Local Binary Quaternion Rotation Pattern for colour texture retrieval

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Motivation

In computer vision, recent trends seem to suggest that the Local binary patterns (LBP) are considered among the most efficient texture features.

- Although, several colour extension of LBP processes the colour texture in a separated processing thanks to grey-level texture features applied on each colour channel.

Contribution

Aware of the high interaction that exists between different channels in the color image.

- We introduce a new vector process to define a local descriptor for colour images called Local Binary Quaternion Rotation Pattern (LBQRP), which based on quaternion representation.

Quaternions

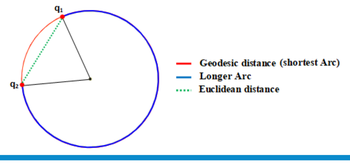
Any quaternion $q \in \mathbb{H}$ may be represented in hypercomplex form $q = a + bi + cj + dk$. Where $\{i, j, k\}$ satisfying $i^2 = j^2 = k^2 = ijk = -1$.

- **Norm :** $\| q \| = \sqrt{a^2 + b^2 + c^2 + d^2}$
- **Conjugate :** $\overline{q} = a - bi - cj - dk$
- **Unit quaternion :** $\| q \| = 1$
- **Polar form :** $q = \| q \| \exp^{\mu\theta}$

$$\begin{cases} \mu = bi + cj + dk / \sqrt{b^2 + c^2 + d^2} \\ \theta = \arccos(a / \| q \|) \end{cases}$$

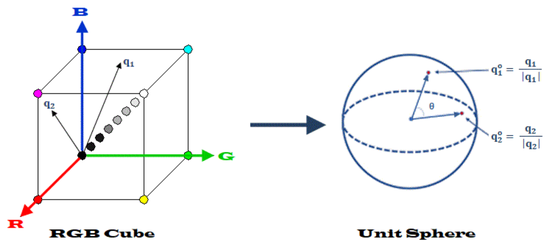
Any rotation $\in \mathbb{R}^3$ can be described using a unit quaternion q as: $q = \cos(\theta/2) + v \sin(\theta/2)$.
The geodesic distance between two unit quaternions or rotations:

$$dist_{\mathbb{H}}(q_1, q_2) = \left\| \log(q_1^{-\frac{1}{2}} q_2 q_1^{-\frac{1}{2}}) \right\| \qquad (1)$$



Local Binary Quaternion Rotation Pattern

Representing color image as a unit quaternion, each color vector can be treated as a rotation.



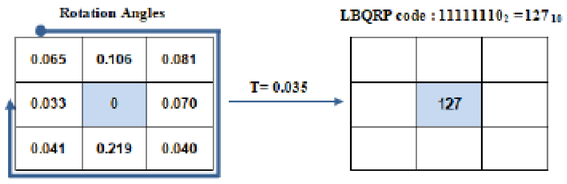
Using the Equation (1), we estimate the geodesic distance (θ) between two chromaticity vectors.

- **Small value of angle θ:** indicate a few chromaticity variation or a great similarity between two color pixels.
- **Big value of angle θ:** indicate a great difference between two color pixels.

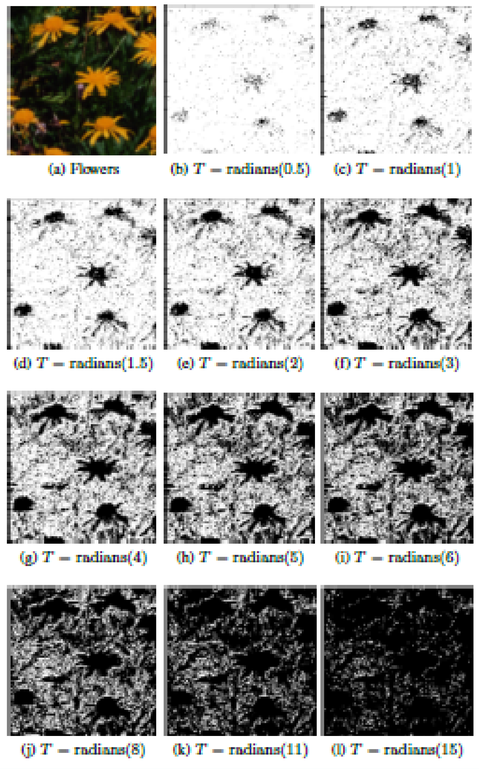
At a given quaternion pixel q_c, LBQRP is defined as an ordered set of binary representation of the chromaticity variation between the center pixel and its n surrounding pixels.

$$LBQRP_{q_c} = \sum_{i=0}^{N-1} B_{i,c} \times 2^i \qquad (2)$$

$$B_{i,c} = \begin{cases} 1 & \text{if } \theta \geq T, \\ 0 & \text{otherwise.} \end{cases}$$



Performance in Classification

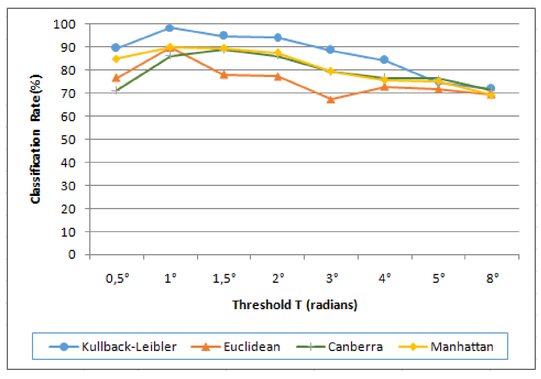


Color image classification:

- Nearest Neighbor Classifier (1-NN).
- Experiments on three challenging color datasets: VisTex, Outex and USPtex.

Best results are given for:

- $T = \text{radians}(1°)$
- Kullback-Leibler divergence



Methods	Year	Vistex	Outex	USPtex
LBPV	2010	-	76.53	77.78
CLBP	2010	-	81.30	88.10
ICCD	2013	98.10	89.30	-
SMGD	2014	97.50	89.70	-
QLBP	2014	98.07	78.19	84.82
Local jet+ Fourier	2015	97.84	87.16	89.63
C_2O	2015	99.30	82.64	-
CLP	2016	97.70	82.10	-
QLRBP	2016	98.41	79.17	86.74
LED+ED	2017	94.70	76.67	90.50
LNDP	2017	-	77.16	80.66
CNN-AlexNet	2017	91.34	69.87	83.57
SMO	2018	99.54	86.47	91.49
LDTP	2018	75.82	80.32	84.11
RC_2O	2018	**100**	92.40	-
LCCMSP	2018	-	84.87	90.01
ARCS-LBP	2019	-	85.72	88.88
Proposed LBQRP		98.37	**92.64**	**91.62**

Conclusion

- A new texture feature
- Very performant for color texture retrieval/classification:
  - In front of the actual state of the art
  - Extension to more datasets and classification criteria are in course

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