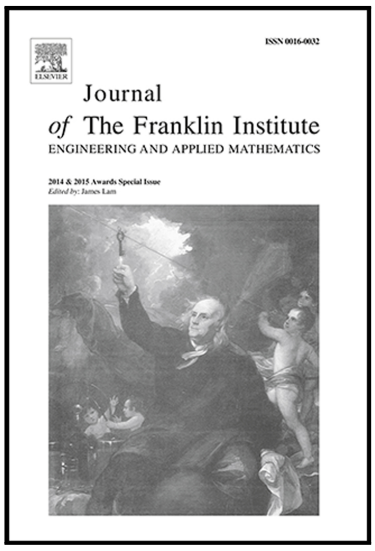

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A neural network-based detection and mitigation system for unintended acceleration

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ABSTRACT

Modern vehicles are equipped with a growing number of electronic devices, which significantly improve the driving experience. However, the complicated architecture of electronic systems also increases the difficulty of fault diagnosis since process models are often unavailable. This paper presents a novel detection and mitigation system for vehicle related anomalies originating in unintended acceleration (UA), which has become one of the most complained-about vehicle problems in recent history. The detection system consists of several neural network-based models, which are created by analyzing historical vehicle data at specific moments such as acceleration peaks and gear shifting. These data-driven models describe the boundary of normal vehicle behavior in the data space. A priori knowledge of complete vehicle structures is not necessary for building them. The detection system combines these models to decide if a UA event has occurred. When a UA event is detected, a mitigation system cuts the engine power and adjusts the braking force accordingly. The whole system was validated in the Simulink/dSPACE environment. UA errors were simulated so that they occurred randomly when human subjects drove virtual cars in a simulated environment. Random noise of sensors were also considered and incorporated to add realism. Various traffic scenarios were included in tests. Test results show that the integrated system is capable of detecting UA in one second with high accuracy and reducing the risk of accidents.

1. Introduction

Automotive electronics have evolved enormously over the past decades. Numerous powerful electronic control units (ECUs) were developed to equip modern vehicles, which made driving much easier and more comfortable. As can be expected, a growing number of autonomous vehicles or partially autonomous vehicles will come to the market in the next few decades. However, driving is an inherently complex task and cars can be very dangerous if not handled properly. As the intelligence level of vehicles increases, people gradually lose direct control of vehicles and raise worries about the safety and reliability of vehicle systems.

One of the typical problems related to electronic systems is unintended acceleration (UA). The US National Highway Traffic Safety Administration (NHTSA) defined UA as "the occurrence of any degree of acceleration that the vehicle driver did not purposely cause to occur." An apparent loss of braking effectiveness often happened at the same time (NHTSA, 2014). UA first came to public attention due to its higher-than-usual occurrence as reported by drivers (Kane, Liberman, DiViesti, & Click, 2010; NASA, 2011). The National Aeronautics and Space Administration (NASA) and NHTSA conducted several investigations of UA. While the cause of the incidents has not been clearly determined, it was concluded that UA was possibly caused by four major problems, which were pedal misapplication, unresponsive pedals, ETC (Electronic Throttle Control) or cruise control failure and stuck throttle. The most plausible reason was considered to be pedal misapplication. However, the possibility of vehicle defects still could not be excluded (National Research Council, 2012; Pollard & Sussman, 1989). Koopman (Koopman, 2014) argued that

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