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A decision support system for monitoring traffic by statistical control charts

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ABSTRACT

Identification of critical traffic conditions based on analysis of traffic variables in a route allows the planners to react timely under such conditions. In this paper, a Decision Support System (DSS) is proposed to determine traffic condition in a route based on the data traffic variables received online in a route such as speed and flow. A knowledge based system is established, which consists of a series of rules (If-Then) to identify the critical traffic conditions when the traffic variables in a route decrease or increase as compared with the previous means, significantly. Statistical control charts are used to identify significant deviations of traffic variables from their means, which are usually caused by events such as accidents. The data for traffic variables, namely flow and speed in 60 hours was collected from one of the main highways of Tehran (Iran's Capital) in peak hours (17 and 18). 35 observations were used to design control limits for two traffic variables, namely flow and speed and the remaining 25 observations were used to monitor traffic conditions in the future (execution of phase 2 of statistical control charts). The results of traffic monitoring in the intended route indicate that the decision support system has a good performance to identify critical traffic conditions.

1. Introduction

Congestion and traffic in the urban highways have become some major problems of living in the new age by the increasing demand for transportation in intracity and intercity routes. Long traffics, waste of time and capital, irregular consumption of fuel, more depreciation of vehicles and environment contamination are some of the evident consequences of traffic. Urban traffic planners and authorities continuously supervise over traffic flow in the routes to find the factors that disturbs traveling in each road so that they can remove the disturbing factor by making special and timely arrangements and measures. In metropolises such as Tehran for example, installation of traffic cameras in different streets and sending the videos to traffic control centers has provided traffic controllers with the opportunity to monitor traffic conditions. By observing the crowd in the monitors of traffic control

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centers and magnification of videos received from the cameras, crowd factors such as accidents and incidents are identified so that they can be removed by informing the relevant organizations such as police, fire department, emergency, etc. However, large number of streets and highways in a city which should be monitored by the staff of control traffic center has complicated traffic monitoring in those centers. Their problem is to control a large number of routes by just one operator, simultaneously.

In Tehran Traffic Control Center, several videos from city routes are randomly displayed on the monitors in front of the operators. They identify traffic problems based on observation of movements of vehicles and their experience and then they review the problem through traffic cameras. In addition, as operators are getting tried, continuous observation of monitors increases their error coefficient as well. Development of a model and a tool capable of automatically and intelligently monitoring traffic and determining traffic condition will help in solving the aforesaid problem. Traffic condition in a time interval, such as one hour may be specified by measuring and analyzing different traffic variables. Each of the traffic variables such as speed, flow or density measures one of the different aspects of traffic.

Decrease or increase of each of them as compared with the related variable average within the past hours does not indicate usual or unusual traffic condition. For example, decreased number of vehicles passing in a reference point of a route within a time interval in a road (flow or quantity) does not alone indicate critical traffic condition. Its change as compared with past hours because of the said variable will have little amounts under two conditions, namely openness of the route with low demand and/or crowded route. In order to separate these two conditions, another traffic variable such as speed should be measured. Simultaneous decrease of speed and flow within a short time interval indicates critical condition of traffic as compared to similar previous days and hours. Considering random changes of traffic variables, it is difficult to distinguish large deviations, which are usually changed by special factors such as accidents from small deviations called noise. Statistical process charts are used to monitor a random variable in the processes. These charts examine the changes of a variable during time, separate accidental deviations (noises) from large deviations in a process by indicating the reason and avoid unreasonable examinations, which are not caused by special factors. In this paper, the diagnostic property of changes of a variable during time is used in control charts to monitor traffic variables in a street.

By designing suitable control charts, reasonable increase or decrease of traffic variables with significant factors are determined and it will be possible to specify traffic condition in a street based on a series of analytical rules. By determining usual and unusual traffic conditions in a road, which is specified based on the changes of traffic variables as compared with similar past days, the problem of control centers in monitoring all routes is decreased and the operators in those centers will only examine the routes, which are under an unusual condition as shown through the proposed traffic condition monitoring system. Historical traffic data for one of the entry highways of Tehran is collected and prepared and the designed system including implementation of control charts and traffic condition specification system are applied on that.

In the second section, research theoretical fundamentals including knowledge based system, determination of traffic condition and control charts are reviewed. The third section includes a case study of research and use of the traffic condition determination system, developed DSS, in one of the highways of Tehran. The final part includes results, conclusions and future researches.

2. Literature review

In this section, theoretical fundamentals of research concerning analysis of traffic variables, determination of traffic condition and statistical process charts are examined. Moreover, experimental records including a review on papers are presented.

2.1. Traffic condition analysis

Traffic engineering is the science of traffic measuring and monitoring aiming at understanding and developing of an optimum road network with an effective traffic movement with the minimum traffic (Pline, 1999). In traffic engineering science, traffic variables are measured and analyzed in order to determine traffic condition. The most important traffic variables include the followings:

Density (D) is the number of vehicles travelling along one unit length of a route (e.g. vehicle/mile).

Quantity (Q) or Flow is the number of passing vehicles within a time interval (e.g. one hour) from a certain section of a route (vehicle/hour).

Speed: The most important traffic variable, i.e., speed, has different definitions in traffic engineering. Eq. (1) and Eq. (2) measure Time Mean Speed (TMS) and Space Mean Speed (SMS) in a route, respectively (HCM, 2000). *n* is the number of typical vehicles, *d* is the length of the route (km) and t_i is the travelling time of i^{th} vehicle (h).

$$TMS = \frac{d\sum_{i=1}^{n}\frac{1}{t_i}}{n} \tag{1}$$

$$SMS = \frac{nd}{\sum_{i=1}^{n} t_i} \tag{2}$$

When a street has a usual traffic condition, each traffic variable randomly varies around a mean of the variable, which depends on road design, lighting and pavement of the road. Although a usual traffic condition in a road may not be an ideal condition according to planners and drivers, determination of usual traffic condition in a route is a relative condition. Usual traffic condition in a route is the traffic condition and quality in a road, which is often in the same condition. Upon any event or accident that affects congestion and slow movement, each of the traffic variables is influenced and their quantities change tangibly as compared to mean changes of each variable when no traffic disturbing factor exists. This deviation to random changes is significant. However, a decrease or increase of just a traffic variable compared to its mean does not along indicate occurrence of a traffic factor. Suppose that quantity variable in a street decreases compared to mean. While it is possible that such decrease may be the result of an accident, maybe the demand for travelling in that route during quantity monitoring has decreased. Thus, interpretation of change of each variable along does not indicate (usual or unusual) traffic condition. However, if at the same time speed in the route decreases compared with its mean in a usual condition, it may be the indication of an accident because in case of an accident, speed and quantity decrease, simultaneously. Therefore, the density will increase.

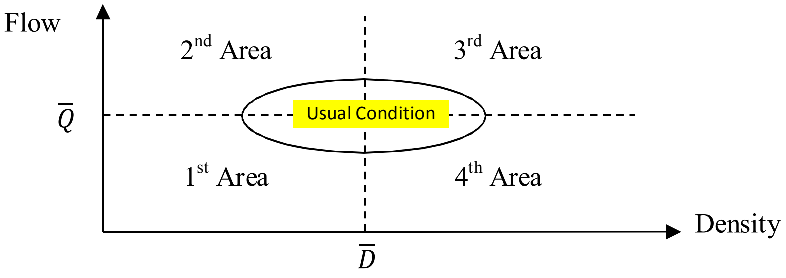

Fig. 1. Different conditions between Flow and Density

Fig. 1 shows different traffic conditions based on two traffic variables, namely density and quantity. Whenever quantity and density are average, traffic condition is usual. Due to random changes of both variables around the mean, usual condition is shown in Fig. 1 in terms of an area. Significant decrease of quantity and density in a route indicates that the route is open because the number of travelling cars (density) has decreased as compared to usual conditions and in such situations, the number of passing vehicles, flow, decreases due to emptiness of the route. A knowledge based system is required to establish an expert system to determine traffic condition to receive variable amounts of traffic (quantity and density). Knowledge based system consists of a series of rules (if-then). The rule of traffic condition determination in the first area is "If quantity and density decrease significantly compared to their means, traffic condition, open route and traffic flow will be usual (flowing)." Similarly, the rules for determination of traffic condition in other areas specified in Fig. 1 and as well as the areas between those four areas can be extracted. These rules are explained in Table 1.

Table 1

Rules of knowledge base for determining the traffic conditio**n**

Rule	Area	Condition (If)	Result (Traffic Condition)
1	Center	If flow and density (or Speed) randomly varies around the mean of each variable when the traffic is in a usual condition	Traffic condition is usual
2	First	If flow and density (or Speed) are significantly lower than the means of related variables	Traffic is unusual and an accident may have occurred
3	Second	If flow is significantly higher than the main and density is lower than density (or Speed) mean under usual conditions	The route is free and the street is empty
4	Third	If flow and density (or Speed) are significantly higher than the relevant variables	Traffic is flowing but the street is crowd
5	Fourth	If flow is significantly lower than the man and density (or Speed) is higher than density mean under usual conditions	Traffic is unusual and an accident may have occurred

From functional viewpoint, traffic accidents and problems in a street can be recognized with a higher possibility by measuring traffic variables in a route, which is done through systems that automatically record traffic data and by specifying significant or random deviation of variables from the mean amount and by using the aforesaid base of rules.

2.2. Statistical Control Charts

Based on the model proposed in this research for monitoring traffic condition in a route based on analyzing its traffic variables, it is necessary to determine significant deviations of traffic variables as compared to their means. Statistical Control Charts or Shewhart charts are one of the means for Statistical Process Control (SPC) (Chen et al., 2011). These charts were first proposed by Walter Shewhart in 1920 based on statistical principles and the theory of statistical assumption test in order to monitor and control the output variables of a process (Montgomery, 2012). In other words, control charts determine significant or random deviations of a variable by monitoring it over time in different time intervals (Woodall & Montgomery, 1999). Process is defined as a series of operations to change the inputs into outputs with additional value. Inputs, outputs, operations, supplier and customers form the elements of a process which is shown in Fig. 2.

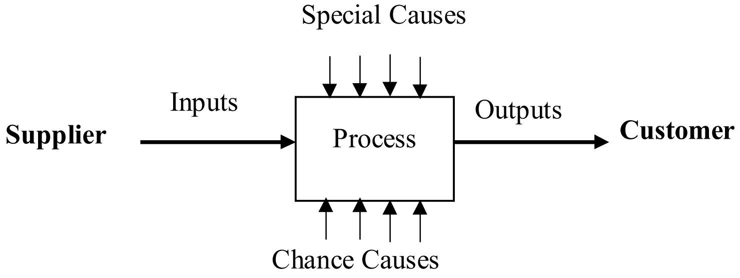

Fig. 2. Components

Performance of a process is manifested in its outputs. In order to monitor a process over time, one or more measurable characteristics are defined for each output and the related amounts are measured at different times and are then analyzed based on the principles of control charts. Deming considers two groups of factors to affect the performance process. These two groups include Chance Causes or Common Causes and Special Causes or Assignable Causes. Common Causes which are resulted by accumulation of several series of small and unavoidable reasons lead to insignificant deviation of functional variables of process around the mean; however, Assignable Causes which may be controlled and modified result in high deviation of variables around the mean. The process, which acts under the influence of Chance Causes or Common Causes is called an Under Control Process and the process which acts under Special Causes or Assignable Causes is called an Uncontrollable Process. Fig. 3 shows a sample of control chart for monitoring the process variable mean together with its components. Control charts are constituted by Upper Control Limit (UCL), Lower Control Limit (LCL) and Central Line (CL). When monitoring a process functional variable, a random sample of outputs is selected and statistical index of sample such as the average is calculated. Mean of a variable at any time indicates the process condition from the previous monitoring until sampling time. Control limits in a diagram are designed in such a manner that if the process is under control during process monitoring (only chance causes affect the process), the sample mean ($\bar{x}$) lays within upper and lower control limits and if the sample mean lies outside control limits, it indicates the effect of special cause.

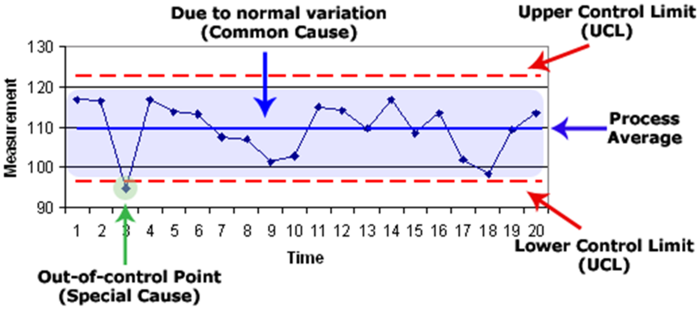

Fig. 3. Components of Statistical Control Charts

CL, UCL and LCL of mean control chart or x̅ chart are calculated from Eqs. (3-5).

$$CL = \mu \tag{3}$$

$$UCL_{\bar{x}} = \mu + 3 \times \frac{\sigma}{\sqrt{n}} \tag{4}$$

$$LCL_{\bar{x}} = \mu - 3 \times \frac{\sigma}{\sqrt{n}} \tag{5}$$

where μ and σ are mean and standard deviation of the variable when the process is under control, simultaneously, n is the size of random sample selected during process monitoring. Control charts are based on the theory of hypothesis test. Null hypothesis includes an under control process. This hypothesis is rejected when the mean of random sample lays outside the control limits. Implementation and use of control charts includes two phases. The first phase, design of control charts includes determination of control limits, sample size and time intervals for process monitoring (Parsath, 2011). In this phase, mean and variance of the monitored variable are estimated to determine the control limits in Eq. (3-5) based on previous data. The goal of phase 2 is fast detection of assignable deviations in the variable in future based on the control chart designed in phase 1. In other words, model parameters in this phase are evident and the main goal of the phase is to test the hypothesis of equality between model parameters and the amounts estimated from phase 1. Different statistical procedures are suitable for each of these two phases and there are different statistical standards to evaluate control charts performance in the two phases. In phase 1, a constant amount is considered for the possibility of error I, alpha, and after calculation of control limits; test capability is calculated by applying different shifts to different parameters which is then used to compare statistical performance of control charts. In phase 2, emphasis is made on fast detection of the processes and shifts. This is usually identified by observing the variable behavior on the chart.

2.3 Research Background

The bases for control charts were designed by Walter Shewhart in 1920s and 1930s. Several researches with design of different control charts as their topics have been conducted since the first activities in this field (Montgomery & Woodall, 1999). Having studied over 250 reputable articles, Woodall (1997) has made an overall review over control charts. Montgomery and Woodall (1999) generally introduced different control charts including mean control charts (x-bar chart), variance (S-Chart or R-Chart), multivariable control charts, control charts for short term productions, economic-statistical design methods and estimation of change point. A study shows that 70% of production companies use mean control charts to monitor the performance of their organizational processes as well as to monitor the quality of the end product of their processes (Smith, 1993). For example, they used control charts to evaluate production quality of asphalt (Kavousi et al., 2010), manufacture of note counting machines (Samimi & Jazayeri, 2008) and traffic monitoring of computer networks (Matias et al., 2011). Woodall (2006) reviewed the use of control charts in healthcare and public health surveillance. Although several researches have been conducted with the topic of the use of control charts, no research has been made concerning the monitor of traffic variables in traffic engineering by using control charts.

3. Case Study

In this section, research theories are presented, i.e., development of statistical control charts in order to monitor traffic and to determine its condition for one of the entry highways to Tehran city.

3.1 Data Collection

Installation and commissioning of mechanized systems for recording traffic data in the streets has facilitated the implementation of the proposed decision support system. Against passage of each vehicle through the installed gates, traffic data recording system in the main entries of Iran Capital, Tehran, records in the database which the data related to the time of passage and speed of vehicles together with the type of vehicle and its passing lane. The traffic data of vehicles from Saveh entry to Tehran (Southeast of Tehran) during January 2010 was collected with more than 17 million records .

3.2 Data Preparation

If we consider a route as a process and its traffic variables as the specifications of that process, in order to design a statistical control chart, we should specify traffic monitoring time interval (time interval for drawing the points of traffic condition on the chart, the horizontal axis of the chart) and sample size in each referral. Considering the high volume of vehicles on the route under study, a time interval of monitoring was selected and set at one hour. On the other hand, in the control charts in each time interval (e.g. periods 1 to 2 in Fig. 3), some of the samples of process should be selected so that the average of specification for the obtained samples is displayed on the control chart. Therefore, in order to monitor traffic within one hour, traffic variables should be calculated within time intervals shorter than one hour such as 15 minutes and traffic variable mean should be shown on the chart in four 15-minute time intervals within an hour so that traffic condition in that hour is determined based on the data. Calculation of traffic variables from raw quantity data in each 15 minutes has been performed in preparation stage. For this purpose, raw data are summarized by using SQL software. Examples of the prepared data are shown in Table 2.

Table 2
Sample prepared traffic data

Month	Day	Hour	Quarter	Week's day	Speed (TMS)	Q
10	1	17	1	Wednesday	105.382	191
10	1	17	2	Wednesday	101.782	239
10	1	17	3	Wednesday	103.708	216
10	1	17	4	Wednesday	102.357	207

In addition to the date and hour of each observation, sample number in the related hour (15 minutes), Time Mean Speed (TMS) of the passing vehicles and number of passages within a quarter (Q) are also shown in Table 2. As it was said, statistical control charts examine the changes of variable as compared to variable mean in the past periods. However, an examination of quantity variable in different hours of a day shows that there were significant amounts between quantity mean in different hours of a day. According to our survey, quantity average during early morning hours is lower than the hours in the middle of the day. This inequality has also been confirmed by analysis variance test with a p-value of zero. The hours of a full day (24 hours) with similar quantity mean are placed in one group by Tuki test. The results of Tuki test are shown in Table 3.

Table 3

Classification of Travelling Hours Based on the Similarity of Quantity Variable

Hour	00	01	02	03	04	05	06	07	08	09	10	11
Mean	532	379	331	327	391	640	899	1057	1051	993	1000	1036
Group	H	I	I	I	I	G	E	C	C	D	D	C
Hour	12	13	14	15	16	**17**	**18**	19	20	21	22	23
Mean	1025	1046	1124	1076	1207	**1348**	**1340**	1207	1060	891	741	644
Group	C	C	C	C	B	**A**	**A**	B	C	E	F	G

Based on the results of the Tuki test (Table 1), hours 17 and 18 each day have the highest quantity among the hours of the day. Considering the disturbance in traffic and traffic problems during peak hours as compared to other hours a day and dissimilarity of traffic condition during the whole hours of a day, control charts have been developed to monitor traffic in peak hours (hours 17 and 18). Therefore, it is expected that traffic means in peak hours (separated observations) have means close to mean and statistical control charts and can be used to monitor them over time. Therefore, summarized data, including traffic data for hours 17 and 18 in the first limit until 22.07.2010 includes 60 hours and mean speed and quantity in 240 quarters have been measured by the inclusion of 4 samples per hour.

3.3. Statistical Control Charts for Traffic Monitoring

In order to discover special causes such as accidents, etc. that change the traffic condition in hours 17 and 18 on the route under study, two statistical control charts have been developed to use the rules indicated in Table 1. As it was said, two phases should be implemented as follows to develop control charts.

3.3.1. Phase 1: Design of Statistical Control Charts

In this stage, the monitored hours (60 hours) are divided into two sections including the first 35 hours of data (including 140 observations) and the final 25 hours of date (100 observations). Data of the first section is used to implement phase 1 of control charts, i.e., determination of control limits of charts. The final 25 observations are used to implement the second phase, i.e., examination of performance of control charts. Phase 1 is allocated to estimation of control limits of control charts. Control limits of each mean control chart are determined by using equations 3 to 5. Since 4 samples are obtained per hour (4 one quarter intervals), the sample size in the above relations (n) is 4; however, in order to determine control limits for the quantity and speed charts, mean (μ) and standard deviation (σ) for each traffic variable should be estimated under the conditions in which special cause has no effect on traffic or the process is under control. Mean sample ($\bar{\bar{X}}$) is used to estimate mean traffic variable (μ) and mean range ($\bar{R}$) is used to estimate the standard deviation (σ). For example, in order to estimate quantity control limits (CL_Q, LCL_Q and UCL_Q), mean quantity of each hour (mean quantity of four quarters in an hour), $\bar{Q}_i$, and quantity range including the difference of highest and lowest quantity in a quarter for each hour, R_i, have been measured for the data of phase 1. Some of the calculations and relations are shown in Table 4.

Table 4

Some of the calculations for estimation of mean and standard deviation of flow in the Phase 1

# Record	Month	Day	Hour	Quarter				$\bar{Q}_i$	R_i
				1	2	3	4		
1	10	1	17	191	239	216	207	$\bar{Q}_1$=213	R_1=48
2	10	1	18	215	189	190	142	$\bar{Q}_2$=184	R_2=73
3	10	2	17	219	243	245	188	$\bar{Q}_3$=223.7	R_3=57
…									
i	.	.	.	q_{i1}	q_{i2}	q_{i3}	q_{i4}	$\bar{Q}_i = \frac{\sum_{j=1}^{4} q_{ij}}{4}$	$R_i = \max_j q_{ij} - \min_j q_{ij}$
42	10	25	18	125	118	118	118	$\bar{Q}_{42}$=119.7	R_{42}=7
								$\bar{\bar{Q}}=\frac{\sum_{i=1}^{42} \bar{Q}_i}{42}$ =192	$\bar{R}$=59.9

$\bar{Q}_i$ and R_i means in Table 4 are $\bar{\bar{Q}}$ and $\bar{R}$ of estimations for quantity mean and standard deviation in the hours under study, respectively. Eq. (6) is used to change the mean of amplitudes to standard deviation.

$$\hat{\sigma} = \frac{\bar{R}}{d_2} \tag{6}$$

$\hat{\sigma}$ is the estimated standard deviation of quantity, $\bar{R}$ is the average of the ranges in Table 4, and d_2 is the constant which depends on the sample size (n) and its amount for n=4 is 2.059. Therefore, limits of quantity mean control chart are as follows based on Eqs. (3-5) and above calculations.

$$CL_Q = \hat{\mu}_Q = \bar{\bar{Q}} = 192 \tag{7}$$

$$UCL_Q = \hat{\mu}_Q + 3 \times \frac{\sigma_Q}{\sqrt{n}} = \bar{\bar{Q}} + 3 \times \frac{\frac{\bar{R}}{d_2}}{\sqrt{n}} = 192 + 3 \times \frac{\frac{59.9}{2.59}}{\sqrt{4}} = 235 \tag{8}$$

$$LCL_Q = \hat{\mu}_Q + 3 \times \frac{\sigma_Q}{\sqrt{n}} = \bar{\bar{Q}} + 3 \times \frac{\frac{\bar{R}}{d_2}}{\sqrt{n}} = 148 \tag{9}$$

Control chart for monitoring the flow (Q variable) in phase 1 is shown in Fig. 4. Quantity mean of 4 samples per hour for the 35 hours under study in phase 1 is placed as a point on the chart. Placement of the point within the control limits indicate that the quantity was under control and that there were no disturbing factors in the traffic. Similarly, mean control limits of speed during peak hours are calculated and the related control chart is drawn as Fig. 5.

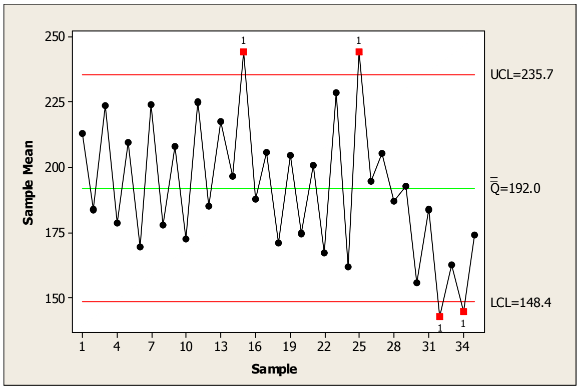

Fig. 4. Flow Control Chart in Phase 1

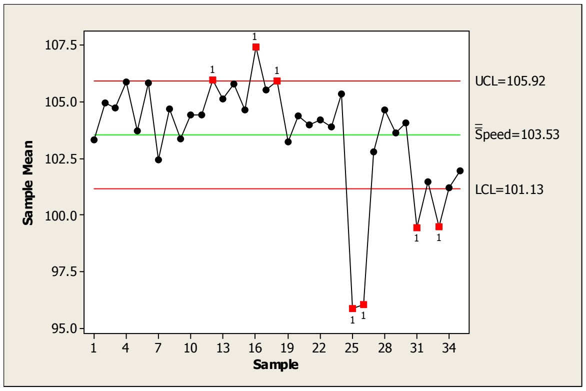

Fig. 5. Speed Control Chart of in Phase 1

Flow and speed in some of the studied hours (Fig. 4 and Fig. 5) have non-random behaviors since some points in both of the above charts are outside control limits. Although in some points the flow and speed are higher than upper control limits which indicate an abnormal behavior, it does not indicate a traffic problem. However, lower speed and quantity than the lower control limits can indicate a traffic problem in the route which should be analyzed according to the rules in Table 1. Since control limits are determined in phase 1 and these limits are used for future monitoring of traffic, it is necessary that all the points under study in phase 1 indicate the lack of any disturbing factor in the traffic. Moreover, points below the lower control limits may indicate a problem in the traffic. According to the design of statistical control charts in which if some points in a chart go outside of the control limits due to a non-random factor, the points should be omitted and control limits should be recalculated, the points under lower control limits are analyzed in Fig. 4 and Fig.5 and those which are outside the control limits due to a traffic control will be omitted. In Fig. 4, samples 32 and 34 have mean quantities lower than the expected value (LCL_Q). Although the related points in Fig. 5 (mean speed monitoring chart) are within control limits, they are so close to the lower control limit. Therefore, it can be concluded that traffic condition in these two hours (related to hour 18 in Sunday and Tuesday) is heavy and unusual due to low speed and quantity. Therefore, the two points of the series of observations in phase 1 are omitted and the control limit is recalculated. New control limits are shown in Fig. 6 and Fig. 7. Of course, samples 25, 26, 31 and 33 in speed monitoring chart are lower than control limits of the relevant chart (Fig. 5); however, since quantity during these hours is not unusual, it can be calculated that traffic in these hours is not unusual and does not indicate any problem in the traffic because these points will not be omitted.

3.3.2. Phase 2: Use of Control Charts to Monitor Traffic

After designing statistical control charts to monitor traffic in phase 1, they are used to monitor the future traffic (phase 2) based on the obtained samples. Observations 36 through 60 in the studied interval, which includes flow and speed means in the aforesaid hours are used for performing phase 2. Fig. 6 and Fig. 7 include flow (Q) and speed control charts, respectively in which control limits are in the first modified phase.

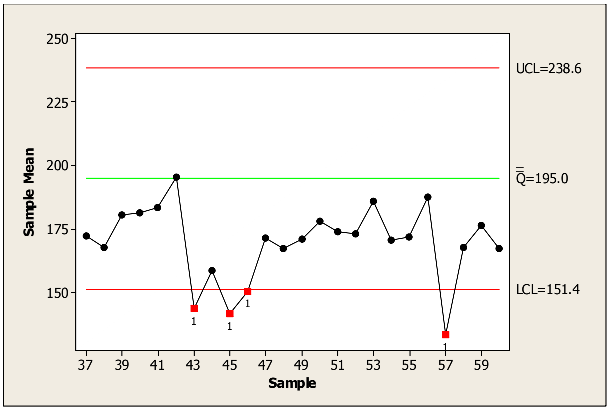

Fig. 7. Flow Control Chart in Phase 2

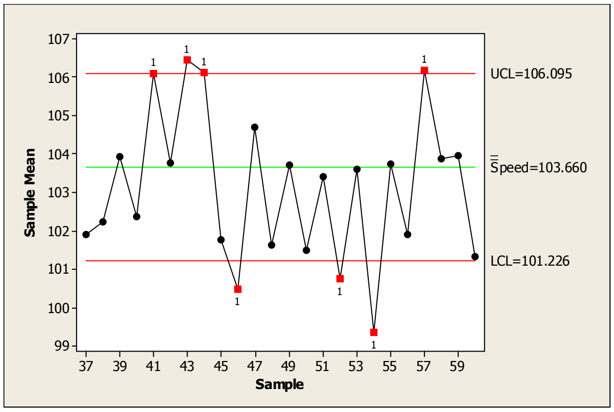

Fig. 8. Speed Control Chart in Phase 2

Placement of sample flow and speed means within the control limits in both of the charts indicates a usual and ordinary traffic in these hours. In samples 43 and 44, they have a quantity mean lower than similar hours while speed mean in these hours is lower than the expected amount. Analysis of traffic condition in these hours indicates a free route with a low volume quantity. However, in sample 46, speed and quantity are lower than their expected amounts. According to rule No. 2 (Table 1), traffic condition in this hour is unusual and critical which is required to be examined more. Speed in some hours such as sample No. 53 is lower than the expected amount while quantity mean in that has a common amount. This condition does not show any critical traffic condition as well.

4. Conclusion

Measurement of traffic variables such as speed and quantity does not necessarily identify traffic condition in a route. Upon occurrence of an incident such as an accident in a route, the amounts of traffic variables decrease as compared with their amounts under usual conditions. Analysis of decrease of these variables whose amounts are often high as compared with their random behavior needs a suitable tool. Statistical control charts are developed to monitor a variable over time. These charts are capable of identifying a variable from its mean. In this paper, two statistical control charts were developed to monitor the quantity and speed means. By receiving the amounts of these two variables within 4 time intervals (four quarters in one hour), the amounts of high deviations from the means were detected. Detection of deviation of a variable alone does not identify traffic condition in a route, but it needs simultaneous analysis of two variables. A knowledge based system consisting of if-then rules was established, which identifies traffic condition in a route based on deviations from traffic variables means.

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