



# Wrocław University of Technology

## Artificial Intelligence Division Institute of Informatics

Faculty of Computer Science and Management  
Wrocław University of Technology

Halina Kwaśnicka

Head of Artificial Intelligence Division  
Deputy Director for Scientific Researches  
of the Institute of Informatics

[halina.kwasnicka@pwr.wroc.pl](mailto:halina.kwasnicka@pwr.wroc.pl)

[www.zsi.ii.pwr.wroc.pl](http://www.zsi.ii.pwr.wroc.pl)

# Outline

- The team of Artificial Intelligence Division (AID)
- A cup of history
- Institute of Informatics - a short view
- Research areas in AID
- Research projects in AID
- Teaching in AID
- Future plan



# Team - the staff

prof. dr hab. inż. Halina Kwasnicka

dr hab. inż. Urszula Markowska-Kaczmar

dr inż. Lukasz Mirosław

dr inż. Pawel Myszkowski

dr inż. Mariusz Paradowski

dr inż. Maciej Piasecki

dr inż. Jerzy Sas

dr inż. Martin Tabakow

dr inż. Elżbieta Hudyma (part time)





# Team - PhD Students

mgr inż. Bartosz Broda

mgr inż. Roman Kurc

mgr inż. Michał Stanek

mgr inż. Tymoteusz Marchwicki

mgr inż. Bartłomiej Dzieńkowski

mgr inż. Grzegorz Jeziorski

mgr inż. Adam Wardynski



E-mails: <name.surname>@pwr.wroc.pl

# A cup of history

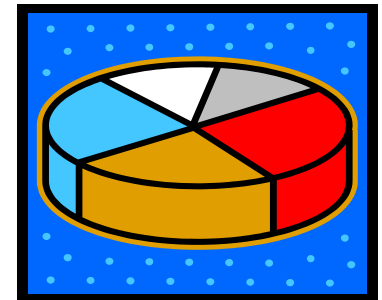
- 1.09.2004: Artificial Intelligence Division is formed as one of five divisions in the Institute of Applied Informatics (formed in 2004)
- 1.09.2008: Artificial Intelligence Division is created as one of nine divisions in the Institute of Informatics (formed in 2008 by fusion of two Institutes, including Institute of Applied Informatics)
- The main goal at the beginning:
  - to conduct research in a group of interested people
  - to obtain new, interesting projects
  - to enhance a scientific achievements of the team members by cooperation
  - to increase scientific activity of every member of the Division



# Structure of the Institute of Informatics

It is composed of 9 divisions:

- Safety and Reliability of Information Systems (Ireneusz Józwiak)
- Intelligent Decision Support Systems (Jerzy Józefczyk)
- Software Engineering (Zbigniew Huzar)
- Distributed Computer Systems (Leszek Borzemski)
- Database Systems (Zygmunt Mazur)
- Information Systems (Aleksander Zgrzywa)
- Knowledge Management Systems (Ngoc Thanh Nguyen)
- Teleinformatics (Adam Grzech)
- Artificial Intelligence (Halina Kwaśnicka)



# Selected Activities of the Institute: projects, teaching

- Research project (main current project, not in AID):
  - New information technologies for the electronic economy and information society based on the paradigm of SOA, the Operational Program *Innovative Economy*, 2007 - 2013 (within the Consortium)
  - Engineering of the Future Internet, the Operational Program *Innovative Economy*, 2007 - 2013 (within the Consortium)
  - COST project: ComplexHPC, Open European Network for High-Performance Computing in Complex Environments
- Teaching
  - At three levels: engineer, master, and PhD
  - English study for international students
  - International cooperations in study (joint master study with Saigon University , Vietnam)





# Selected Activities: some conferences

- ACIIDS -Asian Conference on Intelligent Information and Database Systems (2010: Hue City, Vietnam; 2011: Daegu, Korea)
- KES AMSTA - 4th International KES Symposium on Agents and Multi-agent Systems - Technologies and Applications (Gdynia, Poland)
- ICSS - International Conference on Systems Science (Poland)
- ISAT -International Conference Information Systems Architecture and Technology (Poland)
- AAIA - International Symposium Advances in Artificial Intelligence and Applications [www.aaia.fedcsis.org](http://www.aaia.fedcsis.org)



# Research area of AID: Natural Language Technology and Computational Linguistics

Research in the area of language tools encompasses:

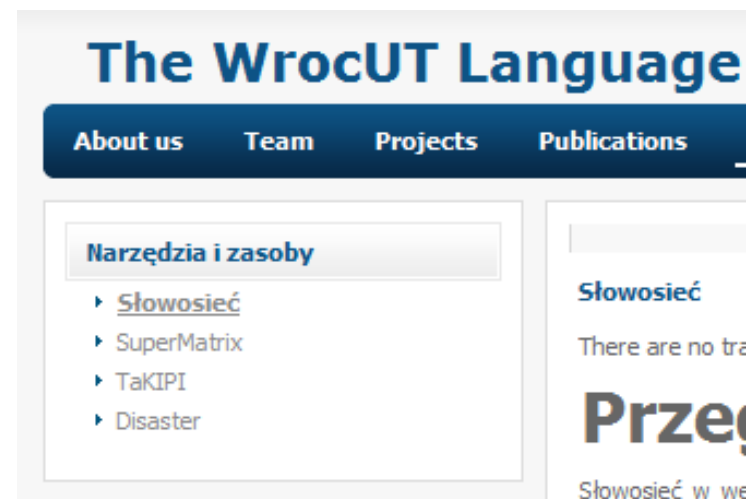
- Morpho-syntactic analysis (TaKIPI)
- Shallow syntactic processing
- Shallow semantic analysis of large corpora (SuperMatrix)
- Word sense disambiguation
- Extraction of lexico-semantic networks (WordnetWeaver)
- Named entity recognitions and event recognition
- Linguistic research is focused on formalized description of lexical semantics, methodology of wordnet construction, shallow syntactic description of Polish and Polish multi-word expressions



# Natural Language Technology and Computational Linguistics

- Achievements:
  - plWordNet - the large Polish wordnet, and several annotated Polish corpora (**granted eight licenses**)
  - WordnetWeaver - system supporting semi-automatic wordnet expansion
  - TaKIPI - a morphosyntactic tagger for Polish
  - SuperMatrix - a multi-purpose system supporting Distributional Semantics methods

## G4.19 Language Technology Research Group



<http://nlp.pwr.wroc.pl>

# Computational Linguistics: the application areas

- Information Extraction
- Open Domain Question Answering
- Large scale Language Technology Infrastructure and knowledge acquisition from text corpora



plWordNet

Search for:  Search

[Project homepage](#) [plWordNet](#) [Semantic similarity of lexical units](#) [Semi-automatic extension of plWordNet](#) [Statistics](#) [Contact](#)

Change site language: Polish

Copyright © 2006-2010 Wrocław University of Technology  
Available for demonstration only.

Commercial usage and copying in any form or by any means without permission from authors is strictly forbidden.

<http://plwordnet.pwr.wroc.pl/>

Search for: zdrowy

zdrowy 1

Synset: zdrowy 1, sprawny 1, dobry 7

Part of speech: adjective

Synset relations:

- [hiperonimia \(2/2\)](#)

Lexical unit relations:

- [antonimia: forma kanoniczna \(1/1\)](#)
- [relacyjność \(1/2\)](#)
- [odnośność \(1/1\)](#)

zdrowy 2

Synset: normalny 2, zdrowy 2

Part of speech: adjective

No synset relations

No lexical unit relations

zdrowy 3

Synset: zdrowotny 1, zdrowy 3

Part of speech: adjective

No synset relations

Lexical unit relations:

- [antonimia: forma kanoniczna \(1/1\)](#)

zdrowy 4

Synset: niezsputy 1, zdrowy 4

Part of speech: adjective

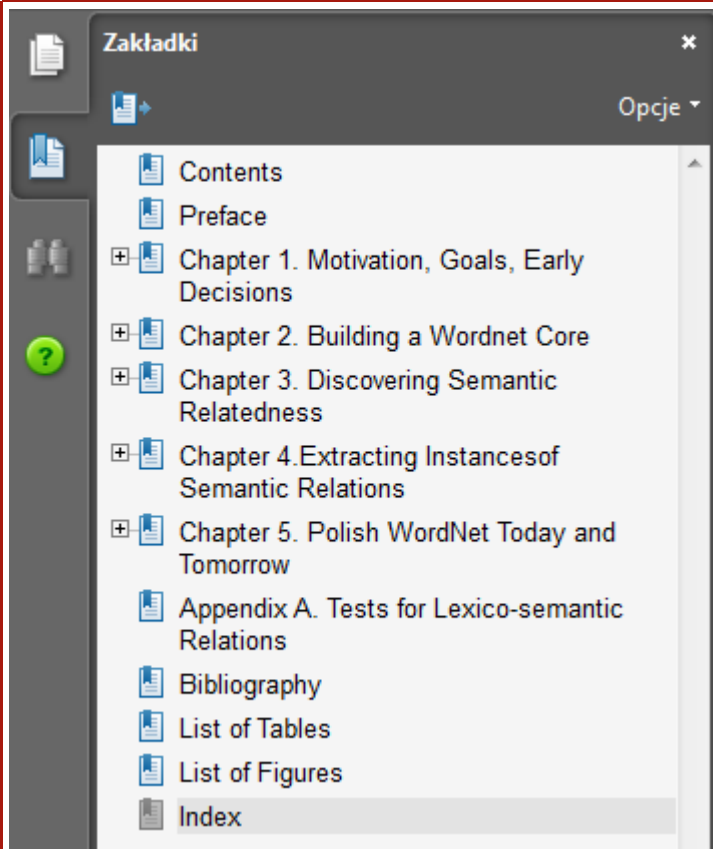
No synset relations

Lexical unit relations:

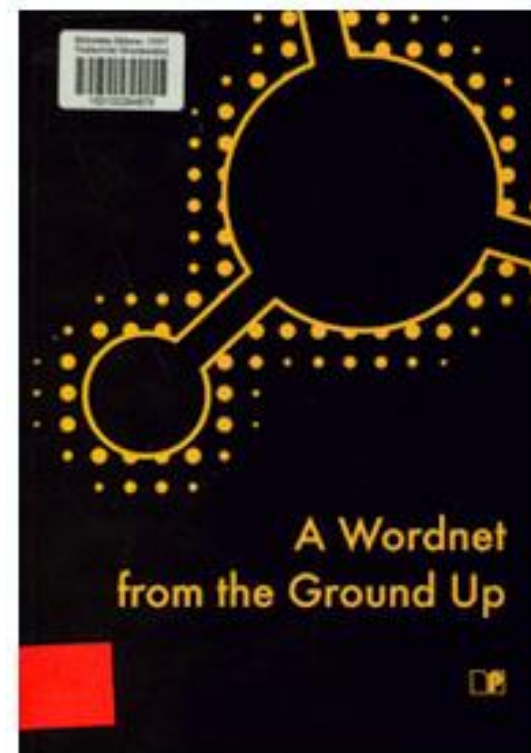
- [antonimia: forma kanoniczna \(1/2\)](#)

Change site language: Polish

# Interesting book: A Wordnet from the ground up (M. Piasecki, S. Szpakowicz, B. Broda)



*Publisher* : Oficyna Wydawnicza PWr.  
*Place of publication*: Wrocław  
*Date*: 2009  
*Resource Identifier*:  
oai:www.dbc.wroc.pl:4220  
*Rights Management*:  
Politechnika Wroclawska  
*Publication collections*:  
Lower Silesian Digital Library  
Wrocław University of  
Technology  
*All available editions*:  
<http://www.dbc.wroc.pl/publication/4367>



- [http://www.plwordnet.pwr.wroc.pl/main/content/files/publications/A\\_Wordnet\\_from\\_the\\_Ground\\_Up.pdf](http://www.plwordnet.pwr.wroc.pl/main/content/files/publications/A_Wordnet_from_the_Ground_Up.pdf)
- [http://www.site.uottawa.ca/~szpak/pub/A\\_Wordnet\\_from\\_the\\_Ground\\_Up.pdf](http://www.site.uottawa.ca/~szpak/pub/A_Wordnet_from_the_Ground_Up.pdf)

# Research area: low and high level machine vision

- The scope: Image auto-annotation methods
  - Using machine learning methods
  - Choosing appropriate set of features
  - Choosing appropriate similarity measures

$W = \{sky, water, tree, green, cloud, man, people\}$



*A method of  
images  
automatic  
annotation*



$D =$   
 $\{sky,$   
 $tree,$   
 $green\}$



*A training set – images and their descriptions*

- *incompleteness of descriptions*
- *a lack of information about dependency between words and feature vectors*

# Research area: low and high level machine vision

- The scope: Visual similarity of images
  - The use of local features, such as key points, to search for 'near-duplicate' images (without objects recognition)
  - Using global features to search for similar images
  - Combining approaches: the use of local and global features
  - Including ontology to support the interpretation of images
  - Visual similarity of images seen by the human



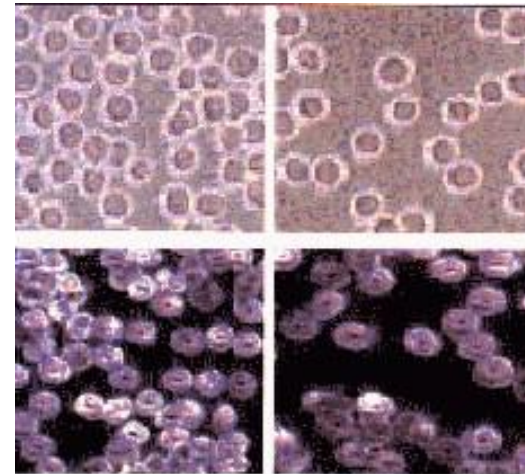
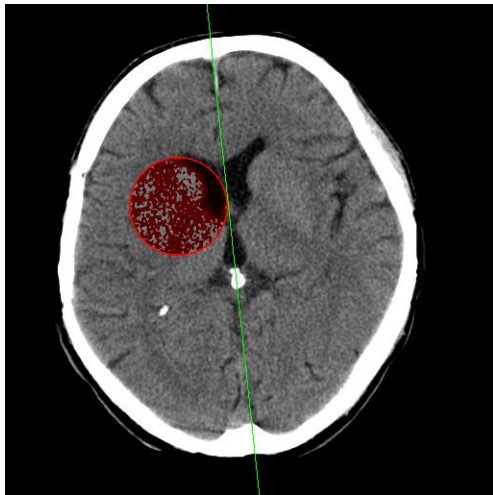
# Research area: image retrieval using annotations

Hypothesis: Images similar in appearance are likely to share the same annotation



# Research area: medical images processing

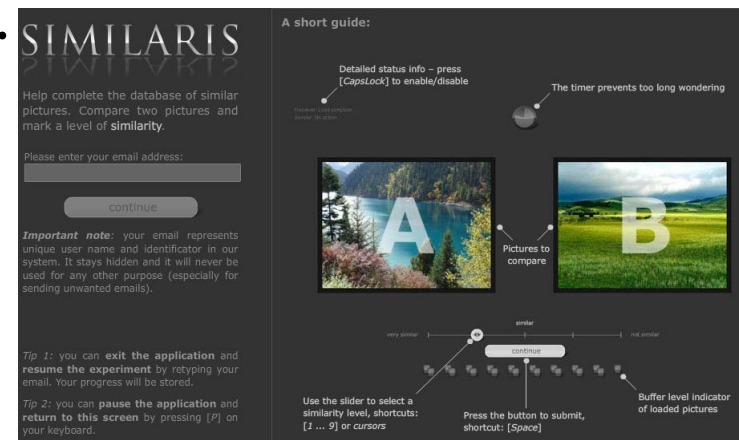
- Medical decision support systems
  - Analysis of Computer Tomography images in dementia and tumor diagnosis
  - Analysis of capillaroscopy images in evaluation of health threats
  - Analysis of the histopathology images in cancer diagnosis





# Images analysis: The results

- Medical Systems:
  - Early Detection ischemic stroke (presented in Wrocław TV),
  - The shape of the capillaries analysis,
  - The identification of cells cancer.
- Tools:
  - For feature extraction and analysis visual images (framework),
  - SIMILARIS - a program for the study visual perception by human (Inter-rater agreement assessment).
- Participation in the competition ImageCLEF (twice)  
<http://www.imageclef.org/>

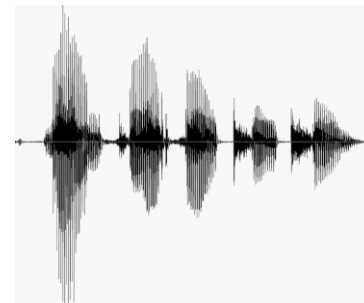


# Research area: speech recognition

- The development of useful methods for effective speech recognition
- Rapid adaptation to individual speakers
- The use of a hybrid approach (HMM and NLP methods)
- GPU acceleration
- Application to medical information systems

## Achievements:

- Computer system for medical speech analyzing (description of medical images), the system was presented in Wrocław TV

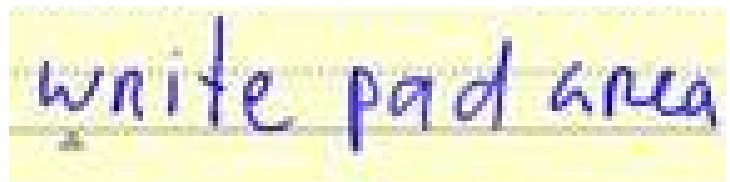


# Research area: handwriting recognition

- Smart handwritten text segmentation method
- The construction of classifiers for handwriting recognition (characters)
- Semi-automatic learning methods to recognize characters
- The use of language models

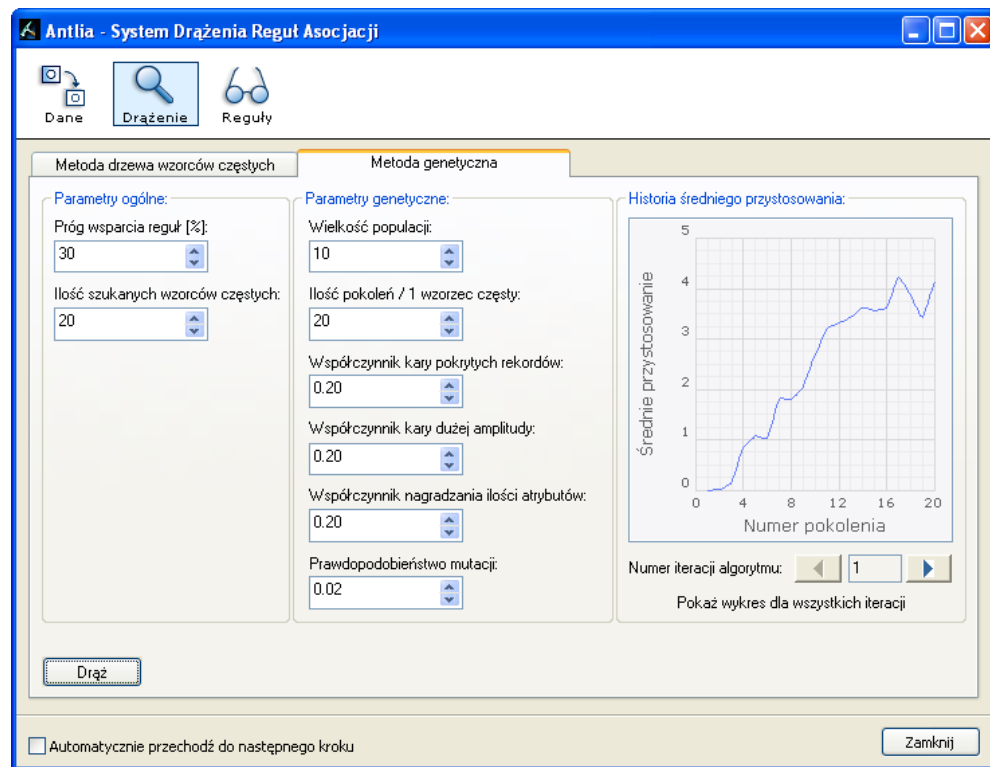
## Achievements:

- Computer system reads the order of patients to the medical analysis laboratory, the system was presented in Wrocław TV



# Research areas: Evolutionary Computation in applications - data mining

- Knowledge acquisition from different type of data,
- Rule induction, data visualization,
- Features selection in classification task.

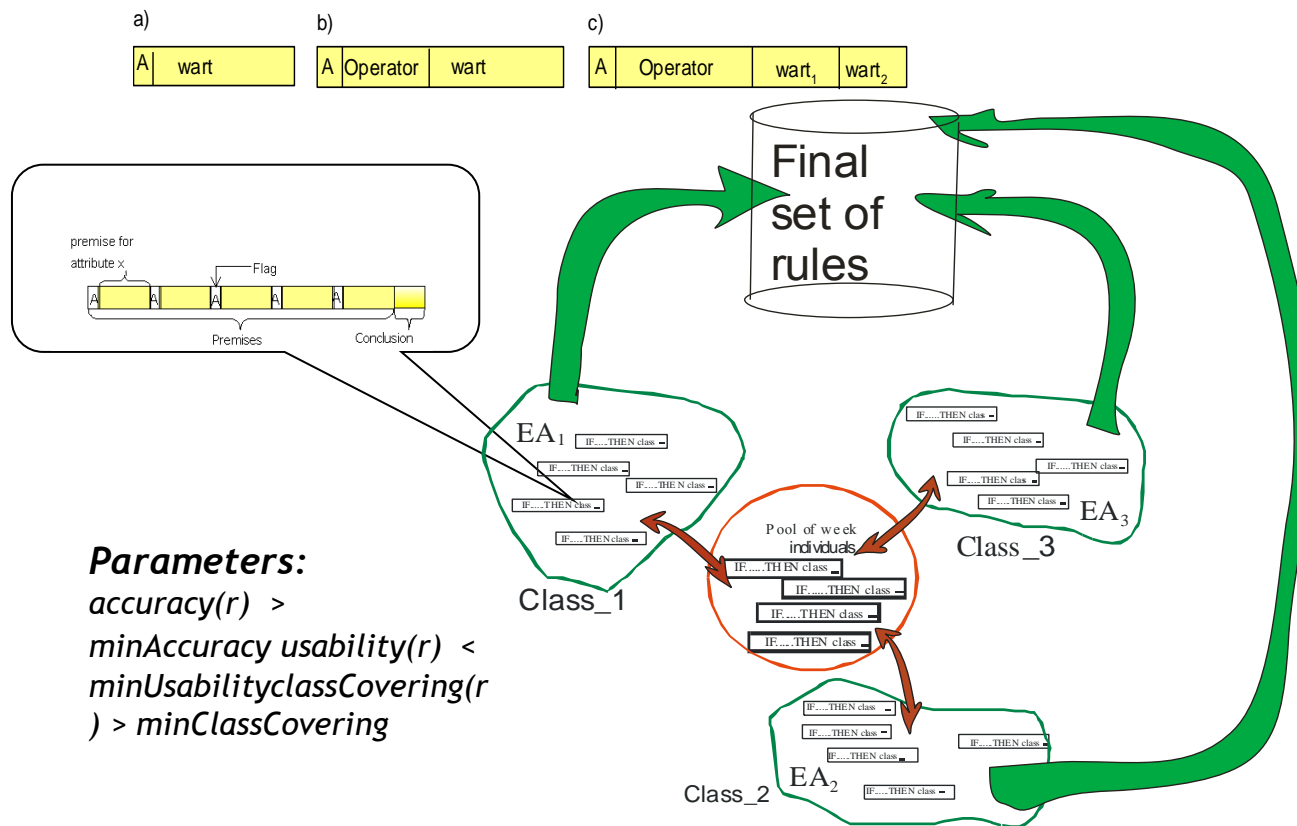


Antlia - generation of association rules as well as classification rules using classic FP-Tree algorithm and authors' evolutionary method - EGAR method

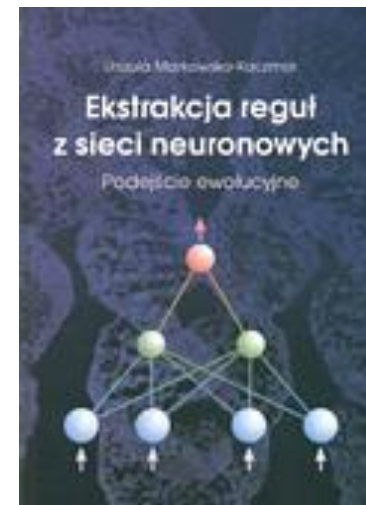
# Research areas: Evolutionary Computation in applications

- Rule extraction from neural networks based on evolutionary algorithms

GEX method- the idea



**Parameters:**  
 $accuracy(r) >$   
 $minAccuracy usability(r) <$   
 $minUsabilityclassCovering(r)$   
 $> minClassCovering$



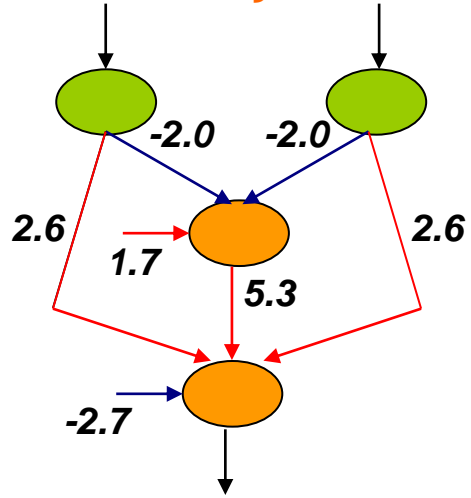
U. Markowska-Kaczmarska, *Ekstrakcja reguł z sieci neuronowych. Podejście ewolucyjne.* Oficyna Wydawnicza PWr. Wrocław. 2006.

# Research areas: evolutionary methods for practical applications

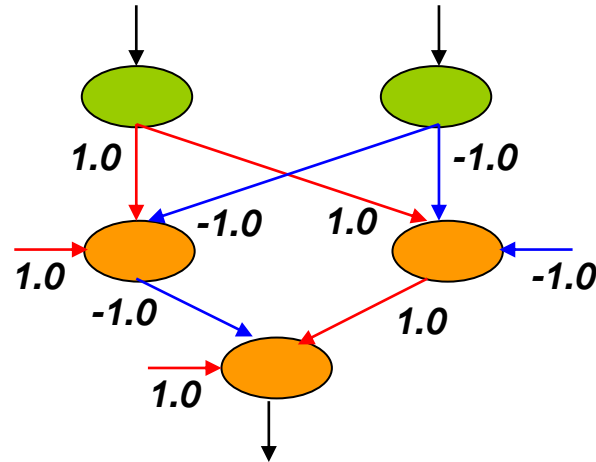
- Evolutionary Neural Network design: ability of direct and indirect encoding to evolve accurate and small NN

- *A relatively simple problem - XOR function*

- *Direct Coding*
- *Evolutionary learning*



- *Indirect coding*
- *Evolutionary and backpropagation training*

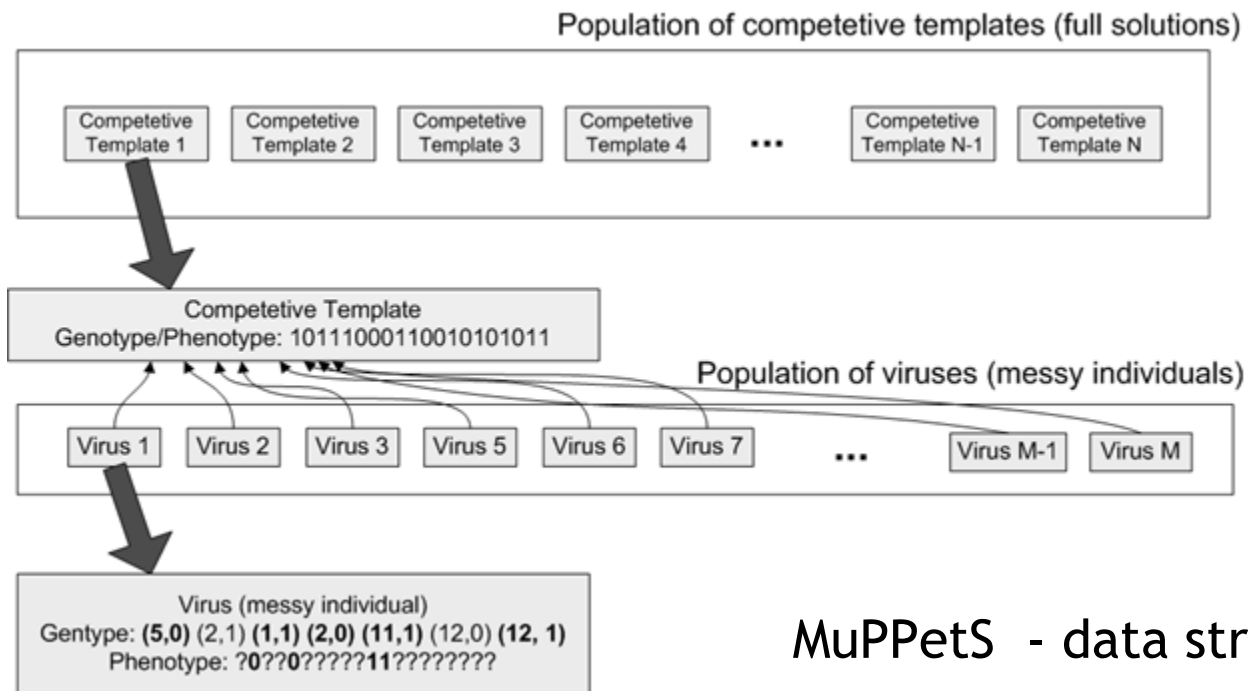


H. Kwaśnicka, *Ewolucyjne projektowanie sieci neuronowych*. Oficyna Wydawnicza PWr. Wrocław. 2007.

# Research areas: evolutionary methods for practical applications

## Flow assignment in computer networks

### MuPPetS - Multi Population Pattern Searching Algorithm



MuPPetS - data structure

# Research area: Intelligent systems that help human beings

- BPiT - *Bimbuś Pajęczek i Ty*
- The Computer system helps education of children with dyslexia
- Unfortunately, we have made only prototype

Zabawa w uzupełnianie wyrazów

**Przykład**

 **łódź**  
↓  
 **łodzie**

Proszę o powtórzenie treści ćwiczenia

Proszę o podpowiedź

Zadanie wykonane

	<b>dziób</b> dzioby	<b>dół</b> doły	<b>wóz</b> wozy	<b>róg</b> rogi	<b>nóż</b> noże
 	<b>słój</b> słoje	<b>rów</b> rowy	<b>bór</b> bory	<b>stóg</b> stogi	<b>miód</b> miody

Pamiętaj o naszej zasadzie :

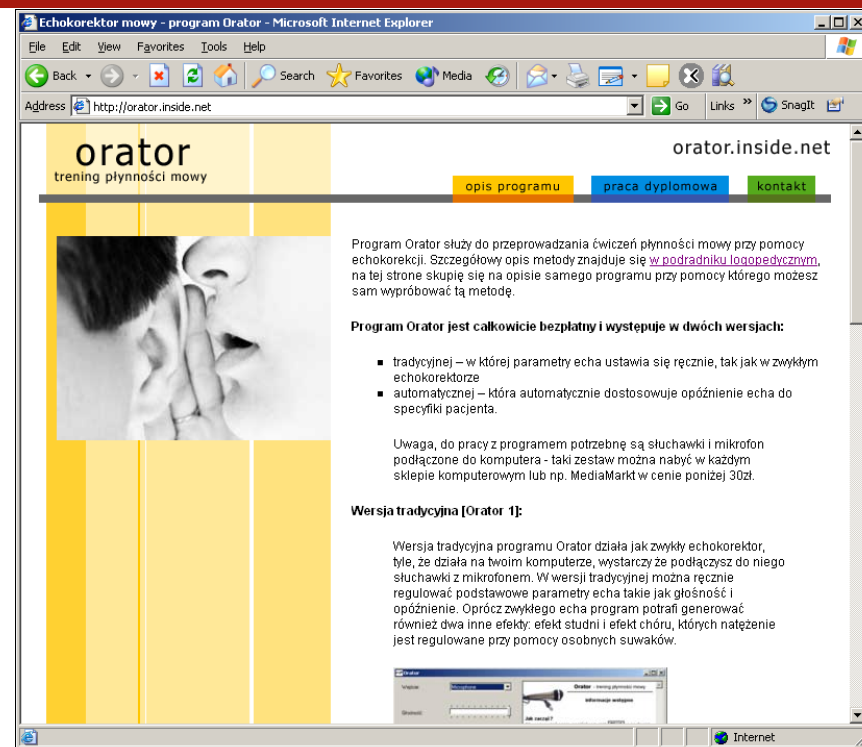
"ó" piszemy w rzeczownikach liczby pojedynczej wtedy, gdy w formie mnogiej danego wyrazu wymienia się na "o"

*(...) even revolutionary approach to working with people with special difficulties (...) combines fun with learning in an unconventional way, attractive, ... The computer is a partner, a friend of the child, leads them in a difficult world of spelling and reading (...) A crucial element of the program is positive verbal reinforcement, which accompanies the task performed (...) extracted from the dyslexia specialist's opinion.*



# Intelligent systems that help some human beings

- Orator - an intelligent system supporting stuttering therapy
- Main modules (functions):
  - Stuttering Detection module
  - Therapy Controller
  - Therapy Provider
  - user interface



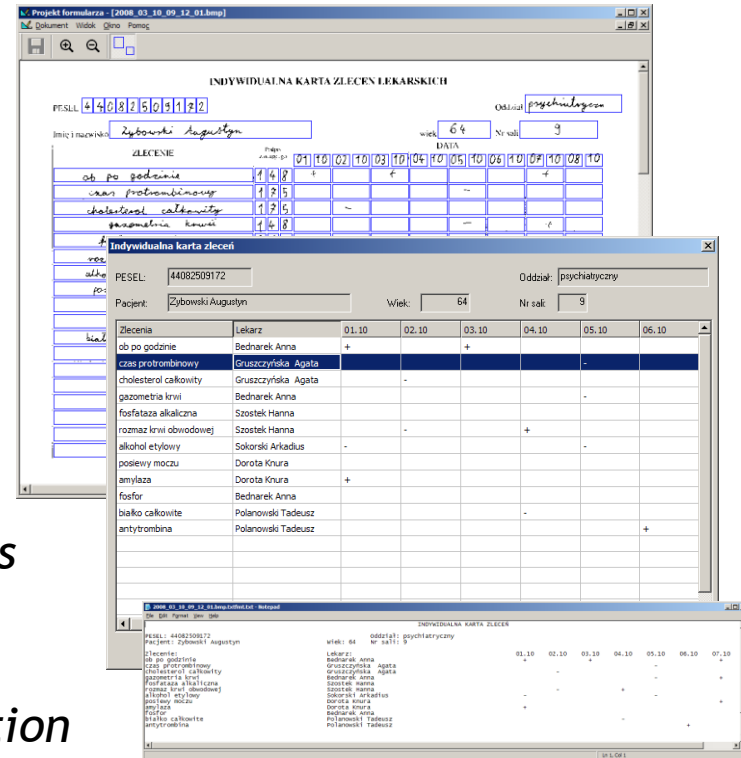
*Specialist's opinion: Orator application is highly useful in therapy of stuttering children, particularly the fact that a child can use it at home. Everyday work is very important for the therapy results and traditional echo-correction devices are often unavailable for our patients because they are simply too expensive (...) Therapeutic session carried out with it seems to give much better results than one carried just with a traditional device (...).*

# Intelligent systems that help some human beings

- The System for Automatic Recognition of Handwritten Forms of Medical Orders

- **Main functionalities:**

- *Flexible definition of the form layout*
- *Automatic scanning of document bunches*
- *Automatic text are extraction*
- *Handwritten text fields content recognition*
- *Manual correction of recognized text*
- *Automatic assessment of recognition reliability*
- *Recognition results export to text files or databases*

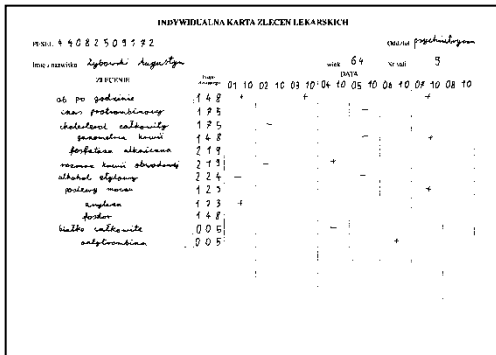




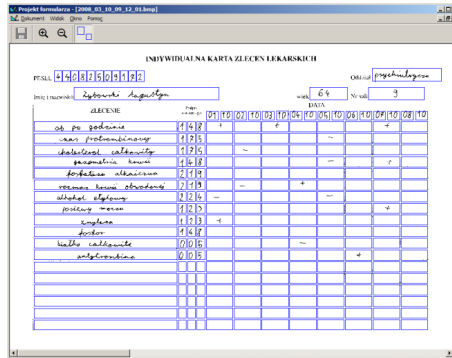
# Intelligent systems that help some human beings

- *The System for Automatic Recognition of Handwritten Forms of Medical Orders*

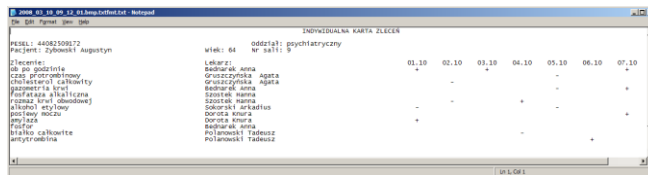
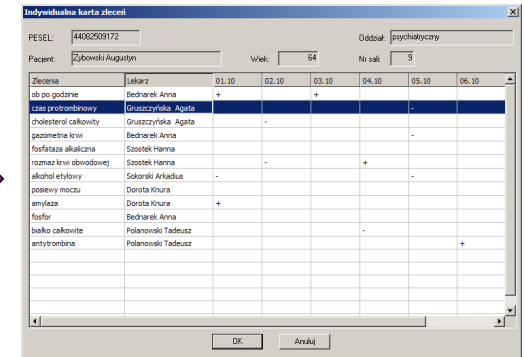
Document scanning and image processing



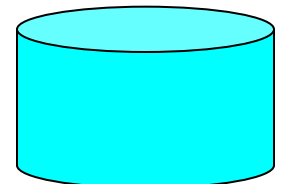
Automatic text fields extraction



Manual correction



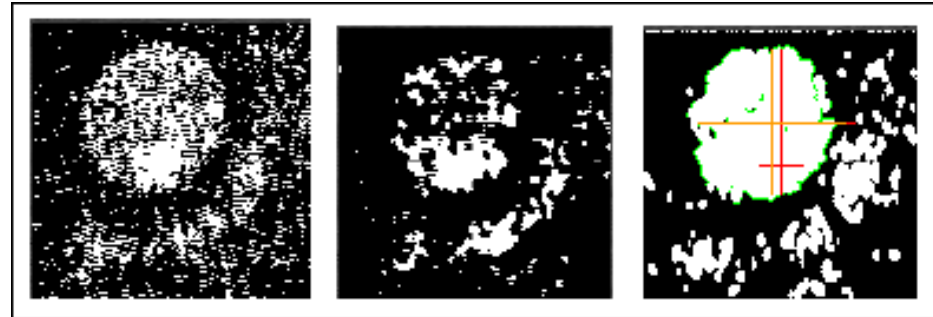
Export to text files



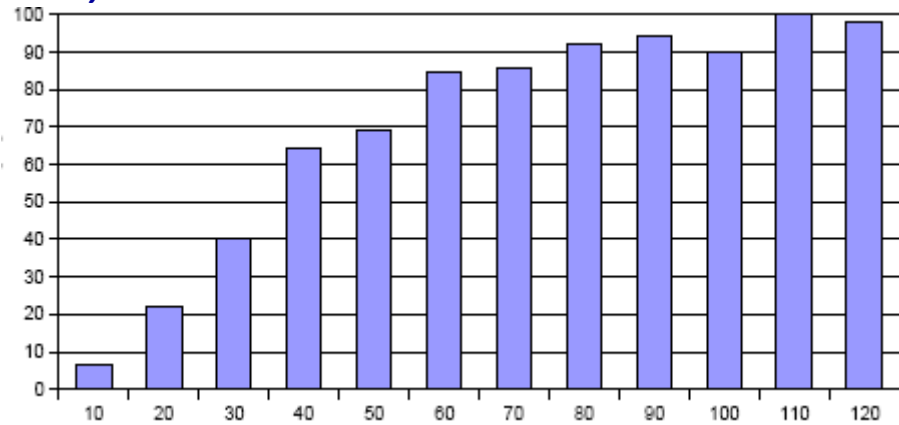
Export to databases

# Intelligent systems that help some human beings

VCOP - The System of Visual Communication with Computers for Paralyzed Users



*accuracy*



*Size of the area [pixels]*

# Current Research Projects

- Ministerial projects (research projects, special kind for the scientific degree and title)
- Projects with international cooperation (Clarín, Singapore)
- The project under the Innovation Economy (NEKST)
- Project NCBiR (SYNAT)
- New projects (achieved)

## Formal cooperation:



## Source of funding:



MINISTRY OF SCIENCE  
AND HIGHER EDUCATION



Narodowe Centrum Badań i Rozwoju

*The National Centre for Research and  
Development*



*National Science Centre*



# Singapore-Poland Joint Research Project

- Title: Framework for Visual Information Retrieval and Building Content-Based Visual Search Engines
- Purpose of research: algorithms for search systems of visual content in databases
- Basic assumption: query has a visual form
- The system finds in the database images that are visually similar to the content query
- Potential applications:
- The most spectacular area of application is the development of image search engines
- Another important area of application are intelligent robotic systems

# CLARIN - Common Language Resources and Technology Infrastructure

- Type: FP7, ESFRI, roadmap for research infrastructures
- Objectives:
  - pooling resources and language tools for all European languages into one common network - a tool for scientists working with the broad humanities and social sciences
  - design Center of Polish Language Technology
  - research on adaptation, expansion and integration of the Polish language technology with the European network



<http://www.clarin.eu>  
[nlp.pwr.wroc.pl/clarin](http://nlp.pwr.wroc.pl/clarin)



# NEKST - Enhanced Knowledge Sharing natively Technologies

- Type: The Programme Innovative Economy, research project
- Title: Adaptive problem solving support system based on analyzing the content of available electronic resources
- Objectives:
  - design and development of many basic resources and tools for Polish language,
  - system for extracting information from Polish texts,
  - Open Domain Question Answering, expressed in natural language,
  - tools for information extracting from the image contained in documents.





# SYNAT - NCBiR research project

- Title: Creation of a universal, open, repositories and communication hosting platform for networked knowledge resources for science, education and open knowledge-based society
- Objectives: building a network platform to integrate and share scientific information resources
- Our task: Automatic extraction of information, it covers:
  - building and integration of basic resources and tools for Polish language,
  - methods for automatic extraction of meta-data from documents,
  - deeper semantic analysis of text,
  - methods of hierarchical, semantic clustering of images,
  - construction of large scale, distributed architecture of the Center of Language Technology for Polish language.



# Słownosieć 2.0 (plWordNet 2.0)

## plwordnet.pwr.wroc.pl

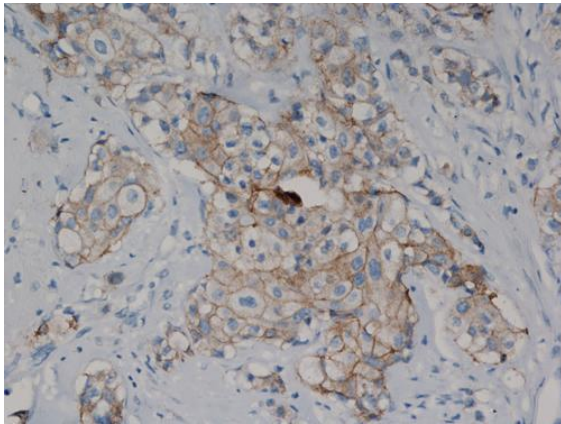
- Type: Ministry of Science and Higher Education, a research
- Title: The construction of lexical resources by recognizing the semantic relationships on the basis of morphosyntactic and semantic data in a text corpora
- Objectives:
  - expansion of the Polish Wordnet (target: over 135 000 lexical meanings - in total, due to the support also from NEKST and SyNaT projects)
  - improving algorithms for the extraction of lexical semantic relations from text corpora
  - development of the WordnetWeaver system allowing for semiautomatic extension of Słownosieć
  - algorithms for automatic identification of semantic relations expressed via derivational pairs



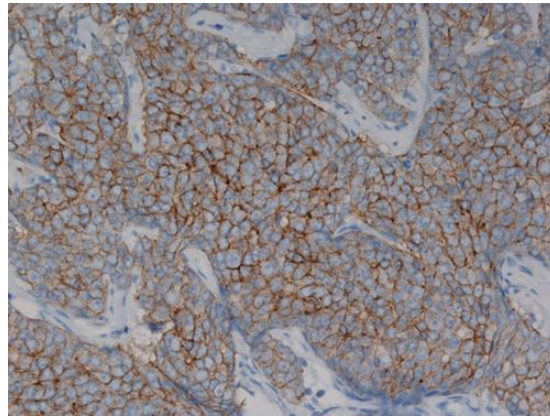
# New project granted by the Ministry, realized in cooperation with *Wrocław Medical Academy*

- Title: Application of methods of image analysis to assess the expression of HER-2 receptor in breast cancer cells
- Objective: Computer system of enabling qualitative and quantitative diagnosis of the expression of HER-2 receptor and other membrane proteins in the breast carcinomas:
- new, dedicated methods, analyzing the expression of various proteins used to mark tumor cells and the degree of consistency of the tumor cell membrane,
- selection of important geometric features,
- using machine learning methods,
- analyze the similarity of histopathological images as a useful approach for diagnosis.

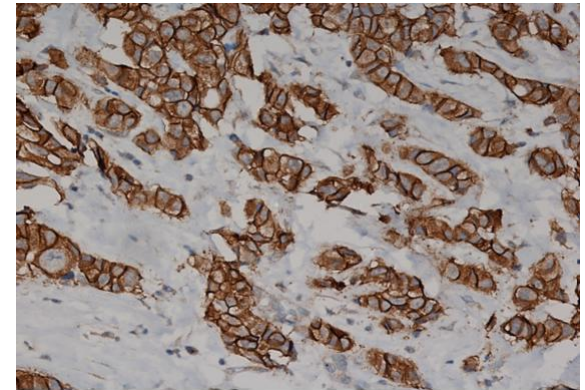
# Examples of HER2 images belonging to category 1+, 2+ 3+



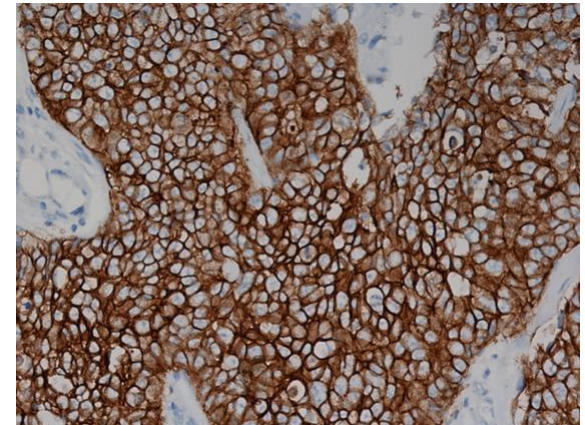
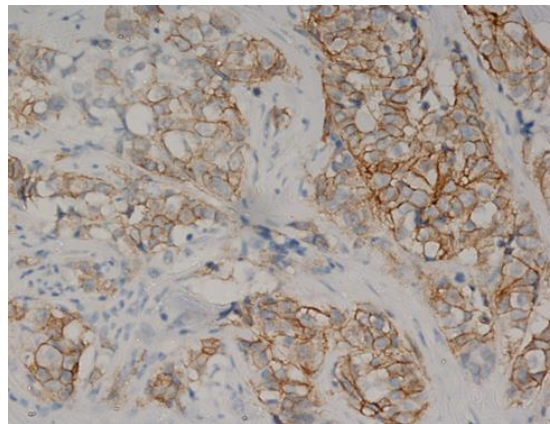
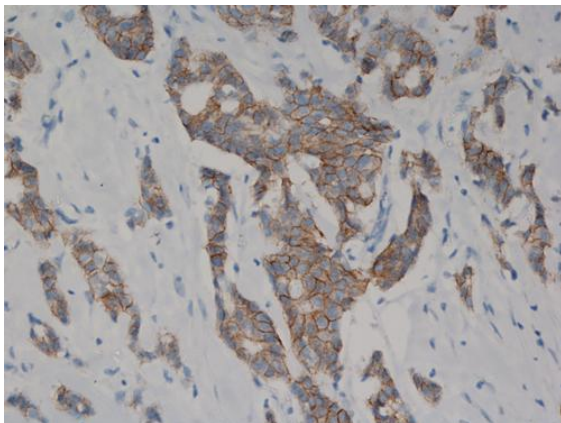
Class 1+



Class 2+



Class 3+



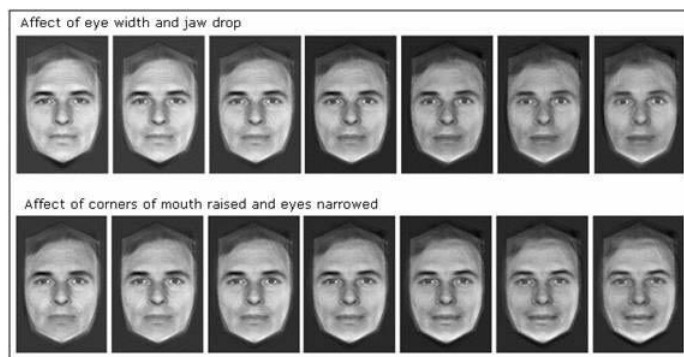


# Plans for the future

- Further research in the aforementioned domains/topics
- Ontology in analysis of images - interpretation of images
- Medical Decision Support Systems
- Data mining, using soft computing (e.g., evolutionary computations) in data mining and knowledge acquisition tasks
- Recognition of emotion
- Multi-agent systems in applications

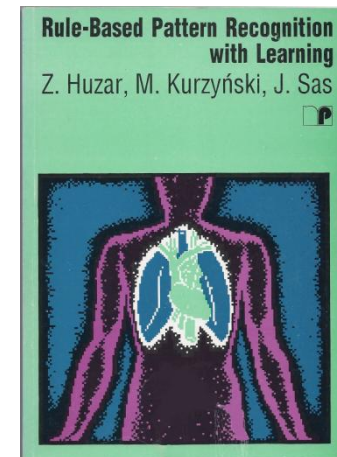
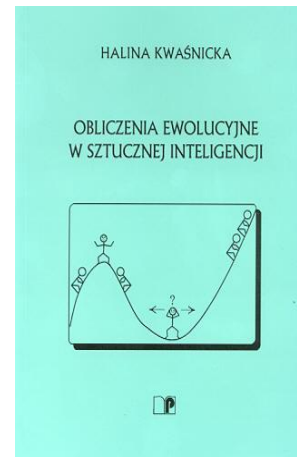
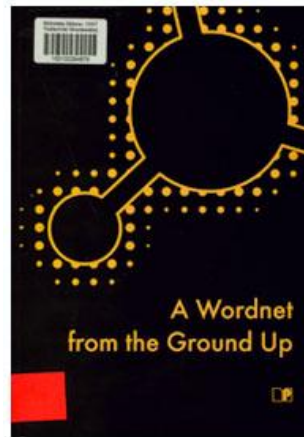
# Plans for the future: video analysis

- Video analysis and search for 'similar' videos
- Video interpretation (understanding) - combining speech and images analysis
- Video capillaroscopy analysis
- Automatic sign language interpreter





# Some books





# Some publications

- Przewoźniczek M., Kwaśnicka H.: Multi Population Pattern Searching Algorithm - a new evolutionary method based on the idea of messy Genetic Algorithm. Accepted for publication by *IEEE Transaction on Evolutionary Computation* (final decision in January 2011).
- Kwaśnicka H., Markowska-Kaczmar U., Mikosik M.: Flocking behaviour in simple ecosystems as a result of artificial evolution. *Applied Soft Computing*. 2011, vol. 11, No. 1, pp. 982-990.
- Ahmad K., Ostfeld P. Meier U. Kwaśnicka H.: Exploitation of multiple hyperspace dimensions to realize coexistence optimized wireless automation systems. *IEEE Transactions on Industrial Informatics*. 2010, vol. 6, No. 4, pp. 758-766.
- Broda B., Piasecki M., Szpakowicz S.: Extraction of Polish noun senses from large corpora by means of clustering. *Control and Cybernetics*. 2010, vol. 39, No. spec. 2, pp. 401-420.
- Tabakow M., Kwaśnicka H., Krynicki K.: A rule-based region growing fuzzy segmentation system for pathological brain computed tomography images. *Systems Science*. 2010, vol. 36, No. 2, pp. 23-32.
- Michalak K., Kwaśnicka H.: Correlation based feature selection method. *International Journal of Bio-Inspired Computation*. 2010, vol. 2, No. 5, pp. 319-332.
- Sas J.: Application of local bidirectional language model to error correction in Polish medical speech recognition. *Journal of Medical Informatics & Technologies*. 2010, vol. 15, pp. 127-134.
- Paradowski M., Kwaśnicka H.: Improved resulted word counts optimizer for automatic image annotation problem. *Fundamenta Informaticae*. 2009, vol. 96, No. 4, pp. 435-463.
- Markowska-Kaczmar U., Kordas B.: Multi-class iteratively refined negative selection classifier. *Applied Soft Computing*. 2008, vol. 8, No. 2, pp. 972-984.





# Some publications (more)

- Kwaśnicka H., Paradowski M.: Resulted word counts optimization - a new approach for better automatic image annotation. *Pattern Recognition*. 2008, vol. 41, No. 12, pp. 3562-3571.
- Piasecki M.: Towards semi-automatic extraction of lexical semantics relations for Polish. *International Journal of Intelligent Information and Database Systems*. 2008 vol. 2, No. 3, pp. 336-353.
- Kwaśnicka H., Stanek M.: Reinforcement approach to adaptive package scheduling in routers. *Systems Science*. 2008, vol. 34, No. 4, pp. 53-65.
- Kosinski W., Markowska-Kaczmar U.: Evolutionary algorithm determining defuzzyfication functional. *Task Quarterly*, vol.11, No.1-2, 2007.
- Markowska-Kaczmar U., Trelak W.: Fuzzy logic and evolutionary algorithm - two techniques in rule extraction from neural networks, *Neurocomputing*, 2005 vol. 63 pp. 359-379.
- Drożdż K., Kwaśnicka H.: Feature set reduction by evolutionary selection and construction. *Lecture Notes in Artificial Intelligence*. 2010, vol. 6071, pp. 140-149.
- Dziękowski B., Markowska-Kaczmar U.: Biologically inspired agent system based on spiking neural network. *Lecture Notes in Artificial Intelligence*. 2010, vol 6071, pp. 110-119.
- Kwaśnicka H., Gruszczyk W.: Coalition formation using combined deterministic and evolutionary approach. *Lecture Notes in Computer Science. Lecture Notes in Artificial Intelligence*. 2010, vol. 5990, s. 282-293.
- Markowska-Kaczmar U., Krygowski F.: The influence of using design patterns on the process of implementing genetic algorithms. *Lecture Notes in Computer Science. Lecture Notes in Artificial Intelligence*. 2010, vol. 6097, s. 173-182.



# Thank you for your attention



*Wroclaw University of Technology – the main building*