Report on the ESF Exploratory Workshop:
Fundamentals of Medical Informatics

Elspeet, the Netherlands, 27–29 October 2002

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1   Executive summary

1.1   Organisation of the event

The workshop *Fundamentals of Medical Informatics* was held on Monday 28th and Tuesday 29th October, 2002, with, for people coming from abroad, the 27th October taken as day of arrival and the 30th October as day of departure. Location of the workshop was Mennorode Hotel and Conference Centre, Elspeet, the Netherlands. A Web page describing the workshop is available at `http://www.cs.kun.nl/~peterl/esf.html`.

The workshop was organised by the following team of people:

Dr Peter Lucas, MD	University of Nijmegen, Netherlands	Convenor
Mrs Nicole el Moustakim	University of Nijmegen, Netherlands	Management Assistant
Dr Ameen Abu-Hanna	University of Amsterdam, Netherlands	Co-convenor
Dr Nada Lavrač	Jozef Stefan Institute, Slovenia	Co-convenor

1.2   Motivation

As the use of computers in health-care has evolved rapidly the last decade, medical-informatics researchers are increasingly involved in practical work, often initiated by the medical community. This intensified involvement with the medical field has offered interesting opportunities for researchers to evaluate ideas in a real-world setting. However, this trend has also resulted in a gradual shift away from fundamental research in Medical Informatics. The process has been ongoing at least since the beginning of the 1990s. In the 1970s en 1980s, medical-informatics research stood at the for-front of fundamental research in computer science, contributing to important achievements. Methods and techniques, originally developed for dealing with medical problems, were successfully applied by computer scientists to other fields. Examples include semantic databases, rule-based expert systems,

conceptual modelling, machine learning, decision-theoretic planning, neural networks, Bayesian networks, computer simulation, and signal and image processing. Medical Informatics also offers a natural context for performing Bioinformatics research.

Due to the repositioning of medical-informatics research as a result of the abundance of practical IT opportunities, the influence of Medical Informatics on computer science and equally on other fields has diminished considerably. Many medical computer scientists also seem to neglect the opportunities offered by the progress in the Life Sciences, and remain far removed from basic research. This trend may be regarded as indicative for the current state of research in Medical Informatics, and may contribute to undermining fundamentally oriented research which has proved itself in the past, and which is necessary for the scientific future of Medical Informatics research. The goal of the Exploratory Workshop was to consolidate and revitalise fundamental research in Medical Informatics by bringing together key researchers in Medical Informatics and related fields, such as Bioinformatics, Biomedical Engineering, and Machine Learning and Statistics.

1.3 Timeliness

Until recently, clinical patient data have been stored in almost inaccessible paper form, hampering scientific use of this information. Furthermore, the IT infrastructure of hospitals consisted for more than 25 years only of a hospital-wide information system, storing administrative data and laboratory data. However, this infrastructure is currently being revolutionised by the introduction of electronic communication and clinical information systems in the wards. Similar developments are taking place in primary care. From a scientific point of view, these developments are extremely interesting, since it will create an environment that is better suited to medical-informatics research than ever before. Given the fact that Bioinformatics has given a major impetus to fundamental research in the Life Sciences, Medical Informatics can also profit from this by carrying out complementary research within the context of medicine. This will provide new opportunities for testing fundamental principles of Medical Informatics. Hence, it appears to be the appropriate time to reconsider the research directions in Medical Informatics, as the infrastructure to carry out that research will soon expand in university hospitals, and clinical applications of basic research in the Life Sciences are expected soon.

1.4 Invitation process

Two types of participant were invited to the workshop: (1) senior researchers who were seen as key researchers in their field; (2) motivated junior researchers who were expected to be able to take over the lead of the research in the future. Fields of expertise included: data analysis and machine learning in biomedicine, Bayesian networks, biomedical imaging, knowledge representation in biomedicine. The senior researchers were requested to submit two of their best relevant papers to the workshop and, in addition, an abstract summarising their views on the workshop's themes. The papers and abstracts were collected as working notes, which were distributed to the participants at the beginning of the workshop. A copy of the working notes was also given to the ESF EMRC representative present at the workshop. Only senior researchers were requested to give a presentation on research considered relevant to the workshop's aims.

2 Scientific content of the event

The workshop consisted of presentations by experts in their field about topics related to:

- machine learning and data-mining in medicine, human biology and pharmacology;

- the representation of biomedical knowledge in guidelines and in medical decision-making, using techniques such as Bayesian networks and logic;

- Bioinformatics challenges in medicine.

In their talks, the researchers tried to relate their methods and techniques to biomedical, pharmacological, clinical and epidemiological problems. Given the emphasis in modern medicine and biology on the analysis of data, it was not surprising that the focus of the workshop was on data analysis, data-mining and machine learning. However, this theme was frequently approaches from the viewpoint of representation, e.g. of patterns in data or knowledge that can be extracted from the data. Both statistical and logical constraint-based methods were discussed.

3 Assessment of the results

The ultimate aim of the workshop was to develop a proposal for a book on foundations of Biomedical Informatics (i.e. Medical Informatics integrated with human-oriented Life Sciences research). This aim was achieved. The proposal, which was drafted at the end of the workshop, will be submitted to The MIT Press and to Springer Press. It was decided that the book would be split up into a two volume set; volume I will be devoted to data-mining and machine learning in Biomedicine, and volume II to the modelling of biomedical knowledge.

The participants saw the workshop as a start for establishing a community of researchers interested in fundamental research in Biomedical Informatics. There was significant interest among the participants to start an ESF Network on fundamental research in Biomedical Informatics. This ESF network was expected to be responsible for the organisation of regular meetings of researchers in this area, and in particular for setting up and maintaining Web resources (offering on-line papers on fundamental research in Biomedical Informatics and relevant software).

If time allows, a proposal for an ESF Network in the area of Biomedical Informatics will be submitted to the ESF somewhere next year.

4 Final programme

1st day (Sunday, 27 October, 2002)

- *Arrival*

- 18:30–20.00 *Dinner*

2nd day (Monday, 28 October, 2002)

- 09.20 – 09.30 Peter Lucas: **Welcome**

- 09.30 – 10.30 Jan Komorowski and Ameen Abu-Hanna: **Modelling biological systems and clinical problems using machine Learning**

- 10.30 – 11.00 *Coffee break*

- 11.00 – 12.00 Mar Marcos and Lucila Ohno-Machado: **Representation, formalisation and verification of medical guidelines**

- 12.00 – 12.10 Hui Wang: **Introduction to the European Science Foundation**

- 12.30 – 14.00 *Lunch*

- 14.00 – 15.00 Gregory Cooper and Linda van der Gaag: **Bayesian networks – causality, modelling, learning, and evaluation**

- 15.00 – 16.00 Pedro Larrañaga and José Peña: **Bayesian-network structure learning, evolutionary algorithms**

- 16.00 – 17.00 *Refreshments and Walking*

- 17.00 – 18.00 Luc De Raedt and Nada Lavrač: **Constraint-based data-mining and subgroup discovery**

- 18.30 – 20.00 *Dinner*

3rd day (Tuesday, 29 October, 2002)

- 09.30 – 10.30 Luc Dehaspe and Lucila Ohno Machado: **Machine learning methods in bioinformatics**

- 10.30 – 11.00 *Coffee break*

- 11.00 – 12.00 Peter Hammond and Peter Lucas: **Modelling of biological and medical features and problem solving**

- 12.00 – 12.30 **Start of discussions about the content of book**

- 12.30 – 14.00 *Lunch*

- 14.00 – 15.00 Riccardo Bellazzi and Marie-Odile Cordier: **Representation and reasoning with temporal knowledge**

- 15.00 – 18.00 **Working session: discussion of outcome, and production of book proposal**

- 18.00 – 20.00 *Dinner*

4th day (Wednesday, 30th October, 2002)

Departure

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5   Final list of participants

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3. **Dr Ameen Abu-Hanna**, *Co-convenor*, Department of Medical Informatics, University of Amsterdam/AMC, Meibergdreef 15, 1105 AZ Amsterdam, Netherlands; E-mail: a.abu-hanna@amc.uva.nl

4. **Dr Nada Lavrač**, *Co-convenor*, Jozef Stefan Institute, Jarnova 39, Ljubljana, Slovenia; E-mail: Nada.Lavrac@ijs.si

5. **Dr Hui Wang**, *ESF EMRC Representative*, European Science Foundation, 1 quai Lezay-Mamésia, 67080 Strasbourg Cedex, France; e-mail: hwang@esf.org

6. **Prof Riccardo Bellazzi**, Dipartimento di Informatica e Sistemistica, University of Pavia, Via Ferrata 1, 27100 Pavia, Italy; E-mail: ric@aim.unipv.it

7. **Prof Gregory Cooper, MD,** University of Pitssburgh, Center for Biomedical Informatics, Suite 8084 Forbes Tower, 200 Lothrop Street, Pittsburgh, PA 15213-2582, USA; E-mail: gfc@cbmi.upmc.edu

8. **Prof Marie-Odile Cordier**, IRISA, Campus de Beaulieu, F-35042 RENNES Cedex, France; E-mail: Marie-Odile.Cordier@irisa.fr

9. **Dr Luc Dehaspe**, PharmaDM, Ambachtenlaan 54D, B-3001 Heverlee, Belgium; E-mail: Luc.Dehaspe@pharmadm.com

10. **Prof Linda van der Gaag**, Institute of Computer and Information Sciences, Utrecht University, P.O.Box 80.089, 3508 TB Utrecht, Netherlands; E-mail: linda@cs.uu.nl

11. **Dr Dragan Gamberger**, Rudjer Boskovic Institute, Division of Electronics, Laboratory for Information Systems, Bijenicka 54, 10 000 Zagreb, Croatia; E-mail: dragan.gamberger@irb.hr

12. **Prof Peter Hammond**, Eastman Dental Institute for Oral Health Care Sciences, University of London, 256 Gray's Inn Road, London WC1X 8LD, UK; E-mail: p.hammond@eastman.ucl.ac.uk

13. **Prof Pedro Larrañaga**, Departamento de Ciencias de la Computación e Inteligencia Artificial Facultad de Informática, Universidad del País Vasco / Euskal Herriko Unibertsitatea P.O.Box 649, 20080 Donostia - San Sebastián, Basque Country, Spain; E-mail: ccplamup@si.ehu.es

14. **Prof Jan Komorowski**, The Linneus Centre for Bioinformatics, Uppsala University, PO Box 598, 751 24 UPPSALA, Sweden; E-mail: Jan.Komorowski@idi.ntnu.no

15. **Prof Mar Marcos**, Departament d'Enginyeria i Ciència dels Computadors, Universitat Jaume I, Campus de Riu Sec, 12071 Castellon, Spain; E-mail: marcos@icc.uji.es

16. **Prof Lucila Ohno-Machado, MD,** Decision Systems Group, Harvard Medical School and MIT, Thorn 309, Brigham and Women's Hospital, 17 Francis Street, Boston, MA 02115, USA; E-mail: machado@dsg.harvard.edu

17. **Dr Niels Peek**, Department of Medical Informatics, University of Amsterdam/AMC, Meibergdreef 15, 1105 AZ Amsterdam, Netherlands; E-mail: N.B.Peek@amc.uva.nl

18. **Linda Peelen, MSc**, Department of Medical Informatics, University of Amsterdam/ AMC, Meibergdreef 15, 1105 AZ Amsterdam, Netherlands; E-mail: l.peelen@amc.uva.nl

19. **Dr Jose M. Peña**, Room E1-117, Section on Decision Support Systems, Department of Computer Science, Aalborg University, Fredrik Bajers Vej 7E, DK-9220 Aalborg, Denmark; E-mail: jmp@cs.auc.dk

20. **Prof Luc De Raedt**, Maschinelles Lernen und Natürlichsprachliche Systeme, Institut für Informatik Albert-Ludwigs-Universität Freiburg Georges-Köhler-Allee, Gebäude 079, D-79110 Freiburg i. Br, Germany; E-mail: deraedt@informatik.uni-freiburg.de

21. **Danielle Sent, MSc**, Institute of Computer and Information Sciences, Utrecht University, PO Box 80.089, 3508 TB Utrecht, Netherlands; E-mail: danielle@cs.uu.nl

6 Statistical information

- **Country of origin:**

  - Belgium: 1
  - Croatia: 1
  - Denmark: 1
  - France: 1
  - Germany: 1
  - Italy: 1
  - Netherlands: 7
  - Slovenia: 1
  - Spain: 2
  - Sweden: 1
  - United Kingdom: 1
  - USA: 2

- **Age:**

  - 20-30: 2
  - 30-40: 5
  - 40-50: 13

- **Gender:**

- – Male: 12
- – Female: 8

- **Field of research (overlapping):**
  - – Artificial Intelligence: 9
  - – Bioinformatics: 7
  - – Computing science: 10
  - – Decision-support systems: 5
  - – Machine learning: 12
  - – Medical informatics: 9
  - – Medicine: 3