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| Project | **Specification of Sensor Interface for Cyber and Physical World**<https://sagroups.ieee.org/2888/ > |
| Title | **Proposal of JSON-formatted vehicle information for cyber vehicle and physical vehicle** |
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| Re: |  |
| Abstract | Proposal of JSON-formatted vehicle information to reflect vehicle information into the virtual world and to manage the physical vehicle with easy.  |
| Purpose | To start discussion on purpose of the standard |
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# Introduction

Interfacing cyber world and physical world provide various opportunities for new kind of service providers as well as gaming industry based on virtual reality. One example is regarding automobile industry and a couple of use cases based on technology interfacing cyber world and physical world.

# Vehicle Information

## Auto maintenance/regular inspection

 Vehicle information is necessary for checking status of vehicle. The engine is the most important part in the vehicle and various sensors are attached in the vehicle for warning to driver. Of course, driver can take regular inspection of vehicle, but we cannot know when engine failure happens suddenly. With vehicle information from physical world, we can take care of vehicle in the cyber space. We can get critical information related to engine such as engine temperature sensor, oil pressure sensor, coolant sensor and brake fluid sensor from vehicle and also obtain warning information like tire pressure sensor and battery sensor.

 When regular inspection, we check it whether have to replace parts of vehicle or not. Normally, we replace engine oil when we take a vehicle 7000-10000 km and replace tire when taking 80000 km. If we know that how much kilometers we drive the vehicle in the cyber space, it will become easier to manage parts of vehicle.

 So, for management of vehicle, the following information is needed:

* Engine temperature
* Engine oil pressure
* Coolant temperature
* Brake fluid
* Tire pressure
* Battery current
* Mileage

## Monitoring for Eco-friendly driving

One of the most important factors of the eco-friendly driving is fuel efficiency. Even without a fuel efficiency sensor in the vehicle, the vehicle speed sensor and the mass air flow sensor can be used to calculate the current gas mileage and the fuel level sensor can be used for compensating the error from calculating the instantaneous fuel efficiency.

Instantaneous fuel efficiency (mile per gallon, MPG) can be calculated as follows:

$$MPG=\frac{14.7×6.17×454×VSS×0.621371}{3600×\frac{MAF}{100}}$$

, where VSS is the vehicle speed in kilometers per hour which can be informed by the vehicle speed sensor, 14.7 means 14.7 grams of air to 1 gram of gasoline which is an ideal air to fuel ratio, 6.17 means 6.17 pounds per gallon which is density of the gasoline, 454 means 454 grams per pound conversion, 0.621371 means the value for miles per hour to kilometers per hour conversion, 3600 means seconds per hour, MAF is mass air flow rate in 100 grams per second which can be informed by the mass air flow sensor, 100 is to correct MAF to get grams per second.

If there is no MAF sensor, then one can fill up the fuel tank to calibrate the volumetric efficiency (VE). Then one can calculate an MPG without MAF sensor. Example formula is as follows:

$$IMAP=RPM×\frac{MAP}{IAT}$$

, where IMAP is intake manifold absolute pressure, MAP can be informed by manifold absolute pressure sensor, IAT is intake air temperature which can be informed by intake air temperature sensor.

$$MAF=\frac{IMAP}{120}×\frac{VE}{100}×ED×\frac{28.97}{8.314}$$

,where ED is engine displacement which is measured in liters, 28.97 is average molecular mass of air measured in g/mole, 8.314 means J/°K/mole.

With information from engine rpm sensor and speed sensor, fuel efficiency can be calculated, and driver can see one’s own driving habit in the virtual world and cure the habit for fuel efficiency.

In summary, information for fuel efficiency is needed such as:

* Vehicle Speed
* MAF (Mass air flow rate)
* Volumetric Efficiency
* IMAP(Intake manifold absolute pressure)
* MAP(Manifold absolute pressure)
* IAT(Intake air temperature)
* ED(Engine displacement measured in liters)

# JSON-formatted Vehicle Information

We checked which data is needed to manage a vehicle and for fuel efficiency. The vehicle information from various sensors can be generated to JSON-formatted information in order to reflect the vehicle information into the virtual world and we can examine status of the vehicle comfortably in the cyber space. By checking vehicle information in the virtual world, we can manage the physical vehicle to prevent a critical problem and change the driving habit to use fuel efficiently.

 We created JSON-formatted syntax and example for expressing vehicle information. Apart from above-mentioned vehicle information, additional information is necessary such as vehicle model, date of manufacture, name of manufacture and oil type.

{

 "$Schema" : "http://json-schema.org/draft-04/schema#",

 "title" : "Vehicle Information Scheme",

 "type" : "object",

 "properties" : {

 "Name-of-Manufacture " : {"type" : "string"}

 "Model-Name" : {"type" : "string"},

 "Date-of-Manufacture" : {"type" : "string"},

 "Oil-Type" : {"type" : "string"},

 "Engine-Temperature" : {

 "Value" : {"type" : "number"},

 "Unit" : {"type" : "string"}

 },

"Engine-Oil-Pressure" : {

 "Value" : {"type" : "number"},

 "Unit" : {"type" : "string"}

 },

"Coolant-Temperature" : {

 "Value" : {"type" : "number"},

 "Unit" : {"type" : "string"}

 },

 "Brake-Fluid" : {

 "Value" : {"type" : "number"},

 "Unit" : {"type" : "string"}

 },

 "Tire-Pressure" : {

 "Value" : {"type" : "number"},

 "Unit" : {"type" : "string"}

 },

 "Battery-Current" : {

 "Value" : {"type" : "number"},

 "Unit" : {"type" : "string"}

 },

 "Mileage" : {

 "Value" : {"type" : "number"},

 "Unit" : {"type" : "string"}

 },

 "Vehicle-Speed" : {

 "Value" : {"type" : "number"},

 "Unit" : {"type" : "string"}

 },

"Mass-Air-Flow" : {

 "Value" : {"type" : "number"},

 "Unit" : {"type" : "string"}

 },

 "Intake-Manifold-Absolute-Pressure" : {

 "Value" : {"type" : "number"},

 "Unit" : {"type" : "string"}

 },

 "Manifold-Absolute-Pressure" : {

 "Value" : {"type" : "number"},

 "Unit" : {"type" : "string"}

 },

"Intake-Air-Temperature" : {

 "Value" : {"type" : "number"},

 "Unit" : {"type" : "string"}

 },

 "Engine-Displacement" : {

 "Value" : {"type" : "number"},

 "Unit" : {"type" : "string"}

 }

 }

}

Figure 1. JSON Scheme for vehicle information

{

 "Name-of-Manufacture" : "Hyundai",

 "Model-Name": "Veloster i30 1.6 Sports",

 "Date-of-Manufacture": "2020-02-19",

 "Oil-Type" : "Gasoline",

 "Engine-Temperature": {

 "Degree": 90,

 "Unit": "Celsius"

 },

 "Engine-Oil-Pressure": {

 "Value": 2,

 "Unit": "Bar"

 },

 "Coolant-Temperature": {

 "Value": 80,

 "Unit": "Celsius"

 },

 "Mileage" : {

 "Value" : 1234,

 "Unit" : "Kilometers"

 }

}

Figure 2. JSON-formatted vehicle information example

# Conclusion

We contributed JSON-formatted vehicle information obtained from vehicle. Patterning information can generate virtual vehicle or digital twin vehicle in the cyber space and driver can check status of vehicle without difficulty in virtual space and furthermore driver can manage the physical vehicle.