

# Eighth International Symposium on the 3-D Analysis of Human Movement

## SCHEDULE

.....  
**Tuesday, March 30<sup>th</sup>**

19:00-20:00 Registration

.....

**Wednesday, March 31<sup>st</sup>**

8:00-8:55 Registration

9:00-9:15 Adjourn - Welcome - Organizing Committee & USF representative

**Welcome**

**Dr. Renu Khator, Provost; University of South Florida**

**Keynote Address**

*Moderator: Georgios Stylianides*

9:15-10:15 **Nonlinearly constrained optimization for motion synthesis and analysis**

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**Dr. Zoran Popović, USA**

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**Morning Session**

*Moderator(s): Michael Whittle*

10:20-10:45 **Estimation of body segment kinematics from inertial sensor kinematics..1**

Chris T.M. [Baten](mailto:C.Baten@rrd.nl)<sup>1</sup>, M..D. Klein Horsman<sup>1</sup>, W.H.K. de Vries<sup>1</sup>, D.J. Magermans<sup>2</sup>, H.F.J.M. Koopman<sup>3</sup>, F.C.T. van der Helm<sup>2</sup>, P.H. Veltink<sup>3</sup>.

<sup>1</sup>Roessingh Research and Development, Enschede, Netherlands, [C.Baten@rrd.nl](mailto:C.Baten@rrd.nl) , <sup>2</sup>University of Delft, Delft, Netherlands, <sup>3</sup>University of Twente, Enschede, Netherlands

10:45-11:10 **Design and evaluation of a kalman filter for estimating body segment orientation using inertial and magnetic sensing near ferromagnetic materials**.....5

Daniel Roetenberg<sup>1</sup>, Chris Baten<sup>2</sup> en Peter Veltink<sup>1</sup>

<sup>1</sup>Institute for Biomedical Technology (BMTI), Biomedical Signals and Systems Group, University of Twente, [ed.roetenberg@utwente.nl](mailto:ed.roetenberg@utwente.nl)

<sup>2</sup>Roessingh Research and Development, Enschede, The Netherlands

11:10-11:35 **Integration of electromagnetic tracking systems and virtual reality simulation for 3-d dynamic analyses of spinal loading**.....9

Mohammad Abdoli, Michael J. Agnew, Joan Stevenson

Biomechanics Laboratory, Queen’s University, Kingston, Ontario, Canada  
[10ema@qmlink.queensu.ca](mailto:10ema@qmlink.queensu.ca)

11:35-12:00 **Estimation of body segment parameters from three-dimensional gait data using optimization**.....13

Benjamin J. Fregly<sup>1,2</sup> and Jeffrey A. Reinbolt<sup>1</sup>

<sup>1</sup>Department. of Mechanical & Aerospace Engineering, University of Florida, [fregly@ufl.edu](mailto:fregly@ufl.edu) , Web: [www.mae.ufl.edu/~fregly](http://www.mae.ufl.edu/~fregly), <sup>2</sup>Dept. of Biomedical Engineering, University of Florida, Gainesville, FL, USA

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12:00-13:20 Lunch  
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13:25-13:55 **Industrial Company Presentation: CodaMotion**.....xx  
David Mitchelson; [www.codamotion.com](http://www.codamotion.com)

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**Evening Session**

*Moderator(s): Chris Baten*

14:00-14:25 **Effect of rearfoot notch orientations on the deformation of a foot orthosis**.....17

Paul Allard<sup>1</sup>, Carl-Éric Aubin<sup>2</sup>, Geneviève Trahan-Petit<sup>2</sup>, Sébastien Hinse<sup>3</sup> and Ronald Perrault<sup>3</sup>

<sup>1</sup>. Department of Kinesiology, University of Montreal, Canada, [paulallard1@yahoo.com](mailto:paulallard1@yahoo.com), <sup>2</sup>. Mechanical Engineering, École Polytechnique de Montréal, Canada, <sup>3</sup>. Cryos Technologies Inc., Joliette, Canada

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	Zohara <u>Cohen</u> and Frances Sheehan	
	Physical Disabilities Branch, National Institutes of Health, Bethesda, Maryland, USA, <a href="mailto:zohara_cohen@yahoo.com">zohara_cohen@yahoo.com</a> , <a href="http://pdb.cc.nih.gov">http://pdb.cc.nih.gov</a>	
14:50-15:15	<b>Utility of a multi-segment foot model.....</b>	25
	Kirsten <u>Tulchin</u> and Nasreen Haideri	
	Texas Scottish Rite Hospital for Children, Dallas, Texas, USA <a href="mailto:ktulchin@tsrh.org">ktulchin@tsrh.org</a>	
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	Yi-chung Lin <sup>1</sup> and Benjamin J. <u>Fregly</u> <sup>1,2</sup>	
	<sup>1</sup> Department of Mechanical & Aerospace Engineering, University of Florida	
	<sup>2</sup> Dept. of Biomedical Engineering, University of Florida, Gainesville, FL, USA, <a href="mailto:fregly@ufl.edu">fregly@ufl.edu</a> , Web: <a href="http://www.mae.ufl.edu/~fregly">www.mae.ufl.edu/~fregly</a>	
.....		
15:40-16:00	Break	
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16:00-16:25	<b>Studying 3-d deformation of the thorax under load using computed tomography imaging.....</b>	33
	Tahsin <u>Ali</u> , Jason L. Forman, Jason M. Mattice, Richard W. Kent	
	Center for Applied Biomechanics, University of Virginia, Charlottesville, Virginia, USA <a href="mailto:tahsin@virginia.edu">tahsin@virginia.edu</a>	
16:25-16:50	<b>Finite helical analysis of the thoracic spine.....</b>	37
	Gordon J. <u>Alderink</u>	
	Biomechanics and Motor Performance Laboratory, Grand Valley State University, Grand Rapids, MI, USA, <a href="mailto:aldering@gvsu.edu">aldering@gvsu.edu</a>	

16:50-17:15 **3D Dynamic Model of Biomechanical Factors in Load Carriage**.....41

S.A. Reid<sup>1</sup>, J.T. Bryant<sup>2</sup>, J.M. Stevenson<sup>1</sup>, M. Abdoli<sup>1</sup>

<sup>1</sup>Ergonomics Research Group, [sar@post.queensu.ca](mailto:sar@post.queensu.ca)

<sup>2</sup>Human Mobility Research Centre Queen's University, Kingston, Ontario, Canada

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**Thursday, April 1<sup>st</sup>**

**Keynote Address: Herman Woltring Memorial**      *Moderator: Paul Allard*

8:00-9:00 **Computing with Words and its Applications**.....xiii

**Dr. Lotfi Zadeh, USA**

Berkeley Initiative in Soft Computing (BISC), Computer Science Division  
Electrical Engineering and Computer Sciences Department, UC Berkeley  
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**Morning Session - Woltring Memorial**      *Moderator(s): Paul Allard*

9:10-9:35 **The three dimensional measurement of head movement**.....45

Whittle, MW & Walker, JR

The University of Tennessee at Chattanooga, Chattanooga, Tennessee 37403,  
USA, [Michael-Whittle@utc.edu](mailto:Michael-Whittle@utc.edu)

9:35-10:00 **Three dimensional modeling of human motion using kinematic chains  
and multiple cameras for tracking**.....49

Aravind Sundaresan<sup>1</sup> , Rama Chellappa<sup>2</sup> and Amit Roy Chowdhury<sup>3</sup>  
[aravinds@cfar.umd.edu](mailto:aravinds@cfar.umd.edu);

<sup>2</sup>Center for Automation Research, University of Maryland, College Park,  
Maryland, USA, <sup>3</sup> Department of Electrical Engineering, University of  
California, Riverside, California, USA

10:00-10:25 **Estimation of skeletal kinematics through high feature density video based motion capture**.....53

Eugene J. Alexander<sup>1</sup> , Thomas P. Andriacchi<sup>1</sup> and Christoph Bregler<sup>2</sup>

<sup>1</sup>Department of Mechanical Engineering, Stanford University, Stanford, CA, USA [gene.alexander@stanford.edu](mailto:gene.alexander@stanford.edu) ,  
[http://www.stanford.edu/~genealex/3dmotion\\_2004.htm](http://www.stanford.edu/~genealex/3dmotion_2004.htm)

<sup>2</sup>Department of Computer Science, New York University, New York, NY, USA

10:25-10:50 **Motion simulation of the hip joint using an optimized markers configuration**..... 57

Lydia Yahia-Cherif, Tom Molet, Nadia Magnenat-Thalmann  
MIRALab - University of Geneva, Switzerland, [yahia@miralab.unige.ch](mailto:yahia@miralab.unige.ch)

10:50-11:15 **Defining the knee joint flexion-extension axis for purposes of quantitative gait analysis: an evaluation of methods**.....61

Anthony Schache<sup>1,2</sup>, Richard Baker<sup>2</sup> and Larry Lamoreux<sup>3</sup>

<sup>1</sup>Murdoch Childrens Research Institute, Royal Children's Hospital, Melbourne, Australia, <sup>2</sup>Hugh Williamson Gait Laboratory, Royal Children's Hospital, Melbourne, Australia, [anthony.schache@mcri.edu.au](mailto:anthony.schache@mcri.edu.au), <sup>3</sup>Gait Dimension, Benicia, California, USA

11:20-11:50 **Industrial Company Presentation: Motion Analysis Corporation**  
Tom Whitaker; [www.motionanalysis.com](http://www.motionanalysis.com)

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11:50-13:10 Lunch  
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**Keynote Address**

*Moderator: K. Dino Vrongistinos*

13:15-14:15 **Model construction of nonrigid biological objects from images**.....xvi

**Dr. Dmitry Goldgof, USA**

Department of Computer Science and Engineering, University of South Florida, [goldgof@csee.usf.edu](mailto:goldgof@csee.usf.edu), <http://figment.csee.usf.edu/~goldgof/>

**Evening Session**

*Moderator(s): Richard Baker*

14:20-14:45 **A simple marker set for 3d kinematic of the lower limb.....65**

Mario Lamontagne<sup>1,3,4</sup>, Dany Lafontaine<sup>1,2,3</sup>, Daniel L. Benoit<sup>5</sup>, and Lanyi Xu<sup>3</sup>

<sup>1</sup>School of Human Kinetics, <sup>2</sup>Department of Cellular and Molecular Medicine, <sup>3</sup> Laboratory for Research on Biomechanics of Hockey, <sup>4</sup>Department of Mechanical Engineering, at the University of Ottawa, Ottawa, Canada, and <sup>5</sup>Section of Sports Medicine, Dept of Orthopaedics, Karolinska Institutet, Stockholm, Sweden

14:45-15:10 **Parallel decomposition methods for biomechanical optimization.....69**

Byung Il Koh<sup>1</sup>, Jeffrey A. Reinbolt<sup>2,3</sup>, Benjamin J. Fregly<sup>2,3</sup>, and Alan D. George<sup>1</sup>

<sup>1</sup>Department of Electrical & Computer Engineering, University of Florida, Gainesville, FL, <sup>2</sup>Department of Mechanical & Aerospace Engineering, University of Florida, Gainesville, FL, <sup>3</sup>Department of Biomedical Engineering, University of Florida, Gainesville, FL, [fregly@ufl.edu](mailto:fregly@ufl.edu), [www.mae.ufl.edu/~fregly](http://www.mae.ufl.edu/~fregly)

15:10-15:35 **A virtual reality comparison between different camera solutions for use in human motion analysis: high resolution or many cameras? .....73**

Björn Holmberg and Håkan Lanshammar

Systems Analysis Group, Division of Systems and Control, Department of Information, [Bjorn.Holmberg@it.uu.se](mailto:Bjorn.Holmberg@it.uu.se), Technology, Uppsala University, Sweden

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15:45-16:10 **Functional alignment procedure for joint-specific movement analysis: in vitro tibiotalar example.....77**

Kevin A. Ball<sup>1</sup>, Michael R. Pierrynowski<sup>2</sup>, Thomas M. Greiner<sup>1</sup> and Scot P. Woodward<sup>1,3</sup>

<sup>1</sup>New York Chiropractic College, Seneca Falls, New York, USA, <sup>2</sup>McMaster University, Hamilton, Ontario, Canada, <sup>3</sup>Alpine Chiropractic, Saranac Lake, New York, USA, [kevin.ball@utoronto.ca](mailto:kevin.ball@utoronto.ca)

16:10-16:35 **Determining body segment pose in the presence of noise.....81**

John H. Challis

Biomechanics Laboratory, Pennsylvania State University, University Park,  
Pennsylvania, USA, [jhc10@psu.edu](mailto:jhc10@psu.edu)

16:35-17:00 **An inverse dynamics optimization approach for predicting human  
movement.....85**

Kelly Rooney<sup>1</sup> and Benjamin J. Fregly<sup>1,2</sup>

<sup>1</sup>Department of Biomedical Engineering, University of Florida, Gainesville,  
FL, USA, <sup>2</sup>Department of Mechanical & Aerospace Engineering, University  
of Florida, [fregly@ufl.edu](mailto:fregly@ufl.edu) , [www.mae.ufl.edu/~fregly](http://www.mae.ufl.edu/~fregly)

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**Friday, April 2**

**Keynote Address**

*Moderator: Michael Whittle*

8:00-9:00 **Going round in circles: A systematic approach to defining 3D joint angles  
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**Dr. Richard Baker, Australia**

Hugh Williamson Gait Analysis Laboratory, Division of Surgery,  
Royal Children's Hospital, Melbourne, Australia, [richard.baker@rch.org.au](mailto:richard.baker@rch.org.au),  
[http://www.rch.org.au/gait/index.cfm?doc\\_id=1597#richard](http://www.rch.org.au/gait/index.cfm?doc_id=1597#richard)

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**Morning Session**

*Moderator(s): William Lee*

9:10-9:35 **Three-dimensional gait analysis of the effect of bilateral sub-thalamic  
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W. Liu<sup>1</sup>, L. Nathan<sup>1</sup>, S.H. Kim<sup>1</sup>, K. McIntire<sup>1</sup>, J. Zhang<sup>1</sup>, S. Dascalos<sup>2</sup>, K.E.  
Lyons<sup>2</sup>, R. Pahwa<sup>2</sup>

<sup>1</sup>Department of Physical Therapy & Rehabilitation Sciences, <sup>2</sup>Department of  
Neurology, University of Kansas Medical Center, Kansas City, USA

9:35-10:00	<b>A three-dimensional data visualization technique for reporting movement pattern deviations.....</b>	93
	Kurt <u>Manal</u> <sup>1</sup> , Chih-Chung Chang <sup>1</sup> , Joseph Hamill <sup>2</sup> and Steven J. Stanhope <sup>3</sup>	
	<sup>1</sup> Center of Biomedical Engineering Research, University of Delaware, Newark, DE, USA <sup>2</sup> University of Massachusetts, Amherst, MA, USA	
	<sup>3</sup> Physical Disabilities Branch, National Institutes of Health, Bethesda, MD, USA	
10:00-10:25	<b>An approach to studying the effects of limb lengthening on muscle function during human walking.....</b>	97
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	<sup>1</sup> Biomedical Engineering, University of South Florida, Tampa, FL, USA <a href="mailto:pittner@mail.usf.edu">pittner@mail.usf.edu</a> , <sup>2</sup> Motion Analysis Laboratory, Shriners Hospitals for Children, Tampa, FL, USA	
10:25-10:50	<b>Minimizing the energy cost of walking does not necessarily require minimizing the vertical excursion of the centre of mass.....</b>	101
	Richard <u>Baker</u> <sup>1</sup> , Chris Kirtley <sup>2</sup> , Marcus Pandy <sup>3</sup>	
	<sup>1</sup> Royal Children’s Hospital, Melbourne, Australia, <a href="mailto:richard.baker@rch.org.au">richard.baker@rch.org.au</a>	
	<sup>2</sup> The Catholic University of America, Washington DC, USA, <sup>3</sup> University of Texas, USA	
10:50-11:15	<b>In vitro motion of the talonavicular joint.....</b>	105
	Thomas M. <u>Greiner</u> <sup>1</sup> , Kevin A. Ball <sup>2</sup> and Scot P. Woodward <sup>2</sup>	
	<sup>1</sup> Department of Anatomy, <a href="mailto:tgreiner@nycc.edu">tgreiner@nycc.edu</a> , <sup>2</sup> Department of Research New York Chiropractic College, Seneca Falls, NY, USA	
11:20-11:50	<b>Industrial Company Presentation: Vicon Motion Systems.....</b>	xxv
	Peter Meddings; <a href="http://www.vicon.com">www.vicon.com</a>	
.....		
11:50-13:10	Lunch	
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**Keynote Address**

*Moderator: Georgios Stylianides*

13:15-14:15 **Application-specific VLSI Hardware as a Solution**.....xix

**Dr. N. Ranganathan, USA**

Department of Computer Science and Engineering, University of South Florida, [ranganat@csee.usf.edu](mailto:ranganat@csee.usf.edu) , <http://www.csee.usf.edu/~ranganat/>

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**Evening Session**

*Moderator(s): Frank Barbier*

14:20-14:45 **Effects of ankle bracing on knee motions during trunk rotational tasks** .....109

Santos, M J, McIntire, K, Foecking, J, and Liu, W  
University of Kansas Medical Center, Kansas City, KS

14:45-15:10 **Three Dimensional Analysis Of Walking Stereotype On Patients After Stroke Or Brain Injury**.....113

Zahálka František<sup>1</sup>, Šifta Petr<sup>1</sup>, Sussová Jana<sup>2</sup>

<sup>1</sup>Faculty of Physical Education and Sports, Charles University of Prague, Czech Republic, [zahalka@ftvs.cuni.cz](mailto:zahalka@ftvs.cuni.cz) , <sup>2</sup>First Medical Faculty, Charles University of Prague, Czech Republic

15:10-15:35 **An ambulatory technique to assess 3D knee functions after ACL rupture** .....117

B. Najafi<sup>1</sup>, B.M. Jolles<sup>2</sup>, J. Favre<sup>1</sup>, L. Vieira De Mello<sup>1</sup>, F. Luthi<sup>2,3</sup>, O. Siegrist<sup>2</sup>, K. Aminian<sup>1</sup>

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15:35-15:45 Break

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15:45-16:10 **Outcome evaluation in shoulder surgery using 3d kinematics sensors...121**

Brian Coley<sup>1</sup>, Brigitte M. Jollès<sup>2</sup>, François Nussbaumer<sup>2</sup>, Alain Farron<sup>2</sup>,  
Kamiar Aminian<sup>1</sup>

<sup>1</sup>Laboratory of Movement Analysis and Measurement, EPFL, Lausanne,  
Switzerland, [brian.coley@epfl.ch](mailto:brian.coley@epfl.ch), <sup>2</sup>Hôpital Orthopédique de la Suisse  
Romande, Lausanne, Switzerland

16:10-16:35 **Three-dimensional kinematics and inter-segmental coordination of arm-  
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Yankai A, Smith RM and NJ O’Dwyer

School of Exercise and Sport Science, Faculty of Health Sciences,  
The University of Sydney, Australia, [ayan4067@mail.usyd.edu.au](mailto:ayan4067@mail.usyd.edu.au)

16:35-17:00 **Evaluation of three different models of the shoulder kinematics.  
Application to kayak paddling.....128**

Kjartan Halvorsen, Toni Arndt, Hans Rosdahl and Alf Thorstensson

Biomechanics and Motor Control, Stockholm University College of Physical  
Education and Sports, Sweden, [kjartanh@ihs.se](mailto:kjartanh@ihs.se)