UDC 004.9:625.7

B.R. Prokopovych
O.N. Romanyuk

VISUALIZATION OF ROAD NETWORK CONDITION DATA ON INTERACTIVE MAPS

Vinnytsia National Technical University

Анотація

У тезах розглядається проблема візуалізації даних про стан дорожньої мережі з використанням інтерактивних картографічних систем. Описано основні підходи до збору, обробки та представлення дорожніх даних на цифрових картах, а також огляд сучасних інструментів і бібліотек для побудови інтерактивних карт. Наведено результати аналізу ефективності запропонованих методів для підтримки прийняття рішень у сфері управління дорожньою інфраструктурою.

Ключові слова: дорожня мережа, інтерактивна карта, візуалізація даних, ГІС, моніторинг доріг, веб-картографія, стан дорожнього покриття.

Abstract

The paper addresses the problem of visualizing road network condition data using interactive mapping systems. The main approaches to collecting, processing, and presenting road data on digital maps are described, along with an overview of modern tools and libraries for building interactive maps. The results of analyzing the effectiveness of the proposed methods for supporting decision-making in road infrastructure management are presented.

Keywords: road network, interactive map, data visualization, GIS, road monitoring, web cartography, road surface condition.

Introduction

The condition of road infrastructure directly affects transportation safety, economic efficiency, and the quality of life of citizens. Modern information technologies provide new opportunities for monitoring, analyzing, and presenting data about road networks. Among the most promising directions is the use of interactive maps that allow for dynamic visualization of road condition data in an intuitive and accessible format [1]. The relevance of this topic is determined by the need to improve road management systems and ensure timely response to infrastructure problems.

Main Part

The basis for visualizing road network data is geographic information systems (GIS), which allow spatial data to be stored, processed, and displayed. Modern web-based GIS platforms, such as Leaflet.js, OpenLayers, and Mapbox GL JS, provide powerful tools for creating interactive maps in the browser environment [2]. These frameworks support various types of layers, custom markers, heat maps, and dynamic data filtering, which makes them well suited for displaying road condition information.

The process of collecting data about the condition of road surfaces can be carried out through various methods: manual inspection, automated sensors installed on vehicles, satellite imagery analysis, and data obtained from users of mobile applications [3]. The integration of these data sources into a unified system ensures comprehensive monitoring of the road network. Preprocessing of the collected data includes noise filtering, normalization, classification of road segments by condition, and spatial indexing for efficient retrieval.

For the purposes of visualization, road segments are typically categorized into several condition classes (e.g., good, satisfactory, poor, critical), each of which is represented on the map using a corresponding color scheme. The use of choropleth maps and heat maps allows for the rapid identification of problem areas in the road network [4]. Interactive elements such as pop-up information panels, filtering by date and damage type, and the ability to switch between different map layers significantly enhance the usability of the system.

The architecture of the proposed software solution includes a server part responsible for data storage and processing (PostgreSQL with PostGIS extension), a REST API for data exchange, and a client web application that renders interactive maps using Leaflet.js [2]. Road segment data is transmitted in GeoJSON format, which

is a standard for representing geographical objects in JSON. This approach ensures cross-platform compatibility and simplifies integration with third-party services.

The use of clustering algorithms allows for efficient display of a large number of road condition markers without overloading the visual interface. At small zoom levels, markers are grouped into clusters, while at larger zoom levels, individual road segments with their detailed condition data become visible. Such behavior ensures a smooth user experience regardless of the data volume [5].

Conclusions

The visualization of road network condition data on interactive maps is an effective tool for supporting decision-making in road infrastructure management. The use of modern web cartography frameworks, combined with GIS technologies and standardized data formats, enables the creation of informative, user-friendly, and scalable monitoring systems. The proposed approach allows road condition information to be presented clearly to engineers, administrators, and the general public, thereby contributing to more timely maintenance and improved road safety. Future work may focus on integrating machine learning methods for automated road damage detection and predictive analytics.

REFERENCES

1. Goodchild M. F. Citizens as sensors: the world of volunteered geography // GeoJournal. 2007. Vol. 69, No. 4. P. 211–221.
2. Agafonkin V. Leaflet: an open-source JavaScript library for mobile-friendly interactive maps. URL: https://leafletjs.com (Accessed: May 25, 2026).
3. Eriksson J., Girod L., Hull B., Newton R., Madden S., Balakrishnan H. The Pothole Patrol: Using a Mobile Sensor Platform for Road Surface Monitoring // Proc. of MobiSys'08. 2008. P. 29–39.
4. Brewer C. A. Designing Better Maps: A Guide for GIS Users. Redlands: ESRI Press, 2005. 220 p.
5. MacEachren A. M. How Maps Work: Representation, Visualization, and Design. New York: Guilford Press, 1995. 513 p.

Прокопович Богдан Романович – студент групи 1ПІ-22б, факультет інформаційних технологій та комп'ютерної інженерії, Вінницький національний технічний університет, м. Вінниця, e–mail: prokopovychbogdan22@gmail.com.

Романюк Олександр Никифорович – доктор технічних наук, професор, професор кафедри програмного забезпечення, завідувач кафедри програмного забезпечення, Вінницький національний технічний університет, м. Вінниця, e–mail: rom8591@gmail.com.

Prokopovych Bohdan R. – student of group 1PI-22b, Faculty of Information Technologies and Computer Engineering, Vinnytsia National Technical University, Vinnytsia, e-mail: prokopovychbogdan22@gmail.com.

Romanyuk Oleksandr N. – Doctor of Technical Sciences, Professor, Professor of the Software Engineering Department, Head of the Software Engineering Department, Vinnytsia National Technical University, Vinnytsia, e–mail: rom8591@gmail.com.