'Smart' Engine Shows Promise for Leaner, Greener Vehicle

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An advanced controller is showing “promising results” by learning on-the-fly how to operate an engine cleaner and more efficiently, say researchers at the University of Missouri-Rolla.

Dr. Jagannathan Sarangapani, professor of electrical and computer engineering at UMR, and Dr. Jim Drallmeier, professor of mechanical and aerospace engineering at UMR, and their students have spent the last two years developing the controller, which may one day transform current engines into leaner, greener devices.

The researchers believe the sophisticated controller shows the most promise with exhaust gas recirculation (EGR), a technique used to reduce nitrogen oxide emissions.

Spark-ignition engines need both fuel and air to operate, Drallmeier says. “If, however, I can operate the engine in a situation where I can give it less fuel for the same amount of air or dilute the mixture with inert gases such as EGR, the engine will behave differently,” Drallmeier explains. “And that’s what we’re doing here.”

The researchers created a neural network controller that is implemented as a software program. Artificial neural networks are adaptive systems, which “learn” based on the successful connections they make between neurons or nodes. “The neural network observer part of the controller will assess the total air and fuel in a given cylinder in a given time,” Sarangapani says. “It then sends that estimate to another neural network, which generates the fuel commands and tells the engine how much fuel to change each cycle.”

Speed is a critical component, Drallmeier says.

“This controller observes what an engine cycle is doing, makes measurements in that period of time, reduces that data, and decides how you need to push the engine in the next cycle,” Drallmeier explains. “It does all that before the next cycle starts. We’re talking about a matter of milliseconds.”

Significant theoretical challenges encountered during controller design must be overcome before the controller can be implemented on the hardware, Sarangapani says.

“Very limited information is known to the controller from the engine, and the controller must generate an appropriate fuel command signal per cycle while ensuring overall performance,” Sarangapani explains. “The actor-critic neural network learns on-the-fly using reinforcement signals.”

Although increasing EGR can reduce nitrogen oxide emissions, it can cause significant cyclic dispersion in heat release.

“Cyclic dispersion is a cycle-to-cycle variability in engine output,” Drallmeier says. “A good example of people experiencing cyclic dispersion is when they’re sitting in their car at a stop light and they feel their car shaking. The more EGR you can add, the lower your nitrogen oxide emissions. The question is how far can we push it and still keep cyclic dispersion in a reasonable range.”

The auto industry depends on catalytic converters to meet the EPA’s tight emission requirements. But there are points in an engine operation when catalytic converters don’t work, such as during a cold start before the engine gets hot, Drallmeier says.

A smart controller that can reduce cyclic dispersion would open new possibilities to engine efficiency.

“The key is you’re opening doors into new modes of engine operation that were not available before through sophisticated controllers,” Drallmeier says. “Where future engine designs will go is multimode operation. The only way you’re going to get there is through sophisticated controllers.”

Source: University of Missouri-Rolla