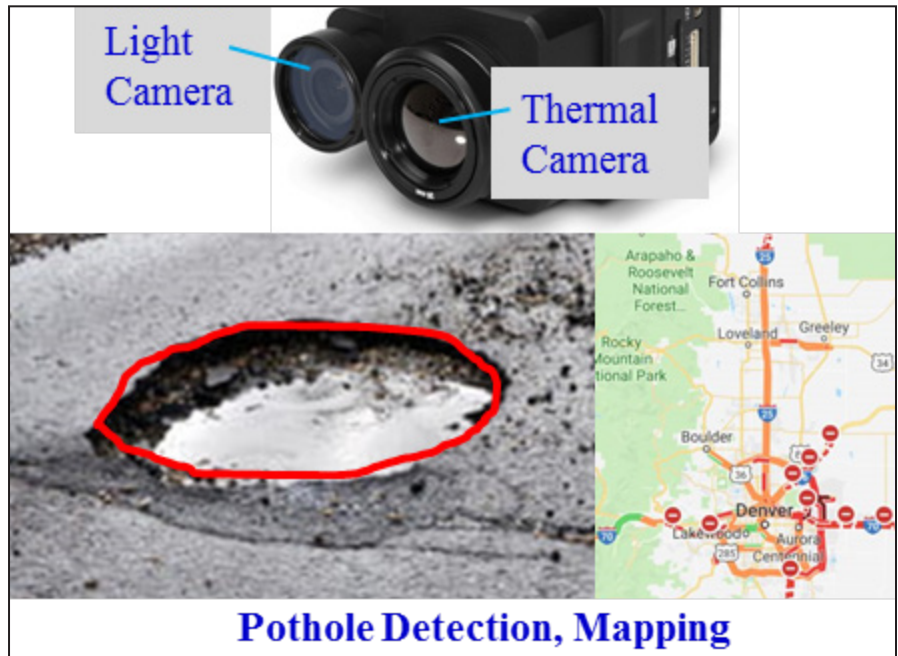


# MOUNTAIN-PLAINS CONSORTIUM

RESEARCH BRIEF | MPC 24-559 (project 620) | September 2024

Visible & Thermal Imaging and Deep Learning Based Approach for Automated Robust Detection of Potholes to Prioritize Highway Maintenance



## the ISSUE

Potholes are a significant pavement distress compromising safety and causing costly damage to vehicles. Accurately and efficiently detecting potholes is essential for timely road maintenance and safety improvement.

## the RESEARCH

This research developed an automated deep learning-based pothole detection and mapping tool using the fusion of visible and thermal images. Traditional methods using only visible images struggle with poor lighting and adverse weather, while thermal images alone lack the necessary detail. By fusing visible and thermal images, this project aimed to enhance detection accuracy across different conditions. This research created a database of labeled, geotagged images collected with a low-cost FLIR ONE thermal camera mounted on a vehicle. Three machine learning models were tested: Anisotropic Diffusion Fusion (ADF) + Mask R-CNN, RTFNet, and RTFNet with enhancement parameters (EPs). These models were trained on the database to detect potholes under various lighting conditions, including daytime, nighttime, and cloudy environments. The developed tool allows users to upload images for automatic pothole detection and mapping based on GPS coordinates, making it easier for transportation agencies to prioritize road repairs.



A University Transportation Center sponsored by the U.S. Department of Transportation serving the Mountain-Plains Region. Consortium members:

Colorado State University  
North Dakota State University  
South Dakota State University

University of Colorado Denver  
University of Denver  
University of Utah

Utah State University  
University of Wyoming



### Lead Investigator(s)

Gaofeng Jia  
gaofeng.jia@colostate.edu

### Research Assistant(s)

Wei-Hsiang Chen, GRA, MS

### Project Title

Visible and Thermal Imaging  
in a Deep-Learning Approach  
to Robust Automated Pothole  
Detection and Highway  
Maintenance Prioritization

### Sponsors | Partners

Colorado State University  
USDOT, Research and  
Innovative Technology  
Administration

## the FINDINGS

The RTFNet machine learning model provided the highest detection accuracy, achieving F1 scores of 93.7% during the day and 90.9% at night. The inclusion of EPs further improved the performance under low-light conditions. The research demonstrated that fusing visible and thermal images significantly enhances pothole detection accuracy compared with using visible images alone. This approach is particularly useful in poor lighting and adverse weather, where relying only on visible images tends to fail. The project also developed an easy-to-use tool with a graphical user interface that allows highway maintenance teams to upload images and automatically detect potholes from images and map their locations for more efficient highway maintenance.

## the IMPACT

This research will improve road safety and reduce maintenance costs by providing transportation agencies with a more accurate and efficient way to detect and repair potholes. The automated detection tool, which combines visible and thermal images, ensures reliable pothole identification under various conditions, particularly in regions with challenging weather. By streamlining pothole detection and mapping, agencies can allocate resources more effectively, prioritize repairs, and reduce the risks to motorists posed by deteriorating roads. This approach is scalable and cost-effective, making it accessible to agencies of various sizes.

For more information on this project, download the Main report at <https://www.ugpti.org/resources/reports/details.php?id=1205>

For more information or additional copies, visit the Web site at [www.mountain-plains.org](http://www.mountain-plains.org), call (701) 231-7767 or write to Mountain-Plains Consortium, Upper Great Plains Transportation Institute, North Dakota State University, Dept. 2880, PO Box 6050, Fargo, ND 58108-6050.



This publication was produced by the Mountain-Plains Consortium at North Dakota State University. The contents of this brief reflect the views of the authors, who are responsible for facts and the accuracy of the information presented herein. This document is disseminated under the program management of the USDOT, Office of Research and Innovative Technology Administration in the interest of information exchange. The U.S. Government assumes no liability for the contents or use thereof.



NDSU does not discriminate in its programs and activities on the basis of age, color, gender expression/identity, genetic information, marital status, national origin, participation in lawful off-campus activity, physical or mental disability, pregnancy, public assistance status, race, religion, sex, sexual orientation, spousal relationship to current employee, or veteran status, as applicable. Direct inquiries to Vice Provost, Title IX/ADA Coordinator, Old Main 201, 701-231-7708, [ndsueoaa@ndsu.edu](mailto:ndsueoaa@ndsu.edu).