The Use of Object-Oriented GIS for Traffic Police Services in ArRass City

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Abstract

The expansion of a nation's road and transportation systems is crucial to that nation's economic development. Social interaction and economic growth happen because of these road networks within and between regions. It is among the most important ways to measure an area's social, economic, and business growth. This research deals with the problem of applying object-oriented GIS to the traffic road network in ArRass City. In contrast, it investigates the flexibility of object-oriented GIS in the analysis, measurement, and processing of traffic congestion based on data on traffic and spatial and temporal information in different ways. The planning and spatial evolution of the road networks in the study area were examined. The study used a descriptive-analytical approach by collecting data and information through various methods (reference books, periodicals, and websites). Also, through a primary method (the design question method), it was evident from the discussion that the new system of object-oriented GIS can be an essential reorganization of roads and traffic. While handling this system and the problems plaguing traffic management, this new system helps avoid all the difficulties that have been pending for many years within ArRass City. The study results show an immediate and urgent need for improvements and required changes in the road network, such as the construction of new roads. To increase the density of the road network, which gives another important and better prediction for the standards of the road network in ArRass City.

Keywords: Object-Oriented GIS; Traffic police Services; ArRass City; Global position system (GPS); Digital Map

استخدام نظم المعلومات الجغرافية كائنية التوجه لخدمات شرطة المرور بمدينة الرس

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المستخلص

يعد توسيع أنظمة الطرق والمواصلات في أي دولة أمرًا حاسمًا للتنمية الاقتصادية لتلك الدولة. يحدث التفاعل الاجتماعي والنمو الاقتصادي بسبب شبكات الطرق هذه داخل المناطق وفيما بينها. إنه من بين أهم الطرق لقياس النمو الاجتماعي والاقتصادي والتجاري للمنطقة. يتناول هذا البحث مشكلة تطبيق نظم المعلومات الجغرافية كائنية التوجه على شبكة الطرق المرورية بمدينة الرس. في المقابل، فإنه يبحث في مرونة نظم المعلومات الجغرافية كائنية التوجه في تحليل وقياس ومعالجة الازدحام المروري بناءً على البيانات المتعلقة بالحركة والمعلومات المكانية والزمانية بطرق مختلفة. تم فحص التخطيط والتطور المكاني لشبكات الطرق في منطقة الدراسة. استخدمت الدراسة المنهج الوصفي التحليلي من خلال جمع البيانات والمعلومات بطرق مختلفة (المراجع والدوريات والمواقع الإلكترونية)..... كان واضحًا من المناقشة أن النظام الجديد لنظم المعلومات الجغرافية كائنية التوجه يمكن أن يكون إعادة تنظيم أساسية للطرق وحركة المرور. أثناء التعامل مع هذا النظام والمشكلات التي تعاني منها إدارة حركة المرور، يساعد هذا النظام الجديد على تجنب كل الصعوبات التي ظلت معلقة لسنوات عديدة داخل مدينة الرس. تظهر نتائج الدراسة حاجة فورية وملحة للتحسينات والتغييرات المطلوبة في شبكة الطرق، مثل إنشاء طرق جديدة. زيادة كثافة شبكة الطرق مما يعطي تنبؤًا آخر مهمًا وأفضل لمعايير شبكة الطرق في مدينة الرس.

الكلمات المفتاحية: نظم المعلومات الجغرافية كائنية التوجه؛ خدمات شرطة المرور؛ مدينة الرس؛ نظام تحديد المواقع العالمي (GPS)؛ خريطة رقمية

1. Introduction:

Countries pay special attention to their road networks because they are an essential part of the infrastructure that helps the economy grow and provides security and strength.(Ouma, 2022, Qtiashat *et al*., 2018) Road networks in cities are a conventional form of transportation that significantly interest many study communities.(Bando et al., 1995, Wang *et al*., 2012) With the city's population and car ownership expected to continue rising, traffic congestion is a pressing issue that must be addressed through research into urban road traffic networks. Transportation infrastructure is a human activity closely tied to place, highlighting its relevance in population activities. To make the idea of movement real, we need to build roads that go from one place to another. Transportation activities and decisions about how to use land often have a lot in common. For example, the way land is used and how easy it is to get to different places and destinations, which in turn affects how people travel and how much they travel. The road system, a component of the transportation system, is a particular land use that raises demand for transportation.(Ahmed and Mahmood, 2021) The vehicle is integral to land use planning because it makes it easy for people and things to get where they need to go. It also connects financial services to the transportation system and infrastructures, like bus stops, gas stations, and places to park cars. Poor roads and infrastructure in Ar Rass city caused traffic jams and made it harder to get from one place to another, which is the most goal of the transport network. In general, trips took longer and required more work because the way land was used changed. This problem can be solved by rethinking land use and looking at other plans.(Qtiashat *et al*., 2018) The most significant development in GIS over the past ten years has been implementing the concept of object-oriented GIS. Data abstraction, which typically deals with algorithmic programs involving complex data structures, has been linked to the advent of object-centered design. The fact that the data model is now object-centric rather than geometry-centric, as it was in the past, is perhaps the initial advantage of this field. As a result, the representation of reality no longer includes different geometric shapes connected to specific tables, but rather the phenomena are represented as they are, with all their attributes, interactions, and relationships, no

matter how complex, a single object category in the database.(Golledge, 1996 and Algamdy, 2006).

Object-Oriented Programming views a software system as a collection of "objects" with an identity, a state represented by member variables, and a behavior expressed by methods (Bellaachia, 2016). Instead of functions and procedures, OOP uses objects. Classes group items. Most modern programming languages, such Java, C/C++, and PHP, are object-oriented. Every computer technology field uses object-oriented concept. Object-Oriented technology benefits more than only developers. IT professionals are applying the technologies. That's why we hear so much about Object-Oriented Database Management System (OODMS), OOPL, OOSD, OOSA, OOGIS, and others. Geographic Information System models complicated objects using object-oriented technology. GIS data models have three forms: vector data models portray geography as points, lines, and polygons; raster models as cell matrices that hold numeric values; and the Triangulated Irregular Network (TIN) model as sets of contiguous three-dimensional coordinates (x, y, z) arranged in a network of non-overlapping triangles. OOP implements object notions immediately rather than mimicking them with older languages . TIGRIS, Smallworld GIS, GeoStar, and Laser Scan's GAE are examples of object-oriented systems. (OnuF *et al.*, 2016)

1.1 Objectives:

1. To investigate the role of GIS in the context of load, measure, and manage traffic congestion based on traffic, location, and time on different highways.
2. To evaluate of the system's incorporation into traffic enforcement and response to the needs of owners of both public and private cars about road conditions and traffic congestion at specific locations and times.
3. To figure out how well the system can direct transportation by gathering spatial and temporal data and information and figuring out the best way to get from one site to another in the city quickly and with less traffic. We should evaluate this in conjunction with the previous two steps.

2. Literature Review

2.1 The Role of Object-Oriented Programming (OOP) in Modeling of Geographic Information Systems (GIS)

When creating new technologies for software development, software developers can no longer ignore the geographic information system (GIS) market due to its enormous growth in popularity. The idea of object-oriented programming (OOP), which includes GIS and software modeling in general, has completely changed the software development business. This article describes how to model a GIS program using the ideas found in Object-Oriented Programming Languages (OOPLs). The report dissected the ideal characteristics of GIS software using secondary source materials and a case study approach to assess the applicability of OOP in GIS modeling. Additionally, current GIS Modeling software features were examined rigorously and discovered to use a number of OOP principles and methodologies. ArcGIS, a GIS program, was used as a case study to demonstrate how closely GIS software models resemble OOP implementation languages like C++, Java, and C#. The study found that OOP concepts were particularly applicable to GIS modeling, even though several GIS-related issues were not yet entirely resolved by current software. (OnuF *et al*., 2016)

2.2 Object-oriented data model of the municipal transportation

The issue of adequate transportation is consistently one of the primary challenges that every major city throughout the world must confront. Using geographic information systems (GIS) to manage municipal transportation is rapidly becoming an essential trend. Additionally, the data model serves as the foundation for the transportation information system. The design of the system must give careful consideration to the data's arrangement as well as its storage. In addition to being able to fulfill the need that the transportation navigates, the data model must be capable of producing pleasing visual effects and of managing and maintaining the information pertaining to traffic. In object-oriented theory and practice, a road is broken up into segments and intersections at strategic points along its length. This study analyzed the driveway, marking, sign, and other transportation facilities, as well as their relationship with the segment and intersection, and it constructed

the municipal transportation data model that is adequate to meet the demand of vehicles in terms of navigation, visual, and management. In addition to that, the study organizes the many sorts of transportation data. The exercise demonstrates that this data model is capable of meeting the requirements imposed by the application used by the traffic control system. (Yuqing *et al*., 2008)

2.3 Identification And Analysis of the Recreational Behaviour Forms and the Needed Recreational Space Using the Integrated Spatial and Object-Oriented Gis: Concepts and Statements

This paper is about how to measure and look into changes in how people spend their free time and how much space they need to do so in Polish seaside recreation areas over the past few years. Spatial information is an important part of figuring out what people do for fun and how much space they need to do it in. So, we think that integrated object-oriented GIS and Decision Support Technology should include all spatial information. In this paper, we argue that the existing theoretical approaches, which are based on descriptions and technical details, do not give directions for how it should be used and how it should be judged. They don't try to explain the processes that spatial information goes through or come up with good data models. Object-oriented structures and ideas from expert systems are being used in new ways to approach GIS, and they will help people understand GIS more and more. For representing spatial phenomena, it's not crazy to think that the most important thing is to use a data model or object-oriented model that closely matches the user's idea of the geographic object. We've found that most Polish users in this field can't directly get the information they need. So, they have to use methods and techniques like SWOT analysis that can't be found in GIS. Based on what we've seen, the identification and analysis of recreational behavior and the required recreational space should be defined as a system approach in which: I recreational space requires an object, (ii) the state of recreational space is defined by the set of values of recreational space features, and (iii) the utility of the recreational space is defined by a set of features. In the presented method, the features/utilities matrix of the recreation space and the computer map are used to figure out and analyze how people use the space for recreation. For such a system to be built, there need to be a lot of organizational changes. It is shown that in many GIS

applications, organizational factors, not technical ones, determine their future and make way for new spatial analysis techniques. (Kubiak *et al*., 2023)

3.Materials and methods

Object-oriented GIS analysis tools were used to determine land and road use patterns and describe their characteristics. Using methods like surveys, statistical space analysis, and areas' topographical studies. This includes the best way to use land and how to evaluate it to figure out how cities will grow in the future and the role of the road network in the study area, which helps solve the problem. The research method depends as follows:

- A description and compilation of the data.
- organizing and presenting the data.
- A description of the data.
- Data analysis and decision-making.

1.2 3.1. Location of the Ar Rass city

Ar Rass is one of the cities of the Al-Qassim Region in the Kingdom of Saudi Arabia. It covers an area of about 1600 square kilometers. Ar Rass city has a perfect geographical location, as it is located in the middle of latitudes 25–52 and longitudes 31–43, and it has been a known city since ancient times. The city of Ar Rass is followed by many of the small regions and known villages. I consider it a cultural and commercial center of the surrounding Badia of the presence of the markets, retail centers, civilization, and institutes.(Alkhalifah and Alshwesh, 2019) About 385 kilometers separate Ar Rass City from Riyadh, the country's capital. (Aageeb, 2019) Figure 1 shows the location of the city. Figures 2 and 3, respectively, show the layer of administrative boundaries of the city’s neighborhoods and the road network. Figure 4 shows the merging of the two layers of administrative boundaries of neighborhoods with the layer of the road network. Figures 5 and 6 also show the tables of road names and the names of the city's neighborhoods within the system.

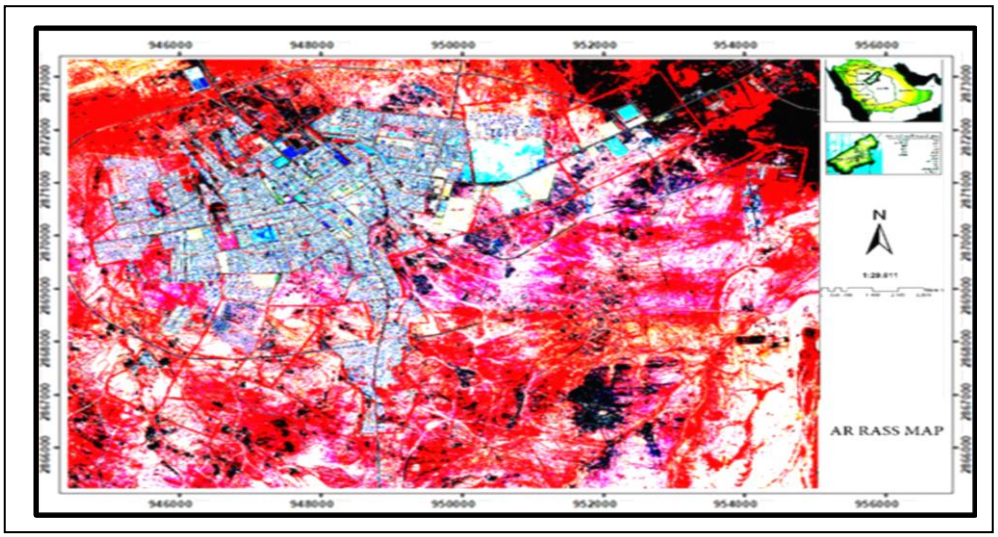

Figure 1. Basic Map , Location Map of the Ar Rass City

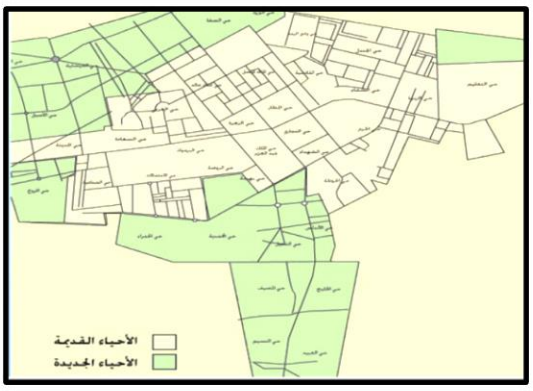

Figure 2. Neighborhood boundaries

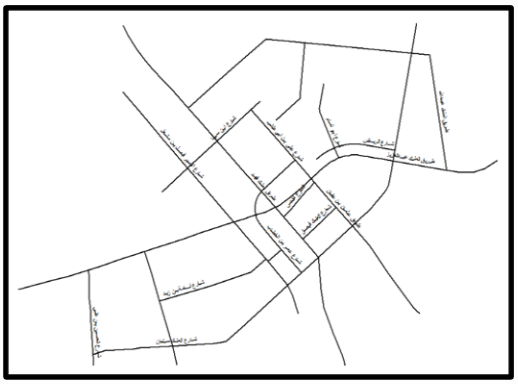

Figure 3. Roads

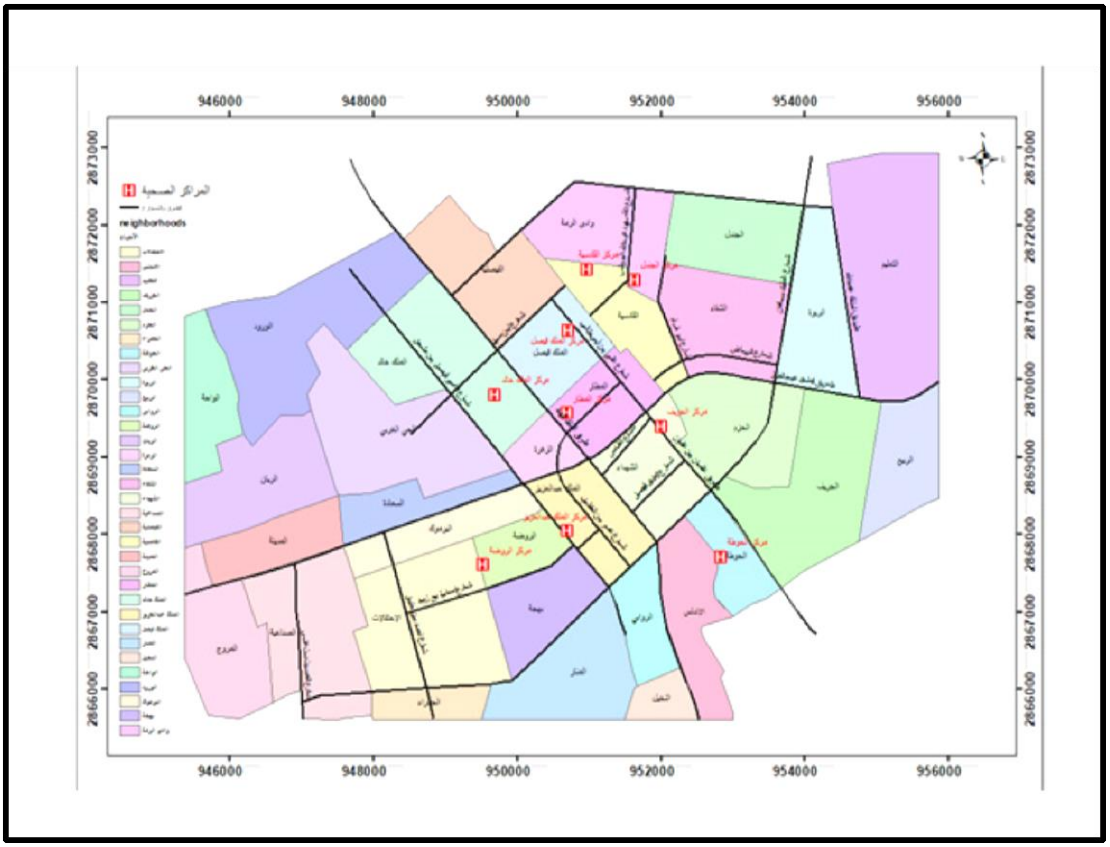

Figure 4. Layers of roads & Neighborhood boundaries

3.2. Routes

Ar Rass roads are paved, and there is adequate and adequate lighting. To enhance traffic flow and people's mobility, the Municipality of Ar Rass is currently engaged in a project called "structural streets." Along the path taken by Prince Faisal bin Meshaal, the project will link the Northern Ring Road to the Southern Ring Road. The municipality is working to permanently connect the internal Southern Ring Road, which is currently used to connect the Eastern Ring Road to the Western Ring Road.

Table

Streets

FID	Shape *	StreetName	NameAR
0	Polyline	King Fahd Road	طريق الملك فهد
1	Polyline	King Abdulaziz Road	طريق الملك عبدالعزيز
2	Polyline	Prince Faisal bin Mishal St	شارع الأمير فيصل بن مشعل
3	Polyline	King Salman Street	شارع الملك سلمان
4	Polyline	Othman bin Affan Road	طريق عثمان بن عفان
5	Polyline	Ibn Sina Street	شارع ابن سينا
6	Polyline	Ali Bin Abi Talib Street	شارع علي بن أبي طالب
7	Polyline	Al Quds street	شارع القدس
8	Polyline	King Faisal Street	شارع الملك فيصل
9	Polyline	Omar bin al-Khattab Street	شارع عمر بن الخطاب
10	Polyline	Ahmed Bin Hanbal Street	شارع أحمد بن حنبل
11	Polyline	Osama Bin Zaid Street	شارع أسامة بن زيد
12	Polyline	Riyadh Street	شارع الرياض
13	Polyline	Omar Bin Abdul Aziz Stree	شارع عمر بن عبدالعزيز
14	Polyline	Abu Tammam Street	شارع أبو تمام
15	Polyline	Al Hussein Bin Ali Street	شارع الحسين بن علي
16	Polyline	King Abdullah Road	طريق الملك عبدالله
17	Polyline	Al Shaheed Abdullah Al Ho	شارع الشهيد عبدالله الحوشا

Figure 5. Table of roads.

Table

neighborhoods

FID	Shape *	Id	Name	NameA	Population	CentersNum
0	Polygon	0	King Khaled	الملك خالد	2626	1
1	Polygon	0	King Faisal	الملك فيصل	3956	1
2	Polygon	0	Almatar	المطار	7001	1
3	Polygon	0	alqadisia	القادسية	1090	1
7	Polygon	0	Wadi Rumah	وادي الرمة	3074	1
20	Polygon	0	Alhotah	الحوطة	1833	1
27	Polygon	0	Alshohda	الشهداء	5459	1
28	Polygon	0	King Abdulaziz	الملك عبدالع	4508	1
32	Polygon	0	Al ruwdah	الروضة	5367	1
4	Polygon	0	alshifa	الشفاء	2577	0
5	Polygon	0	alhazm	الحزم	2578	0
6	Polygon	0	Al Faisaliah	الفيصلية	45	0
8	Polygon	0	al gandal	الجندل	201	0
9	Polygon	0	alrabuah	الربوه	1407	0
10	Polygon	0	altaelim	التعليم	103	0
11	Polygon	0	Al wuroud	الورود	233	0
12	Polygon	0	Waha	الواحة	0	0
13	Polygon	0	Al-Rayyan	الريان	68	0
14	Polygon	0	Al Murooj	المروج	26	0
15	Polygon	0	alsinaeia	الصناعية	0	0
16	Polygon	0	alhamra	الحمراء	6	0
17	Polygon	0	Almnar	المنار	446	0
18	Polygon	0	alnakhil	النخيل	867	0
19	Polygon	0	alaindilus	الاندلس	367	0
21	Polygon	0	aljarif	الجريف	173	0
22	Polygon	0	alrbye	الربيع	0	0
23	Polygon	0	al gharbi	الحي الغربي	2150	0
24	Polygon	0	Al-Medina	المدينة	981	0
25	Polygon	0	alsaeada	السعاده	3008	0
26	Polygon	0	Alzahrh	الزهره	5796	0
29	Polygon	0	alrawabi	الروابي	2464	0
30	Polygon	0	alyarmuk	اليرموك	3091	0
31	Polygon	0	alaihtifalat	الاحتفالات	1912	0
33	Polygon	0	Bahjh	بهجة	3822	0

1 (0 out of 34 Selected)

neighborhoods

Figure 6. Table of neighborhoods.

3.3. Population and demographic indicators

Table 1. Population of Ar Rass city

City	Population								
	Saudi			Non-Saudi			Total		
	Males	Females	Total	Males	Females	Total	Males	Females	Total
Ar Rass	42104	42187	84291	18626	6634	25260	60730	48821	109551

(Statistics, 2022)

The method involves using GIS to evaluate the road network in the study area. For a GIS-based evaluation of an urban road network, you must collect the data sources, digitize the web, build a transport network database, extract the network structure, and so on. In this study, Arc GIS 10 was used. These data came from different places, such as the titles of roads and intersections, the number of people living there, and the number of vehicles. There were also detailed data, like sector maps for Ar Rass town with a scale of 1:1000, maps of basic design with a ranking of 1:600,000, and satellite images (Quick Bird U.S. Satellite) with an accuracy of 60 cm. All the roads, including main roads, streets that connect to other routes, and local streets, were digitized from the satellite image. Also, all the lengths needed have been measured.

3.4 . Spatial Statistical Analysis

We used the following stages as the foundation for the statistical study of the road network.

1- Determine the density of the city's road system in relation to its size.

The density of the roads is calculated by multiplying the length of the roads by the city's area and dividing the result by 100.

$D=(\sum L/S) *100\%$.

D = Density .

$\sum L$ = Length.

S = Area .

2- figuring out how dense the road network is in relation to how dense the population is. that the population is the most important factor in how well the road system works and how easy it is to get to for business.

D=(∑L/P) *10000

D = Density

∑L = Length

P = Population

3- Road density as a percentage of total vehicles:

D = (∑L/V) *1000

D= Density

∑L = Length

V= Vehicles

4- It is possible to compute the average number of people per car.

M = P/VN

M= mean occupants per vehicle

P= population

VN= Vehicle number.(Ouma, 2022 and Qtiashat *et al*., 2018)

Utilizing the Neighborhood Link Method, the distribution pattern of the roadways was examined. The continuous quantitative criterion used to determine the road network's spatial distribution serves as the basis for this measurement.(Li *et al*., 2016)

GIS software was utilized to analyze statistical factors. To measure the real distance between each station and the adjacent station to determine the spatial distribution pattern of the road network.

$$R=2D \text{ X } \left(\frac{N}{A}\right)2 \quad \mathbf{1.3}$$

R= Value of a local link

D= Actual distance between stations

N= number of stations on the road network

A= Area.(Li *et al*., 2016 and Ouma, 2022)

1.4 4. Results and Discussions

The analysis is carried out by building layers based on the information supplied on the map of the area of study. Four layers separate each layer; however, the road layer, which stands for the layer that contains the routes, connects the layers. Considering the average speed of roads and the amount of time needed to find the best way between two spots, such as police and accident sites, as well as hospitals, The classifications contain tables of their results from statistical processes, including traffic streets that have been classed as most severe and as cases of injury, whether an injury has resulted in death, and other categories.

4.1. Classification of streets :

The streets that are most likely to have accidents in the following order

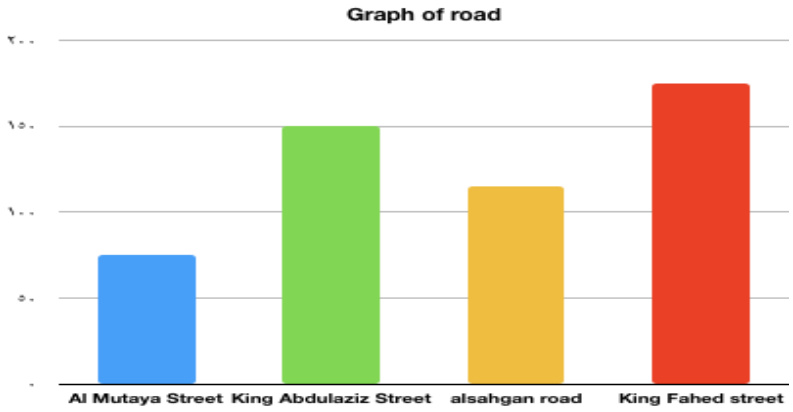

Figure7. Gravity-based classification of streets

The age groups driving the vehicles are classified into several types, as follows:

Table 2. The age range driving the vehicles

Division	Age range
A	under 18 years old
B	18-30
C	30-40
D	40-50
E	50-60
F	Greater than 60

4.2. Classification of months most traffic accidents

In this category, accidents were divided according to their occurrence in the month observed, as shown in the figure below

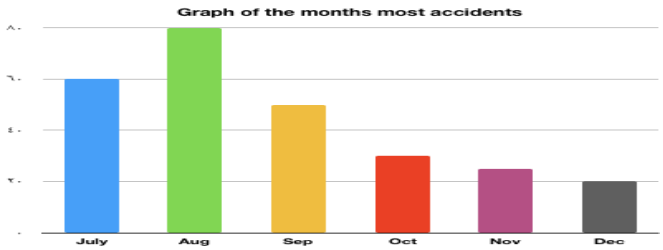

Figure 8. Classification of months most traffic accidents

4.3. Accident classification in terms of the cause of the accident

Accidents were classified in this case according to the reason that led to the accident of negligence, recklessness, skipping, etc., as in the following figure:

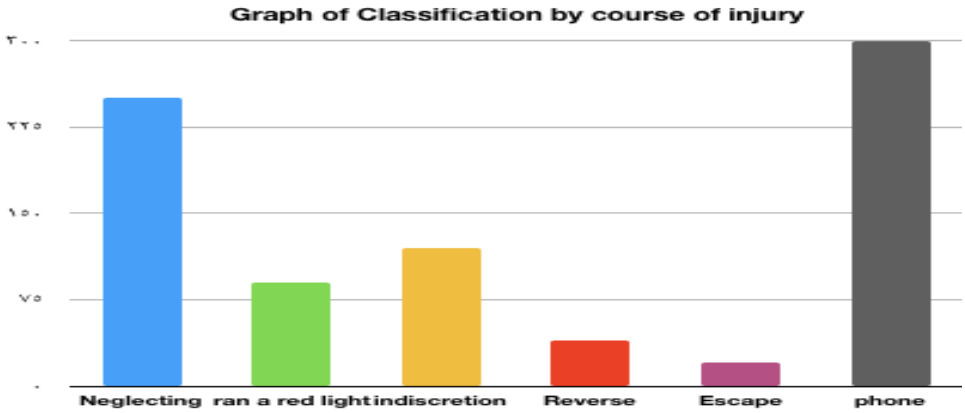

Figure 9. Accident classification in terms of the cause of the accident

2.4 After analysis, the following results were obtained:

1.5 - Most accidents occur on King Fahd Street

1.6 - Age group B (18-30) is the most common category of accidents

1.7 - The car is the most class of vehicle for accident

1.8 -August - the most month of accidents

1.9 - It was found that the cases of serious injury more than deaths

1.10 - The study found that negligence and phone is the most common cause of accidents

1.11 - The study found areas with a deficit in the hospital's coverage and the police station.

1.12 Conclusion

This research used object-oriented GIS technology to produce maps. Link the service center layer and the main road layer in the study area to the road accident site layer. Then, classify the traffic accidents to identify some characteristics that aid the analysis. This will show the shortest distance between two places and the closest service center for the scene.

Recommendations:

After the analysis of the study area, we reached a set of recommendations, the most important of which are the following:

1. Constant observation of equipment and road conditions.

2- To achieve the best outcomes and understand the causes of accidents, we advise studying, processing, presenting, and analyzing connected data throughout GIS.

3-Give the General Directorate of Traffic the option to view analysis and visual processing through a Geographic Information System (GIS).

4- Holding training sessions and coordinating with the two leaders' intense training.

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