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A neural network approach to fluid quantity measurement in dynamic environments

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ABSTRACT

Sloshing causes liquid to fluctuate, making accurate level readings difficult to obtain. In this paper, a measurement system has been described that can accurately determine fluid quantity in the presence of slosh. The measurement system uses a single-tube capacitive sensor to obtain instantaneous level of the fluid surface. A neural network based classification technique has been applied to predict the actual quantity of the fluid under sloshing conditions. Effects of temperature variations and contamination on the capacitive sensor have been discussed and it is proposed that these effects can also be eliminated with the proposed neural network based classification system. To examine the performance of the classification system, many field trials were carried out on a running vehicle at various tank volume levels that range from 5 L to 50 L. The paper also investigates the effectiveness of signal enhancement on the neural network based signal classification system. Signal enhancement is performed using selected signal smoothing functions such Moving Mean, Moving Median, and Wavelet filters. Results obtained from the investigation are compared with traditionally used statistical averaging methods, and it proved that the neural network based measurement system can produce highly accurate fluid quantity measurements in a dynamic environment. The approach demonstrated herein will enable a wide range of fluid quantity measurement applications in the fields of automotive, naval and aviation industries to produce accurate fluid level readings.

1. Introduction

In the design of sensors, it is important to consider the robustness of the sensors as well as their accuracy in the target operating environment. In real-life situations, sensors have to face the challenges of dynamic variations in temperature, humidity, vibration, corrosion and contamination, etc. In many consumer and industrial applications, these dynamic changes in the environmental factors can abruptly change from one state to another, which can adverse the properties of the sensors, thus making them useless thereafter or even hazardous. Any change in the physical properties of the sensor or its ambient environment can affect the accuracy of the measurement system. To provide increased robustness and better confidence in the sensor accuracy, sensor industries are focusing on developing more intelligent sensors with digital signal processing advantages. This paper describes an intelligent fluid quantity measurement system using a signal capacitive sensor. The paper uses a fuel level measurement application in automotive vehicles to exemplify the dynamic environment. In brief, the measurement system described in here incorporates artificial intelligence to provide highly accurate fuel level measurements in a running vehicle. The paper provides a systematic approach for the analysis and improvement of the sensor readings that are influenced by the environmental parameters by adopting the artificial neural network based signal processing technique. Furthermore, it will enable automotive, naval and aviation industries to obtain highly accurate fluid level readings, as well as to monitor fuel consumption and determine possible leaks in fluid containers. In particular, the neural network based method is suitable for use in professional car racing where vehicle is subjected to a highly dynamic manoeuvres. Drivers of cars equipped with this measurement method can confidently drive higher number of laps without fear of running out of fuel in situations where fuel level in the tank is low.

The existing fuel level sensor technology in automotive vehicles is mainly based on resistive type potentiometers, where the resistance value of the potentiometer changes with the fluid level. These sensors are mechanical devices that are prone to wear and corrosion [1]; therefore, they have limited functional life. Capacitive sensors are non-mechanical sensors hence they are being used to replace traditional mechanical sensors. The electrical

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