```
    sns.pairplot(data=train,
                 y_vars='Survived',
                 x_vars=top_features[index: index + plots_in_row],
                 kind="reg",
                 height = 3.2)
plt.show()
```

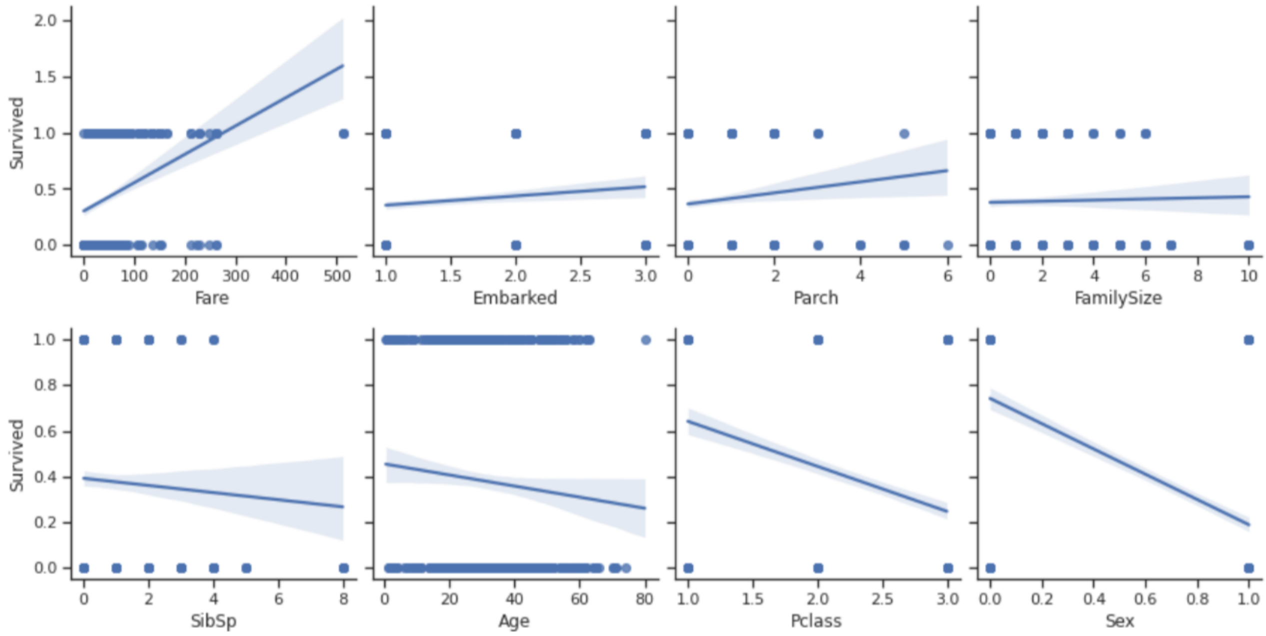

Рисунок 2. Графік співвідношень ознак з ознакою 'survived'

Висновок. За допомогою бібліотеки matplotlib на мові програмування python можна побудувати векторні графіки, діаграми та багато іншого. Бібліотека підтримується та оновлюється, а її використання є безкоштовним.

Список літературних джерел:

1. *Сайт бібліотеки Matplotlib – [Електронний ресурс]. Режим доступу: https://matplotlib.org/*
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3. *Сайт бібліотеки Seaborn– [Електронний ресурс]. Режим доступу: https://seaborn.pydata.org/*

УДК 004.942+656.052.1

Nikolyuk P.K., professor of information technology department of Vasil Stus Donetsk National department
Olena-Maria Pryamukhina, student
Artem Perepelytsia, student

NAVIGATION ALGORITHM FOR OPTIMAL CHOICE OF THE VEHICLE CITY ROUTE

Vasil Stus' Donetsk National University (Ukraine)

The study focuses on solving actual global problem, namely the problem of congestion in large cities. Therefore, the object of our work is the transport networks of megacities. The problem to be solved – the subject of the study – is congestion on urban transport networks. Creating an algorithm for optimal routes navigating for each vehicle involved in traffic is the main goal of the work. Research methods: i). methods of modeling complex systems theory; ii) methods of graph theory; iii). java programming technologies; iv). optimization methods; v). A-star algorithm.

Knowledge of city streets congestion level is a starting point in solving the problem of traffic regulation. If have place redirection vehicles from the central congested streets on uninhabited ones the traffic will go to a state that will approach equilibrium.

The aim of the study is to create basic elements of technology that can stabilize urban traffic and bring it to a qualitatively new state. To achieve the stated goal, the following tasks were set:

– to create a model of a city transport network in the form of an oriented weighted non-planar multigraph with dynamically loaded arcs;

– activate an electronic map of city in the TMC and with the help of this map to accompany each vehicle;

– to navigate the optimal routes for all those vehicles that ordered such routes;

Full program code of our investigation is available on a GitHub service at the link [1]. The fundamental question is to navigate an optimal (as to minimum time) route for each vehicle. To do this, it is need to introduce the basic concepts, which are formulated as follows.

Definition 1. Resistance $R_j(h,t)$ *of any intersection* j *from the side of the lane h at time* t *is essentially a virtual path that car would travel at an average speed* V_{ij} *during the time it was delayed at the intersection . Such resistance of the intersection is defined as*

$$R_j(h,t) = S_j(h,t) \cdot V_{ij} \cdot T_j, \tag{1}$$

where V_{ij} – the average speed of vehicles flow on a road directed from the intersection i to intersection j (further it will be mark as $i \to j$); $T_j = t_j^{red}(h) + t_j^{green}(h)$ – duration of traffic light switching cycle at the intersection j; $S_j(h,t)$ – the value specified as follows

$$S_j(h,t)=\begin{cases}\delta \\ t_j(h)/T_j+\delta \\ t_j^{red}(h)/T_j+C_j(h)+\delta \\ t_j^{green}(h)/T_j+C_j(h)+\delta\end{cases},$$

(2)

where value $\delta << 1$ corresponds to the ratio = time of travel by vehicle at intersection / duration of a switching cycle of traffic lights T_j; that is, in the case of the first term, vehicle crosses the intersection without delay; value in the second term is obtained when the vehicle approaches the intersection at a time of red light, delayed for a while $t_j(h) \le t_j^{red}(h)$ and passes this intersection immediately after the inclusion of the green phase; the value $t_j^{red}(h)/T_j + C_j(h)$ in the third term consists of a fraction $t_j^{red}(h)/T_j$ plus the number of traffic light switching cycles ($C_j(h) \ge 1$), during which the car is delayed at an intersection; $t_j^{green}(h)/T_j + C_j(h)$ – the part of the fourth term value consisting of a fraction T_j in sum with an integer number of traffic light switching cycles ($C_j(h)$).

Delay time of car at an intersection

$$t_j^{delay}(h)=\begin{cases}\delta\cdot T_j \\ t_j(h)+\delta\cdot T_j \\ t_j^{red}(h)+C_j(h)\cdot T_j+\delta\cdot T_j \\ t_j^{green}(h)+C_j(h)\cdot T_j+\delta\cdot T_j\end{cases} \quad (3)$$

The weight $W(n_{ij})$ of each arc of the graph is a sum of the resistance $R_j(h,t)$ of an intersection j on the side of the lane h and the own length L_{ij} of the lane, i.e.

$$W^h(n_{ij}) = S_j(h,t)V_{ij}T_j + L_{ij}. \quad (4)$$

Here n_{ij} means the lane directed from the intersection i to the intersection j; the symbol n indicates name of lanes (a, b, c, d, …).

The strategic task set in this paper is as follows

$$\sum_{h=1}^{I}(S_j(h,t)\cdot V_{ij}\cdot T_j(h)+L_{ij})\rightarrow \min .$$

(5)

Here I is the set of all city intersections. Expression (5) consists of variable (first term) and constant components (second term). The variable component is a function of time because a traffic in city is a highly dynamic entity.

Expression (5) can be represented as a record

$$\sum_h W^h(n_{ij}) \to \min, \qquad (6)$$

which is an objective function of the problem: the total weight of all consecutively located along the route lanes should be minimal. The minimization of function (6) is performed by an A-star algorithm, the main code of which for the graph [2].

Definition 2. The weight of a route (6) is a minimum virtual path traveled by the vehicle from the starting position to the final one. The passage of such route takes a minimum of time (taking into account the same average speed V_{ij} $(i, j \in A)$ car movement in the city).

Expression (6) is equivalent to the following

$$t^{trip} = \sum_{j=1}^{I} (t_j^{delay} + L_{ij} / V_{ij}) \to \min, \qquad (7)$$

where t^{trip} – travel time of vehicle from its starting position to the destination one.

Definition 3. Equivalence of expressions (6) and (7) gives grounds to talk about the optimization of vehicle travel on selected route just in time. Accordingly, the total time spent by all vehicless involved in traffic will also be optimal (minimal).

Thus, the algorithm proposed in the study minimizes an actual travel time of the vehicle on the selected route.

1. A multigraph model that reproduces the transport network of a city district, simulates all an actual existing lanes. Each arc of the graph receives a weight that changes synchronously according to changes in traffic.

2. The study developed a working software module [1] that navigates an optimal time routes in graph, and hence in the real transport network. The investigation uses a heuristic A-star algorithm – a powerful computational method of graph theory. This makes it possible to synchronize vehicles flows and therefore urban traffic takes a qualitatively new level.

VI. LIST OF REFERENCES

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2. Sewall, J., van den Berg, J., Lin, M. C., & Manocha, D. (2011). Virtualized Traffic: Reconstructing Traffic Flows from Discrete Spatiotemporal Data. IEEE Transactions on Visualization and Computer Graphics, 17(1), 26-37. https://doi.org/10.1109/tvcg.2010.27

УДК 004.9

Пархоменко В.В., студент 2 курсу спеціальності 122 «Комп'ютерні науки»
Потапова Н. А., к.е.н., доцент,