Semantic Principal Curvature (SPC)

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Outline

• Position of the problem
• Principal Curvatures (not Gaussian Curvature)
• Histogram: aggregation of the curvatures
• Metric
• Results
• Discussion, Conclusion
Motivation

• 3D sensors are more and more popular, Kinect, Lidar, etc

• In some conditions like by night, it is difficult to recognize an object based on colors

• Recognition of an object based on the Point Cloud and rotation-translation invariants

• Some algorithms exist that are local. Here we propose a global approach.

• Gestalt Principle: *Perception of the overall shape emerges from individual stimuli*
Principal curvature

- Principal curvature $K_1$ and $K_2$
- Second order description of a surface
- Local
- Invariant
  - Translation
  - Rotation
- Different from Gaussian curvature $[K_1;K_2]$ not $K_1 \times K_2$
Second order fit of the Neighborhood

- The curvature is based on a neighborhood

\[ r_\lambda = \lambda \cdot \max_{p,q} (\|v_p - v_q\|_2), \lambda \in [0; 1] \]

\[ B(v_i, r_\lambda) = \{ p \in \mathbb{R}^3 \mid \|v_i - p\|_2 \leq r_\lambda \}. \]

- Polynomial fit (2\textsuperscript{nd} order) on the neighboring points

\[ \varepsilon = \sum_{v_k \in B_{v_i}, \lambda} \left( J_{i,n}(v_k) - z(v_k) \right)^2 \]
Signature of an object, concatenation of the First Principal Curvature (K1) histogram and the Second Principal curvature (K2) histogram.
Metric

- The signature is first normalized
- Distance chosen is the Khi$^2$ distance

$$d_{\chi^2}(A, R) = \sum_j \frac{(H_A(j) - H_R(j))^2}{H_A(j) + H_R(j)}$$

- Khi$^2$ distance good metric for the distance between 2 histograms
Objects to recognize
Realistic corruptions of Point Clouds

- Noise related to
  - quality of the 3D sensors
  - distance of acquisition
  - light condition
  - material of the observed objects

- Down-sampling: related to sensor resolution

- Occlusions
  - in a real scene an object can be occluded by another object
  - in some case the object is seen from only one point of view.
Resilience to down-sampling

![Graph showing recognition rate against resampling ratio for principal curvatures and Gaussian curvatures.](image-url)
Resilience to noise

Recognition rate (%)

- Principal curvatures
- Gaussian curvatures

σ (%)
Resilience to occlusion (20%)
Discussion, Conclusion

- Our method provides good results for occlusions, noise and down-sampling
- Easy to implement
- Compared to local methods (key points) our method is more robust in noisy conditions
- Combined with Lidarbox (Razali & Ouarti, ICIP 2017), possibilities to segment and to classify.
Questions?