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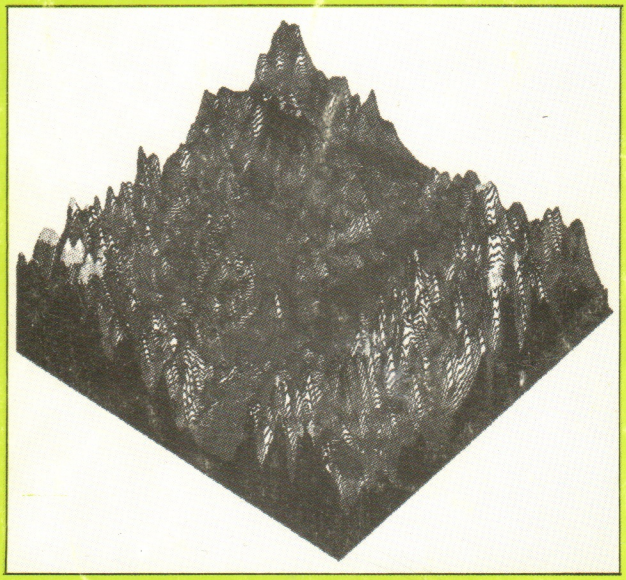
Modelling and New Methods in Image Processing and in Geographical Information Systems

(Modellbildung und neue Methoden in der Bildverarbeitung und in Geographischen Informationssystemen)



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Pattern Recognition and Computer Vision in Slovenia — an Overview

ABSTRACT

An overview of current and past computer vision and pattern recognition research in Slovenia is given, including the most important bibliographical references.

1 Introduction

Research and application of Pattern Recognition was started in Slovenia by the academician prof. dr. Ludvik Gyergyek. In the Laboratory for Systems, Automatics and Cybernetics, still directed by him, work on recognition of handwritting [29] and fingerprints [12.22] began in the 1970's. Soon, analysis of various biomedical signals followed and still later the laboratory became involved in analysis of pictures so that computer vision methods were also gradually introduced. Since this is a university laboratory, a large number of undergraduate and graduate students were educated in the process of preparing and writting their diploma, master and doctoral works. Almost all researchers who work in pattern recognition or computer vision in Slovenia began their career in this laboratory. Therefore it is almost unavoidable

not to begin this overview of pattern recognition and computer vision research in Slovenia with the Laboratory for Systems, Automatics and Cybernetics at University of Ljubljana.

Next, we will talk about the recently started Computer Vision Laboratory in the Computer Science Department at University of Ljubljana. We will continue this short overview by mentioning other groups of researchers who are partially involved in research or application of pattern recognition and computer vision methods.

2 Laboratory for Systems, Automatics and Cybernetics and Laboratory for Artificial Perception

Laboratory for Systems, Automatics and Cybernetics and Laboratory for Artificial Perception are headed by the academician prof. dr. Ludvik Gyergyek and by prof. dr. Nikola Pavešić, respectively. About 15 full-time researchers are working in both laboratories all the time. Pattern recognition research in those two laboratories could be conveniently divided into analysis of one, two and three-dimensional signals.

- Analysis of one-dimensional signals:
  - Analysis of electrocardiograms began almost 20 years ago in cooperation with physicians from the University hospital in Ljubljana. Probably the most important result of this work was the development of a microprocessor based machine for analysis of electrocardiograms during stress testing that can detect simple kinds of arrythmias and other diagnostic parameters in the shape of individual QRS parts [14,39,13]. The analysis machine was in serial production for a few years by Gorenje. Currently, research in ECG analysis is concentrated in detection of more sophisticated types of arrythmias using automatic and human supervised learning.
  - A few years ago recognition of continuous Slovenian speech began. Known methods of speech recognition were further developed and adapted to the Slovenian language [27,28].
- Analysis of two-dimensional signals:
  - One half of the research consists of morphometric analysis of microscopic images of muscle tissue [16,18,19,20,21,22]. Research is conducted in close

cooperation with researchers from the Institute od Anatomy at the Medical School in Ljubljana. Computer methods are developed for establishing standards for the histochemical structure of healthy human muscle tissue of different age and sex groups. Knowledge of the morphology and functioning of muscles in normal human subjects is a prerequisite for various comparative and developmental studies as well as for experimental and pathological investigations. A pattern recognition method was developed for establishing the muscle type from photographs of muscle cross-sections prepared using histochemical stains. The method enables quantitative analysis of muscle type such as diameter, area, composition ratio and spatial arrangement. Those parameters are necessary for establishing and predicting different physiological processes.

- The other half of two-dimensional shape analysis research deals with recognition of human faces [34,35,36,37,38]. The model-based analysis of a human face is founded on the anthropological model of a human face which incorporates about 30 facial parameters of a male face. On the basis of this parameters it is possible to analyse, recognize, and to identify the human face. The systems is model-based where extracted contour features are checked against stored prototypical models.

- Analysis of three-dimensional signals is concentrated mainly on processing of computer tomography images of the human brain [3,5,6,11,24]. The final goal is the development of a work station for analysis and evaluation of CT (computer tomography) and PET (positron emission tomography) images, especially the cross-evaluation of those two types of images since the first one gives insight into the anatomical structure of the brain and the second one into the physiological processes. The system under development is based on an anatomical atlas of the healty human brain. This 3-D atlas is matched to CT images of individual subjects by elastic deformations. Research issues in this work are filtering and interpolation of 3-D data, segmentation, contour following, registration and matching of 3-D pictorial data, atlas creation and finally visualisation of the data during and after the processing.

The laboratory has several ties to other groups of researchers (University of Pennsylvania, Philadelphia, Universität Erlangen-Nürnberg, Gorenje-Processing equipment, Institute of Anatomy and Institute of histology and embriology, both at the Medical School at University of Ljubljana).

Equipment in both laboratories is based mostly on IBM PC compatible personal computers and HP Unix workstations.

3 Computer Vision Laboratory

Computer Vision Laboratory is headed by assistant prof. dr. Franc Solina. The laboratory was officially founded in January 1991 as part of the Computer Science Department of the Faculty of Electrical Engineering and Computer Science, University of Ljubljana. At the moment, only three full time researchers are members of the laboratory.

The laboratory is dedicated to all aspects of computer vision, especially to problems involved with 3-D vision. Work is done in interpretation of natural and man-made scenes in terms of suitable geometric and physical models giving such descriptions of the physical world that enable locating, handling and identifying of objects. We are interested in the open issue of bottom-up interpretation (merging smaller surface patches) versus top-down interpretation (directly using volumetric models of larger granularity) and image segmentation with parametric models. The general working assumption is that no specific object models are given aside from generic models that encompass a large set of all possible part shapes—a vocabulary for describing the scene. The goal is to perform shape recovery and segmentation simultaneously in order to make interpretation more robust [4]. In particular,

- we focus on using recovery of superquadric models [32,2] for range image interpretation, a technique that has already found tentative applications in sorting of mail pieces [31], in the Mars Rover project [15] and in grasping with robot hands in general [1]. We are working on extending the recovery method to apply 3-D model based vision on 2-D contours helped by sparse (qualitative) range data.
- we work on segmentation of range images and intensity images into piecewise continuous patches [25]. Data aggregation is peformed via model recovery in terms of variable-order bi-variate polynomials using iterative regression. All the recovered models are potential candidates for the final description of the data. Selection of models is achieved through an iterative optimizing algorithm. The procedure can be adapted to prefer certain kind of descriptions (one that

describes more data points, or has smaller error, or has lower order of models). The novelty of the approach is in combining model extraction and model selection in a dynamic way. Partial recovery is always followed by optimization where only the "best" models are kept to develop further.

The laboratory is involved also in color vision, texture analysis and extraction of physical properties of materials by means of vision [23] as well as the use of vision in robotic applications from navigation and obstacle avoidance to grasping and exploration in general, such as strategies for directing the imaging sensors [26] (where to look next—active vision). Part of this work is done in collaboration with the Robotic laboratory at Faculty of Electrical Engineering and Computer Science.

Some research of the Computer Vision Laboratory is directed also to areas related to computer vision such as scientific visualization and multi-media.

The laboratory has numerous connections to other laboratories working in the area of computer vision and also some joint projects (General Robotics and Sensory Perception Laboratory at University of Pennsylvania). The laboratory is equiped with UNIX based work stations, Macintosh computers and equipment for image capturing.

4 Other Laboratories

There are also some other groups of researchers in Slovenia who are partially involved in pattern recognition or computer vision research and application development.

In the Laboratory for Computer Structures and Systems and Laboratory for Adaptive Digital Systems, both at the Faculty of Electrical Engineering and Computer Science, University of Ljubljana a group of researchers is developing a neural-net based system for visual tracking, capable of recognizing a probable target and predicting its trajectory [8,9]. Several targets could be followed simultaneously.

There are also two laboratories at the Jožef Stefan Institute, University of Ljubljana that are involved in computer vision/pattern recognition applications. The labora-

tory dedicated to computer vision is involved in developing hardware for computer vision and in digitalization of large area drawings and maps where lines and figure contours are automatically coded as sets of vectors that can be processed with standard software packages [7]. The laboratory for computer based natural language understanding, on the other hand, is involved in research geared towards natural language based computer user interfaces and applications (with focus on Slovenian language) [33], including understanding of spoken language [30].

5 Conclusion

Slovenia has a relatively small body of researchers in computer vision and pattern recognition. Individual researchers have spent up to few years abroad, in north America and in Western Europe. Contacts with researchers in the field from abroad are active and well established so that adapting to more competitive funding policy in Slovenia should not be too difficult. The new research funding policy in Slovenia requires from the researchers a stronger presence in the international community (through publications as well as participation in international projects) and active collaboration in the restructuring of the Slovenian industry by initiating new applications.

At the end, we also hope that Slovenian researchers in pattern recognition and computer vision will soon be able to become members of the International Association for Pattern Recognition through their own national society.

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