Accident Details for the year 2020									
District	Accident Type					Persons Involved			
	Fatal	Grevious	Minor	Non Injury	Total	Death	Grevious	Minor	Total
THIRUVANANTHAPURAM CITY	107	976	95	36	**1214**	108	1024	239	**1371**
THIRUVANANTHAPURAM RURAL	241	1987	84	31	**2343**	259	2182	323	**2764**
KOLLAM CITY	187	1105	93	26	**1411**	194	1206	175	**1575**
KOLLAM RURAL	112	899	69	25	**1105**	121	982	187	**1290**
PATHANAMTHITTA	107	900	152	0	**1159**	108	987	354	**1449**
ALAPPUZHA	236	1912	361	20	**2529**	249	2071	750	**3070**
KOTTAYAM	188	1524	276	63	**2051**	208	1691	600	**2499**
IDUKKI	76	648	140	41	**905**	78	710	359	**1147**
ERNAKULAM CITY	98	1067	195	77	**1437**	101	1122	284	**1507**
ERNAKULAM RURAL	212	1936	381	1	**2530**	227	2067	805	**3099**
THRISSUR CITY	129	1030	253	52	**1464**	134	1102	530	**1766**
THRISSUR RURAL	131	997	209	64	**1401**	141	1067	500	**1708**
PALAKKAD	252	987	380	51	**1670**	273	1068	692	**2033**
MALAPPURAM	237	1229	170	148	**1784**	247	1368	460	**2075**
KOZHIKODE CITY	90	708	147	58	**1003**	91	762	250	**1103**
KOZHIKODE RURAL	141	950	144	49	**1284**	148	1061	381	**1590**
WAYANAD	47	315	85	15	**462**	48	347	246	**641**
KANNUR	167	928	373	64	**1532**	172	1059	813	**2044**
KASARAGOD	65	295	212	21	**593**	72	348	338	**758**
Total	**2823**	**20393**	**3819**	**842**	**27877**	**2979**	**22224**	**8286**	**33489**

Table 3 – Collected Data

DETAILS OF ROAD ACCIDENT FOR THE YEAR 2021									
DISTRICT	Accident Type					Persons Involved			
	Fatal	Grevious	Minor	Non Injury	Total	Death	Grevious	Minor	Total
THIRUVANANTHAPURAM CITY	112	1194	98	34	**1438**	117	1254	261	**1632**
THIRUVANANTHAPURAM RURAL	276	2289	79	49	**2693**	293	2516	353	**3162**
KOLLAM CITY	173	1238	121	20	**1552**	184	1344	303	**1831**
KOLLAM RURAL	161	1137	83	26	**1407**	170	1242	211	**1623**
PATHANAMTHITTA	131	954	191	1	**1277**	134	1071	409	**1614**
ALAPPUZHA	278	2217	407	12	**2914**	297	2432	908	**3637**
KOTTAYAM	208	1648	316	49	**2221**	214	1784	639	**2637**
IDUKKI	71	661	152	65	**949**	73	737	315	**1125**
ERNAKULAM CITY	134	1289	282	76	**1781**	141	1343	415	**1899**
ERNAKULAM RURAL	262	2311	511	1	**3085**	271	2426	1083	**3780**
THRISSUR CITY	193	1183	268	75	**1719**	201	1281	594	**2076**
THRISSUR RURAL	164	1292	263	85	**1804**	167	1392	558	**2117**
PALAKKAD	256	1174	410	69	**1909**	278	1279	870	**2427**
MALAPPURAM	284	1497	221	145	**2147**	291	1733	651	**2675**
KOZHIKODE CITY	123	944	218	92	**1377**	131	997	394	**1522**
KOZHIKODE RURAL	132	1211	241	84	**1668**	139	1348	583	**2070**
WAYANAD	51	382	85	27	**545**	54	438	185	**677**
KANNUR CITY	113	686	311	64	**1174**	122	764	563	**1449**
KANNUR RURAL	66	550	157	26	**799**	67	629	375	**1071**
KASARAGOD	74	418	305	40	**837**	85	485	610	**1180**
Total	**3262**	**24275**	**4719**	**1040**	**33296**	**3429**	**26495**	**10280**	**40204**

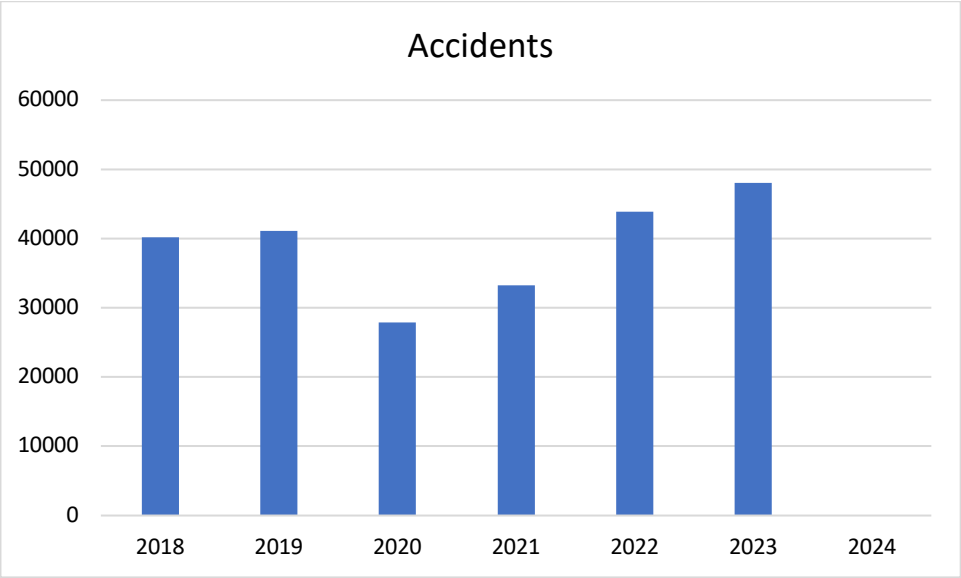
Table 4 – Collected Date

DETAILS OF ROAD ACCIDENTS FOR THE YEAR 2022									
District	Accident Type					Persons Involved			
	Fatal	Grievous	Minor	Non Injury	Total	Death	Grievous	Minor	Total
THIRUVANANTHAPURAM CITY	167	1422	144	92	**1825**	171	1512	398	**2081**
THIRUVANANTHAPURAM RURAL	353	2622	179	106	**3260**	372	2860	560	**3792**
KOLLAM CITY	206	1700	148	29	**2083**	214	1836	340	**2390**
KOLLAM RURAL	199	1449	143	21	**1812**	207	1589	338	**2134**
PATHANAMTHITTA	183	1243	227	1	**1654**	198	1389	549	**2136**
ALAPPUZHA	344	2739	521	62	**3666**	365	3006	1148	**4519**
KOTTAYAM	277	2028	451	90	**2846**	290	2213	805	**3308**
IDUKKI	99	814	229	56	**1198**	103	919	673	**1695**
ERNAKULAM CITY	154	1735	381	162	**2432**	156	1819	542	**2517**
ERNAKULAM RURAL	335	2956	746	10	**4047**	351	3142	1345	**4838**
THRISSUR CITY	206	1597	453	118	**2374**	210	1727	984	**2921**
THRISSUR RURAL	194	1717	383	80	**2374**	205	1860	864	**2929**
PALAKKAD	321	1478	612	94	**2505**	348	1624	1261	**3233**
MALAPPURAM	313	2192	305	181	**2991**	320	2521	978	**3819**
KOZHIKODE CITY	189	1408	317	140	**2054**	195	1527	637	**2359**
KOZHIKODE RURAL	176	1640	250	116	**2182**	194	1842	751	**2787**
WAYANAD	57	549	136	32	**774**	67	592	292	**951**
KANNUR CITY	143	989	433	70	**1635**	149	1139	979	**2267**
KANNUR RURAL	86	740	210	43	**1079**	91	836	516	**1443**
KASARAGOD	102	566	406	45	**1119**	111	685	709	**1505**
Total	**4104**	**31584**	**6674**	**1548**	**43910**	**4317**	**34638**	**14669**	**53624**

Table 5 – Collected Data

DISTRICT WISE DETAILS OF ROAD ACCIDENTS FOR THE YEAR 2023									
	Accident Type					Persons Involved			
	Fatal Cases	Grevious Injury Cases	Minor Injury Cases	Non Injury Cases	Total Cases	Death	Grevious Injury	Minor Injury	Total Injuries
THIRUVANANTHAPURAM CITY	132	1768	206	107	2213	137	1888	438	2463
THIRUVANANTHAPURAM RURAL	318	2813	193	112	3436	325	3076	620	4021
KOLLAM CITY	202	1748	146	40	2136	211	1918	400	2529
KOLLAM RURAL	186	1527	140	63	1916	192	1708	353	2253
PATHANAMTHITTA	190	1419	243	43	1895	197	1657	711	2565
ALAPPUZHA	355	3090	646	54	4145	377	3345	1378	5100
KOTTAYAM	264	2448	613	122	3447	277	2714	1202	4193
IDUKKI	96	846	220	71	1233	105	978	789	1872
ERNAKULAM CITY	170	1939	476	218	2803	177	2028	760	2965
ERNAKULAM RURAL	271	3125	906	23	4325	282	3332	1539	5153
THRISSUR CITY	222	1685	537	169	2613	231	1846	1183	3260
THRISSUR RURAL	197	1713	348	132	2390	208	1900	849	2957
PALAKKAD	322	1826	679	131	2958	329	1946	1259	3534
MALAPPURAM	293	2405	344	211	3253	309	2735	1066	4110
KOZHIKODE CITY	167	1527	332	168	2194	172	1640	625	2437
KOZHIKODE RURAL	144	1735	396	186	2461	160	1908	923	2991
WAYANAD	70	638	152	50	910	84	706	344	1134
KANNUR CITY	107	903	521	105	1636	117	1005	1013	2135
KANNUR RURAL	73	684	235	67	1059	78	742	468	1288
KASARAGOD	105	566	358	39	1068	112	636	692	1440
Total	3884	34405	7691	2111	48091	4080	37708	16612	58400

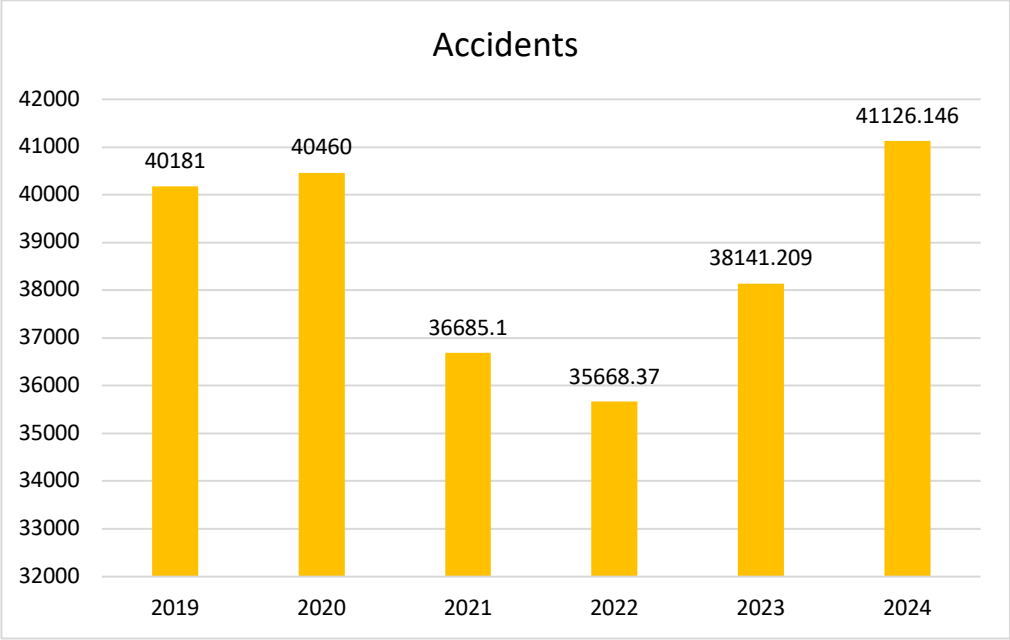
Table 6 – Collected Data



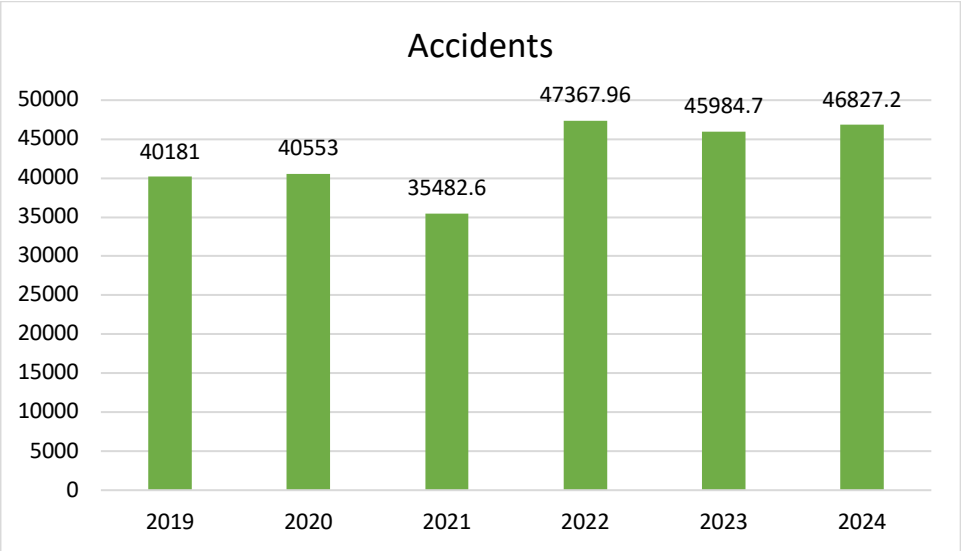
Actual results

Results

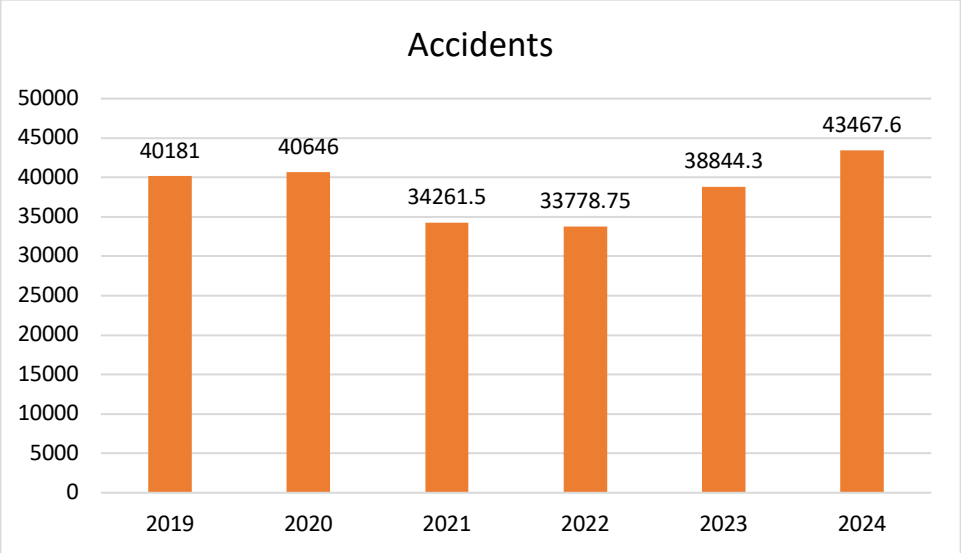
The accident forecasting results using Simple exponential smoothing can be seen in figure 1. An acute shortage of accidents in Kerala is expected in the coming year. There is considerable change in the forecasted values with changes in the smoothing factors. In our study we forecasted for three different smoothing factors 0.5, 0.4 and 0.3. Then the graph of actual no. of accidents and forecasted no. of accidents against time was plotted. Comparison of the actual annual accidents with forecasted annual accidents for the year 2024 has been done.



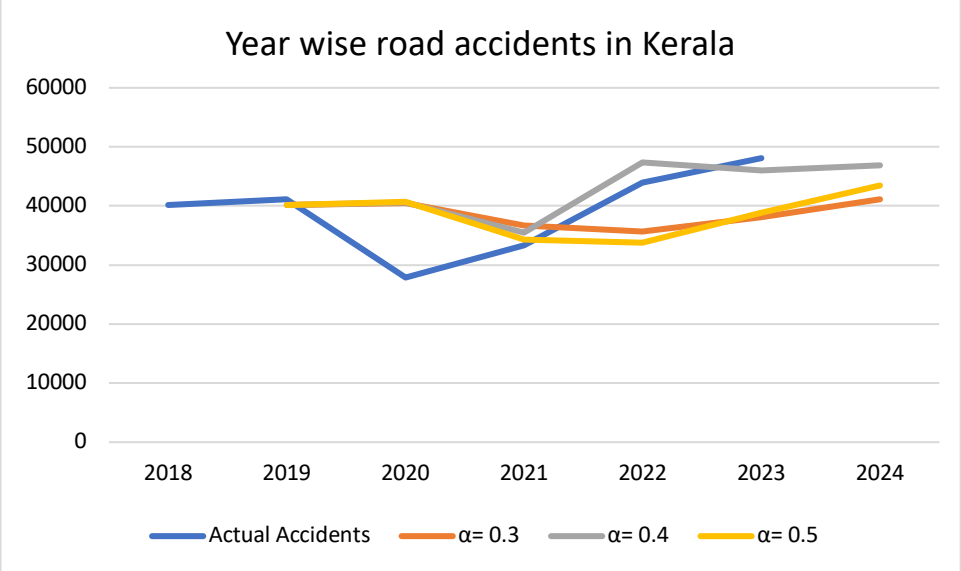
Forecasted results with smoothing factor 0.3



Forecasted results with smoothing factor 0.4



Forecasted results with smoothing factor 0.5



Actual and Forecasted accidents over the years

Analysis

Using the Simple Exponential Smoothing, the accident prediction results were effectively calculated by using Kerala's 6 years accident data from 2018 to 2023.
Additionally, we could determine the SES method's level of accident prediction accuracy use MSE. The MSE findings for each smoothing factor and the total no. of accidents data for Kerala are displayed below.

Smoothing Factor	Mean Square Error
0.5	373736562.6
0.4	395917957.1
0.3	338160913.1

The MSE value for each smoothing factor are evidently fairly high. Smoothing factor (α) 0.3 yields the value that is closest to the real value. It appears that the no. of accident prediction is not a good fit for the Simple exponential Approach.

CONCLUSION

In this work, we attempt to forecast the amount of accidents in Kerala, a state of southern India. The Kerala Police Department provided the dataset from 2018 to 2023, and we used the Single Exponential Smoothing (SES) method to anticipate the accident that may occur in 2024. The forecasting results are shown in the publication. A decrease in no. of accidents is expected in Kerala. Among the smoothing factor tested, smoothing factor 0.3 produced the most accurate results. While the no. of accidents in Kerala can be predicted using the SES approach, the accuracy of the prediction is not very high. The conclusion can be drawn from the MSE value, which is relatively high.

The following conclusions can be drawn from the foregoing findings:

- The figures for the number of accidents and fatalities are consistently increasing. This may be due to rapid expansion in motorization without adequate improvement in road safety.
- Accident rates are very low in National highway compared to other roads.
- Motorcycles/Scooters account for a large proportion of road traffic accidents. Driving without helmets causes serious injuries while traffic crashes.
- For the years 2020 and 2021, the accident rates are dipping due to the COVID-19 restrictions and Lockdown imposed by the State Government.

Suggestion

- Follow advisory speed limits.
- Be vigilant to identify and choose low-risk modes of transportation.
- Give preference to pedestrians and children while crossing the road.
- Ensure the use of helmets while travelling in scooters.
- Ensure the use of seat belts in cars.

- Realize road safety is a basic right and be aware of what is our duty to avoid crashes in road.

ACKNOWLGEMENT

I would like to show my gratitude to Dr. Sreelekha Menon, professor, SCMS school of engineering and technology, for her guidance and mentorship throughout this study.

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