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Toward Sustainable Smart City: An Intelligent Transportation Model for Enabling Smart Services

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Abstract:- with the rapid growth of Information and Communication Technology (ICT) smart city applications has become imperative to ad dress the continually escalating urbanization demands worldwide. These increasing demands pose significant challenges to urban infrastructure, necessitating a sustainable approach for future Smart Cities. The surging service requirements inherent in the smart city paradigm necessitate effective monitoring and management of the constrained infrastructures within smart cities to uphold the Quality of Service (QoS) for essential services of smart cities. To address the exponential growth in ser vice demand and ensure the maintain QoS, it is essential to incorporate context-aware computing in conjunction with fog computing. In this pa per, authors envisioned to improve the QoS of traffic while employing a ML technique at the fog layer to manage the smart traffic services and an intelligent context-aware communication technique, which further improve the QoS of smart city. The aforesaid network simulated CloudSim and image process using python. The performance of the proposed scheme improves prediction efficacy by approximately 11% to 20% when compared to existing context sharing based algorithms.

Keywords: *Smart city, IoT, Intelligent Transport System, Sustainable computing. Image Processing.*

1. Introduction

According to research conducted over the past decade, “smart cities” are large urban communities that aim to provide residents with a high standard of living by providing first-rate amenities and services provided by advanced ICT infrastructure. Convenience services (CPS) are defined as “constantly accessible, ubiquitous services that enhance life satisfaction” [1]. New advances of cyber physical systems can enable smart cities implementation of smart services. Incorporating cross-domain IoT in smart city, it may be seen as the integration of a large number of standalone applications from several domains to streamline and improve the delivery of complex services [2]. In the event of an emergency, such as an automobile accident or a medical emergency, the victim must contact an ambulance or trusted individuals for assistance. However, this may not always be possible. To make sure the right hospital is contacted and that information is relayed to loved ones, smart vehicle and smart city applications coordinate their efforts in such situations. Only until the many smart city IoT applications are fully interoperable and work together toward a variety of goals will this be possible. Many scientists all over the world were inspired by this concept to develop a solid framework for a system that could support real-time applications across multiple IoT domains [3]. The generated data from smart vehicles, sensors, security cameras, traffic lights, smart buildings, smart houses, and smart grid and meters collected from across many layers making cloud infrastructure the ideal setting for big data analytic in the context of smart cities. Fog nodes operate as a bridge from device to cloud. Fig 1 presents the three-tiered smart city service architecture. Fog node layer context-aware computing has proven to be highly successful in managing total service time [4, 5]. Most major cities’ traffic-related services fall short of expectations because they rely on antiquated infrastructure that has been overcrowded as a result of recent technological advancements and because they lack effective ICT and Internet of Things-based service applications. Smart city services provided by the Internet of Things are not yet efficient enough to provide users with comprehensive services in real time. Use of context aware computing along with fog-enabled cross domain architecture can offer a complete solution for smart city [5, 6].

Figure 1. Three Layered Smart City Architecture

Fig.1 presents a smart city three layered architecture, where the bottom layer consists of sensors and devices, these devices generate huge amount of real time information and send to its nearest Fog node for further processing. Fog nodes are deployed as middle layer devices for real-time processing and to provide service incoming responses on real time basis, later it is pushed to cloud for data analytic.

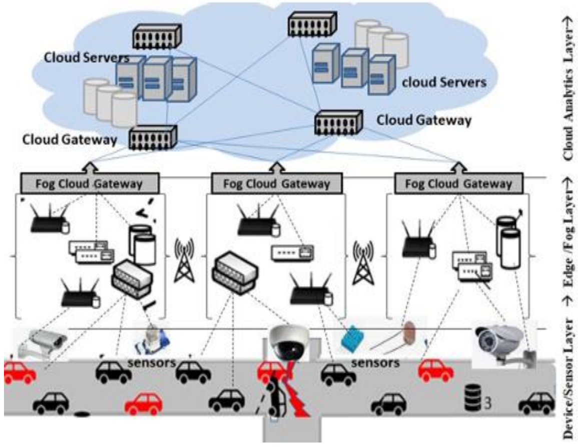

Figure 2. Instantaneous Traffic Control in Metropolitan Environments

Fig.2 presents a real scenario of city traffic with Fog node deployment, it gives an idea of fog node architecture design.

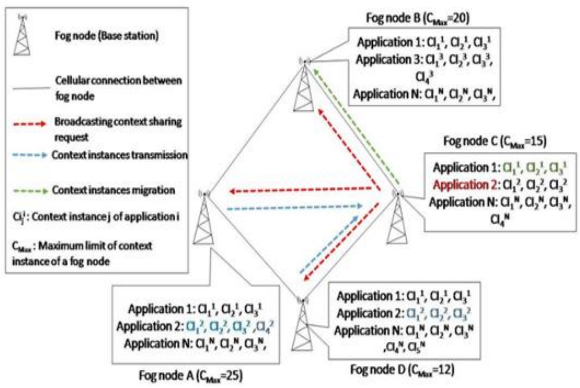

Figure 3. Fog Network Architecture for Smart City

Fig.3 presents proposed a smart city network architecture, where edge devices are deployed in a distributed area in overlapped sensing range. Each Fog node is capable to handle certain number of applications. If a fog node F_i receives a service request SR_J of a particular application then it check the availability of application, computation, context instance and the deadline to complete the service request and it migrate the service request to any nearby for nodes when it fails to do it so. Each Fog node equipped with computing resources along with network unit and buffer space. In the proposed model, homogeneous computational capability is assigned to all Fog nodes. Whereas assigned buffer size is different. The number of applications that Fog node can handle is also randomly generated. The assigned buffer space is presented in terms of context instances. In Fig. 3, c1,c2,c3..cn indicates the number of context instances are at present and Cmax indicates the total number of context instance can store. These context instances are collected through the deployed sensors and other IoT enabled devices. The fetched information from these devices is converted into context. The details of context generation not included in this manuscript, as context conversion or context generation is well addressed topic and number of works presented the details of context generation. Context sharing and context migration between fog nodes takes place in case of shortage of buffer space to manage the required context instances or required context instance are not available or not sufficient at particular Fog node for processing a request, on these cases sharing and migration of context instances approaches are applicable. To manage efficient way of context instance and to maintain the quality of service, an effective sharing and migration techniques are required. More about architecture, nutshell algorithms like sharing, migration presented in earlier work [4,5].

The primary goal of the proposed model is to manage the traffic load while optimizing the traffic signal time. To realize these goals, we model a Fog-enabled network infrastructure that collects data on traffic from the cameras in use and predicts the state of traffic by means of a machine-learning-based canny edge detection technique.

This is how the remainder of the paper is structured. A succinct summary of the problems and topics related to smart cities is provided in Section 2. In Section 3, the suggested smart city model is thoroughly explained. While Section 4 outlines the simulation various scenarios performed. The subsequent section, Section 5, contains the presentation and analysis of the experimental findings. Lastly, in Section 6, we present our conclusions.

2. Literature Survey

Fog computing allows provisioning of autonomous services on any item, which boosts system performance when putting those services into an action. To aid in the migration of IoT services, Kai et al. [7] proposed a platform for service management systems. The migration service is managed with the goal of minimizing communication costs by while considering factors like the number of hops, the throughput, the latency, etc. Adaptive services, which rearrange the services, can deal with the disturbance caused by migration. For the problem of migration in smart cities, Rzevski et al. [8] suggested a concept called Multi-agent technology (MAT), where physical resources, virtual software agents, humans, and a knowledge base systems, which is able to detect differences in services utilizing intelligent and rapid decision making technologies. This concept facilitates the smooth transition from traditional to smart city. With Google Maps, Chavhan et al. [9] presented a context-based car route service. Model components include a decision management subsystem and an estimating and id-finder subsystem. DMM calculates the likelihood of a disruption event, while EIAFM uses the average speed of vehicles and the variation in travel time to calculate the event's margin of error. The suggested system monitors traffic density in real time and optimizes it along a number of different routes. The average commuting time is cut in half with the proposed approach. The VM controller collecting data from the control units and adding it to a service request queue. When a sufficient number of context occurrences have occurred, the VM controller will cede control to service requests. Since finding the optimal allocation of virtual machines (VMs) for smart city tasks is an NP-complete problem, one approach is to use a metaheuristic algorithm. By combining GA with an improved SCS algorithm, we can significantly cut down on both migrations and energy use. Giuseppe et al. [10] presented a smart city service system (SCSS) made up of people, resources, organizations, and shared data that may generate and deliver value to service providers, consumers, and others. Incorporating existing ontologies that facilitate rapid service development and adaptation based on citizen data requires a philosophical model that employs a scenario-based methodology. The scenario-based model accomplishes the most precious resource of a smart city, the illustration and usage of information. The scenario-based approach has a number of problems, one of the most significant being a mismatch between the times it takes for the reasoning process to finish and the rate at which data is generated.

3. Intelligent Traffic Service Management (ITM)

If In smart city, efficient & effective transportation are major problematic area, and they need to be addressed through intelligent solution. Traveling has turned out to be a profoundly hectic activity in today's world with the uncontrolled population rise. When a greater number of vehicles are introduced in an already overcrowded traffic network, a new traffic management system that uses advanced technology is urgently required to enable optimal use of the current infrastructures. More attention should be paid to making better and more cautious use of the infrastructure that already exists rather than building new highways, flyovers, or freeways, which require substantial planning, a large amount of money, and time. Previously, various strategies had been suggested to gain traffic, such as infrared-light sensor, induction loop, etc. From last decade, image processing is showing promising results in the acquisition of traffic in real time using surveillance footage mounted to the traffic light. Different strategies for gleaning data on traffic were suggested. Few of them have absolute pixel numbers [2], some other work measures number of vehicles. These approaches have shown promising results in analysing the traffic data set. The increase in the number of travellers has caused a dramatic rise in traffic at every corner of the city. Re searchers have suggested several solutions for dealing with managing city travel time as well. Some of the solutions currently in use are the timer concept. Traffic can be effectively controlled by using timers at each point of the traffic. When individuals are caught in traffic, they must wait for hours in order to escape the predicament. But by using image processing to incorporate this density dependent traffic control system, help to control the traffic lights on a continuous basis and divert the traffic in light loaded route to avoid the long queue in traffics. The entire proposed model is classified into two major components:

- Real-time Canny-Edge Based vehicle identification.
- Smart-Traffic-Service Management.

This approach uses image analysis techniques such as context subtraction to calculate the number of vehicles that can be used for traffic signal light control, on the road. It is thus very much possible to use the image processing tools. This concept can be portrayed in place of real traffic lights using a timer.

A. Real-time Canny-Edge Based vehicle identification

This proposed solution discusses an algorithm that can be used to lessen traffic congestion. When determining the level of congestion at a given traffic light, it is necessary to take into account the influx and egress of cars in all four directions.

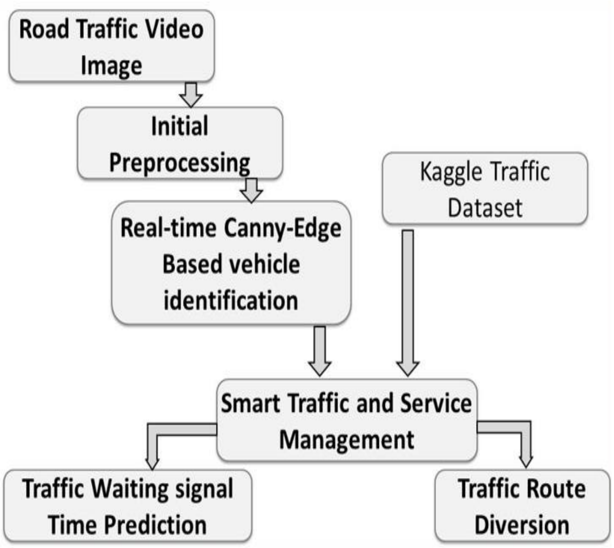

Figure 4. Implementation Workflow Model of ITM

The proposed method for gauging traffic congestion involves a number of stages. Assigning waiting time to specific direction traffic is one of the pro cesses taken based on vehicle count and countermeasures to avoid congestion. Image Pre-processing: Here, high-resolution photographs of traffic coming from all directions are captured via CCTV. In preparation for edge detection, these raw images are stored and analyzed. In this section, edge detection is utilized to isolate vehicle objects from the background. After looking at a number of other edge detectors, we found that the Canny edge detector was the best fit for this proposed solution [11,12]. The time allocation that has been proposed is speculative. Time allocation in the present day could be affected by a variety of variables, including the volume of traffic and the availability of alternative routes [13].

The increasing number of vehicles combined with the insufficient capacity of existing infrastructures has led to a rise in traffic congestion in recent years. In [14], timer-based analysis of traffic density suggests that prioritizing the most economically-significant trips or one of the better ways to manage the economic drag of traffic congestion may be to provide alternate modes of transportation so that people may access transportation even when it is hindered by traffic.

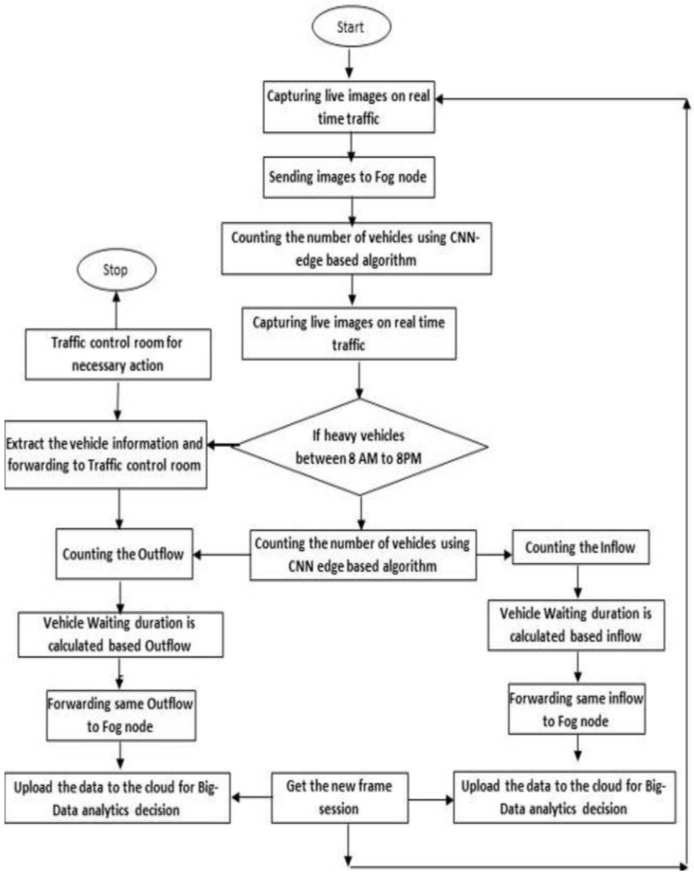

Figure 5. Workflow Model of Canny-Edge Detection

The truth is that each day brings more people and more cars to the streets of the city. The necessity for control of roadways, highways, and roads is an important issue that must be addressed in response to the growing urban population and subsequent growth in the number of automobiles. The current technologies utilized to regulate traffic flow are major contributors to congestion. Modern traffic management systems aren't reliable since they don't pay enough attention to real-time traffic conditions [15]. Our method, built with PyCharm, is meant to alleviate excessive traffic. This proposed approach also makes advantage of the image processing method. A street scene is photographed to begin, and the subsequent steps are detailed as follows: A webcam installed in a traffic lane captures images of the road ahead as cars and trucks pass. Following this, the photos are effectively retained so that the direction of traffic flow can be learned [16] and the details of real-time canny-edge based vehicle identification approach presented [20] in Fig.5.

B. Smart Traffic Service Management (STMS)

A smart traffic service management algorithm deployed to manage the traffic services in effective way [18]. Each fog node act as a master node for taking traffic decision (predicting waiting time and route diversion) at traffic control point, whereas other nearby fog nodes cooperate to effective decision at real time basis. Aforesaid concept of context awareness is extensively used for effective communication between fog nodes. Algorithm 1 presents the specifics of the intelligent traffic service management algorithm.

Algorithm1: Smart Traffic Management System

```
Begin
@ each Fog node
  @each time interval
inFlow_image_streaming_processing()
IFC=cannyEdgeDetection(IFI)
outFlow_image_streaming_processing()
     OFC=cannyEdgeDetection(IFI)
  End
If(IFC >= IFCThreashold) then
semdTrafficMessage(IFC, IFP)
  Endif
If(OFC >= OFCThreashold) then
semdTrafficMessage(OFC, OFP)
  Endif
End
@ each Fog node:On receipt of  TrafficMessage()
   If(!Traffic_Control_Point()) then
forwardTrafficMessage(IFC, IFP);
ElseIf(IFC >= IFCThreashold) then
If(Traffic_Divert_Control_Point()) then
Generate_Traffic_Waiting_Signal();
          Generate_Traffic_Divert_Signal();
          Endif
     Endif
    If(!Traffic_Control_Point()) then
forwardTrafficMessage(IFC, IFP);
forwardTrafficMessage(OFC, OFP);
       Else If(IFC >= IFCThreashold) then
If(Traffic_Divert_Control_Point()) then
Generate_Traffic_Waiting_Signal();
          Generate_Traffic_Divert_Signal();
           Endif
     Endif
End.
```

4. Simulation Details

Two distinct phases are used to implement the complete proposed concept. The first step involves feeding a live feed of traffic to a canny-detection algorithm so that it can count the cars. The results of the first phase are fed into the second phase, which is responsible for overseeing traffic services. The Intelligent Traffic Service Management Model's implemented workflow model is shown in Figure 5. The IT service management (ITSM) model demonstrates how all of its parts function together. Kaggle traffic data set [17] is used to evaluate the performance of smart traffic service management. Subsequently, recordings of traffic on nearby roads were recorded, processed with a canny-detection algorithm, and a data set analogous to Kaggle's traffic set was extracted. Fog nodes were used to create a dispersed fog network for the simulation. The initial number of nodes was set at 50, and after each simulation, 10 additional nodes were added until a total of 100 had been attained. The authors have previously presented a simulation network comparable to this one [4]. In our simulation model, fog nodes are spread out evenly across the smart city and are all within detecting distance of one another. These

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fog nodes are able to process and identify the quantity and types of vehicles in real time. Actual traffic collected by cameras and analyzed by fog nodes. For our experiment, we processed traffic footage separately and fed it to the smart traffic service management simulation model. A global training model is created by integrating all local trained models on the cloud. Training the model is sent back to fog nodes for real-time decision-making. This is repeated throughout simulation. These globally trained models are implemented as services at fog nodes, enabling each fog node to improve the trained model through local data training and use it for prediction [19]. Every fog node communicates in context and shares its contexts on demand. We previously considered context sharing and migration [4]. Context sharing across Fog nodes minimizes QoS breaches. To compare outcomes, the suggested ITSM model and Greedy method share the same parameter values. Despite being dynamic, simulation model performance is treated as the average value of multiple runs with standard deviation.

5. Results Discussion

This section details the simulation experiments performed and their findings in order to assess the efficacy of the suggested model. Traffic That Was Noticed These tests are known as Benchmarked since they use the Kaggle dataset [17]. Timestamp and traffic volume data is included in the afore mentioned dataset. STSM is able to successfully manage traffic by modifying the waiting time for traffic signals and redirecting vehicles along alternate routes with the appropriate messages based on time stamp data. The cooperation of other fog nodes is what allows this to happen. Although the specific application of ground-truth predictions concerning the cars in a given scene is the subject of this study, it may be readily expanded to other kinds of high-value truths by simply increasing the number of columns in the detection prediction matrix.

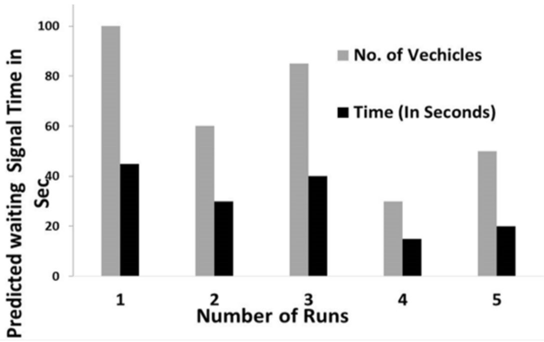

Figure 6: Estimated Traffic Signal Queue Allocation Time Based on ITSM Performance Analysis

Fig. 6 shows that the waiting time projected in the simulated environment decreases in proportion to the number of cars. The reason is due to the fact that the waiting time is determined by various traffic conditions, including the width of the traffic road and the volume of incoming traffic. The prediction accuracy of two distinct accuracy prediction algorithms with regard to a fixed input dataset is shown in Fig. 7. In the case of a decentralized model, or federated model, the prediction accuracy percentage increases along with the number of updates the global model receives from various data sets of vehicles. In these scenarios, the traffic signal waiting time and point of diversion are significantly higher than in the case of a centralized model, or single point.

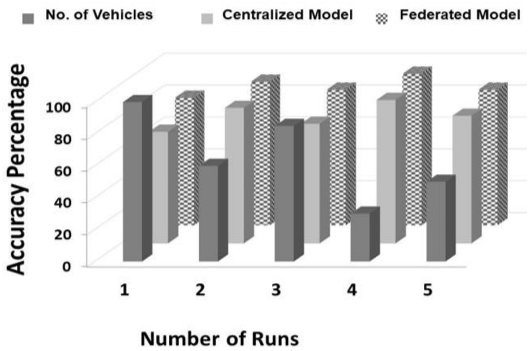

Figure 7. ITSM Performance Analysis: Prediction Accuracy Comparison.

6. Conclusion

This paper presents a novel traffic management model for modern smart cities that enhances the quality of service (QoS) of smart traffic by using a Canny-edge detection machine learning approach at the fog layer to manage the smart traffic services and an intelligent context-aware communication technique within the fog nodes to reduce communication traffic. Real-time traffic load identification and object classification using a hybrid CNN model facilitates efficient distributed smart traffic service management. Our simulation findings reveal that the proposed hybrid model, which combines context-aware service enabled fog network model with machine learning (canny-edge detection) to reach state-of-the-art performance, achieves higher than 95% accuracy for RGB pictures.

IT service management for smart cities is concerned with providing on-demand maintenance through the use of incremental federated learning. When compared to the centralized method and the randomized method, the proposed method is more effective.

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