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Embedded Swarm Traffic Controller Based on Image Processing and Android Application

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Abstract: **The increase in the number of vehicles in the last two decade, has led into such traffic congestion such that people are stuck in traffic for hours, this is the major problem in metro cities. We need smart traffic for smart cities. This paper proposes a solution for the above problem in the form of an embedded system which uses swarm intelligence. The proposed system captures images of traffic on camera and through edge detection processes the images for incoming traffic and directs the traffic lights. The traffic lights are interconnected through Wi-Fi and through swarm intelligence the traffic is routed to different routes to avoid congestion. Another important feature is added in this paper is the traffic updates which we will receive on our android phones which will help us to find the less congestion routes for our travel. Through App-Inventor an application is designed which will provide the traffic updates to registered users, who only can use the Wi-Fi network to find the least congestion route for their faster travel.**

Keywords: **App-Inventor, Embedded System, Image Processing, Swarm Intelligence.**

I. INTRODUCTION

Swarm Intelligence (SI) describes the collective behavior of decentralized, self-organized systems. It is the technique wherein several decentralized intelligent independent units function and aid each other in task. SI provides a basis with which it is possible to explore collective (or distributed) problems solving without centralized control or the provision of a global model. Many units can function in tandem, reducing load and increasing efficiency**.** This also removes the need for a central server. In SI there are several units working together, helping each other without any central control over them.

II. RELATED WORK

A. Graph Theory Based:

The classical minimum shortest route algorithm such as Dijkstra algorithm, Priority queues, bidirectional search etc. are used by many research for road traffic management [1]. Appert et al. [2] utilized graph theory for the measuring urban road network vulnerability. Baruah and Baruah [3] proposed cut-set of graph for the traffic control problem. As the complexity of traffic control on network expansions it becomes more complicated to coordinate the actions of the large number of heterogeneous traffic management instruments that are available in the network. One way of handling this complexity is to divide the coordination problem into smaller coherent sub-problems that can be solved with a minimum of interaction. Multi agent systems can aid in the distribution of the problem (over the various agents that comprise the multi agent system) and facilitate the coordination of the activities of these agents when required. In the literature no consensus exists about the best configuration of the traffic managing multi agent system and how the activities of the agents that comprise the multi agent system should be coordinated [4]. Katwijk et al. [4] reported a test bed for multi agent control systems in road traffic management that can deals the traffic managing multi agent system can be configured, evaluated in a realistic simulated traffic environment, easily transferred to a real world application. Raza and Rao [5] proposed agent based urban traffic and transportation control. This paper gives a theoretical foundation of an intelligent traffic clouds.

B. Genetic Algorithm based:

Genetic Algorithms (GAs) have been demonstrated to be a promising search and optimization technique. It has been successfully applied to system identification and a wide range of applications including filter design, scheduling, routing, control, and others. For applying GAs to complex problems has been the high computational cost due to their slow convergence rate is one of the main obstacles. Han and Tabata [6] combined a genetic algorithm and controlling lethal gene for solving of the vehicle routine problem but the performance for the practical example was not investigated. Meshkat and Vrancken [7] used multi objective technique for the road network partitioning. This study fast and elitist Non-dominated Sorting Genetic Algorithm (NSGA-II) and Pareto Archived Evolution Strategy (PAES) were implemented. Jiang et al. [8] proposed an agent model with adaptive weight based multi-objective algorithm to manage road-network congestion problem. The aim of this study was to construct a quantitative index series to describe the road network congestion distribution, and use such indexes as weights in the multi-objective algorithm to shunt vehicles on those congested links. In the first phase, a multi-agent system was built, where each agent stands for a vehicle that adapts its route to real-time road network congestion status by a two-objective optimization process: the shortest path and the minimal congested degree of the target link. The agent-based approach captures the nonlinear feedback between vehicle routing behaviours and road-network congestion states. Next, a series of quantitative indexes was constructed to describe the congested degree of nodes, and such indexes were used as weights in the two objective functions which were employed by the agents for routing decisions and congestion avoidance.

C. Fuzzy Logic Based:

The fuzzy logic appeared in 1965 by Zadeh introducing the concept of fuzzy sets. It was shown as a very capable mathematical approach for dealing with subjectivity, ambiguity, uncertainty, and imprecision [13]. Fuzzy logic was used as a framework to solve transportation problems such as traffic assignment problem, accident analysis and prevention, traffic control at roads intersection, and traffic light control. During the last decade, some developments in information acquisition technologies through advanced traveller information systems have been done. However, many contextual factors (such as departure time, travel distance, usual driving speed of the driver, weather information, personal preferences, roadwork information, and other information which could be available to the guidance systems in real-time) increase the uncertainty of the itinerary choice.

Ridwan [22] used choice function based fuzzy preferences relations and considered the spatial knowledge of individual drivers. This method strengthened the travel decision by fuzzy preference relations but it utilized small number of influence factors and in real scenario there are multiple influence factors. Hawas [23] estimated the route utility by using neuro-fuzzy data training with a hidden neuron in each fuzzy process. This method used adaptive to the variation of perceptions from drivers but there is no fuzzification training exist. Arslan and Khisty [24] developed route choice model. They utilized hybrid model based on fuzzy logic and analytical hierarchy process. The preference was extracted from driver's psychology. Ghatee and Hashemi [25] proposed quasi logist formula based algorithm for traffic assignment. It maximizes the level of certainty and minimizes the perceived travel delays. The limitation of this study is no results for real networks. Balaji and Srinivasan proposed multi agent system based on type-2 fuzzy decision module for urban traffic management. This method reduces the total delay of vehicles and it was simulated on real traffic of Singapore. The limitation of this method is unavailability of vehicle route guidance. Kammoun et al. [9] [10] proposed an adaptive multi agent system based on the ant colony behaviour and the hierarchical fuzzy model. This system allows adjusting efficiently the road traffic according to the real time changes in road networks by the integration of adaptive vehicle route guidance system. This system was implemented and simulated under a multi agent platform in order to discuss the improvement of the global road traffic quality in terms of time, fluidity and adaptively.

D. Swarm Intelligence Based:

The swarm intelligence has been used to model complex traffic and transportation processes. In fact, the self-organization of the social insects is based on relatively simple rules of individual insect's behaviour. Among the different colony insects, the ant colony succeeds to find food by following the path with highest pheromone quantity deposited by other ants [12]. The pheromone signal represents the communication tool between individual ants. It contributes to the formation of collective intelligence of social ant colonies that can be considered as multi-agent systems. Bertelle et al. [27] proposed road traffic management by using ant system for shortest path in weighted dynamic graph. This method utilized neural networks for traffic flow regulation and it simulated using multi agent platform. Yang et al. [28] proposed optimization model based on coarse-grain parallel ant colony algorithm for the bus network optimization. It was

demonstrated on data of Dalian city, China but it did not consider the real time traffic management. Deng et al.[29] proposed hybrid particle swarm optimization algorithm by combining fluid neural network. This method is influenced by search best path in stochastic traffic networks and this method was simulated with only 20 nodes road network. D'Acierno et al. [30] proposed swarm intelligence algorithm to optimize the signal setting of each intersection for the asymmetric traffic assignment and it lacks on real time management. Garcia-Nietoa et al. [31] used particle swarm intelligence to find cycle programs of traffic lights and implemented for 2 cities in Spain. Mostly, Ant Colony Optimization was used to solve transportation problems such as Travelling Salesman Problem (TSP) and Vehicle Routing Problem (VRP), only few works based on swarm intelligence are developed to solve road traffic management problem [13]. In fact, the problem cannot be solved using the classic versions: artificial ants are able only to generate successively shorter feasible tours by using information accumulated in the form of a pheromone trail deposited on the graph edges.

III. WORKING OF THE PROPOSED SYSTEM

Our aim is to develop the system at signals; this system will have multifunctional operations. Initially the system will measure the traffic density at different signals using image processing using edge detection and accordingly change the time delays for traffic lights viz. the side at which the traffic is high the signal will remain green for more time. Secondly it will also communicate with the adjacent junction signal. Both the signals will collectively manage the traffic depending on the density. So in the same way all signals of the city will communicate with each other forming a SWARM dedicated system. Also send message to next signal when panic key is pressed using Wi-Fi module.

A. Edge Detection:

Edge detection is an image processing technique for finding the boundaries of objects within images. It works by detecting discontinuities in brightness. Edge detection is used for image segmentation and data extraction in areas such as image processing, computer vision, and machine vision.[32] There are many methods for edge detection but most of them can be grouped into two categories, search based and zero-crossing based [33]. Common edge detection algorithms include Sobel, Canny, Prewitt, Roberts, and fuzzy logic methods.

Fig.1. Image segmentation using Sobel method

Fig.2. Image segmentation using Canny method

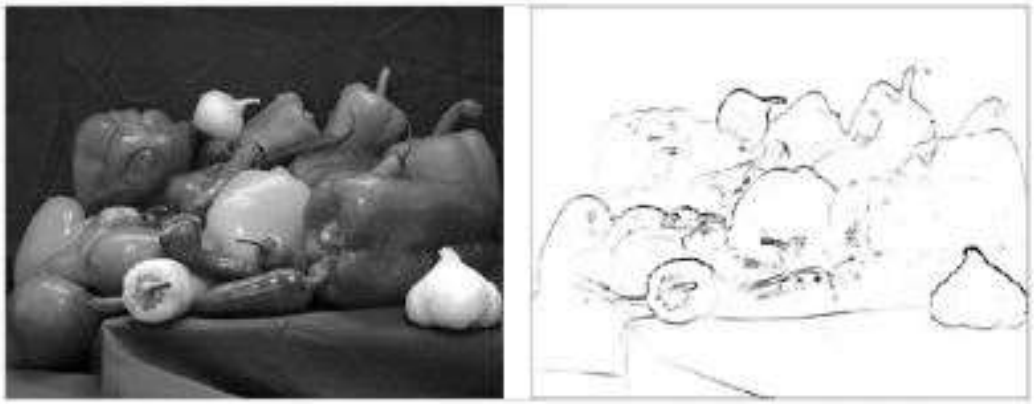

Fig.3. Image segmentation using Fuzzy Logic method

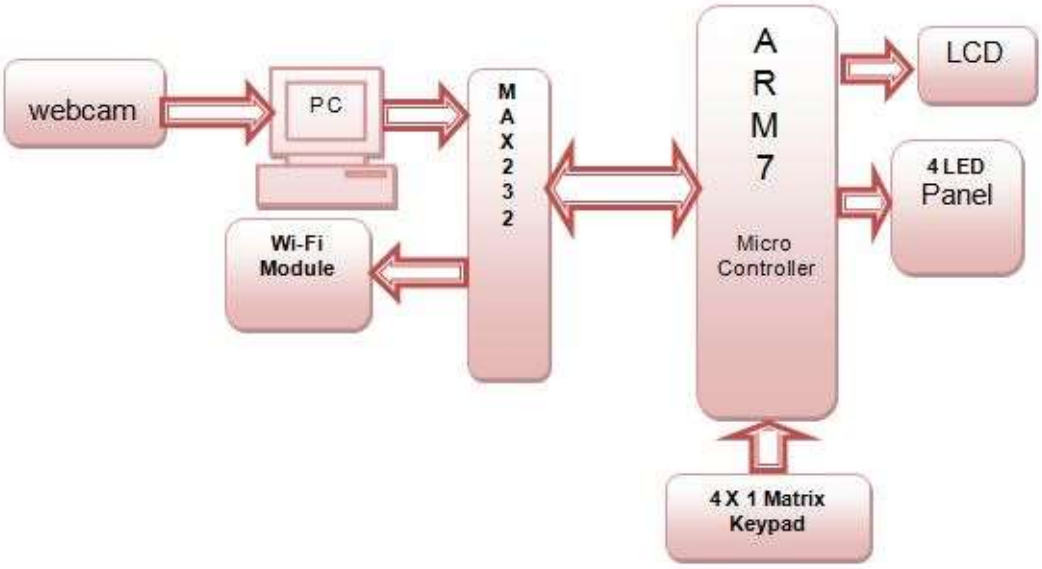

Fig.4 Block diagram of the system at unit signal 1and 2

B. MAX232:

MAX 232 is the name of IC which is used for TTL to RS232 or RS232 to TTL conversion. To communicate serially between two devices, that devices must be TTL compatible. TTL compatibility means TTL logic levels (logic 1/ logic 0) must be same for both the devices. MAX232 converts TTL of 5v in to RS232 standard or RS232 standard in to TTL of 5v. Whereas MAX3232 converts TTL of 3.3v in to RS232 standard or RS232 standard in to TTL of 3.3v

C. ARM7 Microcontroller:

The original ARM7 was based on the earlier ARM6 design and used the same ARMv3 instruction set. The ARM710 variant was used in a CPU module for the Acorn Risc PC. This forms the core of our system, where decisions based on the inputs from the computer are made and respective LEDs are made to glow for desired time intervals. It also controls the Wi-Fi module which is responsible for the communication between the signals.

D. Wi-Fi Module (ESP8266):

ESP8266 offers a complete and self-contained Wi-Fi networking solution, allowing it to either host the application or to offload all Wi-Fi networking functions from another application processor. When ESP8266 hosts the application, and when it is the only application processor in the device, it is able to boot up directly from an external flash. It has integrated cache to improve the performance of the system in such applications, and to minimize the memory requirements. Alternately, serving as a Wi-Fi adapter, wireless internet access can be added to any microcontroller-based design with simple connectivity through UART interface or the CPU AHB bridge interface.

E. LED Panel:

The LED panel forms the visual part of the system which will direct the traffic flow. The LEDs are controlled by the micro-controller and based on its control action.

F. LCD Display:

LCD display is used to display messages to the public in case of emergencies or suggestions for alternate routes. It can also be used to display the general traffic conditions of the next signal so that the drivers can decide their routes wisely.

G. Android Phone:

Android phone is used to receive the traffic updates so that we can select the best route for our faster travel. Block programming is written using App-inventor through which our android phone can measures the less congestion routes and display them on our screen.

App-Inventor is a open source web application designed by Google. It uses a graphical interface, very similar to Scratch and the StarLogo TNG user interface, which allows users to drag-and-drop visual objects to create an application that can run on Android devices. In creating App Inventor, Google drew upon significant prior research in educational computing, as well as work done within Google on online development environments.

IV. APPLICATION

A. Smart City:

A smart city uses information and communication technologies (ICT) to enhance quality, performance and interactivity of urban services, to reduce costs and resource consumption and to improve contact between citizens and government. Sectors that have been developing smart city technology include government services, transport and traffic management, energy, health care, water and waste. Smart city applications are developed with the goal of improving the management of urban flows and allowing for real time responses to challenges. A smart city may therefore be more prepared to respond to challenges than one with a simple 'transactional' relationship with its citizens. Other terms that have been used for similar concepts include ‘cyberville, ‘digital city’’, ‘electronic communities’, ‘flexicity’, ‘information city’, 'intelligent city', ‘knowledge-based city, 'MESH city', ‘telicity, ‘teletopia’’, 'Ubiquitous city', ‘wired city’.

B. Direction of Management of Traffic:

In addition to the earlier method of traffic congestion detection, one more method can be used. A server can be maintained which can receive certain crucial data calculated by the Controller of the signals. The main aim is to implement a system that would trace the travel time of individual cars as they pass the roadside controllers and compute an average trip time using a rule-based system to decide whether the area is congested or uncongested. If congestion is sensed then system would control traffic signals / generate automatic re-routing messages to selected approaching vehicles.

C. Automatic Detection of Speed:

We can use this technique to calculate the speed of a motorist and to detect if he violates the prescribed/set speed limit. If the motorist violates the rule, a warning message will be sent to the motorist via audio and/or video interface and penalty will be calculated in the server and billed monthly to the vehicle owner.

D. Automatic Billing:

Automatic toll collection and automatic ―core area charge‖ collections are also done using the same framework. Controller unit will be placed at toll-booth and along the motor able roads around the core area which will detect each individual vehicle uniquely within its zone by capturing their device ids and will keep records of the time during which the vehicle was seen by those Controllers within its reading zone. This information will be sent to a main server. Accordingly the main server will calculate the charges and raise bills against the vehicle ids.

E. Selection of Less Congestion Route:

Through our android phone we can select the less congestion routes for our travels. This feature has been include in the above proposed system.

V. CONCLUSION

This project can be used for smart traffic in smart city. It introduces us to the vast world of image processing, which is used in several modern day applications. The project tried to touch every field the device can be related to, like designing, programming involved, circuitry, construction, working and application. In a nutshell, it certainly reduces to the modern day problems we are facing with today, that of traffic congestion.

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