Kernel local descriptors with implicit rotation matching
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Overview
- We consider kernelized patch encodings → vectorized patch representation
- Revisiting the SIFT descriptor with match kernels
- Jointly encode pixel gradient and position continuously (no quantization)
- Fast dominant orientation alignment without descriptor re-computation

Match kernels
Local descriptor representation: set of pixel attributes
\[ X = \{x_1, \ldots, x_n\}, \quad x_i \in \mathbb{R}^d \]
e.g. d = 1 for grayscale patches; d = 4 in this work
Match kernel to compare two patches
\[ K(X,Y) = \beta(X)\beta(Y) \sum_{x \in \mathbb{X}} K(x,y) \]
Vector mapping \( \psi: \mathbb{R}^d \rightarrow \mathbb{R}^{d'}, \) such that \( \psi(x, y) \) encodes pixel gradient and position.
Patch representation:
\[ X = \beta(X) \sum_{x \in \mathbb{X}} \psi(x) \]
(such that \( kK = 1 \))
Match kernel computation via inner product
\[ K(X,Y) = \beta(X)\beta(Y) \sum_{x \in \mathbb{X}} \sum_{y \in \mathbb{Y}} K(x,y) \psi(x)\psi(y) \]

We seek to
- Identify a kernel function for patches that reflects their resemblance in terms of gradients and their proximity in terms of spatial position.
- Create vectorized local descriptor representation aggregating multiple pixel attributes, such that inner product of two such patch representations approximates a match kernel of the form:
\[ K(X,Y) = \beta(X)\beta(Y) \sum_{x \in \mathbb{X}} \sum_{y \in \mathbb{Y}} K(x,y) \psi(x)\psi(y) \]

Embedding and aggregating pixel attributes
\[ \theta \text{ and } \varphi \text{ are angles and are trivially mapped with (2).} \]
The radius \( \rho \) of each pixel \( x \) is mapped to an angle by \( \rho = \rho_0 \pi, \) with \( \rho_0 \in [0, 1] \) and then embedded with (2).

2D weighting function for 3 sample pixels. Colors reflect spatial similarity to other pixels. Red corresponds to maximum similarity.

Final local descriptor representation:
\[ X' = \beta(X') \sum_{x \in \mathbb{X}'} \psi(x) = \beta(X') \sum_{x \in \mathbb{X}'} \rho_0 \psi(\rho_0 \gamma) \otimes \psi(\gamma) \otimes \psi(\varphi) \]
\[ K(x', y') = \sum_{x \in \mathbb{X}'} \sum_{y \in \mathbb{Y}'} K(x,y) \psi(x)\psi(y) = K(X', Y') \]

References