

# Intelligent Traffic Information System a Real-Time Traffic Information System on the Shiraz Bypass

Amir Sodagaran<sup>1</sup>, Narjes Zarei<sup>1</sup> and Zohreh Azimifar<sup>2</sup>

<sup>1</sup>Shiraz Traffic Control Centre, Shiraz Municipality, Shiraz, Iran

<sup>2</sup>Electrical and Computer Engineering, Shiraz University, Shiraz, Iran

**Abstract.** Real-time traffic information system is an Intelligent Transportation System (ITS) that allows commuters to make their traveling plan better. In this regard, an intelligent and real-time traffic information system was developed based on the video detection and an image processing algorithm was applied to measure traffic-flow according to the average speed of vehicles. Then, traffic status of each pass way is broadcasted to the electronic boards installed on all decision making entrance / exit. Different levels of congestion related to the routes ahead are shown on the boards with different colors in order to assist commuters. This system was implemented on the Shiraz Dry River's bypasses which account as vital routes to moderate traffic of city center. Experimental results are promising due to the proximity of determined traffic status by the system compared to the detection done by traffic experts. Average speed improvement is another result of using this system. This intelligent system developed and implemented in Shiraz city for the first time in Iran.s.

## 1 Introduction

Nowadays, travelers desire to be aware of real-time traffic flow which allows them to optimize the routes according to their destination. This issue becomes more significant in the roads with limited entrances and exits without secondary paths such as tunnels and bridges. Indeed, in such roads, if the drivers enter the passage without knowledge of traffic condition, they should tolerate the condition until next exit which result in a long delay and travelers inconvenience. Shiraz Dry River's bypasses are example of such special roads. More precisely, Shiraz bypasses pass diagonally from the middle of the city and connect northwest to southeast and vice versa. They accounts as a minor but vital pathway that passes traffic from the city center especially in peak hours. According to nature of Shiraz bypass with high distance between most entrances and exits, real-time traffic information is greatly valuable for bypasses' traveler decision making.

In this regard, Intelligent Transportation systems (ITS) suggest real-time traffic status systems as an effective solution to apply traffic control strategies which provides drivers with traffic information. Obviously, a reliable real-time traffic status information system is obtained through three steps: data collection, processing and dissemination in which a great variety of technologies has been developed for each step [1].

There is a variety of sensing technologies for detecting vehicles in the roadway such as inductive loops, vehicles probes, radar sensors, aerial surveillance and

cameras. Although collected data using embedded detectors is accurate, maintenance cost of employing these technologies such as wiring and digging is the main challenges. In addition, regard to their limited detection area, gathering the data need employing many detectors. Recently, video detection is the most commonly used method regard to its wide-area detection. At the following, collected data such as occupancy, volume and speed of passed cars received from videos and other detectors should be carefully e integrated and translated to provide useful traffic information which is primary task of traffic control centers (TCCs).

In the current work, optical flow is used to detect vehicle motion in the received images which is defined as pattern of apparent motion of objects, surfaces, and edges in a visual scene caused by the relative motion between an observer and the scene [2], [3]. Recently, the term optical flow is also used by roboticists, encompassing related techniques from image processing and control of navigation including motion detection, object segmentation, time-to-contact information and motion compensated encoding [4], [5]. Various methods are proposed to compute optical flow and motion detection [6] - [9].

Finally, after intelligent detection, real-time traffic information should be disseminated to the road users through various technologies such as television, telephone, radio, boards, internet, cell phones and navigation devices [1]. Recently, tendency of methods is toward using variable message signs (VMS) which are the most easily accessible one for the most travelers.

Indeed, VMSs are easily used by all road user types with different facilities and educational level.

As an example of such real-time traffic condition information, we can refer to real-time of traffic information in Shanghai. In 2003, the Shanghai Urban Construction & Communications Center, Shanghai Electrical Apparatus Research Institute and Tongji University developed 'urban intelligent traffic navigation system' to serve the drivers with real-time traffic information of shanghai's highways. In this regard, 196 electronic traffic information boards were installed to show different levels of congestion with three colors; red, yellow and green." Red means blocked (speed less than 20km/h), yellow indicates jammed (speed between 20km/h and 45km/h), while green shows smooth traffic (speed of more than 45km/h). Some boards can also provide estimated arrival times to the next exit." Data collection in this system is done through 3,278 underground sensors installed at 300-400m intervals on the main roads. As mentioned above, although collected data by these methods is accurate, digging, wiring and maintenance cost are the main challenges of the embedded detectors. In addition, regard to limited detection area, gathering the data need employing many detectors. At the other hand, received data from many detectors should integrated and translated to provide traffic information [10].

Another popular ITS method to extract and process the current state of the roads is Automatic Number Plate Recognition (ANPR). For example, Traffic Scotland has implemented ANPR cameras to record the Vehicle Registration Numbers (VRN) of passing traffic. These are then encrypted at a computer outstation and stored alongside the related time stamp and camera location. By matching the encrypted VRN between camera locations, a journey time can be derived between those two ANPR locations. This information is then collated by the Traffic Scotland Control Centre, and will be used in the future to inform drivers using variable message signs (VMS). Although, by this method an accurate journey time and average speed is estimated for long distance journeys, there are some delays in real-time dissemination of traffic information and the price of ANPR cameras makes this solution as an expensive one [11].

The reminder of this paper is organized as follows: section II describes the specification of Shiraz Dry River's bypasses while a short description of ITS technology is presented in section III. Proposed method is then explained in section IV. Finally, experimental results and conclusion are presented in section V and VI, respectively.

## 2 Shiraz dry river's bypasses

Shiraz is sixth most populous city of Iran and accounts as a east-west city. Shiraz Dry River's bypasses are the roads which connect northwest to southeast and vice versa with length of 15 kilometers, width of 8 meters and 21 entryways and exits.

The most important challenge related to these bypasses is that as the cars entered the track, there is no

alternate route until the next exit and since there is no prior information about the traffic status of bypasses, if the drivers faced with congestion, they should tolerate the condition until the next exit which results in a long delay and inconvenience. In addition, entry of other vehicles in heavy traffic status, double the problem and result in traffic anomalies and dangerous violation such as circumvent the ban and reverse gear.

At the other hand, given the vital role of the bypasses as a route which helps to evacuate traffic of city center especially in the morning and evening peak hours, awareness of traffic flows ahead in the decision making entrance/exit can be so useful. Therefore, providing drivers with real-time traffic information is purpose of this article..

## 3 Intelligent transportation system

Nowadays, it is believed that solving the problem of traffic congestion, rely not only on improving transportation facilities but also on employing different technologies for more efficient use of existing infrastructure. In this regard, IT technology has been increasingly applied in the transportation industry and allows the elements in this domain to use microchips and sensors in order to communicate with each other. The efforts in this regard led to formation of Intelligent Transportation Systems (ITS) which are commonly grouped within different categories, such as; Advanced Traveler Information Systems (ATIS) includes the applications such as Real-time Traffic Information Provision, Route Guidance/Navigation Systems, Parking and Weather Information Systems. Some other systems which try to apply traffic control strategies are placed in the Advanced Transportation Management Systems (ATMS) category such as Ramp Metering, Dynamic Traffic Signal Control that are mostly managed in the Traffic Control Centers [1].

To provide real-time traffic information system, different technologies are applied such as Global Positioning System (GPS), Dedicated-Short Range Communications (DSRC), wireless networks, mobile telephony, radio wave or infrared beacons, roadside camera recognition and probe vehicles or devices [1]. Indeed, the underlying technologies are used in collection, management and broadcasting traffic information data on online maps, cell phones or variable message signs (VMS) in the roads to help drivers choosing an optimal route with less congestion.

## 4 Proposed method

To come up with a precise explanation of developed intelligent traffic status information system, proposed method is described below through three phases: (1) Data collection, (2) Data aggregation and translation and then (3) information dissemination.

### 4.1. Data collection

Among different sensing technologies for detecting vehicles, tendency of recently methods is toward

employing cameras which provide efficient wide-area detection besides giving a full monitoring facility that result in extracting more information about traffic events, accident and also weather conditions. Data collection is done through 21 pan/tilt/zoom cameras installed at 500 meter intervals on the roads and transmitted to the traffic control center (TCC) via fiber and wireless networks. Due to the capability of cameras for defining multi-presets, more than 40 critical segments (points) are covered by these cameras. Indeed, for each camera, two or more presets are defined and every two minutes, the cameras rotate once upon these points. Thus, one segment may be covered by more than one view delivered by different presets of different cameras. In this case, the traffic status determined for that segment is combination of the status detected from different views. More precisely, the worst case is reported as the traffic status of that segment.

## 4.2 Image processing algorithm

At the following step, received real-time videos from cameras should be processed and translated to deliver traffic status information. To come up with this, an image processing algorithm is applied through 4 steps: (1) filter out background, (2) calculate optical flow and then (3) measure the displacement after noise removing and then finally (4) estimate the velocity of vehicles to determine volume of traffic which is determinative of traffic status.

### 4.2.1 Filter out the background

As it is obvious, the images taken from the cameras included a lot of unrelated objects such as trees and landscapes with plenty of edges. Since the applied image processing algorithm is based on the detected edges, omitting unrelated ones result in increase of system accuracy besides frame rate increment. To achieve this, a filtering step is done at the beginning of system configuration to determine region of interest (ROI). It is worth to mention that, since the presets of cameras are pre-defined, there is no need for automatic recognition of ROIs and the traffic expert determines the region of interest for all presets of cameras.

### 4.2.2 Calculate optical flow

After filtering the background, remaining regions are considered in the calculation. In this regard, vehicles motion in the videos is calculated using optical flow algorithm. More precisely, after converting videos to continuous frames, a corner detection algorithm is applied on each frame and flow of detected corners is recognized through ongoing frames. Then, the distance of selected points is calculated in two continuous frames. In this order, the displacement traveled by the vehicles is measured.

### 4.2.3 Remove noise and background

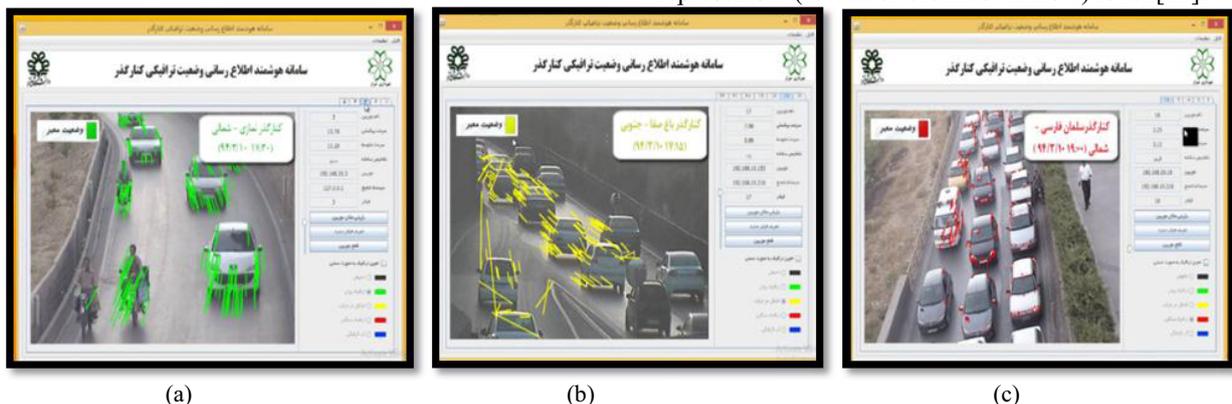
Due to the noise-sensitivity of optical flow algorithm, the computed displacement may be calculated with error. To decrease the error, we model all calculated displacement using a Gaussian function.

Since there is no sudden jump in the vehicles motion, the fourth quartile which relate to the high displacement is omitted. On the other hand, motionless points which belong to the background should also be ignored. First quartile indicates displacement of these points and should be omitted. Average speed is then calculated based on the displacement of remaining points. After omitting displacement of error points, vehicles speed should be calculated based on the remaining displacement which is computed based on dividing distance with time as in "Eq. (1)"

$$v = d/t \quad (1)$$

### 4.2.4 Velocity estimation

At the following, average speed of displacement which is actually average vehicles speed is calculated for each segment and real-time traffic status determined based on it. In the proposed method, traffic level was measured by transportation engineers according to level of service (LOS) scale defined in the Highway Capacity Manual publication. In our qualitative classification, green color represents A (free flow), B (reasonably free flow) and C (stable flow, at or near free flow) levels, yellow color represents D (approaching unstable flow) and E (unstable flow, operating at capacity) levels and red color represents F (forced or breakdown flow) level [12].



**Figure 1.** Examples of intelligent traffic status detection of developed system in different status: (a) free flowing (b) slow (c) congested status indicated by green, yellow and red respectively.

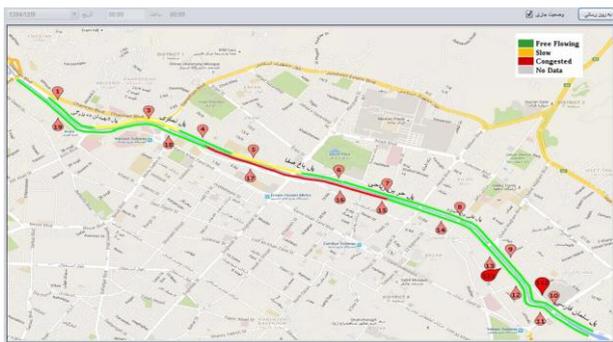
Indeed, regard to the specification of passages and also knowledge of traffic experts, different average speed intervals are assigned to one level of congestion. More specifically, in the developed system, average speed of more than 40 km/h is assigned to the free flowing traffic status (A). If the calculated speed is less than 20 km/h, the related traffic status is considered as congestion or breakdown flow (F). Unstable flow as D is assigned to the average speed between 20 km/h and 40 km/h. Different real-time traffic status detected intelligently by the developed system is presented in “Fig. 1”.

### 4.3 Information Dissemination

Finally, the real-time traffic status determined for each segment should be disseminated for public use. Among different types of information dissemination, dynamic message sign(VMS) is the most easily accessible one for the dominant travelers. Therefore, the real-time traffic information is passed digitally to 21 boards installed before all entrance and exit of bypasses. For more convenient usage, the digital boards show real-time traffic status by three colors; green, yellow and red. Green shows free flowing traffic status while yellow indicates slow traffic status and red means heavy traffic or congestion. “Fig. 2” represents an example of digital board installed before an entrance of Shiraz bypasses which show real-time traffic status related to four segments ahead. In addition, real-time traffic status information of bypasses is also shown on an online map as in “Fig. 3” and can be used via cell-phones and internet and etc.



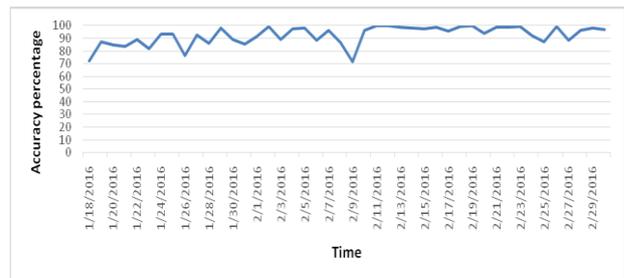
**Figure 2.** An example of digital board installed before an entrance of Shiraz bypasses which show real-time traffic status related to four segments ahead.



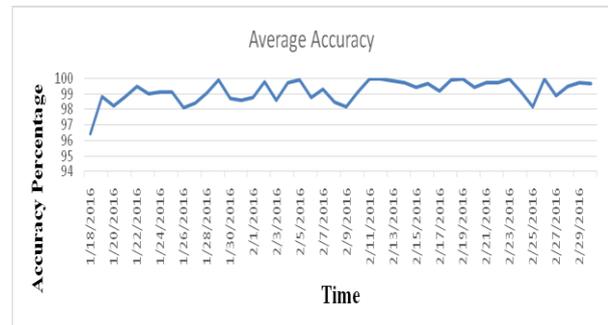
**Figure 3.** Shiraz Bypasses real-time traffic information map. Red, yellow and green colors show traffic status of flow flowing, slow and Congestion, respectively.

## 5 Experimental results

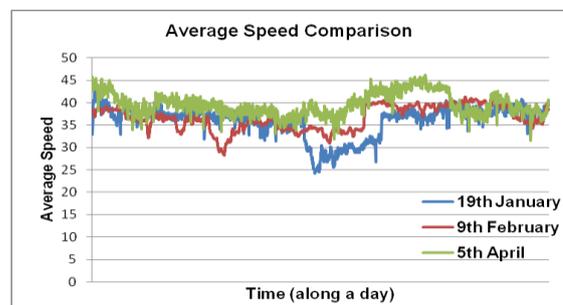
To evaluate the accuracy of implemented system, a comparison of manual state and auto is done for period of nearly two months. More precisely, traffic status determined intelligently by the system was inserted in the database and at the same time, traffic experts were employed to consider a full observation of traffic conditions and record their traffic status detection. Accuracy of the system was computed by considering the differences between auto and manual detections. “Fig. 4” is related to a segment of bypasses with the worst accuracy. This specific segment experiences highly variable traffic status during a day and is one of the most challenging bypasses.



**Figure 4.** The worst accuracy of intelligent traffic information system in one of the most challenging segment of the Shiraz bypasses.



**Figure 5.** Average accuracy of intelligent traffic information system for all the segments of Shiraz bypasses.



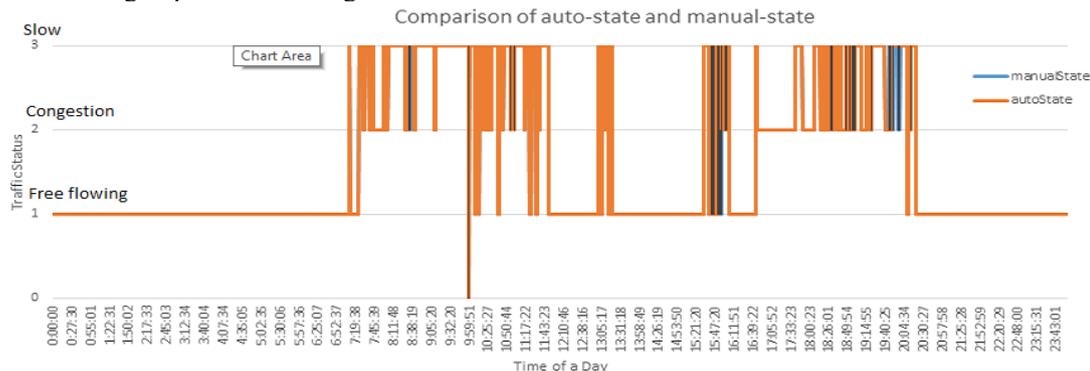
**Figure 6.** Average of average speed between all segments on 3 Tuesdays in January, February and April.

In “Fig. 5”, average accuracy of the system for all the segments of bypasses is indicated. As it is shown, in both figures, the accuracy of intelligent real-time traffic status is improved through period of two months.

As another effect of employing this intelligent real-time traffic information, average speed of vehicles in the bypasses is reported in “Fig. 6”. Given that a greater

number of citizens become familiar with the system over the time and rely on it to plan their trip based on the real-time traffic information, we are witnessing an improvement in average speed as in “Fig. 6”. In this

figure, average speed of all segments is averaged on three Tuesday selected from three months: January, February and April.



**Figure 7.** Comparison of intelligently determined traffic status with the detection done by traffic experts. Number 0 in the figure indicated off-camera.

For further investigation on the miss detection of system, a sample day in a week, specifically, Tuesday is considered. As we know, Tuesday is commonly selected in traffic domain, because it is a day with normal traffic state without special traffic behavior. In “Fig. 7”, a clear comparison is considered between traffic status determined intelligently and by traffic experts. The points with blue color are the miss detection of system. Obviously, the beginning and end of chart indicate free flowing traffic status which is related daybreak hours.

## 6 Conclusions and future work

It is widely accepted that, awareness of traffic flows ahead result in better route choosing for travelers with less congestion. However, providing real-time traffic information and the way of sharing the information is so important. The implemented system employs cameras and image processing algorithm to provide accurate traffic status information on digital boards on the Shiraz Dry River bypasses.

Reducing staffing operations which result in reduction of human errors and providing 24-hours continuous functionality are the main obtained advantages.

Extension of similar intelligent traffic information systems to other passages of Shiraz city in order to detect real-time traffic status is considered on the agenda. In addition, accident detection and also congestion detection based on occupancy are the two options considered to be added the in future work.

On the other hand, due to nature of Shiraz bypasses and proximity of them to the river, one of the important usages of the developed system is the time of heavy rain. Currently, in such situations, the system is manually set to blue color for flooded roads to avoid entrance of travelers. Intelligently detection of flooded roads is another option which is planned to be added to the system.

## References

1. Stephen Ezell. “*Intelligent Transportation Systems*”. The Formation Technology & Innovation Foundation (ITIF) (January 2010).
2. Burton, Andrew, and John Radford, eds. *Thinking in perspective: critical essays in the study of thought processes*. Methuen, (1978).
3. Warren, David H., and Edward R. Strelow, eds. *Electronic Spatial Sensing for the Blind: Contributions from Perception, Rehabilitation, and Computer Vision*. Springer Science & Business Media, **99**, (2013).
4. Aires, Kelson RT, Andre M. Santana, and Adelardo AD Medeiros. "Optical flow using color information: preliminary results." *Proceedings of the 2008 ACM symposium on Applied computing*. ACM, (2008).
5. Beauchemin, Steven S., and John L. Barron. "The computation of optical flow." *ACM computing surveys (CSUR)* 27.3 (1995): 433-466.
6. Tao, Michael, et al. "SimpleFlow: A Non-iterative, Sublinear Optical Flow Algorithm." *Computer Graphics Forum*. Vol. 31. No. 2pt1. Blackwell Publishing Ltd, (2012).
7. Zach, Christopher, Thomas Pock, and Horst Bischof. "A duality based approach for realtime TV-L 1 optical flow." *Pattern Recognition*. Springer Berlin Heidelberg, (2007).
8. Wei, Shui-gen, et al. "Motion detection based on optical flow and self-adaptive threshold segmentation." *Procedia Engineering* 15 (2011): 3471-3476.
9. Klappstein, Jens, et al. *Moving object segmentation using optical flow and depth information*. Springer Berlin Heidelberg, (2009).
10. <http://www.traffictechnologytoday.com/news.php?NewsID=3624>
11. <http://www.transport.gov.scot/road/technology-and-traffic-scotland>.
12. Manual, Highway Capacity. "Transportation research board." *National Research Council, Washington, DC* 113 (2000).