

# Ride comfort mobile app

## Background:

The idea of this ride comfort app is to measure customer's ride quality when they make a journey in a vehicle. It is particularly interesting when it comes to quantify the ride quality of driverless vehicle. The existing measurement of the ride quality of a journey is using an expensive sensors, see picture below (figure 1 &2). It is essentially an accelerometer and gyroscope, but with much higher accuracy. However, nowadays the smartphone is well equipped with a good accelerometer and gyroscope; it could potentially achieve the required accuracy for the ride quality measurement.

- Sensor setup



Figure 1: vibration sensor in the car

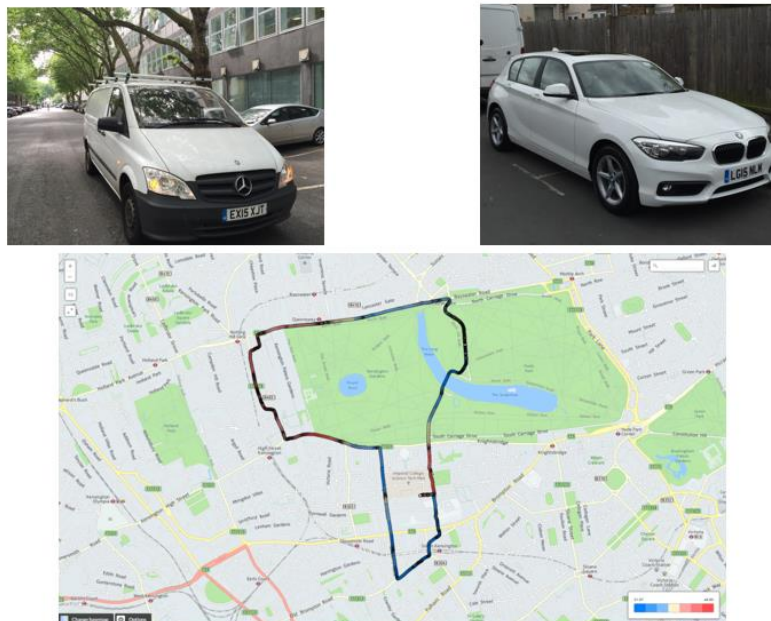


Figure 2: comparison of ride quality between car and van

## App Specs:

### Functionality:

1. Get sensor raw readings from the accelerometer and gyroscope;
2. Calculate running RMS, minimum, maximum RMS for each axis;
3. Be able to use the device to collect data, view data;
4. Be able to adjust sample frequency;
5. Upload data to backend and user can request to send data via email.

### Design:

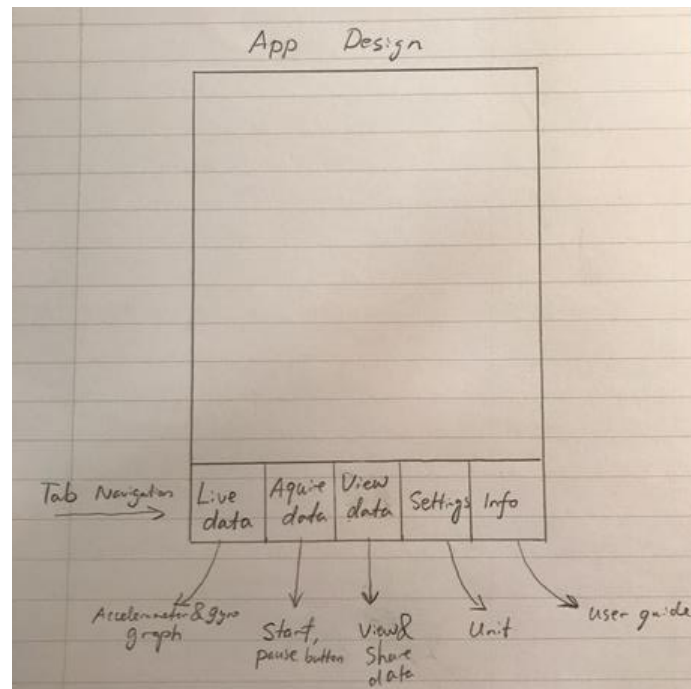


Figure 3: Brief overview of app layout

App name:

ICL-RideComfort

## Calculating ride quality metrics:

### Calculation of ride quality metrics

- Standard metrics:

- RMS

- VDV

#### Running R.M.S acceleration value

$$a_w(t_0) = \left[ \frac{1}{\tau} \int_{t_0-\tau}^{t_0} a_w^2(t) dt \right]^{\frac{1}{2}}$$

Where  
 $a_w(t)$  : Instantaneous value of vibration acceleration to which frequency weighting was applied  
 $t$  : Moving average integral time (s)  
 $\tau$  : Time (integral variable)  
 $t_0$  : Observation time point (instantaneous time)

#### Maximum Transient Vibration Value (MTVV)

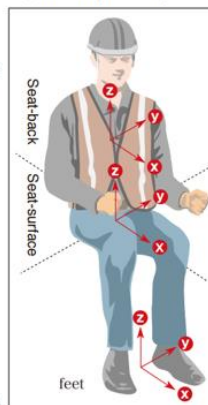
$$MTVV = \max[a_w(t_0)]$$

#### Vibration Dose Value (VDV)

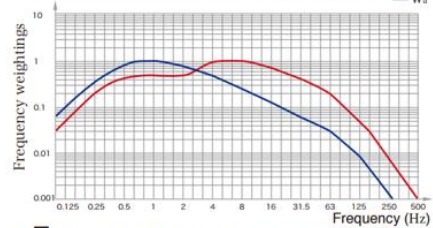
$$VDV = \left[ \int_0^T a_w^4(t) dt \right]^{\frac{1}{4}}$$

Where  
 $a_w(t)$  : Instantaneous value of translational or rotary vibration acceleration to which frequency weighting was applied  
 $T$  : Continuous measurement time (s)

#### Basicentric axes of the human body (Seated position)



#### Frequency weighting curves for principal weightings



#### Guide for application of frequency-weighting curves for principal weightings

Frequency weighting	$W_k$	$W_d$
Health	z-axis, Seat-surface	x,y-axis, Seat-surface
Comfort	z-axis, Seat-surface z-axis, Standing vertical recumbent (expect head)	x,y-axis, Seat-surface x,y-axis, Standing horizontal recumbent y,z-axis, Seat-back
Perception	z-axis, Seat-surface z-axis, Standing vertical recumbent (expect head)	x,y-axis, Seat-surface x,y-axis, Standing horizontal recumbent

#### Values needs to be calculated:

X: running RMS, min RMS, max RMS

Y: running RMS, min RMS, max RMS

Z : running RMS, min RMS, max RMS

Overall RMS

#### Example calculation:

Time	Accelerometer reading		
	X-axis	Y-axis	Z-axis
0	0.17158	0.205341	0.98495
0.1	0.097244	0.190006	0.998675
0.2	0.064279	0.151361	1.048559
0.3	0.065042	0.106226	1.036592
0.4	0.062876	0.054812	0.979403
0.5	0.121148	0.084047	1.010871

Running RMS:

$$RMS = \sqrt{\frac{a_t^2}{t - t_{t-1}}}$$

Time	Accelerometer reading			Running RMS for each axis (m/s2)		
	X-axis	Y-axis	Z-axis	RMS-X	RMS-Y	RMS-Z
0	0.17158	0.205341	0.98495			
0.1	0.097244	0.190006	0.998675	0.30751253	0.600852	3.158088
0.2	0.064279	0.151361	1.048559	0.20326805	0.478646	3.315835
0.3	0.065042	0.106226	1.036592	0.20568086	0.335916	3.277992
0.4	0.062876	0.054812	0.979403	0.19883137	0.173331	3.097144
0.5	0.121148	0.084047	1.010871	0.38310361	0.26578	3.196655