Automatic matching of digital aerospace snapshots with using of Radon integrated transform

S.A.Stankevych

Kyjiv Air Force institute
252186, Kyjiv-186, Povitroflotsky avenue, 30
Phone: (044) 271-6236

Пропонується використания інтегрального перетворення Радона для будування бієкції сегментів комплекту цифрових зображень ділянки аеролландшафту. Сподіване підвищення точності сполучення аерознімків має істотну роль при комплексному дешифруванні матеріалів видового аерокосмічного моніторингу.

The using of Radon integrated transform for construction of bijection between segments of a complete set of the digital images of an aerolandscape section is offered. The expected accuracy increasing of matching of aerosnapshots has an essential role for complex interpretation of imagery aerospace monitoring materials.

The matching of various digital images is the one important class of problems of automated processing of materials of imagery aerospace monitoring. These images are an aerospace snapshots obtained in a miscellany time, into various spectral zones, from systems with distinguish geometry of images creation or generally of various applicability – for example, during outlines binding of an aerosnapshot to a digital terrain map. The obtaining of synthesized digital images on materials of multizonal aerospace survey is impossible without high-precision preliminary matching of source zonal aerospace snapshots [4,5].

In existing systems of matching of digital images is applied morphing on a base points system. These points are determinates by the operator manually. In [3] the morphing system is represented as two components: the generalized linear transform, that nsure a main part of transformation, and residual non-linear elastic deformation by a field of dismatching vectors. A nontrivial problem is the automatic construction of a base points system of matched images. Usually for these purposes the chosen outlines of segments of digital images are used [1]. Defect of the mentioned approach is the rather low energy of an outline of a segment comparable with a noise level of an actual digital image. Traditionally, the reduction of high-frequency spatial noise of digital images is executed by the integrating operators.

One of such convenient operators represents an integrated Radon transform – is a generalized expansion of a $f(x_n)$ function of initial n-dimension space $x_n \in X_n$ to its integrals along every possible hyperplanes ξ_{n-1} [6]:

$$F(\xi_{n-1}) = \int_{\xi_{n-1} \in X_n} f(x_n)\, dx_n \quad (1)$$

There is exist an inverse transform, that regenerating initial function by value of it Radon transform:

$$f(x_n) = \frac{2\,\nabla_n^2}{(-4\pi)^{(n-1)/2}\,\Gamma(n/2)} \int_{x_n \in \xi_{n-1}} F(\xi_{n-1})\, d\xi_{n-1} \quad (2)$$

where

$$\nabla_n^2 = \sum_{i=1}^{n} \frac{\partial^2}{\partial x_i^2} \quad (3)$$

is the Laplace operator.

The Fig.1 illustrates a consecutive using of the direct and inverse Radon transform to a test digital image.

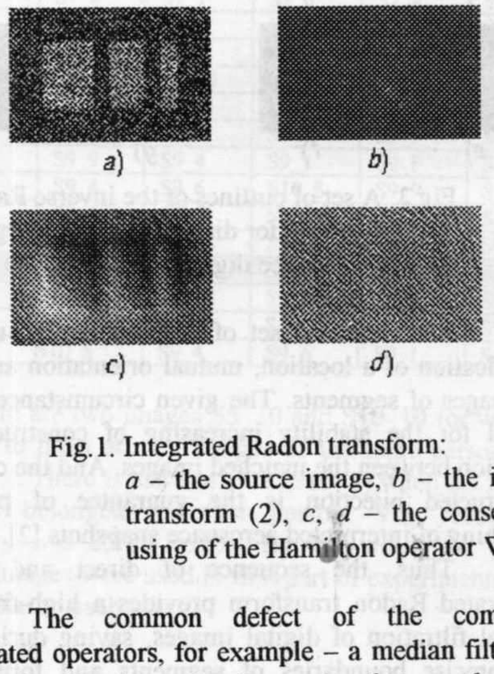

Fig.1. Integrated Radon transform: *a* – the source image, *b* – the inverse transform (2), *c*, *d* – the consecutive using of the Hamilton operator ∇_n

The common defect of the competing integrated operators, for example – a median filtration, is the localization of using acts, that results to a diffusion of the boundaries of segments after derivation. It is illustrated a Fig.2 (*c* and *d* against *g* and *h*).

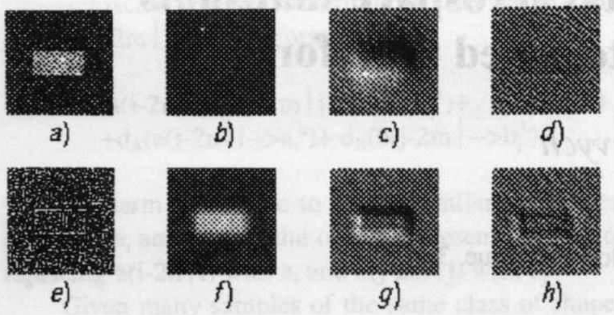

Fig.2. A comparison of Radon transform (*b*) with local filtration (*f*) of an source digital image (*a*)

It is obviously, that the recovery of the boundaries of a segment till a Fig.2*d* is possible with higher accuracy, rather than till a Fig.2*h*. An important feature of Radon transform using to processing digital images – is the capability, on the one hand, acts to limit only of some lines of initial plane and, accordingly, to allocate the boundaries of segments only collinear by it, and on the other hand – to use as a hyperplane, along which the integration conduct, any arbitrary points set of an source image, and not just lines set. The given circumstance allows to apply such generalized Radon transform to allocate segments of the certain beforehand specific configuration on a digital image.

The inverse Radon transform forms on a digital image some regular texture including a set of outlines, appropriate to segments configuration, that the Fig.3 is illustrated.

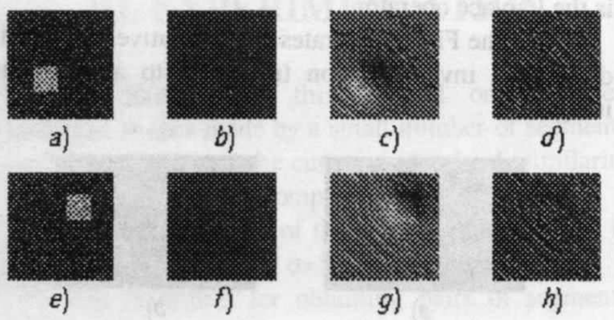

Fig.3. A set of outlines of the inverse Radon transform for displacement of a segment of an source digital image (*a*) - (*e*)

The indicated set of outlines can be used for clarification of a location, mutual orientation and scale of images of segments. The given circumstance can be useful for the stability increasing of construction of bijection between the matched images. And the correctly constructed bijection is the guarantee of precision matching of interpreted aerospace snapshots [2].

Thus, the sequence of direct and inverse integrated Radon transform provides a high-frequency spatial filtration of digital images, saving during of it the precise boundaries of segments and forming an additional set of signs of their shape and orientation. With reference to aerospace snapshots the described property can represent itself as a base for construction of bijection between different images of one section of an aerolandscape by the analysis of topological invariants of segments [1]. The order of operations for automatic matching of digital aerospace snapshots is explained to a Fig.4.

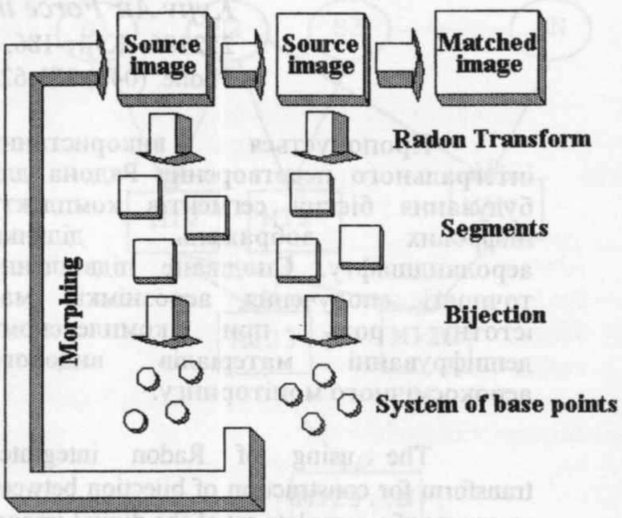

Fig.4. The scheme of automatic matching of digital aerospace snapshots

REFERENCES

1. *Станкевич С.А.* Моделі автоматичного сполучен-ня сегментованих дискретних зображень // Праці другої Всеукраїнської міжнародної конференції з обробки сигналів і зображень та розпізнавання образів.- Київ: ІК НАН України, 1994.- С.167-169.
2. *Станкевич С.А.* Оценка качества синтезирован-ных цифровых изображений // Информационные технологии в дешифрировании изображений: Классификация и оценка эффективности.- Киев: МО Украины, 1995.- С.36-51.
3. *Станкевич С.А., Шестаков К.В.* Модель биектив-ного совмещения цифровых изображений // Про-блемы повышения эффективности энергетичес-ких, разведывательных и управляющих комплек-сов / Материалы военно-научной конференции.- Киев: МО Украины, КИ ВВС, 1996.- С.53-56.
4. *Stankevich S.A.* The Linear Models of Optimal Syn-thesis of the Discretic Zonal Images // Proceedings of the Third All-Ukrainian Conference by Signal/Image Processing and Pattern Recognition.- Kyjiv: NAS IC, 1996.- P.149-152.
5. *Станкевич С.А.* Оптимальное факторное синтези-рование зональных цифровых изображений // Проблеми здобування, збору та обробки даних повітряної розвідки / Збірник наукових праць.- Київ: МО України, КІ ВПС, 1998.- С.18-22.
6. *Хелгасон С.* Преобразование Радона: Пер. с англ.- М.: Мир, 1983.- 152 с.