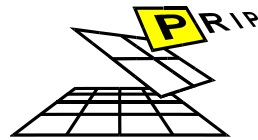


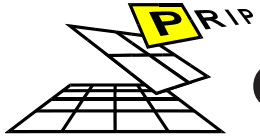
History of Computer Vision

A Personal Perspective

Walter G. Kropatsch

Institute of Computer Aided Automation 183/2 Vienna University of Technology
Pattern Recognition and Image Processing Group





What is CV?

Computer vision is the science and technology of machines that see.

- **As a scientific discipline:**
the theory for building artificial systems that obtain information from images.
- **image data:** a video sequence,
views from multiple cameras, or
multi-dimensional data from a medical scanner.
- **As a technological discipline:** construction of computer vision systems.

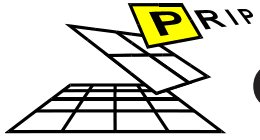
$$CV = \text{Camera} + \text{Computer} + ?$$

Pattern Recognition

$$PR = (\text{Data} \longrightarrow \text{Information})$$

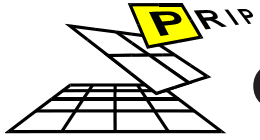
J. Bezdek

$$CV \subset PR$$



Computer Vision Systems are used for ...

- Controlling processes (e.g. an industrial robot or an autonomous vehicle).
- Detecting events (e.g. for visual surveillance or people counting).
- Organizing information (e.g. for indexing databases of images and image sequences).
- Modeling objects or environments (e.g. industrial inspection, medical image analysis or topographical modeling).
- Interaction (e.g. as the input to a device for computer-human interaction).
- ...



Computer Vision \longleftrightarrow Biological Vision

Computer vision

studies and describes

artificial vision systems

implemented in software

and/or hardware.

Biological vision

visual perception

of humans and animals

resulting in models

how these systems operate

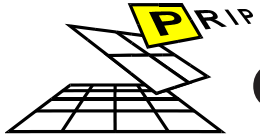
in terms of physiological processes.

Interdisciplinary exchange between biological and computer vision
has proven increasingly fruitful for both fields.

Example **NFN Cognitive Vision**

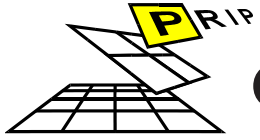
Perception

- process of attaining awareness or understanding of sensory information.
- a task far more complex than was imagined in the 1950s and 1960s:
”*building perceiving machines would take about a decade*”
but still very far from reality.
- Aristotle’s five senses are **sight, hearing, touch, smell, taste**.
- sensory illusions → theory of active perception (Richard L. Gregory).
- conjectures a dynamic relationship between
”**description**” (in the brain) \longleftrightarrow senses \longleftrightarrow surrounding.



CONTENTS

- What is Vision?
- Early History
- Learning the discipline and people
- CV in Austria
- IAPR
- Next 40 Years?
- Conclusion - Vision



Early CV History (A. Rosenfeld, 1998)

since **1960** Digital image processing by computer

1968 1. Journal: *Pattern Recognition* (Pergamon, now Elsevier)

1969 1. Textbook: *Picture Processing by Computer* (A. Rosenfeld)

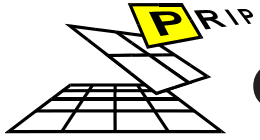
1970 1. International Conference on Pattern Recognition (*ICPR*)

1977 1. Computer Vision and Pattern Recognition (*CVPR*)

1978 International Association for Pattern Recognition (*IAPR*)

1979 IEEE Transactions on Pattern Analysis and Machine Intelligence (*PAMI*)

1987 1. International Conference on Computer Vision (*ICCV*)



Early CV @ TU Graz

1974 Franz LEBERL to NASA JPL

1975 Johannes G. MOIK to NASA Goddard SFC

1978/79 Leberl & Kropatsch: DIBAG @ JR
CV @ basement(TU Graz)



DIBAG around 1980

1st IP software from Joachim Wiesel (Karlsruhe): DIDAK transformed/extended into DIBAG

input	output
artificially created matrices	arrays of numbers
magn.tapes of LANDSAT MSS	overprinted printout of several m^2
small donated pictures	overprints, diapositives



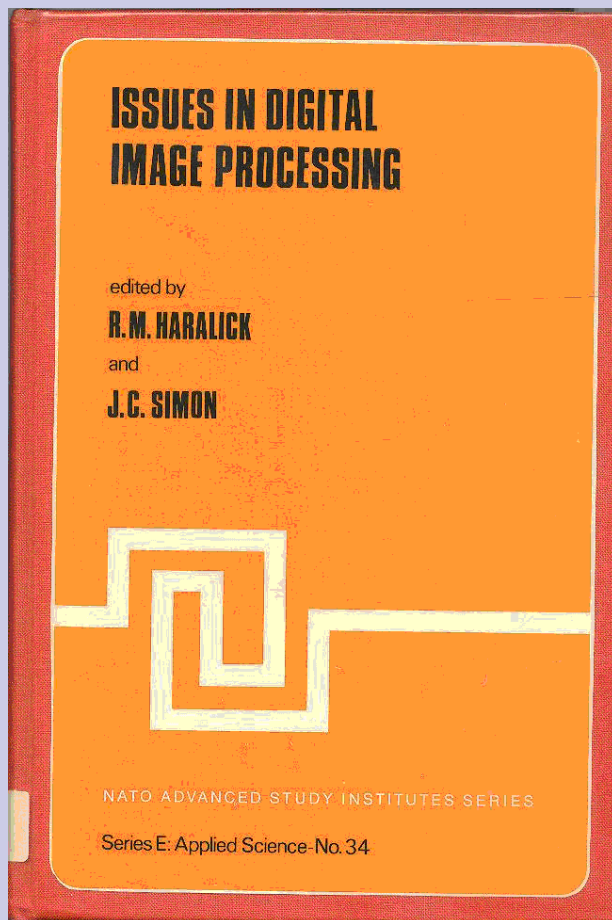
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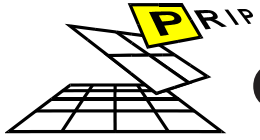
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NATO ASI Bonas 1978



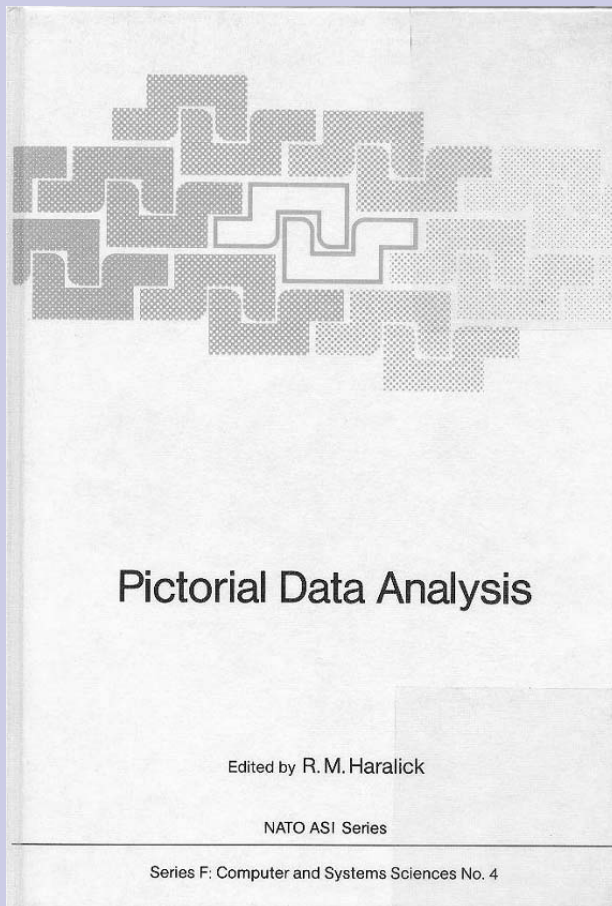
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NATO ASI Maratea 1979

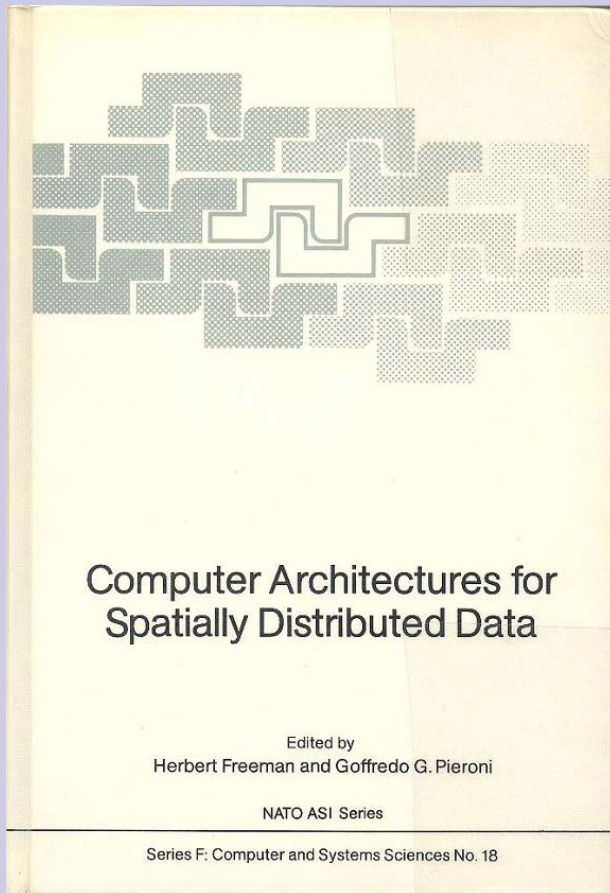
Freeman, H., Pieroni, G. G. (Eds.):
Map Data Processing.
Academic Press, New York, 1980.

NATO ASI Bonas 1982



I.	NEIGHBORHOOD OPERATORS: AN OUTLOOK	
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NATO ASI Cetraro 1983



1. Algorithm-Driven Architecture for Parallel Image Processing
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2. Architectures of SIMD Cellular Logic Image Processing Arrays
M.J.B. Duff
3. Classification Schemes for Image Processing Architectures
V. Cantoni
12. Pyramid Architectures for Image Analysis
Azriel Rosenfeld
13. Using Quadtrees to Represent Spatial Data
Ranan Samet
14. Octrees: A Data Structure for Solid-Object Modeling
H. Freeman and D. Meagher
15. Efficient Storage of Quadtrees and Octrees
Markku Tamminen
16. Image Processing with Hierarchical Cellular Logic
S.L. Tanimoto
17. Considerations on Pyramidal Pipelines for Spatial Analysis of Geoscience Map Data
T. Kasvand and A.G. Fabbri

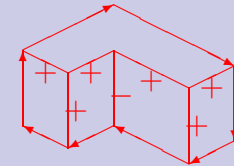
CV Systems (Linda G. Shapiro, 1983)

1965 Roberts' PhD@MIT: 1st CV system

1968 Guzman's PhD@MIT: SEE, blocks world

1971-77 Binford, Agin, Nevatia, Marr: generalized cylinders

1971-78 Huffman, Clowes, Waltz label line drawings of 3D objects

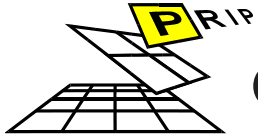


1976 Rosenfeld, Hummel, Zucker: MSYS, relaxation




1974-78 Hanson, Riseman VISIONS, 'schema'

1981 Brooks' PhD@Stanford: ACRONYM, contains graphs for: objects, restrictions, predictions, observations, interpretations.

1982 Haralick, Shapiro@VPI: GIPSY, rel. data structure, spatial reasoning

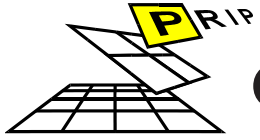


CV in Austria

- 1980** DIBAG @ : Digitale Bildauswertung Graz (10...30 researchers)
- 1981/1987** Österreichische Arbeitsgemeinschaft für Mustererkennung (*ÖAGM*, 10...100 members)
- 1984,1994,2005** *DAGM* Symposia in Österreich, 200 participants
- 1990**  PRIP @ TU Wien: Pattern Recognition and Image Processing group
- 1994-2000** FWF FSP S70: Image Processing
- 1996** *13. ICPR* in Wien, 1000 participants
- 1992**  ICG @ TU Graz: Computer Graphics and Vision
- 2000-2007** K-plus center ACV: Advanced Computer Vision
- 2004-2009** FWF NFN S91: Cognitive Vision



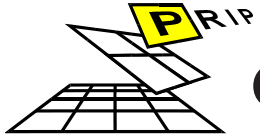
ÖAGM-Meetings



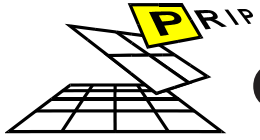
ÖAGM-Meetings

- were held since 1979
- The following list contains:
- the dates,
- where it was held,
- the *"title of the meeting"*, and
- the *invited speakers*.

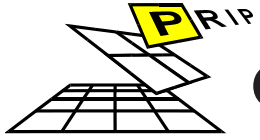




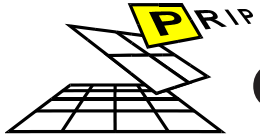
Nb.	When	Where:	Title, Invited
1		? ?	
2	6.- 7.11.1980	Ramsau:	<i>"Mustererkennung und Bildverarbeitung in Österreich"</i>
3	7.- 8. 5.1982	Gallneukirchen:	<i>"Robotik und Bildverarbeitung"</i>
4	29.-30.10.1982	Wien:	<i>"Bildverarbeitung: Datenstrukturen, Anwendungen"</i> , Hanan Samet (CfAR)
5	9.-10.12.1983	Salzburg:	<i>"Array-Prozessoren in der Bildverarbeitung und Mustererkennung"</i> , P. Gemmar (FIM)
6	18.-19. 5.1984	Innsbruck:	<i>"Mustererkennung bei der Sprachsignalverarbeitung"</i> , H. Kindler (Hannover)
7	2.- 4.10.1984	Graz:	<i>"Mustererkennung 1984 (gem. mit DAGM)"</i> , Linda G. Shapiro, Werner Horn
8	7.- 8. 6.1985	Wien:	<i>"Bildverarbeitung und Mustererkennung in der Medizin"</i> , Michael L. Rhodes (USA)
9	8.- 9.11.1985	Klagenfurt:	<i>"Bildverarbeitung in den Geowissenschaften"</i>
10	4.- 5. 7.1986	Graz:	<i>"Bildpyramiden"</i> , Azriel Rosenfeld (CfAR)



Nb.	When	Where:	Title, Invited
11	15.-16. 5.1987	Linz:	<i>"Statistik und Mustererkennung", Josef Kittler (Surrey), Eckhard Hundt (Siemens D)</i>
12	17.-18. 6.1988	Innsbruck:	<i>"Mustererkennung in Medizin und Biologie", Siegfried J. Pöppel (München)</i>
13	26.-27. 5.1989	Wien:	<i>"Wissensbasierte Mustererkennung", Peter J. Burt (Sarnoff)</i>
14	3.- 4. 5.1990	Salzburg:	<i>"Image Acquisition and Real-Time Visualiza- tion"</i>
15	24.-26. 4.1991	Klagenfurt:	<i>"Modelling and New Methods in Image Pro- cessing and Geographical Information Systems", Peter A. Burrough (Utrecht)</i>
16	6.- 8. 5.1992	Wien:	<i>"Pattern Recognition 1992", Annick Montanvert (Grenoble, F)</i>
17	2.- 4. 6.1993	Graz:	<i>"Image Analysis and Sythesis", B. Batchelor (Wales), A. Soifer (Samara), P. Yaroslavsky (NIH)</i>



Nb.	When	Where:	Title, Invited
18	21.-23. 9.1994	Wien:	<i>"Mustererkennung 1994 'Erkennen und Lernen' (gem. mit DAGM)", Yiannis Aloimonos (UMD), Franz Leberl (TUG), Werner von Seelen (Bochum)</i>
19	11.-12. 5.1995	Maribor, SLO:	<i>"Visual Modules", Greg Hager(Yale)</i>
20	9.-10. 5.1996	Leibnitz:	<i>"Pattern Recognition 1996", Henry Maître (ENS Paris)</i>
21	26.-27. 5.1997	Hallstadt:	<i>"Pattern Recognition 1997", Terry Caelli (Perth, ASU), C.P. Suarez Araujo (Gran Canaria)</i>
22	14.-15. 5.1998	Illmitz:	<i>"Pattern Recognition and Medical Computer Vision", H.P.Meinzer (DKFZ), E. Wenger (ÖAW)</i>
23	27.-28. 5.1999	Steyr:	<i>"Robust Vision for Industrial Applications", Giulio Sandini (Genoa), Henrik I. Christensen (KTH)</i>
24	25.-26. 5.2000	Villach:	<i>"Applications of 3D-Imaging and Graph-based Modelling", Pierre Boulanger (NRC Canada)</i>
25	7.- 8. 6.2001	Berchtesgaden:	<i>"Computer Vision, Computer Graphics and Photogrammetry - a Common Viewpoint", Andrew Zisserman (Oxford), Wolfgang Förstner (Bonn)</i>

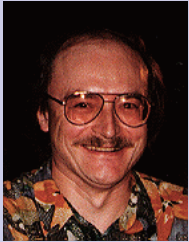


Nb.	When	Where:	Title, Invited
26	10.-11. 9.2002	Graz:	<i>"Vision with Non-Traditional Sensors", Luv van Gool (ETH), Gerd Hirzinger (DLR)</i>
27	5.- 6. 6.2003	Laxenburg:	<i>"Vision in a Dynamic World", Anil Jain (MSU)</i>
28	17.-18. 6.2004	Hagenberg:	<i>"Digital Imaging in Media and Education", Pascal Fua (EPFL)</i>
29	11.-13. 5.2005	Veszprem, Ungarn:	<i>"Joint Hungarian-Austrian Confer- ence on Image Processing and Pattern Recognition", Andrew Fitzgibbon (Oxford)</i>
30	2.- 3. 3.2006	Obergurgl:	<i>"Digital Imaging and Pattern Recognition"</i>
31	3.- 4. 5.2007	Krumbach:	<i>"Performance Evaluation for Computer Vi- sion", Cordelia Schmid (INRIA)</i>
32	26.-27. 5.2008	Linz:	<i>"Challenges in the Biosciences: Image Analysis and Pattern Recognition Aspects", Lucas J. van Vliet (Delft), Wiro Niessen (Erasmus MC), Fred A. Hamprecht (Heidelberg)</i>

Austria meets the CV-World

A → World

World → A



→ CfAR

invited speakers to ÖAGM
DAGM 84, 94, 06

1984/85 1990-

ERASMUS student, teacher ex-
change, intensive programs

PRIP guest professors (Hlavac 95,
Lienhard 01, Gonzalez-Diaz 08)

Ed./Rev. major Journals (PRL, PR,
CVIU, IEEE-PAMI, SPIE-JEI,...)

ICPR 96, ECCV 06, CAIP 07

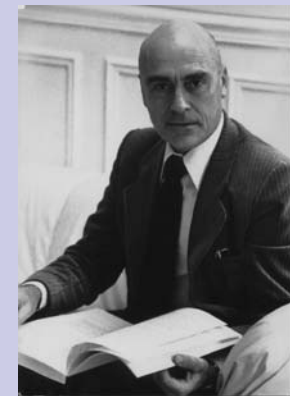
involved in IAPR TC: 7, 15, 19

CVWW yearly since 97
(PRIP+CMP+CVL+ICG)



ExCo: Treasurer, 1st VP, president 2004-2006

ICPR + K.S.Fu Award Winners 2006-1998



2006 Hong Kong: Josef Kittler, On Context, Modelling, Dimensionality ...

2004 Cambridge: J. K. Aggarwal, structure and motion from image sequences

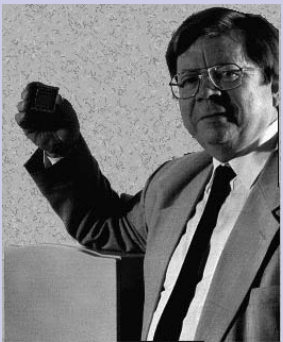
2002 Quebec City: Thomas S. Huang, 3D motion

2000 Barcelona: Theo Pavlidis, structural pattern recognition

Lecture: <http://www.theopavlidis.com/technology/KSFuLecture.htm>

1998 Brisbane: Jean-Claude Simon, automated recognition of handwritten words

ICPR + K.S.Fu Award Winners 1996-1988



1996 Vienna: Teuvo Kohonen, Self-organizing map

1994 Jerusalem: Herbert Freeman, Chain Code; Automated Cartographic Text Placement

1992 The Hague: Levin Kanal

1990 Atlantic City: R.L. Kashyap

1988 Rome: Azriel Rosenfeld, computer image analysis, digital geometry and topology

Celebrating 40 years of Pattern Recognition



1. Volume 41, Issue 7, Pages 2137-2434 (July 2008)
2. Celebrating 40 years of Pattern Recognition-Introductory remarks Page 2137
Robert S. Ledley, Ching Y. Suen
3. Celebrating 40 years of Pattern Recognition-In his own words Page 2138
Robert S. Ledley
4. Celebrating 40 years of Pattern Recognition-Reflections Pages 2139-2144
Henry M. Beisner

Research Strategy for the Future (Julian R. Ullman)

...

PP: *Can you identify the object*

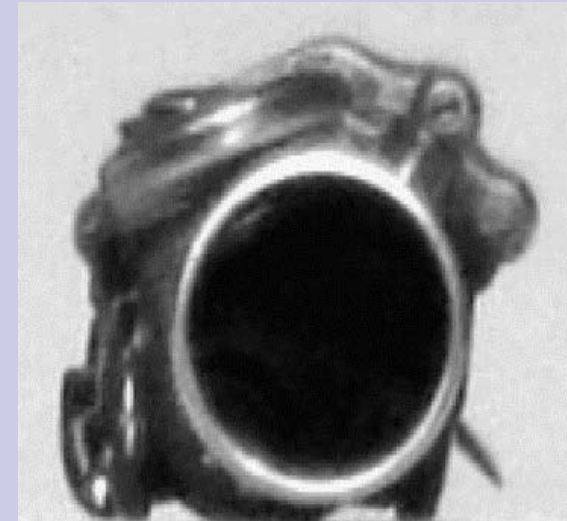
SE: *No.*

PP: *You can't recognize it but you can see it?*

SE: *That's right.*

PP: *So we can see things that we can't recognize?*

...



We can sometimes see the reason for failure

PP: ... *A smudge could cause a machine to misrecognize the '1' as a '7'.*

You and I can see that the smudge affects all the characters.

Ink spots could cause a machine to misrecognize the 'P' as 'R'.

You and I can see that this region of the document is affected by ink spots.

SE: *We simply need a training set that includes smudged and ink-spotted characters.*

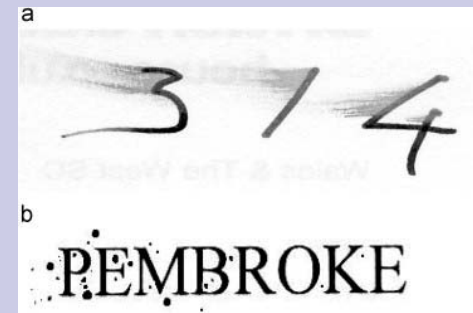
PP: *We need that when the system can't see for itself.*

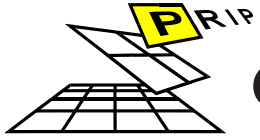
But can we rely on having a training set that includes all possible eventualities?

*I think **George Nagy** was right when he said that the training set is never big enough.*

SE: *Some people might disagree with that.*

...





Next 40 Years:

PP: *...there will be more effort towards devising processes*

that can be implemented in highly parallel associative hardware instead of some kind of stored-instruction computer.

The currently fashionable preoccupation with mathematics needs to be counterbalanced by more exploration of parallel hardware implementation.

PP: *.... Human recognition capability greatly exceeds that of machines.*

We don't have an exact and complete wiring diagram for the human visual system, but we can reasonably assert that it is highly parallel.

After a neuron has fired, it can't fire again until after about ten milliseconds.

Without high parallelism, the human visual system couldn't work as rapidly as it actually does.

...

Fashions, Trends...

EVS Expert Vision Systems 1982++

ANN Artificial Neural Networks 1985++

CV Computer Vision 1987++

CogVis Cognitive Vision 2002++

Trends last about 5 years, boost grant money
mislead sometimes.



Conclusion

- INPUT available in large quantities
- COMPUTERS are by magnitudes faster
- pictorial OUTPUT in excellent quality
- higher level OUTPUT?

Mt. Rainier, 9/11/01



Marco Gori, Simone Marinai,
Walter Kropatsch

- personal experience: **CONTACTS, CONTACTS, CONTACTS**

● **Computers will SEE**

but moreover ALSO

Conclusion →

VISION

- Computers will SEE
- **Computers will HEAR**
- **Computers will SMELL**
- **Computers will TOUCH**
- **Computers will TALK to YOU ... like HUMANS do**
- **as ACTIVE PARTS of our WORLD**

