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Model-Based Plausibility of Traffic Census
(Case Study of Southern Part of North Rhine-Westphalia, Germany)

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Abstract: The importance of traffic data has become more important than ever. However, data collection is only achieved through the regular traffic census. Moreover, the quality of data has to be considered because it leads to the basis of transport modeling. Errors in data could create errors in the model and will guide to wrong decisions as well as wrong implementation of policies, strategies and investments in transport sector. This study attempts to develop a procedure by which the quality of the traffic data can be assessed. In this case also, the plausibility of count station which relates to the traffic flow from traffic census can be determined. The basic method used, is propagation of measured values, which is implemented in the traffic planning Software VISUM. This method enables us to empirically distribute the determined values of a road network. For the practical application of the study, a traffic model of the southern part of North Rhine-Westphalia has been provided by PTV AG. From the method implementation, it is proven that this plausibility based model is suitable to check the plausibility of traffic census.

Key Words: Traffic Census, Propagation Measured Values, Plausibility, VISUM

1 INTRODUCTION

The concept of forecasting the future use of the road network in terms of traffic flow is generally an accepted approach world-wide. The traffic forecasting is basically possible upon collection of traffic data. The accuracy of traffic data collection and the subsequent predictions are of paramount importance in the fulfillment of an appropriate planning, design, operation, maintenance monitoring and management of the road network.

In order to monitor the traffic development and to identify the traffic flow on the road network, the five year routine collection of traffic data has been performed in the Federal Republic of Germany since 1970 by means of a nationwide road traffic census (RTC). This realization emanated from concerns raised with regard to the amount of traffic volume, the composition of the different types of vehicles, their speed, total gross weight, number of axles, axle loads and origin and destination of the journeys. Therefore, nowadays traffic censuses or counts have more important meanings in terms of traffic data.

There is actually a wide range of traffic counting methods available. It is sufficient to use a direct counting method to gather the traffic volume for local investigations, but for more complex investigations such as traffic forecasting, a transport model is required. Traffic data is

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1 Visum („Verkehr in Städten Umlegung“) is a software product of the company PTV AG Karlsruhe
needed to build a transport model so that the calculated results can be compared to the actual situation. Moreover, it is also possible to recognize the validity of the demonstrated (verified) models.

Generally, screen-line counts are divided into sampling counts and continuous counts. A sampling count will be only counted in a limited period to extrapolate into the mean (ADT, AAWDT\(^2\), etc.), whereas in continuous count, station records continuously the real occurring traffic volume in a screen-line. Both types of the counts although often referred as the "truth", can still be prone to error.

In the analysis of continuous counts, for Germany’s freeways and federal highways, the integrity of the census as well as the plausibility of the result must be taken into account. Nevertheless, these data are generally considered as reliable. Because of the large number of cross-sections which should be collected, generally surveys will be done using random sampling count. Recent surveys have shown that acquisition and extrapolation problems, cause doubts and mistakes on the traffic flow values in traffic volume of the official maps. In the end, this problem makes the basis of the modeling and planning process more difficult.

This study will develop a procedure by which the quality of each count values can be assessed. As a basis method for this study is a propagation of measured values [Vortisch, 2006], which has been developed for traffic management. The method enables us to distribute the empirically determined values of a road network. So that the gap of information in a road network among counted values can be determined. By using this method it is possible to distribute an empirically determined load values, not only locally in a cross-section but also in a road network. The weight of the empirically determined load values will decrease along with the increase of road distance. This spatial distribution is based on the route information from a traffic model which is derived from the part of the turnoff. This method is implemented in the traffic planning software VISUM, which will be used for this study.

In this study, the propagation method will be investigated and simulated using the traffic data census. The result of this method will enable the estimation of the quality of each counted values. Another objective of this study is to develop a variation of the propagation method that will provide evidence of errors in counted values. This can be achieved through comparison of propagated values, i.e. values of active and passive measured value.

The aim of the study is a software independent method that can determine the reliability of the sampling censuses based on the continuous count station values. For example, the derivation of an index of confidence on behalf of each count location (if sufficient information is available), and how far the calculated load value contradicts with other measured values. For practical application of the study, the PTV AG has provided a real traffic model of a partial traffic area (the southern part of North Rhine-Westphalia).

2 BASIC CONCEPTS AND STRUCTURES

2.1 Traffic Survey

Related to the traffic survey, it is necessary to distinguish between a census and a survey. A census involves either measurement or enumeration of every member of a subject population. (The word “population” is used here to define the universe of the units of interest to the study, which may be people, vehicles, buildings, etc.) A survey involves a sample from a universe [Hensher, et al., 2000]. This sample may be small or large, depending on many factors.

\(^2\) ADT = annual average daily traffic; AAWDT = annual average weekday traffic
However, the intention is always to draw a sample from the population that can be considered as representative of the entire population, no matter how small or large the sample is.

### 2.1.1 Methods of Survey

In general, the methods of survey can be divided into three methods [FGSV, 1991] as follow; traffic counting, observation and interview. The traffic counting covers the movement of persons and goods in transport infrastructure within the investigation area and comprises the following scopes: object counts, screen-line counts or roadside counts, intersection counts and directional counts. The observations identify physical characteristics, existing situation and the visible behaviors of traveler which are recorded individually. Through an interview, the traffic activities and traffic behavior background of an individual with regards to the real-time, spatial, and socio demography can be obtained. Interview can be done in a traffic network, a household, an activity location, as well as in a company.

### 2.1.2 Methods of Conducting Volume Counts

In order to do the traffic counting and the regular road traffic census, the method generally used is the screen-line counts. The screen-line counts falls in two main categories, namely: manual counts and automatic counts.

Most application of manual counts requires small sample of data at any given location. Manual counts are sometimes used when the effort and expense of automatic equipment are not justified and required if automatic equipment is not available. In other side, the automatic count method provides a means for gathering large amounts of traffic data. Automatic counts are usually taken in 1-hour intervals for each 24-hour period. The counts may extend for a week, a month, or a year. Because the counts are recorded for each 24-hour time period, then it is possible to identify the peak flow period. Detector is one of the automatic count equipments, which is a acquisition device system to measure the traffic volume and/ or velocity

### 2.2 Road Traffic Census (RTC) in Germany

A nationwide road traffic census (RTC) has been performed in the Federal Republic of Germany since 1970 as part of the regular five year rota in order to monitor the traffic development and lead the investigation of traffic volumes on the road space. The RTC is carried out by the State Department of Highway Construction on behalf of the Federal Ministry of Transport, Building and Urban Affairs and is coordinated by the Federal Highway research Institute. The census occurs on free routes which include the network of federal trunk roads (motorways and federal roads), the network of state roads and mostly on the country roads [Meier, 2007]. Those are the comprehensive and representative statements for the traffic volume of the possible qualified road network.

There are two methods available to conduct traffic volume counts namely automatic and manual. The result of manual counts is usually made more accurate and more complete than the result from the automatic counters which monitor the traffic on the most loaded sections all year round offering the added possibility of distinguishing among different vehicle types [United Nation, 2007]. No manual count is required at points where the traffic intensity is monitored by automatic counting equipment.

The difference implementation between automatic count location and manual count location in Germany is presented in Table 1.
Table 1: Methods of traffic volume count [Koßmann, 2005]

<table>
<thead>
<tr>
<th></th>
<th>Automatic counting stations</th>
<th>Manual road traffic count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collection method</td>
<td>automatic</td>
<td>manual</td>
</tr>
<tr>
<td>Collection period</td>
<td>yearly</td>
<td>Every 5 years (last 2005)</td>
</tr>
<tr>
<td>Collection duration</td>
<td>24h / day</td>
<td>6 / 8 representative days of year</td>
</tr>
<tr>
<td>Starting year</td>
<td>1975</td>
<td>1952 / 1953</td>
</tr>
<tr>
<td>Responsible for collection</td>
<td>federal states</td>
<td>federal states</td>
</tr>
<tr>
<td>Road category</td>
<td>motorways and national roads</td>
<td>classified road</td>
</tr>
<tr>
<td>Number of sampling units</td>
<td>about 1,300</td>
<td>about 40,000</td>
</tr>
<tr>
<td>Vehicle types</td>
<td>motor vehicles (up to 8 + 1 vehicle types)</td>
<td>motor vehicles (6 vehicle types) + bicycles</td>
</tr>
<tr>
<td>Data</td>
<td>data per hour and lane</td>
<td>aggregated yearly data per cross-section</td>
</tr>
<tr>
<td>Application</td>
<td>decisions for investment</td>
<td>decisions for investment</td>
</tr>
<tr>
<td></td>
<td>estimation of yearly traffic loads</td>
<td>basis for yearly extrapolation of</td>
</tr>
<tr>
<td></td>
<td>basis for estimation of short-term counts</td>
<td>automatic counts</td>
</tr>
</tbody>
</table>

2.3 Propagation of Measured Value

As a basic method for this study is a propagation of measured values. This method has been developed by Vortisch for the real-time traffic state estimation in urban road networks. The propagation method is based on the idea that the traffic volume is measured at a cross section which consists of different traffic flows. They branch out before and after the cross section within the network. The user knows from the assignment calculation the different traffic flows which amount to the measured value. As a result, it is possible to allocate the percentage of each traffic flow to the routes within the network [Vortisch, 2006].

This following illustration will describe this basic idea as follows. It is given; that there are 100 measured vehicles. At the next intersection 20% of them will be turning left. It can then be assumed that on the left link 20 vehicles that have previously passed the detector, will drive through that left link (see Figure 1). The same principle can be applied in the opposite way, i.e. in the reverse direction. It means also that every detector can propagate its traffic streams upstream and downstream through the network and the overall traffic volume on each link is the result from the total of all these propagated streams.

![Figure 1: Propagation of measured traffic volumes along routes in the network [Vortisch, 2006]](image)

This propagation method carried a reliability value, which have a range between 1 and 0. At
the detector site is by definition 1. As a result of the propagation, the reliability depends on several factors. The reliability depends on the distance between the detectors, as well as the number and type of nodes situated between the considered link and detectors. The further the distance from the detector in a link, the less reliable the propagated share of the detector is. The reliability is calculated using the following formula:

\[ z = \exp\left\{ -\alpha \left( \beta \cdot \sum_{i=1}^{L} \text{Length}(i) + \sum_{i=1}^{L} a_i \right) \right\} \]

Where:
- \( \alpha \) calibration parameter
- \( \beta \) weight of the link distance
- \( a_i \) number of turning possibilities at the end of the link \( i \)
- \( L \) set of links between detector and considered link
- \( z \) resulting reliability on the link

### 2.4 Introduction of VISUM Program (Software)

VISUM is a software product of the PTV AG which is a comprehensive, flexible software system for transportation planning, travel demand modeling and network data management. The software can be used in all continents for metropolitan, regional, statewide and national planning applications. Designed for multimodal analysis, VISUM integrates all relevant modes of transportation (i.e., car, car passenger, truck, bus, train, pedestrians and bicyclists) into one consistent network model. It provides a variety of assignment procedures and 4-stage modeling components, which include trip-end based as well as activity based approaches. VISUM supports the planner in the development of transport measures and calculates the effects of these measures.

### 3 METHODOLOGY

The completion of the study will be offered in three procedures, they are incremental propagation procedure with and without measured value as well as assignment procedure. By using the model in VISUM software, it is possible to perform the propagation procedure that exists in the incremental propagation as well as the assignment procedure.

#### 3.1 Procedure of Propagation Method

In approaching the first procedure of study, several steps are needed to perform the propagation procedure with measured values. It can be called as propagation in active condition, because the measured values of each count station will be used in the simulation. Figure 2 illustrates the steps of the proposed information flow to solve the study by using incremental propagation. The basics steps are proposed as follows:

- Start by using the road network model based on VISUM model (if already available, if not it must be started by building up the road network model), which is integrated by the links, nodes, zones, count stations, connectors, etc.
- Check the road network, particularly the tools which are necessary for the propagation procedure. In this case, the links with their characteristics (traffic flow, type of road, lane, direction, etc) and the count stations. This part is important as a basis. However, an incomplete model leads to incorrect results.

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3 http://www.ptvaq.com/traffic/software-system-solutions/visum/
• The links have to be distinguished into the link with count station (detector) and the link without count station. As information, the observation of this study is only defined for passenger cars.

  a. Link with detector,

   \[ P_{oDV} = ZWert2(P_{kw}) - NSeg(QZD - P_{AP}) > 1 \]
   
   Whereas:
   
   \[ ZWert2(P_{kw}) = \text{measured value for passenger car (Veh/h)} \]
   
   \[ NSeg(QZD - P_{AP}) = \text{measured value for through traffic (Veh/h)} \]

   Thus, \( P_{oDV} \) is the measured value of passenger car without the through traffic. The value must be more than 1, so that the procedure can be done. \( P_{oDV} \) which is less than 1 must be sorted out, because it can guide to an incorrect result in the end.

   As input for the link in detector side, \( HasQ \) and \( MeasQ = 1 \), so that in the further simulation it will be read as link with detector and link with measured values available.

  b. Link without detector,

   \( HasQ \) and \( MeasQ = 0 \) as input. It means there is no detector and no measured values available.

• Both of the links (with detector and without detector) are simulated with iterative propagation with a certain parameter setting.

• One of the results of iterative propagation is the reliability values. These values must have a range between 0 and 1. The link, in which a detector exists, must have a reliability value of exactly 1. The simulation finishes if the requirements above are complete, otherwise the parameter setting has to be changed and the simulation has to be repeated again. Therefore, it is important to understand the parameter setting to get the desired results.

The second procedure is also incremental propagation but the procedure is performed without measured value or it can be called passive condition. Actually, it is similar to the first procedure, but in this procedure the desired measured value of the individual count station will be switched off (passive), therefore the \( HasQ \) and \( MeasQ \) as inputs must be changed into 0. This procedure performs alternately in each count station in the whole network and then the other qualifications procedure as the first procedure is applied. The last procedure is assignment process; in this case the equilibrium procedure. Finally, the calculated data of the three procedures yields the solution approach of the study.

![Figure 2: Information flow of propagation method in the application area](image)
3.2 Solution Approach Tasks

The main objective of the study is to check the plausibility of count station, which relates to the traffic flow from traffic census. This solution tasks part will support the tool conception and implementation into forecasting quality of count stations. The solution approach of the study offers into three possible procedures. Two of them are propagation procedures, namely propagation with and without measured values and the other is assignment procedure. Through these procedures, we consider only the detector side.

In principle, every count station has a traffic flow as input as well as output. The output of the procedures in individual count station in this case is the traffic flow has to be compared. If the traffic flow results from the three procedures has a wide discrepancy, it means there is a gap information within the count station, then it can be considered as failure, certainly in a specific condition.

In order to determine the discrepancy of the result in each count station, then the deviation value is used. The deviation value gives empirical as well as numerical information about the correlation of the results. Moreover, the values in a whole network will be classified in a designate range (i.e. range of 10%). Furthermore, this classification of the deviation values is possible to guide us into the decision of the quality of count station. The count stations with low deviation values indicate that there are correlations or harmony within the calculated values. On the other hand, the count stations which have large deviation values signify the variation of calculated values and can be assumed as default count station. This issue has to be investigated further to get the cause factors. So, the quality of count station depends on the result of deviation values of procedures. Hereby, the authoress tries to define the quality of count station into the following classification (see Table 2). A more specific explanation about this term in its application as well as in the results will be given in the next section.

<table>
<thead>
<tr>
<th>Deviation Values</th>
<th>Quality of Count Station</th>
</tr>
</thead>
<tbody>
<tr>
<td>0% - ≤30%</td>
<td>Correct forecast</td>
</tr>
<tr>
<td>30% - ≤60%</td>
<td>Tends to be a correct forecast</td>
</tr>
<tr>
<td>60% - ≤100%</td>
<td>Incorrect forecast</td>
</tr>
</tbody>
</table>

4 APPLICATION OF THE METHODS IN A CONCRETE SAMPLE AREA

4.1 The Study Area

The application area of the method exists in the southern part of North Rhine-Westphalia particularly in the borderland between the States of North Rhine-Westphalia and Rhineland-Palatinate. The area is essentially the area surrounding the diagonal line drawn from the southern part of Cologne to northern part of Koblenz (see Figure 3).
The investigation area is limited by the following boundaries: in the north by the motorway A4 at Rodenichener Bridge, in the south by the motorway A48 northern of Koblenz, in the west by the motorway A555 or the motorway A61 towards Koblenz and in the east by the motorway A3.

There was strong heterogeneity population within the study area. Since the metropolitan region Cologne and the urban area Bonn are in the northern part, this area had much higher population density than in the southern area. The attractiveness of the district in business and livelihood was mainly justified due to the excellent location quality, which included the immediate neighborhood of the city of Bonn and the metropolitan region of Cologne, which had several characteristic namely excellent transport links, above-average facilities with science, research, and educational institutions, a very highly skilled workforce and wide range of attractive low-cost industrial land.

4.2 Overview of the Current Traffic Situation

Because of the excellent location, not only regional traffic passed through this district, but also national traffic. This was influenced by these following conditions as follows:

- the economic wealth in the region of Rhine-Main from Cologne, Bonn, Koblenz to Frankfurt).
- the large number of commuters to and from Bonn
- the expanding utility of the Cologne/Bonn airport
- the growth of population in Bonn and the district of Rhine-Sieg
- the high load of infrastructure in motorized transport as well as public transport.

The road traffic network particularly in the location between Cologne and Bonn had good accessibility. It was also indicated by the motorways connection (see Figure 3), which was denser than in the southern part of the study area.

A good public transport system was available in the study area, particularly the rail transport. There are long-distance traffic (ICE, IC, EC⁴), regional traffic (RB, RE⁵), rail rapid transit (S-Bahn), as well as underground (U-Bahn) and tram through the inner city of the study area. Bus, of course was also available. The rail route between Cologne and Bonn was the densest among rail routes in the regional transport system. The commuters travel every day between these cities.

4.3 Traffic Model

4.3.1 Basis of Data

Traffic model is an essential element to solve the approaching tasks of the study. PTV AG provides the traffic model of southern part North Rhine-Westphalia, whose basis model, is derived by PTV-Validate. The PTV-Validate supplies the regular updated traffic model, not only Germany-wide but also in world-wide traffic model. Even now it is the world’s largest transportation model.

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⁴ ICE = Intercity-Express, IC = Intercity, EC = Euro City
⁵ RB = Regional Bahn, RE = Regional Express

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Figure 4: Counting stations in the road network of study area
For this study, several items in the traffic model had to be touched for subsequent validation so that the desired model is suitable for the entire objectives of the study. For further operation of the study, it is necessary to know the derivation data of traffic count stations. In the model of the study area, the basis data was obtained from BAST 04, manual count and RTC 05.

### 4.3.2 The Actual Traffic Counting Stations

Figure 4 describes the road network of the study area. The various types of road are described with different colors and the counting stations are marked as black triangle which is already supported by the data of traffic count. The road network model consists of approximately 26,510 links.

The percentage distribution of counting points in relation to the road category and the input data is described in Figure 5. There are total 596 counting points in the study area. In general, the majority of derivation data in all road types were obtained from RTC 05. In the motorway, the most derivation data were from the manual count and BAST 04. Most of the counts stations in the study area were located in country road, which most of its input data were derived from RTC 05 existing not only in country road, but also in other roads and federal roads with 2 lanes.

![Figure 5: Distribution of counting station based on road type and input data](image)

### 4.3.3 Application of Iterative Propagation in VISUM

By using the model in VISUM software, it is possible to perform the assignment and propagation procedure. The result of assignment and propagation procedure is able to be indentified and described in the network model. In order to operate the incremental propagation procedure, it is necessary to know which parameter setting is suitable for the study. Each parameter has to be understood and simulated several times until the desired result which approaches the theory is acquired.

The three procedures are implemented step by step in VISUM, from one procedure to another procedure in every count station in the investigation area. It is possible to combine the three procedures in VISUM with VBA Excel, so that the procedures perform automatically step by step in the whole of investigation area. The result of the three procedures can be automatically represented in MS Excel as table. So in the next steps the results can be compared easily. A failure can be assumed, if the traffic flow result from the three procedures differs greatly. This indicates an information gap within the count station, especially in a specific condition. The results of the whole study and its analyses will be explained in more details in the next section.
An illustration of this procedure in an intersection is described in Figure 5. It is clearly shown, that there are 6 counting stations in three links which are difference in direction. Every count station has a traffic flow as input, for a given in RTC 05.

Figure 6: Illustration of plausibility check in an Intersection after calculation

5 RESULTS

5.1 Results of the Method

5.1.1 Reliability

Reliability is one of the results of the method. The result can be visually illustrated in the whole study area by various bar-widths and distinguished into various colors, in which each color represents a certain range of reliability values and the bar-width represents the scaled reliability value. This also serves as visual control. The reliabilities have values between 0 and 1, in which the value 1 means that it is the detector side. Moreover as control of the propagation method, in the detector side, the input measured value ($MeasQ$) and the output calculated value ($ResultQ$) must have the same value ($MeasQ = ResultQ$).

Figure 7: Reliabilities result after propagation of measured values

The above figure demonstrates the distribution of reliabilities and detector position in a part of the investigation area. The detectors or count stations are illustrated in black triangle, the detector value with black colors is the measured value or the result of propagation measured value while the value in red is the assignment value. It clearly shown, that the various colors and bar-width represent the range of the reliability values. The lowest reliability values, which is 0.2, is represented by the dark red color and the highest values i.e. 1 is determined by the dark green color. At all detector side, the reliabilities values are exactly 1 and illustrated in dark green. Based on the previously described theory, it is proven that the reliabilities values
are lesser if the distance is farther from the counting station and depend also on types of passed nodes/intersections. This can be seen from the gradation of the colors from the detector site to the next links.

5.1.2 Length of Links

There are approximately 26,510 links in the road network model of the study area. In VISUM, a link is represented as a directed element and is described by the $FromNode$-number and $ToNode$-number. Both of the directions of a link are independent network objects but they share the same link number. The length of an individual link in the study area is not equal, because every link has its own attributes, e.g., links type and permissible transport system.

![Figure 8: Example of reliability value in a link](image)

In relation to the result of reliability, the reliability value in a link is equal whether in a long link or a short link. Figure 8 describes an example of a link with its reliability value. If a link is split in an equal interval, the further a link from the detector is, the more the reliability value diminishes as well as the more variation the reliabilities values have. The reliability value will be also relatively unchanged, in this case as long as in the next links, there are no nodes/intersections and no objectives available.

5.1.3 Reliability value in passive condition

![Figure 9: Distribution of reliability values in passive condition](image)

The reliability value in passive condition is the calculated value of incremental propagation procedure which is carried out without measured value. During the propagation procedure in passive condition, every detector is switched off alternately, and then the measured values are propagated. It was applied in the whole of study area as one of the procedures to identify the alteration value among the propagation procedures with and without measured values.
Figure 9 represents the result of propagation without measured values (in passive condition) and illustrates the distribution in a ranged value of reliabilities. In total, there are 596 count stations or detectors in the study area. Five percent of them still have a reliability value of almost 1 and the majority of them i.e. about 51% have reliability value between 0.90 and 0.995. The two biggest shares are situated in the reliability values between 0.90 and 0.80 as well as between 0.80 and 0.70 with about 21% and 10%, respectively. The rest of 13% are distributed in a range from 0 until <0.7.

The result indicates that there are no large different or deviation of reliabilities values between propagation with and without measured values. This may occur because the distance between count stations or detectors in the study area are not so extremely far from each other, especially in the northern part of the study area. It may also happen because there are not much passed nodes among the count stations. According to the theory of propagation, it is understood that the influence of reliability value is only until the next count station or detector and depend also on the number and types of passed nodes.

Indirectly, this method enables us to analyze the effectiveness of the count stations in the study area. The count station which has a reliability value almost by 1 (i.e. from <0.995 to ≤1), indicate that there is similar characteristic of count station with the previous count station. It can be assumed that it is not necessary to situate the count station in that location or in other words it is not effective. So, it can lead us to the possibility of saving the expenditure of traffic census in the future.

5.2 Determination of Quality of Measured Values Using the Result from the Method Applied

In the methodology, it is explained that to check the plausibility of count station, in this case measured value, it is required to perform the three procedures which are incremental propagation with and without measured values as well as assignment procedure. The results of the three procedures have to be compared to determine the deviation of the calculated values and to identify how much discrepancy have the calculated values. From the result, it is also possible to determine the quality of measured values or count stations.

5.2.1 Deviation

As already discussed in the previously, the combination of VISUM and VBA Excel tools has calculated the three procedures alternately in the whole study area and generated the calculated values of the three procedures. The simplest way to compare the calculated values is by identifying the deviation of the values. As information, the calculation is only available on the link with a detector, without having to differentiate the derivation data of detector.

Figure 10: The comparison of deviation values relations
Here we are assuming that every calculated procedure value is independent on the other, so it is essential to identify the deviation among two procedures in more details. For instance, the deviation of calculated values between propagation with measured values and without measured values, propagation with measured values and assignment as well as propagation without measured values and assignment. Consequently, three calculated deviation values from the three procedures are generated. These values can be arranged into intervals of deviation value (i.e. interval of 10%) and it is possible to make out the relation between them.

Figure 10 displays the comparison of the three relation deviation values. It is given here, that A is the deviation between propagation with measured values and assignment, then B is the deviation between both of the propagation method and the last is C, which is the deviation between propagation without measured values and assignment. As can be seen in the figure, the three deviation values have particularly high number of count station at the extreme low deviation. In A, it shows that approximately 60% of the count station has deviation less or equal than 10%, which means also that there is no large calculated values difference between propagation measured values and assignment. While in B and C, only approximately 45% and 30% of count stations are found within the deviation range of ≤10%. The tendency shown in A, B and C is that the share of count station will continuously decrease in higher range of deviation, except in the deviation range of ≤100%.

There are indeed some influences between both of the propagation procedures. According to the propagation theory [Vortisch, 2006], the influence of the reliability values and the propagation result in this case traffic flows are only until the next count station. If a detector is switched off in propagation without measured value, then the propagation results (reliability and traffic flow) will depend on how far and how much possibility of turning to the next detector is. While the weight of that influence always depends on the position of the detector in the study area, hence for simplification, we assume that the influences of both propagation procedures are disregarded.

Subsequently, the three deviation values lead us to the mean deviation in order to observe the deviation of the whole procedures in a whole study area. In order to simplify the observation of mean deviation in the study area, it is useful to arrange the mean deviation into the interval (≤10%, ≤20%, …, ≤100%). Figure 11 summarizes the description results obtained from the mean deviation calculation based on derivation data.

Figure 11: Distribution of mean deviation based on the derivation data

In relation with the derivation of data, there are totally three inputs of data in the study area, which is derived from BAST 04, Manual Count and RTC 05. The total share of every input data which has a deviation value ≤10% is projected as follows: BAST (23%), manual count
(28%) and RTC 05 (42%). In the deviation range from ≤10% until ≤30% the most share of number of count station in relation to the derived data is coming from the RTC 05, which is generated using continuous count method. It should be noted that through this study, we expect that the result from the continuous counts, in this case from RTC 05 is more reliable than the manual counts.

5.2.2 Statement of the Quality of Count Stations in the Application

In order to assess the count stations or measured values quality, there are a few things to be discerned. In the count station which has a relatively large mean deviation, it can be assumed that the calculated values of the three procedures are contradictory with each other therefore it can be indicated that there is an error within. Moreover, the indicated error count stations have to be checked individually in the model. This is due to the possibility that the error comes from the input value in the model and/or it is related to the location of the count station in the study area or any other reasons. So, the high quality of count stations is expressed by a low value of deviation. It indicates that the calculated values of three procedures have analogous values with each other or in others word that the count station is assumed to be correct.

Table 3: The quality of count station in the study area

<table>
<thead>
<tr>
<th>Deviation Values</th>
<th>Quality of Count Station</th>
<th>Percentage of Count Station</th>
</tr>
</thead>
<tbody>
<tr>
<td>0% - ≤30%</td>
<td>Correct forecast</td>
<td>82%</td>
</tr>
<tr>
<td>30% - ≤60%</td>
<td>Tends to be a correct forecast</td>
<td>14%</td>
</tr>
<tr>
<td>60% - ≤100%</td>
<td>Incorrect forecast</td>
<td>4%</td>
</tr>
</tbody>
</table>

Table 3 presents the quality classification of count station in the study area. Authoress classifies the correct forecast count stations by the range of deviation between 0 – 30%. It appears that about 82% of the total count stations belong to the correct forecast. About 14% of them are classified into tends to be correct forecast and the rest 4% is indicated to be incorrect forecast.

With regards to the correct forecast category i.e. deviation values between 0 – 30% and also by observing the Figure 11, then it can be concluded that the most reliable data collection in terms of the quality of measured values is derived from RTC 05. In relation to the expected final result of the study, it can be deduced that the most reliable traffic counting is acquired through the continuous or automatic count, which is applied in RTC 05.
The Figure 12 explains also the distribution of mean deviation in quantity as well as in percentage. It can be noticed that the majority share of count stations have a small mean deviation. It is also described, that by the steady decrease of count station percentage, the mean deviation will increase accordingly. This applies only until mean deviation values <90%.

In the further graphical and table illustration of the incorrect forecast count stations in the entire of study area, it can be summarized that from one illustration result to the other that the results are the same, which is good as it shows consistency in the result. However, from a more detail observation into the geographical condition of the network model, it is possible to see the gap of information by considering the influence of mean deviation and the location of count station in the study area. Then, the tendency shows that the count stations with mean deviation between 60% and 90% are mostly located close or direct to the border of investigation area.

On further observations on the numerical result tendency, it can be concluded that the mean deviation of less or equal than 100% is caused when the results of assignment and propagation without measured value method are null. In this case, the mentioned count stations are in fact not suitable to be considered in the deviation calculation. This condition can be considered as an anomaly. The condition is closely related to the count stations location, which in this case are mostly located on or near the border of the study area.

6 CONCLUSION AND RECOMMATION

From the analysis, it is proven that about 82% of the total count stations belongs to the correct forecast, which has a mean deviation between 0 - 30%. The most accurate data collection in terms of quality measured values is derived from RTC 05 (48% of total entire count station of RTC 05). The quality of counts station also depends on the position of count station. The results show that the tendency of incorrect measured values are located near or direct to the border of the study area. It is important to notice that the procedures of the method in this study are also dependent on the quality of the traffic model, we assumed here to be error-free. This study expects also that the result of automatic counting in this case data from RTC is much better than the other counting method. On the other hand, the data quality difference from the manual counting is not large compared with automatic counting. But altogether, this model-based is suitable to check the plausibility of traffic census.

The study area is only a sample of a relatively large area which is representative for the implementation of this method. One of the expectations of this study is that the application of the method does not depend on the selected region but can also be used in the other. There are numerous traffic problems; one of them is traffic census. In the future, the prospects of using automatic counting in RTC are greater, so it is necessary to develop other methods in terms of checking the accuracy of traffic counting.

This propagation method has been developed by Vortisch for the real-time traffic state estimation in urban road networks. It is also possible in the further research to develop this method for other applications in traffic engineering, for example this method may enable us to optimize the location selection of count stations or to analyze the effectiveness of count stations in a traffic network.
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REFERENCES


