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Suggested Method to Solve Traffic Jams in Large Cities Using Artificial Neural Networks

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Abstract:

The Iraqi inter-urban traffic suffers from extremely bad congestion, particularly in the capital Baghdad (with a population of over 7millions) and other major cities. This is mainly due to the abnormal increase in the number of imported vehicles since 2003, while at the same time no new roads were constructed, but on the contrary many roads were closed as a security precaution.Other causes, which we will discuss here, include: shortage of adequate parking spaces to meet this increase in the number of vehicles, traffic signal control problems, heavy trucks bringing imported goods, etc..What the future holds for this situation, if no serious action is taken, is horrifying. Examples from mega cities are reviewed of how they solved this problem of traffic jams by using Artificial Neural Network.

In this paper I have suggested forming a team of experts in the fields of: Artificial Intelligence (AI), Artificial Neural Networks (ANN),and traffic specialists.The objective of the team is tosetup strategies to minimize the present problem of traffic congestion, and submit future plans regarding this issue.

Keywords: Neural Networks, traffic, ANN, IT,Iraq,transportation.

1- Introduction:

I have attempted in this paper to summarize the findings of as large number as possible of research papers and articles relevant to the application of Neural Networks to transportation. A brief introduction to Neural Networks is included, for the benefit of readers unfamiliar with the techniques.

Iraqi citizens, particularly Baghdadians, think that their city is the worst in the world concerning traffic jams. This maybe true, but most cities in the world faced this problem, and most of them were able to solve it by using advanced technology plus cooperation of the citizens. Now we have a powerful tool called “Artificial Neural Network-(ANN)” which can help us to solve this problem, as well as other problems.

The main objective of this paper is to encourage both researchers and other citizens to cooperate together to find suitable solutions to the problems they all face by utilizing the great advancement in technology, particularly in the fields of Information Technology (IT), and particularly in the field of Artificial Neural Networks (ANN).

One such problem is the increasing difficulty of organizing traffic in large cities and to make it as normal as possible.Another difficulty lies in the huge amount of datathat should be fed to the proposedsystem, analyzing these data and then producesuitable outputs.

Suitable solutions are not required for the present only, but most importantly for the short and long terms.

Extract from reference **[1]**: "Companies such as Cisco, Arup and IBM are touting their technological solutions to procurement departments of major cities. According to Pike Research, from 2012 to 2020, $117bn will be invested worldwide on smart city infrastructures, of which $31.2bn will be in the digital systems and infrastructure for smart transport solutions. [Quoted in a UK Departmenrt for Business and Innovation report from 2013, The Smart City Market: Opportunities for the UK.]

this investment, high as it is, is alleged to save much more money. A 2009 report Intelligent Transport Systems and Services – Innovation Platform from the Technology Strategy Board (now Innovate UK), argued that:

- A 5% reduction in travel time on the roads could save businesses around £2.5bn;
- or 0.2% of GDP;
- Eliminating existing road congestion would be worth £7-8bn of GDP each year to the UK;
- The cost of congestion could be an extra £22 bn in 2025 if action is not taken."**[1]**

This paper is divided into the following sections:

2- The Proposed Project:

Handling congestion in urban traffic using artificial intelligence techniques is an important research area. Various models and approaches have beendeveloped using soft computing techniques to tackle with this problem. Major soft computing approaches for this purpose are Fuzzy Approaches, Neural Network and Genetic Algorithms, Petri Nets and many more. Also, multi-agent systems are highly applicable in this approach.

Constructing an intelligent traffic monitoring system firstly depends on automatic identification for vehicles. At present, automatic identification technology based on image and vehicle license plate is going to fall in the trap due to its low recognition rate and affection by adverse weather. Thus it is necessary to apply new technologies to solve this problem, and technologies based on Internet of Things provide a new approach for it.

Research and design show that it is feasible and inexpensive to construct an intelligent traffic monitoring system based on Internet of Things, and the intelligent traffic monitoring system based on Internet of Things has a number of advantages such low

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cost, high reliability, never affected by adverse weather, all weather operations etc. Therefore, it will have a broad applying perspective.[2]

This proposal suggests that:

1- A special committee to be formed which includes specialists in the field of Information Technology, Internet of Things, Neural Networks and transportation specialists.
2- This committee should outline: the main objectives and the strategy to achieve these objectives.
3- Agreement on the system of IT to be utilized.

Some of the main issues to be tackled are:

a) Expanding TransportInfrastructure:

Important projects, such as the ***underground*** and/or electric-driven ***tramways,***should be considered seriously and not as a cheap political propaganda. These projects have many economic and social benefits.

Reference: https://www.weforum.org/agenda/2015/07/how-cities-can-benefit-from-intelligent

b) Traffic Signal Control:

One of the most cost-effective measures for dealing with this problem is traffic signal control. Traffic signal retiming and coordination of existing signals have been proven to bring about substantial reductions in traffic delay, considerable energy savings, and consequently, huge reduction in travel time and increased safety for the public.

Control of traffic signals for efficient movement of traffic on urban streets constitutes a challenging part of an urban traffic control system (UTCS). For UTCS used for controlling traffic signals in a large-scale traffic network, it is crucial that the traffic signal control system has the capability to examine both the microscopic level of the situation (the traffic state of each intersection) as well as the macroscopic level of the situation (the overall traffic state of the traffic network) [3]

c) Solving Parking Problems:

In the USA, the San Francisco Municipal Transportation Agency says that 30 percent of the city's traffic congestion is caused by drivers looking for a place to park. And the Texas Transportation Institute estimates the annual cost of traffic congestion in the United States alone adds up to $87.2 billion in wasted fuel and lost productivity. Much of this congestion could be addressed with smart Internet of Things technologies that already exist.

Start with San Francisco's parking problem. What if you placed a sensor in each parking space? The sensors wouldn't need much power, as they'd only need to transmit when there was a change in a parking space's status. Small lithium battery would do the job for many years before it needed to be replaced. The sensors wouldn't require enormous bandwidth, either, so there

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would be no need for wired connections. You'd want "five nines" uptime, of course, and a network that was resilient enough to be reliable in unpredictable RF environments. This would be a perfect application for a low power, wireless IEEE 802.15.4e mesh network.

The most useful network gateways can connect via either Ethernet or the cellular data networks. That makes it possible to place sensors and Internet gateways anywhere there's cell phone service, even if wired Ethernet connections are not available.

In an adaptive traffic application, the same gateway that connected a sensor mesh network to the Internet could also provide Internet connections for wired devices like traffic cameras, digital signage and traffic signals. The traffic management system would be able to alter traffic signal patterns, provide drivers with information and alerts, and manage traffic in real time. [Extract from Reference 4]

d) **Present Public transport inadequacy:**

Many public transport systems are under used. Taxis constitute highpercentage of the total number of vehicles in the roads, particularly during peak hours. Crowdedness creates discomfort for users as the system copes with a temporary surge in demand. Low ridership makes many services financially unsustainable, particularly in suburban areas. In spite of significant subsidies and cross-financing (e.g. tolls) almost every public transit system cannot generate sufficient income to cover its operating and capital costs. While in the past deficits were deemed acceptable because of the essential service public transit was providing for urban mobility, its financial burden is increasingly controversial.

3- Examples from MegaCities

3.1- The City of London Experience

In 2003, the city of London made a bold move in an effort to tame traffic: It instituted a congestion charge, making motorists pay a fee in order to drive into the city core. The law was the first of its kind in a major city, and similar schemes were later adopted in Stockholm, Milan, and other cities.

Today, 13 years later, the U.K. capital is drowning in vehicles: London has the worst road delays in Europe. What happened?

Several things, say transportation experts—and not all of them are bad. In a sense, London's snarled streets are in part a reflection of its ***roaring success***. It may also be a harbinger of what's coming for many other cities.

The positive spin on this is that London is now in a great position to provide a blueprint for better managing the future of urban congestion everywhere. The solutions:

a- Install Better Traffic Systems
b- Restrict Car Access Even Further
c- London Cycling Campaign :http://lcc.org.uk/
d- Build sub-surface streets
e- Create “Bus Gateways”
f- Introduce Surge Pricing
g- Reroute Delivery Vans
h- Hold Out for Autonomous Vehicles
i- Let Congestion Itself Produce a Modal Shift

[Extract from Reference 5]

3.2- The City of Singapore:”

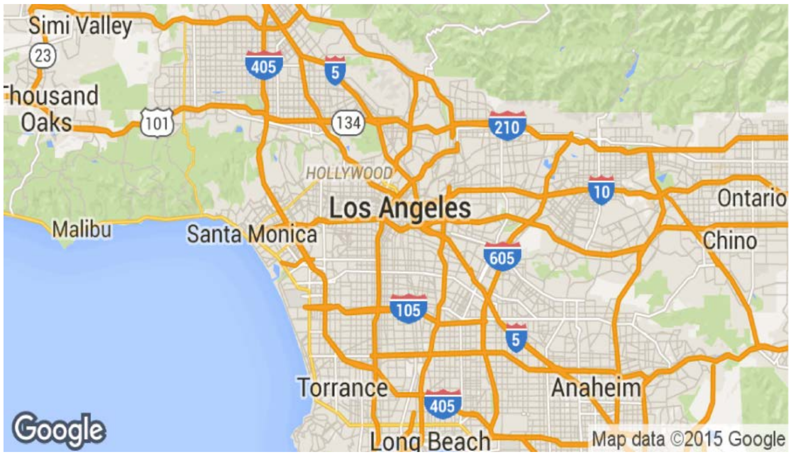
To quote from Reference **[6]:**

“The work presented by Choy *et al.* [7] introduced a hybridmulti-agent system architecture for real-time system control. This paper presents an enhanced version of SPSA-NN-based multi-agent system, which has been tested in more complex scenarios to determine its efficacy. These two multi-agent systems as well as an existing traffic signal control algorithm Green Link Determining (GLIDE) are used to control the signalized intersections of a large simulated traffic network based on a section of the Central Business District (CBD) of Singapore. This paper seeks to demonstrate the efficacy of the hybrid multi-agent system in solving the infinite horizon distributed control problem.

The paper is arranged as follows: Section II describes the modeling of the traffic signal control problem using a form of a directed graph. Section III describes the performance measures that are used to evaluate the traffic signal control models developed in this paper. Section IV presents the SPSA- NN-based multi-agent system, whereas Section V presents the hybrid NN-based multi-agent system. Section VI describes the experimental setup. Finally, Section VII presents the simulation results and, Section VIII concludes the findings of this paper.”

3.3- The city of Los Angeles:

Refer to reference **[2]**which explainin detail (76 pages) how they dealt with the problem of traffic control by using the technology of Artificial Intelligence (AI).



3.4- How Tokyo copes with traffic

Traffic congestion is something that every city in the world faces. Finding a solution could be important for sustaining economic activities. Terrence Terashima explains how the Japanese capital is playing its part.

Tokyo, Japan's capital with population over 13 million people, live and commute.

Over four and half million vehicles rush through these streets of Japanese metropolis, daily.

And like any other cities in the world, traffic problems are not unique.

The Metropolitan government tackle vigorously to find spaces and increase traffic lanes. Widening roads, going underground, or even building expressways on top of each other.

Illegal parking is also a major issue. Blocking one lane, causing congestion.

Taxi Driver, Tokyo, said, "I feel that the authorities should crack down on illegal parking a lot more, to free the roads."

However, even the continuous efforts in public works, creating new passages are not enough to solve the traffic problems. It's a catch twenty-two.

Terrence Treashima, Tokyo, said, "In order to reduce traffic congestion, authorities are promoting more use of public transportation. They say the key in cutting traffic jams is road management."

Masafumi Yukawa, Tokyo Metropolitan Government, said, "In order to ease traffic congestion, we have to increase the road capacities. However, to do so we would need large sums of budget and time. We would need to manage road in the meantime."

And the metropolitan government is doing just that. Technologically upgrading traffic lights, redirect traffic with new signs and routes. Officials hope that the road management scheme and new public works spending will improve road conditions in the metropolis by year 2015.

[Extract from Reference 11]

3.5- The city of Delhi, India

Refer to reference **[11]** to see how Delhi faced the problem of Bus Transportation. The following is a quotation from this paper:

"In this study an attempt has been made to develop a travel time prediction model for urban bus route in Delhi, India with the

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help of ***artificial neural network***. Travel Time is an important component of transport system because it affects the efficiency of system and service attractiveness. If a travel time is appropriate it attracts more commuters along the route and increases the commuters' satisfaction."

The final conclusion in the above- mentioned paper is the following:

"In the present study, ANN model has been developed to predict bus travel time for two selected urban bus-route in Delhi. The performance of the model is evaluated using coefficient of correlation (the R), root mean square error (RMSE), mean absolute percentage error (MAPE), standard deviation and t-test. Results shows that ANN model gives better results than regression model. For further work it is suggested that prediction model can be improved by incorporating the information of schedule adherence. It is also suggested to use Kalman Filter algorithm to predict travel time and compare the results with ANN model."

4- What is Neural Networks?:

"In information technology, a neural network is a system of hardware and/or software patterned after the operation of neurons in the human brain. Neural Networks -- also called Artificial Neural Networks -- are a variety of ***deep learning*** technologies. Commercial applications of these technologies generally focus on solving complex ***signal processing*** or pattern recognition problems. Examples of significant commercial applications since 2000 include handwriting recognition for check processing, speech-to-text transcription, oil-exploration data analysis, weather prediction and facial recognition.

A neural network usually involves a large number of ***processors*** operating in parallel and arranged in tiers. The first tier receives the raw input information -- analogous to optic nerves in human visual processing. Each successive tier receives the output from the tier preceding it, rather than from the raw input -- in the same way neurons further from the optic nerve receive signals from those closer to it. The last tier produces the output of the system.

Each processing node has its own small sphere of knowledge, including what it has seen and any rules it was originally programmed with or developed for itself. The tiers are highly interconnected, which means each node in tier *n* will be connected to many nodes in tier *n-1* -- its inputs -- and in tier *n+1,* which provides input for those nodes. There may be one or multiple nodes in the output layer, from which the answer it produces can be read.

Neural Networks are notable for being adaptive, which means they modify themselves as they learn from initial training and subsequent runs provide more information about the world. The most basic learning model is centered on weighting the input streams, which is how each node weights the importance of input from each of its predecessors. Inputs that contribute to getting right answers are weighted higher.

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Typically, a neural network is initially trained, or fed large amounts of data. Training consists of providing input and telling the network what the output should be. For example, to build a network to identify the faces of actors, initial training might be a series of pictures of actors, non-actors, masks, statuary, animal faces and so on. Each input is accompanied by the matching identification, such as actors' names, "not actor" or "not human" information. Providing the answers allows the model to adjust its internal weightings to learn how to do its job better. For example, if nodes David, Dianne and Dakota tell node Ernie the current input image is a picture of Brad Pitt, but node Durango says it is Betty White, and the training program confirms it is Pitt, Ernie will decrease the weight it assigns to Durango's input and increase the weight it gives to that of David, Dianne and Dakota.

In defining the rules and making determinations -- that is, each node decides what to send on to the next tier based on its own inputs from the previous tier -- Neural Networks use several principles. These include gradient-based training, fuzzy logic, genetic algorithms and Bayesian methods. They may be given some basic rules about object relationships in the space being modeled. For example, a facial recognition system might be instructed, "Eyebrows are found above eyes," or "moustaches are below a nose. Moustaches are above and/or beside a mouth." Preloading rules can make training faster and make the model more powerful sooner. But it also builds in assumptions about the nature of the problem space, which may prove to be either irrelevant and unhelpful or incorrect and counterproductive, making the decision about what, if any, rules to build in very important.

Neural Networks are sometimes described in terms of their depth, including how many layers they have between input and output, or the model's so-called hidden layers. They can also be described by the number of hidden nodes the model has or in terms of how many inputs and outputs each node has. Variations on the classic neural-network design allow various forms of forward and backward propagation of information among tiers.Artificial Neural Networks were first created as part of the broader research effort around artificial intelligence, and they continue to be important in that space, as well as in research around human cognition and consciousness."

Reference:http://searchnetworking.techtarget.com/definition/neural-network

5) Conclusions

Traffic Flow Managementplays an important role to improve traffic in any city in the world. Many new methods are available, which combine various intelligent optimization systems for improving the efficiency of traffic congestions, to reach global optimum solutions, these systems are of great help for the traffic flow control authorities.

Back Propagation Neural Network (BPNN) is widely used for short term Traffic Flow Forecasting. To enhance the performance of BPNN, Adaptive Learning Rate and Additional Momentum Methods can be used [12]. As BPNN is inefficient to predict more complex cross roads, Simulated Annealing Algorithm can be used to overcome the disadvantages of Genetic BP NN algorithm. Simulated Annealing model optimizes the synaptic weights and thresholds of BP NN and thus is more steady, feasible and effective method for Traffic Flow Prediction than the earlier methods on the cross roads in better manner. RBF neural network can also be used for the prediction of urban traffic flow, along with the Particle Swarm Optimization (PSO) technique for getting more accurate results than the BP NN.

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