Intelligent Cross Road Traffic Management System (ICRTMS)

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Abstract— **The aim of this research is to provide a design of an integrated intelligent system for management and controlling traffic lights based on distributed long range Photoelectric Sensors in distances prior to and after the traffic lights. The appropriate distances for sensors are chosen by the traffic management department so that they can monitor cars that are moving towards a specific traffic and then transfer this data to the intelligent software that are installed in the traffic control cabinet, which can control the traffic lights according to the measures that the sensors have read, and applying a proposed algorithm based on the total calculated relative weight of each road. Accordingly, the system will open the traffic that are overcrowded and give it a longer time larger than the given time for other traffics that their measures proved that their traffic density is less. This system can be programmed with very important criteria that enable it to take decisions for intelligent automatic control of traffic lights. Also the proposed system is designed to accept information about any emergency case through an active RFID based technology. Emergency cases such as the passing of presidents, ministries and ambulances vehicles that require immediate opening for the traffic automatically. The system has the ability to open a complete path for such emergency cases from the next traffic until reaching the target destination. (end of the path). As a result the system will guarantee the fluency of traffic for such emergency cases or for the main vital streets and paths that require the fluent traffic all the time, without affecting the fluency of traffic generally at normal streets according to the time of the day and the traffic density. Also the proposed system can be tuned to run automatically without any human intervention or can be tuned to allow human intervention at certain circumstances.**

Keywords- Intelligent Systems; Automatic control,; Traffic control systems; sensors based systems

I. INTRODUCTION

This research proposes a design for an intelligent cross road traffic management system that is very appropriate to be used especially in crowded cities (such as Cairo, New York, etc). This proposed system will have an effective role in increasing the traffic fluency and to eliminate the crowded traffic at the traffic lights. The subject of this paper got a lot of caring from researchers across the world since the first decades of the twentieth century [1]. Also there are many recent researches such as SCOOT system that was implemented and used in UK and it was based on the optimum utilization of time management in traffic lights [2]. Other models were proposed and implemented for providing the driver with important information helping him in choosing the appropriate paths [3]. Some algorithms and models based on counters to measure the traffic movement were designed [4,5]. Also some dynamic models for management the traffic movement were developed to be applied in the short term [6]. Some crossroads traffic management systems were also developed [7]. A framework for a dynamic and automatic traffic light control expert system combined with a simulation was proposed to help analyze the traffic problem[8]. Many recent studies focused on the use of RFID Technology, its applications, and its impact on business operations[9]. These studies showed the importance of RFID technology and opened the door for suggesting the use of RFID technology in traffic and transportation management. A lot of specialized conferences, and workshops in transportation and traffic have been held such as the International Symposiums on Transportation and Traffic Theory that are held in University of Maryland [10]. Also, many applications of fuzzy logic in traffic signal control has been made since the 1970s as traffic flow is usually characterized by randomness and uncertainty [11].

II. RESEARCH PROBLEMS AND OBJECTIVES

A. *PROBLEMS*

After thoroughly studying and monitoring for the way traffic lights are working in many streets in crowded cities, a set of problems have been identified:

- There are traffic jams occurring in some of the important main vital streets, especially in rush hours and special seasons, which lead to a long waiting time, and high costs of fuel consumption.
- Turning to the manual control via the traffic officer in sometimes to solve the problem of the traffic jam especially in the cross roads.
- The used traffic control system doesn't consider the priority of giving longer time period of green light to a certain traffic light more than another

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ones, so that we can clear the over crowded traffics that may exist.

- Giving a long green light to one direction that doesn't need it.
- There is no available information that we can rely on to give priorities or taking traffic decisions.

B. OBJECTIVES

This proposed ICRTMS aims to achieve the following main objectives:

- Overcoming the traffic jams and reducing the waiting time at traffic lights and to achieve the traffic fluency.
- Guaranteeing a clear path for the emergency cases such as ambulance cars.
- Excluding the human factor intervention in the automatic control of the traffic lights and relying completely on the intelligent control that is proposed in this paper.
- Providing the traffic administration department important useful information that can support in making decisions and controlling the roads traffic.

III. PROPOSED INTELLIGENT TRAFFIC MANAGEMENT MODEL

In this section, the main components of the proposed model are explained and the proposed sensors distribution is shown.

A. Main Components of The Proposed Model

The proposed model aims to portray the design of an integrated intelligent system capable of the management and control of the traffic lights in a city streets. Fig. 1 shows the general architecture for the proposed model components.

According to Fig. 1, the system main components are:

1) *Central Control System:*which is installed in the traffic control cabinet that is located in the traffic location. This system performs the following main functions:

- Switching from the normal mode to the intelligent mode and vice versa according to the programmed logic of the system.
- Selecting the candidate traffic to be opened or closed according to the intelligent system priorities.
- Handling the contingency cases.
- Receiving the sensors readings and saving it in a local DB at the cabinet which can be real time replicated to a central DB located at the central traffic management department. This central DB can be used for the overall control of the city traffics and these data can be the base of data mining activities later to decide the proper values of the sensors relative weights and roads directions priorities.

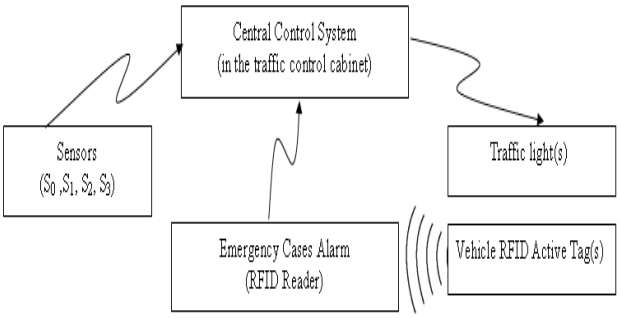

Figure 1. The Proposed Model General Architecture

2) *Sensors:* there are two types of sensors. First type, is used to test whether the destination extensions of the traffic road are clear or not? They are located in the proper places decided by the traffic administration department. Second type, consists of four sensors (from S_0 to S_3) which are located according to the following order: S_0 at the traffic light directly, and the remaining sensors(S_1 to S_3) are distributed on suitable distances prior to the traffic. These distances are determined according to studies done by the traffic administration department for each traffic. All the sensors are allocated at one side of the road, and it is preferable to be the side with no exits.

3) *Contingency Cases Alarm:* the contingency cases include police cars, ambulance, fire trucks, and other contingency cases that require an opened road. Reporting the contingency case is done in this proposed system through one of two ways: First, installation of an active RFID (Radio Frequency Identification) tag in specific vehicles that require such service and it is detected by RFID reader that is located besides the sensor S_3 i.e. the farthest sensor from the traffic light. The readings from the RFID reader are sent to the to the central control system to take the right action. Second, The emergency case vehicle driver is equipped with a mobile device that sends a specific radio signal to the central control system to open the road.

4) *Traffic Light(s):* which is connected to the central control cabinet and works according to the received instructions from the central control system.

B. The Probability Distribution for the cars congestion in the Traffic

Fig. 2 shows the probability distribution for the cars congestion expected to be at a traffic location in rush

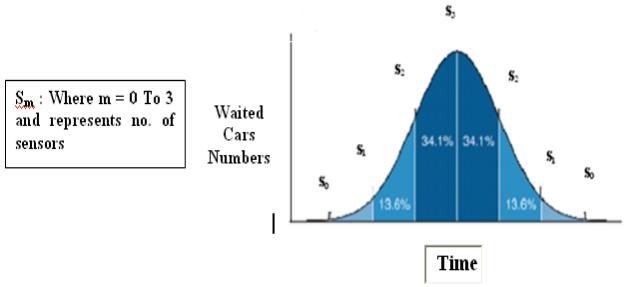

Figure 2. The Probability Distribution For Expected Cars Numbers at Traffic in Rush Hours

hours. It shows three levels for the expected probability distribution of the waited cars in the cross road traffic under study. The first level (from s_0 to s_1) represents the traffic congestion in the normal loads which is the normal state of any traffic, and here the intervention of the proposed intelligent system is not needed. The second level (from s_1 to s_2) represents the traffic state when there is moderate loads, which requires that the traffic is opened for the programmed time in case of moderate loads. The third level (from s_2 to s_3) represents the traffic state when there is too many waited cars (overcrowding), which requires that the traffic is opened for the programmed time in case of overcrowding.

IV. Operation Method of The Proposed System

The proposed intelligent cross road traffic management system depends on using photoelectric sensors on one side of the road, and it is preferable that they are not located on the side with sub exits. These sensors are located on varying distances in the following order (from S0 to S3) as shown in fig. 3. Also, the system depends on using sensors DSj where j represents the possible extensions for a specific road after the traffic, and their main function is to give information about the capability of opening a traffic in these destinations. They report their readings to the central traffic control system at the traffic control cabinet. The proposed system also requires the relative weights of roads priorities to be set by the traffic management authority to the directions according to the importance of each road.

For explaining how the proposed system operates, the following symbols are defined

R_i: R represents the road, and i represents the road no from 1 to 4.

P_i: P represents the relative weight of a road R_i priority, which represents the importance of road i to be opened).

Also, a fixed weight is given to each sensor from S_0 to S_3.

The proposed system is based on applying a trade off between the Total Weight TW(Ri) (The relative weight of a road priority Pi + Weights Sum of occupied sensors (from S0 to S3) for each road Ri from the four crossing roads). A high priority for next traffic opening is given to the traffic

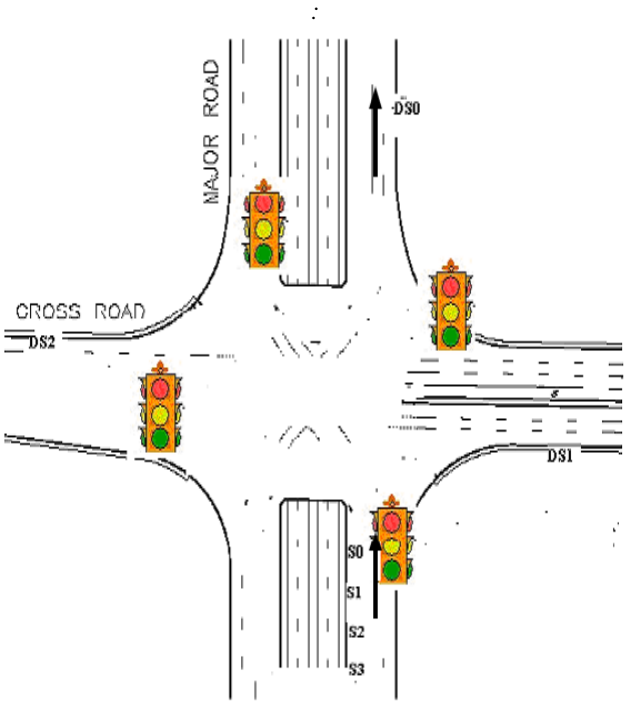

Figure 3. Sensors Distribution on one Direction

with the largest Total Weight TW(Ri) taking into consideration other indicators that will be explained later.

So as we explained, the Total Weight that the opening priority of a specific direction i in the cross road traffic is calculated according to the following equation (1):

$$TW_{(Ri)} = \sum_{m=0}^{3} S_m + P_i \quad (i = 1 \rightarrow 4) \qquad (1)$$

With the condition that it is required to open the traffic to one destination that the destination emptiness sensors readings DSj are positive where j takes the values from 0 to 3, if we have a cross road traffic as the one shown in fig. 3.

An activity chart showing the proposed main algorithm which is applied by the proposed system is shown in fig. 4. Fig. 5 explains how the proposed system deals with the emergency cases.

V. The Proposed System Advantages

The proposed intelligent traffic management system provides the following solutions:

- Overcoming the traffic jam, reducing the waiting time at the traffics, and guaranteeing the flow of traffic.
- Eliminating the human intervention in automatic control of the traffic lights and depending completely on the intelligent control that is applied by the proposed system in the times of traffic congestion, and the emergency cases.
- Availability of information for the traffic administration department which can use it in other decisions and

traffics especially in case of integrating all the traffics across the city using this proposed system. This will lead to the flow of traffic across the whole city streets.

- A good solution for creating a flow of traffic for the emergency cases.
- The proposed system presents an algorithm to calculate the total relative weight which can be used to give the priority for a specific direction, while allowing for the traffic authority to set the values of the system parameters.
- Detecting whether the destination road is empty before opening the traffic for a specific road, which avoids the case of traffic management system failure.
- The proposed system main algorithm will not allow to open the traffic for a road with no cars waiting for the traffic to be opened, which enables the chance to use this time in other crowded direction.
- Switching automatically to the normal system when there is no need for operating the intelligent traffic control system, and vice versa.
- Flexibility of the proposed system to be programmed with varying periods of time that suit many levels of traffic congestion and needs.
- Scalability of the proposed system to be consistent with the evolution of traffic systems and technologies.

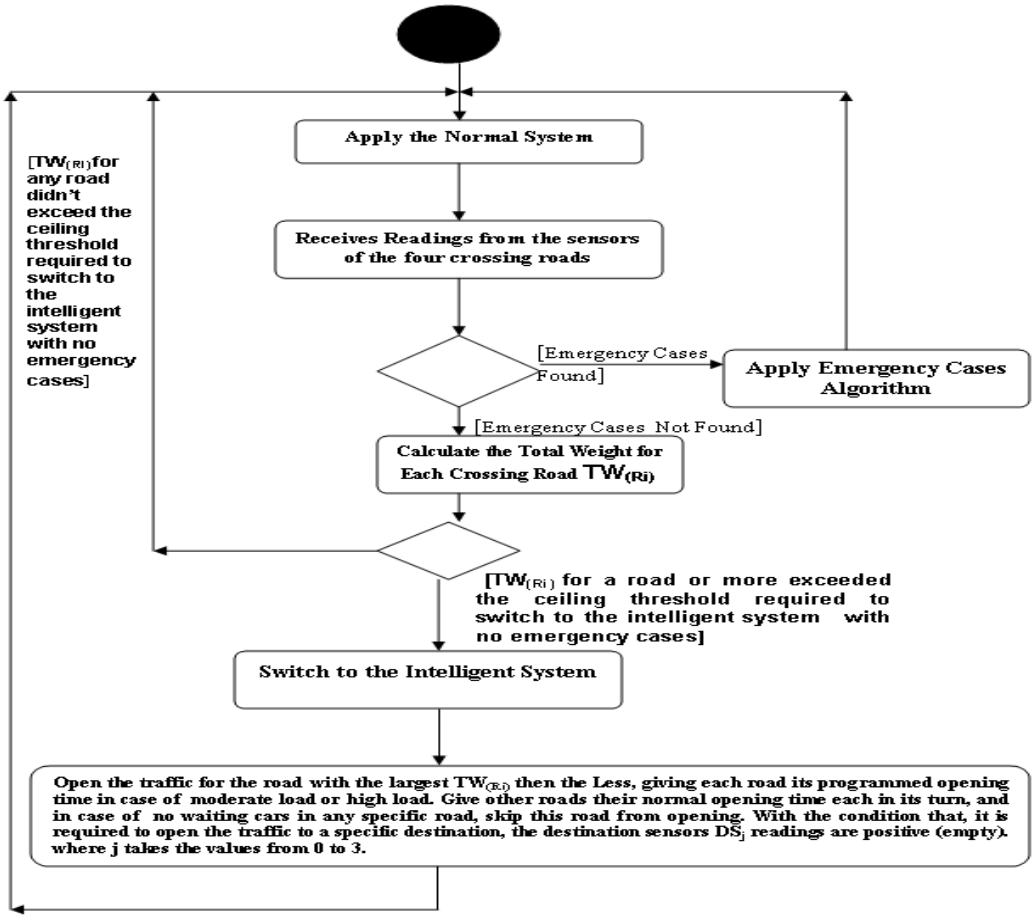

Figure 4. The Central Control System Activity Diagram

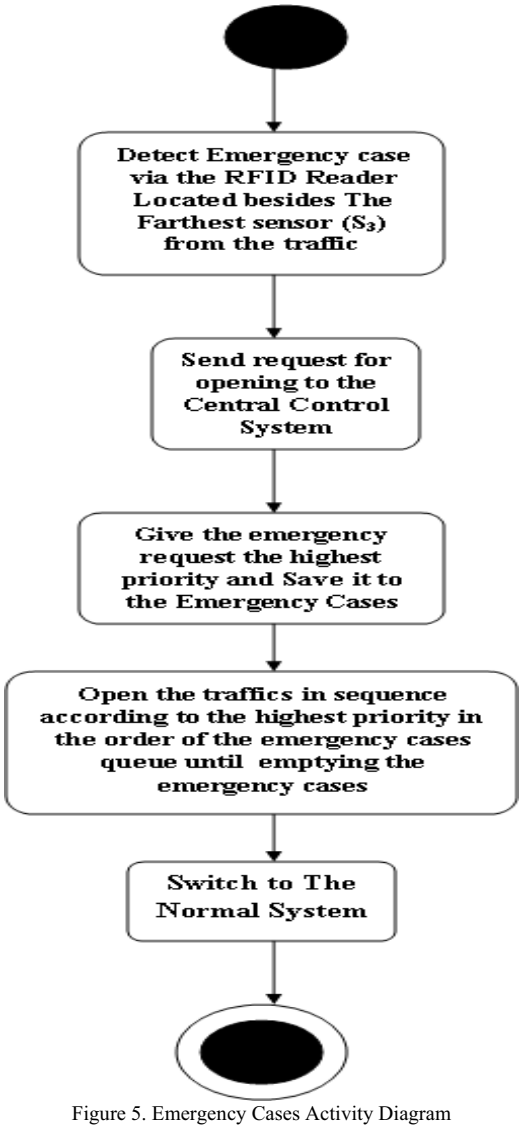

Figure 5. Emergency Cases Activity Diagram

VI. Conclusions and Future Work

In this paper an intelligent cross road traffic management and control system has been introduced. The proposed system aims to overcome the traffic jam, and create a flow of traffic in city streets through applying an intelligent algorithm based on calculating priorities that represent the total calculated relative weight of a specific direction in a cross road traffic. The system is capable of detecting the emergency cases vehicles such as ambulance cars through using a RFID technology or mobile device used by the driver and then providing a flow of traffic for such emergency cases.

This proposed system needs to be applied first on experimental traffics, then to be generalized on all cities streets. In the future, the proposed system will be integrated with different types of transportation sources, including stationary and moving cameras, GPS (Geographic Positioning Systems) devices, historical databases and providing coherent and integrated information to users via a web-based interface.

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