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# Traffic Flow Detection and Forecasting

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## Introduction

Nowadays intelligent transportation systems are being developed very much. But lots of problems such as traffic control, gridlocks, parking, road accidents aren't solved yet [1]. Traffic flow forecasting precision is one of the major tasks in order to improve traffic conditions in the urban streets. The way how to improve traffic flow prediction precision remains an important problem of intelligent transportation systems.

There are two types of Traffic flow forecasting. They are Short- term forecasting and Long- term forecasting. Short- term traffic flow forecasting defines the traffic intensity for the next time interval, usually from 5 to 30 minutes. Long- term forecasting of the traffic intensity can be predicted hours, days or even years ahead.

There are designed many methods of Short- term traffic flow forecasting. Usually Short- term forecasting methods are divided into two types. The first type includes classic methods, such as statistics. And the second type includes modern methods based on models such as neural networks or fuzzy [2]. Methods are being developed and optimized in order to obtain more accurate forecasting information. Various methods are using the historical data base. Often traffic flow forecasting precision depends on accuracy of collected information about traffic flow. The imperfections of many methods are problems of traffic data losing or incorrect traffic data [3].

## Traffic flow forecasting method, based on improved data detection technology

We propose short- term traffic flow forecasting method based on improved data detection technology. The main point of this forecasting method is traffic flow information collecting only in the biggest crossroads and forecasting it in the remaining smaller crossroads. Using proposed method, we crate three different forecasting models. They are linear regression forecasting model, forecasting model based on fuzzy logic and forecasting model based on neural networks.

The most used traffic flow information collection technologies are inductive loop and video processing systems. Inductive loop technology has a lot of disadvantages; therefore we decided to improve traffic flow forecasting method with video detection technology. Designed short- term traffic flow forecasting method based on improved data detection technology is showed in Fig. 1.

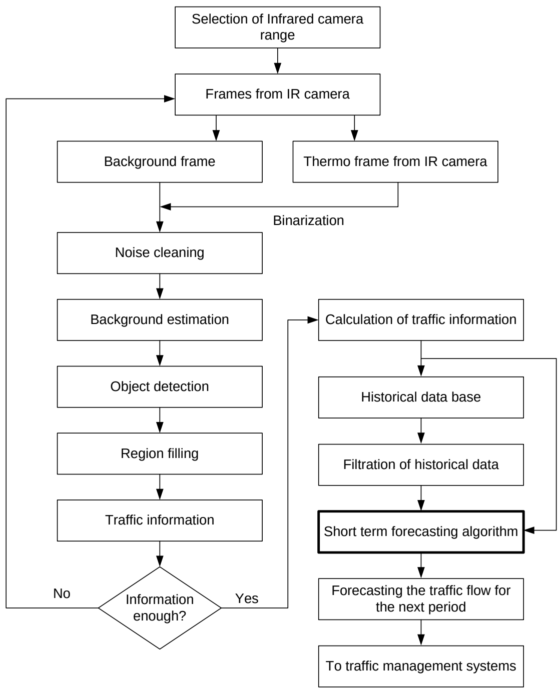


**Fig. 1.** Traffic flow forecasting method based on improved data detection technology

In previous work [4] we research that most common video detection algorithms have a lot of weaknesses. Some of weaknesses are related to weather conditions, such as strong light, rain, fog, darkness and others. Others are related to physical interferences, such as camera vibration, interference in the video transmition and etc. The interferences created by the unwanted weather conditions can be avoided by using IR cameras. Recently the application of thermo- vision technologies becomes more and more popular in Lithuania in such directions as energetic, mechanics and electronics. Transport management can be one of the directions where thermo-vision technologies may be applied too.

## Experiment

In order to create forecasting model, the experiment was performed in two crossroads near supermarket with multistorey parking. During the experiment traffic data was collected with manual method and automatic method. Using manual method, traffic flow data was collected from Karaliaus Mindaugo avenue (KMST and KMSEN) and A. Mickeviciaus street (MICMI). The traffic flow data from parking (PARK) was collected with automatic method. There were used inductive loops for automatic method. Experiment was performed for one week- long. During the experiment, information about vehicles was collected with one hour interval. Experiment's results are showed in Fig. 2.

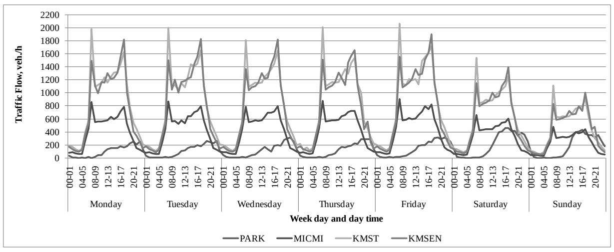


**Fig. 2.** Experiment result

Experiment's results were used for creation of short-term traffic flow forecasting models.

## Forecasting model based on fuzzy logic

Forecasting model based on fuzzy system was created with Matlab programming software. For this model genfis2 function was applied. This function generates Fuzzy system structure from data using subtractive clustering. This method accept each data point as a potential cluster center and calculates the probability, that each data point will be defined as a cluster center, based on the density of surrounding data points.

Using this method, Sugeno type of fuzzy structure is generated. To generate this structure, three inputs and one output are applied. Model's inputs are traffic flows from PARK, traffic flow from KMST and flow KMSEN. For output MICMI traffic flow was used. Generated structure of fuzzy is showed in Fig. 3.

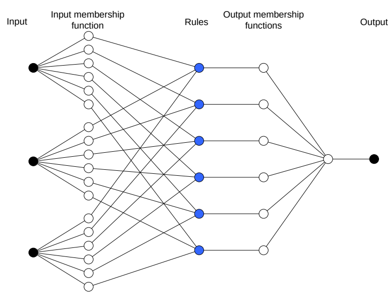


**Fig. 3.** Scheme of Fuzzy architecture

Fuzzy structure has three inputs and one output. Each input has six membership functions. For this fuzzy structure Gausian membership functions was generated. As we see from Fig. 3, fuzzy model is constructed of six rules. The rule extraction method first uses the subtractive clustering function to determine the number of rules. After that uses linear least squares estimation to determine each rule's result equations. Table 1 shows the generated fuzzy rules.

**Table 1.** The Fuzzy rules

| PARK | KMST | KMSEN | REZ |
|---|---|---|---|
| M | LM | M | LM |
| N | D | D | D |
| D | M | LM | M |
| V | LD | LD | LD |
| LM | N | N | N |
| LD | V | V | V |

Explanation of fuzzy labels: LM – very small traffic flow; M – small traffic flow; N – little traffic flow; V – medium traffic flow; D – big traffic flow; LD – very big traffic flow.

Fig. 4, Fig. 5 and Fig. 6 shows the modeling results of fuzzy model.

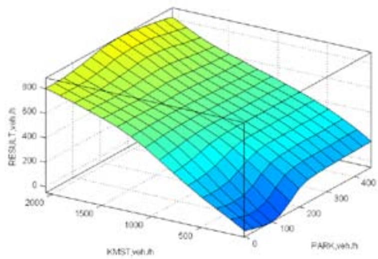

**Fig. 4.** Traffic flows from KMST and PARK

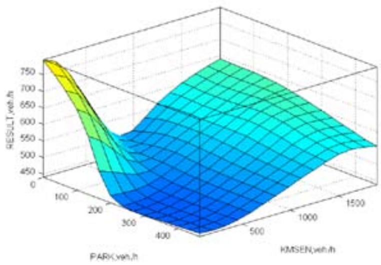

**Fig. 5.** Traffic flows from PARK and KMSEN

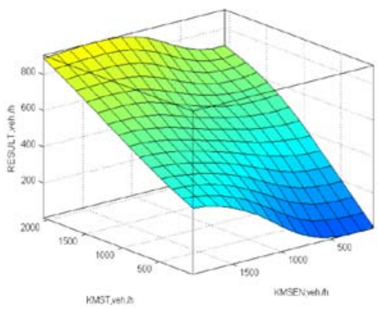

**Fig. 6.** Traffic flows from KMST and KMSEN

The results of forecasting model based on fuzzy logic and experiment results are showed in Fig. 7.

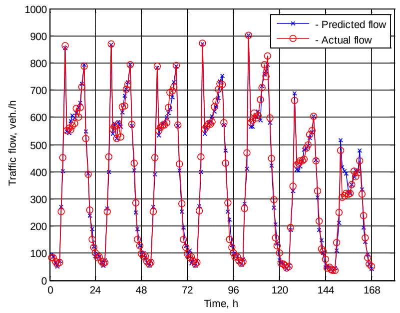


**Fig. 7.** Comparison of real data and predicted data

After the traffic flow forecasting model based on fuzzy logic was created, there was performed a forecasting using improved detection technology. Fig. 8 shows forecasting results with standard data collection system and with improved data collection system.

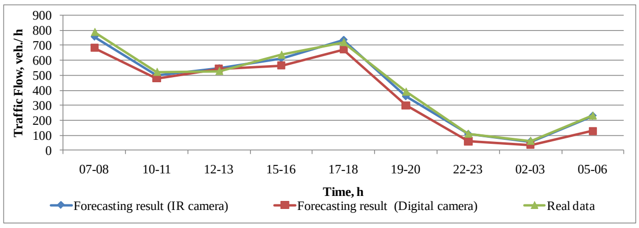


**Fig. 8.** Forecasting results of standard detection technology and improved detection technology

As we can see, the best forecasting results are when using forecasting model based improved data detection technology.

### Forecasting model based on neural network

Second traffic flow forecasting model was developed on neural network. Traffic flow forecasting model based on neural network was realized using the "Matlab" programming package. Standard two-layer, feed-forward neural network with three inputs, one output and 30 hidden neurons was generated. This neural network trained with Lebvenber- Marquardt training optimization method. Network training results are showed in Fig. 9. Regression R values measure the correlation between outputs and targets. In this model R values are 0.99 and it means that relationship between output and target are very similar.

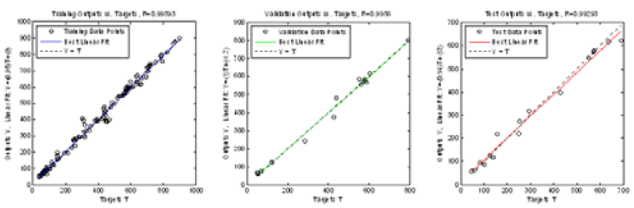

**Fig. 9.** Correlation between outputs and targets

Forecasting with experimental data was performed. You can see forecasting and actual flow results in Fig. 10.

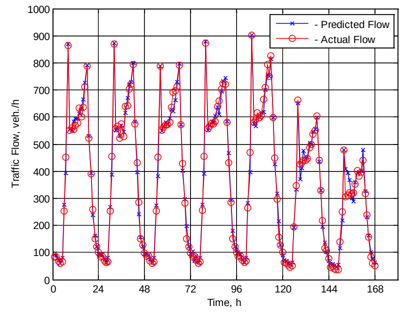


**Fig. 10.** Comparison of real data and predicted data

As you can see from Fig. 10 the forecasting results sufficiently precisely represent the real results of the experiment.

After developing the model based on neural network, there was performed forecasting using improved detection technology. Fig. 11 shows forecasting results with standard detection technology and improved detection technology.

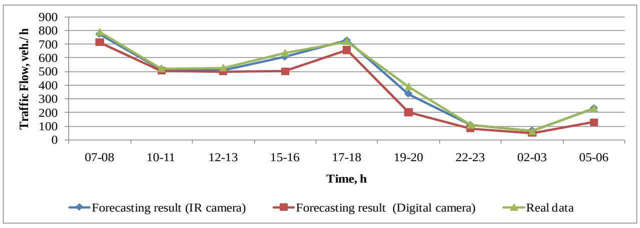


**Fig. 11.** Forecasting results of standard detection technology and improved detection technology

More precise real experiment data represent improved traffic flow detection technology.

### Forecasting using linear regression model

Regression forecasting model assigned to heuristic forecasting methods class. We choose linear regression forecasting model which is represented in previous works [5]. Forecasting results with standard detection technology and improved detection technology are showed in Fig. 12.

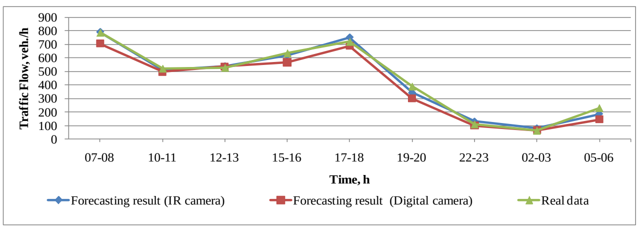


**Fig. 12.** Forecasting results of standart detection technology and improved detection technology

As in forecasting model with fuzzy and neural network using Regression forecasting model we get better forecasting results using improved detection technology.

### Results

Fig. 13. shows results of traffic flow forecasting models using improved traffic data collecting system.

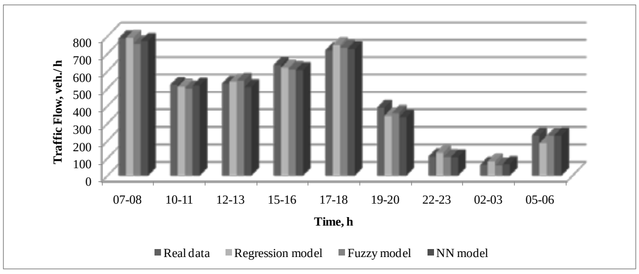


**Fig. 13.** Results of forecasting models

To estimate forecasting precision we calculate root mean square error (RNSE). Root mean square error is calculated using this equation:

$$RMSE = \sqrt{\frac{(F_t - Y_t)^2}{n}}, \qquad (1)$$

here $F_t$ – the forecast for period t; $Y_t$ – actual value at period t. The results of RMSE show that best precision is forecasting model based on fuzzy logic. Worst precision is using regression forecasting model.

## Conclusions

- We propose short- term traffic flow forecasting method based on improved data detection technology. Improved data detection technology uses information from thermo cameras.
- Three short- term traffic flow forecasting models was created. They are linear regression forecasting model, forecasting model based on fuzzy logic and forecasting model based on neural networks. Best prediction precision obtained using forecasting model based on fuzzy logic. Regression forecasting model is suitable for long- term forecasting.
- Forecasting results of all models show that using forecasting with improved data collection technology results are better then using standard detection technology.

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**K. Balsys, A. Valinevičius, D. Eidukas. Traffic Flow Detection and Forecasting // Electronics and Electrical Engineering. – Kaunas: Technologija, 2010. – No. 5(101). – P. 91–94.**

In order to improve traffic conditions in the urban streets, traffic flow forecasting precision is one of the major tasks. How to improve traffic flow prediction precision remains an important problem of intelligent transportation systems. A lot of methods of Short-term traffic flow forecasting are designed. The methods are developed and optimized in order to obtain more accurate forecasting information. Often traffic flow forecasting accurate depends of traffic flow data collection accurate. We propose short- term traffic flow forecasting method based on improved data detection technology. Method tested with different forecasting models. Results show that proposed method is very suitable for short- term traffic flow forecasting. Ill. 13, bibl. 5, tabl. 1 (in English; abstracts in English, Russian and Lithuanian).

**К. Бальсис, А. Валинявичюс, Д. Эйдукас. Обнаружение и прогнозирование транспортных потоков // Электроника и электротехника. – Каунас: Технология, 2010. – № 5(101). – С. 91–97.**

В целях улучшения условий движения на городских улицах, прогнозирование движения транспортных потоков является одной из наиболее важных задач. Как улучшить прогнозирование транспортных потоков остается важной проблемой интеллектуального управления дорожным движением. Было создано очень много методов для прогнозирования движения. Часто точность прогнозов зависит от данных. Мы предлагаем метод для прогнозирования транспортных потоков на основе усовершенствованной технологии сбора данных. Метод опробован с тремя разными моделями прогнозирования. Результаты показали, что разработанный метод очень удобен для краткосрочного прогнозирования транспортных потоков. Ил. 13, библ. 5, табл. 1 (на английском языке; рефераты на английском, русском и литовском яз.).

**K. Balsys, A. Valinevičius, D. Eidukas. Transporto srautų detektavimas ir prognozavimas // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2010. – Nr. 5(101). – P. 91–94.**

Siekiant pagerinti eismo sąlygas miesto gatvėse, svarbu tiksliai prognozuoti transporto srautus. Svarbi intelektualaus transporto valdymo problema – kaip pagerinti transporto srautų prognozavimo tikslumą. Sukurta labai daug metodų transporto srautams prognozuoti. Metodai yra tobulinami ir optimizuojami siekiant gauti tikslesnę prognozavimo informaciją. Dažnu atveju prognozavimo tikslumas priklauso nuo surinktų duomenų apie transporto srautus tikslumo. Sukurtas transporto srautų prognozavimo metodas, pagrįstas patobulinta duomenų surinkimo technologija. Metodas išbandytas su trimis skirtingais prognozavimo modeliais. Rezultatai parodė, jog sukurtas metodas labai tinka trumpalaikiam transporto srautų prognozavimui. Il. 13, bibl. 5, lent. 1 (anglų kalba; santraukos anglų, rusų ir lietuvių k.).