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Tomasz Praczyk
Naval University of Gdynia

RADAR IMAGES COMPRESSION FOR THE NEED OF A POSITIONING COASTAL SYSTEM AND AN ASSESSMENT OF THIS PROCESS

ABSTRACT The article presents how to assess different compression algorithms in the context of using them according to radar images and approximation position methods. Furthermore, an assessment of two images compression methods was shown – Fast Fourier Transform method and projection method.

INTRODUCTION

Radar images are the source of information which allows us to fix the position connected with them. This process could be fulfilled by applying classical radar navigation methods, comparative navigation methods and also artificial intelligence methods such as neural networks [12]. Calculation complexity, which is one of the features of the mentioned above two last methods, forced us to present radar images in more compact form (vector of radar image features) to avoid very complicated calculations in the process of position fixing. Features extraction from radar images is also necessary when we are talking about setting up the positioning system – it concerns parametric function approximation methods such as some of neural networks.

There are a lot of image compression methods but there is a problem with estimation of their usefulness in the radar images processing and position approximation methods. Presented in [5] and [6] results are based on estimating the compressing Kohonen neural network using position accuracy achieved by the positioning system based on radar images compressed by this neural network. Thus, we have the estimation of the given solution without the knowledge about contribution of each part of the system to the final result.

Just, for that reason, it was necessary to find the universal criterion of estimation of the radar image compression algorithms, with reference to position approximation systems. The most important question was to determine what kind of compression will help and what can be considered as an obstacle in the process of fixing the position by approximation system. It was proved that in the case when the learning process of the positioning system will use original compressed radar images – we will have a large set of examples of original radar images taken from the coast area under consideration – then the goal at the compression phase is to save all relations between original radar images in the compressed images domain. This means the situation, when similar radar images will possess representatives in the compressed images domain also similar to each other. Solutions, which would disperse compressed radar images equivalents from positions close to them, would increase the speed of the changeability of the approximating position function in the areas where data are similar to each other but simultaneously are characterized by the considerably different value of the position function. The position function can be presented by the following:

$$f(\mathbf{d}) = \mathbf{p} \tag{1}$$

where, **d** is an compressed radar image and **p** is a latitude and longitude vector.

To ensure appropriate accuracy of positioning system these areas would have to be represented by greater number of learning data extending simultaneously calculation time in the learning or conclusion stage. The evaluation function of radar images is as follows:

$$E = \frac{1}{c}\sum_{i<j}^{n}\left[\left(a_{ij} - a_{ij}^{*}\right)^{2} \big/ a_{ij}\right] \tag{2}$$

$$c = \frac{n(n-1)}{2} \tag{3}$$

where: n – number of test radar images with corresponding features vectors;
i, j – indexes of consecutive radar images and their compressed equivalents;
a_{ij} – normalized Euclidean distance between two radar images;
a^*_{ij} – normalized Euclidean distance between two compressed images;

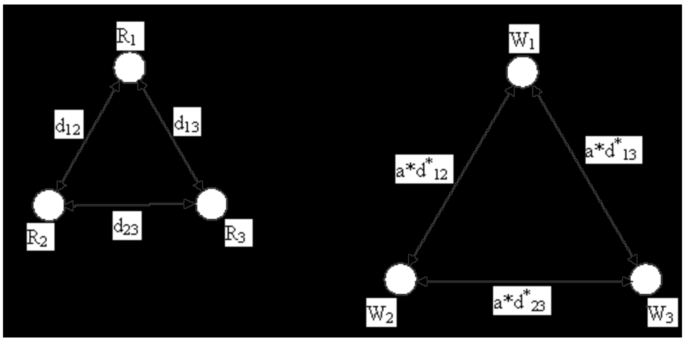
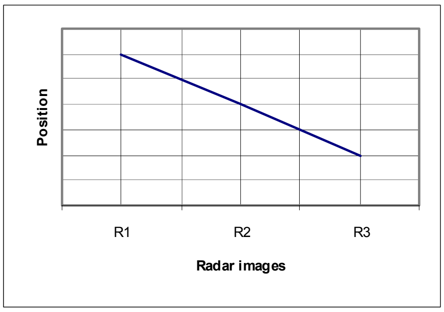
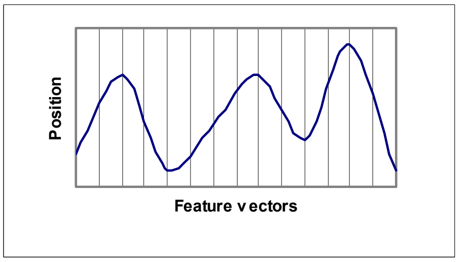


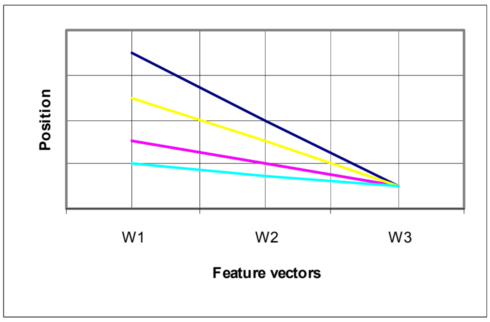
Fig. 1. Compression sub-system functioning perfectly – distances between features vectors (W1, W2, W3) are proportional to the distances between corresponding radar images (R1, R2, R3)



a)



b)



c)

Fig. 2. Comparison between correct and wrong functioning of a radar images compression sub – system: a) – position function in radar images domain,
b) – position function in features vectors domain (wrongly working compression sub – system),
c) – position function in features vectors domain (correctly working compression sub – system)

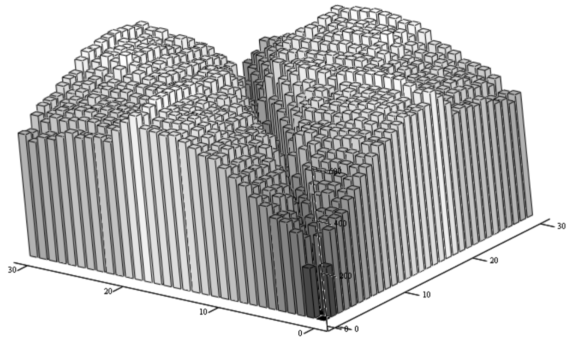
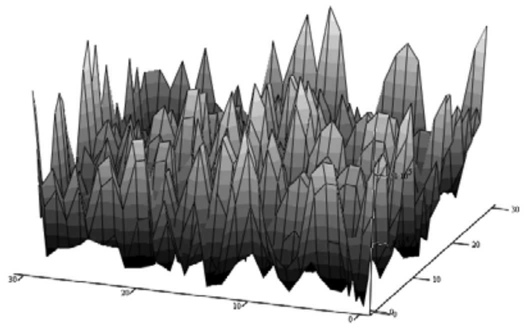
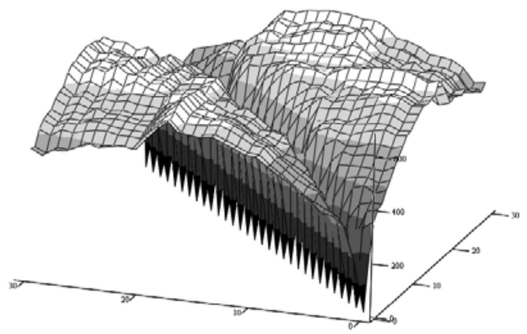


Fig. 3. Hypothetical distance matrix between 31 radar images recorded on the Gdansk Bay – on the two axes are presented indexes of consecutive radar images, radar images which possess neighbouring indexes correspond to close positions.



a)



b)

Fig. 4. Hypothetical distance matrix between the same radar images after a compression (a – bad compression, b – good compression)

On the Fig.2 there are presented three examples of the position functions. In the first case (a) the system is based on original radar images. The position function is easy to approximate. It is a result of the fact that every two similar radar images always correspond to two close positions. Furthermore, two completely different radar images always correspond to two quite distant positions. Certainly the above sentence is not always true. Perhaps we can find places on the world which are situated far to each other and possess a very similar coastline. However, we will consider only those areas which meet presented above condition. Taking all into account we may say that if the position system worked on the basis of original radar images it would not have a difficult task. In our opinion it is possible to have positioning system which will has accuracy good enough which will use a small set of learning data. Unfortunately due to a huge amount of information coming from radar images and troubles with speed of calculation this kind of solution is applied practically very rarely.

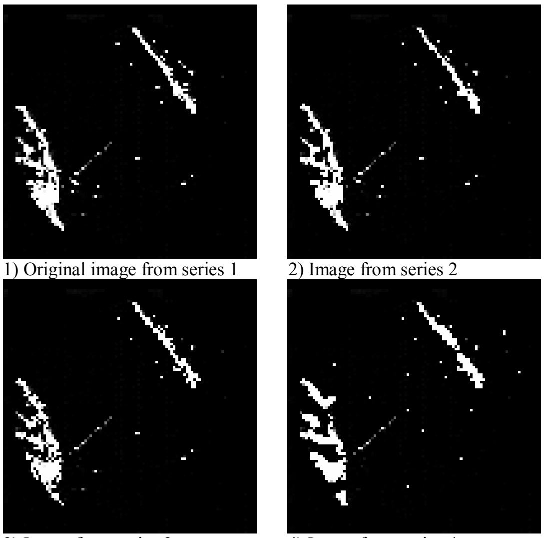
The (b) situation presents the reasoning based on compressed images. The position function is much more complex, what for achieving an enough accurate positioning system will demand to use increasing set of learning data. This will negatively influence a speed of the system. This is the case when the features extraction sub-system of the positioning system does not preserve relations between radar images in the compressed images domain. Distant positions images can be located very close to each other in this case.

The (c) situation corresponds to perfectly working compression sub – system. Relations was saved, what is presented by flat position functions similar to this obtained in the case of using original radar images – (a). To obtain the accurate position approximation system we will need sparse learning set as it was in the (a) case.

THE ASSESSMENT OF RADAR IMAGES COMPRESSION USING THE FFT METHOD AND THE PROJECTION METHOD

To compare the projection and the FFT radar images compression methods, 31 original black and white radar images coming from the Gdansk Bay area were used (distances between consecutive registrations of radar images is about 600 m) and 93 derivatives of these images. Each original image had additionally 3 converted from it equivalents which sums to 4 image series – each consisting of 31 images from different positions (primary series no. 1 with the originals and series no. 2, 3 and 4 with the copies). Images with the same indexes in each of the series corresponded to the same ship position (position registered using GPS).

Additional radar images were constructed by the rotation of original images at an angle from the range of <-3°, +3°> and then after the rotation, deformations to original images were introduced. The rotation was used in order to take a gyro compass error into consideration. A gyro compass is envisaged to use in the positioning system to determine a direction – to arrange radar images according to the N – S direction. The magnitude of introduced deformations was different for each of consecutive images series. The smallest differences occurred between series no. 1 and no. 2, next between series no. 1 and no. 3 and the biggest disparity was between images series no.1 and no. 4.



1) Original image from series 1 2) Image from series 2

3) Image from series 3 4) Image from series 4

Fig. 5. Hypothetical radar images used during researches

All images were reduced to 100*100 pixels size and next compressed. The original radar images contained 10000 information units, during compression, were reduced to 200 information units size vectors. In the case of usage FFT transform, obtaining compressed data, consisted in reading 200 the most significant matrix elements obtained after an image transformation. It was 14 first values from 14 first FFT matrix rows, plus additional elements from the matrix diagonal – FFT[15,15], FFT[16,16], FFT[17,17], FFT[18,18].

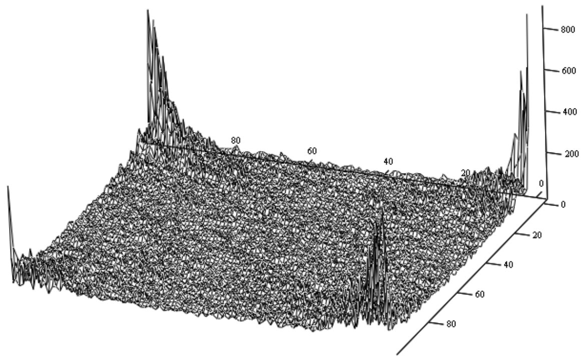


Fig. 6. Fourier transformation of a hypothetical radar image

The projection method is based on calculation of mean pixel value for each of image column and row. Results of the assessment of the projection and FFT method are presented below.

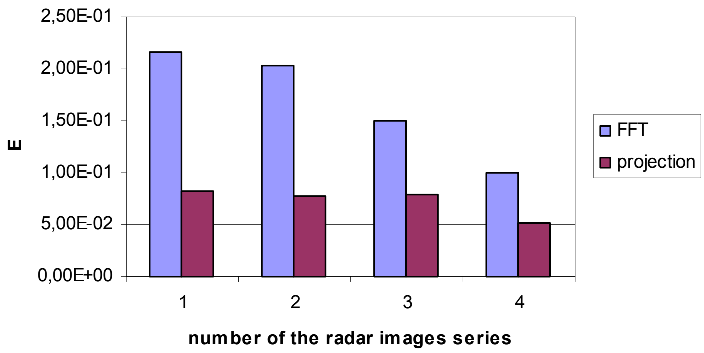


Fig. 7. The comparison of the compression methods: n – number of the images series

From the above figure it is clearly visible that, Fourier transform method preserves concentrations from the radar images domain worse then the simple projection method. It results that a better solution during building the positioning system, demanding the radar images compression, is using the projection method.

SUMMARY

Radar images are the source of information which allows us to determine the position connected with them. This process could be fulfilled by applying classical radar navigation methods, comparative navigation methods and also artificial intelligence methods such as neural networks.

Usually it is necessary to transform images to more compact form saving simultaneously all the most significant features. In the case, when the positioning system is build on the base of original radar images (without using images simulated from electronic chart), the compression sub – system should retain all relations occurring in a compressed equivalents domain. Thus, it will ease a task of final approximation position sub – system not causing unwonted folding of the approximated function, which for achieving the suitably accurate positioning system will demand to use an extensive set of learning data, what we want to avoid at all costs.

In the article is presented the assessment of the two image compression methods in the context of using them in relation to radar images and the considered positioning systems. They were the projection and FFT methods. The solution which better retain whole concentrations occurring in radar images domain on their equivalents site was simple projection method.

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