TRAFFIC LIGHT SIGNAL SYSTEM USING RADAR-BASED TARGET DETECTION AND TRACKING

Manish Munjal^{*1}, Amit Grewal², Karan Gogna³

^{*1,2,3}Department of ECE, Dronacharya College of Engineering, Gurgaon

***Corresponding Author: -**

Abstract: -

A novel system and method of integrating an RF emissions device, such as aradar system (103A), within a traffic control indicator (101) system. The system and method determine, using LFM-CW radar signals (201) and a multi- stage spectral processing algorithm (600), if one or more object/vehicle targets will enter an intersection and comprises receiving a radar echo response (203) indicating the object/vehicle target (104) is approaching the intersection, receiving range and velocity of the object/vehicle targets (104), and based on the receiving, determining if the object/vehicle target (104) will enter the intersection. The system and method can programmatically be configured to activate red-light-hold, green-light-extension, or left-turn- warning.

Distributed under Creative Commons CC BY-NC 4.0 OPEN ACCESS

INTRODUCTION

The present invention is directed to traffic control indicators for controlling automobile traffic in an intersection, and more particularly to radar transceivers used in combination with traffic lights for controlling light signals as a function of vehicles approaching or entering an intersection. As used herein, traffic control indicator means any indicator used to control, notify, or alert vehicle or pedestrian traffic, including but not limited to traffic signals, traffic lights, lights, flashing lights, LED arrays, messages, and other vehicle or pedestrian traffic warning and control indicators. Likewise, the use of a term such as light, light signal, traffic signal and the like is not meant to be limiting, but rather is intended to cover any type of traffic control indicator. The use of terms to generally describe components of the invention, such as lights, is not meant to be limiting. For example, the term lights, means any indicator, such as light bulbs, LED arrays and the like that is an emitted signal intended to notify a recipient of the status thereof and of a particular set of circumstances.

BACKGROUND OF THE INVENTION

Traffic control indicators are used to efficiently control vehicle and pedestrian traffic through along roadways, sidewalks and the like and through crossings and intersections. While traffic signals have been in use for many years, improvements continue to be made in the areas of object/vehicle target sensing and detection, traffic control algorithms and traffic volume detection.

Each year there are thousands of accidents, resulting in numerous injuries and deaths, at roadway intersections due to vehicle drivers running red lights (referred to herein as “Red Light Running” or “RLR”). While solutions exist for identifying and ticketing the offenders, there is an increasing need to prevent the occurrence of such accidents in the first place.

A solution to reduce the occurrence of accidents due to vehicle RLR is to hold the cross-traffic red light during such occurrence. The technology that implements this functionality is typically referred to as Red Light Hold (“RLH”). RLH senses that a driver in a vehicle is going to engage in RLR and maintains the red light on cross traffic until the offending driver has exited the intersection.

CASE STUDY

Most of the serious RLR accidents occur when an offending vehicle enters the intersection between 3 and 8 seconds after the signal turns red. Thus, assuming there is 100 to 200 feet of intersection in front of the traffic signal, a system implementing RLH functionality must be able to detect object/vehicle targets approximately 800 feet from where the traffic signal is mounted in order to implement RLH effectively. In order to determine if the vehicle is going to enter the intersection at a dangerous time, the RLH system must be able to determine the distance and velocity of the approaching vehicle. In many intersections, the cross-traffic green light is delayed a second or two in the all-red condition to provide some safety margin. These green light delays may be longer in higher-speed intersections where RLR object/vehicle targets might travel in excess of 70 mph.

Several systems have been devised that attempt to implement RLH technology. However, these systems failed in field trials since they are based on sensors that do not provide adequate information to a RLH decision algorithm. The system disclosed in U.S. Pat. No. 6,281,808 to Nestor (“Nestor”) is based on video cameras monitoring incoming vehicles. Disadvantageously, the video cameras could only detect the position and velocity of a vehicle within a few hundred feet of the video camera mounted in close proximity to the traffic signal. As a result, this system is unable to prevent most RLR accidents. Another system described in U.S. Pat. No. 6,100,819 to White (“White”) suggests using multiple loop sensors built into the pavement. However, disadvantageously, these sensors simply detect the presence of a vehicle above them. Thus, vehicles can only be detected at places in the roadway where sensors are installed resulting in a limited view of the incoming traffic. Furthermore, these loop sensors are expensive to install and maintain. A system employing one or two loop detectors on an intersection approach is not capable of making consistently accurate RLH decisions. To implement a functional RLH system whereby velocity and range information is obtained over a large portion of the roadway, loop sensors must be installed in each lane of the road every 10 feet for 800 feet. This is impractical in terms of installation cost, reliability, and maintenance cost.

Another algorithm in traffic engineering known as Green Light Extension (referred to herein as “GLE”) is designed to prevent accidents and make the roadways more efficient. GLE refers to dynamically extending the duration of a green light to allow all of the vehicles in a group to pass through the intersection. Ideally, the light should turn red when no more vehicles are close to entering the intersection. Nevertheless, there are times when a sufficient break in traffic is not available. While a GLE system will tend to stop traffic during a break or reduction in approaching traffic, it also will typically have a maximum extension period that will timeout, thus ending the GLE, if no breaks are detected.

There are several benefits to GLE. Because lights are more likely to turn red when no vehicles are approaching, the number of potential red light runners decreases significantly. It is distinguishable from RLH in that GLE can reduce the number of red light runners, while RLH is a means of protecting cross-traffic from cars that actually engage in RLR. In addition, some drivers will stop abruptly when the light turns yellow causing trailing vehicles to rear end them. If the green light is extended using GLE, it will reduce the number of rear-end collisions that occur in intersections. In addition to making intersections safer, GLE reduces the amount of wear on the pavement in front of the intersections. For instance,

large trucks that are forced to stop at the intersection present a significant loading on the pavement for the duration of the red light, with the result that cities are required to make pavement repairs more often for intersections that carry a high volume of truck traffic. Systems that are able to detect oncoming trucks and extend the green light so they can pass will extend the life of the pavement. Additionally, such systems help conserve energy and reduce emissions as GLE results in trucks stopping and starting less often, which results in greater fuel efficiency. Thus, GLE can help save limited natural resources as well as assist in preserving the environment.

UTILITY

Due to the potential benefits, GLE is an active field of research in traffic engineering. However, conventional systems that implement GLE use multiple loop sensors that are built into the pavement. As noted above, these sensors are expensive to install and maintain, and furthermore, are limited in their ability to detect information about vehicles as these sensors simply detect the presence and speed of a vehicle. Because vehicles can only be detected at places in the roadway where sensors are installed, a limited view of the incoming traffic is presented. Algorithms that determine GLE time will perform better when more sensors are present, however, the number of conventional sensors required make such a system inefficient.

In addition, there are many accidents each year resulting from drivers of vehicles making unprotected left turns (referred to herein as “ULT”) across approaching, oncoming traffic or crossing traffic. Due to the geometry of certain intersections, the presence of cars in the opposing left turn lane can block the view of drivers attempting to make a left turn. Even though visibility is significantly reduced, many drivers will still attempt the blind left turn.

One means of reducing the occurrence of accidents due to ULTs is to signal a driver in the left turn lane that another object/vehicle target is approaching from the other direction at such a distance and velocity such that it is unsafe to proceed. The technology that implements this functionality is referred to herein as Left Turn Warning (“LTW”). LTW senses that a driver in an oncoming or crossing object/vehicle target is going to approach the intersection within a certain time frame such that the left turning vehicle is put at risk if it is in the intersection. LTW warns the driver making the ULT that it is not safe to turn.

Adaptive warning signals to drivers have been discussed in the traffic engineering literature. Such signs can be attached near the typical traffic signal stack or can be located on the opposite corner of the intersection where it would be readily visible by drivers attempting to turn. Preferably, the signal would only warn drivers that vehicles are approaching and that conditions are dangerous for turning, not inform drivers that it is safe to turn.

An algorithm that processes information about vehicles approaching the intersection controls these left turn warning signals. Sensors such as loop detectors in the pavement can provide a limited amount of information. As is the case with GLE and RLH, the warning algorithm will perform better when vehicle range and velocity information is available for input into the algorithm.