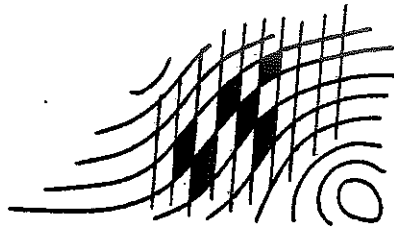


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The 5th Open
German-Russian Workshop
on Pattern Recognition and
Image Understanding

*21-25 September
Herrsching
1998*



FORWISS 1998

The 5th Open German-Russian Workshop on
Pattern Recognition and Image Understanding

Herrsching, Germany
September 21 - 25, 1998

General Information

The general goal of the series of workshops, held in former years in Berlin, St. Petersburg, Erlangen, and Valday, is to establish and improve scientific contacts between researchers from Russia, Germany, and other countries in order to advance the important field of Pattern Recognition and Image Understanding.

Workshop Committee

- | | |
|------------------------|------------------------------|
| Prof. Y. Zhuravlev | (Moscow, Russian Federation) |
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| Prof. P. Levi | (Stuttgart, Germany) |
| Prof. O. Salvetti | (Pisa, Italy) |



**Session IV
Applications II
(16:30-18:30)**

- 7 Mobile Robot Navigation in Context of Spatial Data Processing, *Lubos Král, Miroslav Kulich, Libor Preucil, Petr Stepan*
- 9 Towards an Image Understanding Architecture for a Situated Artificial Communicator, *Christian Bauckhage, Gernot A. Fink, Franz Kummert, Stefan Posch, Gerhard Sagerer, Daniel Schiller*
- 2 A Control Structure for an Observation System for Service Robots, *Petru Moessner, Peter Weierich, Heinrich Niemann*
- 56 On Mathematical Models Related to Automated Safety Systems for Subway Platforms, *I.B. Gurevich, Y.I. Zhuravlev, Y.G. Smetanin*

Wednesday, 23.9.98

**Demonstrations
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- D1 Computer Vision Technology to Improve Safety of Car Driving, *M.M. Lange*
 - D2 Quickly retrainable program system for signal recognition on the basis of support point method (handwritten symbols, spoken commands), *V.V. Mottl, A.B. Blinov, A.V. Kopylov, A.A. Kostin*
 - D3 Program system for the analysis of 3D data of seismic explorations for oil and gas in the crystalline basement interval, *V.V. Mottl, A.B. Blinov, A.A. Kostin, A.S. Yermakov*
 - D4 Demonstration Version of OTEKS Applied Program Package for Processing of Experimental Data Tables, *N.G. Zagoruiko*
 - D5 Program System of Pattern Recognition and Data Analysis LOREG, *V.V. Ryazanov, O.V. Senko, A.P. Vinogradov, V.A. Voronchikhin, Yu.I. Zhuravlev*
 - D6 Open System for Image Analysis and Processing Problems Solving with Data Base Functions, *I.B. Gurevitch, A.V. Khilkov, N.S. Polikarpova, Yu.G. Smetanin, Yu.I. Zhuravlev*
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- 15 Pattern Matching Using Distorted Color Histograms, *Georg Thimm, Juergen Luettin*
 - 19 Research paths coding within an image analysis and synthesis laboratory, *L. Mollato, O. Salvetti, D. Vitulano*

- 43 The Test Recognition Pattern with Genetic Algorithms Use, *A.E. Yankovskaya*
- 31 Optimization procedures in spectral approaches to pattern recognition problems, *S.A. Mukhortykh, M.M. Ustinin*
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Session II
*Image, Signal and
Speech Processing,
Analysis and
Understanding V*
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- 57 Some problems of Image Coding and Stereovision, *V.N. Kozlov*
- 17 Nonlinear Filtering for Solving the Problem of Variability in Speech Recognition, *Alexander M. Krot, Mikhail A. Shcherbakov and Polina P. Tkuchova*
- 11 Computation of Projective Invariants using the Trifocal Tensor, *Eduardo Bayro-Corrochano and Joan Lasenby*
-

Session III
Applications III
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- 20 The Brain Matcher, *Sergio Di Bona, Stefan Huwer, Heinrich Niemann, Ovidio Salvetti*
- 8 Use of Registration Methods to Correct Movement in 3D Magnetic Resonance Breast Images, *Luisa Vieira, Peter Unrill, Fiona Gilbert*
- 58 An Interval Approach to Discover Knowledge from Multiple Fuzzy Estimations, *Vagan Terziyan, Seppo Puuronen, Helen Kuikova*
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Discussion
(16:30-18:00)

Outlook and Further Research
in Pattern Recognition and Image Understanding

The Brain Matcher

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Keywords: Representations, Data Structures and Transforms, Edge and Feature Detection, Size and Shape, Neural Nets

In the Image Analysis field a main problem is to match a "Source" image with a "Target" image, that is to find the rule that controls the modification of the global characteristics of the Source in such a way as to match the Target.

This match may be useful in a lot of practical applications and in particular in medical imaging (MI). For example, in Magnetic Resonance, differences in corresponding slices (i.e. referring to the same scene but at different times) due to the patient's breathing or motion should not be taken into account if tissue lesions must be evaluated; or, in CT scans of the encephalon, where one of the two scenes is deformed by an expansive lesion, an analysis of the deforming agent should determine the law which acts also on those parts where the deforming process is difficult to analyze.

The matching problem in MI can be faced using a neural net (NN) approach, where the nodes are related to the image pixels and the synapses to the pixels' information: locations, grey values, gradients, angles, and so on.

In some cases, NN models for image matching are based on the individuation and marking of corresponding elements in homologous image pairs [1, 2], or they are restricted to images without disparities due to some noise [3].

Anyway, these models operate on images with peculiar characteristics: first, the images are acquired with a few time delay between each other and while the patient keeps his/her position; thus, corresponding slices really refer to corresponding anatomical sections. This is not true with images taken at different times (even years) when the patient is not in exactly the same position, so that corresponding slices may be very different. In the MRI of the brain, for example, a slightly different rotation of the patient's head between two acquisitions, leads to big differences in corresponding slices; furthermore, in images taken over long periods of time, an evident lesion in one slice may be minimal or even absent in the corresponding one: thus, corresponding points in corresponding slices may lie on really different positions.

Besides, usually, only morphometric characteristics are considered, that is only shape deformation is processed.

This paper presents the BrainMatcher project, an approach for a data-driven comparison and registration of digital images of the brain. The approach proposes an innovative neural network model, based on the extension of the method proposed by [1]. The 'Self Organizing Maps' idea, introduced by Teuvo Kohonen [4], is extended in order to match homologous tomographic image pairs with big disparities, considering both their morphometric and densitometric characteristics, in order to find the law able to model a growing intracranial lesion inside the brain.

Images, considered as regular two-dimensional arrays, are manipulated assuming that their pixels are nodes of a network.

The learning steps of a Kohonen Map are simulated by using a Target image as the 'stimuli space' from which a certain number of patterns is selected to be presented in

input to the net. At every input, the net evolves in such a way as to tune itself on the stimuli space, that is to match the Target.

Both the pixels' position and grey level are modified. The process is split into two phases: the stimuli space is firstly defined by the Target pixel positions, while, in a second step, the space is defined by the Target pixel grey levels.

Two optimizing methods are also proposed to improve the learning process: the section and the iso-line methods. Both have the goal to speed up the learning phase defining specific criteria for searching and individuating the corresponding elements in an homologous image pair. In the first case, the images are initially partitioned according to the morphology and symmetry of the brain and then corresponding elements are searched on restricted areas depending on the partitions themselves; in the second case, relevant iso-density contours are detected and the search area are found close to the contours.

The algorithms developed have been tested on real complex cases: pairs of tomographic brain slices of the same patients, containing both normal and pathologic conditions (such as cancer or hematoma), have been processed in order to characterise lesions and to derive the deformation laws that affect anatomical structures and their relationships. The results have been evaluated on the basis both of the Mean Square Error (MSE) between Target and Result images, and of the visual analysis, performed by an expert, of the difference images between Source, Target and result images.

Figure 1 shows an example of image matching. Figure 1a and 1b show corresponding encephalon MR images of the same patient; Figure 1a, where a hematoma is evident in the lower right region, is the Source image, while Figure 1b, taken before the lesion appearance, is the Target image. The result image after the matching process is displayed in Figure 1c.

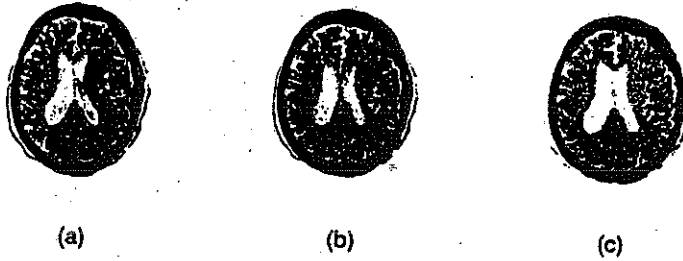


Figure 1: Example of MR brain image matching. (a) Pathologic brain (b) Normal brain (c) Result image.

Figure 2 displays the computed difference between Source and target (a) and Result and Target (b): darker points correspond to higher differences.

It is evident that, in case (b), shape differences, on the skull, as well as density differences, on the hematoma, have almost disappeared.

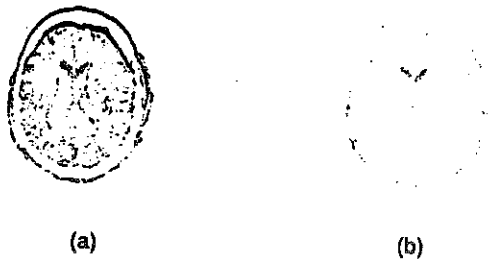


Figure 2: (a) Difference between Source and Target (b) Difference between Result and Target.

The BrainMatcher has been implemented on a "Silicon Graphics XS24 RISC 4000". A database of about 200 CT and MRI brain corresponding slices (*source* and

target images) was used relative to 40 different patients, with the resolution of 256x256 pixels.

As a concluding remark, a consideration should be done on the possibility of using BrainMatcher to build a Correspondence DataBase (CDB), in which the matching laws obtained for a set of homologous image pairs selected as paradigms of classes of pathologies could be stored.

A main problem in neurosurgery is to know accurately where certain neurofunctional districts or important blood vessels have displaced after a growing lesion has deformed a brain.

Using CDB, from a pathologic image, a normal brain section could be reconstructed and, vice versa, a normal brain could be deformed by applying a transformation law. If suitable additional information can be fused to a tomographic slice, BrainMatcher can then help to build a CDB facility useful for computing or simulating the displacements of anatomical or functional districts due to growing intracranial lesions in the brain.

Acknowledgments

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