2007-49TS
Published 10-2-08

RESEARCH
SERVICES SECTION

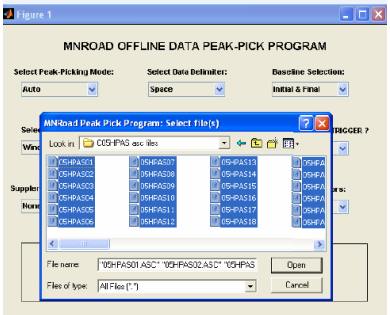
TECHNICAL SUMMARY

Technical Liaison:
Tom Burnham, Mn/DOT
tom.burnham@dot.state.mn.us

Administrative Liaison:
Nelson Cruz, Mn/DOT
nelson.cruz@dot.state.mn.us

Principal Investigators:
Ahmed Tewfik, University of Minnesota
Seshan Srirangarajan,
University of Minnesota

PROJECT COST:
$48,345



The Peak-Pick program can analyze multiple files at once, saving time and improving accuracy.

Developing a Computer Program to Select Peak Dynamic Sensor Responses from Pavement Testing

What Was the Need?

Mn/DOT routinely collects pavement response data from sensors embedded in highway test sections, chiefly at the MnROAD facility located on Interstate 94 northwest of Minneapolis/St. Paul. These sensors measure both environmental conditions and responses to vehicle loads. Mn/DOT uses the data, along with national guidance, to develop improved pavement designs that will lead to roadways that meet real-world use in a cost-effective way.

The large amount of data collected on MnROAD test sections needs to be analyzed carefully to obtain usable information. Analysis of data obtained early in the program was done by examining files individually, a time-consuming process. In 2001, to improve the processing of the data, Mn/DOT sponsored development of the Peak-Pick software program. This program, built at the University of Minnesota using the MATLAB computer language, provided three key benefits:

- Filtering out background noise from the collected data
- Enabling faster, more thorough analysis of the data
- Delivering results in a format compatible with Mn/DOT's database

In the years that followed, improved sensor design and computer processing capabilities made the original Peak-Pick program nearly obsolete. This caused significant increases in data processing and analysis efforts. MnROAD data continues to be collected; several years' worth is available today, waiting to be analyzed. In 2006, the University of Minnesota was asked to update and enhance the Peak-Pick software package to increase processing efficiency.

What Was Our Goal?

The objectives of the project were to significantly enhance the performance of the Peak-Pick program by:

- Extending its ability to accurately locate peaks and troughs in low signal recordings and track possibly shifting baselines.
- Further increasing the speed of data processing.
- Increasing the program's usability by improving interfaces.
- Automating the analysis of all waveform files and identifying those that may require further manual analysis.
- Supporting information in formats compatible with existing Mn/DOT databases.

What Did We Do?

Investigators first focused on developing techniques to reduce background noise in sensor data. Once this problem was addressed, they analyzed pavement response waves to develop algorithms for improving the Peak-Pick program's detection of baseline pavement responses, as tracking the baseline is essential for estimating the peaks and troughs that represent the pavement's response to traffic.

The next task was to improve peak and trough detection. Due to variable vehicle speeds, the true peak response corresponding to the vehicle tire can appear in different

continued

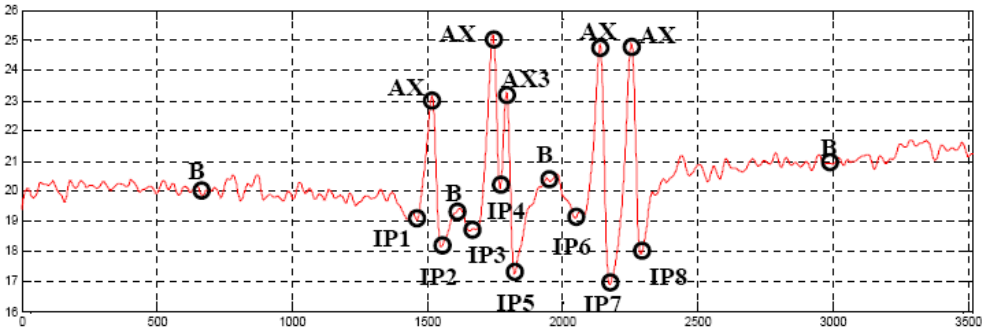
"Mn/DOT had a huge amount of data it needed analyzed. The enhanced program can analyze 100 data files in the time it would take a person to analyze one."

–Ahmed Tewfik,
Professor, University of Minnesota Department of Electrical and Computer Engineering

"With the new program, you open it up, select as many data files as you want, press 'go,' and it's off. The new version is faster, more efficient and has made great strides in reducing noise in the data, providing more accurate results."

–Tom Burnham,
MnROAD Senior Road Research Engineer

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Research Services Section
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
(651) 366-3780
www.research.dot.state.mn.us



This graph shows a denoised pavement response signal as recorded by the improved Peak-Pick program developed for this study. Labels indicate various points of interest, including axle response peaks.

places within a signal response. Investigators examined alternative approaches to enable the program to better adapt to variations in sensor responses.

For the final steps, investigators updated the program's interface and improved usability by working with current users of the program. They also created a detailed user guide as part of the final project report.

What Did We Learn?

Early use of the revised Peak-Pick program has demonstrated a significant improvement in the quantity and quality of vehicle response data processed. The investigators identified critical issues to improve usability. The enhanced program includes:

- **Six operating modes to provide flexibility.** The new program accommodates multiple sensor input types and includes automatic, semiautomatic and manual peak value selection modes. This has allowed for not only more efficient processing of MnROAD data, but adds the ability to process data from other pavement testing sites. This has shifted the focus of the pavement response project from regional to national.
- **Ability to process data in batches, providing faster results.** Analysis of the data is significantly faster. If done manually, it takes roughly one minute to analyze a data file. In that same time, the Peak-Pick program can analyze more than 100 files.
- **Improved accuracy.** The program processes different input file formats and analyzes different vehicle types (two to 10 axles), providing more accurate results.
- **Improved capturing of the baseline.** On hot days, pavement recovery is slow after a vehicle crossing. The original Peak-Pick program could not consistently identify these delayed recoveries, distorting baseline and peak readings that required manual attention to identify and correct. The updated program corrects this and provides much improved baseline and peak reporting.

What's Next?

In order to keep the program current, the University of Minnesota is developing updates to the Peak-Pick program that will allow it to keep pace with developing data formats and sensor technology.

This Technical Summary pertains to Report 2007-49, "Development of a Computer Program for Selecting Peak Dynamic Sensor Responses from Pavement Testing," published August 2007. The full report can be accessed at http://www.lrrb.org/PDF/200749.pdf.