International Journal of Computer Science and Software Engineering (IJCSSE), Volume 6, Issue 4, April 2017
ISSN (Online): 2409-4285 www.IJCSSE.org Page: 83-88

The Role of Data Mining in a Smart City: A literature Review

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ABSTRACT

In cities with old structures, citizens spend too much time doing repetitive and useless activities such as waiting in lines, traveling long distances to buy goods or receive services, and being stuck in traffic jams. There are other problems such as air pollution, environmental issues, old structures, nonstandard urban infrastructures, and telecommunication infrastructures.To rise to these challenges, a city needs to have smart infrastructures and components including smart economy, smart transportation, smart environment, smart citizens, smart lifestyle, and smart administration. To design such infrastructures and components in a smart city, there should be a tool which can process the stored data and provide the resultant information for the government and users. In this regard, data mining is an effective tool which has a major role in designing a smart city and processing big data.This paper reviews previous papers on the smart city and the applications of data mining by searching for keywords such as smart city, electronic city, data mining, and the smart components of a smart city in Farsi and English databases. Then smart components, the infrastructures of a smart city, and the role of data mining in developing a smart city are investigated after presenting concepts and definitions. Although it is not possible to point out all the requirements and barriers, this paper may be able to present a general view of a smart city and the responsibilities of every citizen and the government for life in a smart city; therefore, all the citizens are provided with the path towards comfort and welfare.

Keywords: *Smart City, Electronic City, Data Mining, Designing a Smart City.*

1. INTRODUCTION

The world is constantly changing, and man has always tried to rise to every challenge and create an environment in which the highest level of satisfaction with life can be achieved. One of the new concepts of urban planning is the development of a smart city(1).In a study entitled *the Smart City and Legal Requirements*, Faghihi *et al.* investigated the foundations and concepts of a smart city in addition to the relevant components and features. Then they conducted a general review of successful smart cities in different countries. According to them, a smart city should have smart components such as smart economy, smart transportation, smart environment, smart citizens, smart lifestyle, and smart administration. Some of the most well-known smart cities are Songdo and Busan (South Korea), Vienna (Austria), New York City (USA), Tokyo (Japan), Sidney (Australia), Frankfurt (Germany), London (England), Barcelona (Spain), Amsterdam (the Netherlands), and Copenhagen (Denmark). The Ministry of Interior Affairs of the Islamic Republic of Iran has recently planned to make at least five cities intelligent (Urmia, Isfahan, Tabriz, Mashhad, and Tehran)[2].

In a paper entitled *the Necessities and Barriers to the Creation of a Smart City in Iran*, Behzadfar investigated Iran with respect to virtual communications, cyberspace and intelligence city. The barriers pointed out in this paper are as follows:

Undesirable urban infrastructures: traffic and environmental pollutions in cities; population density, especially in metropolises and specific areas of cities; insufficient homes and the use of unhealthy residential areas in densely-populated areas, impoverished urban areas and suburbs; stratifications; physical and spatial problems in the public areas of cities; issues of financial and banking system; and education.

In a paper entitled *the Role of Data Mining in Urban Transportation Management*, Parsa investigated the applications of data mining in urban transportation management. The aim of this study was to create a roadmap for the better use of data mining in a smart city and determine the techniques, models and analysis methods required to make such a city. This paper was first meant to make the system intelligent. For this purpose, there should be an automated system which can operate by itself in order to predict probabilities.

Therefore, the system should be trained and test afterwards to see how much it has been successful in prediction [3].
In another paper entitled *Data Mining in the Electronic City*, Sa'adi *et al.* investigated the applications of data mining and the challenges of implementing it successfully in an electronic city. In this paper, data mining was used as a potentially useful tool to explore the data of the government and provide good support for the government's decisions and analyses. On the other hand, now 80% of knowledge is stored in texts at organizations, and it is expected that text mining will become one of the most important technologies in the future [4].

2. RESEARCH METHOD

Previous papers on the smart city were reviewed in this paper to investigate the application of data mining in a smart city by searching for the keywords (smart city, designing a smart city, a successful smart city, requirements and solutions for a smart city, electronic city, data mining, and smart components) in Farsi and English databases. The research method was based on desk and documentary studies. The aim of this study was to investigate and define a smart city, parameters influencing the process of making a city intelligent, and the role of data mining in the structures of a smart city by using an analytical and descriptive approach.

3. RESULTS AND ANALYSIS

After reviewing the papers mentioned in Background, a smart city is defined as a city in which urban services are available 24 hours a day. In other words, citizens can access the necessary information and services with quality and security on the Internet anywhere at any time.
A smart city is the result of making a city intelligent by using smart computing technologies to increase intelligence, integration and efficiency of main components, infrastructures, and services required in a city. Such services include city administration, education, health services, public security, real estates, transportation, energy, and water [5].
A smart city deals with urban affairs by using ICT-based technologies and considering the idea that there are many beneficiaries in a city (mayoralty-based cooperation) [2].
A smart city is an innovative city which makes the optimal use of ICT and other devices to improve the quality of life, efficiency of urban operations and services as well as competitiveness. It also guarantees compliance with the requirements of the present and future generations with respect to economic, social, and environmental aspects[6] .

A. The Main Components in the Core of A Smart City

1-Technology (Hardware and Software Technologies)

2-People (Innovation, Diversity, Education)

3-Legal Foundations (Governments and Policies)

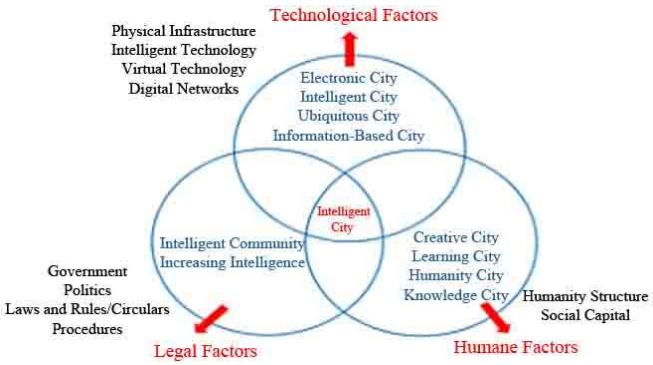

Fig. 2. The Main Components In The Core Of A Smart City

A smart city uses IT for the following purposes:

- ✓Using physical infrastructures (roads, fabricated spaces, and other capabilities of a city) through artificial intelligence and analyzing data to support good economic, health, social, and cultural development
- ✓Effective participation of people in local government and decisions by using open-innovation process, participating electronically, and improving the collective intelligence of urban institutes through electronic government with an emphasis on citizen participation and design (different urban components) cooperatively
- ✓Learning, adaptability, innovation, and more effective and immediate response to changing conditions by improving urban intelligence [7].

The above types of intelligence (humane, collective, and artificial) are realized in three ways in smart cities:

- ✓Orchestration Intelligence: cities and social institutes solve problems cooperatively.
- ✓Empowerment Intelligence: cities create open platforms, pilot facilities, and urban intelligent

infrastructures to classify innovation in specific areas.

- ✓ Instrumentation Intelligence: urban infrastructures are made intelligent through the momentary collection of data and predictive analysis and modeling in urban areas. Such a case was implemented in Amsterdam[8].

To achieve the goals of a smart city, this concept should be analyzed in a specific framework first. This framework is divided into three dimensions here:

1- Technological Framework:

The concept of smart city put a great emphasis on the use of technology. In fact, this concept is a combination of different technological concepts which form the concept of smart city in general. These concepts are as follows:

- ✓ Digital City: this concept combines service-based, communication and innovation services with each other. In fact, a smart community requires a combination of communication and service-based computation infrastructures with respect to the standards of open industry and innovative services meeting the needs of the government, businesses, and citizens. Here the goal is to create an environment in which citizens are connected to each other in order to share information everywhere easily[9].
- ✓ Virtual City: in this concept, urban functions are implemented in a virtual space. It includes the concept of a hybrid city including a fact for all the citizens, their real natures, and a parallel virtual city including identities and virtual people. In fact, this concept is realized through physical tools such as cables, data centers and ICT infrastructures(1).
- ✓ Information City: this concept collects local information and delivers them to a public portal (the government). In such a city, many of the residents are able to live and even work on the Internet because they can obtain any type of information through ICT infrastructures. However, it is possible by sharing information between the citizens themselves [10].
- ✓ Intelligent City: this is a concept in which knowledge, learning process, and creativity are very important. In this city, humane capital is regarded as the most important capital. Particularly, one of the most important features of an intelligence city is that every infrastructure should be up-to-date in it. In other words, it should be equipped with the most recent telecommunication, electronic and mechanical technologies[7] .
- ✓ Ubiquitous City: in this case, an environment is created to connect citizens to every service through services. A ubiquitous city is the expanded concept of a digital city because there are accessible facilities for every infrastructure. Therefore, it is easier for citizens to use each device to connect to each other[11].

2- Humane Framework:

One of the important factors in the development of a smart city is its humane infrastructure which includes jobs, creative workforce, knowledge networks, and volunteer organizations[12].

- ✓ Creative City: creativity is a key impetus for a smart city. In fact, a type of creativity is considered. Social infrastructures such as intellectual and social capitals are the inseparable factors in the creation of a smart city in the humane framework. These infrastructures contain people and their relationships. Smart cities take advantage of social capital. It is much easier to create a smart city if there is a combination of education, culture, art, commerce and business.
- ✓ Learning City: this city trains skilled workforce. Such cities increase competitiveness in the humane environment. In fact, they form the type of cities which learn to be intelligent. Moreover, the city learns how it can become intelligent through the workforce learning process.
- ✓ Humanity City: this concept benefits from the humane potential, especially the knowledge workforce. In this approach, it is possible to concentrate on education and the creation of higher education centers to find more educated people. In this case, a smart city is full of skilled workforce, something which can attract more workforce.
- ✓ Knowledge City: this concept is related to knowledge economy and innovation process. This type of intelligent city is very similar to the learning city. The only difference is that the knowledge city is greatly related to the economy knowledge. It emphasizes innovation. The concept of knowledge city is close to evolving concepts such as the intelligent city and teaching city [13].

3- Institutional Framework:

An intelligent community makes consensus and informed decisions to establish technology as a catalyst to meet social and business needs. It is very important

that such a sue of information technology and resultant improvements can be challenging without the help of institutions. In fact, the intervention of institutions is vital to the success of an intelligent community. Intelligent development is greatly essential because the cooperation of cities and institutions is actually a reaction to the bad procedures of daily activities such as traffic jams, crowded schools, and air pollution. The development of technology is not a goal. It is a tool which can result in the recreation of cities for a new economy and community. Totally, it should be emphasized that a smart city needs the support of the government for success [14].

The Smart Concepts:

1- Smart Economy:

Smart economy refers to cities with intelligent industries having ICT backgrounds as well as other industries including ICT in their communication processes [8].

2- Smart Mobility:

Smart mobility means the procurement of public access to new technologies to use them in daily urban life. The accessibility and quality of ICT infrastructures are important for the intelligent city which depends on a series of smart computing technologies applied to the components of vital infrastructures and services. Smart computations refer to a new generation of integrated hardware, software and network technologies which present IT systems with a real-time awareness of the real world and traffic analysis as well as a sophisticated atmosphere to help make decisions. ICT technology is the main impetus for smart cities [14].

3- Smart Environment:

Smart cities seek innovations for the environment. The concept core of a smart city is the use of technology, sustainable increase and a better management of natural resources. There is a special interest in protecting natural resources and relevant infrastructures such as waterways, sewers, green environments and parks. All of these factors influence and sustainability and vitality of the city; therefore, they should be taken into account when the smart city is investigated. The smart environment refers to the use of new technologies to preserve the environment. The smart environment is characterized by the following factors[7].

4- Smart Governance:

Smart governance includes active and political participation, citizenship services, and the smart use of electronic government. The smart government is one of the important features of a smart city described in the participation of citizens based on public/private participation. A smart government depends on executing the infrastructures of smart governments which should be accountable and transparent. This infrastructure helps grant the permission to cooperate, exchange information, and integrate services with communications. Moreover, the smart government refers to the use of new communication channels such is the electronic state or electronic government [15].

5- Smart Living:

Speaking about smart living means collecting the different aspects which help improve the quality of citizens' lives such as culture, health, safety, housing, and tourism [16].

6- Smart People:

What distinguishes a digital city from a smart city is the presence of smart people who are defined by their skills and training levels. The quality of social interactions such as integration, collective life, and ability to communicate with the world are the instances of smart people. The projects of smart cities influence the quality of citizens' lives, more informed nurture, education and participation. Furthermore, a smart city allows the members to participate in urban governance and management [14].

The Importance of Data Mining in Creating a Smart City:

- ✓ The size of training data generated every year is equal to the total training data of previous years.
- ✓ The total size of data existing in information bases of the world is 2.8 trillion gigabytes.
- ✓ Only 3% of the entire data is read for analysis and data mining.
- ✓ Only 5% of the entire data is used for analysis.
- ✓ According to the latest report by IMP, more than 4.4 data mining experts are required to analyze the information collected in 2015[17].

The Application of Data Mining in Urban Management

Urban planning; transportation and traffic; beautification; urban services; waste management; urban

cultural engineering; communication with citizens; emergency services; new services and facilities; plans for improving citizen satisfaction; plans for educating citizens; geographical analysis for spatial-temporal data; discovery of citizen behavior and the estimation of their areas of activity; analysis of information on real estates, apartments, villas, and other private and public buildings [18].

4. CONCLUSION

This paper reviews previous papers on the smart city and the applications of datamining by searching for keywords such as smart city, electronic city, data mining, and the intelligent components of a smart city in Farsi and English databases. Then the intelligent components, the infrastructures of a smart city, and the role of data mining in the development of a smart city were investigated after presenting concepts and definitions. Although it is not possible to deal with all the requirements and barriers, this paper may be able to provide a general view of a smart city and the responsibilities of each citizen for life to result in the path towards peace and welfare. However, the most important challenges of smart cities include population density and the discrepancy between populations in day and at night in metropolises. Other challenges are vast pollution with light, sound, air, space, traffic, time, and a solution to reduce the pains of living in such cities. The most important issues in such cities is the movement of population which refers to movement by vehicles or crowds in centers providing sales, administrative, and urban welfare services. It is the main cause of many urban issues such as humane problems or urban accidents in large cities.

A plan is necessary to design a smart city. The plan of a smart city includes three or four main components which are briefly described as follows:

The first phase: first, an accurate definition should be provided for a community. This definition includes geography, connections among cities and suburbs, and the movement flow of people in this areas (traffic).

The second phase: before making decisions on the creation of a smart city, the study of a community/city includes identifying citizens, business requirements, and the unique features of a community such as citizens' age range, educational attainments, recreations and urban attractions.

The third phase: a policy should be set to define roles, responsibilities, macro goals, and objective goals. Then the strategies and plans are obtained regarding these goals.

The fourth phase: this is done by involving citizens in the activities of electronic government, open data, and sports events.

5. ACKNOWLEDGEMENTS

We would like to thanks from librarian of my university for all supports in approvment final studies.

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