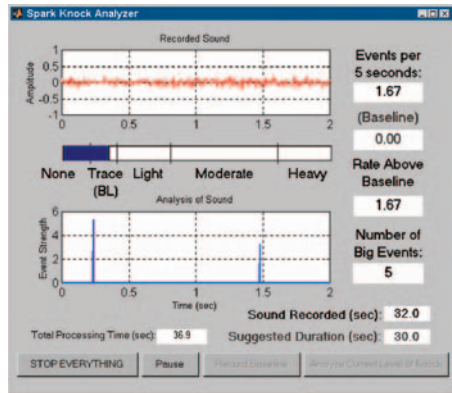


Ford Motor Company Develops and Deploys Sound-Quality Metrics with MATLAB®

Reducing noise—from road, wind, and engine, as well as from power seat adjusters, power mirrors, and other components—has become a key automotive design requirement. Until recently, noise-reduction efforts focused on the overall sound level. Engineers now recognize that other attributes, including sharpness, loudness, and fluctuation, affect perceptions of sound quality.

To ensure an acceptable acoustic environment without conducting expensive and time-consuming listening studies, engineers must obtain objective sound-quality (SQ) metrics that correlate with subjective impressions of sounds.

Ford’s research and advanced engineering and product development groups generate reliable SQ metrics for the company and its worldwide suppliers with a suite of SQ analysis tools developed in MATLAB®. In fewer than three weeks, Ford turns metrics developed with MATLAB into stand-alone applications using the MATLAB Compiler so that relatively novice users can execute the applications without any programming.



GUI for spark knock detector.

and editing; working with databases; analyzing signals; and producing SQ metrics that correlated well with subjective impressions of sound quality.

THE SOLUTION

Ford chose the MATLAB product family as their software platform to rapidly develop algorithms, acquire and analyze data, and build and deploy applications. Using MATLAB with the MATLAB Compiler, they deployed their SQ metrics to different third-party analysis systems using a single version of the MATLAB source code.

Using MATLAB and the MATLAB Compiler, Ford integrates with supplier’s third-party analysis systems by generating MATLAB based DLLs. Third-party SQ analysis systems written in other languages pass signals and data among systems to the generated DLLs. Moreover, Ford used MATLAB to develop a GUI front end for the Simple Sound Quality Tool (SSQT), which they compiled with the MATLAB Compiler before distributing it to their suppliers as a stand-alone application.

THE CHALLENGE

The only metric with an implementation standard—ISO532B—is stationary loudness. All other SQ metrics are vendor-specific: they vary depending on the vendor’s particular implementation techniques.

Ford set out to develop an easy-to-use, scalable measurement and analysis tool that would be inexpensive to distribute with SQ metrics that could interface as plug-ins with third-party analysis systems. The stand-alone version of the tool had to provide basic functionality for recording, playing,

THE CHALLENGE

To develop and deploy sound quality metrics that correlate well with subjective impressions of sound

THE SOLUTION

Use the MATLAB product family to develop a sound quality analysis tool and deploy SQ metrics to the company and its worldwide suppliers

THE RESULTS

- Improved quality of Ford products.
- Development time reduced by six months
- Source code control

With this approach, Ford has saved up to six months in development time by avoiding the process of rewriting the MATLAB application to another language or making the application available to run outside of MATLAB. This approach also enabled them to simplify application maintenance by requiring them to only update the original MATLAB application. They distributed MATLAB based stand-alone application plug-ins to more than 25 worldwide suppliers, enabling them to use their third-party systems for data acquisition and to analyze data using the SSQT metrics.

Using the Signal Processing and Statistics toolboxes, engineers developed versions of SQ metrics for loudness, sharpness, and fluctuation strength, which objectively measure perceived volume, spectral density, and modulation. They use the metrics to evaluate the sound quality of electric motors for seats, pedals, and mirrors as well as switches, wipers, and other interior features.

Engineers also developed algorithms to process several types of time-varying sound, including wind gusting, impulsive engine noise, and spark knock, which are difficult to characterize using standard objective SQ metrics. They used MATLAB development tools and the MATLAB Compiler to develop and run these sound metrics as stand-alone applications.

Ford also uses the Data Acquisition Toolbox to run their spark knock detector and analyzer application in “real time.” Unlike other SQ metrics that are first saved to a file and analyzed at a later time, Ford’s spark knock application uses the Data Acquisition Toolbox so that sound acquired from a standard

PC sound card can be analyzed in MATLAB while the acquisition is still in progress. This application enables engine calibrators to detect spark knock while adjusting engine calibration parameters. It is through advanced spark timing that Ford maximizes engine torque output and minimizes fuel consumption.

MATLAB continues to be widely used to develop Ford’s SQ metrics, while the MATLAB Compiler eases the process of turning these metrics into user-friendly applications.

THE RESULTS

- **Improved quality of Ford products.** The SSQT enables suppliers to meet SQ requirements for Ford products, since they both now use the same metrics and eliminate inconsistencies.
- **Development time reduced by six months.** Ford found deploying their metrics with the MATLAB Compiler to be straightforward, while reducing development time by six months. Without the MATLAB Compiler, plug-ins to some third-party analysis systems would require special versions of the third-party software or much more effort to convert the SQ algorithms into C code.
- **Source code control.** The MATLAB environment makes it easy for engineers to control source code since only a set of MATLAB files needs to be maintained. The stand-alone application and the plug-ins are all generated from the same code, ensuring that all implementations deliver the same result.

To learn more about Ford Motor Company, visit www.ford.com

APPLICATION AREAS

- Algorithm development
- Application deployment
- Automotive
- Data analysis
- Test and measurement

PRODUCTS USED

- MATLAB
- MATLAB Compiler
- Signal Processing Toolbox
- Statistics Toolbox
- Data Acquisition Toolbox

www.mathworks.com