Intelligent Transportation System for Smart-Cities using Fuzzy Logic

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Abstract

According to United Nations population statistics 2017, the world population is 7.6 billion and is growing rapidly almost 11 billion by end of 21 century with a 70% chance of continued growth, this rapid increasing population have created low standards of living in cities. Smart Cities are facing pressures associated with due innovations and globalization to improve their citizens life. Computational intelligence is the study of adaptive mechanism to facilitate intelligent behavior in changing and complex environments. Traffic congestion and monitoring has become one of the critical issues in big cities. The adaptive mechanism of computational intelligence in changing the behavior of complex environments of smart city is very effective. The developing framework and services for smart-city requires sound infrastructure, latest current technology adoption. A framework model with the integration of cloud-data, social network (SN) services that is collecting stream data with smart sensors in the context of smart cities is proposed. The adaptive mechanism of computational intelligence in changing the behavior of complex environments of smart city is very effective. A radical framework that enables the analysis of big-data sets stemming from Social Networking (SN) sites. Smart cities understanding is a broad concept only city transportation sector is focused in this article. Fuzzy logic modeling techniques are used in many fields i.e. medical, engineering. business and computing related problems. To solve various traffic management issues in cities a detailed analysis of fuzzy logic system is proposed. This paper presents an analysis of the results achieved using Fuzzy Logic System (FLS) for smart cities. The results are verified using MATLAB Simulation.

Introduction:

It is the time of Social Networking, Cloud Computing and explosion of smart sensors, robots deployed everywhere [1]. According to UN survey in 2017, almost 70% of world's population is living in city areas [2] and growing surely alerting city planners and

administrators. Connected cities developed by Internet of Things (IoT) technologies and socially-aware network systems aggregate city mayors over a whole connected metropolitan boundary. When thinking of connected urban zones, one may ponder high tech cities that have the prominent pioneering technologies

for their citizens like Copenhagen, London, New York, Chicago, Stockholm or Amsterdam. However, small residential communities also been benefiting from interfacing individuals, administrations, city infrastructure and services. This article investigates city transportation problem and a portion of the difficulties that are involved with developing widespread IoT techniques. The alliance of world-class IoT improvement anticipates working with these smart communities that enable residents to make expertise utilization more sensible, adaptable and sustainable. Many urban cities and towns are turning to socially connected smart gadgets to solve key problems [3], for example, traffic congestion, environmental contamination, health-care, education, security surveillance to enhance the living standards for their public everyday comforts. Smart sensors that are installed throughout the city, in vehicles, in buildings, in roadways, in control monitoring systems, security surveillance and applications and devices that are utilized by individuals who are living or working in the city [4]. Delivering info to the community through these high tech smart cities realization. The big-data analytics are exploited to take decision on how public events are planned, how to convey administrative notifications and how to make the best utilization of the resources more expertly, viably and properly [5].

Therefore, during recent decades most urban cities have embraced huge investments in ICT infrastructure including supercomputers, broadband convenience and some recognizing framework [6]. These structures have engaged various inventive administrations in territories, for example, demographic sensing, urban coordination and real information that makes living ones close.

Such administrations have been widely sent in a few urban cities, accordingly exhibiting the potential advantages of ICT frameworks for organizations and the natives themselves [7]. In current years moreover, it has seen a great development of adaptive systems, along with boom of sensor distributions, internet- of- things [8] current advancements of sensor-based systems have been emerged. Currently, by using the advantages of social network communication, internet- of- things distributions for smart areas have likewise been demonstrated [9].

Current Smart City data analytic implies complex data streams for broaden set of activities aiming to turn into actionable real outcomes [10]. The analysis comprises of following contributions:

An example of a specialist provider is Brain Corp, a San Diego-based software company founded in 2009 and now specializing in the development of machine learning and computer vision systems for the next generation of self-driving, robotic vehicles. It offers EMMA (Enabling Mobile Machine Automation) a commercial grade operating system powered by BrainOS, that perceive the environments, enables mobile robots, control motion and navigate, while detecting and avoiding obstacles. BrainOS integrates machine learning algorithms that forming EMMA's core functionality with the company's cloud-based Robotic Operating Centre and it contains a range of libraries. These include a full navigation stack, static and dynamic obstacle avoidance, single-pass mapping and routing technology, elastic path planning with adaptive behavior, adaptive learning and object anomaly detection.

Most of autonomous systems have the ability to access huge data sets, massive

computational power and all manner of APIs that give potential benefits. Many cloud-based applications have been proposed for mobile/autonomous vehicles, surgical machines, robot careers and assistants, household devices, industrial and military systems and robotic agricultural machines.

The prime candidates of the cloud technologies are humanoid robots. Natural language technologies through speech recognitions are interact with humanoids to humans, the ability to understand the refinements of context and meaning, poses a huge technological challenge and requires massive and signal processing something that cannot realistically be incorporated into a small humanoid robot. In most cases today humanoid robot's speech is still limited to artificial systems programmed responses are based on trigger and pre-set behavior. Cocoro a SoftBank company developed a cloud robotic artificial intelligence system which has linked 25 on-board sensors which acquire sight, sound, touch and movement information. Pepper robot credited by Wikipedia that can be connected to the Internet through Wi-Fi or an Ethernet link. Human actions or questions are responded by the most appropriate ways of collected information by sensors which is transmitted to cloud for processing. Speech recognition is a cloud-based capability which is done by Pepper robot to make decision by using itself. Microsoft Corporation and Softbank Robotics announced a strategic collaboration in 2016 for next generation artificial intelligence. Microsoft's cloud-based Azure Iot (Suite) and SoftBank Pepper will work together to create next generation cloud-enabled robots. They plan to develop a cloud-enabled robot to serve customer in person for the retail industry using

Microsoft's large screen Surface-Hub and Surface 2-in-1 devices. By using the Azure IoT suite for analysis of large volumes of store-data, customer behavior and point-of-sale purchase to be integrated with similar data from smartphones, e-commerce sites and other sources which is surfaces by the Pepper and in-store connected devices.

SMART-CITY KEY FEATURES DOMAINS

The availability of smart solutions for cities has risen quickly over the most recent years. Therefore, technical solutions exist for each city to become smarter. The challenge today is mostly to execute proper solutions proficiently, as opposed to just concentrating on innovations. Smart city areas cannot be developed through a patchwork approach, yet by the well-ordered adoption of incremental changes. The most proper way of smart-city realization is introducing a smart system working group of volunteers characterize its manageability vision and afterwards lays out an electronic well-ordered guide and execution design. The capacity to distinguish the acutest bottlenecks to send coordinated and flexible solutions and afterwards to use these outcomes into other smart community's activities requires involvement and strong specialized expertise.

Smart City Key Resources: Transportation, Climate Change, Energy, Utilities, Security Surveillance, Healthcare, Business Management etc.

Connected cities enhance the experience of workers by analyzing data and smart city coordinators by breaking down information from reporting frameworks including sensors, roadside cameras, brilliant monitoring systems and speed check signs. Applying IoT

chunks perform specific operations, related to collecting data, messaging, data accessing, semantic annotation, examination or perception where applications can join segments from different layers in light of their specific pre-requisites. The major city applications are plug and play using all the current state of the art advance technologies. Interactive organization services and objects are coordinated together for real time machine to machine and person to person communication correspondence using the present extraordinary cutting-edge advances are portability in smart-phones [12].

Main Components of the Model

The layered framework model of a smart city is having four main layers described below: -

a) Sensing Layer

Sensor Layer comprises tens to thousands of sensor hubs connected using smart remote technologies. They gather data from the environment and convey it to other connected devices that pass the data to the cloud server over the Internet.

b) Communication Layer

Wireless heart innovative technology gives excellent remote protocol access to the full range of processors capacity, control, and resource management to applications. DigiMesh is an exclusive shared systems networking topology for use in remote end-point network connectivity through the physical Internet.

c) Data Layer

The capacity and processing of data should be possible on the edge of the networks itself or in a cloud server. If any preprocessing of data is a need, then it is typically done at either the sensor or some other proximate device. The

processed data is then regularly sent to a remote server. The capacity and processing abilities of an IoT object are additionally controlled by the assets accessible, which are regularly exceptionally compelled because of constraints of capacity, vitality, control, and computational ability.

d) Application Layer

The application layer is responsible for data organization and presentation. The application layer on the Internet is regularly in light of HTTP/FTP standards. The proposed events in this examination are sharing of dynamic data to customers using mobile phones as a particular device. It may be HTTP is not reasonable in resource enabling situations since it is relatively verbose and this manner brings about a significant parsing overhead. Many other innovative conventions have been produced for IoT resources, for example, MQTT (Message Queue Telemetry Transport) and CoAP (Constrained Application Protocol).

Conceptual Framework for Smart-Cities

The proposed technique in this study is sharing of dynamic information to users using smartphones as a communication device. Current day advanced modern technologies of knowledge mobilization, cloud-servers and the smart-city app are integrated into a new era of quick communication. Advanced smart-phones may have limited sensing capabilities but enhanced computational strength, lesser cost, excessive usage, availability of GSM (Global System for Mobile- communication) and mobile internet signals, availability of different sensors in smartphones like a gyroscope, digital compass, proximity sensor etc. Services available like Google map, Google weather, IBM live streaming analytics etc. is prime

LIDAR, cameras and GPS. Watson enables travelers to collaborate conversationally with Olli which reacts to their inquiries as they enter the vehicle. It can give data about

particular vehicle capacities and travelers can likewise ask for points of interest of nearby goals, for example, eateries or recorded locales.

Figure 3 Olli, the electric vehicle which can interact with passengers using natural language.
(Credit: Google Local Motors)

Proposed MFIS based Solution

This section explains in detail Mamdani Fuzzy Inference System (MFIS) based on smart-city Traffic Congestion Conditions (TCC) controls. The facts given below explain the measuring of TCC for the Smart-city for smart drive facility which is based on Mamdani Fuzzy logic principles.

In this article, the planned MFIS which is capable of measuring the TCC for the city algorithm is given in table-1. The five inputs and one output MFIS is proposed to calculate TCC.

In this method five inputs that are: Vehicle Speed (S), Road Capacity (C), Traffic

Signals (T), Distance between Signal (D), Riding Distance (R) are taken. These inputs are used to build up lookup table given in table-3 to decide TCC for a respective algorithm for input-output relation given by MFIS. Its mathematical representation as show in equation 1.

$$\mu_{CG} = \text{MFIS} [\mu_{VS}, \mu_{RD}, \mu_{TS}, \mu_{DTS}, \mu_{RD}] \dots \dots \dots (1)$$

Table No 1: Proposed MFIS based TCC Algorithm**1. Inputs:**

In this system 5, Fuzzy Input variables are used which are the following (Vehicle Speed, Road Capacity, Traffic Signal, Distance Traffic Signal and Riding Distance)

2. Each Fuzzy Input variable has different types of membership functions.

3. Every Fuzzy membership function is used to build fuzzy inference rules.

In this article, measuring the Intelligent Transportation System (ITS) using Mamdani Fuzzy Inference System (MFIS). TABLE-1 shows the proposed MFIS Based ITS algorithm. The I/O surface for MFIS is given in Fig 4.

Fig. 4 Input and output surface for MFIS**Input Fuzzy Sets**

Fuzzy input variable is statistical values that are used to calculate the Traffic Congestion Condition in smart cities.

Table No 2. Input Variable Ranges

Sr #	Input Parameters	Ranges	Semantic sign
1	VS	0-50 45-75 60-120	Slow Medium Fast
2	Cap	0-50 40-100 90-150	Narrow Average Wide
3	TS	0-5 4-10 9-15	Fewer Normal Too much
4	DTS	2-4 3-6 5-10	Nearer Average Far
5	RD	0-10 8-20 18-30	Nearer Center Far

Fuzzy Output Variable

Fuzzy output variable Traffic Congestion Control (TCC) is used to calculate the result by the values of input variables in the world of discourse. The details of output are shown in TABLE-III.

TABLE 3. Output Variable Ranges

Sr #	Output of MFIS	Ranges	Semantic sign for Congestion
1	Congestion Control	0 - 0.5 0.2 - 0.7 0.5 - 1	No delay (Less) Average delay (Medium) Much delay (High)

Membership Functions

Membership function gives curve value between 0 and 1, and it provides a mathematical function which provides statistical values of input and output variable. Membership functions are also available in

MATLAB tool. The propose solution uses the membership functions which are as follows.

- Trim
- Trapmf

Trim is a triangular curve built-in MATLAB function. For calculation of this function, three scalar parameters are used in the proposed solution which is Low, Medium, and High. The mathematical equations and graphical representation of membership function are given below.

Figure No 5

Figure No 6 Member functions for ITS

Rule-Based

In this system most, suitable rules for system understanding are applied. This rule-base system contains approximately 81 input-output rules, the system complexity increased if the number of rules increased. The Mamdani Fuzzy Inference rules are shown in Fig 6.

Inference Engine

The Mamdani Inference Engine is used to map five inputs to one output (TCC).

Figure No 7 I/O Rules for ITS

De- Fuzzifier

In this article centroid, De- Fuzzifier is used. The Fig 9 (a), Fig 9 (b) and Fig 9 (c) represents rule surface plot of Mamdani Fuzzy Inference System (MFIS).

Fig. 8 (a) shows that if Vehicle Speed is (0-80 km/s) and Traffic Signals are (10-15 in nos.), then Traffic Congestion is approximately 80% which is high. It also shows that if vehicular speed between (80 – 120 km/s or > 80 km) and Traffic Signal is (10-15 in nos.), then Congestion is low approximately (.1 or 10%).

Figure No 8 (a) Rule surface for Traffic Signals and Vehicle Speed

Fig 7 (b) shows Congestion Control using input variables Traffic signals and Riding Distance. This diagram shows that congestion is approximately 80% when Traffic signals are (10-15 in nos.). Riding Distance Source to Destination is (8 to 20 km) approximately, and congestion is approximately 60% if Traffic signals (9 10 10) and riding distance (8 – 20 km/s or > 8 km).

Figure No 8 (b) Rule surface for Traffic Signals and Riding Distance

Fig. 8 (c) shows Congestion depends upon input variables Road Capacity and Riding Distance source to destination. Approximately no Congestion when road capacity is extensive or (110 to 120 vehicles on the road) and Riding Distance source to destination is (9 to 20 km). If Road Capacity between approximately (100 to 110) and Riding Distance between (10 to 20 km) congestion is increased from (0 to 20) approximately 20 % increase. If road capacity is less than >90 or narrow road, then the congestion is up to 50%. So it concludes that Congestion is high as Road Capacity decreases or narrowing the roadway.

Figure No 8 (c) Rule surface for Riding Distance and Road Capacity

Simulation Results

For simulation results, MATLAB R2017a tool is used. MATLAB is also used for modelling, simulation, algorithm development, prototyping and many other fields. MATLAB is an efficient tool for programming, data analysis, visualisation and computing. For simulation results, five inputs and one output Congestion Control variable is used.

Table 4. Congestion Control based on rules defined

Input Variables					Output
VS	RC	TS	DTS	RD	Congestion
H	W	L	H	H	Less Delay
H	N	H	L	L	Medium Delay
L	N	H	L	L	High Delay

Table 7 explains the rules viewer lookup results shown in fig. 9 (a), fig. 9 (b) and fig. 9 (c) below. Fig 13 shows the congestion is less if vehicular speed is high and road capacity is wide. It further depicts that if a traffic signal is few and distance between signals is high and riding distance is far congestion is low. Fig 14 shows that congestion is Medium if the vehicle speed is high and Road Capacity is Narrow, and traffic signals are too much, and the distance between signals is low, and riding distance is far then congestion is medium. Fig. 15 explains congestion is high if the vehicle speed is Low and Road Capacity is Narrow, and traffic signals are too much, and the distance between signals is small, and riding distance is also low than congestion is high.

Figure No 9 (a) Lookup Diagram for Low TCC

Figure No 9 (b) Lookup Diagram for Medium TCC

Figure No 9 (c) Lookup Diagram for High TCC

VII Conclusion And Future Work

Implementation of smart-cities infrastructure and services is a long-game process. The advantages of smart-city to communities will

not likely be quick and will probably be incremental in the first step. Nevertheless, to accomplish smart-cities infrastructure through the utilization of SNA, Information

Communication Technologies and IoT's to scale their city framework and extend services reasonably while offering substantial financial advantages. This TCC fuzzy expert system is designed with the help of 5 input and one output variable. Mamdani Fuzzy Inference System (MFIS) is used to evaluate the Traffic Congestion Conditions (TCC) in smart-city. The proposed system design of TCC has been beneficial to determine the city traffic congestion. Through this system, anybody can check any traffic congestion. In future this work could be further enhanced to the different parameters of smart-city like Environmental Conditions, Energy Consumption, Healthcare and Security Surveillance etc using FIS. Other expert systems could also be developed which could be able to predict core-important sectors of the smart-city. It is evident from the

developments and applications discussed above that cloud robotics technology is rapidly coming of age. Internet connectivity and dedicated highly versatile cloud computing services suggests that rapid progress is inevitable, interpersonal organization services and objects are coordinated together for a new time machine to machine and person to person communication correspondence. Further, the capabilities of cloud robots will invariably be enhanced by developments in several fields of artificial intelligence, particularly pattern recognition and natural language processing. Even though cloud robotics is still in its infancy, it is not unreasonable to speculate that connection to cloud-based computer systems will be a standard feature of almost all robots in the future.

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