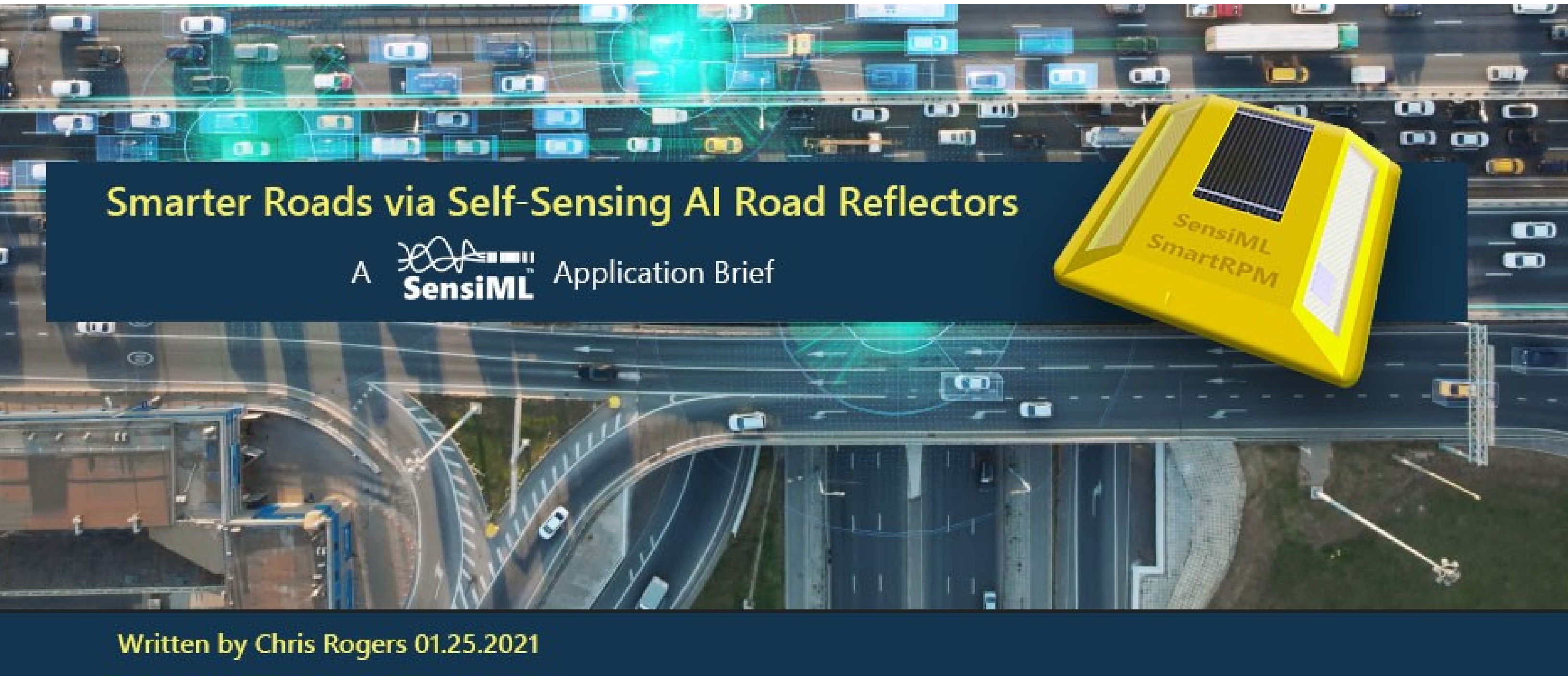


SUMMARY

We have all seen them, they are everywhere on our roads and highways, yet few people give them a second thought. The common road reflector or raised pavement marker (RPM) as they are properly called, is a ubiquitous yet humble passive safety device. But consider for a moment what might be possible if reimagined as an intelligent active IoT edge sensor instead.

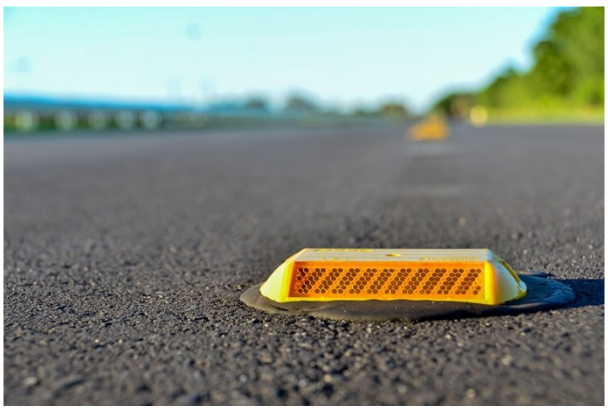
SensiML has been thinking along these lines for some time and has built prototype units to prove out the possibilities for smart RPMs capable of analyzing sound, vibration, temperature, and humidity and conveying next generation smart roadway insights in real-time using color changing reflector LEDs locally and wireless network connectivity remotely.

Combined with on-device machine learning algorithms powered by SensiML Analytics Toolkit, these smart RPMs can offer planners with detailed traffic profiles by vehicle type, first responders with instantaneous alerts for accidents, transportation department operations with automated tools to alert drivers to road use restrictions and warnings, and drivers with life-saving alerts of black ice, standing water, road deterioration hazards, and stopped or stalled traffic in low visibility conditions.

This article describes the patent pending application, SensiML's prototype, and the benefits for making smart infrastructure safer and better with edge AI in ubiquitous, low-cost road sensing devices.

The ability of smart IoT devices to gather and process data is becoming ubiquitous. It is commonplace now for devices to incorporate embedded computing, connectivity and sensing giving them the ability to process raw sensor data using algorithms to convey key insights. With low-power and low-cost processors now capable of supporting advanced machine learning models, we are entering a new era of AI enabled smart devices with capabilities not long ago the realm of science fiction. The combination of local edge device processing and pervasive connectivity brings additional benefits as aggregated pre-processed insight from many such devices can present still broader observations and applications. This distributed sensor processing opens up many new types of applications not previously practical using only centralized cloud analytics.

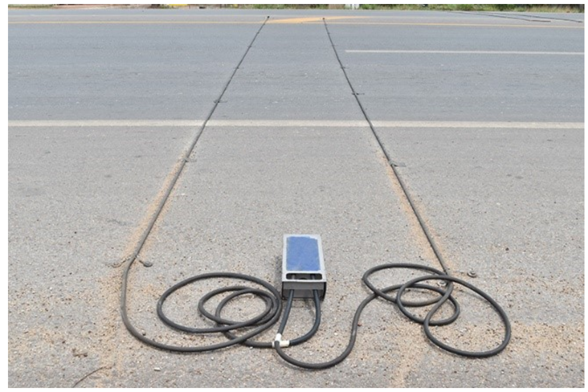
One application where this distributed sensor processing can be applied with transformative impact over existing systems is in smart roadway and traffic management. Today's use of smart road technology tends to be concentrated within strategic points on high-density thoroughfares and intersections where the expense of costly sensors and systems can be rationalized. Case in point are today's "smart" traffic lights that rely on the sparse information obtainable from inductive coil loops embedded in the road surface at major intersections to provide incremental improvements over simple timing-based traffic signal control. Camera-based traffic monitoring also provides limited value mostly for central traffic planning and operations use in accident response, but with far fewer insights for drivers themselves limited to infrequently placed display board messages.



Alternatively consider the possibilities enabled by augmenting these existing high-cost systems with pervasive low-cost sensor/alerting devices. On roadways across the world, there are few items more pervasive than the ordinary raised pavement marker (RPM). This simple passive device improves safety of roads and highways by aiding drivers in discerning lanes and pavement boundaries in poor visibility conditions. Now consider the prospect of building intelligence into these same devices, with each possessing low-power sensors, a microcontroller system-on-chip, and wireless connectivity.

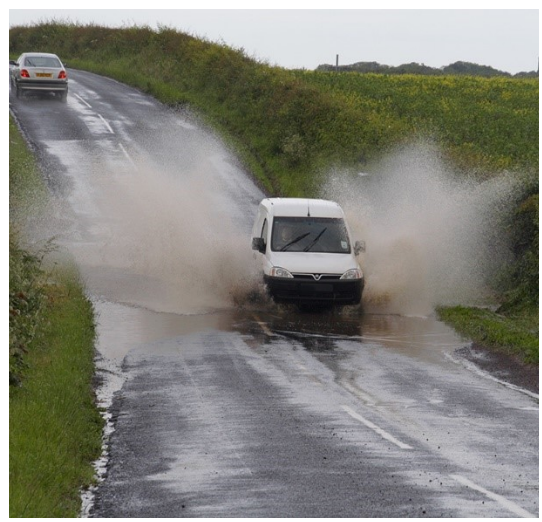
Using low-cost microphone, accelerometer, temperature, and humidity sensors along with edge IoT processing, many new and compelling possibilities emerge for assisting transportation planners, law-enforcement, first responders, and drivers alike:

Vehicle class identification - Are cars, motorcycles, light trucks, buses, or heavy trucks traveling by this location? If so, when and how many? Acoustic ML classification of microphone and vibration data can provide real-time classification of vehicle classes of passing traffic useful for a variety of uses.

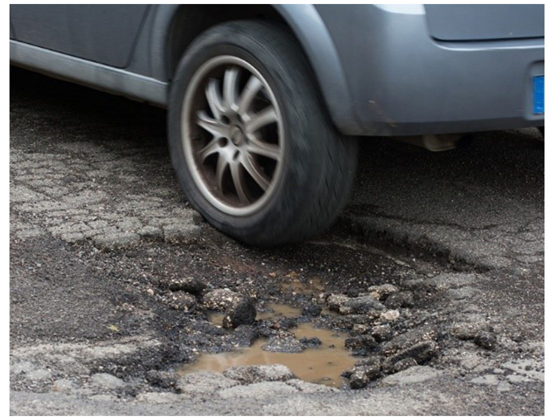


The obvious use case is replacement of age-old pneumatic rubber hose style traffic survey devices. Simple and impervious RPMs can be placed and left in place indefinitely, greatly expanding the budgets and productivity of DoT planners. Additionally, real-time traffic classification is also helpful for enforcement of restricted roadway traffic types and policies (i.e. no trucks allowed on this road, bus only lanes, motorcycle lane splitting), real-time driver warnings of probable excess vehicle weight on low-capacity rural bridges from AI correlation of emitted vehicle noise to weight class.

Pavement surface hazards – By comparing measured tire noise against learned norms and combining with temperature and humidity sensors, machine learning algorithms in the RPM can detect and alert to hazards associated with poor road surface conditions like standing deep water or icing conditions that can cause loss of traction and control. Such insight can be displayed in real-time with flashing LED alert beacons at the RPM device itself and conveyed upstream to nearby RPMs on the approach to an unsafe location to extend alert notification distance.



Pavement maintenance and warning – Tire noise and thumps caused by degrading pavement condition can provide valuable data on needed road repairs and potholes and even alert drivers to nearby surface hazards helping to prevent costly vehicle damage or loss of control.



Traffic condition warnings - Dense traffic and reduced visibility from rain or fog can trigger chain reaction accidents where drivers find no option because reaction time is insufficient to safely slow to a stop. Detecting acoustic signatures of locked screeching tires and vehicle impacts, RPMs can provide real-time alerting conveyed to upstream RPMs for driver signaling of imminent danger. Remote dispatch can also be instantly conveyed to first responders as well.

Private use applications – Beyond public infrastructure uses, smart RPMs could provide a variety of related benefits for private facilities such as parking garages, lots, access gates, driveways, and access roads. Alerts of sensed pedestrians with blind corners and limited visibility, enforcement of allowed vehicle types, even recognition of specific vehicles. Adaptive algorithms that can be easily taught acoustic and sensor vibration patterns of interest can drive a variety of control and insight applications for vehicular traffic in private settings as well.

SensiML Prototype Platform

SensiML has prototyped RPM device hardware for pilot projects. Resembling the common passive RPM, the SensiML SmartRPM integrates 3-axis accelerometer, temperature, humidity, and microphone sensors, along with an Arm Cortex-M4F microcontroller, flash and SRAM memories, lithium polymer battery, photovoltaic cell and charging circuitry, Bluetooth BLE radio, and a high intensity RGB LED. All of this is enclosed in a hardened compact, waterproof enclosure.

To program the system, SensiML employed its SensiML Analytics Toolkit, an end-to-end AI software solution used to capture and label raw sensor data and transform that labeled data into functioning, optimized machine learning firmware that recognizes patterns of interest in the data. SensiML Analytics Toolkit is a powerful system that provides a highly automated workflow for creating and testing functioning machine learning algorithms with a minimum of data science expertise and algorithm coding effort. Furthermore, SensiML Analytics Toolkit can quickly build working binary, library, or source code format output for rapid integration and prototyping of physical devices.

	Northbound												Southbound												
	0:00	2:00	4:00	6:00	8:00	10:00	12:00	14:00	16:00	18:00	20:00	22:00	0:00	2:00	4:00	6:00	8:00	10:00	12:00	14:00	16:00	18:00	20:00	22:00	
Motorcycle	3	2	2	4	10	9	8	9	17	15	10	7	3	2	4	9	18	12	7	5	9	10	11	8	194
Compact Car	87	46	70	168	390	288	240	315	691	553	330	215	86	66	140	398	654	438	216	234	364	413	314	232	6948
Full Size Car	91	53	91	226	475	317	299	324	920	551	433	270	97	79	142	473	822	520	204	230	530	430	440	252	8269
Light Duty Truck	24	12	20	50	102	84	83	82	219	165	118	53	28	14	35	85	191	137	54	53	107	104	100	61	1981
Medium Duty Truck	10	4	6	18	39	32	27	31	66	48	30	23	9	5	11	30	82	39	25	24	43	39	34	25	700
Heavy Duty Truck	2	1	1	3	7	6	4	7	14	10	8	3	2	2	2	5	12	9	3	5	10	8	6	3	133
Total Vehicular Traffic	217	118	190	469	1023	736	661	768	1927	1342	929	571	225	168	334	1000	1779	1155	509	551	1063	1004	905	581	

Once SensiML had completed physical prototyping, development of initial functioning proof-of-concept code was completed in two weeks including the time required to collect raw sensor data. Data consisted of vehicle pass-by samples for a variety of vehicles with classification of vehicle type used as ground truth for train/test.

As you can see, SensiML Analytics Studio can help solve a variety of IoT challenges through ideation, prototyping and testing, down to the validation of your own results for faster "go to market readiness" in your niche product development cycle.

Contact SensiML to discuss your edge IoT application project.

SensiML™

8285 SW Nimbus Ave. Suite #151
Beaverton · OR · 97008 · USA
+1 (503) 567-1248
info@sensiml.com