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Rotation, Scaling and Illumination Invariant Pattern Recognition Using Joint Transform Correlator for Object Detection and Tracking

Introduction
The joint transform correlator (JTC) based techniques such as Fringe-adjusted JTC (FJTC) can be efficiently used for real-time optical pattern recognition and tracking applications. The main advantage of JTC is that it does not require apriori fabrication of a complex filter. However, JTC is sensitive to rotation, scale and illumination changes of objects that presented in input scenes.

Methodology
Our proposed scheme contains two components: Local Phase (LP) and Synthetic Discriminant Function (SDF).

Local Phase
Monogenic signal: \( f_M(x) = f(x) - (i,j)f_R(x) \), where \( f_R(x) = \frac{x}{2\pi M^2} f(x) \)
Local phase (LP): \( \varphi(x) = \arg(f_M(x)) \)

Synesthetic Discriminant Function
SDF image is formed from training images:
\[
SDF = \sum_{i=0}^{n} a_i r_i(x,y)
\]
where \( r_i \text{ : training images, } a_i \text{ : coefficients} \)
Correlation between SDF and each training images:
\[
corr_r = SDF \odot r_i(x,y)
\]
Error:
\[
err = \frac{corr_{max} - corr_{min}}{corr_{max}}
\]
Updated coefficients:
\[
a_i = a_i \cdot (corr_{max} - corr_{min}) \times \delta
\]
i: iteration number, \( \delta \) : relaxation factor

Test Results on Tracking
A robust fringe-adjusted joint transform correlator based on SDF and the monogenic signal is proposed. By utilizing monogenic signal enable us to significantly reduce the effect of background illumination thereby achieving illumination invariance, while the SDF helps to eliminate object distortion such as rotation and scaling. Experimental results show that he proposed technique can be used as a real-time region-of-interest detector in wide-area surveillance for automatic object detection and tracking.

Test Results on Object Detection

Conclusion

Motivation
Objects in an input scene could be mainly distorted by three factors:

- **Rotation**
- **Scaling**
- **Illumination**

These introduce a difficulty for JTC-based techniques for efficient target discrimination. Therefore, our goal is to reduce the sensitivity to target distortion such as rotation, scaling and illumination, so that improve the detection efficiency of JTC in terms of sharper correlation peak intensity, narrow correlation width and higher pattern discriminability.

Fig. 1 A Fringe-adjusted JTC architecture.
Fig. 2 Distortion Factors.
Fig. 3 SDF.
Fig. 4 Tracking results. FJTC (Green), Logarithmic FJTC (Yellow) Proposed (Red)
Fig. 5 Training set to generate SDF.
Fig. 6 SDF composite image.
Fig. 7 (a) Test image, (b) 3D correlation.
Fig. 8 Detection Results in different scaling.
Fig. 9 LP-based JTC correlation output.
Fig. 10 Detection result in low illumination.