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ARTIFICIAL INTELLIGENCE USING FOR CONTROL AND OPTIMISATION VEHICLE MOTION

This paper describes method and possibility of utilization artificial intelligence method for group of vehicle traffic control in dynamical changeable environment with possibility of path optimization. As a example was described possibility utilization of genetic algorithm connected to simulation computer program as tools for generation and motion optimization.

WYKORZYSTANIE METOD SZTUCZNEJ INTELIGENCJI DO STEROWANIA I OPTYMALIZACJI RUCHU POJAZDÓW

W artykule opisano sposób i możliwości wykorzystania metod sztucznej inteligencji do sterowania ruchem grupy pojazdów w środowisku z dynamicznie zmieniającą się konfiguracją przeszkód oraz możliwości optymalizacji drogi. Opisano również przykład wykorzystania algorytmu ewolucyjnego połączonego z programem symulacyjnym jako narzędzia do generowania i optymalizacji drogi.

1. INTRODUCTION

Complexity of transport system forces necessity of working out method of their control and optimization. Today the method of vehicle control in order to path optimization, enforce not only necessity of high reliability of system work as well as requirement of the work in reality time in dynamically changing environment. In this paper I present method for group of vehicle traffic control and its aim is to reach determined goals in itineraries through the shortest way with possibility bypassed the barrier. Elaborated system of vehicle control on the space which is limited through field of camera's work, was verified through written computer program which is simulating his work.

The assumption of discussed control system is possibility of controlling group vehicle in reality time with possibility of motions optimization without necessity of permanent vehicle control over superior agreement by retain low cost of control agreement. A great stress was laid on using advantages of central as well as non central control during working out the system. Structure of this system is built so that in normal work time (when vehicle no meet a barrier), behaves like an autonomous unit. But in the case when the vehicle meet a barrier with complex configuration, it sends information about his position and coordinates of the goal to superior unit. Superior unit which is equipped with module of artificial intelligence

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receives picture of working space from set of cameras and on this basis it works out a trajectory for this vehicle [1].

This trajectory is sent to control agreement as the data vector form, which describes elementary dynamical vehicle motion. This solution permits to minimize way and realizes transport task.

This system was worked out to realize task of vehicle group control, on the factory hall which have complex structure, for example: autonomic vehicle AGV [1,2,4,5]. Theoretical assumption of this system no limited its practical application only to this implementation.

This kind of vehicles control maybe use everywhere, where we have possibility obtain model of the vehicle working space or set's cameras or worked out numerical model.

Study of this system was not the only goal of conducted research. The realized problem would have served also to verification of earlier worked out method of artificial intelligence which depend on coupling of evolutionary algorithm and artificial intelligence networks [1]. This method permit to connect action speed of artificial neural networks for classification task and high efficient of evolutionary algorithm in case of work out a new solutions. Also, the evolutionary algorithm was considerably modernized and contain simulation within. This simulation's solution are enabled to evaluate individuals population activity and choice the best solution [3]. The control system was worked out in order to search the shortest way to goal. This search does not depend on scanning very big data base, but depends on two – phases action depended on kind of problem that it meets. When the barrier configuration is known, system fast adapts solution through usage the neural network. In the opposite situation the system sends picture of the problem to evolutionary algorithm. This algorithm bases on the simulation and generates new solution. This solution is sent to vehicle control arrangement increase the same number of solution contain in artificial neural network. For sending this simple information would be sufficient to use protocol TCPiP or similar, because requirements of vehicle's communications with artificial intelligence module is minimal. This control system have a few new advantages. The most important is speed of generation the solution apart from if the configuration of the barrier is known and it is enough to adapt existing solution or dynamically changing environment forces on control system necessity way to generate for new barrier. Moreover, algorithm optimizes the way optimize in the short time with high efficiency. The scheme of work system is showed on picture 1.

In this applied, evolutionary algorithm is established that the goal function is arriving by vehicle to fixed place on the shortest way with possibility to bypass barrier. For the solution of described problem was used evolutionary algorithm with modify action. This modification is concerned both whole computation and details used for operator computation. The general scheme of working evolutionary system is showed on the picture 2. the assumption was that the number of generation is fixed rigid and it is fifteen whereas number of individuals in each generation is ten. Simulation is carrying out for each individual with maximally two hundred steps (step in this layer is elementary vehicle motion on early generating direction). Values of genes in initial population is determined on de randomize way on interval from 0 to 10. the possibility was introduced to receive gene's values from the best of previous generation and possibility manual write gene's values by the user. The selection is proportional to evaluation received from previous generation and crossing is one-pointed. The mutation have an evenly distribution and its action may caused replacement existed gene's value by randomize value or through complement generating.

Additionally, it is possible to introduce values which values of mutation ratio will be systematically increased. Within a framework of conducted work was investigated influence of action modifications mentioned above and it was chosen this values of ratios which system prove highest efficiency for. These parameters are showed on chart 1.

Additional stage was introduced to evolutionary algorithm, which is described as a life of population. At this stage of conducted simulation of vehicles motion on the workspace with a barrier. These individuals, which during the simulation reach fixed goals through the shortest way, will obtain automatically high evaluation and will have a chance to transition to next generation. Each individual is defined as set gene's values and described as chromosome. Each gene is understood as a certain method of individual's behavior on the different situations.

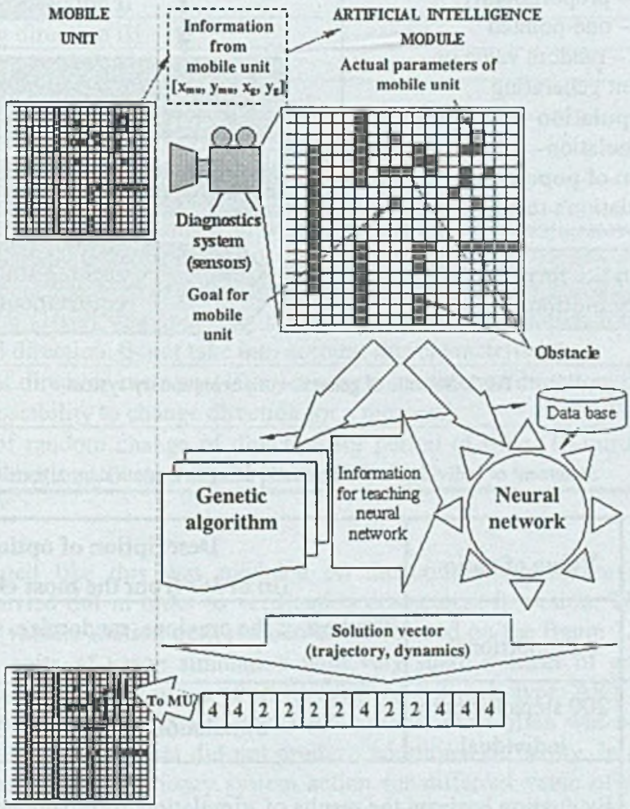

Fig.1. Scheme of work control system

On the table 2 is statement of individual's characteristic using in evolutionary algorithm.

Individual gene can receive values: 0,1,2,...10 that will correspond to degree of participation given characteristic in individual. Additionally, to different characteristics we can ascribe individual weights which gives possibility to diversify their sense. Particular characteristics which are illustrated in table 2 have influence on the whole behavior of individual and their sense have nature of probability of using specify characteristic.

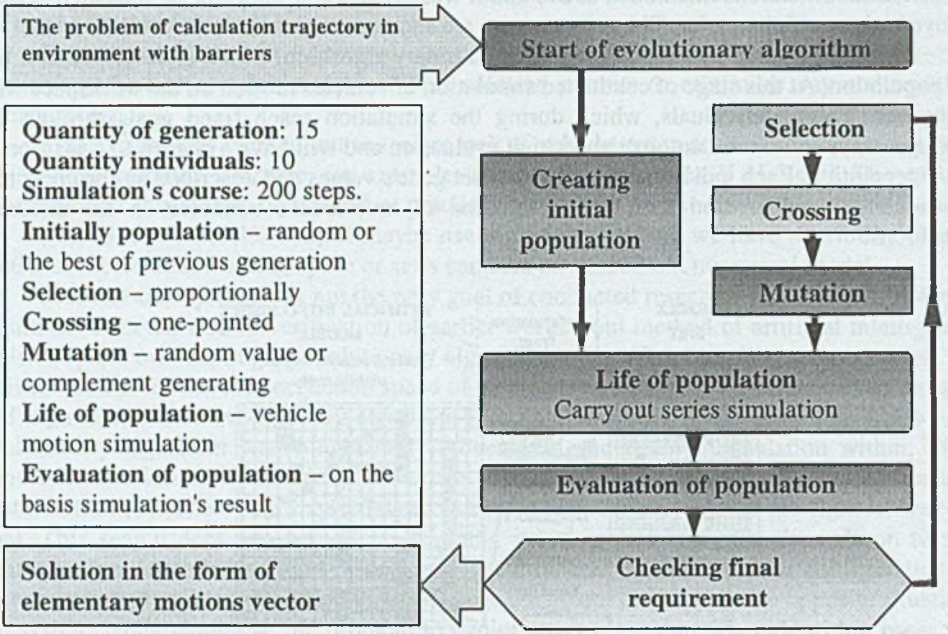

Fig.2. Scheme of general work evolutionary system

Table 1

Statement of individual's characteristic using in evolutionary algorithm

Operator	Value of ratio	Description of options (in order from the most efficiency)
Initial population	Proportional	The best of the previous, randomize, standard value, user arrangement
Life of population	200 steps for each individual	Simulation with oscillation erase
Evaluation of population	Evaluation basis on the results of simulation as remainder between maximum way length (200) and receive results (i.e. 135 elementary steps : 200 –135=65	
Selection	The higher evaluation of individual, the larger survive probability	
Crossing	0.2	One-pointed
Mutation	0.05	Additional ratio of increment "pm+" in value 0.005, creating complement of value, randomize value choice for selected gene.

Table 2

Statement of individual's characteristic using in evolutionary algorithm

Gene	Description of encode characteristic	Weight
1	Direction force in the side of the goal (0-absence of characteristic, 10-direction this forced , 1÷9 permit to frequent change direction i.e. in order to bypass frontal barrier)	6
2	Forcing direction I	2
3	Forcing direction II	2
4	Forcing direction III	2
5	Forcing direction IV	2
6	Reflection from barrier to direction I	3
7	Reflection from barrier to direction II	3
8	Reflection from barrier to direction III	3
9	Reflection from barrier to direction IV	3
10	Ratio of avoiding of paths with width 1 (0-ratio is not essential now, 10-individual do not entry path with width 1)	5
11	Ratio depended on distance from the goal and motion force to his direction (10- if you area long distance from the goal motion force to parallel direction, 0- not take into account this characteristic)	4
12	Ratio of direction memory (10-try move on in the same direction, 0-you have possibility to change direction for a moment)	6
13	Ratio of random change of direction for period of time (10-introduce chaotic motions, 0- methodical proceed)	3

System designed like this was modeled on the computer program and series of simulations were carried out in order to verification correctness its action. The example of modeled and tested vehicle motion between barriers is showed on the figure 3. On this basis we can say that in spite of usage simulation with very small number of generations and individuals for this algorithm and usage of artificial neural network, type: ART B, this system ordered high efficiency of action [5,6]. Generated solutions most often was near to optimal solution, and control of vehicles set did not produce additional difficulty. In order to make possibility of comparing the efficiency system action for different value of parameters we introduced a few indicators which permitted us to estimate efficiency of system action.

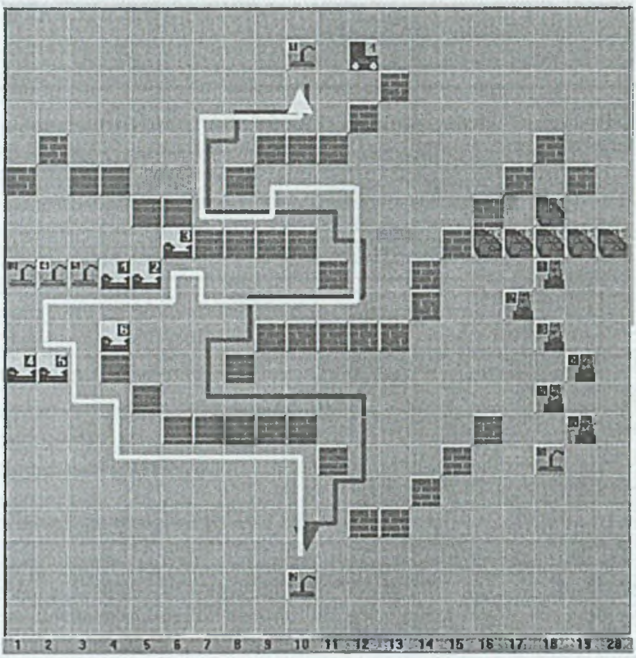

Fig.3. Example of model and testing vehicle motion between barriers

One of basic indicator is efficiency of module artificial intelligence action, which is composed of two components. Firs component is E_1, which concerns relationship between length of minimal way and length of way which was generated through module artificial intelligence according formula 1.

$$E_1 = \frac{D_{min}}{D_{gen}} \tag{1}$$

where: D_{min}- length of minimally way,

D_{gen}- length of way which was generated through artificial intelligence module.

Second component E_2, defines relationship between time which is needed to motion the vehicle on generated way and time of generating this way.

$$E_2 = \frac{t_{mot}}{t_{gen}} \tag{2}$$

$$E'_2 = \frac{t_{mot}}{t'_{gen}} \tag{3}$$

where: t_{mot}- time whichis needed to motion vehicle on generated way,

t'_{gen}- time which is needed to generate way for the first time,

t_{gen}- time which is needed to generate way in the following cases.

Time of generating the way in case when artificial intelligence module generates solution for specific problem for the first time, it must use evolutionary algorithm. Work time which is needed to generate solutions in the first time is longer than work time needed to generate way in the following cases, because for the first time system uses genetic algorithm to generate solution and for the second time (fixed process) system using an artificial neural network. Therefore final efficiency was defined by two parameters: efficiency in the case of fixed process η and efficiency connected to generating solution for the first time η', and this is described in formulas 4 and 5.

$$\eta = E_1 \cdot E_2 \cdot 100\% \tag{4}$$

$$\eta' = E_1 \cdot E'_2 \cdot 100\% \tag{5}$$

For considered example parameters were determined with permit to assign efficiency of artificial intelligence module. These components were contained in table 3. We estimated that time indispensable to generate the way through artificial intelligence module without visualization is seven-times shorter than with simultaneous visualization.

Table 3

Parameters permit to assign efficiency of module artificial intelligence

W_s	B	D_{min} []	D_{gen} []	t_{mot} [s]	t_{gen*} [s]	t_{gen} [s] /7	t'_{gen} [s]	E_1	E_2	E'_2	η [%]	η' [%]	Direction
7x8	15	23	5+20	0.89	8	1.14	0.94	**0.92**	**0.78**	**0.95**	**71.7**	**87.4**	→
		23	9+53	2.21	17	2.43	2.26	**0.37**	**0.91**	**0.98**	**33.6**	**36.2**	←

where:

W_s- size of the barrier as higher dimension of contour rectangle,

B - absolute dimension between the goals.

We proved during research that effective of action vehicle control system was formed 62% to 94%. Effectiveness was changed and it depends on usage of option of module artificial intelligence. This permit us to determine parameters values which gave the most effective artificial intelligence module – table 4.

Worked out and simulated control system showed high effectiveness and reliability of action in spite of very small number generations and individuals. This system is characterized also by simplicity of action and low cost of control agreement vehicle, assisted by only one artificial intelligence module, which maybe computer PC. Its theoretical assumption does not introduce limit of the number controlled vehicle and the size of works space. The main disadvantages are possibility of controlling of vehicle which can be found in camera's works space or space earlier defined. The great inconvenience of system is necessity of direction and works space digitizing.

Table 4

Options and parameters of evolutionary algorithm values, for which system were the most efficient

Operator	Ratio value	Option, which gave the most effective artificial intelligence module
Initially population	Proportionally	Randomized generation value with possibility of usage the best of preview generation value
Selection	Proportional to individual evaluation	-
Crossing	p_c=0.2	One-pointed
Mutation	p_m=0.05 p_{m+}=0.005	Creation complement value of gene with additional option increment of value mutation ratio p_m
Life of population	200 steps for every individuals	Simulation with oscillation erase
Evaluation of population	maximal way – way of individual	Evaluation of individuals and evaluation matching whole of population

On the further works, the evolutionary algorithm should be modified so as to make more possible generation paths with more number of steps, population and individuals. Besides, the algorithms may contain more method of path generating i.e. Dijkstra's algorithm and choose the best of generating solutions.

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Reviewer: Prof. Romuald Szopa