Expressions of Interests

I. Research Group Heading/Name & Full Address/Affiliation.

The Image Processing and Pattern Recognition Group

Our main activities are research and teaching in the fields of image processing, pattern recognition, computer vision and medical image processing.

- **To contact us:**

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II. Name of the Group's Leader with a Short BIO (CV).

Prof. Ryszard S. Choraś, PhD EE, DSc EE

Prof. Ryszard S. Choraś is currently Full Professor in the Institute of Telecommunications and Computer Sciences of the UTP University of Sciences and Technology, Bydgoszcz, Poland. His research experience covers image processing and analysis, image coding, feature extraction and computer vision. At present, he is working in the field of image retrieval and indexing, mainly in low- and high-level features extraction and knowledge extraction in CBIR systems. He is the author of Computer Vision. Methods of Image Interpretation and Identification (2005) and more than 183 articles in journals and conference proceedings.

He is the member of the Polish Cybernetical Society, Polish Neural Networks Society, IASTED, and the Polish Image Processing Association. Professor Choras

is a member of the editorial boards of *Machine Vision and Graphics, International Journal of Biometrics (IJBM), International Journal of Biology and Biomedical Engineering, Recent Patents On Signal Processing (Bentham Open).* He is the editor-in-chief of *WSEAS Transaction on Signal Processing Journal, Image Processing and Communications, An International Journal and a*ssociate editor-in-chief *Computer Science Journals (CSC Journals) Image Processing (IJIP)*.
He has served on numerous conference committees, e.g., as Visualization, Imaging, and Image Processing (VIIP) , IASTED International Conference on Signal Processing, Pattern Recognition and Applications (SPPRA) and International Conference on Computer Vision and Graphics, ICINCO\ICATE Conference.

III. Names of the Group's Members, and Their Research Areas/Interests.

- Mirosław Maszewski PhD EE
- Adam Marchewka PhD EE
- Mirosław Miciak PhD EE
- Łukasz Saganowski PhD EE

IV. Leading Research Topic of the Group.

- Image compression
- Biometrics
- Biomedical image processing
- CBIR systems
- Pattern recognition
- Computer vision, Robotics

V. Best Realizations of the Main Research Topic (Brief Characteristics or Description).

VI. General Expression of Interests.

Research Program

Members of the Image Processing Group have expertise in the area of telecommunications systems and computer science and engineering. The primary emphasize in research is given to image processing, pattern recognition, computer vision, and medical imaging. Other important areas of study include computer graphics image retrieval, person identification and telemedicine.

Computer vision and image processing have applications in many areas of human activity such as industry and medicine. The common task in all applications is a need for an image processing, e.g. to remove noise or restore image, followed by an image analysis in order to recognize certain parts of the scene and then perform image-based measurements or visualization of desired structures.

Research areas in image processing and computer vision include techniques for image filtering, image enhancement, image restoration, image segmentation, image labeling, image understanding. A number of techniques is used in building the solutions for various computer vision problems including neural networks, genetic algorithms, expert systems, physics-based deformable models, clustering algorithms, optimization algorithms, and mathematical morphology.

Biomedical image processing and analysis has been one of the main IPG research topics. Modern medical imaging modalities provide medical doctors with huge amount of information that requires quantitative analysis for diagnostic and interventional medical purposes. The image data can be two-dimensional (2-D) or three-dimensional (3-D) and can be a static image or an image sequence. The structure of interest has to be extracted using pattern recognition methods. The obtained structure can be measured and visualized for use by a medical doctor.

Image management techniques are used to store, retrieve, and display image data and integrate this information into various information systems.

We are specially interested in texture perception, grey level shape analysis and mathematical models for image representation.

Another important task in computer vision is the extraction of low level image characteristics, like edge points, ridge and valley lines, local extrema, etc. In literature we find a large number of extraction methods which consist in approximations to the definitions of these concepts. Our aim is to translate this idea into computer vision regarding the salient characteristics of images as points and curves on a surface.

The recognition of objects and their structural distribution on the image implies the formation and representation of geometrical models, and the understanding of phenomena resulting from the projection of objects on the image. We are working in this field in two areas : document recognition, and object recognition in complex scenes.

In the area of 2D model-based object recognition, we have been working on the aspect of complexity reduction. We approach the problem of 2D model-based object recognition as the problem of finding a transformation that matches model features to a subset of image features. We look for that transformation in a "Transformation Parameter Space", that allows us to make an efficient search. The method works on polynomial-time, while it is robust in the presence of geometric uncertainty. Features used consist of line and curved segments from the contour of the objects. We introduce unary geometric constraints that in practice reduce the complexity of the method. Experimental results are given applying the method to the license plates recognition problem.

A feature-based recognition of objects which is independent of their position, size, orientation and other variations has been the goal of much recent research. The problem of reducing the representation of an image to a small number of components carrying enough discriminating information is referred to as feature extraction. The features should be informative and invariant under affine transformations.

There have been several kinds of features used for recognition: visual features (contours, textures), transform coefficient features, statistical features (moment invariants).

Texture and color are two important visual cues that give a lot of information from surfaces in the scene Texture is the visual cue due to the repetition of image patterns. It is used in several tasks such as classification of materials, scene segmentation and extraction of surface shapes from the texture variations. Much work in computer vision has focused on the texture perception problem. Psychophysical experiments and neurobiological evidences have provided the basis for the definition of computational models of texture perception.

The color visual cue is the result of the observation of an specific illuminant on a given surface using three different types of sensors. In computer vision color has been used in region segmentation tasks, image classification, image database retrieval, surface chromatic constancy analysis, etc. The representation of color has been largely studied emphasizing the aspects of constructing perceptual spaces that allow to apply the computer vision methods.

Recently, several studies have been directed to the problem of co-joint representations for texture and color – e.g. image retrieval systems.

Content-based retrieval can be divided in the following steps:
Preprocessing: The image is first processed in order to extract the features, which describe its contents. The processing involves filtering, normalization, segmentation, and object identification. The output of this stage is a set of significant regions and objects.
Feature extraction: Features such as shape, texture, color, etc. are used to describe the content of the image. Image features can be classified into primitive. We can extract features at various levels.

The main motivation to use Gabor Wavelets is that the receptive fields of the simple cells in the primary visual cortex of mammals are oriented and have characteristic spatial frequencies. These could be modelled as complex 2-D Gabor filters. Gabor filters are efficient in reducing image redundancy and robust to noise. Such filters can be either convolved with the whole image or applied to a limited range of positions. In such case, a region around a pixel is described by the responses of a set of Gabor filters of different frequencies and orientations, all centred on that pixel position.
Gabor proved that a signal's specificity in time and frequency is fundamentally limited by a lower bound on the product of its bandwidth and duration and from this he derived the uncertainty principle for information. Gabor's theory leads to the idea that a visual system should analyse visual information most economically by using pairs of perceptive fields of symmetrical and asymmetrical response profiles in order to achieve minimum uncertainty in both spatial localisation and spatial frequency.

Gabor-based hierarchical object recognition uses Gabor features. The Gabor features are the responses of the Gabor filter with selected values of filter parameters.

Feature extraction is one of the most important steps in biometrics. Our research is focused on passive human identification based on face and ear images as well as fingerprint. The two major approaches based on global or local features have been taken to automatic fingerprint identification.

VII. Specific Interests and Additional Topics of Extended Interest.

VIII. Other Important Characteristics of the Group.

Prof. Ryszard S. Choraś is Editor-in-Chief of an International Journal ***Image Processing & Communications*** which is published in Poland.

IMAGE PROCESSING & COMMUNICATIONS deals with publications of original science articles and providing information about the state of knowledge, methods and tools connected with image processing. Journal is going to be a forum which stimulate progress of researches. Magazine accepts both theoretical and experimental articles.

Journal is interested in following disciplines:

- Image processing: coding, analysis, detection
- Image processing
- Transmission of video data
- Networks for video data transmission; their architecture.
- Coding technologies and algorithms, used in ATM networks
- Protocols for image transmission
- New services for ATM networks

IX. Main Group's Achievements.

X. Max. 5 Best Selected Publications and/or Other Relevant Accomplishments

1. Ryszard S. Choraś, KOMPUTEROWA WIZJA. METODY INTERPRETACJI I IDENTYFIKACJI OBIEKTÓW, Akademicka Oficyna Wydawnicza EXIT, Warszawa 2005.
2. Ryszard S. Choraś, T. Andrysiak, M. Choraś, Content Based Image Retrieval Technique - Pattern Analysis and Applications, vol. 10, no. 4 /October, pp. 333-343, 2007
3. Ryszard S. Choraś, Feature Extraction for Classification and Retrieval Mammogram in Databases - Int. J. Medical Engineering and Informatics, vol1, no.1 2008
4. Ryszard S. Choraś, Mirosław Maszewski, Łukasz Saganowski - Handwritten Digits Recognition System Based on CDWT and Matching Pursuit Transformations - *Recent Patents on Signal Processing,* 2010, *2,* 90-97
5. Ryszard S. Choraś, An Image Analysis of Breast Thermograms - Computer Technology and Application 6 (2015) 64-69