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Time Series Analysis of Accidents in Chandigarh City

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ABSTRACT

The rapid increase in the loss of life through traffic accidents has created a major health and development concern. The United Nation has declared 2011-2020, the Decade of Action for Road Safety. In this paper, identification of high frequency accident locations in Chandigarh city is carried out using Geographical Information System (GIS) technology and the dependency of the said accidents is analysed in terms of time as a variable. Four years of traffic data is collected from the Chandigarh traffic police in the city. All the accident points are plotted in the geographical co-ordinate digitized map of Chandigarh integrated to a tolerance of 100m. Subsequently, collective event converts the accident point data to weighted point data and gives the icount of coincident accident locations. The distance band required for the analysis is calculated using Incremental Spatial Autocorrelation. The weighted point data and distance band is then used in the analysis of hot spot (Getis-Ord Gi*), which identifies statistically significant hot spots and cold spots. The time dependency of the identified hotspot is further checked using one-way ANOVA. The analysis carried out, (F<Fcritical), results in time dependency of accidents. Hence, the city government can enforce better regulation and safety measures to be adopted in identified hot spots during all peak hours to reduce the accident rates. Provisions for proper traffic signs and optimum traffic signals cycle should also be ensured in these locations.

Keywords: GIS; Hotspot; Road accidents.

1. INTRODUCTION

Traffic accidents claim numerous human lives yearly all over the world and is increasing at a rapid rate. It is estimated that over 1.3 million people die in traffic accidents yearly out of which 90% account to traffic accidents occurring in low and middle level income countries. In India, National Crime Records Bureau (NCRB) reported that traffic accidents claim about 135,000 deaths yearly and is considered to be the highest traffic accident frequency in the world. Traffic accident with the loss of life is also responsible for the loss of property. It proves to be a dire problem all around the world. Thus, the UN has declared the period 2011-2020 "The Decade of Action for Road Safety" with goals to halt or reverse the increasing trend of traffic accident fatalities all over the world. The city of Chandigarh is one of the early planned cities of India and is also one of the cleanest city in India. According to the 2011 census, Chandigarh's population is 1,055,450 with a population growth rate of 17.19% during the period 2001 to 2011. The increase in population has also led to an increase in the number of vehicles owned and is declared to be the city with the largest number of vehicles per capita all over India. To reduce traffic accident related deaths, traffic accident countermeasures needs to implemented which necessities traffic accident analysis. Thus it becomes imperative to identify the accident-prone areas and existing accident pattern in the city.

The analysis of traffic accident can be done using various statistical analysis. In this paper, we have used Geographic Information System (GIS) to analyse the traffic accidents in Chandigarh City. For the identification of accident-prone areas, data of accidents need to be collected. To identify the accident-prone point, Getis-Ord Gi* analysis is performed with the available accident data. After the identification of the spot, it is necessary to identify variables responsible for the accident occurring in the said points. From the count, obtained to perform the Getis-Ord Gi* analysis, areas exceeding 16 accidents in all four years are selected. The areas are then further analysed to check if the accident occurring is time dependent or not, i.e., whether most number of accidents occur during the night hours. The dependency of time as a variable is checked using ANOVA analysis. The result obtained can be used in the preparation and implementation of traffic accident management policies aimed to reduce traffic related accidents.

2. LITERATURE REVIEW

Geographic Information System (GIS) in the recent years has been popular for its application in road transportation. Its array of applications includes traffic modelling, accident analysis, highway management and route planning. GIS has proved its relevance in the field of transportation and traffic engineering with its ability

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to link the spatial data with its attribute and perform statistical analysis promoting easy and fast decision making ability and in many cases cost effective. GIS makes the data easily comprehensible. The identification of accident spot and its analysis using GIS has been carried out by many researches and agencies. Erdogan *et al.* 2008 used GIS as a management system for accident analysis and determination of hot spots in Turkey. The application is widely used in different divisions including road safety analysis and management. Mahmud *et al.* 1998 used GIS to visualize accident data on a set of criteria and incorporate multiple experts and knowledge base into the system. GIS application along being used to identify accident spots is also extensively used to identify the cause or factors responsible for the accidents occurring at a specified location. Prathap, *et al.* (2011) used GIS technology for data collection and its analysis. The data from the live traffic analysis was used to come up with a cost effective method to mitigate congestion. Anderson (2008) used GIS to identify high density areas of accident in London creating a clustering technique which determined indicators likely to be present at that time. Arampatzis *et al.* (2004), modelled a GIS based decision support system for planning urban transportation policies. DSS (Decision Support System) working on three levels namely transportation network analysis, energy consumption and pollutant emissions and several selected policies, was integrated in a GIS system to analyse and evaluate different policies. With multitudes of use in the engineering world, the knowledge and the technological improvement of GIS in the coming future is vital for the development in the advancement of transport engineering.

3. METHODOLOGY

The information of accidents occurring in the city can be obtained from all the police stations located within the city. For this project, the data of traffic accidents was collected from Chandigarh traffic police. The data during the year 2011-2014 is utilized in this paper. To plot the accident points, topological map of India is required. The study area, the city of Chandigarh, comprises four topological map scaled 1:50000 obtained from the Survey of India. The geo-coordinates are then used to digitize the map. A geo-database is created named Chandigarh City. Since, we need to identify various regions with frequent traffic accidents, only the roads needs to be digitized along with the borders of the city. Incident points can be plotted in ArcGIS easily as a point data if X and Y co-ordinates are available. The latitude and longitude of the accident points are converted into decimal degrees. The data in excel format is then directly linked to ArcGIS which plots all the points using longitude field as designated X co-ordinate and the latitude field as the Y co-ordinate. All the points are plotted and visible in the map.

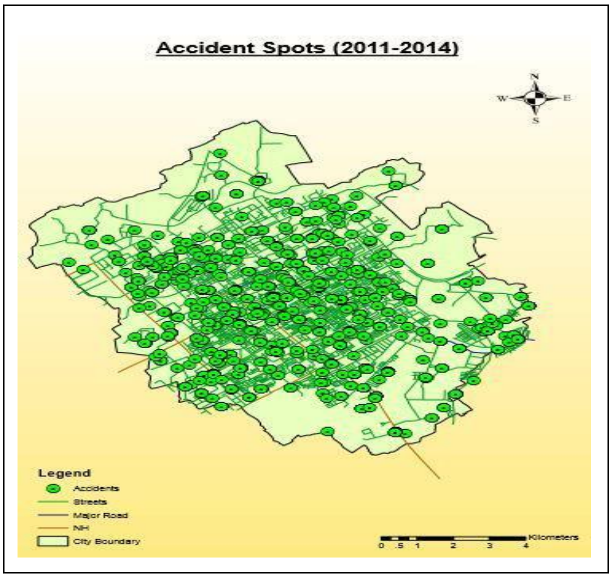

Fig. 1: Accident spots in chandigarh (2011-2014).

The co-ordinates of the accident points, as the data is in text format, were obtained with the designated name of place as a reference. This lessens the accuracy of the data. Thus, the above data was integrated. In ArcGIS, integrate tool can be used to snap points within the specified XY tolerance. The integrate tool changes the data. In this case, a tolerance of 100m is used. The integrate tool used snaps all the points within 100m tolerance. The tool, collective events is then used to convert accident points to weighted points required to perform the Getis-Ord Gi*h hot spot analysis. The changed data obtained after the use of integrate tool is used as an input file in the collective events tool. Collective events result gives the count "icount" of accidents at each unique location. The result obtained is divided into four classes. To perform the Getis-Ord Gi*h hot spot analysis, we require as z-value and an appropriate distance bandwidth. Icount from collective events is used as the z-value. A different tool, Incremental Spatial Autocorrelation is used to obtain the distance bandwidth. This tool measures spatial autocorrelation for a series of distances and creates a line graph with those distances and their corresponding z-scores. The significant peak z-values gives us the distance of pronounced spatial clustering. Only one peak was obtained from the graph and thus the maximum peak obtained at the distance is used as the distance bandwidth in the Getis-Ord Gi*h hot spot analysis. To call a spot statistically significant, not only should it have a high value but should also be surrounded by other features with high value. The local sum for a feature and its neighbour is compared proportionally to the sum of all features; when the local sum is very different from the expected local sum, and the difference too large to be random chance, a statistically significant z-score results. From the result, the count where accidents in all fours years are exceeding 16 is selected for further analysis.

Hot spot analysis has given us the cold and hot spots of the city as displayed in the map. The cold spot represent low cluster areas and the hot spot represent high areas. Total 16 hot spots are identified. The attributes of the said 16 points are further analysed and the time dependency of all the accidents occurring in the 16 points is checked. The time dependency is checked using ANOVA. The accident data is further analysed to study the accident trend prevalent in the city.

4. RESULTS

From the hot spot analysis, 16 points out of 248 points have more than 16 accidents occurrence in four years. Therefore 16 points constitute more than 6.4% of the total accident points. The time dependency of the hot spot points is done using ANOVA. In this paper, F<Fcritical, therefore the accidents occurring in the specified points are time dependent.

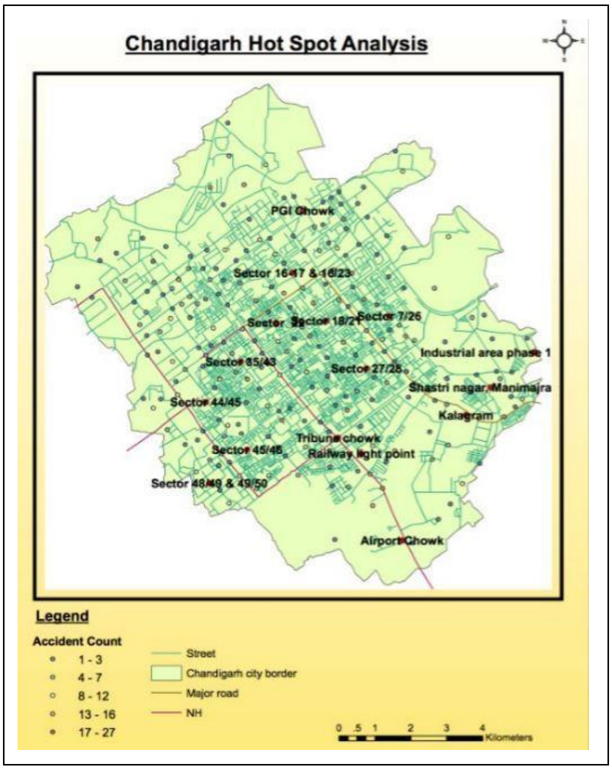

Fig. 2: Accident spots exceeding 16 accidents in four years.

Table 1. Summary Anova single factor.

Variance	Average	Sum	Count	Groups
0.9523	1.5714	11	7	01:00-03:00
0.0000	1.0000	4	4	03:00-05:00
0.0000	1.0000	3	3	05:00-07:00
0.8106	1.5833	19	12	07:00-09:00
3.0727	2.4545	27	11	09:00-11:00
2.0666	2.2666	34	15	11:00-13:00
1.2954	2.2500	27	12	13:00-15:00
0.9102	2.0769	27	13	15:00-17:00
4.1297	2.4375	39	16	17:00-19:00
1.3809	2.6667	40	15	19:00-21:00
2.5625	3.1875	51	16	21:00-23:00
2.6287	2.5833	31	12	23:00-01:00

The traffic accident data was analysed to study the ongoing traffic accident trend. From the data, it is seen that the month of July has the highest accident frequency in all four years, which amounts to 12% of total accidents. Other months with high accidents frequency are October and November accounting 11% and 9% of total accidents in all four years (2011-2014) respectively.

Hours 21:00-22:00 and 22:00-23:00 is when most fatal accident occur. The data is the compilation to all the accidents occurring in all four years. Fig. 3 depicts that 2011 had the maximum number of accidents. We can also infer that 2014 had higher cases of fatality in accidents ad compared to the total number of accidents in the same year. Although the data shows a decline in traffic accident trend, it is almost impossible to believe so considering the increase in the number of vehicles and Chandigarh being the city with largest number of vehicles per capita all over India. It should also be kept in mind as mentioned before that many of the cases are not registered and since the registration is also textual, the accuracy of the data depletes.

Table 2. Anova table.

$F_{Critical}$	P Value	F_{Cal}	MS	Df	Sum of Sq.	Sources of Variation
1.866654	0.06973	1.75164	3.5045	11	35.5500	Between Groups
			2.0007	124	248.0896	Within Groups
				135	286.6397	Total

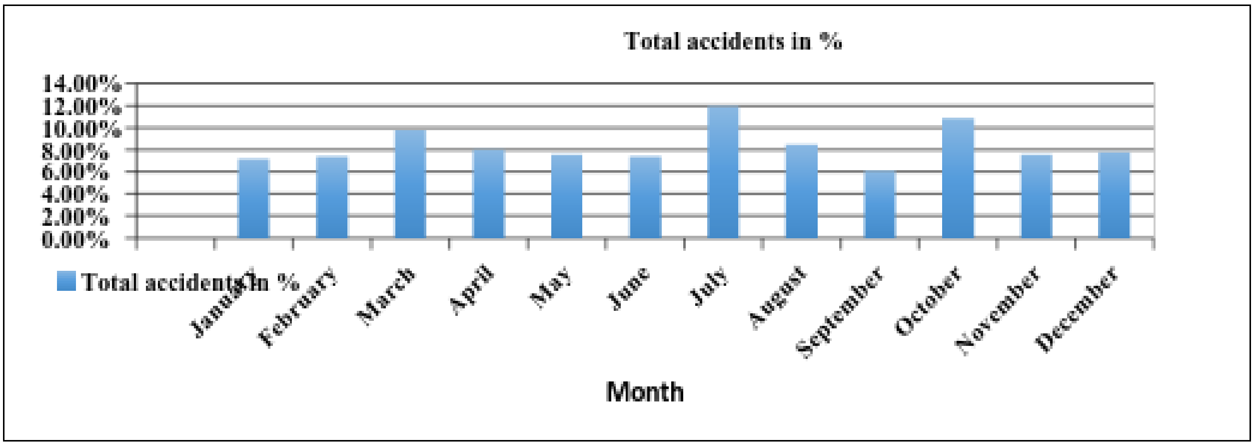

Fig. 3: Monthly variation of accidents.

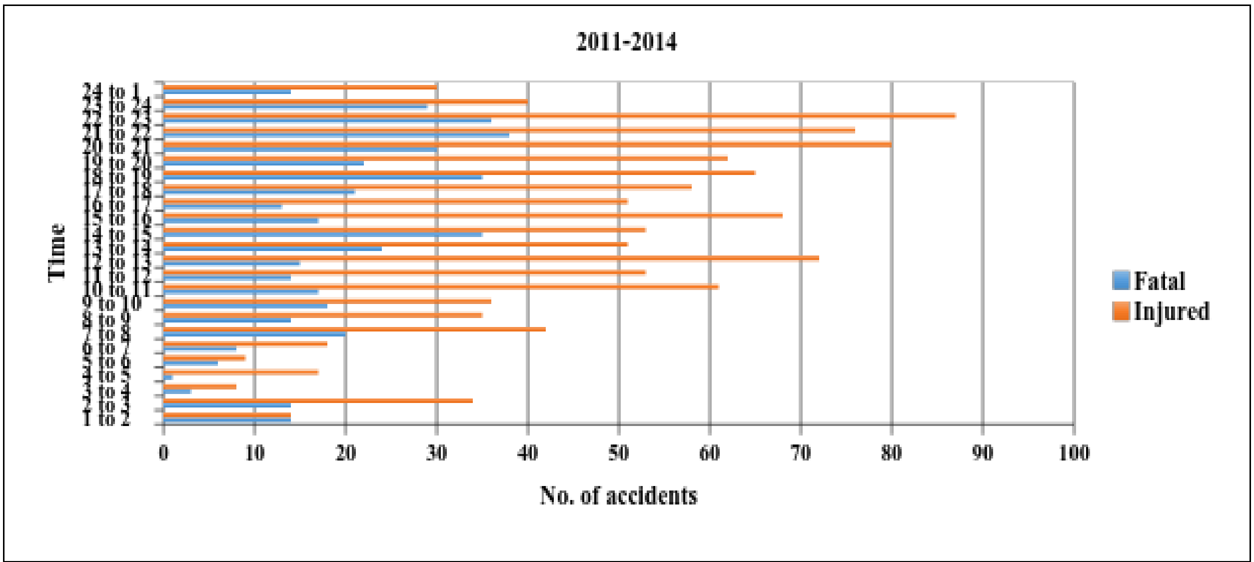

Fig. 4: Hourly variations of accidents.

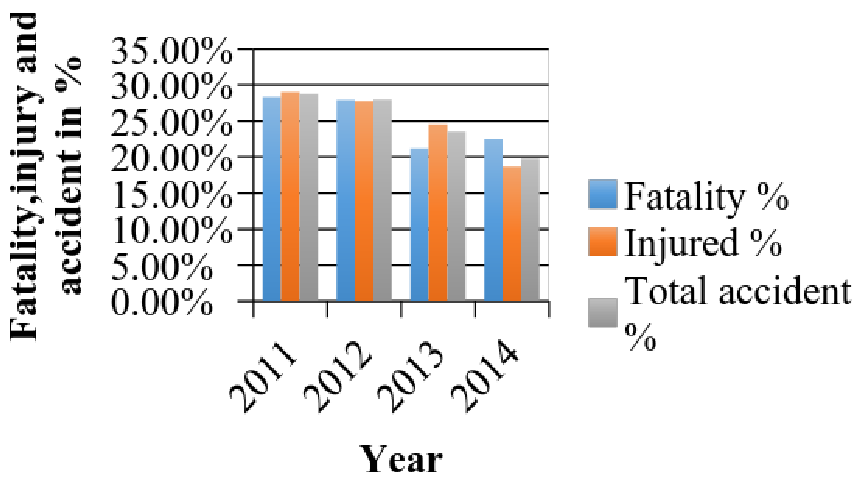

Fig. 5: Fatality, injury and accident variation (2011-2014).

5. CONCLUSION

Accidents prove to be a bane all around the world. The loss of life is through road accidents needs to be reduced in the coming years especially with the rapid increase in the number of vehicles on the road. The study of accident data is a vital source for identifying and implementing any measures to reduce the deaths due to accidents. In this project, the places exceeding 16 accident counts in all four year are also identified in the layout map. 16 points of 248 points have more than 16 accident occurrences in four years, i.e., they constitute 6.4% of the total accident points. Moreover, ANOVA analysis tells us that the accidents occurring in the said place is time dependent, occurring mostly during night hours. From all the above inferences, some precautionary methods the government can adopt to reduce the numbers of accident are as follows:

- Provisions for proper traffic signs and optimum traffic signals cycle should also be ensured in these locations.
- Increase the number of traffic personnel during night hours for better regulations.
- Pedestrian flow should be regulated properly during all hours to reduce accident.
- Proper installation of all traffic signals in all intersections and other minor roads.
- Regulation in the speed of vehicles.
- Strict regulation while issuing driver's license must be adopted by concerning traffic personnel.
- In India, traffic is mixed. Thus, it becomes more imperative to strictly regulate such traffic and make sure the traffic rules are being followed.
- Strict punishment and fines should be carried out to traffic defaulters so the traffic rules are adhered to in the future.
- Proper object marking should be done for better visibility in the dark hours.

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CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

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