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PROBLEMS WITH EFFECTIVE TRAFFIC MANAGEMENT

Abstract: Our research aim was to identify a solution to problems around effective traffic management in cities. By researching existing approaches to traffic management, we have identified opportunities to improve monitoring systems through the use of artificial intelligence. We propose a solution that is based on the use of video recording cameras which is comparatively low-cost against other approaches that give the same results.

Keywords: traffic, monitoring of transport flows, intelligent transport systems.

Introduction

Every year the amount of traffic on roads is intensifying, which in turn leads to an increase in the number of traffic jams, especially in cities.

Traffic jams are mainly related to the intensive use of private cars, which have the advantage of facilitating personal mobility, providing a sense of security and even enhancing the status of the traveller, especially in developing countries. However, they are not an effective means of passenger transport, as on average during rush hour each passenger in a car causes around 11 times more congestion than a passenger in a bus.

The cost of congestion is extremely high. According to conservative estimates, for example, an increase in the average speed of private cars by 1 km / h, and the speed of public transport by 0.5 km / h will reduce travel time and operating costs by the equivalent of 0.1% of gross domestic product (GDP) [1].

The situation is even worse in regions that have problems arising out of the road design and maintenance in their cities. Inaccurate information about traffic conditions and poor management of responsible authorities are all problems found in modern transport systems.

We are seeing a steady growth rate in the number of vehicles in cities, and there are currently no methods for effectively managing traffic flows that take into account various factors.

The aim of the study is to identify problems that affect the ability to improve the efficiency of traffic flow monitoring systems on busy highways in cities and large transport hubs and to assess the possibility of using artificial intelligence and computer vision to improve the situation on roads in cities and on busy highways. The object of this study is the systems of monitoring traffic flows and the possibility of improving them in general.

Background

Today, there are several types of systems that allow us to monitor traffic flows in large cities or on busy highways. These can be referred to as Intelligent Transport System (ITS) [2]. ITS is an advanced application that aims to provide innovative services related to various types of transport and traffic management, as well as allowing users to be more informed and feel safer, more coordinated and more confident in the use of transport networks. They are, for example;

GPS methods. Many vehicles are equipped with GPS (satellite navigation) systems, which have a two-way connection with traffic data providers. The position readings of these devices are used to calculate the speeds of vehicles. Modern methods may not use special equipment, but instead use solutions based on smartphones using so-called Telematics 2.0 approaches. [3] The main problem with this method of measuring the number of cars is the possible inaccuracy of the data obtained, especially if it is necessary to calculate the number of cars on a short distance (the number in front of the checkpoint or traffic light in one direction only).

Smartphone-based monitoring. Smartphones with different sensors can be used to track the speed and density of traffic. Accelerometer data from smartphones used by drivers are monitored to determine speed and road quality [4]. Audio data and GPS-markings of smartphones allow you to determine the density of traffic and possible traffic jams. As in the method above, there is a problem with estimating the number of vehicles on small sections of the route. However, they can be used successfully over long distances, where there is no need to calculate the number of cars over a short distance.

Probing systems for ITS - these are network systems based on vehicles and infrastructure, i.e. intelligent vehicle technologies [5]. Infrastructure sensors are non-destructive devices (eg road reflectors) that are installed or built into the road or its surroundings (eg on buildings, poles and signs) and, if necessary, can be distributed manually during road maintenance or by means of touch injection technology for rapid deployment. Vehicle sensing systems include the deployment of electronic infrastructure beacons to the vehicle and the vehicle to the infrastructure for identification communications, and can use automatic video license plate recognition or magnetic signature detection technology at the required intervals to increase continuous monitoring of vehicles operating in critical situations. The main disadvantage of this method is the inability to quickly move the system in space which means that unfortunately if we need to change the boundaries or size of the area without physical intervention in the system this will not work.

Another form of vehicle detection - is traffic flow measurement and automatic **detection with video cameras** [6]. Because video detection systems, such as automatic license plate recognition systems, do not install any components directly onto the pavement or road surface this type of system is known as an unobtrusive method of detecting traffic. Video from the cameras is fed to processors that analyze changes in the characteristics of the video image during the passage of vehicles. Cameras are usually mounted on poles or structures above or adjacent to the roadway. Most video detection systems require some initial configuration to teach the processor the basic background image. Typically, this involves the introduction of known measurements, such as the distance between the lines of the lane or the height of the camera above the roadway. One video detection processor can simultaneously detect traffic from one to eight cameras, depending on the model. Typical exits from the video surveillance system are traffic speeds, traffic counters and lane occupancy. Some systems provide additional exits, including space, travel, detection of a stopped vehicle and incorrect car alarm. However, the systems providing additional exits are prone to being affected by additional factors such as lighting or visibility according to weather conditions.

Materials and methods

Now we will identify and critique the varying possibilities of using artificial intelligence to improve the efficiency of traffic monitoring systems.

GPS methods. The fundamental problem with this method of measuring the number of cars is the lack of accuracy of the data, especially if you need to calculate the number of cars on a short section of road. Therefore, data of this type is not very suitable for obtaining operational information but can however, be used to model traffic [7, 8, 9].

Smartphone-based monitoring. This type of system was implemented in Bangalore, India, as part of the Nericell research experimental system [4]. There were however several problems with estimating the number of vehicles on small sections of the route, but it was possible to estimate the complexity of traffic. Another complication is that the system uses data from smartphone speakers and accelerometers, which can be seen as an invasion of the privacy of the device's owner.

Probing systems for ITS. The main disadvantage of this method is the inability to quickly move the system in space, which significantly limits their use. Such systems are widely used in public transport logistics and in automated warehouses operated by artificial intelligence systems [5].

Using camera recorders. The most promising is the use of computer vision to measure traffic flow and automatically detect accidents with video cameras. Because we will have video cameras located in a designated area with good coverage, this will allow us to use computer vision to obtain information on the number of vehicles for a given period of time without human intervention. [10] We would be required to provide recommendations for the location and number of cameras, as well as a system that combines algorithms for calibrating the detection of the vehicle, its tracking and estimating its speed. Vehicle counting and speed estimation results are compared with manual counting data and GPS data. The comparison shows that the system has a greater potential to obtain reliable information about traffic conditions from video surveillance systems.

The main requirements for the use of computer vision to obtain data from video cameras are:

1. Availability of sufficient computer power to enable the recognition subsystem to work. If statistics are to be collected in real time, the capacity should be sufficient to calculate all the necessary calculations. If the system collects information for further analysis and use,

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then the computing power may be weaker, because there is no need to deliver information immediately.

2. Placing the camera in a place where the traffic flow and road users are clearly visible.
3. Favorable weather conditions with a minimum visibility of 1-2 km.

If all conditions are met, we will be able to integrate the recognition subsystem into the existing system without interfering with it, because all you need is a video file recording the movement of cars.

Results

To solve this problem, it will be advisable to use video cameras, as this method is low-cost compared to others, and also gives fairly accurate results without the need to mark each individual car with labels or additional devices. To implement this method, you can use several approaches:

1. recognition using neural networks;
2. recognition by the method of comparison with a given sample;
3. statistical methods;
4. structural and syntactic methods.

The first method is the most interesting and promising, because its accuracy is the best. Also, a wide range of possible implementations, such as YOLO [11], opens a wide springboard for experiments. With YOLO, we do not look for regions of interest in the image that could contain a specific object. Instead, we divide the image into areas, usually a grid of size 19 × 19. Each cell will be responsible for predicting a number of constraint fields (if there is more than one object in that cell). This will give a large number of limiting regions for the image. Most of them will not have the required objects inside, so we must provide a parameter value that will indicate the presence of the object in a given area. In the next step, we remove blocks with a low probability of the contents of objects and merge the frames with the largest common area (the process is called non-max suppression).

It should also be noted that in this case we are only interested in the number of available cars on the stream, which is why we may make a small error in recognition, because the boundaries of objects, their brands, type, size are not significant to our system.

Test images of one of the main arteries of the city, where the traffic is relatively high for the possibility of such an experiment, were used for the experiment. First, a video was taken, which we then divided into separate frames. These frames were shuffled randomly so that the number of cars in each time period differed from the previous one.

Next, in the imaginary system, we randomly submit footage from the video, after which the system recognizes all available cars in it and sends data to a central server. The data comes in the form of: direction of movement, number of detected cars, exact time and date. Then there is an analysis of whether there is a need to adjust the direction of movement at a given time. This data is passed every 5 seconds, to avoid the problem of recalculating the same objects several times in the near future.

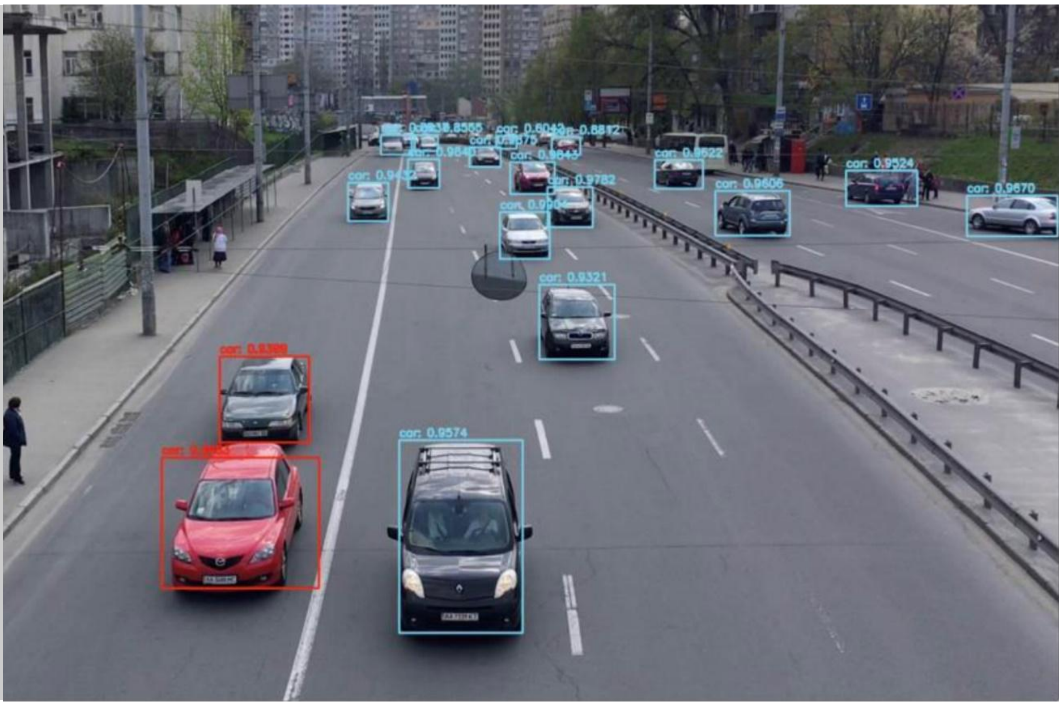

Figure 1. An example of object recognition in traffic

The results of the study showed that the system is able to recognize a standard image with Full HD 1920x1080 pixels in 300-550 ms (all studies were performed on a desktop computer, and therefore in industrial use, the results may be even better). At the same time, the recognition accuracy reached 99.4% with an average value of 95.2%. The maximum number of recognized objects is 43 out of the 48 available; the closer the object is to the camera, the higher the accuracy.

With full control by the algorithm, a problem may arise when the peripheral flow that enters the main street with the most amount of traffic takes all the time, and therefore the peripheral streets will not receive travel time, which can create a problem when an insufficient number of cars will stand in the adjacent traffic jam for a few minutes. That is why the system must measure time, and in the presence of at least one car to switch the regulation for the allotted period of time (60-80s).

Among the shortcomings at the moment: lack of regulation in the system, taking into account the priority of the flow (in which there are ambulances and state emergency services; ambulance, police, fire safety), lack of consideration of people waiting to cross the street, and no priority for public transport.

Taking into account the above factors, we can say that the system will not be ready for use in densely populated cities, but now it can be tested remotely from residential areas and intersections, which are regulated by traffic lights.

The predicted outcome of the introduction of this monitoring method is to reduce the amount of time vehicles spend in traffic jams by 2-4%.

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