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SmartRoadSense

A collaborative project for monitoring road surface conditions

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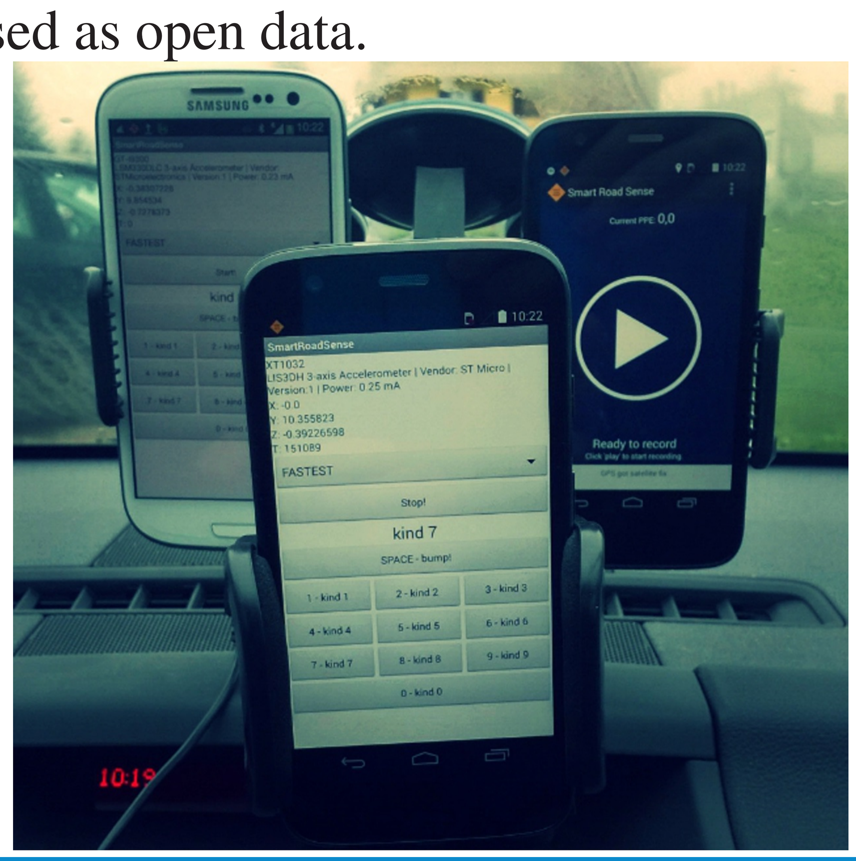
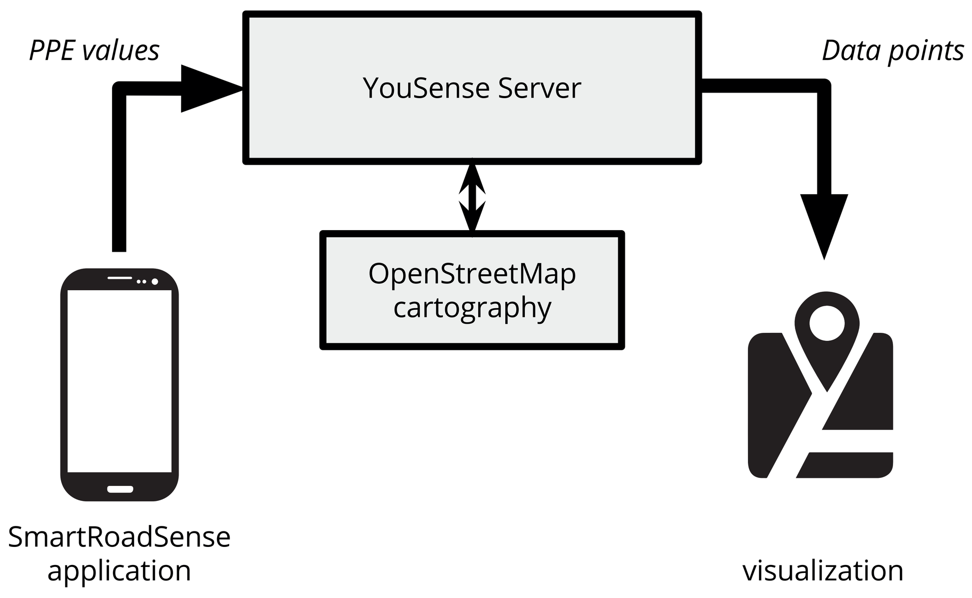
About SmartRoadSense

SmartRoadSense (http://smartroadsense.it/) is a crowd sensing project, which makes use of the accelerometers of car-mounted smartphones to estimate the roughness of the road surface. Roughness estimates are then collected by a server, aggregated, reported on a map, and released as open data.



Architecture



The software architecture of SmartRoadSense is designed as a three-tiered system, encompassing:

1. An Android application at user level that processes raw data from the accelerometers and transmits the result of the computation together with GPS data to a server.
2. A back-end server running a geographic information system where GPS data is properly aggregated, organized and stored.
3. A graphical front-end based on a cloud platform service for visualization.

Accelerometer data

The accelerometer senses the vibrations induced in the car cabin by the road profile through tires and suspensions. These vibrations convey information about the roughness of road surface.

The accelerometer also senses (i) the gravity, (ii) vehicle accelerations, (iii) centrifugal accelerations at curves, (iv) roll, pitch, yaw accelerations due to road trend, and (v) vibrations due to the engine. These accelerations are slowly varying or periodic in nature.

SmartRoadSense uses LPC analysis of the accelerometer data to remove all predictable components. The LPC analysis returns a residue that depends only on data relative to the road surface.

Contact Us

For more information contact us:
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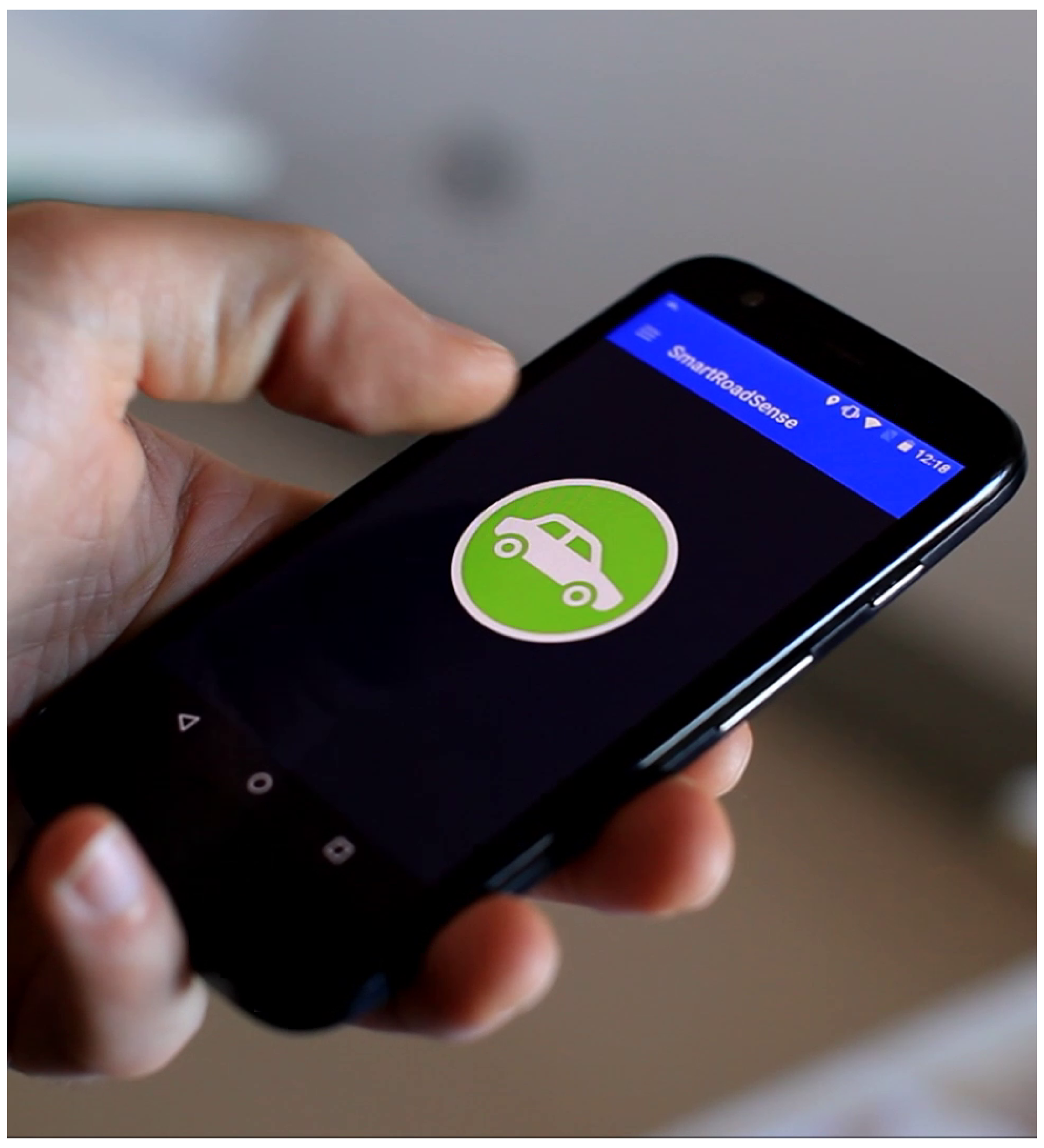
SmartRoadSense data analysis

The SmartRoadSense application records accelerometer data at 100 Hz and GPS data at 1 Hz.

1. Triaxial accelerations are segmented in blocks of 100 samples with 25% overlap.
2. Average value is removed from each block to reduce gravity and vehicle accelerations.
3. LPC analysis is performed on each block using the Levinson-Durbin recursion.
4. The residual error, $e_\xi(n)$, where $\xi \in \{x, y, z\}$ is computed for each component:
$$e_\xi(n) = a_\xi(n) + \sum_{i=1}^{N} \lambda_i a_\xi(n-i).$$
5. The power of residual error, P_{E_ξ}, is estimated for each component:
$$P_{E_\xi} = \frac{1}{M} \sum_{n=1}^{M-1} e_\xi^2(n).$$
6. Eventually, a roughness index R_I is computed by averaging the three components:
$$R_I = \frac{1}{3}\left(P_{E_x} + P_{E_x} + P_{E_z}\right).$$

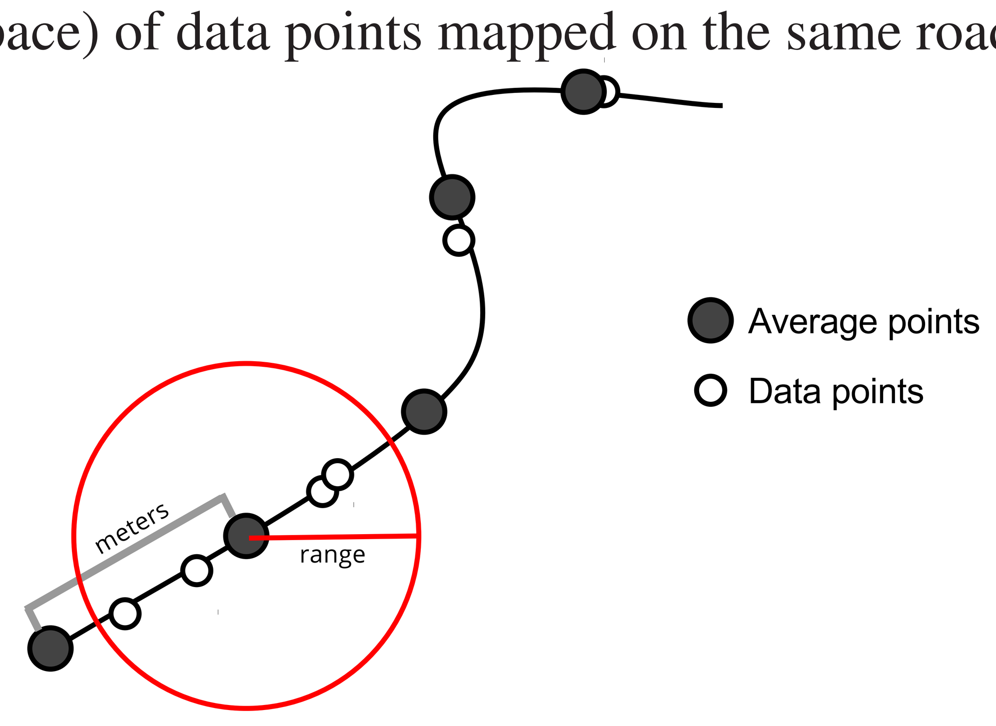


Data Collection

The roughness indexes R_I are periodically transmitted to a remote server (every 15 minutes or opportunistically).

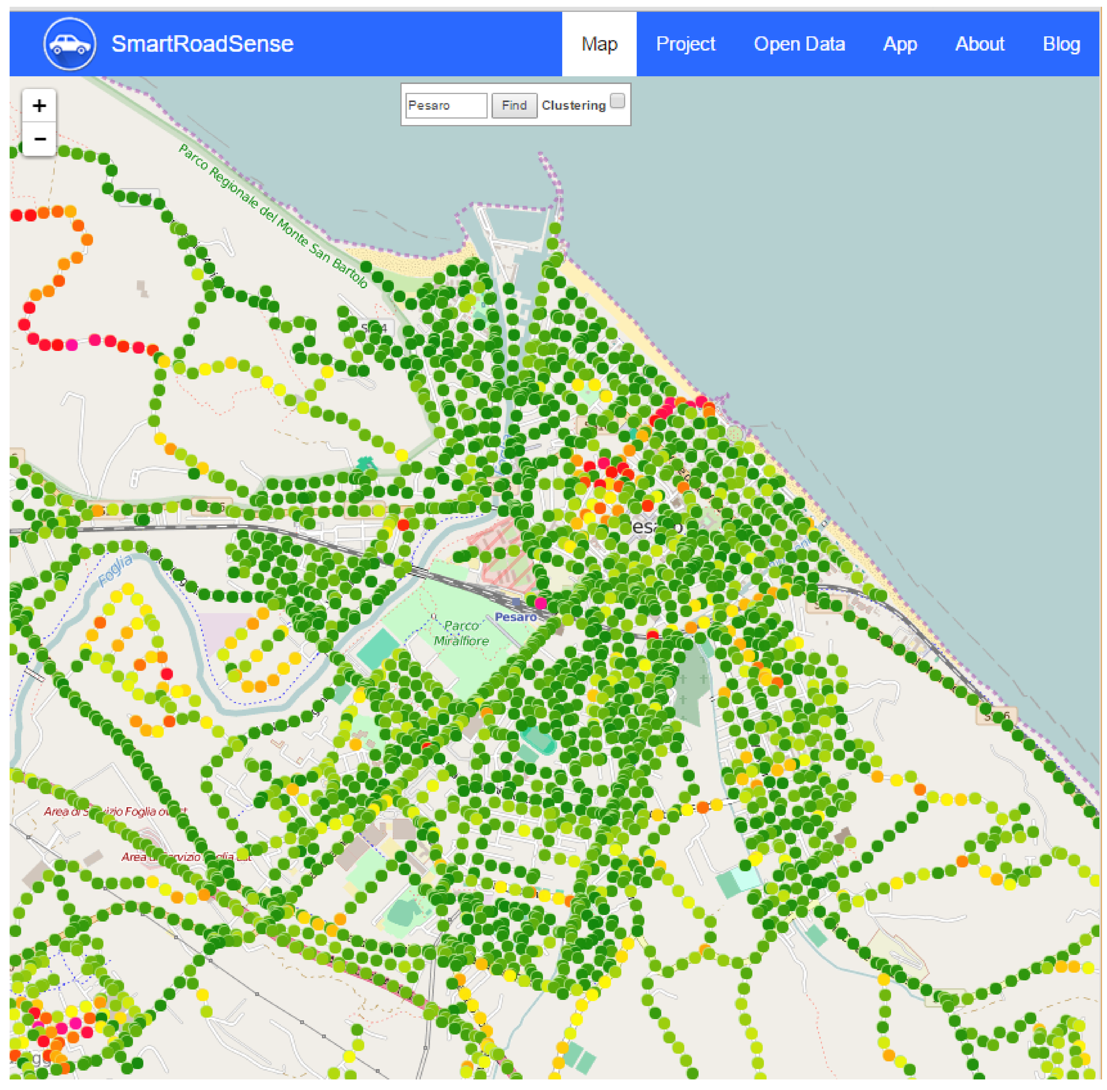
Newly collected data are processed periodically: the set $P_{new} = \{P_1, P_2, \cdots, P_n\}$ of new points is mapped to the closest road (using the geographical database OpenStreetMap).

A set of roads, $R_{new} = \{R_1, R_2, \cdots, R_m\}$, has new data. From each road, a set of *average points* is extracted at regular intervals. The final roughness index of each *average point* is computed as a weighted average (over time and space) of data points mapped on the same road.



Data Aggregation

After this process has completed, the database has a new set of average roughness points.



The final roughness points are displayed as an overlay on a geographical map: green points indicate low roughness values, while red points mark areas with high roughness values, indicating a bumpy road.

References

[1] G. Alessandroni et al., "Sensing road roughness via mobile devices: a study on speed influence", ISPA 2015.
[2] S. Delpriori et al., "Efficient Algorithms for Accuracy Improvement in Mobile Crowdsensing Vehicular Applications", UBICOMM 2015.
[3] G. Alessandroni et al., "Demo: Mobile Crowdsensing of Road Surface Roughness", MobiSys 2015.
[4] V. Freschi et al., "Geospatial data aggregation and reduction in vehicular sensing applications: the case of road surface monitoring", IEEE ICCVE 2014.
[5] G. Alessandroni et al., "SmartRoadSense: Collaborative Road Surface Condition Monitoring", UBICOMM 2014.