

MACSI-net

MAThematics, COmputing and SIMulation for INDUSTRY

WG12 Shape and Size in Medicine and Biotechnology



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Milan Research Centre for
Industrial and Applied
Mathematics

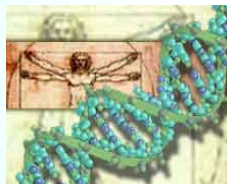
Università degli Studi di Milano

AIMS

Shape analysis deals with the geometrical informations of objects that is left after location, scale and rotation effects are removed.

If scale effects are not removed, then we are led to form (size and shape).

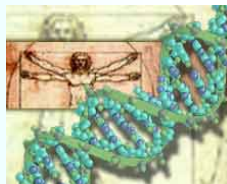
In applications, bodies rarely have exactly the same shape within measurement error; hence randomness of shapes need to be taken into account.



Thanks to the development of information technologies, the last decade has seen a considerable growth of interest in the statistical theory of shape and its application to many and diverse scientific areas.

From the mathematical point of view shape analysis uses a variety of mathematical tools from differential geometry, geometric measure theory, stochastic geometry, etc.

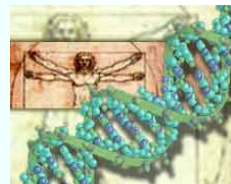
As far as applications are concerned, we will emphasize topics which are relevant in medicine and biotechnology.



We will care about direct and inverse problems.

Among direct problems spatio-temporal pattern formation deals with the analysis of how patterns are created and develop in biology.

Among inverse problems, various statistical techniques of shape analysis will be proposed to measure in a quantitative way the random variability of objects; recent methods of image analysis include optical imaging of objects in turbid media, which can be used as a non-invasive technique for the detection of tumors in the body.



The contribution of the events to the strategic goals of MACSInet



In all the established collaborations projects biotechnologists and medical doctors will provide to mathematicians images, coming from real experiments, related to open problems in which the diagnosis of a pathology, or the description of a biological process mainly depend on the shapes present in such images. The mathematicians and/or statisticians will provide and apply on case studies methods of Shape Analysis and/or Pattern Formation to solve the direct and inverse problems related to the phenomena depicted in the images.



The contribution of the events to the strategic goals of MACSInet



Foreseen events include:

a. Workshops with presentations of current **problems** by “industry” and of current **methods** by “academia”

b. Awareness seminars

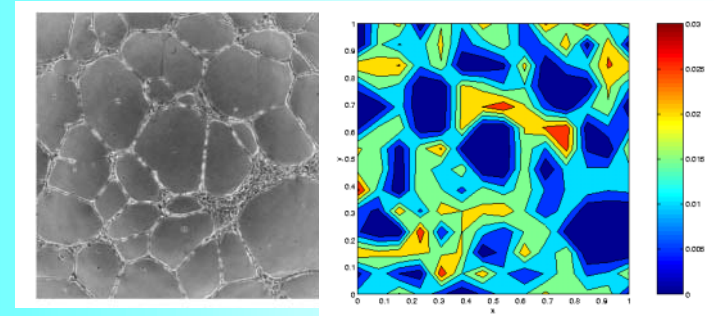
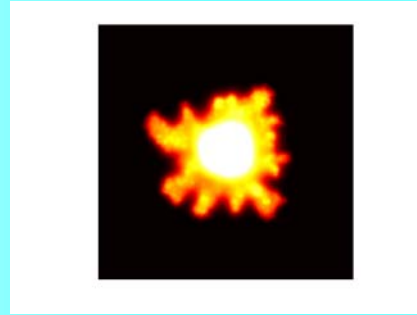
with

- “industry” providing data/ proposing test cases
- academics running test cases with innovative methods

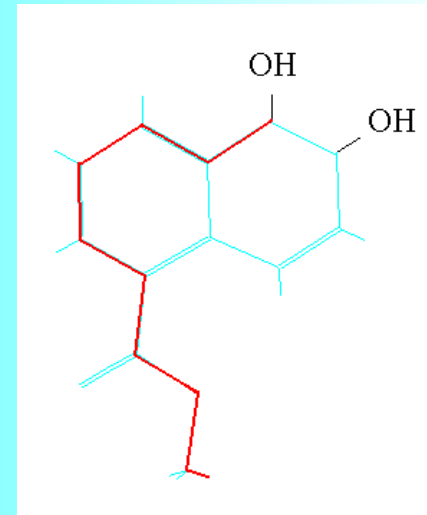


Particular attention will be paid to

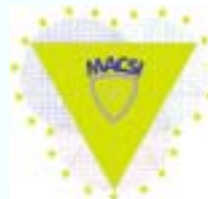
- pattern formation in tumor growth and angiogenesis



- morphology applied to the control of biological reactions (in particular for the production of oxygenated compounds)



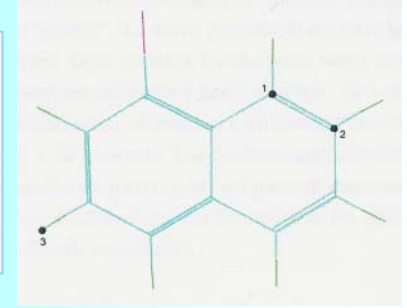
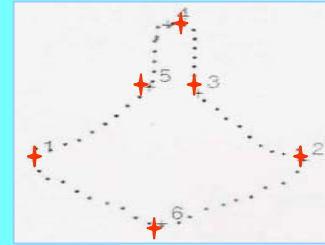
- characterization of relevant morphological traits of single HRC (Hairy Root Cultures, derived from tobacco plants) and HRC-clusters



The WG is a multicenter cluster made of 5 different subgroups

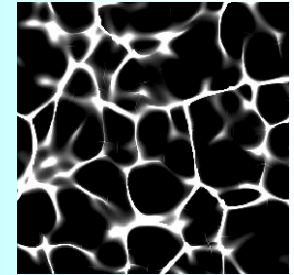
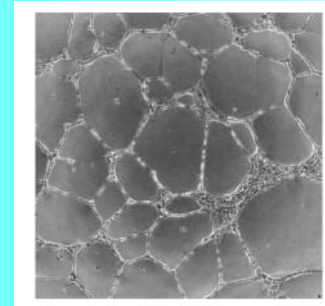
1. Shape analysis

Coordinator: dr. Alessandra Micheletti
(MIRIAM, University of Milan)



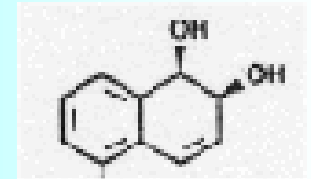
2. Tumor growth and angiogenesis

Coordinators: Prof. Luigi Preziosi
(Department of Mathematics,
Politecnico di Torino)
Dr. H. Byrne
(University of Nottingham)



3. Production of oxygenated compounds

Coordinator: Prof. Enrica Galli
(Department of Genetics and Microbiology,
University of Milan)



4. Morphological traits of HRC

Coordinator: Prof. Willi Jaeger
(IWR, University of Heidelberg)

5. Image analysis

Coordinator: Prof. Luis Bonilla
(Department of Mathematics,
University Carlos III, Leganes, Madrid)



PARTICIPANTS FROM "INDUSTRY"

(contact person)

Institute for Cancer Research and Treatment, Torino (Federico Bussolino)

Institute for Pharmacological Research "Mario Negri", Bergamo (Raffaella Giavazzi)

ITMC, Naples (Paolo Netti)

The Biomedical Research Centre, Ninewells Hospital, Dundee

Department of Surgery and Molecular Oncology, Ninewells Hospital, Dundee
(Mark Chaplain)

Cyclacel (Biotech company involved in anticancer drugs), UK (Mark Chaplain)

Department of Pathology, University of Sheffield Medical School (Claire Lewis)

Gray Labs, Mount Vernon Hospital, London (Gill Tozer)

Cancer Research Laboratories, Nottingham (Malcom Stevens and Charles Laughton)

Laboratoire de Rheologie, CNRS, Grenoble (Claude Verdier)

Norpharma SpA, San Donato Milanese (Milano) (Giancarlo Tonon)

ROOTec GmbH, Heidelberg (E. Wildi)

SEITA-ALTADIS Group, Bergerac (Rene Delon)

Department of Genetics and Microbiology, University of Milan (Enrica Galli)

Department of Environmental Sciences, University of Milano-Bicocca
(Giuseppina Bestetti)

Department of Chemistry, University of Milan (Guido Sello)

Hospital Gregorio Maranon (Madrid)

STMicronics, Agrate Brianza (Giovanni Di Bona)





PARTICIPANTS FROM "ACADEMIA"

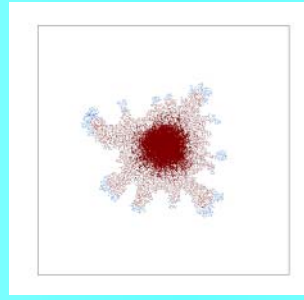
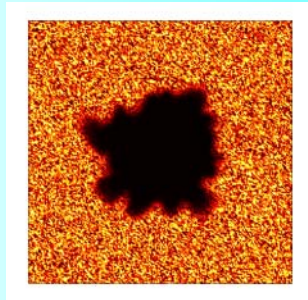
(contact person)

- *MIRIAM, University of Milano* (Alessandra Micheletti and Daniela Morale)
- *Dept. of Mathematics, Politecnico di Torino* (Luigi Preziosi)
- *Dept. of Mathematics, University of Dundee* (Mark Chaplain)
- *Division of Theoretical Mechanics, School of Mathematical Sciences, University of Nottingham* (Helen Byrne)
- *IWR(Iterdisziplinaeres Zentrum fuer Wissenschaftliches Rechnen), Heidelberg* (Willi Jaeger)
- *Department of Mathematics, University Carlos III, Leganes, Madrid* (Luis Bonilla)

Plans for follow up's

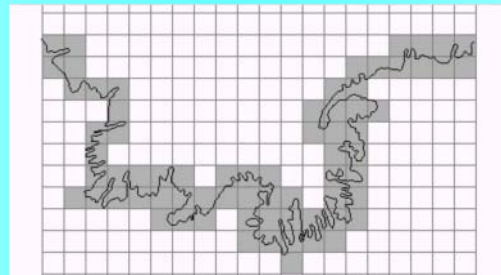
Workshops- brainstorming on site have been planned in labs of medicine or biotechnology .
At the moment

- a meeting has occurred in Dundee on November 12, 2002 (between the Miriam group and the group of Prof. Chaplain) on patterns of tumor growth



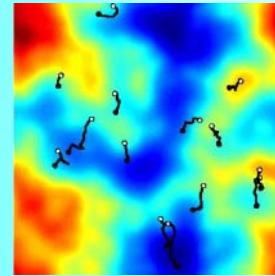
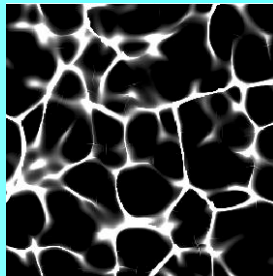
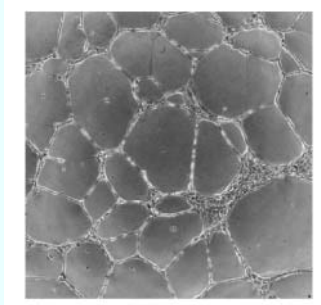
- an awareness seminar has occurred on November 25, 2002 at the dept. of Neuroradiology of Ospedale Niguarda in Milano about methods of Statistical Shape Analysis vs. pathologies of the brain vascular systems

- another meeting is planned in Birmingham in December 2002 or January 2003 (between the Miriam group and the group of prof. Landini) on the shape of malignant tumor cells



- A minisymposium at the EMS-SMAI-SMF Joint Conference on Applied Mathematics - Applications of Mathematics, Nice , February 10-13, 2003 on the subject "Stochastic Shape and Size in Biomedicine and Material Sciences" is being organized by V.Capasso, MIRIAM Centre, Milano

- A Workshop on "Mathematical Modelling and Computer Simulations in Cancer Therapy" to be held in Torino (Italy), 3-4 March 2003, is being organized by Luigi Preziosi, Politecnico di Torino.



Summary and highlights

MEETING OF THE WORKING GROUP "SHAPE AND SIZE IN MEDICINE AND BIOTECHNOLOGY" MILANO, July 4-5, 2002

The first workshop of the MACSI-net working group "SHAPE AND SIZE IN MEDICINE AND BIOTECHNOLOGY" has been held in Milano on July 4-5, as a parallel session of the 5th International Conference of the European Society of Mathematical and Theoretical Biology (ESMTB).



**Mathematical Modelling & Computing
in Biology and Medicine**

The workshop has been organized by

V.Capasso, A.Micheletti, D.Morale (MIRIAM, University of Milan)



and L. Preziosi (Dept. of Mathematics,
Politecnico di Torino).



It was divided into 2 sessions, with 9 main speakers, chosen between experts of mathematical modelling of biological systems and biologist and medical doctors experts in the fields of bioconversions and tumor growth.

PROGRAMME

July 4, 2002

Vincenzo Capasso, University of Milan, MIRIAM and Dept. of Mathematics

Presentation of the Working Group "Shape and Size in Medicine and Biotechnology"

Guido Sello, University of Milan, Dept. of Chemistry

Substrate structural demands in oxygenation reactions catalyzed by oxygenases from Pseudomonas strains

Alessandra Micheletti, University of Milan, MIRIAM and Dept. of Mathematics

Shape analysis applied to the study of the yields of bioconversions of oxygenated compounds

Markus Kirkilionis, IWR - University of Heidelberg

Development of form and shape in plant roots and leaves

Miguel Moscoso, University Carlos III Madrid, Dept. of Mathematics

Polarization-sensitive Techniques in Optical Imaging

July 5, 2002

Gabriel Landini, Oral Pathology Unit, School of Dentistry, The University of Birmingham

Epithelial tumour shape complexity: global and local fractal features.

Moritz Konerding, Department of Anatomy, Johannes-Gutenberg-University Mainz

Microvascular networks in tumors, normal tissues, and inflammation

Alexander Anderson, University of Dundee, Dept. of Mathematics

Mathematical Modelling of Angiogenesis: Predicting Drug Flow Through Vascular Networks

Daniela Morale, Dept. of Mathematics, University of Torino and MIRIAM, University of Milano

Modelling cell interactions. Application to angiogenesis.

Davide Ambrosi, Dept. Of Mathematics, Politecnico di Torino

Mechanical aspects in tumor growth

DIFFUSION OF INFORMATION

The event has been widely announced in the main academic, biotechnological and medical environments which might have been interested in it.

A leaflet has been produced and sent to the departments of Mathematics, Biology, Medicine and Biotechnologies of the main universities in Milan and to the secretariat of MACSI-net for diffusion in the centres of the MACSI-net network. The leaflet has also been distributed to all participants at the ESMTB conference.

E-mail announcements have been sent to other various relevant public and private research laboratories of Milan (like, for example, Istituto Mario Negri).

The event has been announced and described on the web pages of MACSI-net, on the web page of the main conference, and on the web page of the MIRIAM research centre (the node of MACSI net hosting the event).



PARTICIPANTS

Thanks to the fact that the event has been held during the European Conference of ESMTB, which had more than 500 participants, a number of academic mathematicians and biologists were on hand.

During the two sessions, more than 80 persons from both communities have participated in the workshop.

Special mention deserves the participation of

The President of the European Mathematical Society [R.Jeltsch]

A Delegate of the Society for Mathematical Biology [L. Sattenspiel]

A Delegate of the Japan Association for Mathematical Biology



During this event useful [contacts](#) between the participants have been established for future joint research projects. In particular:

- a collaboration has started between the research group of MIRIAM, University of Milano (experts of Mathematical Statistics and Mathematical Shape Analysis) and the research group of G. Landini, University of Birmingham (medical doctors, working on tumors of the mouth).
- a collaboration has been established between the research group of MIRIAM, University of Milano (experts of Mathematical Statistics and Mathematical Shape Analysis) and the research group of M.Chaplain, University of Dundee (mathematicians, with strong links with medical research labs)
- A collaboration has been established between the research group of Luigi Preziosi, Politecnico di Torino (experts of Mathematical Physics) and groups of biotechnologists and medical doctors of Istituto Mario Negri, Bergamo (Italy), and the Institute for Cancer Research and Treatment, Torino, about problems of angiogenesis.
- Various collaborations between the groups of mathematicians which participated to the workshop, in particular between the MIRIAM Centre (Milano, Italy), the University of Aarhus (Denmark), the IWR Centre (Heidelberg, Germany), the University Carlos III of Madrid (Spain).



EXPANSION OF THE NETWORK:

- **University of Aarhus** [Eva Jensen]
- **University of Linz** [Martin Burger]
- **IASI-CNR of Rome** [Alberto Gandolfi]
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FURTHER DIFFUSION OF INFORMATION

Next Issue of the MACSI-net Newsletter will include the following Articles

- **Presentation of the WORKING GROUP 12 :
SHAPE AND SIZE IN MEDICINE AND BIOTECHNOLOGY**
- **The MIRIAM Workshop “Shape and Size in Medicine and Biotechnology”**
- **Mathematical Modelling of Avascular Solid Tumor Growth, Tumor-Induced Angiogenesis, Tissue Invasion and Metastasis (Mark Chaplain)**
- **The Stochastic Geometry of Random Tessellations (Vincenzo Capasso and Alessandra Micheletti)**
- **Shape and Size in Tissue Engineering (Federico Bussolino and Luigi Preziosi)**
- **Shape and Size in Cancer Pathology (Gabriel Landini)**
- **Shape and Size in Biotechnology and Material Sciences (V. Capasso, A.Micheletti)**

