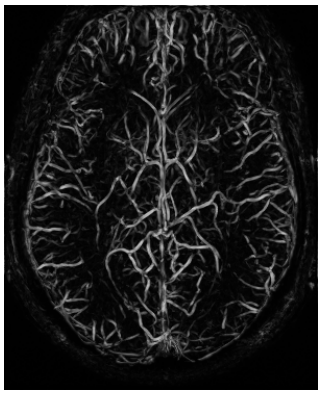
COST Action B21

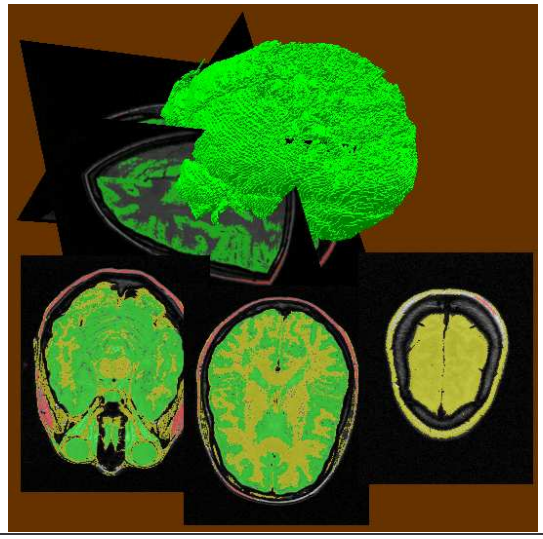
Domain Committee
Biomedicine and Molecular Biosciences
(BMBS)

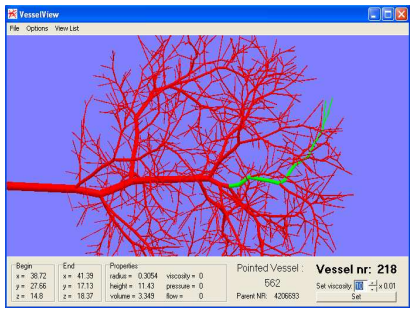
Physiological Modelling of MR Image Formation

ANNUAL PROGRESS REPORT

Period: *from December 2003*
to December 2006







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1. OVERVIEW: ACTION IDENTIFICATION DATA

A. Action Fact Sheet

II. Action B21: Physiological modelling of MR image formation

III. Domain : Biomedicine and Molecular Biosciences

Action details

Draft MoU : 284/02
CSO approval date : 02/12/2002

Entry into force : 30/04/2003
End of Action : 14/12/2007

Objectives

The main objective of the Action is to establish how software technology based on development of magnetic resonance imaging (MRI), simulation techniques and data processing algorithms can offer a flexible and economically feasible environment for the modelling of tissue physiology. This is an innovative idea which could have a dramatic and exciting outcome, opening up the detailed characterisation of disease processes by MR and other imaging methods. The health benefi ts to the European citizen could be great and a planned outcome of the work would be a European software product, not yet existing in the USA or Japan and entirely ground breaking in its scope and application.

Signatures

Country	Date	Status	Country	Date	Status	Country	Date	Status
Austria	05/08/2003	Confirmed	Belgium	16/06/2003	Confirmed	Croatia	02/12/2003	Confirmed
Cyprus	23/05/2003	Confirmed	Czech Republic	06/08/2003	Confirmed	Denmark	05/06/2003	Confirmed
France	05/07/2003	Confirmed	Germany	26/02/2003	Confirmed	Hungary	07/11/2003	Confirmed
Italy	28/02/2003	Confirmed	Lithuania	10/12/2004	Confirmed	Norway	06/08/2003	Confirmed
Poland	30/04/2003	Confirmed	Romania	04/03/2003	Confirmed	Serbia	10/03/2006	Confirmed
Slovakia	11/06/2004	Confirmed	Slovenia	08/12/2003	Confirmed	Spain	25/09/2003	Confirmed
Switzerland	16/12/2003	Confirmed	United Kingdom	26/02/2003	Confirmed			
Total	20							

Intentions to sign

Canada	30/04/2003	Intention
Total	1	

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Non COST Institutions

Institution name
Neurological Institute Montreal (CA)
National Research Council of Canada - NRCC (CA)

2. OBJECTIVES

The main objective of the action is to establish how software technology based on the development of magnetic resonance imaging (MRI), simulation techniques and data processing algorithms can offer a flexible and economically feasible environment for the *modelling of tissue physiology*. This is an innovative idea which could have a dramatic and exciting outcome, opening up the detailed characterisation of disease processes by MR and other imaging methods. The health benefits to the European citizen could indeed be great and a planned outcome of the work would be a European software product, not existing in the USA or Japan and entirely *ground breaking* in its scope and application.

3. TECHNICAL DESCRIPTION AND IMPLEMENTATION

The work has been sub-divided into three working groups, viz.:

WG1 Tissue parameters and physiological data
WG2 Software and simulation
WG3 Experimental verification and trials

Secretarial services have been organised through the COST Office.

4. PARTICIPATION AND COORDINATION

4.1 Management Committee

Chairperson: Dr R A Lerski
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COUNTRY	MEMBERS
AUSTRIA	Prof. Dr E Moser, University of Vienna, Vienna Prof. Dr S Trattnig, University of Vienna, Vienna
BELGIUM	Prof. Dr R Dommisse, Universiteit Antwerpen, Antwerp
CANADA	Dr R Baumgartner, Biomedical Informatics Group, Manitoba Prof. A Evans, Montreal Neurological Institute, Montreal
CROATIA	Prof. S Loncaric, University of Zagreb, Zagreb Prof. M Marotti, University Hospital – Sisters of Charity, Zagreb
CZECH REPUBLIC	Dr M Hajek, Institute for Clinical and Experimental Medicine, Prague Dr M Dezortova, Institute for Clinical and Experimental Medicine, Prague
CYPRUS	Dr G Gregoriou, Intercollege, Nicosia Dr C Constantinides, Chi Biomedical Limited, Nicosia
DENMARK	Dr H Stødkilde-Jørgensen, Aarhus Universitehospital, Aarhus Prof. A Karlsson, The Royal Veterinary and Agricultural University, Frederiksberg C
FRANCE	Prof. J Chambron, Université Louis Pasteur, Strasbourg Prof. J de Certaines, Université de Rennes I, Rennes
GERMANY	Prof. L Schad, Deutsches Krebsforschungszentrum, Heidelberg PD Dr J Reichenbach, Universität Jena, Jena
HUNGARY	Prof. T Járdánházy, University of Szeged, Szeged Prof. J Molnar, University of Szeged, Szeged
ITALY	Prof. A Spisni, Universita di parma, Parma Dr N Culeddu, CNR, ICB Sesione di Sassari, Li Punti Sassari
LITHUANIA	Prof. A Lukosevicius, Kaunas University of Technology, Kaunas Prof. A Tamasauskas, Kaunas University of Medicine, Kaunas
NORWAY	Prof. O Lundervold, University of Bergen, Bergen Prof. O Haraldseth, Norwegian University of Science & Technology, Trondheim
POLAND	Prof. A Materka, Technical Univeristy of Lódz, Lódz Dr M Strzelecki, Technical Univeristy of Lódz, Lódz
ROMANIA	Prof. B Carstocea, Spitalul Militar Central, Romania Dr A Staicu, Nat. Inst. for Lasers, Plasma & Radiation Physics, Bucharest
SERBIA	Prof. G Bacic, University of Belgrade
SLOVAKIA	Prof. D Dobrota, Comenius University, Martin Dr V Mlynarik, Dérer Faculty Hospital, Bratislava
SLOVENIA	Prof. S Kovacic, University of Lubjliana, Lubjliana
SPAIN	Prof. A Santos, Universidad Politécnica de Madrid, Madrid Prof. M Desco, Hospital General Universitario 'Gregorio Maranon', Madrid
SWITZERLAND	Prof. G Szekely, Swiss Federal Institute of Technology, Zurich
UNITED KINGDOM	Dr R A Lerski, University of Dundee, Dundee Prof. M Petrou, Imperial College, London

4.2 **Participating Institutions**

University of Dundee, Scotland, UK

German Cancer Research Centre, Heidelberg, Germany
Technical University of Lódz (TUL), Poland
Universiteit Antwerpen, Belgium
Institut de Physique Biologique, Strasbourg, France
Norwegian University of Science and Technology, Norway
Aarhus University Hospital, Denmark
Ciudad Universitaria, Madrid, Spain
University of Vienna, Austria
Inst. for Clinical and Experimental Medicine, Prague, CZ
University of Bergen, Norway
Istituto di Chimica Biologica, Parma, Italy
Hospital GU "Gregorio Marañon", Madrid, Spain
ETH-Zentrum, Zurich, Switzerland
University of Rennes, Rennes, France
University of Belgrade, Serbia
University of Surrey, UK
University of Ljubljana, Slovenia
Intercollege, Nicosia, Cyprus
Spitalul Militar Central, Bucharest, Romania
CNR ICB, Sezione di Sassari, Li Punti Sassari, Italy
Comenius University, Martin, Slovakia
Diagnostic Centre of "Ayios Therissos", Nicosia, Cyprus
Montreal Neurological Inst., Montreal, QC, Canada
University of Szeged, Hungary
Research Unit for Meat Science, Frederiksberg, Denmark
Centre de Biophysique Moléculaire, Orléans, France
Dérer Faculty Hospital, Bratislava, Slovakia
Klinikum der Friedrich-Schiller-Universität Jena, Germany
Nat. Inst. for Lasers, Plasma and Radiation Physics, Bucharest, Romania

4.3 **Meetings of the Management Committee**

Brussels, Belgium	-	15 December 2003
Dundee, UK	-	13 March 2004
Ayia Napa, Cyprus	-	2 October 2004
Szeged, Hungary	-	19 March 2005
Lodz, Poland	-	8 October 2005
Alghero, Sardinia	-	1 April 2006
Brussels, Belgium	-	20 October 2006

Management Committee meetings are planned for March and October 2007.

4.4 **Meetings of the Working Groups**

Dundee, UK	-	12/13 March 2004
Brussels, Belgium	-	25/26 June 2004
Ayia Napa, Cyprus	-	1/2 October 2004
Brussels, Belgium	-	17 January 2005
Szeged, Hungary	-	18 March 2005
Lodz, Poland	-	6/7 October 2005
Alghero, Sardinia	-	30/31 April 2006
Brussels, Belgium	-	18/19 October 2006

A working group meeting is planned for December 2006 in Bergen.

4.5 **Short-term scientific missions**

J Sedlacik (Germany) – From 26/06/04 to 04/07/04
To: University of Vienna, Austria
Topic: MRI technique familiarisation

S Witoszynskyj (Austria) – From 01/09/04 to 30/09/04
To: Universitat Jena, Germany
Topic: MRI experiments

S Jespersen (Denmark) – From 05/12/04 to 13/12/04
To: Universitat Jena, Germany
Topic: Bayesian analysis of MRI diffusion images

V Kovalev (UK) – From 20/6/05 to 11/7/05
To: Universitat Jena, Germany
Topic: Investigation on the influence of scanning protocols to the gradients of higher-order image statistics

A Deistung (Germany) – From 24/4/05 to 14/5/05
To: Technical University of Lodz, Poland
Topic: Exploring the feasibility to extract the venous vessel tree from high-resolution SWI data

O Olsen (Norway) – From 6/6/05 to 1/7/05
To: University of Surrey, UK
Topic: Development of software tools for segmentation of optic nerves in animals.

R Sance (Madrid) – 01/05/06 to 20/05/06
To: University of Bergen, Norway
Topic: Image registration for quantitative analysis of kidney function using MRI

P Szczypinski (Lodz) – 17/6/06 to 22/06/06
To: University of Rennes, France
Topic: Presentation of new capabilities of MaZda software, training in 2D and 3D image processing including ROI drawing, computing textural image features, statistical data analysis and classification.

5. **RESULTS**

5.1 WG1 – Tissue parameters and physiological data

The main goal of working Group 1 (WG1) within the B21 action is to develop and implement MR sequences and/or techniques related to the following areas – Perfusion, DWI and DTI, BOLD-imaging (including SWI), and ^{23}Na imaging. WG1 encompasses both scientists working in the field of MRI and MRS and clinicians interested in the application of the available techniques. To reach the aforementioned goals, there have been dedicated presentations at both Management Committee (MC) and common Working Group meetings held throughout 2005 in Szeged, Hungary and Lodz, Poland, respectively. These meetings triggered short-term scientific missions (STSMs) in 2005 between WG1 and WG 2 (see section 4.5).

There have been several contributions to conferences in 2005 based on the different STSMs conducted so far as well as on the ongoing discussions within and between the Working groups, which have been published as abstracts (see section 6)

A jointly written manuscript between WG 1 and WG 2 has been submitted and is currently under revision (again see section 6).

There are two papers currently in preparation based on the results obtained during the STSM of Dr. Vassili Kovalev to Jena in 2005 and Jan Sedlacik to Vienna in 2004.

Future Plans

WG1 will continue to concentrate on the development of measuring techniques in the main areas of susceptibility-weighted imaging, perfusion, diffusion, MR-spectroscopy and ^{23}Na imaging. The challenges will be to develop phantoms which are able to mimic the *in vivo* situation satisfactorily, to refine the experimental results with simulations and to transfer these techniques to animal models and clinical investigations. The tentative workplan of WG1 for 2006 looks as follows:

- To further develop, construct or refine physiological test objects
- To further develop and/or optimise pulse sequences and imaging protocols
- To test different techniques and link it to modelling and simulations with WG2
- To perform animal studies and to transfer techniques into clinical applications (link to WG3)
- To implement more STSMs
- To publish the results
- To invite an external expert to one of the B21 MC and WG meetings in 2006

5.2 WG2 – Software and Simulation

Software development

1. MaZda module for 3D texture analysis. Currently, this module implements the following functions:
   - loading bitmap file sequence and 3D files (a special bmf file format defined to store 3D floating point image data)
   - definition of regions of interest for 3D data (volumes of interest)
   - estimating histogram parameters and co-occurrence based texture features for 3D ROIs
   - loading of DICOM file sequence;
   - displaying information about 3D ROI dimension and location.
2. MaZda module for texture feature selection based on *mutual* information.
3. MaZda module for texture feature selection based on unsupervised clustering.
4. Unsupervised data classification and image segmentation modules implemented in B11.

Collaboration has been established with the software development team of the Institute for Biodiagnostics, Winnipeg, Canada. The team has launched a Scopira C++ software library that comprises biomedical image analysis functions. The collaborative tasks cover

development of means of data exchange between MaZda and Scopira software, and a MaZda interface to execute image processing and classification procedures implemented within Scopira.

Modelling and simulation

1. Collaboration has been established with a team of the Research and Application Centre in Image and Signal Processing (INSA), Lyon, France who developed a versatile and interactive 3D MRI simulator (SIMRI). This collaboration is aimed at providing means to study correlation between simulated physical objects and their MRI properties.
2. A collaborative project has been started on venous vessel extraction from high-resolution SWI data (Jena – Lodz, STSM support).
3. A collaborative project has been started on simulation of blood vessel tree growth and drug release through it (Bergen – Lodz, Marie-Curie scholarship support).
4. Analysis of 3D textures based on Markov Random Fields has been performed:
   - generation of 3D MRF sample textures;
   - texture classification using estimated MRF parameters and co-occurrence matrix features;
   - segmentation of textures using 3D synchronized oscillator network and perceptron-based artificial neural network.

Plan for 2006

TUL group will propose specification of a flexible program architecture, which will allow its easy functional expansion and interface to external numerical procedures (Scopira)

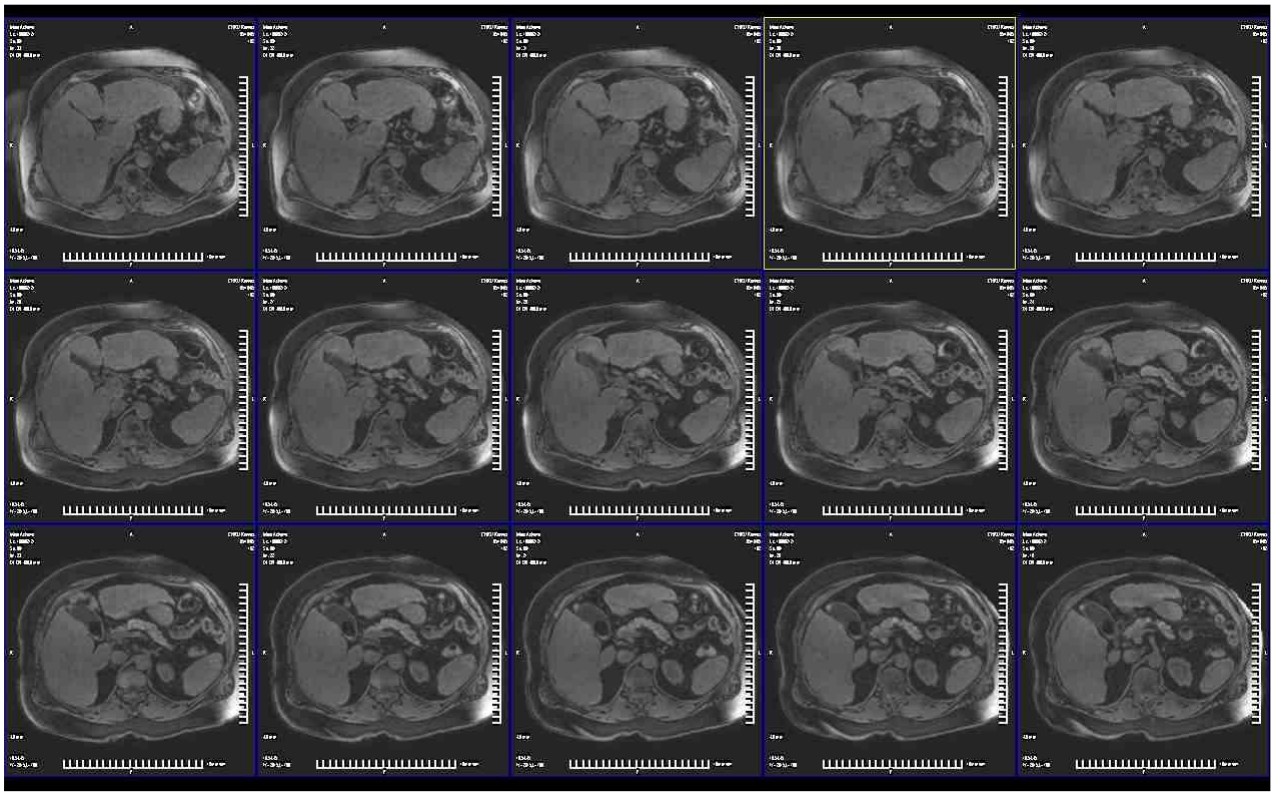
- Specific tasks will be suggested to be performed by other teams to expand the MaZda functionality, in particular
- 3D texture parameter computation (Lodz, Madrid, Rennes , Surrey),
- pixelwise multimodal images registration and classification (Bergen, Lubjliana, Zagreb)
- general image processing, object shape analysis, selected model matching, etc. (Lubjliana, Nicosia, Zagreb)
- Development of blood vessel reconstruction method using deformable cylinder models
- Testing of MaZda to check its collaboration with DirectShow module for video sequence analysis.
- Updating the MaZda manual.
- Setting up a MazDa website.
- Application of developed 3D texture classification and segmentation methods to biomedical data.
- Studies on correlation between simulated physical objects and their MRI properties, with emphasis on vessel trees.

Short-term missions planned for 2006

- P. Majewski to Rennes (MRI simulation),
- One person to Canada or from Canada (SCOPIRA).

5.3 WG3 – Experimental verification and trials

Working Group 3 has presently been focussing on the organisation of a database of clinical images which can be used by WG2 (and to a lesser extent WG1) for testing of procedures developed. The figure shows an example of 3D data from the liver.



Presently, the following 3D image databases are being constructed (Fields 1.5 Tesla and 3 Tesla).

	Contributors	**Users**
1.5 T Brain	Szeged (H) Martin (SK) Prague (CZ) Heidelberg (D) Jena (D)	All contributors + Rennes (F), London (UK) and Lodz (PL)
1.5 T Liver	Martin (SK) Prague (CZ) Dundee (UK)	All contributors + Heidelberg (D), Jena (D) and Lodz (PL)
3 T Brain	Bergen (N) Rennes (F) Dundee (UK)	All contributors + London (UK), Prague (CZ), Lodz (PL), Heidelberg (D) and Jena (D)
3 T Liver	Rennes (F) Dundee (UK)	All contributors + London (UK), Prague (CZ) and Lodz (PL)

5. RESULTS AND STATUS (2006)

5.1 WG1 – Tissue parameters and physiological data

The main goal of working Group 1 (WG1) within the B21 action is to develop and implement MR sequences and/or techniques related to the following areas – perfusion, DWI and DTI, susceptibility weighted imaging (SWI), MR spectroscopy and ^{23}Na imaging. WG1 encompasses both scientists working in the field of MRI and MRS and clinicians interested in the application of the available techniques. To reach the aforementioned goals, there have been dedicated presentations at both Management Committee (MC) and common Working Group meetings held throughout 2006 in Alghero, Sardinia and Brussels, Belgium, respectively.

There have been several contributions to national and international conferences in 2006 based on the different STSMs conducted so far as well as on the ongoing discussions within and between the Working groups, which have been published as abstracts. Beneficiaries of the STSMs were S. Witoszynskyj, A. Deistung, and J. Sedlacik.

1. A. Rauscher, M. Barth, S. Witoszynskyj, J. Sedlacik, J.R. Reichenbach
Phase map based simulation of signal dephasing in gradient echo MR imaging
ECR 2006, European Congress of Radiology, March 3-7, 2006, Vienna, Austria
Eur Radiol 2006; 16(2), Suppl.1:286-7.

2. A. Deistung, A. Rauscher, J. Sedlacik, S. Witoszynskyj, J.R. Reichenbach
Optimized image processing in susceptibility weighted MR-imaging (SWI)
ECR 2006, European Congress of Radiology, March 3-7, 2006, Vienna, Austria
Eur Radiol 2006; 16(2), Suppl.1:314.

3. A. Deistung, M. Kocinski, P. Szczypinski, A. Materka, J.R. Reichenbach
Segmentation of Venous Vessels using Multi-Scale Vessel Enhancement Filtering in Susceptibility Weighted Imaging
14th Scientific Meeting and Exhibition of the International Society of Magnetic Resonance in Medicine, May 6-12, 2006, Seattle, Washington, USA
Proc Intl Soc Magn Reson Med 14 (2006) p.1948

4. A. Rauscher, J. Sedlacik, M. Barth, S. Witoszynskyj, J.R. Reichenbach
Phase Map Based Investigation of Intravoxel Signal Dephasing in Gradient Echo MRI
14th Scientific Meeting and Exhibition of the International Society of Magnetic Resonance in Medicine, May 6-12, 2006, Seattle, Washington, USA
Proc Intl Soc Mag Reson Med 14 (2006) p.2792

5. A. Deistung, M. Kocinski, P. Szczypinski, A. Materka, J.R. Reichenbach
Segmentierung venöser Gefäße aus suszeptibilitätsgewicheteten MRT-Daten unter Verwendung eines multi-scale Linienverstärkungsfilters
Medizinische Physik 2006, 37. Jahrestagung der Deutschen Gesellschaft für Medizinische Physik e.V.
Regensburg, 20.-23. September 2006 (Hrsg. L. Bogner, B. Dobler), ISBN 3-925218-84-4, Druck Kartenhauskollektiv Regensburg, S. 22-24.

6. S.W. Witoszynskyj, A. Rauscher, J.R. Reichenbach, M. Barth
Ein verbesserter Region Growing Algorithmus für das Entwrappen von MR Phasenbildern
Medizinische Physik 2006, 37. Jahrestagung der Deutschen Gesellschaft für Medizinische Physik e.V.
Regensburg, 20.-23. September 2006 (Hrsg. L. Bogner, B. Dobler), ISBN 3-925218-84-4, Druck Kartenhauskollektiv Regensburg, S. 71-72.

7. M. Kocinski, A. Deistung, P.M. Szczypinski, J.R. Reichenbach, M. Barth, A. Lundervold, A. Materka
Towards segmentation, visualization and quantification of vascular trees obtained from high resolution
susceptibility weighted MR imaging (SWI) and time-of-flight angiography of the human brain
ESMRMB 2006 Congress, 23rd Annual Scientific Meeting Warsaw/PL, Sept. 21– 23, 2006
MAGMA 2006;19 (Suppl. 1): 46

8. A. Deistung, M. Kocinski, A. Materka, A. Rauscher, J.R. Reichenbach
Application of vessel masks to BOLD fMRI and dynamic susceptibility enhanced MR-perfusion data
ESMRMB 2006 Congress, 23rd Annual Scientific Meeting Warsaw/PL, Sept. 21–23, 2006
MAGMA 2006;19 (Suppl. 1): 88

The following paper was published with members of WG 1:

1. I.-M. Noebauer-Huhmann, K. Pinker, M. Barth, V. Mlynarik, A. Ba-Ssalamah, W.F. Saringer, M. Weber, T. Benesch, S. Witoszynskyj, A. Rauscher, J.R. Reichenbach, S. Trattnig*Contrast-enhanced, high-resolution, susceptibility-weighted MR imaging (CE-SWI) of the brain: Dose-dependent optimization at 3 Tesla and 1.5 Tesla in healthy volunteers* Invest Radiol **41**(3):249-255

(2006)

A jointly written manuscript between WG 1 and WG 2 which is based on the results of an STSM (beneficiary V.A. Kovalev) has been published.

1. M. Petrou, V.A. Kovalev, J.R. Reichenbach3D Non-linear invisible boundary detection
IEEE Trans Image Process 15(10):3020-3032 (2006)

The last issue in 2006 of the journal „*Zeitschrift für Medizinische Physik*", which is the offical organ of the German, Austrian and Suisse Societies for Medical Physics, will contain a special section on susceptibility weighted MR imaging containing the following two articles of members of WG 1:

1. A. Rauscher, J. Sedlacik, A. Deistung, H.-J Mentzel, J.R. Reichenbach
Susceptibility Weighted Imaging: Data Acquisition, Image Reconstruction and Clinical Applications
Z Med Phys 2006, *in press*

2. A. Deistung, H.-J. Mentzel, A. Rauscher, S. Witoszynskyj, W.A. Kaiser, J.R. Reichenbach
Demonstration of paramagnetic and diamagnetic cerebral lesions by using susceptibility weighted phase imaging (SWI)
Z Med Phys 2006, *in press*

There is one paper currently under revision, which contains results of experiments conducted by Jan Sedlacik during his STSM to Vienna (COST-STSM-B21-00305):

1. J. Sedlacik, A. Rauscher, J.R. Reichenbach
MR Signal Behaviour in the Presence of Single Venous Vessels to Obtain Blood Oxygenation Levels
Magn Reson Med 2006, *under revision*

Future Plans

WG1 will continue to concentrate on the development of measuring techniques in the main areas of susceptibility-weighted imaging, perfusion, diffusion, MR-spectroscopy and ^{23}Na imaging. The challenges will be to develop phantoms which are able to mimic the *in vivo* situation satisfactorily, to refine the experimental results with simulations and to transfer these techniques to animal models and clinical investigations.

There is a joint scientific proposal between the Jena group (WG 1 – J.R. Reichenbach) and the Lodz group (WG 2 – A. Materka) within the frame of the recently signed Memorandum of Understanding of Scientific Cooperation between The Deutsche Forschungsgemeischaft (DFG, Germany) and The Minister Edukacji I Nauki of the Republic of Poland, which is a direct continuation of the cooperation between the two groups established during the COST B21 action. This proposal will be submitted in November 2006.

A meeting is planned within WG1 dedicated on MRI on kidney applications in Bergen, Norway, 8 December 2006, which will be organized by A. Lundervold.

A new STSM application is planned between the Ljubljana group (WG 2 – S. Kovacic) and the Jena group (WG 1 – J.R. Reichenbach) in spring 2007 to explore new methods of image registration.

The workplan of WG1 for 2007 looks as follows:

- To further develop, construct or refine physiological test objects

- To further develop and/or optimise pulse sequences and imaging protocols
- To test different techniques and link it to modelling and simulations with WG2
- To publish the results

5.2 WG2 – Software, Simulation and Modelling

Software Development

1. Introduction of vaiables and loops in MaZda interpreter script language.
2. Adding new commands to the MaZda language (e.g. FeatureSelection).
3. Further development of 3D VOI editing through automatic fit of elastic surface VOI boundaries.
4. Implementation of 4-level undo function to the sequence of MaZda operation steps.
5. Development of a new MaZda module for calculation of planar region shape descriptors.
6. MaZda module for texture feature selection based on exhaustive search for optimal pairs and triples of texture parameters.
7. MaZda manual update.
8. Preparation of contents and materials for MaZda training course.
9. Running two training courses for MaZda advanced users and beginners (Rennes June 2006, Brussels October 2006).
10. Development of MaZda plugins, as a tool of flexible program architecture, which will allows its functional expansion and provides interface to external numerical procedures.
11. Testing of beta version of MaZda website.

Modelling and simulation, MRI analysis

1. Runing projects on cardiac motion estimation from MRI sequences (Madrid), simulation of hepatic MRI (Rennes), visualisation of pancreatic islets in 3D MRI liver images (Prague, Lodz), texture classification (Rouffach, Strassbourg) and registration (Lubljana), unsupervised feature selection through data vector clustering (Lodz), simulation and 3D texture analysis of vascular trees (Lodz).
2. Collaborative project on simulation of blood vessel tree growth, drug release through it, perfusion and fluid exchange with tissues modelling (Bergen – Lodz, Marie-Curie scholarship support for 7 months of a Polish PhD student stay in Bergen in 2005-06).
3. Preparation of a 3-year grant proposal (Development of fast non-invasive magnetic resonance angiography sequences for segmentation and quantification of the cerebral artery and vein 3D images at high spatial resolution) under Polish-German Memorandum of Understanding umbrella.
4. Project on "3D image texture analysis of simulated vascular trees" - journal paper manuscript in preparation.
6. Research project on "Segmentation of 3D liver MRI images with the use of 3D synchronized oscillator network ".
7. Finalizing PhD project (thesis submitted at TUL, under revision) on unsupervised texture feature selection and image segmentation methods.

Short-term missions

Lodz to Rennes: Piotr Szczypinski, June 2006.

Publications

* M. Strzelecki, A. Materka, J. Drozdz, M. Krzeminska-Pakula, J. Kasprzak, "Classification and segmentation of intracardiac masses in cardiac tumor echocardiograms", Computerized Medical Imaging and Graphics, Vol. 30, No. 2, March 2006, str. 95-107.
* M. Strzelecki, A. Materka, "On the accuracy of selected texture segmentation method", Computer Vision and Graphics, International Confenece ICCGV 2004, Warsaw, September 2004, Proceedings (eds. K. Wojciechowski, B. Smolka, H. Palus, R.S. Kozera, W. Skarbek, L. Noakes), Springer 2006, str. 546-551.
* A. Deistung, M. Kocinski, P. Szczypinski, A. Materka, J. R. Reichenbach "Segmentation of venous vessels using multi-scale vessel enhancement filtering in susceptibility weighted imaging", 14th ISMRM, Seattle, WA, 6-12 May 2006, str. 1948.
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* A. Materka "What is the texture?", w M. Hajek, M. Dezortova, A. Materka, R. Lerski (eds.): Texture Analysis for Magnetic Resonance Imaging. Med4publishing, Prague, 2006. ISBN: 80-903660-0-7, str. 7-41.
* A. Materka "Statistical methods", w M. Hajek, M. Dezortova, A. Materka, R. Lerski (eds.): Texture Analysis for Magnetic Resonance Imaging. Med4publishing, Prague, 2006. ISBN: 80-903660-0-7, str. 79-103. * M. Strzelecki, A. Materka, P. Szczypinski "MaZda", w M. Hajek, M. Dezortova, A. Materka, R. Lerski (eds.): Texture Analysis for Magnetic Resonance Imaging. Med4publishing, Prague, 2006. ISBN: 80-903660-0-7, str. 105-111.
* M. Strzelecki, Segmentation of 3D Images Using Network of Synchronised Oscillators, Proc. ICSES 06, Lodz 2006, pp.
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Plan for 2007

1. Adding new modules for 3D texture features calculation (e.g. autoregressive model, gradient features).
2. Saving VOI parameters into textfile.
3. Unsupervised texture feature selection module (clustering quality driven genetic algorithm).
4. Participation in clinical data analysis projects.

5.3 WG3 – Experimental verification and trials

Working Group 3 has continued to assembly a larger database of brain and liver data for analysis. Detailed protocols are under final development and a further team (that of Goran Bacic, Serbia) has been added to the brain analysis team. First results are expected imminently.

6. DISSEMINATION OF RESULTS

6.1 Publications and Reports

Sedlacik J, Rauscher A, Maaβ P, Reichenbach J R. Multiecho Susceptibility Weighted Imaging (SWI) – Phantom and in-vivo measurements. Beiträge zur 38. Jahrestagung der Deutschen Gesellschaft für Biomedizinische Technik im VDE – BMT 2004, TU Ilmenau, 22-24 September 2004, ISSN 0939-4990, Biomed Tech (Berl) 49 (2004) Ergänzungsband 2, Teil 1, S.148-149 (*Abstract in German).*

Sedlacik J, Rauscher A, Reichenbach J R. In vitro und in vivo suszepibilitätsgewichtete Bildgebung (SWI). Medizinische Physik 2004, 35. Wissenschaftliche Tagung der Deuttschen Gesellschaft für Medizinische Physik, Leipzig, 22-25 September 2004 (Hrsg. U. Wolf, W Wilke), ISBN 3-925218-84-X, Gärtner Druck Leipzig, S. 50-51 (*Abstract in German*).

Szczerba D and Szekely G. Computational Model of Flow-Tissue Interactions in Intussusceptive Angiogenesis. Journal of Theoretical Biology (accepted).

Schad L R. Problems in texture analysis with magnetic resonance imaging. Dialogues Clin. Neurosci. 6(2) : 235-242 (2004)

Molnár J, Thornton B S, Molnar A, Gaál D, Luo L, Bergmann-Leitner E. Thermodynamic Aspects of Cancer: Possible role of negative entropy in tumor growth, its relation to kinetic and genetic resistance. Letters in Drug Design and Discovery 2, 429-438 (2005).

Klepaczko A, Materka A. Clustering quality feature selection based method. Machine Graphics and Vision 913(4) : 355-375 (2004)

Klepaczko A, Materka A. Feature Selection in Unsupervised Context: Clustering Based Approach, chapter in Computer Recognitition Systems, Proc. of the 4th International Conference on computer Recognition Systems CORES 2005 (eds. M Kurzynski, E Puchala, M Wozniak, A Zolnierek). Springer Verlag: 219-226 (2005)

Strzelecki M, Materka A, Drozdz J. Krzeminska-Pakula M, Kasprzak J D. Classification and Segmentation of Intracardiac Masses in Cardiac tumour Echocardiograms. Computerized Medical Imaging and Graphics (accepted).

Mayerhoefer M E, Breitsenseher M J, Kramer J, Aigner N, Hofmann S, Materka A. Texture analysis for tissue discrimination on T1-weighted MR images of the knee joint in a multicenter study: Transferability of texture features and comparison of feature selection methods and classifiers. Journal of Magnetic Resonance Imaging, 22 : 674-680 (2005)

Petrou M. Kovalev V, R Reichenbach J R. 3D Non-linear invisible boundary detection. IEEE Transactions on Imaging Processing (under revision).

Petrou M, Kovalev V, Reichenbach J R. Investigating the influence of MRI scanning protocols to high-order image statistics. Magnetic Resonance Imaging (about to be submitted).

Huszhty P C, Brekken C, Pederson T B, Thorsen F, Sakariasses P O, Skaftnesmo K O, Haraldseth O, Lonning P E, Bjerkvig R, Enger P O. Local delivery of species-specific endostatin improves anti-tumor efficacy. J. Neurosurg. 2005 (in press).

M Chekenya, Brekke C, Lundervold A, Enger P O, Brekken C, Stalsett E, Pedersen T B, Haraldseth O, Krüger P G, Bjerkvig R. NG2 expression regulates vascular morphology and function in human brain tumours. Neuroimaging 2005 (in press).

Martinussen M, Fischl B, Larsson H B, Skranes J, Kulseng S, Vangbert T R, Vik T, Brubakk A M, Haraldseth O, Dale A M. Cerebral cortex thickness in 15-year-old adolescents with low birth weight measured by an automated MRI-based method. Brain, 128 : 2588-2596 (2005).

Thuen M, Singstad T E, Pedersen T B, Haraldseth O, Berry M, Sandvig A, Brekken C. Manganese-enhanced MRI of the optic visual pathway and optic nerve injury in adult rats. JMRI 22 : 492-500 (2005).

Skjold A, Vangberg T R, Kristoffersen A, Haraldseth O, Jynge P, Larsson H B W. Relaxation enhancing properties of MnDPDP in human myocardium. JMRI 20 : 948-52 (2004).

Håberg A, Kvistad K A, Unsgård G, Haraldseth O. Preoperative blood oxygen level-dependent functional magnetic resonance imaging in patients with primary brain tumors: clinical application and outcome. Neurosurgery 54 : 902-914 (2004).

Vangberg T R, Skranes J, Tuch D S, Dale A M, Brubakk A-M, Larsson H B, Haraldseth O. Changes in white matter diffusion anisotropy in adolescents born prematurely (submitted Neuroimage).

Martinussen M, Fischl B, Dale A, Brubakk A M, Larsson H B W, Haraldseth O. Subcortical gray matter in prematurely born children using MR morphometry (in preparation).

Larsson H B W, Keil T, Vangberg T R, Kristoffersen, Steen P A, Kvaernes J, Haraldseth O. Improved perfusion imaging of the human brain using dynamic T1-weighted contrast enhanced MRI at 3 Tesla (in preparation).

A. Deistung, M. Kocinski, P. Szczypinski, A. Materka, J. Reichenbach, Segmentation of Venous Vessels using Multi-Scale Vessel Enhancement Filtering in Susceptibility Weighted Imaging, ISMRM Scientific Meeting & Exhibition, Seattle WA, May 2006, submitted.

Chen G, Jespersen S, Pedersen M, Pang Q, Horsman MR, Stodkilde Jorgensen H. Evaluation of anti-vascular therapy with texture analysis. Anticancer Res. 2005 ;25(5):3399-405.

Bendtsen M, Xuenong Z, Haisheng L, Mygind T, Stødkilde Jørgensen H, Cody Bünger E. A Porcine Model of Intervertebral Disc Degeneration Evaluated by MRI, X-Ray, and Histology. Spine. Submitted.

Chen G, Pedersen M, Pang Q, Horsman MR, Stodkilde Jorgensen H. Tumour blood perfusion and fluid diffusion after treatment with CA4DP and DMXAA. In preparation.

Chen G, Michael Strzelecki, Stodkilde Jorgensen H. Imaging texture analysis. Book chapter. In preparation.

Zou X, Li H, Chen G, Bendtsen B, Stødkilde-Jørgensen H, Lind M, Bünger C. Using MR imaging to identify the fusion and pseudoarthrodesis of porous tantalum interbody fusion devices in a pig spinal fusion model. Spine. In preparation.

6.2 Conferences and Workshops

Witoszynskyj S, Rauscher A, Reichenbach J R, Barth M. Quality Maps for Automated Phase Unwrapping of MR Images. ECR 2005, 17th European Congress of Radiology, March 4-8 2005, Vienna, Austria. Eur Radiol 2005;15(2), Suppl.1:155

Sedlacik J, Rauscher A, Xu Y, Haacke E M, Reichenbach J R. SWI – Phantom Studies investigating the BOLD Effect: Gradient Echo Signal Recovery at Late TE due to Partial Volume Effect. 13th Annual Scientific Meeting of the International Society of Magnetic Resonance in Medicine, May 7-13, 2005, Miami Beach, USA. Proc Intl Soc Mag Reson Med 13 (2005) p.1559 (ISSN 1545-4436).

Witoszynskyj S, Rauscher A, Reichenbach J R, Barth M. "Automated Phase Unwrapping of MR Images at Different Field Strengths using Multiple Quality Maps. 13th Annual Scientific Meeting of the International Society of Magnetic Resonance in Medicine, May 7-14, 2005, Miami Beach, USA. Proc Intl Soc Mag Reson Med 13 (2005) p.2249 (ISSN 1545-4436).

Rauscher A, Witoszynskyj S, Sedlacik J, Barth M, Reichenbach J R. Simulation of intravoxel signal dephasing in gradient echo imaging based on high resolution phase maps. 13th Annual Scientific Meeting of the International Society of Magnetic Resonance in Medicine, May 7-14, 2005, Miami Beach, USA.

An invited talk at the Biomedical Engineering Seminar of the Mayo Clinics: Szekely G: Biophysical Models of Tissue Formation and Growth. 13 August 2004, Rochester MA.

Sedlacik J, Rauscher A, Xu Y, Haacke E M, Reichenbach J R. Signal Behaviour of Capillary Phantoms and In Vivo Measurements using Multi-Echo Susceptibility Weighted Imaging (SWI). Proceedings of the jointly held Congresses ICMP 2005, 14th International Conference of Medical Physics of the International Organization for Medical Physics (IOMP), the European Federation of Organizations in Medical Physics (EFOMP) and the German Society for Medical Physics (DGMP) and BMT 2005, 39th Annual Congress of the German Society for Biomedical Engineering (DGBMT) within VDE. 14th-17th September 2005, Nuremberg, Germany. Biomed Tech (Berl) 50 (2005) Supplementary volume 1, Part 1, pp. 1166-67.

Deistung A, Rauscher A, Sedlacik J, Witoszynskyj S, Reichenbach J R. Optimization of Data Processing in Sucseptibility-Weighted Imaging. Proceedings of the jointly held Congresses ICMP 2005, 14th International Conference of Medical Physics of the International Organization for Medical Physics (IOMP), the European Federation of Organizations in Medical Physics (EFOMP) and the German Society for Medical Physics (DGMP) and BMT 2005, 39th Annual Congress of the German Society for Biomedical Engineering (DGBMT) within VDE. 14th-17th September 2005, Nuremberg, Germany. Biomed Tech (Berl) 50 (2005) Supplementary volume 1, Part 1, pp. 1168-69.

Materka A, Segmentation/Image processing (invited talk), International Conference of the European Society of Magnetic Resonance In Medicine and Biology, ESMRMB 2005, Basle, September 2005

Lerski R A, Texture analysis in MRI (invited talk), International Conference of the European Society of Magnetic Resonance In Medicine and Biology, ESMRMB 2005, Basle, September 2005

6.3 Web site

A web site (http://www.die.upm.es/costb21/frame_main.html) has been established by the Spanish partner Andres Santos. This allows interested parties to access all the reports in text of the Action's meetings, download the software package MaZda for texture analysis and a database of MR images for testing.

6.4 Scientific and Technical Cooperation

All these indicate *new* ongoing collaborations which have arisen due to the Action.

Heidelberg (D)	Lódz (PL)	Software development
Dundee (UK)	Lódz (PL)	Software development
Prague (CZ)	Lódz (PL)	Clinical data analysis
Dundee (UK)	Madrid (E)	Data classification
Antwerp (B)	Lódz (PL)	Software
Heidelberg (D)	Dundee (UK)	Test object scanning
Strasbourg (F)	Heidelberg (D)	Software implementation
Madrid (E)	Lódz (PL)	Software use
Rennes (F)	Dundee (UK)	Texture concepts
Aarhus (DK)	Lódz (PL)	Clinical applications
Vienna (A)	Dundee (UK)	Trabecular bones

A number of short term missions (8) have taken place in order to enhance the collaboration between partners and speed the development of agreed techniques. These have been detailed in separate reports and are listed in section 4.5. More are planned for 2007.

7. ECONOMIC DIMENSION

The economic dimesnion of the Action in Person years is as follows:
2004 - 6.8 py
2005 - 7.1 py
2006 - 7.3 py

The funds (all in Euros) received from the COST Office are as follows (information from the Scientific Secretary):

Action B21 Total Action Budget 2003-2006

Meetings

Meeting Type	Date	Place	Avg per person	Total Paid	Planned reimburs	Requested reimb	Paid participants	Cost	Status	Total
Joint MC/WG	31/03/2006	Alghero - Sardinia (IT)	927	24107.61	27	26	26	24107.6	PAID	
Joint MC/WG	18/10/2006	Brussels (BE)	786	20431.75	48	26	26	20431.8	PAID	
WG	8/12/2006	Bergen (NO)	852	8521.35	10	10	10	8521.35	PAID	
									2006	**53061**
WG	17/01/2005	Brussels (BE)	717	6453.12	18	9	9	6453	PAID	
Joint MC/WG	18/03/2005	Szeged (HU)	898	16162.8	35	18	18	16163	PAID	
Joint MC/WG	6/10/2005	Lodz (PL)	915	20131.1	36	22	22	20131	PAID	
									2005	**42747**
MC	15/12/2003	Brussels (BE)	697	13250.32	56	19	19	13250	PAID	
Joint MC/WG	12/03/2004	Dundee (GB)	967	24174.76	32	26	25	25142	PAID	
WG	26/06/2004	Brussels (BE)	654	11779.02	20	18	18	11779	PAID	
Joint MC/WG	1/10/2004	Nicosia (CY)	1043	28149.02	38	27	27	28149	PAID	
Domain Committee	25/10/2004	Brussels (BE)	524	523.94	1	1	1	524	PAID	
									2004	**78844**
Meetings									**2003**	**13250**
									Total	**187902**

STSM

Beneficiary	Date	From	To					Cost	Status	Total
Dr Piotr Szczypinski	17/06/2006	Lodz (PL)	rennes (FR)					990	APPROVED	
Ms Rosario Sance	1/05/2006	Madrid (ES)	Bergen (NO)					1560	APPROVED	
									2006	**2550**
Oystein OLSEN	6/06/2005	Trondheim	Guildford					2489	APPROVED	

		(NO)	(GB)							
Dr Vassili Kovalev	20/06/2005	Guildford (GB)	Jena (DE)					1294	APPROVED	
									2005	**3783**
									Total	**6333**

Workshops

Title	Date	Place						Cost	Status	Total
										0

General Support Grants

Title	Date							Cost	Status	Total
General	13/12/2006							2000.00		
									Total	**2000.00**

Schools

Title	Date	Place						Cost	Status	Total
										0

Action Total	**196235**