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Xuan-Hien NGUYEN[1], Hai-Quan VU[2], Dac-Phong TRINH[3]

SOFTWARE DEVELOPMENT FOR SELECTING AN INSTALLATION OPTION OF PHOTO-VIDEO FIXATION FOR TRAFFIC VIOLATIONS

Summary. The article discusses the software proposed by the authors for selecting the optimal option for installing a photo-video fixation system of traffic violations. The software uses the Microsoft Visual FoxPro 9.0 programming language, which is simple, easy to use and provides an overview of the technical solution in the application of the ITS system.
Keywords: photo-video fixation system, traffic violations, software, ITS, road safety

1. INTRODUCTION

Along with the issue of traffic management, the issue of road safety in Vietnam is very important at the moment. In Vietnam, about 8,000 people die in road accidents every year (Fig. 1) [1, 2, 4]. The number of people who receive serious injuries is 3 times higher. And after the Covid-19 pandemic, this number tends to increase.

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[1]Faculty of Automobile Technology, Hanoi University of Industry (HaUI), 298 Cau Dien street, Hanoi, Vietnam. Email: hien.nguyen15@haui.edu.vn. ORCID: https://orcid.org/0000-0002-1552-1867
[2]Faculty of Automobile Technology, Hanoi University of Industry (HaUI), 298 Cau Dien street, Hanoi, Vietnam. Email: quanvh@haui.edu.vn. ORCID: https://orcid.org/0000-0002-9560-8662
[3]Faculty of Automobile Technology, Hanoi University of Industry (HaUI), 298 Cau Dien street, Hanoi, Vietnam. Email: phongtd@haui.edu.vn. ORCID: https://orcid.org/0000-0003-1413-9575

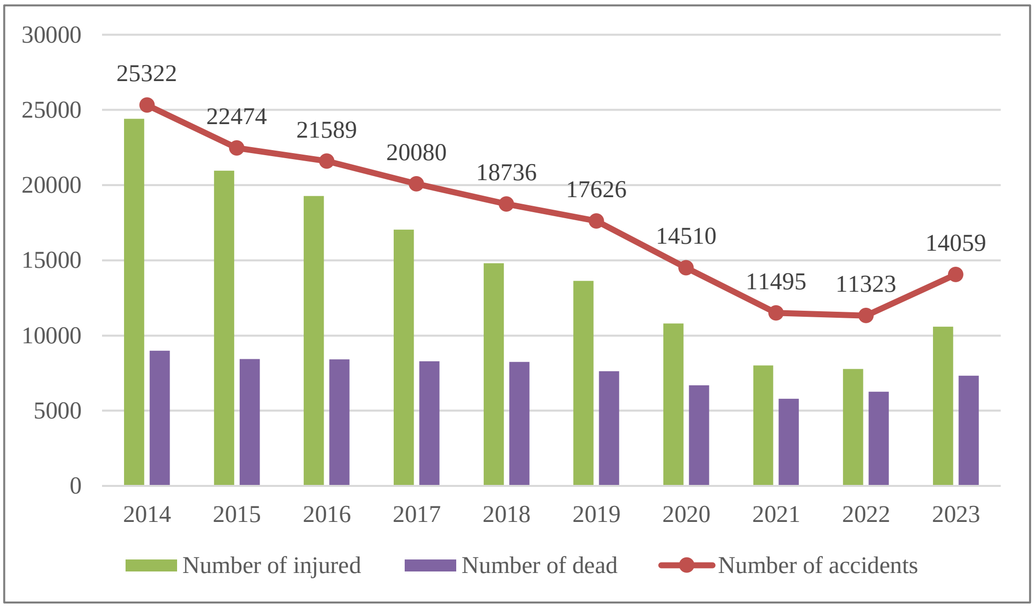

Fig. 1. Traffic accident statistics in Vietnam

In addition, as the cultural, economic, and political center of Vietnam, Hanoi is also one of the cities with a high rate of traffic accidents [1, 3, 4, 6]. Statistics show that the number of traffic accidents and fatalities tends to decrease across all three criteria; however, the numbers remain high (Fig. 2). This decline is inconsistent, with a significant surge in accidents, fatalities, and injuries in 2023. Observations reveal that during peak hours on major inner-city routes and other high-traffic areas, collisions frequently occur due to the increase in vehicle volume; construction projects obstruct traffic, creating potential for localized congestion. Additionally, some residents and transport companies lack compliance with traffic laws and safety regulations, including violations like driving under the influence, entering restricted roads, traveling in the wrong direction, and neglecting to wear helmets when riding motorbikes, scooters, or e-bikes. This indicates that traffic safety in Hanoi remains a pressing concern.

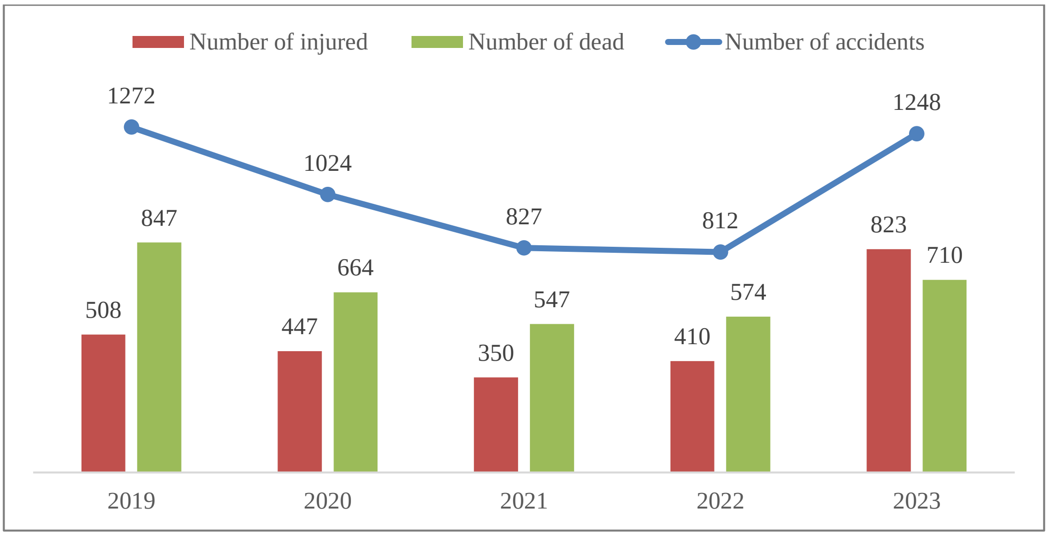

Fig. 2. Traffic accident statistics in Hanoi

One of the measures currently being implemented by Hanoi to solve this issue is the installation of a network of traffic violation monitoring cameras on several main city roads [4, 5]. Hanoi operates 600 cameras connected to 60 screens installed at the Traffic Management Center to monitor the city's transport network [1, 3]. However, the photo-video fixation (PVF) system for traffic violations in Hanoi has not yet achieved maximum efficiency in identifying and penalizing offenders for several reasons: a lack of uniform technical standards for the installation and management of the PVF system, uncoordinated camera operations, and a primary focus on monitoring traffic flow, among others [5, 6].

To improve the efficiency of the existing traffic management equipment, the city should more actively implement scientific, technical, and technological solutions for the installation and operation of the PVF system. The software used to determine optimal camera placement should feature a user-friendly interface, be based on real data about the road network and camera specifications, consider installation costs, and offer the best options for camera placement on transport facilities.

2. THE BASIS FOR SOFTWARE DEVELOPMENT

According to the algorithm shown in Fig. 3, a mathematical model was developed to determine the optimal placement of the PVF system [7, 8]. The model calculates the number of issues in the study area before and after installing the PVF system, enabling an evaluation of installation efficiency, as well as the calculation of the necessary installation costs. The optimal installation option is the one with the highest efficiency [9].

Some requirements and limitations of the software during its development and deployment are as follows:

- Computer requirements: The software is developed for the Windows operating environment (compatible with operating systems starting from Windows XP) and is written in the Microsoft Visual FoxPro 9.0 programming language [10]. The minimum technical requirements for the computer include a Pentium processor, 32 MB of RAM, and 10 MB of free hard drive space. The screen resolution must be at least 1200x800.
- Limitations of the test version of the software: Since the functions of the test version must align with the previously developed mathematical model, the following conditions were adopted: 11 factors (typical traffic violations) were selected (For example: speeding, running red lights/stop signs, going in the wrong lane, driving under the influence, failing to yield, etc.); For each point under study, the parameter weights are fixed; The number of PVF devices and their variations should not exceed 9.

The software (Fig. 4) is based on the values of traffic safety and traffic control parameters selected for analysis, including violations affecting traffic safety and control. It also takes into account the relationship between these parameters at fixed points within the accident hotspot study. Additionally, weighting factors that represent the impact of the PVF system on these parameters are used to calculate specific indicators for each point under study, both before and after the system’s installation.

The output data is presented in a table, sorted in descending order based on the efficiency indicators of the corresponding PVF system installations. Using the data from this table, the installation costs of the PVF system can be calculated.

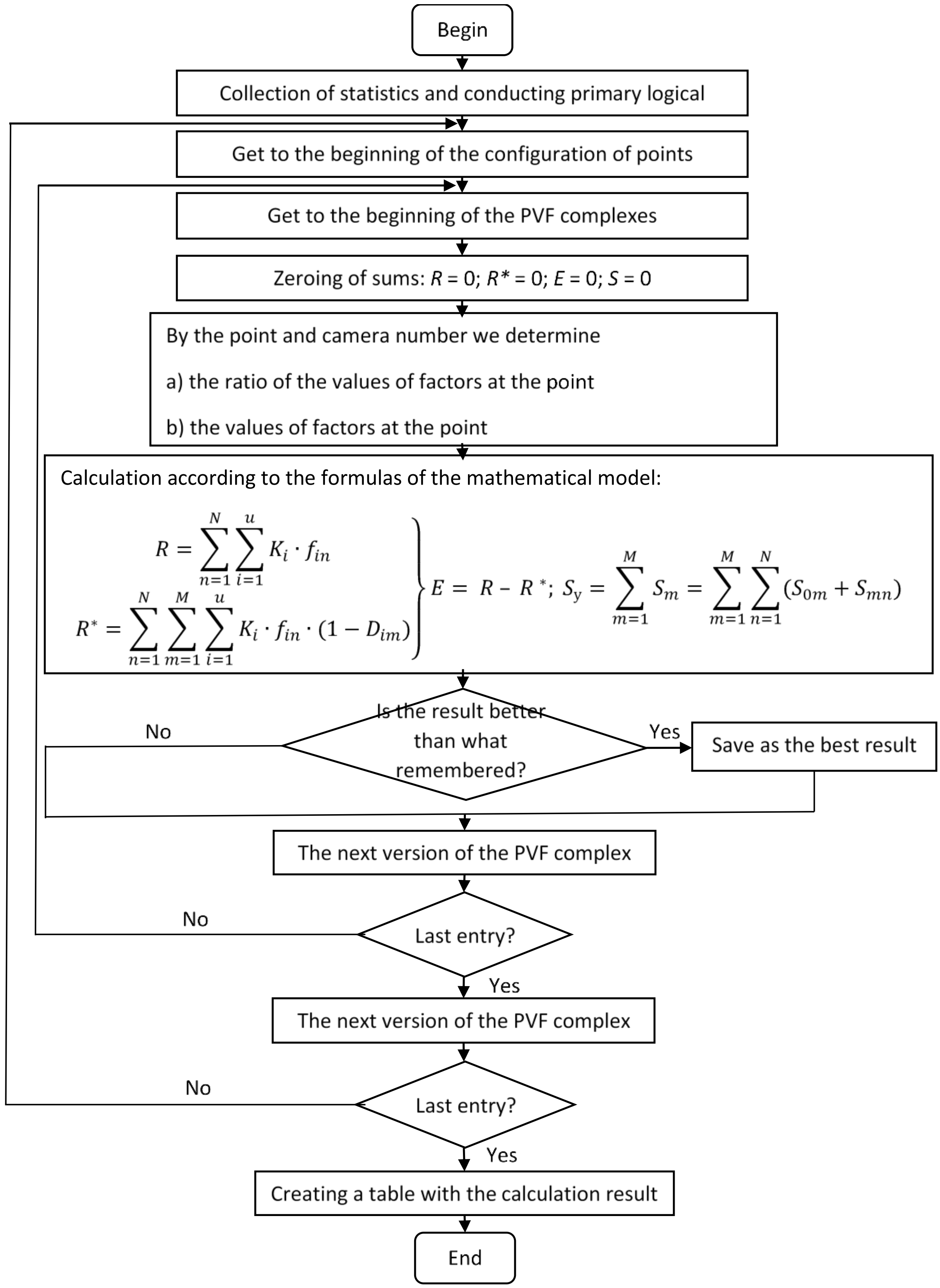

Fig. 3. Algorithm for determining the optimal solution using software based on the formulas from the mathematical model.

Where:

R – the total weighted value of the analyzed intersections before the installation of the PVF system;

K_i – weighted value of the i^{th} factor at one intersection;

f_{in} – number of i^{th} violation at the n^{th} intersection;

N – the total number of accident clusters;

n – the accident cluster, $n = 1,\dots,N$;

u – the number of traffic violations;

i – traffic violation, $i = 1,\dots,u$;

R^* – the total weighted value of the analyzed intersections after the installation of the PVF system;

m – PVF device;

D_{im} – weighted influence of the m^{th} device on the i^{th} factor;

E – the efficiency of the installed PVF system;

S_y – the cost of installing the PVF complex at an intersection:

$$S_y = \sum_{m=1}^{M} S_m \leq S \quad (1)$$

S_m – the cost of installing the m^{th} complex PVF at the n^{th} intersection;

S_{0m} – the cost of the m^{th} complex PVF;

S_{nm} – the cost of communication of the m^{th}-complex of the PVF at the n^{th}- intersection;

M – the number of PVF complexes;

S – the investment amount of the region (city, district) for the implementation of the PVF system in total.

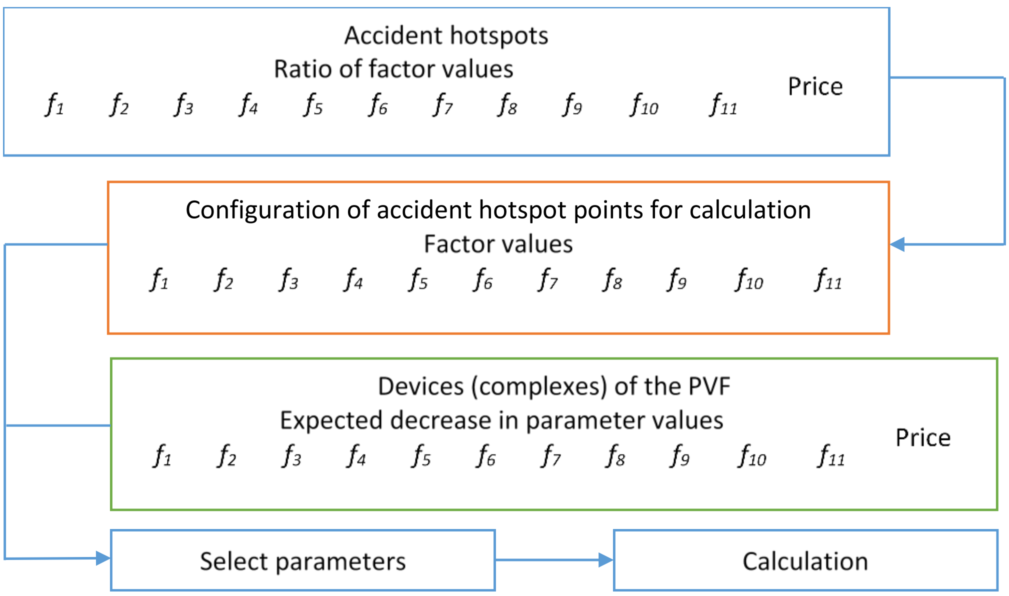

Fig. 4. Software architecture diagram

3. SOFTWARE ARCHITECTURE

All the main actions in the program are accessible via on-screen buttons (Fig. 5).

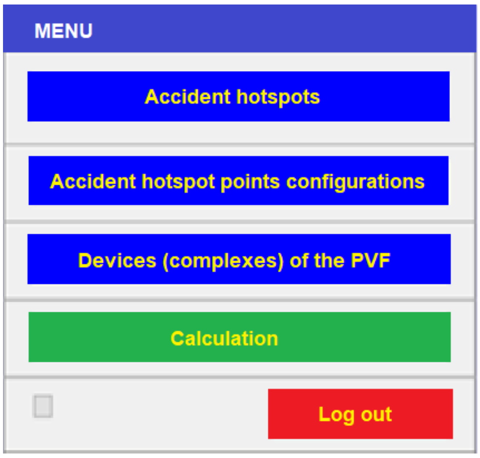

Fig. 5. Main program menu

Button operations are performed using a computer mouse (or similar input devices). Information is edited through on-screen input forms. From the main program menu, users can navigate to the following sections for managing the program's initial data:

- **List of accident hotspots/traffic violations**: This section contains points where traffic violations or road traffic accidents frequently occur in the study area. It also includes weighting factors for traffic violations and accidents at each location (the weighting factors are determined through expert assessment method), as well as the costs of installing equipment in these areas to ensure the efficient operation of the PVF system. The information in this section can be edited and updated as needed.
- **List of accident hotspot point configurations**: This section provides a list of the points under study for calculations. These points are selected from the "List of accident hotspots/traffic violations" folder and can be edited, updated with new names, or modified with additional characteristics of the locations under study.
- **List of PVF devices (complexes)**: This section shows the interface for the PVF system, including violations, the weighting factors of the camera system - obtained from the expert assessment method, depending on the characteristics of each type of camera; their impact on the number of violations, and the costs of installing and maintaining equipment at each control site.
- **Selection of calculation parameters**: Based on the selected data, the software will perform the calculation and display a list, sorted in descending order, of the efficiency of camera installations before and after implementation. The results include a list of optimal camera installation locations, the type and number of cameras needed, and the efficiency and total costs of installation. For each installation option, the software will display the "before" and "after" values, indicating the efficiency gained and the cost of installing monitoring equipment.

After completing the calculations, the program provides an option on the main screen to save the results in three corresponding files (Fig. 6): a file with the calculation table, a file listing the devices with numbering for input into the calculation table, and a file of the surveyed locations with numbering for input into the calculation table.

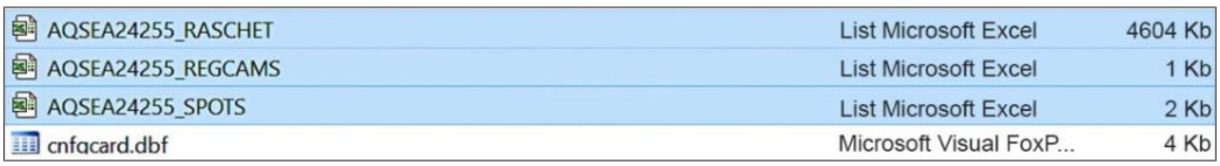

Fig. 6. The calculation results files of the software

The software is designed to analyze real data on traffic activity, violations in specific traffic sections, and the characteristics of the PVF system to determine the optimal camera installation plan (camera type, location, quantity). The goal is to achieve the highest efficiency within a limited equipment budget.

4. APPLICATION OF THE STUDY

The software was developed based on a mathematical model, which was studied and built using a database collected from Hanoi, Vietnam. The study area includes 20 points where traffic violations and accidents frequently occur (Fig. 7). Of these 20 points, 10 are already equipped with the PVF system, allowing for an analysis of its current efficiency, while the other 10 points are not yet equipped with PVF systems.

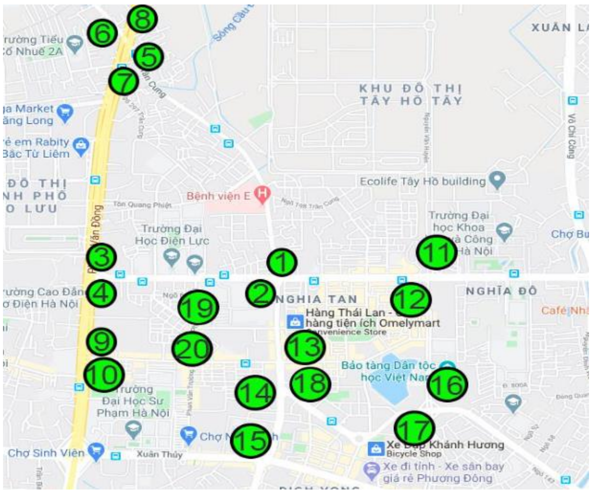

Fig. 7. Selected locations for analysis

The authors used data on 5 different PVF camera systems for traffic violations, including: Dahua (camera No. 1), Hikvision (camera No. 2), Osamic 2400 (camera No. 3), Vantech (camera No. 4), and Wisenet SNP (camera No. 5).

After gathering data on the studied points and camera types, the information was entered into the software. When running the calculation function, the program generated the results presented in Tab. 1. As shown, with 20 points and 5 camera complexes, 15504 installation options were obtained (Fig. 8). Using the program’s optimal result sorting function, the best installation option is listed first in the calculation results.

Based on the sorting of the efficiency and reduced efficiency columns, the optimal solution for installing the PVF system was identified. For instance, with a regional budget of 3 billion Vietnam Dong, reduced efficiency of 0,374297, and an installation cost of 2558 million Vietnam Dong, the following camera placements are recommended: Camera No. 4 (Vantech) at Point 3, Camera No. 1 (Dahua) at Point 4, Camera No. 2 (Hikvision) at Point 9, Camera No. 5 (Wisenet SNP) at Point 17, and Camera No. 3 (Osamic 2400) at Point 18.

Tab. 1

Software calculation results

No. of installation options	No. of point					No. of PVF complex					*R*	*R**	*E*	*S*	*E/S*	*S/E*
1	3	4	9	17	18	4	1	2	5	3	4692.741	3735.290	957.450	2558	0.374297	2.671678
2	2	3	4	9	18	4	5	1	2	3	4680.733	3726.129	954.603	2585	0.369286	2.707931
3	3	4	8	9	18	5	1	4	2	3	4652.4	3699.267	953.132	2585	0.368717	2.71211
4	2	4	9	17	18	4	1	2	5	3	4638.032	3686.763	951.268	2528	0.376293	2.657504
5	4	8	9	17	18	1	4	2	5	3	4609.699	3659.901	949.797	2528	0.375711	2.66162
6	2	3	4	9	17	4	1	3	2	5	4639.015	3690.483	948.531	2603	0.364399	2.744243
7	3	4	8	9	17	1	3	4	2	5	4610.682	3663.621	947.060	2603	0.363834	2.748505
8	3	4	7	9	18	5	1	4	2	3	4573.194	3628.124	945.069	2585	0.365597	2.735249
9	2	4	8	9	18	5	1	4	2	3	4597.691	3653.136	944.554	2555	0.369689	2.704979
10	3	4	6	9	18	5	1	4	2	3	4565.762	3621.254	944.507	2570	0.367513	2.720996
…																
15494	10	11	12	13	19	2	1	5	3	4	2088.273	1630.438	457.834	2437	0.187868	5.322883
15495	10	12	14	19	20	2	5	3	4	1	2077.089	1621.404	455.684	2403	0.189631	5.273387
15496	10	11	12	14	19	2	3	5	1	4	2072.155	1618.933	453.221	2437	0.185975	5.377067
15497	11	13	14	19	20	5	3	2	4	1	2115.088	1662.359	452.728	2358	0.191997	5.208416
15498	11	12	13	14	20	5	4	3	2	1	2115.605	1663.318	452.286	2392	0.189083	5.288681
15499	5	11	12	19	20	2	3	5	4	1	2024.352	1574.451	449.900	2415	0.186294	5.36785
15500	12	13	14	19	20	5	3	2	4	1	2076.543	1627.600	448.942	2358	0.190391	5.252348
15501	11	12	13	14	19	1	5	3	2	4	2071.609	1625.384	446.224	2392	0.186548	5.360536
15502	10	11	12	19	20	2	3	5	4	1	1960.36	1530.212	430.147	2430	0.177015	5.649227
15503	11	12	13	19	20	3	5	2	4	1	1959.814	1536.742	423.071	2385	0.177388	5.637347
15504	11	12	14	19	20	3	5	2	4	1	1943.696	1525.159	418.536	2385	0.175487	5.698424

5. CONCLUSIONS

Based on theoretical and practical research, software was developed to evaluate the effectiveness of the PVF system installation for traffic violations. The software also assesses the impact of specific parameters at the study points and calculates indicators for each accident hotspot before and after the system's installation. The effectiveness of the software is measured by the reduction in the number of accidents, including both the number of incidents and the severity of damage at accident hotspots.

However, the software has several limitations:

- Data collection limitations: Vietnam currently lacks a unified road data system, legal framework, and common standards for traffic safety and intelligent transport systems, making data collection challenging.
- Limitations of the expert assessment method: The expert assessment method relies on the personal experience of road traffic specialists, meaning the accuracy of calculations depends on subjective expert opinions. This requires the involvement of highly qualified specialists with deep knowledge in the field.

- Software limitations: The software is developed using Microsoft Visual FoxPro 9.0, a simple and easy-to-use programming language that offers algorithmic solutions for the problem. However, it is not ideal for handling large volumes of input data.

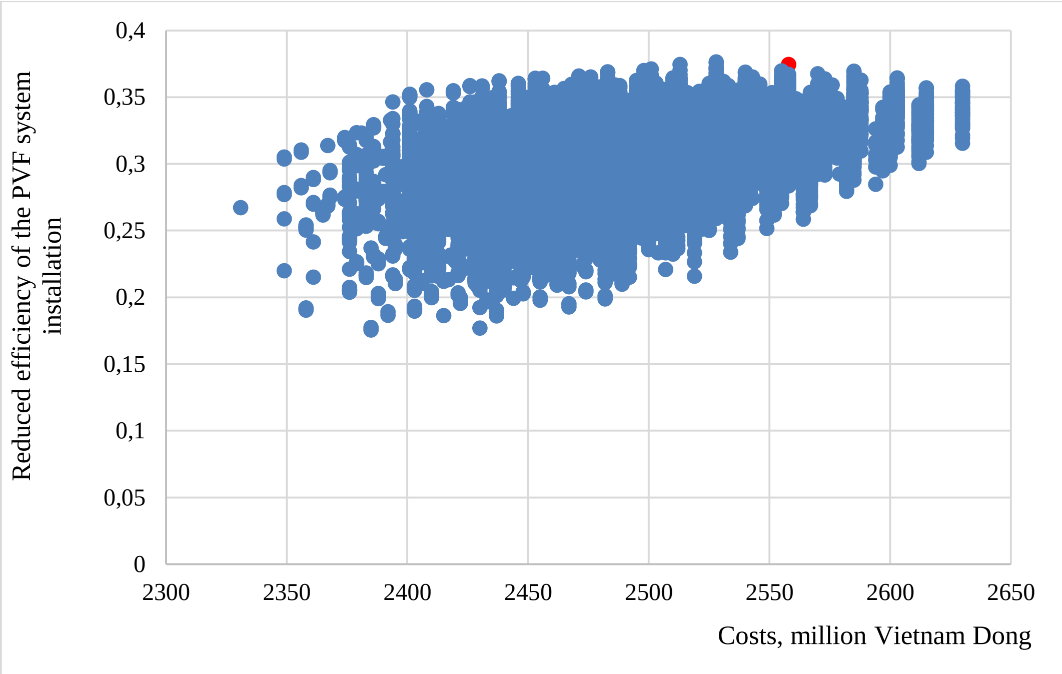

Fig. 8. Software calculation results graph

To enable the software to function with full capabilities, modern programming languages can be utilized to optimize its ability to handle large datasets and provide more advanced analytical algorithms. Languages like Python, R, or AI and Machine Learning platforms could support complex data analysis and offer more accurate predictions on traffic violation trends at specific hotspots. Upgrading the software would not only improve computation speed but also expand its integration capabilities with other intelligent traffic systems, laying the groundwork for a synchronized and complete traffic database. This would contribute positively to reducing traffic accidents at black spots, enhancing traffic management effectiveness, and ensuring road safety in the future.

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