

Safe Road

As aforementioned, especially equipped vehicles within the xRAP programmes are optimal in how they facilitate exhaustive road inspections and ratings. Alternative approaches, however, have been sought using various cost-effective setups.

For example, in [20] an embedded device is realized to support various sensing techniques in road surface monitoring. Meanwhile, the system in [21] is proposed for the detection of wet-road conditions based on images captured by cameras mounted on the rear-view mirror of a vehicle. Specifically, the system employs image analysis for extracting features related to water and snow on the road. Other systems require the addition of simple hardware to such vehicles to widen the scope of the detection applications. For instance, the pothole patrol [22] depends on the deployment of 3-axis accelerometers on board of vehicles for detecting such road conditions through monitoring vibration. Another example proposed in [23] is a system that detects ice on roads by analyzing tire-to-road friction ultrasonic noise detected by a transducer installed behind the front bumper.

Several works have also employed sensing features in smartphones and tablets. For example, the work in [24] aims at recognizing road surface anomalies through the combination of accelerometers and GPS data on a tablet, allowing for ease of data aggregation and reduced cost.

A smartphone system of note is *Nericell*, which utilizes smartphone accelerometers, microphones, and GPS to detect events related to the quality of the road, e.g., potholes and bumps [25]. Vibration thresholds are used to decide on detecting such road conditions, and to detect events linked to traffic including braking and vehicles' noise. Deceleration thresholds that are sustained for a predefined time interval are used to detect braking events, while microphones are used for detecting the noise levels.