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DIGITAL CAMERA AS A DATA SOURCE OF ITS SOLUTIONS IN TRAFFIC CONTROL AND MANAGEMENT

Summary. The traffic adaptive-control processes and Intelligent Transportation Systems (*ITS*) work on traffic characteristics provided by vehicles various detectors. In majority cases the algorithms work on vehicles number evidences only, recorded on traffic lanes. The expected data concerns the vehicles number and a time schedule observed at stop-lines on intersection inlets or another points of the traffic intensity checking. A satisfactory usage of the video technology needs various simplifications of the data source structure and the processing algorithms. For simplification of these all processes several solutions must be implemented. One can try reducing the data size and improve the processing algorithms. Better results can be expected after proper selection of the data sampling intervals, namely the data granularity finding. Several conclusions concerning the traffic recording and modeling are presented in this work. The discussed technology was implemented to produce.

KAMERA CYFROWA JAKO ŹRÓDŁO DANYCH KONCEPCJI ITS DLA STEROWANIA I ZARZĄDZANIA RUCHEM DROGOWYM

Streszczenie. Adaptacyjne sterowanie procesem transportowym oraz tzw. Inteligentne Systemy Transportowe (*ITS*) korzystają z charakterystycznych danych zarejestrowanych za pomocą różnych detektorów ruchu. W większości przypadków algorytmy sterowania wykorzystują zapis o liczbie pojazdów na pasach ruchu. Potrzebne dane dotyczą zarówno liczby pojazdów, jak i czasów ich dojazdu do linii zatrzymania na wlocie skrzyżowania lub innego charakterystycznego punktu pomiaru natężenia ruchu. Zadowalające zastosowanie technik pomiarowych wideo uwarunkowane jest wprowadzeniem wielu uproszczeń dla rejestrowanych danych i algorytmów przetwarzania. Modelowanie strumieni pojazdów wiąże się zwykle z pewnymi stratami rejestrowanych danych. Często te dane są nadmiarowe dla uzyskania zadowalającej jakości sterowania ruchem. Dla uproszczenia wszystkich faz sterowania przedstawiono kilka ważnych rozwiązań z teorii rejestracji i przetwarzania danych. Można dokonać znaczącej redukcji rozmiaru plików danych wejściowych oraz uprościć algorytmy ich przetwarzania, nie tracąc niczego z jakości sterowania. Dobrym sposobem dla tych ograniczeń jest określenie właściwego interwału próbkowania danych pomiarowych oraz zdefiniowanie rozmiarów ziarna pomiarowego systemu sterowania. Kilka istotnych rozwiązań, dotyczących rejestracji i modelowania procesów transportowych, zaprezentowano w niniejszym artykule. Opracowania te zostały wdrożone do produkcji.

1. INTRODUCTION

The fashionable today video detection systems, also used for a traffic data real time registration, provide the user with not only valuable but also very complex data files for analysis. For these real-time processes the traffic controllers and management have limited time window for the data registration and processing. This time window is usually matched with a speed and number of passing vehicles. The traffic adaptive-control processes are recommended for delivering a free time on selected traffic inlets into the overloaded traffic lanes. The traffic capacity has to be measured precisely to put the idea of the adaptive control into practice [3, 4, 6]. A needed data for the control can be found within various measurements of the traffic intensity at adjacent intersections and their surrounding points. The multi-sensors data fusion can determine the vehicle parameters, such as: position, velocity, dimensions, forbidden or dangerous manoeuvres [3, 4, 6, 21, 26] and others.

The traffic control systems need to respond to specified events e. g. presence of an incoming vehicle in a detection area and the vehicles queue at intersection inlets discharging. Traditional solutions for the traffic control are based on number of cars detected at inductive loops fields, although they do not indicate any proper occupation states (traffic intensity) on traffic lanes. The long queues of vehicles on the intersection inlets means large time period needed for their discharging.

Let us presume an example with 7 vehicles, waiting in the queue and the sampling rate of this scenery is set to 10 seconds; selected arbitrary, based on historical traffic data analysis. It is obvious that the queue on intersection is discharged in much longer time than 10 seconds. That is why the sampling rate of the traffic scene may be set lower.

Instead of troublesome inductive measuring techniques the video traffic detection technology is recommended [3, 6, 10]. Then not only the number of cars defines the green light time. The image analysis provides us with additional data like cars classes, their dynamics and distances between them in move.

Due to cope with the complexity of the image processing, provided by the video camera, many pre-processing algorithms are used.

At the beginning specific rules for the traffic description are defined [9, 14]. They allow determining a data set size that is necessary for the traffic processes proper calculation, although minimised into acceptable dimensions. One can notice that in the searched time window for passing cars and queues observation the distances between the cars are not noticed (Fig. 1).

Fig. 1. An example of the traffic lanes small saturation
Rys. 1. Przykład niskiego nasycenia pasa ruchu

Avoiding the gaps assignment we make the control processes not precise enough, even the controlling procedures will not be effective at all. Remarkable part from this counted car-number will not cross the intersection in the defined green light time [9].

2. THE TRAFFIC GRANULATION IDEA AND CELLULAR AUTOMATON

A big amount of the data provided by the video equipment has to be reduced into properly extracted data part in the defined time samples.

The granular computing

The data sampling rate determine the granular computing intervals known in many computation theories. They determine the data granules with their: classes, clusters, subsets, groups and computing intervals [8, 19, 33].

Instead of operating on number of vehicles visible on the traffic lane or in queue the automaton operates on cells state (the traffic saturation level) giving better measures for lanes occupancy, as for the example in Fig. 1. One can observe the automaton cells of the cellular traffic model, with several cells in a single lane, with different occupation levels.

Numerous works have dealt with granular computing approach into a data mining that aims at discovering knowledge embedded in the data [1, 2, 19, 26, 27]. They enable direct determination of temporal characteristics for the recognised and extracted traffic states. The processing methods combine the granular computing algorithms with specific features of the cellular automata traffic model.

The introduced in the contribution experiments, with cellular automata, prove that a sampling rate of the traffic detectors measurements can considerably be lower for large number of vehicles in queue. That is indirect proof for the traffic sampling rate, which is not related to number of cars, while the cellular automaton for the traffic control is used.

The transportation means detection and the decision making algorithms have to provide us with not only vehicles time approach prediction (at the intersections) but also finding possible solution for avoiding critical queues at the intersection [9, 20, 32].

In order to obtain the satisfactory data of the discussed example the cellular automaton with the data uncertainties assignments is implemented. This combination of the description presents the conclusions in fuzzy values ranges [8, 21, 28, 38]. In the video detection systems, many detection zones are indicated within the camera observation field. Thus, the video detection results are directly used for the cellular automata traffic model updating [32, 39].

In many cases the data granules automatically identified themselves by the discrete traffic models characteristics [9, 28] where the cellular automata approach into the traffic control plays a key role.

The road traffic parameters are evaluated for a given road part and for time interval of the analysis cycle. Thus, the space and time granulation are discussed, after that they are used for further data analysis. The identification of the traffic data granules enables implementation of the granular computing methods for the traffic control.

The analysis of the data sampling rate (the granulation level) consists of several steps:
a) possibility of the data granulation, used for the control by means of cellular automata,
b) statistical prediction of the traffic parameters, on the base of historical data records,
c) the image sampling rate finding for traffic intensity satisfying analysis.

First of all the transportation network description has to be made by means of cellular automata microscopic model, where the traffic parameters are assigned by fuzzy numbers [9, 28]. The random nature of the traffic attendee's behaviour is taken into account in the form of the likelihood of reducing the speed of vehicles at every step of the simulation procedures. The calibration of the model was performed by the same examples made for comparison in VISSIM simulation package [36].

Description of average overtaking manoeuvres in the traffic model can be abandoned, assuming that the differences in calculation procedures are compensated by fuzzy description of input and output variables with their appropriate calibration in the final traffic model. Number of vehicles waiting in the queue is not important for the discharge time of the queue. To simulate the traffic on multi-lane roads the same model as for the single lane traffic can be used [9].

The investigated and implemented approximation assumes that the queue length in a multi-lane model is equal to the length of the queue in the single-lane model, divided by number of lanes. In

addition to the number of vehicles, the lanes occupancy complemented by number of empty cells in the automaton (between vehicles) has undoubtedly to be taken into account.

The cellular model assigns the vehicles load in form of a discrete number of fuzzy membership functions. The function of the vehicle belonging to a cell has a value in the interval [0, 1]. One can find two cars with membership function of the same cell bigger than zero. It means probability that the front of the next vehicle entering the cell is bigger than zero. Vehicles appearing in the transportation network belong into several classes, according to differing values of the variables used to describe them; such as: the initial position of the vehicle on a road section, the initial speed, maximal speed, acceleration and the vehicle length.

Remarkable difference between the fuzzy model, with imperfect data set, and the traditional one concerns possibilities of removing the traffic random factors from the modeling process.

The cellular models

The cellular models divide the traffic lanes into small parts called cells. The microscopic model uses the cells that are occupied by single vehicles. The macroscopic model assumes bigger size of the cell, where more than single vehicle are placed [9, 28]. The cell is considered as a data granule in the description model of the road traffic stream.

The space granulation is defined according to the idea of the cellular automata traffic control process. Furthermore, zooming-out and zooming-in operators are used for the traffic granulation better assignment [9, 20].

The state of the cell defines a value of traffic density, using a number of vehicles belonging into the cell. Thus, the granulation is described by a set of cells {i}, with their current state:

$$C_L = \left\{ c_{1,L}, c_{2,L}, ..., c_{n(L),L} \right\} \tag{1}$$

where: L - denotes the granularity level, $c_{i,L}$ - is a state of cell number i, at granularity level L, $n(L)$ - is a number of cells at granularity level L.

At the lowest granularity level ($L = 1$) states of the cells have binary values: $c_{i,1} = 0$, if the cell i is empty and $c_{i,1} = 1$, if vehicle is in the cell i.

At higher granularity levels ($L > 1$) the cells state values denote number of vehicles belonging into the cell: $c_{i,L} \in \left\{ 0,1,...,L \right\}$.

The algorithms of traffic signals control, e. g. [1, 2, 9, 19] utilize traffic characteristics for the traffic detection zones that are located at approaches into an intersection, on the particular traffic lanes. The passing vehicles assign the lanes occupancy. Other measurements are also performed; e. g. velocity, vehicles classes, over-speeding objects and so on.

The traffic volume updating determines states of cells, in a real time mode that is performed for an on-line computation. The observation objects include: recognition of vehicles locations, cells states determination and the time of intersection leaving by the vehicle.

The applied granulation method simplifies the traffic states description, determining the vehicles queue discharge time τ and the discharging rule, defined as:

$$\text{if } TS \models C_L \text{ then } \tau \in T \tag{2}$$

where: the condition $TS \models C_L$ assigns the registered traffic state TS for the cells C_L.

The decision rules

Accuracy of the control prediction is higher for the rules extracted at higher level of granularity, as the traffic description using larger cells (granules) is more general than configurations with small cells. For higher granularity level the rule is extracted from larger data set than in case of lower granularity level. In practical applications the task of granularity selection for traffic model is realised by determination of the detection zones. Thus, the presented method may be used for evaluation and optimisation of the vehicles detection zones assignment.

Implementation of fuzzy automaton approach into a traffic modeling allows us taking into account uncertainty of vehicles location on the traffic lane. Description of the remaining traffic variables in category of fuzzy sets, allow avoiding very inconvenient random factors in Nagel Schreckenberg cellular automata transportation model [13].

Both the position of the vehicle and time of its approach into the stop-line are calculated as fuzzy numbers. The fuzzy cellular automaton takes into account (in addition to the number of vehicles) the vehicles positions and time the vehicles are entering the stop-line zone. This makes it possible to overcome the intersection during the green light the defined column of vehicles, regardless of the spaces between them.

A classical machine of Nagel-Schreckenberg introduces the vehicles positions in sharp dimensions, however due to a random factor present in its executing rules the values of these items may be faulty. The fuzzy cellular automaton displays positions of vehicles by fuzzy numbers. The highest value of membership function of fuzzy number is the most probable position of the vehicle. While blurring the position of the vehicle can be regarded as a probable distribution of that position.

3. THE DIGITAL CAMERA OBSERVATION FIELD

Implementation of the fuzzy logic for making decisions in the traffic model allows us taking under consideration uncertainty of vehicles placement on a traffic lane. The description of traffic variables in category of fuzzy sets, allow us avoiding very inconvenient random factors in the cellular automata procedures [13]. Using the digital camera for the traffic data assignment one can find a real traffic saturation level defining more precisely the lanes occupation state.

The uncertainty of the vehicles states is assigned by means of fuzzy numbers. In case of video detection, many detection zones may be defined within the camera field of view. Thus, the video readings may be directly used for cellular traffic model updating. The updating process involves cells state determination in real time that enables on-line computation of the traffic parameters.

The standard video cameras are checking the image 25 times per second, recording hundreds of images in an observation zone. This provide us with immense set of images not needed in this number for this very slow process description, that is why a data sampling grid has to be found.

The video image size must be reduced into necessary dimensions, using various programming or hardware solutions [15, 16, 30, 31]. The source image size reduction allows us finding_satisfying information set for an on-line traffic fast control in a limited time window, of the control cycle.

In the investigations presented below the image segmentation algorithms were implemented with numerous combination of the image space division, space growing of the image, image segments' borders detection and also simple static segmentation procedures.

The image segmentation

The segmentation process is used for extracting objects fulfilling specific criteria, distinguishing objects (vehicles) and defining unified background of the image. Pixels attributes of the source image are compared with the given threshold values [12, 22]. The image segmentation is used as preprocessing procedure extracting the image segments with their characteristic features.

In Figure 2 the example source image of the road scene is presented. In the image analysis the labeled indexes of the current segment is assigned. The segmentation method is using products of the image filtering algorithm that produces maps of objects edges. This source image is processed in several steps, namely: noise filtering, detection of objects edges, and the filtering threshold finding. This operation is free from the image quality destruction (as by using convolution filters).

The segments edges recognition has been carried out by Sobel operator [23, 24] indicating every rapid change of the image lightness.

Fig. 2. A source image of the road scene
Rys. 2. Obraz źródłowy sceny na drodze

Several orthogonal masks, which are used in the method, are presented in Fig. 3.

-1	0	1
-2	0	2
-1	0	1

-1	-2	-1
0	0	0
1	2	1

Fig. 3. Orthogonal masks of Sobel operator
Rys. 3. Maska ortogonalna operatora Sobela

For the algorithm simplification a modular formula was applied:

$$M_{i,j} = \left| M_{Hi,j} \right| + \left| M_{Vi,j} \right| \tag{3}$$

where: $M_{Hi,j}$ - lightness of the pixel attribute value for horizontal edges, $M_{Vi,j}$ - lightness of the pixel attribute value for vertical edges,

$$i = 0 \ldots n-1, \; j = 0 \ldots m-1 \tag{4}$$

The image binarisation is made after the image edges are defined. The results give us significant reduction of the image size. The threshold for the elaborated method finding is achieved by using two values of the image grey scale, by lightness medium square function:

$$p = \sqrt{\frac{\sum\limits_{i=0..n-1} \sum\limits_{j=0..m-1} M_{i,j}^{2}}{n \cdot m}} \tag{5}$$

where: $M_{i,j}$ - lightness of pixels with co-ordinates indexes $\langle i, j \rangle$, n - is width and m is height of the camera observation field.

The threshold value is used for data binarisation of the image and its edges that describe the source data unit:

$$P_{i,j} = \begin{cases} 0 & for & M_{i,j} \geq p \\ 1 & for & M_{i,j} < p \end{cases} \tag{6}$$

where: $i = 0 \ldots n-1, j = 0 \ldots m-1$, n - width, m - height; of the camera observation field.

The Smith's segmentation algorithm is the most effective method, with simple procedures and fast extraction of objects (from image in Fig.1). The map of edges is coding the image by two values of pixels $P_{i,j}$:

$$P_{i,j} = \begin{cases} 1 & for \quad pixels \quad on \quad edges \quad (black \quad colour), \\ 0 & for \quad object \quad - \quad piksels \quad (white \quad colour). \end{cases} \qquad (7)$$

where: $i = 0 \ldots n-1$, $j = 0 \ldots m-1$, n - width, m -height of the camera observation field.

For internal field of the objects map finding the image segmentation process has been implemented. The internal surface of the object is assigned by its current decimal number (k). The pixel's value equal to one belongs to the object's edge. In Figure 4 the image after the segmentation is shown.
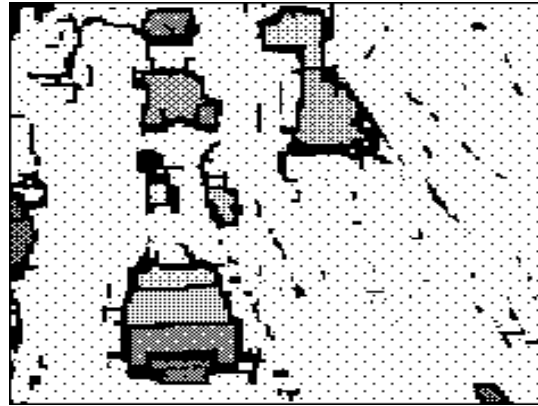
Fig. 4. The image after segmentation
Rys. 4. Obraz po segmentacji

The parameterisation algorithm distinguishes between local, geometrical descriptors and global descriptors introducing number of segments in the image (characteristic values of segments) [32].

The local descriptors concern surface S, assigned by sum of pixels $P_{i,j}$ in segment $k : S(k) = \sum_k P_{i,j}$ and the length of the segment edge, defined by number of pixels on the object's edge:

$$L = \frac{\pi}{4} \cdot \left[\cdot a \cdot \left(N_0 + N_{90} + \frac{a}{\sqrt{2}} \cdot (N_0 + N_{90}) \right) \right] \qquad (8)$$

where: N_0, N_{45}, N_{90}, N_{135} - are segment projections, a - is the distance between image points.

This is a new definition of the length on the segment edge L, the set of pixel pairs on the segment k edge [12]. The Feret diameter (D_v, D_h) defines linear parameters of the segment size; vertical v and horizontal h of segment k in pixels $P_{i,j}$ (Fig. 5):

$$D_v = \max(i) - \min(i) \text{ for } P_{i,j} = k \qquad D_h = \max(j) - \min(j) \text{ for } P_{i,j} = k$$
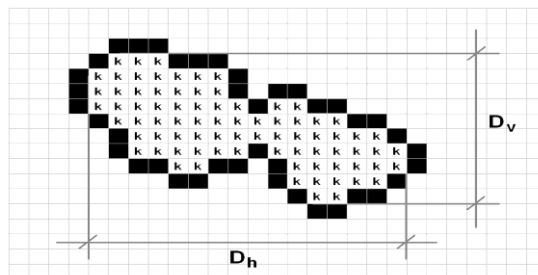

Fig. 5. An example of segment k Feret diameters
Rys. 5. Przykład średnic Fereta dla segmentu k

The centre of gravity describes the object location that is found by an object's moment of torpidity M_i, M_j for a surface $S(k)$: $M_i = \dfrac{1}{S(k)} \sum_k i_k$ $M_j = \dfrac{1}{S(k)} \sum_k j_k$

The projections lengths, are described by measures of the segment (I_z, I_p) for full size (the object's length and Feret diameter) in any defined length. (Fig. 6). The shape coefficients are defined by one of several methods described in details in the paper [22].
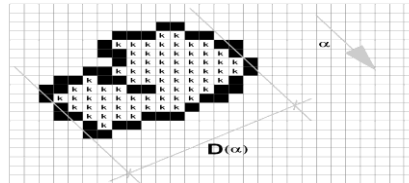

Fig. 6. The object projection length
Rys. 6. Miara kierunkowa obiektu

The object shape and content R_z of the image segment was defined as:

$$R_z = \frac{L^2}{4\pi S} \tag{9}$$

where: S - surface of the segment, L - the segment periphery.

Elongation of R_F the object: $R_F = \dfrac{D_h}{D_v}$, where: D_h, D_v - are the Feret vertical and horizontal diameters, respectively. The Smith's algorithm significantly simplifies the parameterisation process. It uses: surface, periphery, Feret diameters and gravity centres of the segment.

In the beginning small objects are erased from the image. Next the chosen threshold extracts bigger objects from the surface. Finally the extracted image (Fig. 7) can be under further analysis.

Fig. 7. The image after objects selection
Rys. 7. Obraz po selekcji obiektów

The classification procedures find the objects fulfilling the defined filters (threshold levels) of all the above characteristic measures (for example the threshold $S_p = 100$ pixels and shape coefficient $R_{z\_pr} = 15$). With white background of the image the applied method allows us avoiding this background coding, and consequently considerably reduces the memory size needed for saving the image data.

4. THE VEHICLE MOVEMENT TRJECTORIES

One of the most unique applications of video-detection is tracking of vehicles' movement. In case we want to recognise the expected, dangerous or forbidden manoeuvres of vehicles, on or between traffic lanes more data is needed than we can obtain from inductive loops.

Although the sampling interval need not to be bigger than the car is doing this manoeuvre, the controller needs a time for the data set analysis. The data sampling rate has to be adequate to a number of the traffic attendees, saturation of the traffic on the lane and the calculations complexity.

Syntactic

The syntactic primitives and the description language are used for the description and analysis of vehicles movement. The carried out works provided us with a method that allows tracking vehicles' trajectories and manoeuvres on and between traffic lanes in a short time [24, 25, 34]. Instead of using the pixels bitmap descriptors, the vehicle's route is divided into smaller, elementary units. They allow us to describe the vehicle's route in a satisfactory manner. The movement trajectories can be described by several elementary symbols, namely: straight lines and curves. When the vehicle is changing the traffic lane the movement can be assigned by two curves and one straight line in between; by three elementary symbols. This simplification will not be loosing the description quality, reducing remarkably a size of the video image file, although the data units are kept in readable and efficient form. In Figure 8 the trajectories primitives were introduced.
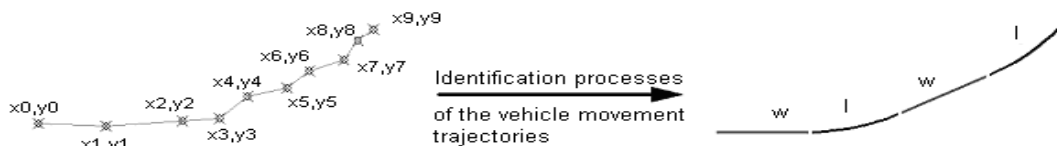

Fig. 8. The syntactic primitives description
Rys. 8. Opis elementów syntaktycznych

The traffic route recognition means identification of the vehicle's primitive descriptors that are used for the analysed objects assignment [23, 34]. The analysis concerns recognition of several description factors, present or not in the image description principles. On a left side of the figure some geometrical coordinates were indicated. On the right side, there is the assignment of the description language symbols. The analysis algorithm distinguishes main and not eligible movements, properly defined by traffic law of road incidents [22, 23].

In Figure 9 the illustration of geometrical description symbols has been introduced, as: driving ahead - „w", turning to the left - „l", turning to the right - „p" and reverse driving - „c". They are used for the movement trajectories assignment.
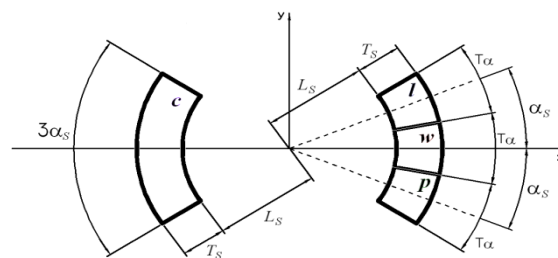

Fig. 9. The syntactic symbols geometrical description
Rys. 9. Opis geometryczny symboli syntaktycznych

In the description equivalences angle coordinates are used, like [24]:
- driving ahead: w (1.8, 0.4, 0, 0.16),
- turning left: l (1.8, 0.4, 0.16, 0.16),
- turning right: p (1.8, 0.4, –0.16, 0.16),
- reverse: c (1.8, 0.4, π, 0.16).

The trajectories description symbols are used as a pattern for comparison, when the shape vectors are close to any primitives of the language (Fig. 10) [24].
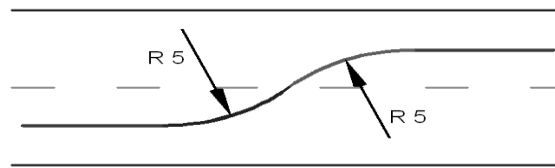
Fig. 10. The traffic lanes change manoeuvres; with radius R=5 m
Rys. 10. Manewr zmiany pasa ruchu; z promieniem R=5 m

In junctions of traffic lanes one can observe remarkable changes of vehicles speed and driving directions. Combining a data sampling rate with the vehicles' localisation we can find their speed and the driving history. On the base of analysis of these data samples the vehicles' dynamic characteristics can also be described. The vehicles' localisation checking, in the video sequence, indicates: acceleration, slowing down or braking of the vehicle. The movement trajectories analysis allows us to indicate all eligible and forbidden manoeuvres of vehicles.

5. THE TRAJECTORIES DESCRIPTION LANGUAGE

The discussed above primitives, of the traffic description, assign the descriptors alphabet of this specific language. The defined grammar allows us describing and modelling of the transportation network scene. The language, using the alphabet, defines every combination and subset of these symbols [25]. They produce words and sentences of the language. The undefined or unrecognised movement is not classified by the language formulas.

The vehicle's movement description and recognition mechanisms are encoded by the language grammar, with several combinations of elementary symbols. The definitions of the language grammar [34] are expressed by several relations of:

$$G = \left(\sum\nolimits_N, \sum\nolimits_T, P, S \right) \tag{10}$$

where: $\sum_N$ - defines a set of non-terminals, $\sum_T$ - set of terminals, P - is a finite set of rules or productions, S - is the starting symbol $S \in \sum_N$.

The set of terminals $\sum_T$ contains the defined {w, l, p, c} trajectories descriptors. The non-terminals $\sum_N$ consist of variables, used in words construction of the language body, and then the production set P is used for the words construction. The belonging rules P for the traffic lane changes allow us finding up to 16 words of these states description, using the alphabet $\sum$ (Fig 11).
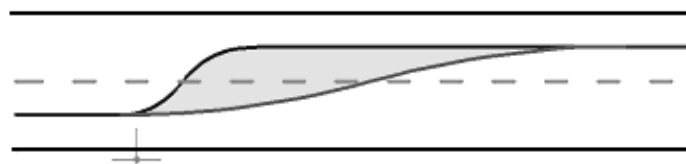

Fig. 11. The traffic lane change illustration
Rys. 11. Ilustracja manewru zmiany pasa ruchu

The grey area shows an example of an eligible change zone (surface) on the traffic lane: G_{change_left}. The grammar constructions for traffic lane change descriptors were defined similarly to the above manoeuvre of turning left. Additional movements symbols in the vehicles manoeuvres description language; for overtaking and turning of the vehicle, were also considered. Their grammar elements are used for the manoeuvres assignment; with trajectories defined in similar way.

Traffic states description

The presented work introduces the programming implementation of the automata, constructed as a parser [34], corresponding with the procedure of the syntactic assignment of traffic accidents in the transportation network. The parser constructions for identifying the network states can be expressed by the states:

$$P = (Q, \Sigma, \delta, q_0, F)$$

(11)

where: Q - finite, not empty set of states, Σ - finite inputs alphabet, δ - the transition function (for mapping), q_0 - starting delimiter, F - ending delimiter.

The defined parsers [35] of the road incidents identifiers concern manoeuvres: turning the vehicle, traffic lane change, overtaking and U-turn of vehicle. The parser construction for a turn left manoeuvres is assigned by the expressions:

$$P_{turn\_left} = (Q, \Sigma, \delta, q_0, F)_{turn\_left}$$

(12)

where: Q - { q0, q1, q2, q3, q4, q5, q6, q7, q8}, Σ - { w, 1 }, δ - is defined by graph 1 (fig.7), q_0 - {q0}, F - {q9}.

6. CONCLUSIONS

Today's attention given to the video-cameras on the roads comes from very useful data available for various analyses and fashionable technique. They provide the traffic control with unique data; not only a number of passing vehicles but their dimensions, speed, classes, etc. It is more than it is available from traditional measurement technologies; using inductive loops or photo radars. The elaborated, algorithm allows us not only to detect the passing vehicles. The method identifies the vehicles' movement trajectories with many traffic incidents or accidents, visible in a camera.

The steps of the development works were verified continuously in time of EC project development, carried on for ZIR-SSR Bytom by the research team in Informatics Systems Department of Transport, at Faculty of Transport, in years 2006 – 2008 [16, 17, 31, 32]. The video detector card – the final product, presented in Fig. 1.

**Vehicle Detection Algorithm
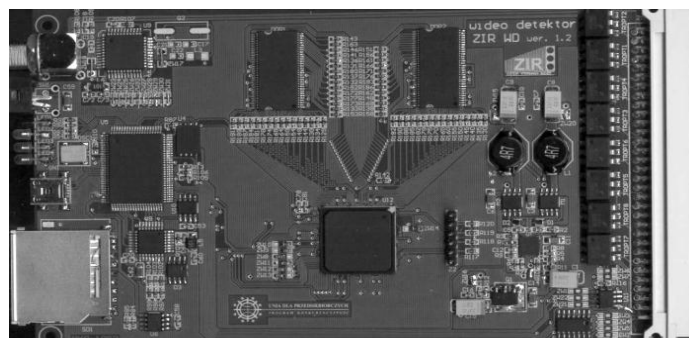for FPGA Based Implementation**

ZIR-WD video detector

Fig. 12. The video detector implementation
Rys. 12. Realizacja detektora wideo

Majority of recently developed fast real time controlling machines, apply gate-level technologies (PLA, FPGA, GAL, etc.) [14, 15, 18].

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