Automotive radar is an enabling technology for collision mitigation, blind-spot alerts, adaptive cruise control, and many other active safety features. Radar systems provide range, range rate, and azimuth information data on vehicles and other objects. The accuracy of this data depends on precise alignment of the radar sensor.

Delphi used MATLAB® and MATLAB Coder™ to accelerate the design, simulation, and implementation of a production radar sensor alignment algorithm.

"With MATLAB we can analyze data and design algorithms in one environment, so we can rapidly try out new ideas and then evaluate them with plots and statistical analysis," says Liang Ma, Delphi system engineer. "Once we’ve verified an algorithm, we use MATLAB Coder to generate production C code that is as efficient as handwritten code."

The Challenge
The radar sensor alignment algorithm executes more than 40 times every second while the vehicle is running. In 1 millisecond it must calculate the misalignment angle based on data provided by the radar sensor, as well as the vehicle speed, the sensor’s position on the vehicle, and its pointing angle.

The Solution
Delphi adopted MATLAB and MATLAB Coder to develop and implement the radar sensor alignment algorithm. Liang used MATLAB to analyze recorded sensor data captured from road testing a real vehicle. With huge amounts of testing data and the help of powerful MATLAB built-in functions, Liang realized and verified a radar sensor alignment algorithm that calculates sensor misalignment angles from raw radar detection and host vehicle speed. The algorithm computes the least squares solution to a system of linear equations. It also estimates the computed angle’s accuracy based on the residual of the least squares solution.

The Results
• Generated C code as efficient as handwritten C code for this algorithm
• Development time halved
• Algorithm changes easily verified and coded in seconds

Delphi Develops Radar Sensor Alignment Algorithm for Automotive Active Safety System

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code by calling a MEX function within the MATLAB testing code and comparing the results of the generated code with the results of the original MATLAB algorithm, completing each iteration in minutes.

Initially, the generated C code running on an ARM10 processor computed the misalignment angle in more than 3 milliseconds. Liang removed redundant logic, combined for-loops, and performed other optimizations in the MATLAB code until the generated code completed its computations in less than 1 millisecond, which met the throughput requirements.

On schedule, Liang delivered the verified C code for the improved algorithm to the software integration team for integration into the production system.

Delphi already uses this radar sensor alignment algorithm in active safety systems in production vehicles for several OEMs, with no reported defects.

Liang and his co-workers have used MATLAB and MATLAB Coder to design and implement several other production algorithms, including a target selection algorithm that uses fusion tracks information, camera vision objects, and host vehicle information to select appropriate targets for OEMs’ active safety features.

The Results
Generated C code as efficient as handwritten C code for this algorithm. “The C code we generated with MATLAB Coder runs as fast as an earlier implementation of the algorithm that was hand-coded,” says Liang. “The generated code is also easy to integrate and free of defects—we never modify it.”

Development time halved. “I developed the algorithm in three weeks, leaving just one week to implement it in C and verify it,” says Liang. “MATLAB Coder enabled me to complete the project on schedule. Hand-coding by a software engineer would have required up to four more weeks.”

Algorithm changes easily verified and coded in seconds. “With our traditional approach, it could take a week for a software engineer to implement a change I had made to an algorithm,” says Liang. “With MATLAB and MATLAB Coder I can generate production C code myself in less than a minute, enabling me to evaluate new ideas quickly.”

Industry
- Automotive

Application Areas
- Embedded systems
- Digital signal processing

Capabilities
- Data analysis
- Algorithm development

Products Used
- MATLAB
- MATLAB Coder

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