4th International Conference Photonics and Information Optics, PhIO 2015, 28-30 January 2015

MINACE filters: recognition of the images received from various independent sources

N.N. Evtikhiev, E.K. Petrova, R.S. Starikov, D.V. Shaulskiy, E.Yu. Zlokov*  
National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), Kashirskoye shosse 31, Moscow, 115409, Russia

Abstract

The investigation results of distortion invariant correlation filters application to recognition of objects captured by different independent digital cameras in different conditions are presented. © 2015 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/). Peer-review under responsibility of the National Research Nuclear University MEPhI (Moscow Engineering Physics Institute)

Keywords: correlation pattern recognition; distortion invariant filters; MINACE filter.

1. Introduction

Application of distortion invariant correlation filters (DIF) allows to achieve invariance of correlation image recognition method to different distortions of target object such as planar and spatial rotation, scaling, illumination variations, deformation, etc. DIF application approach is based on replacement of target object image by synthesized effective fiducial object – correlation filter (CF), which includes a priori defined information about possible distortions. One of the most perspective types of CF is filter with minimization of noise and average correlation energy (MINACE) [Cassasent et.al (1992)]. This filters showed effective results of application to invariant recognition of target object represented by grayscale images in presence of complex background noises. Moreover MINACE filters are economic in terms of computational burden during its synthesis. Early researches showed the possibility to achieve a high recognition characteristics using CF MINACE. Special interest of CF MINACE application is connected to possibility of its realization in optical image correlators [Cassasent et.al (2005-2008) Evtikhiev et.al (2012-2014)].

* Corresponding author. Tel.: +7-926 215 12 18; fax: +7-499-324-74-03.  
E-mail address: ezlokov@gmail.com

doi:10.1016/j.phpro.2015.09.165
The major goal of the present article is investigation of optimal representation of training information about target object for CF MINACE synthesis for target object images recognition in conditions close to real life problems.

2. Object recognition problem

Modal formulation of recognition problem assumes distinguishing of “true” object images from the images of tree types “false” object with similar shapes in condition of spatial rotation of objects; see for example [Evtikhiev et.al (2012-2014)]. We used 256-levels (8 bit) grayscale images with the resolution of 256x256 pixels. Figure 1 illustrates the examples of test images that were used in our researches.

![Fig 1. Examples of test images used in our investigations: columns 1–3 – “false” objects; column 4 – “true” object](image)

Images been used in the work:

1) Two independently achieved sets contained by 358 images of scale models of “true” and “false” objects subjected to rotation in the range of 360 degrees with different viewing angles captured by digital reflex photo camera,

2) Two independently achieved sets contained by 358 images of scale models of “true” and “false” objects subjected to rotation in the range of 360 degrees with different viewing angles captured by commercial web-camera,

3) Images obtained using vector 3D model of “true” object in the range of 360 degrees of rotation

4) Different images of real test objects from random view points captured in different environment conditions

The synthesis of CF MINACE was provided analogously to [Evtikhiev et.al (2012-2014)]. The amount of training images of target object varied during the synthesis, the developed software allows to use more than 800 images to be used in filter generation. For each synthesized filter we numerically calculated the cross-correlation function between filter and test images and obtained the discrimination characteristic – the dependence of filter response from the count number of object viewpoint. Two types of correlation metrics were used to provide the achieved correlation fields post-processing: the height of correlation peak and peak-to-sidelobe ratio value. Statistical characteristic of each filter discrimination ability was estimated according to Neyman-Pearson criterion.

3. Recognition of images captured by different cameras

There are three cases were investigated for test images of objects scale models with the uniform background, different viewpoints and different amount of training images used for CF MINACE synthesis:

1) The same collection of images captured by digital reflection camera were used as training images for filter synthesis and as test images to be recognized (C1-C1 case)

2) Different collection of images captured by the same digital reflection camera were used as training and as test images to be recognized (C1-C2 case)
3) Training images collection and test images collection to be recognized were captured by different cameras (reflection digital camera and web-camera) in different illumination conditions. The illumination variability was partially adjusted during the preliminary processing (C1-W case).

When uniform background was used in test images we achieved the next results: in C1-C1 case probability of recognition error was less then 0,1%, in case C1-C2 it was about 1% while in case C1-W probability of error was 10%. The discrimination characteristics of these cases are illustrated on figures 2-4. In all the investigated cases the optimal condition of CF MINACE synthesis was established.

![Fig 2: The example of CF MINACE discrimination characteristic. Illustrated plot represents the dependency of correlation peak amplitude from the number of object image in chosen collection in C1-C1 case for all the test objects used in simulations. The number of image in collection corresponds to the same viewpoint for all collections of objects. Viewpoint polar angle was fixed on 50 degrees; the range of viewpoint azimuthal angle variation is 90 degrees with angular step of 1 degree.](image1)

![Fig 3. CF MINACE discrimination characteristics for C1-C2 case in same simulations conditions as in Fig.2.](image2)
4. Recognition of real object images using filters generated from the images of scaled models photographs

Recognition of real objects images using CF MINACE synthesized from scaled models photographs considered by means of investigation of cross-correlation function. In some cases it was observed that in such a rough conditions the quality of correlation function remained acceptable for correct recognition. Figure 5 illustrates one of these cases. The conditions of these tests require an additional investigation and will be considered in our further researches.

![Fig 5. A photographs of a real object and its scaled model with uniform background, used as target for CF MINACE training images set formation (upper row); the intensity of cross-correlation function between these images with the filter synthesized using 358 images of target object.](image-url)
5. Conclusion

In this report we demonstrated the possibilities of correlation pattern recognition method based on CF MINACE application for identification of images of target object in presence of clutter objects captured by different acquisition devices. The conditions of optimal representation of filter training information investigated in the work allowed successful implementation of this method.

Acknowledgements

This work was supported by grant 14-19-01751 from the Russian Science Foundation (RSF).

References