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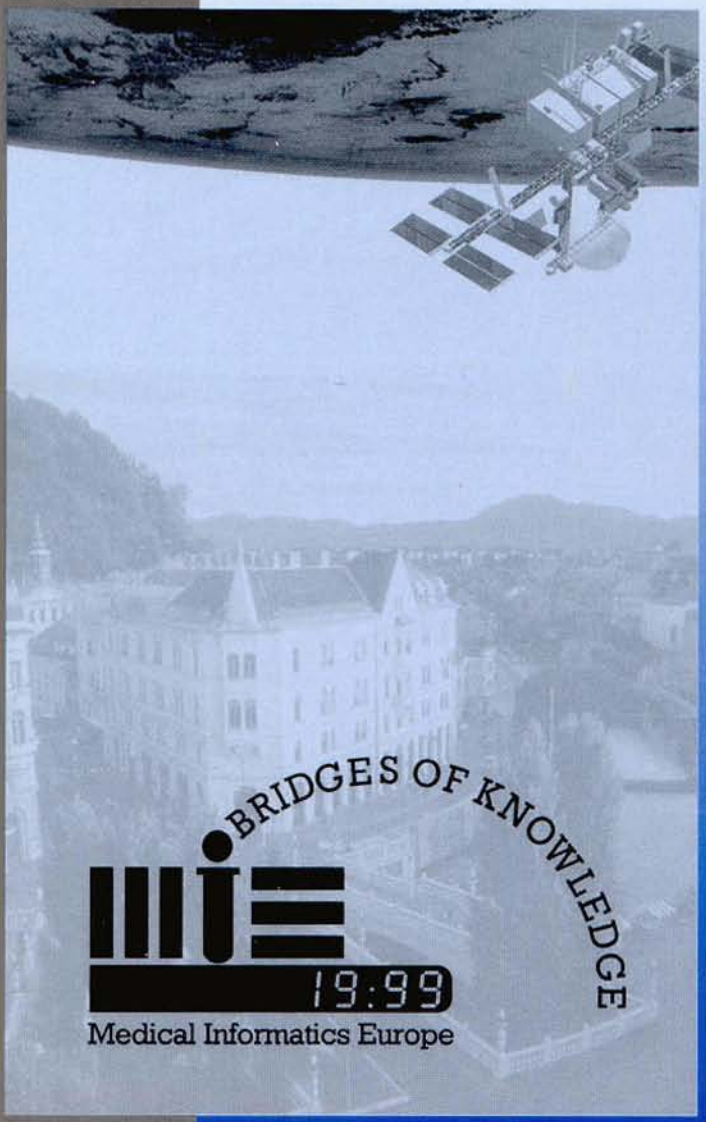

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Contents

Information Systems in Health Care and Medicine

Applications, Implementations, Projects

A Matrix-Approach Proposal for the Treatment of Contents to be Integrated into Multimedia Health Resources for Citizens, *A. Alonso, C. Díaz and F. Sanz* 3

Expanding DIOGENE with a Clinical Information System Based on a New Hospital-Wide Clinical Finding Dictionary, *C. Bréant, F. Borst, D. Campi, V. Griesser and H.S. Le* 7

Metabolic Drug Pointing and Information Processing, *R. Hofestädt, U. Mischke, M. Prüß and U. Scholz* 12

MedicDAT - Making Information Available, *C.-M. Reng, A. Tsakpinis and J. Schoelmerich* 16

How to Structure Clinical Information: A Practical Example, *R. Schweiger, T. Bürkle, F. Köhn and J. Dudeck* 20

Hospital Information Systems: Chances and Obstacles on the Way to Integration, *R. Lenz, R. Blaser and K.A. Kuhn* 25

A Simulation of Dynamic Tasks Routing to Improve Cooperation in Intensive Care Units, *J.-M. Renard, N. Bricon-Souf, J.-M. Geib and R. Beuscart* 31

A Prototype of an Information System for Assessing the Health Status of Prison Inmates, *A. Duhamel, E. Archer, P. Devos, M.C. Nuttens and R. Beuscart* 37

ArchAIDS Connects a Clinical Department and a Virological Laboratory to Automatize the Follow Up of AIDS Patients, *M. Giacomini, C. Ruggiero, I. Martini, J.L. McDermott and O.E. Varnier* 42

An Information System on Toxicological Risks Linked to Drug Manipulation, *E. Pourabbas, N. Mucci, R. Maceratini and M. Rafanelli* 46

Outpatient Health Care Statistics Data Warehouse - Implementation, *D. Zilli* 50

Implementing HISA Standard in the Middleware Layer of our Applications, *N. Planinc, B. Berčič and M. Pikec* 55

Databases

European and Latin-American Countries Associated in a Networked Database of Outstanding Guidelines in Unusual Clinical Cases (ELCANO), *C. Ohmann, H.P. Eich, J.J. Sancho, C. Diaz, G. Faba, N. Oliveri, S. Clamp, J.M. Cavanillas and E. Coello* 59

A Uniform Database of Rehabilitation as a Basis for Evaluating the Outcome Quality, *S. Flierl, B. Alt, K. Hornig and E. Jacobi* 64

A Unified Framework for Data Modeling on Medical Information Systems, *J. Neves, P. Cortez, M. Rocha, A. Abelha, J. Machado, V. Alves, S. Basto, H. Botelho and J. Neves* 68

Preliminary Study on Relevant Data for Health Management in Hospitals, *S. Brusaferro and M. Scarbolo* 72

An Approach for Access Differentiation Design in Medical Distributed Applications Built on Databases, *S.K. Shoukourian, A.M. Vasilyan, A.A. Avagyan and A.K. Shukurian* 78
Integrated Databases - The Foundation for the Information Linking of the Actors in the National Health Care and Health Insurance Systems, *T. Marčun and F. Košir* 83
Compulsory Health Insurance Databases, *J. Svoljšak and I. Dovžan* 89
Database for Gynecological Laparoscopy, *E. Bernad, S. Bernad and I. Munteanu* 95

Evaluation
Application Report: Preliminary Evaluation of the T-IDDM Project in Pavia, *R. Bellazzi, A. Riva, S. Montani, C. Larizza, M. Bestazza, S. Fiocchi, G. d'Annunzio, R. Lorini and M. Stefanelli* 99
Lesson Learnt from a Halt of the Hospital Information System, *M.C. Mazzoleni, P. Baiardi and I. Giorgi* 102
Selection of Hospital Information Systems: User Participation, *J. Stausberg* 106
The Use of the Balanced ScoreCard (BSC) in the Model for Investment and Evaluation of Medical Information Systems, *K.U. Niss* 110
HIS Purchase Project: Preliminary Report, *M. Madjaric, W. Leodolter, H. Leitner and G. Gell* 115

Reports About National HIS
The Survey of Health Care Software in Yugoslavia, *D. Grbic, S. Simic, J. Marinkovic, N. Kocev and B. Matijevic* 121
Developing a Health Care Information System for Scotland, *M.H. Williams, G. Venters, G. Venters and D. Marwick* 125
Paediatric Case-Mix of the Lorraine Regional Database in 1994 and 1995, *P. Gillois, H. Garin and F. Kohler* 129
Introduction of a New Hospital Information System at the Innsbruck University Hospital, *V. Callegari, K.P. Pfeiffer and G. Lechleitner* 135
The Health Management Information System of Romania, *D.D. Farcas* 140
National Information System on Hospital Treatment, *G. Raič* 146
An IT Awareness Programme for the Health Sector in Ireland, *J. Grimson, M. Flahive, W. Grimson, R. O'Moore, J. Nolan and G. Chadwick* 151
Slovenian National Health Insurance Card: The Next Step, *T. Kalin, G. Kandus, D. Trcek and B. Zupan* 156
Transformation of the Process of Administrative Patient Management, *M. Črv* 161
National Health Care Providers' Database (NHCPD) of Slovenia - Information Technology Solution for Health Care Planning and Management, *T. Albreht and M. Paulin* 165

Theory, Models, Human Aspects
A Unified Model to Support an Information Intensive Health Care Environment, *C. Burdis, B. Eaglestone and P. Procter* 171
Human Aspects of Medical Computer Application, *G. Lakner* 175
An Architecture for Bridging between Research and Practical Use in Health Informatics, *S.K. Andersen, C. Nøhr, K. Bernstein and S. Vingtoft* 179
The Bridge between Administrative and Clinical Information System, *F. Borst, C. Bréant, D. Campi, S. Momjian, P. Rossier, G. Thurler, C. Revillard and R. Baud* 185

Research Needs and Priorities in Health Informatics - Early Results of a Delphi Study, *J. Brender, P. McNair and C. Nøhr* 191
Success Factors of Hospital Information System Implementation: What Must Go Right?, *V. Prijatelj* 197

Telemedicine and Telematics

Applications

The Community Social Alarm Service as a Primary Health Care Service, *D. Rudel, M. Premik and N. Licer* 203
Psychiatry by Videophone: A Trial Service in North West England, *C.R. May, N.T. Ellis, T. Atkinson, L. Gask, F. Mair and C. Smith* 207
Telepathology and Imaging Spectroscopy as a New Modality in Histopathology, *S.G. Vari, G. Müller, J.M. Lerner and R.-D. Naber* 211
Transtelephonic ECG in Slovenia, *V. Gorjup, A. Jazbec and B. Geršak* 217
Southern Health Board - Advanced Telematic/Telemedicine in Healthcare Services in the South West of Ireland, *U.M. O'Sullivan and J. Somers* 223

Consulting

Using IP-Videoconferencing Systems in a Surgery Consulting, *N. Halin, P. Loula, P. Jaatinen and P. Aarnio* 229
Teleconsultation for Endoscopic Diagnosis of Gastrointestinal Diseases - Concepts and Architecture of the Service ENDOTEL, *T. Balbach, H. Sußmann, T. Jansen, H.-D. Allescher and A. Horsch* 234
Electronic Consultations and Referrals in Kymenlaakso Hospital District, *E. Läike, T. Koivu, R. Järvinen and A. Ahtola* 238
The Hip Status: A Telemedical Application, *D. Smrke, G. Cerkvenik, D. Piškur-Kosmač and V. Stankovski* 241
The Telemedicine and Second Medical Opinion, *B. Gersak, V. Gorjup and A. Jazbec* 245

Networks, Communications

Computerized System for the Networking of Health Services (Proposed Solution for the Informational Support of the Health Insurance Law in Romania), *M. Teseleanu, V. Afteni, M. Sucholotiuc, L. Stefan and I. Dobre* 247
End-User Point of View to Establish Real-Time Broadband ATM Connection over Europe, *P. Loula, T. Lummevaara, J. Ilola and P. Aarnio* 251
Real-Time Medical Applications and Telecommunications, *M. Štravs* 257
Barriers for Dissemination of a National Health Care Data Network: A List of Recommendations for Better Dissemination, *I. Johansen and L. Kaalund Thiel* 262
Regional Health Care Networks, *M. Bruun-Rasmussen, K. Bernstein, S. Vari and B. Bercic* 265

Telemedicine

Teleradiology as a Seed of the Regional Health Care Intranet in a Rural Region in Spain, *J.P. de Castro, R. Hornero, A. Alonso, B. Medina, R. Mompó, E. Abril and M. López* 270
Teledermatology - UK Experience of Setting Up an Integrated Teledermatology Service, *M. Clarke, R.W. Jones, D. Lioupis, S. George and D. Cairns* 274
Third Generation Electronic Pharmacy Communications, *K. Demkjær, I. Johansen*

and K. Bernstein 278
Telemedicine in the Malaysian Multimedia Super Corridor: Towards Personalized Lifetime Health Plans, *S.S.R. Abidi and Z. Yusoff* 283

Security

Communication Security in Open Health Care Networks, *B. Blobel, P. Pharow, K. Engel, V. Spiegel and R. Krohn* 291
Can a Database be Anonymous?, *C. Quantin, F.A. Allaert, P. d'Athis and L. Dusserre* 297
A Secure Web-Based Interface to Maternity Records with Decision Support, *M.H. Williams, O. Liew, K. Boddy, A. Varias and M. Eydmann* 302
Personal Identifying Number as a Unique Patient Identifier in Database on Clinically Treated Patients in Belgrade: Its Use, Advantages and Drawbacks, *A. Saulic, J. Marinkovic, S. Simic, N. Kocev and N. Marjanovic* 306
Experiences with a New Security Standard for Healthcare Information Systems, *K. Louwerse, M. van Ditmarsch and E. Flikkenschild* 311
Authorisation & Security Aspects in the Middleware-Based Healthcare Information System, *J. Andany, C. Bjorkendal, F.M. Ferrara, J.-R. Scherrer and S. Spahni* 315

Biomedical Processing, Data Analysis and Image Processing

Bias in Meta-Analysis and Funnel Plot Asymmetry, *B. Milicic, J. Marinkovic, B. Jeremic and M. Radotic* 323
Developing Shared Understanding through Simulation, *N. Hardiker and S. Kay* 329
Data Integration to Assist Gastric Emptying Data Analysis, *M. Giacomini, C. Ruggiero, P. Borro and C. Mansi* 335
Three-Dimensional ROIs in Brain PET, *J. Mykkänen, M. Juhola and U. Ruotsalainen* 339
A Computerized Study of the Results of In-Vitro-Fertilisation, *J. Cadman, B. Richards, S. d'Souza, B.A. Lieberman, P. Buck and E. Rivlin* 343
Uniforming of Outpatient Health Care Statistics, *M. Rogač and D. Moravec Berger* 347
Application of Space Technologies for Valuation of a Stress Level, *O.Y. Mayorov and R.M. Baevsky* 352
An Efficient Algorithm for Automatic Decoding of ECG Signals, *E.A. Palamarchouk* 357
Frequency Domain Methods for Measurement of Heart Rate Variability, *M. Bulica and V. dan Moga* 359
A Signal Analysis Method for Impulse-Like Eye Movements, *M. Juhola, H. Aalto and T. Hirvonen* 365
Lossless Compression of Eye Movement Signals, *T. Tossavainen, M. Juhola and A. Koski* 369
Use of Time-Variant Coherence as a General Tool for Analysis of Interrelations between Brain Electrical Processes, *H. Witte, M. Arnold, W. Miltner, T. Rosburg and C. Schelenz* 374
Computer EEG-Monitoring of Laserotherapy Effects in Patients with Asteno-Depressive Syndrome, *V.P. Omelchenko, I.S. Baranchook and M.N. Dmitriev* 380
Parametric Time-Varying Spectrum and Its Application to SEMG Signals, *D. Korošec* 385
Monte Carlo Simulation of the Radiographic Imaging Procedure for Electronically Designed Phantoms, *D. Lazos, Z. Kolitsi and N. Pallikarakis* 391

Computed Tomography Image Analyzer: Segmentation Applying Active Contour Models - "Snakes", *R. Maksimovič, S. Stankovič, D. Milovanovič, J. Marinkovič, B. Goldner, M. Janičijevič and P.M. Seferovič* 395
A New Way for the Anàlysis of the Exocytosis, *J.L. Sánchez, M.A. Brioso, F. Segura and R. Borges* 400

Data Warehousing, Data Mining and Knowledge Discovery

Knowledge Discovery for Advanced Clinical Data Management and Analysis, *A. Babic* 409
Application of the Medical Data Warehousing Architecture Epidware to Epidemiological Follow-Up: Data Extraction and Transformation, *E. Kerkri, C. Quantin, K. Yetongnon, F.A. Allaert and L. Dusserre* 414
Statistical Approaches for Evaluation of Genetic Risk Factor of Peripheral Arterial Occlusive Disease, *J. Svatoš, M. Orendáč, B. Mušková, J. Hyánek, V. Kožich and J. Zvárová* 419
Data Warehousing as a Basis for Web-Based Documentation of Data Mining and Analysis, *J. Karlsson, P. Eklund, C.-G. Hallgren and J.-G. Sjödin* 423
Treatment of Missing Values with Imputation for the Analysis of Otologic Data, *J. Laurikkala, E. Kentala, M. Juhola and I. Pyykkö* 428
Data Warehousing as a Tool for Quality Management in Oncology, *S. Hölzer, A.G. Tafazzoli, U. Altmann, W. Wächter and J. Dudeck* 432
Naive Bayesian-Based Nomogram for Prediction of Prostate Cancer Recurrence, *J. Demšar, B. Zupan, M.W. Kattan, J.R. Beck and I. Bratko* 436
Increasing the Diversity of Medical Data Mining through Distributed Object Technology, *M. Holeňa, A. Sochorová and J. Zvárová* 442
Outpatient Health Care Statistics Data Warehouse - Logical Design, *S. Natek* 448
Applying Data Mining in Healthcare: An Info-Structure for Delivering "Data-Driven" Strategic Services, *S.S.R. Abidi* 453
Quantitative Data Analysis for Exploring Outcomes in Cardiac Surgery, *A. Kircher, J. Antonsson, A. Babic and H. Casimir-Ahn* 457

Training and Education

Post-Doc: Satisfying the Information Needs of General Practitioners in Continuing Medical Education and Daily Practice, *C. Dickmann, J. van der Baaren and K. Spitzer* 463
The Interactive Use of Networking Multimedia - Innovative Education Resource for Professionals and Patients, *H.K. Matthies, G.F. Walter, A. Brandis, A.C. Stan, A. Ammann, U. von Jan and A.J. Porth* 467
WWW as a Teaching Resource for Introductory Medical Informatics in Primary Care, *I.R. Young, P.J. McCullagh and W.G. Kernohan* 472
The Electronic Learning Zone in Health Informatics, *J. Bryant and T. Olsson* 478
Medical Informatics in the Medical Curriculum - When?, *J. Kern* 484
Communication between the Higher Education and Industry, *R. Dimitriu, M. Bazavan, R. Sima, D. Lungeanu and G. Mihalas* 489
CISMeF: Catalogue and Index of French-Speaking Health Resources, *S.J. Darmoni, J.P. Leroy, F. Baudic, M. Douyère, J. Piot and B. Thirion* 493
Medical Informatics Educational Tasks Seen from Practical Perspective, *D. Lungeanu,*

R. Dimitriu, M. Bazavan, R. Sima, B. Richards, R. Neame, J. Murphy and G. Mihalas 497
An Orthopaedic Discussion Group, Linking and Teaching the Orthopaedic Community, *I. Callanan, U. Gormalley and T. O'Brien* 500
Education and Training Possibilities in Europe for Chaining Ambulatory and Hospital Inpatients Care, *F.H. Roger France* 503
Globalisation and the Cultural Impact on Distance Education, *W. McPhee and C. Nøhr* 508

Internet/Intranet

Knowledge Sharing

The Case-Based Internet Textbook ODITEB for Multi-Modal Diagnosis of Tumors - Development, Features and First Experiences, *A. Horsch, T. Balbach, M. Hogg, F. Sturm and C. Minov* 513
From Bridges to Super-Highways: Transmitting Meaning within and between Professions, and Across Time and Space - Beginning the Process, *A.J. Sheridan, M.J. Rigby and R.J. Draper* 517
Are Healthcare Professionals Really Prepared to Deal with Information-Empowered Citizens?, *J. Roberts* 523
An Internet Implementation of an International Clinical Study, *R.A. Hollingsworth, C. Hay and B. Richards* 528
Accessing a WWW Reference Library of 3D Models of Pathological Organs to Support Medical Education, *M. Crudele, G.J. Clapworthy, F. Dong, M.A. Krokos, N. Vasilonikolidakis and G. Salcito* 532

WWW

Sharing Electronic Medical Record on the WWW Using InterCare Architecture and Smart Cards, *M. Rotonen, P. Ruotsalainen, A. Kaskihalme and M. Aarnio* 538
The Need for Evaluation when Managing the IMIA.ORG Web-Site, *T. Kleinoeder, U. Jahn and O. Rienhoff* 543
WWW Search Engine for Slovenian and English Medical Documents, *J. Dimec, S. Džeroski, L. Todorovski and D. Hristovski* 547
Analysis of Free MEDLINE on the WWW, *E. Klemenčič and L. Todorovski* 553
Organization and Dissemination of Multimedia Medical Databases on the WWW, *L. Todorovski, S. Ribarič, J. Dimec, E. Hudomalj and T. Lunder* 557

Other

GIN AUSTRIA: Assuring Quality and Relevance on Internet-Health-Informations for Patients, *G. Göbel and K.P. Pfeiffer* 562
Generalisation and Extension of a Web-Based Data Collection System for Clinical Studies Using Java and CORBA, *H.P. Eich and C. Ohmann* 568
Evaluation of Medical Knowledge Using Electronic Textbooks and ExaMe Program on Internet, *J. Zvárová, K. Zvára Jr., P. Hanzlíček, J. Neustadt, P. Rošický, K. Buriánek, R. Augustinová and J. Prox* 573
A JAVA Implementation of a Medical Knowledge Base for Decision Support, *V. Ambrosiadou, D. Goulis, V. Shankararaman and G. Shamtani* 578
Java-Based Framework for the Secure Distribution of Electronic Medical Records, *A. Goh* 582

Resource Management

NISPLAN - Projecting Hospital Beds and Hospital Stays, *S. Østerlund Petersen* 591
Automated Computer-Assisted Evaluation of Diagnosis-and-Procedure-Reports in Austrian Hospitals, *E. Hagenbichler, D. Klingler, L. Neuner and K.-P. Pfeiffer* 594
Healthcare Users and Computerised Resources, *G. Stephens, P. Gaffney and J. Grimson* 600
Bed Utilization Performances of Slovenian and Croatian Acute Hospitals Systems, *M. Premik, V. Mayer, M. Kuzman and M. Mayer* 606
The Optimization of Turnaround Time for Blood Samples in an Emergency Clinical Laboratory, *V. Prijatelj, A. Vučkovič and D. Černe* 610

Intelligent Medical Systems

Applications

MOBISIM - Package for Simulation in Molecular Biology, *G.I. Mihalas, G. Macovievici, Z. Simon, G. Mihalas, G. Balea and D. Lungeanu* 617
Automatization of Physicians' Phone-In Hours, *J. Turunen, P. Loula and H. Soininen* 621
AIDMAN - Advanced Informatics Distributed Medical Access Network, *M. Clarke, R.W. Jones, N. Kanellopoulos, D. Lioupis and A. Nassiopoulos* 625
Multimedia Stimulation for Psychophysiological Investigation, *P.J. McCullagh, G.P. Gent and H.G. McAllister* 631
Classification of Metabolic Patients Using Dynamic Variables, *S. Svacina, T. Haas, M. Matoulek and K. Nedelniková* 636

Decision Support Systems

Computer-Aided Diagnostic System in Dentistry, *D. Grošelj, M. Malus and I. Grabec* 639
Supporting Decisions in Diabetic Patients Management through Case-Based Retrieval, *S. Montani, R. Bellazzi, L. Portinale, S. Fiocchi, G. d'Annunzio and M. Stefanelli* 645
An Integration System to Rapidly Identify Aquatic Bacteria, *M. Giacomini, S. Bertone, C. Ruggiero, F. Caneva Soumetz, A. Bisio, G. Odino and L. Calegari* 650
A Diagnostic Advice System Based on Pathophysiological Models of Diseases, *W.J. ter Burg, P. Lucas and E. ter Braak* 654
Modelling Oculomotor Data with Decision Tree Induction, *K. Viikki, E. Isotalo, M. Juhola and I. Pyykkö* 660
A Decision Support System for Cholinesterase Genotyping, *B. Richards, J. Cadman and M. France* 664
Hierarchical Multi-Attribute Decision Models and their Application in Health Care, *M. Bohanec, B. Zupan and V. Rajkovič* 670
The Influence of Class Discretization to Attribute Hierarchy of Decision Trees, *Š. Hleb Babič, P. Kokol, M. Zorman and V. Podgorelec* 676

Methods

A Micropopulational Modelling of a Viral Epidemic by Using a Special Neural Network, *C.N. Zaharia and A. Cristea* 682
Computer-Assisted Planning and Simulation of Hip Operations Using Virtual Three-Dimensional Models, *H. Handels, J. Ehrhardt, W. Plötz and S.J. Pöppl* 686

A Probabilistic Approach to Improved Antibiotic Therapy, *N. de Bruijn, P. Lucas, K. Schurink and A. Hoepelman* 690
Possibilities of See5 Software in Forecasting of Life Expectancy not Achieving, *S. Vuletič, J. Kern, Z. Sonicki and D. Ivanković* 696
Intelligent Systems in Medical Diagnosis, *B. Novak* 700
Power of Heterogeneous Computing as a Vehicle for Implementing E^3 Medical Decision Support Systems, *V. Podgorelec, J. Brest and P. Kokol* 703
Neural Network in Communication with Medical Computer System, *E. Kącki, J. Stempczyńska and R. Wawrzyniak* 709

Theory
Concepts, Contexts and Expert Systems, *D. Karlsson, O. Aspevall and U. Forsum* 713
Availability Humanization Expert Model, *M. Molan and G. Molan* 716
TIDE: An Intelligent Home-Based Healthcare Information and Diagnostic Environment, *S.S.R. Abidi* 720
Healthcare Knowledge Management through Building and Operationalising Healthcare Enterprise Memory, *Y.-N. Cheah and S.S.R. Abidi* 726

Health Guidelines and Protocols

Guidelines in Healthcare: The Experience of the Prestige Project, *C. Gordon, M. Veloso and The Prestige Consortium* 733
The RITHME Inter-Mediation Platform for Data Exchanges between Healthcare Professionals, *R. Beuscart, M.-C. Beuscart-Zéphir, J.-M. Renard, D. Delerue and A. Souf* 739
Development of a Reminder System for General Practitioners, *R. Bindels, A. Hasman and R.A.G. Winkens* 745
Quantitative Collagen as a Golden Standard in Differential Diagnosing of Fibrotic Changes in Liver Tissue, *J. Jonsson and A. Babic* 749
A Development Protocol for a Diagnostic DSS, *Y.-L. O, W.J.P.P. ter Burg, E.W.M.T. ter Braak, J.P. Neijt, W.A.J.J. Wiegerinck, M.J. Nijman and H.J. Kappen* 755
A Protocol Building Software Tool for Medical Device Quality Control Tests, *Y. Theodorakos, K. Gueorguieva, J. Bliznakov, Z. Kolitsi and N. Pallikarakis* 759
Telematics Applications to Support the Role of the Community Pharmacists as Self-Medication Advisors, *F. Sanz, C. Silveira, A. Alonso, C. Diaz, M.I. Loza, L. Cordero, F. Fernandez-Llimós, L. Tiddens, F. Giorgio, H. Cranz, J. Mircheva and The TESEMED Consortium* 764
The "Mediator Service", a Component to Ease the Integration of Medical Applications in the SynEx Framework, *Y. Xu, D. Sauquet, E. Zapletal, D. Lemaitre and P. Degoulet* 768
Emergency Protocols in Prehospital Emergency Medicine in Slovenia, *J. Leskovšek and A. Žmavc* 774
A System for the Description of Healthcare Guidelines, *P. Grifoni, D. Luzi and F.L. Ricci* 779
Take Care: Guidelines for Patients with Chronic Hepatitis C, *K. Hedin, A. Babic and A. Frydén* 783

Electronic Patient Encounter, Card Technology, Electronic Data Interchange

C3: Java-Based Medical Record System for Cardiology, *A. Taddei, S. Dalmiani, G. Cecchetti, A. Macerata, C. Carpeggiani, L. Chelozzi and C. Marchesi* 791
An Experimental Electronic Patient Record for Stroke Patients, *M.J. van der Meijden, H.J. Tange, J. Boiten, J. Troost and A. Hasman* 795
QUALIDIAB: Implementation of the Diabcare Project in the French-Speaking Environment: Regional, National and International Issues, *R. Beuscart, M.P. VanHoecke, P. Devos, R. Allouche, L. Kleinebreil and The Qualidiab Group* 799
The Electronic Patient Records of the Hannover Medical School, *A.J. Porth, C. Niehoff and H.K. Matthies* 801
DIABCARD Core System - A Chip Card Medical Information System for Diabetes Care, *G. Gogou, A. Mavromatis, N. Maglaveras, C. Pappas and R. Engelbrecht* 805
Electronic Patient Record for N.N. Burdenko Neurosurgical Institute: On the Verge of Implementation, *M.A. Shifrin and E.E. Kalinina* 809
Towards A Multi-Professional Patient Record - A Study of the Use of Headings, *H. Åhlfeldt, M. Ehnfors and L. Ridderstolpe* 813
Validation of a European Message Standard for Electronic Health Records, *D. Markwell, L. Fogarty and A. Hinchley* 818
Clinicians Must Invest Resources when Implementing Electronic Patient Records, *R.E. Nikula, P.B. Elberg and H.B. Svedberg* 824
Constructing Scenarios for Validating the Electronic Health Care Record Architecture, *S. Kay, T. Marley, P.A. Lundgren, H. Broberg and H. Prytz* 828
Realization of a CPR Using HL7 Queries from Communication Server to Information Server, *U. Schrader, A.W. Zaiss, S. Büchele, M. Binder, U. Leupolz and R. Klar* 834
Design of the SGML-Based Electronic Patient Record System with the Use of Object-Oriented Analysis Methods, *E. Kuikka, A. Eerola, J. Porrasmaa, A. Miettinen and J. Komulainen* 838
Computerized Patient Record with Distributed Objects, *T. Gornik, A. Orel, D. Roblek and R. Verhovšek* 842
The Holistic Architectural Approach to Integrating the Healthcare Record in the Overall Information System, *F.M. Ferrara, P.A. Sottile and W. Grimson* 847
Document Versus Data Centred Approach to the EPR, *R. Baud, A.-M. Rassinoux and C. Lovis* 853
Donor and the Health Insurance Card, *A. Posega and D. Pleterski Rigler* 858
Structuring Clinical Information in Healthcare Records, *A. Rossi Mori and F. Consorti* 862
Security for Electronic Patient Record Systems, *M.A. Pronkin and M.A. Shifrin* 866
Professional Knowledge as the Basis of Electronic Patient Record Systems, *T.E. Pronkina and M.A. Shifrin* 869

Terminology

A Method for an Automated Decomposition of a Complex Term into Its Conceptual Components, *V. Barac'h, A. Burgun, D. Delamarre and P. le Beux* 875

Automatic Enrichment of the Unified Medical Language System Starting from the ADM Knowledge Base, *F. Le Duff, A. Burgun, B. Pouliquen, D. Delamarre and P. Le Beux* 881
Maintenance of Self-Consistency of Coding Tables by Statistical Analysis of Word Co-Occurrences, *G. Surján and G. Héja* 887
Towards a Multilingual Morpheme Thesaurus for Medical Free-Text Retrieval, *S. Schulz, M. Romacker, P. Franz, A. Zaiss, R. Klar and U. Hahn* 891
A Model for Integration and Continuous Development of Standards for Tumour Documentation Using Relational Database Techniques and Extensible Markup Language, *U. Altmann, W. Wächter, A.G. Tafazzoli, F.R. Katz, R. Schweiger and J. Dudeck* 895
Preliminary Report: Concepts and Terms Used to Describe Urinary Tract Infection in Primary Health Care and in the Clinical Microbiology Laboratory, *O. Aspevall, U. Forsum and D. Karlsson* 899
Galen: A Third Generation Terminology Tool to Support a Multipurpose National Coding System for Surgical Procedures, *B. Trombert-Paviot, J.M. Rodrigues, J.E. Rogers, R. Baud, E. van der Haring, A.M. Rassinoux, V. Abrial, L. Clavel and H. Idir* 901
Synapses/SynEx Goes XML, *B. Jung and J. Grimson* 906
German Adaptations of ICD-10, *B. Graubner and G. Brenner* 912

Nursing Informatics

SysTerN: A Nursing Terminology System Based on ICNP, *S. Alecu, I. Moisil and E. Jitaru* 921
Electronic Dissemination Media for Promoting ICNP in CEE Countries, *I.I. Moisil, E. Jitaru and I. Pertache* 926
The Development and Testing of Information System for Community Nursing, *R. Leskovar, O. Šušteršič, V. Rajkovič, I. Bitenc and I. Zelič* 930
Plea for a Standardised Detailed Clinical Nomenclature, *S. Momjian, F. Borst and N. de Tribolet* 935
A Computerized Guideline for Pressure Ulcer Prevention, *S. Quaglini, M. Grandi, P. Baiardi, M.C. Mazzoleni, C. Fassino, G. Franchi and S. Melino* 940
How Can We Improve Informatics Education for German Nurses? Statements Derived from the First German Nursing Informatics Summer School, *T. Bürkle and U. Schrader* 944
A Tutor for Nursing Process Education, *A. Habjanic, V. Brumec, P. Kokol and M. Zorman* 948
Towards a Nursing Information System in Slovenia, *B. Filej, P. Kersnič, V. Kunstek Pretnar and M. Šlajmer Japelj* 954
Internet Provides Fast and Inexpensive Information to Home Care, *N. Bjørn* 958

Posters

Interdisciplinary Dialogue Center - A Model for Collaborative Work, *F. Filip, A. Trica, E. Jitaru, M.C. Jitaru, R. Dop, I. Gutiu, I. Dumitrache, B. Richards and C. Pappas* 963
Establishment of National Information Infrastructure Program, *I. Tchaklosh, Y. Tchaklosh, I. Luchechko and J. Lubinets* 967

Hierarchical Multi-Attribute Models for Decision Support in the Management of Diabetic Foot Syndrome, *G. Plaper, M. Piletič, M. Bohanec, V. Rajkovič and B. Urh* 970
Failure Analysis of Thyroid Laboratory Diagnostic Module, *Z. Sonicki, T. Plasaj, J. Kern, D. Ivanković and Z. Kusić* 973
A Software Tool to Assist the Planning of Electrophysiological Experiments on Rat Brain Slices, *A. Bocioaca, C. Badea, C. Papatheodoropoulos and G. Kostopoulos* 976
A National Society for the Medical Informatics Community: BMiS, *T. McCart and C. Gordon* 980
TeCoMed - Online Consulting of Acute Health Risks, *G. Greiner, G. Kundt and L. Gierl* 983
Site Specific Outcomes Analysis: Inducing Knowledge from a Limited Set of the Cardiac Assist Support Data, *A. Babic* 987
Application of Thanatos in Creating Thyroid Cancer Registry, *T. Plasaj, M. Lechpammer, D. Šimunovič, I. Cvjetko, M. Strnad, Z. Kusić and M. Belicza* 990
Can Humoral Factors Help to Identify Hypertension?, *J. Peleška, J. Reissigová, D. Janeba, J. Zvárová, K. Horký, M. Jáchymová, A. Jindra, S. Heller, Z. Marečková and V. Umnerová* 994
A Survey on the Current State of Development, Dissemination and Implementation of Guidelines of Clinical Practice in European Countries, *S. Courté-Wienecke, M. Struppe and R. Engelbrecht* 998

Author Index 1003

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Application Of Space Technologies For Valuation Of A Stress Level

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Abstract: The adaptation of large long-term experience of application Heat Rate Variability in space biology and medicine and medical researches is represented. The description of the new approaches is given which are fixed in a basis of diagnostic computer systems "NeuroReserchertm 5.0" (or System of Computer Vegetology "CardioTensionTest™ 5.0" as module in the frame of "NeuroReserchertm 5.0") and "Varicard". These systems for thorough clinical and experimental scientific investigations and experimental investigations (for specialists of R&D institutes, doctors of functional diagnosis rooms of hospitals possessing clinical bases of R&D institute and medical university chairs, during clinical and preclinical testing of drugs, medical and biological R&D institutes carrying out Nneurophysiological investigations in the field of labour medicine and sport medicine, development of infantile nervous system, medical education establishments.

1. Introduction

At the boundary of XX and XXI Centuries the significance of emotional stress on health of the people is promptly increased. In this connection the necessity in simple for realisation, scientific based methods of a quantitative evaluation of power of systems regulation of an organism increases. There is a necessity because of objective quantitative measurements of a level of emotional stress and reserves of regulation cardio-vessels systems regulation in time to apply the reasonable methods of treatment and preventive maintenance of stress-genesis diseases, to predict outcomes myocardial infarction or origin " of sudden death " on a hum noise of complete well-being.

The problem of valuation of a stress level of the space crewmembers has arisen from the most first steps of cosmonautics development. It solution was connected to development of the concept about cardiovascular system as an indicator of adaptive reactions whole body.

Since the 60-th years during the first human flights in space was developed the technology of researches, based on the heart rate variability analysis and valuation on these data of a autonomic system state and activity of subcortical centres, connected with psycho-emotional excitation and increasing the energo-metabolic processes at physical loads. In the subsequent years the Heart Rate Variability analysis begins widely to be used in USSR (Russia and Ukraine) in clinical and preventive medicine, and from 80-th years has applied in Western Europe and USA. Hundreds articles and reports about using of the heart rate variability analysis in clinical practice and applied physiology are at present annually published.

However, so far in earthly medicine the space technology of stress level valuation is not enough used. The important of this technology is determined by that the majority of diseases is results of overstrain and exhaustion of the mechanisms of physiological functions regulation and diagnostics of a regulatory systems state is the most effective on Heart Rate Variability parameters.

Therefore in a space medicine 10-balls scale of valuations of a stress level is developed, that permits to determine risk of diseases and to supervise results of fulfilment of the preventive recommendations.

The adaptation of large long-term experience of application Heat Rate Variability has allowed to create computer diagnostic systems **"CardioTensionTest™ 5.0"** and **"Varicard"**.

2. Functionality's of systems

These systems allow:

- To quantitatively evaluate the emotional stress rate;
- To quantitatively evaluate the "regulation stability" under extreme conditions;
- To evaluate the regulatory systems tension level reflecting the activation rate of neuro-endocrine of "stress axes";
- To carry out medical control and prediction of an organism's functional possibilities, to diagnose the following states: a) satisfactory adaptation; b) functional tension; c) unsatisfactory adaptation; d) adaptation failure.
- To determine the functional state of a heart rhythm regulation system according to R.M. Bayevsky's classifier [1] pointing out five cardiac rhythm features: 1. Indication of summary effect of all regulatory influences; 2. Cardiac muscle automatism; 3. Regulatory influences on stability rate; 4. State and interaction of VNS parts (vegetative homeostasis); 5. Indication of subcortical nervous centres state.
- To evaluate arterial pressure regulation system activity (Ssw1);
- To evaluate thermal regulation system activity (Ssw2).
- "CardioTensionTest™ 5.0" and "Varicard" have substantial advantages over other available systems.

It is necessary to mark some important features of these systems, which increase reliability and reliability of results.

3. " CardioTensionTest™ 5.0 "

3.1. Detection of R-peaks and R-R intervals

Reliable automatic discrimination of R-peaks is of primary importance. In the available systems R-peaks are discriminated by means of an electronic amplitude filter, i.e. An R-peak is discriminated from other ECG peaks (P, T) by its higher amplitude. Such approach has low reliability because under emotional stress, in the periods of negative emotional state, in cases of hypoxia and myocardial ischemia of different etiology, a T-peak amplitude significantly increases.

Besides, hardware-based discrimination of R-peaks does not permit to account for the presence of artifacts (spikes, displacements and other ECG distortions) [2]. At the same time, discrimination of only one "false" R-peak (or omission of a real R-peak) causes a nonlinear distortion of the analysis results by 60-80 times [1].

The stage of detection consists of two steps - on a first step of the analysis the system uses methods of automatic detection.

3.2. Automatic detection

Automatic detection of R - peaks (waves) and R-R- intervals - not hardware, but computer detection of R-waves according to three specially designed independent criteria.

An original algorithm is used for this purpose that makes it possible to reliably detect R-waves not only for clinical purposes at rest, but also for investigations of under the conditions of operator's activity - operators, pilots, sports persons etc., as well as animals under the condition of free behaviour in chronic experiment.

On second step of recognition R- peaks in the system the quality control of detection, and then semiautomatic and hand-operated correction is carried out.

3.3. Visual checking of R peak detection

Makes it possible to check up visually on the monitor screen the detected R-waves with further manual correction (detection or elimination) of 'false' or omitted R-waves in a defect section.

3.4. Automatic editing

Detection or elimination of 'false' or omitted R-waves in a defect section basing on the original correction algorithm.

3.5. Manual correction

Manual correction (insertion or elimination) of 'false' or omitted R-waves in a defect section (especially important when investigating the subjects (operators) during their activity or functional tests.

4. Mathematical and statistical analysis

The reliability of R-peaks selection ensures at a stage of a mathematical and statistical analysis high reliability of results. The universal analysis is carried out which allows evaluating practically all levels of regulation.

Calculation of a set of well known from the literature mathematical and statistical values (31 value) reflecting the result of statistical, correlation and spectral analysis of the cardiac rhythm. Integral interference-proof from the point of view of computer processing index AI (anxiety index) and ART (anxiety reaction type index) are used;

4.1 Correlation analysis

Sequences of R-R (N-N) intervals, that makes it possible to estimate the degree of control centralisation, domination of one of the vegetative nervous system sections, quantitatively estimate the degree of emotional stress;

4.2. Spectral analysis

Sequence of R-R (N-N) intervals that makes it possible to estimate the degree of activation of subcortical nervous centres controlling the blood flow regulation apparatus, measure the degree of stress of the neuro-endocrine function regulation apparatus;

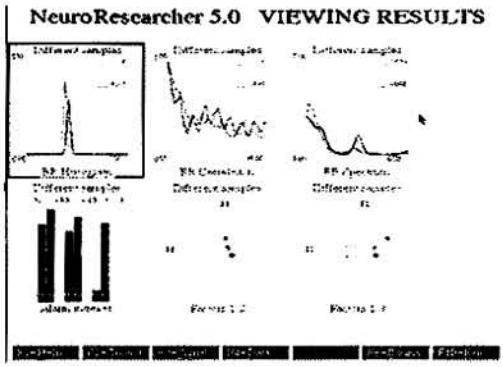

Fig.1. Visualization of result - in the form of charts of R-R- (N-N) interval distribution histograms, correlograms and spectra; results of factor analysis, possibility to present in one chart and compare several states simultaneously.

4.3. Multidimensional factor analysis

Makes it possible to compress information and reduce a large number of values to 2-3 factors [3]. This approach makes it possible to range (quantitatively estimate and compare) the subjects as to the level of stress of the regulation systems, 'regulation stability'; quantitative estimate the state of integrative function of hypothalamus. The ranging results are output to a 3D chart. There is a possibility to create factor models for various age groups and contingents of the subjects [3].

Large advantage "CardioTensionTest™ 5.0" is the possibility of inclusion it in the structure of the developed advanced system of the computer EEG "NeuroResearcher™ 5.0". It allows simultaneously to conduct a research of an EEG, and to compare results to data of a calculus of Heart Rate Variability.

5. " Varicard "

"Varicard" is specialised hardware-software complex for the Heart Rate Variability analysis is at present developed, in which are used as western standards of this technique, as created in a space medicine criterion of stress level estimation. Is allocated three zones (Fig. 2)(green, yellow and red) determining danger of development of diseases. In a complex structure there is base of knowledge, forming individual preventive and healthcare

recommendation by results of valuation at stress level. The complex is tested in a number of clinical establishments, is used at mass preventive examinations of thousands people, as well as at investigation of the health in schools.

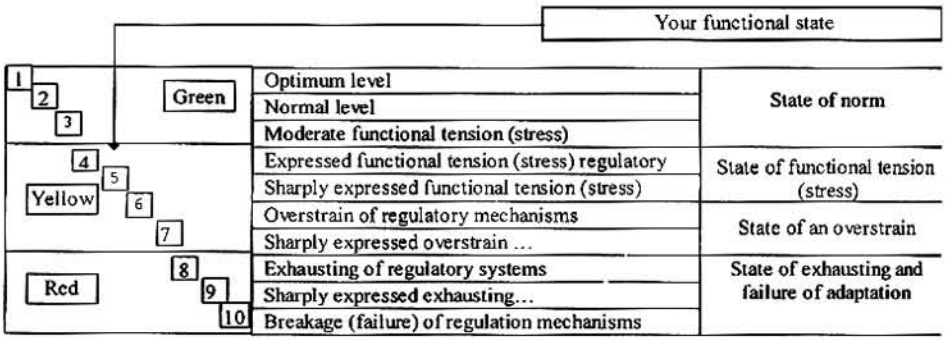

Fig.2. " A Ladder of states " and system of an evaluation of functional states of a type "Traffic Light".

6. Summary

The Heart Rate Variability analysis is modern technology of valuation of the health states in applied physiology, clinical practice, rehabilitation and preventive medicine. This technology was developed in space medicine as the method for stress level estimation. Widely application of this approach in different parts of human sciences is very important for understanding the unity and differences of the health and disease.

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