Technology Counseling: Technology in Paralympic

Use of tracking systems for athlete/coach feedback

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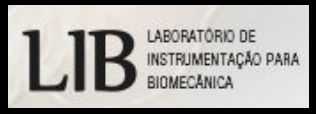

Tracking systems for athlete/coach feedback

Summary

1. Introduction.
2. Tracking systems:
   Applications in Olympic sports
3. Tracking systems:
   Applications in Paralympic sports
4. Tracking systems:
   Current trends and challenges

Introduction

One of the most challenging problem in sport science is the data collection and analysis during real competitions.

Athlete's physical, technical or tactical performance can substantially decrease or increase from training or laboratory to playing situations.

Recently, tracking systems have been used to provide interesting information about athlete's performances during competitions.

Tracking systems: Definition

A system able to provide a *kinematic analysis* of a body.

From the mechanics:

Kinematics describes the motion of points, bodies and systems of bodies without consideration of the causes of motion.

Tracking systems: Classification

1. Systems based on images
2. Non-Optical systems

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Tracking systems: Applications in Olympic sports

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Barros et al.

Automatic tracking of soccer players.

Congress of the International Society of Biomechanics, 2001, Zurich. p. 236-239.

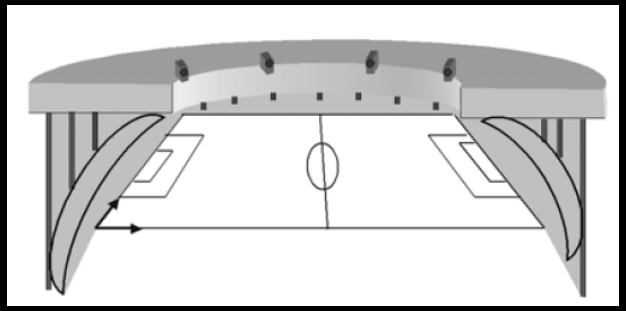
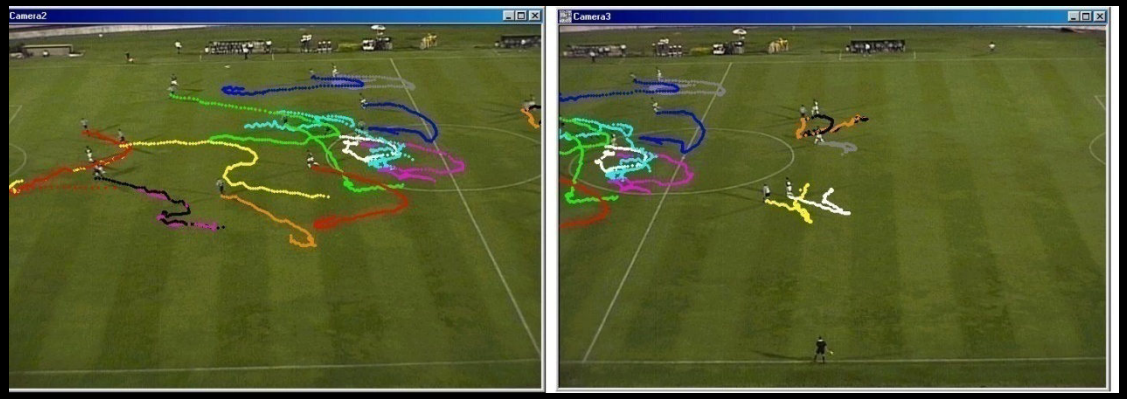


Figure 1: (left side): One camera view and figure 1b: (right size) the segmentation using: 1) motion filtering and 2) players' segmentation.



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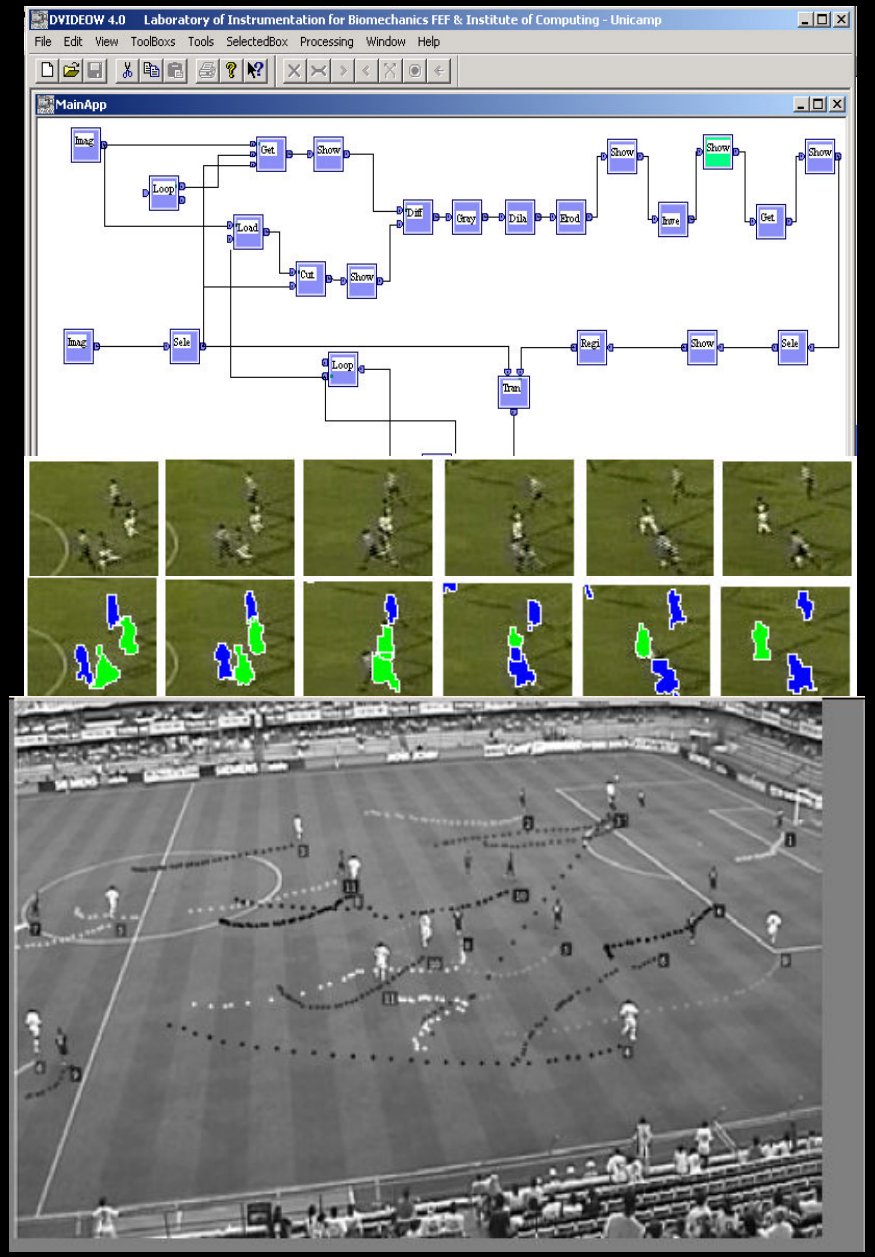
Pascual Jovino Figueroa. PhD, 2004.

Background recovering in outdoor image sequences: An example of soccer players segmentation. Image and Vision Computing. , v.24, p.363 - 374, 2006.

Tracking soccer players aiming their kinematical motion analysis. Computer Vision and Image Understanding. , v.101, p.122 - 135, 2006.



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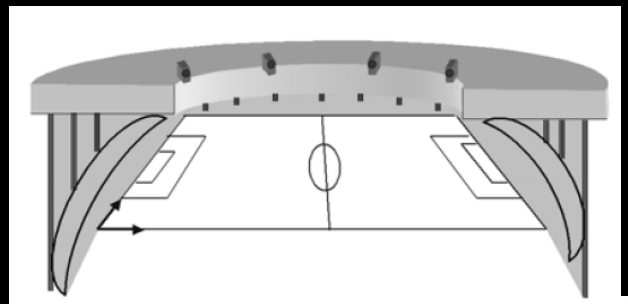
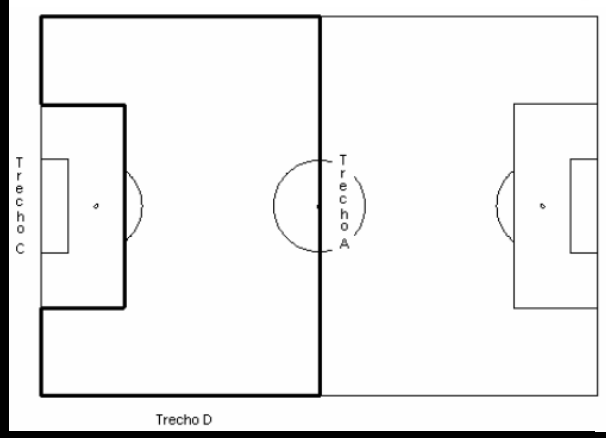
Milton Shoiti Misuta. Master, 2004

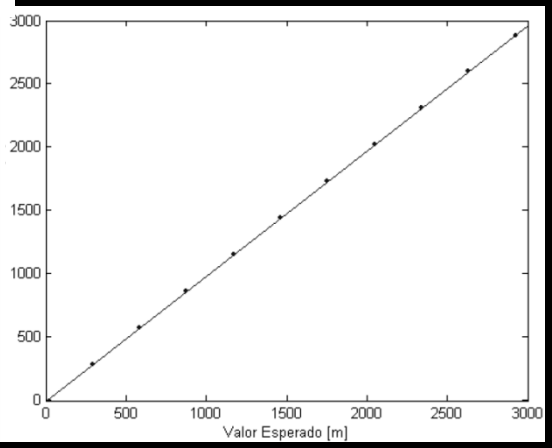
Automatic tracking of Soccer Players: Validation of a method and analysis of results.

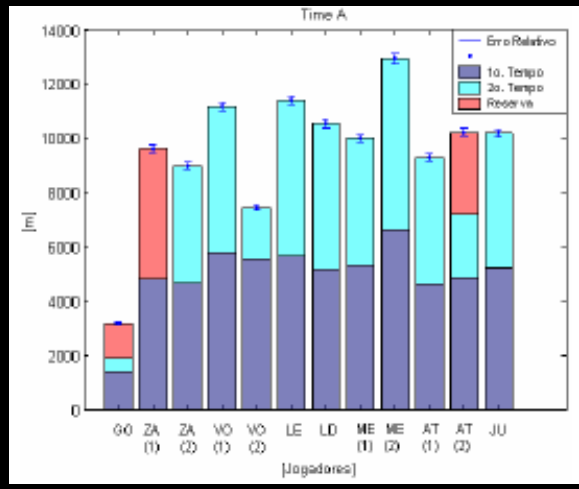
Barros et al.

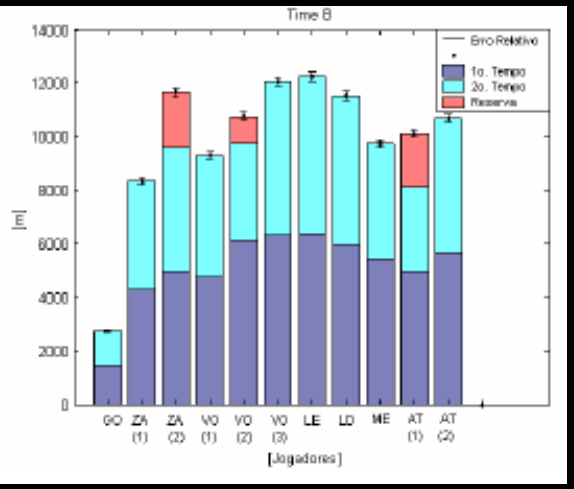
Analysis of the distances covered by First Division Brazilian soccer players obtained with an automatic tracking method. Journal of Sports Science and Medicine v.6, p.233 - 242, 2007.











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Commercial Systems

Prozone® System (Leeds, UK)

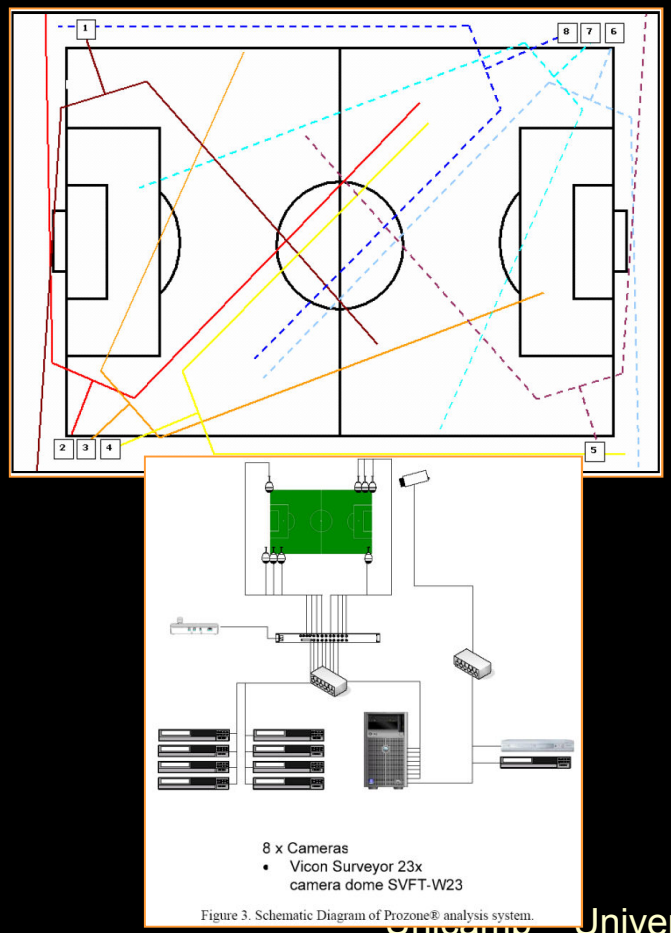
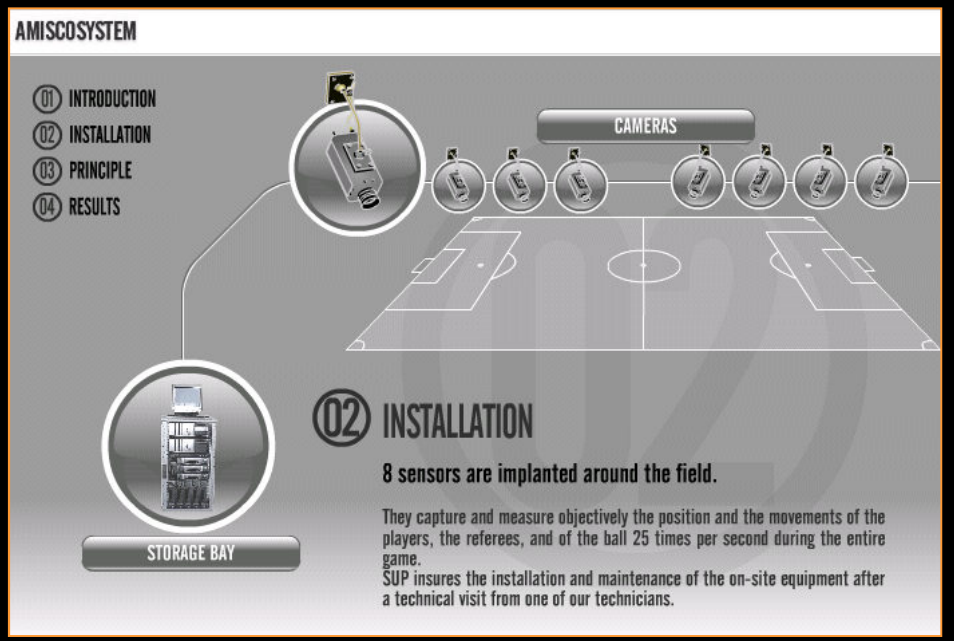


Figure 3. Schematic Diagram of Prozone® analysis system.

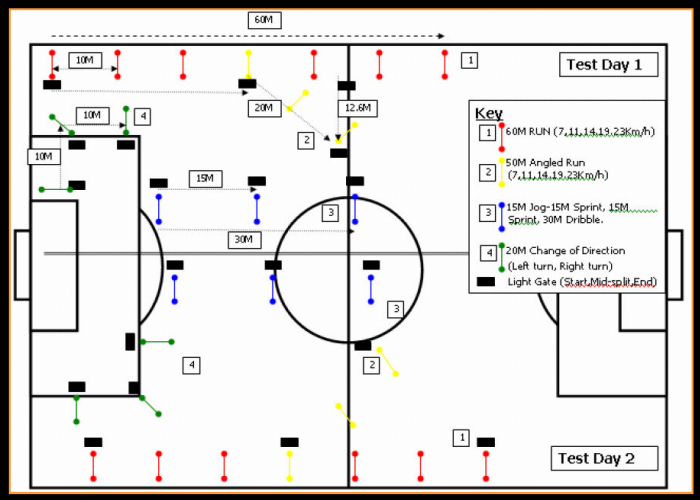
AMISCO ® -System (Nice, France)



Prozone® Validation

Runs at different speeds and locations of the pitch were performed and tracked with the system.

The correlations with measures taken from time gates were very high.

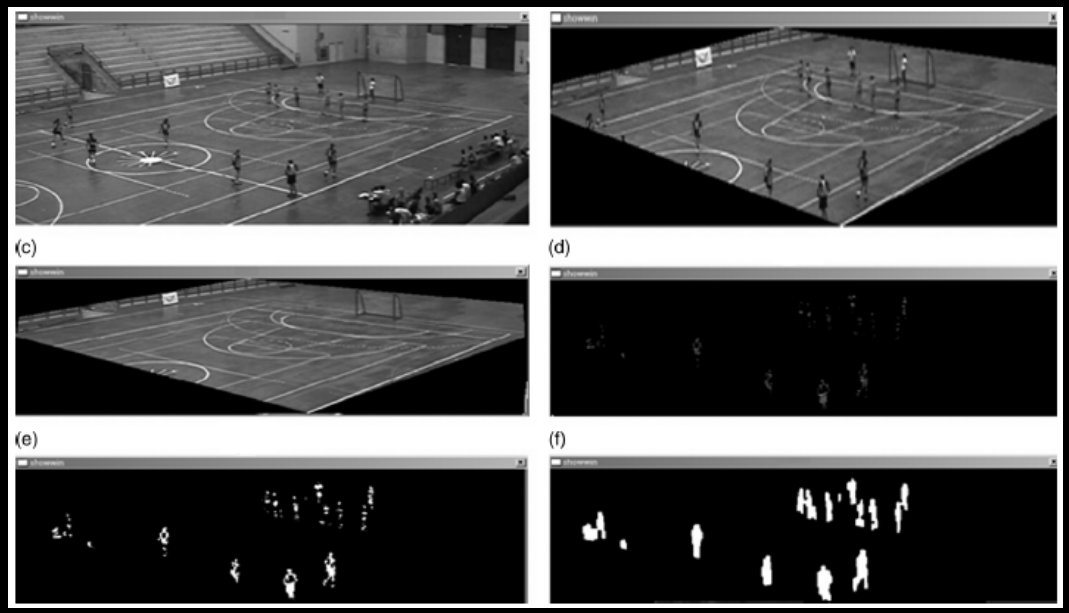


Test	Typical Error (Upper and Lower Confidence Limits)	Total Error (Limits of Agreement)	Intraclass Correlation Coefficient	Typical Error as CV (%)
60m running	0.04 (0.06-0.03)	0.05 (0.12)	0.999	0.2
50m curving	0.07 (0.11-0.05)	0.09 (0.22)	0.999	0.3
15m sprint	0.01 (0.04-0.01)	0.02 (0.05)	0.999	0.2
20m sprint and turn	0.23 (0.58-0.15)	0.23 (0.85)	0.950	1.3

Di Salvo, V., Collins, A., Mc Neill, B. and Cardinale, M. (2006) Validation of Prozone ®: A new video-based performance analysis system. *International Journal of Performance Analysis in Sport (serial online)*

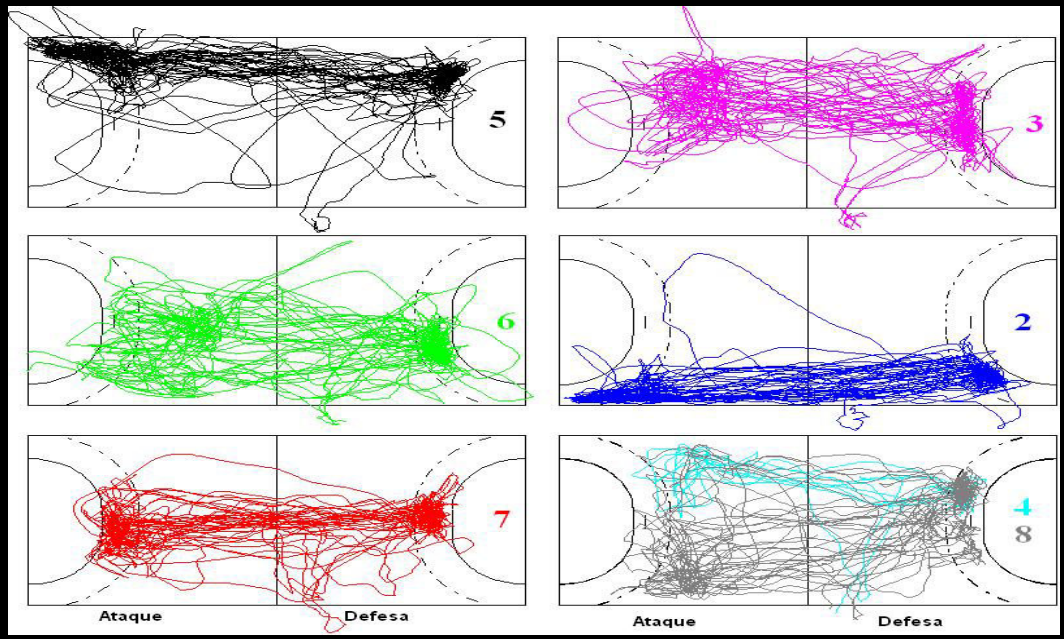
Rafael Pombo Menezes. Master's thesis, 2007

Kinematic Analysis of Handball Players.



Barros, Ricardo M. L. et al.

Measuring handball players trajectories using an automatically trained boosting algorithm. Computer Methods in Biomechanics and Biomedical Engineering, v. 14, p. 1-10, 2010.

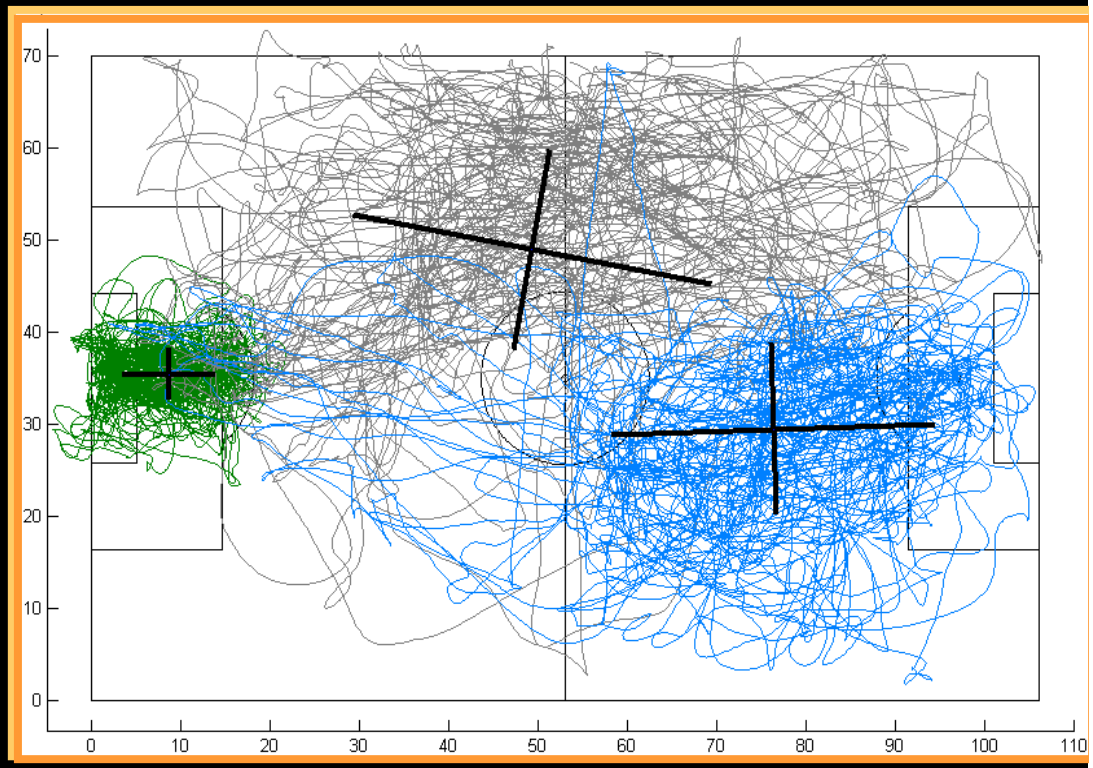


Representation of Soccer Player/Team Motion

The great amount of data generated by automatic tracking methods requires ways of representing and analyzing the results.

Principal Component Analysis

Graphical Representation: Two orthogonal segments are centered at the mean vector position (**O**). The segments directions are driven by the eigenvectors found in PCA (**u**, **v**). Each segment is one standard deviation long symmetrically in relation to the origin.



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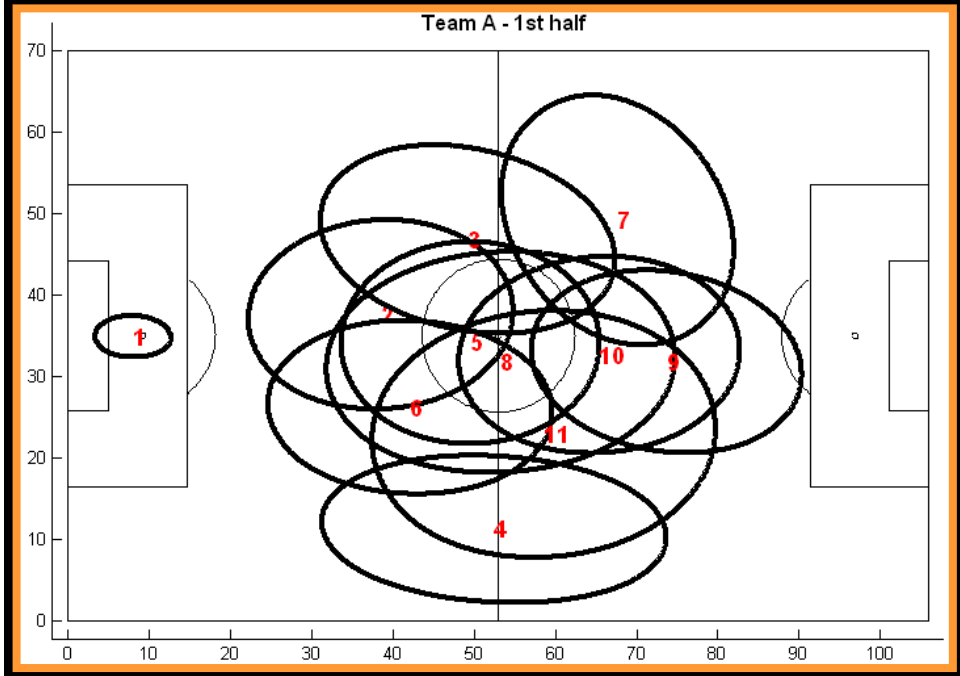
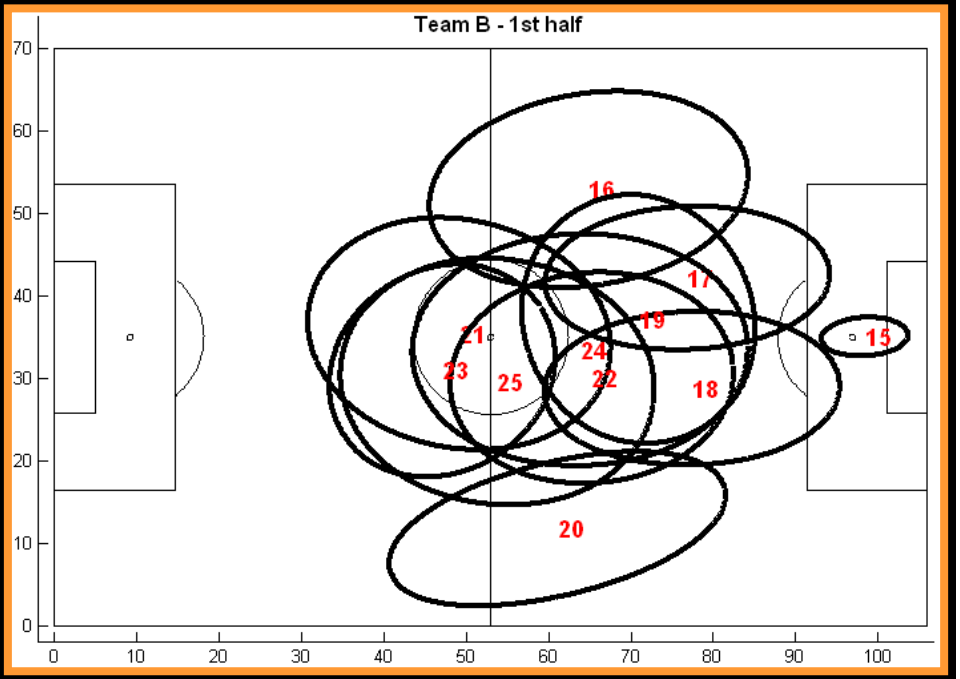
Tactical Analysis

Santos

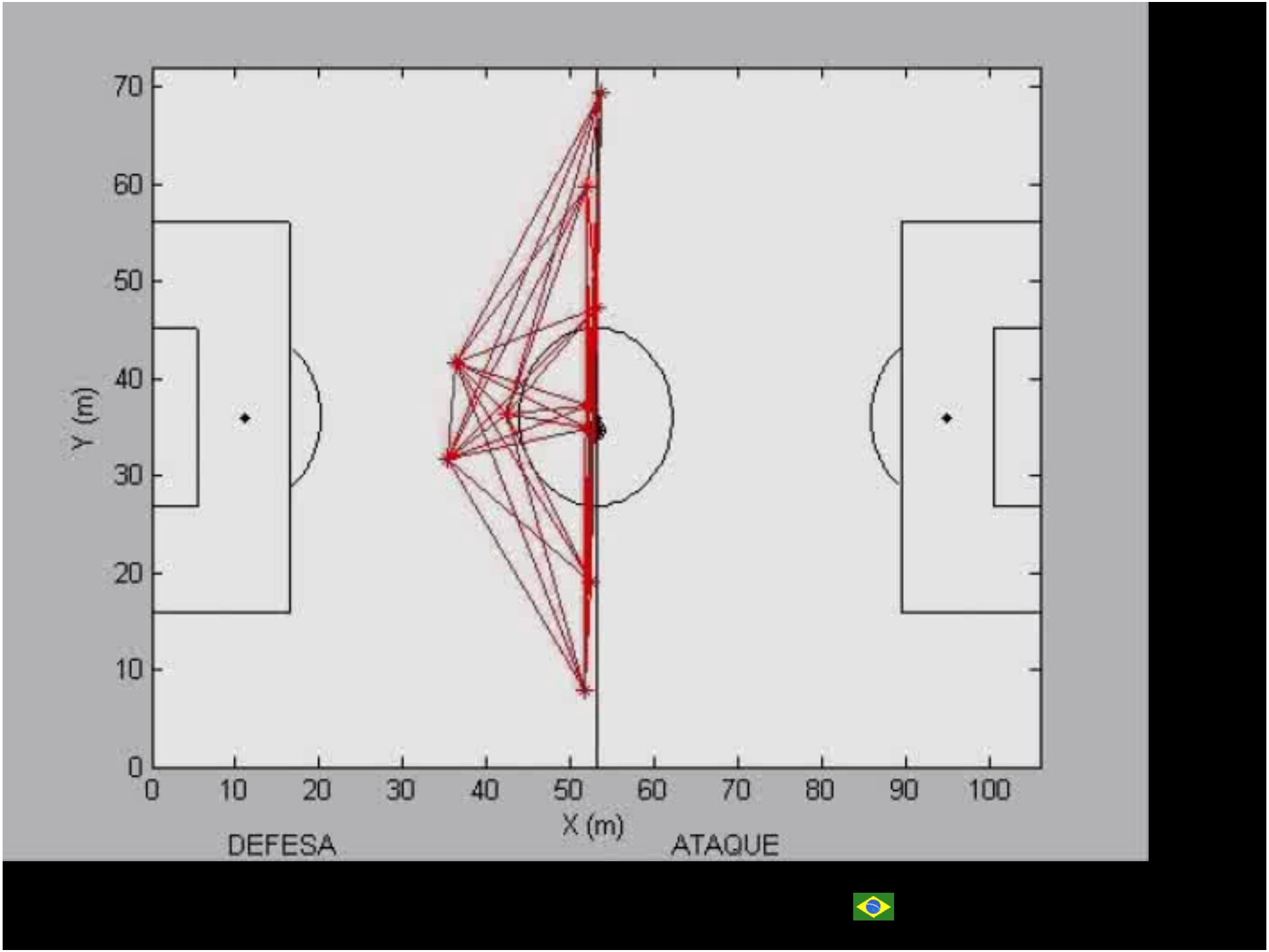


Offensive Characteristic

Ituano



Defensive Characteristic


70
60
50
40
30
20
10
0
Y (m)
0
10
20
30
40
50
60
70
80
90
100
X (m)
DEFESA
ATAQUE

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Felipe Moura., Ph.D.

Quantitative analysis of Brazilian football players' organisation on the pitch. Sports biomechanics, v. 11, p. 85-96, 2012.

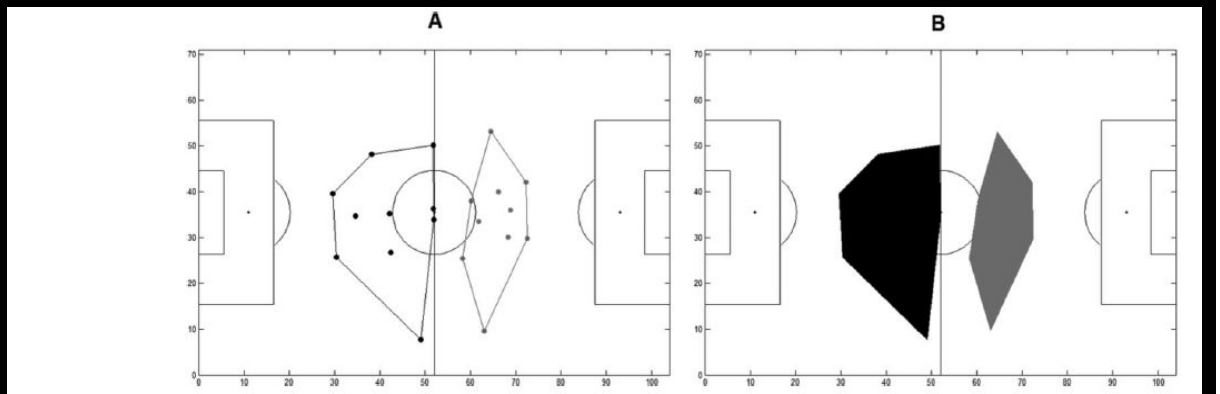

Figure 2. Teams convex hulls (A) and the representation of the surface areas (B).

A spectral analysis of team dynamics and tactics in Brazilian football. J. Sports Sciences, 2013

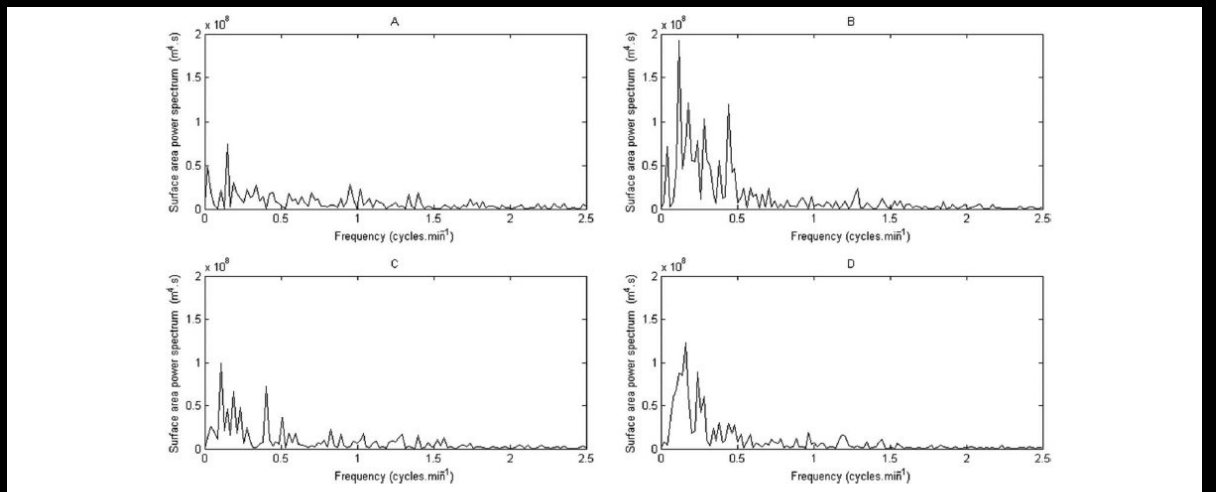

Figure 5. Results of the spectral analysis for the surface area time series of *tm3* (A – 1st half; B – 2nd half) and *tm4* (C – 1st half; D – 2nd half).

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TRACKING SYSTEMS IN PARALYMPIC SPORTS

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Tracking of wheelchair rugby players in the 2008 Demolition Derby final

Karine J. Sarro, Milton S. Misuta, Brendan Burkett, Laurie A. Malone, Ricardo M. L. Barros

Journal of sports sciences 28 (2), 193-200, 2010.

International Cooperation supported by IPC

University of the Sunshine Coast, Australia

Lakeshore Foundation, Birmingham, Alabama, USA

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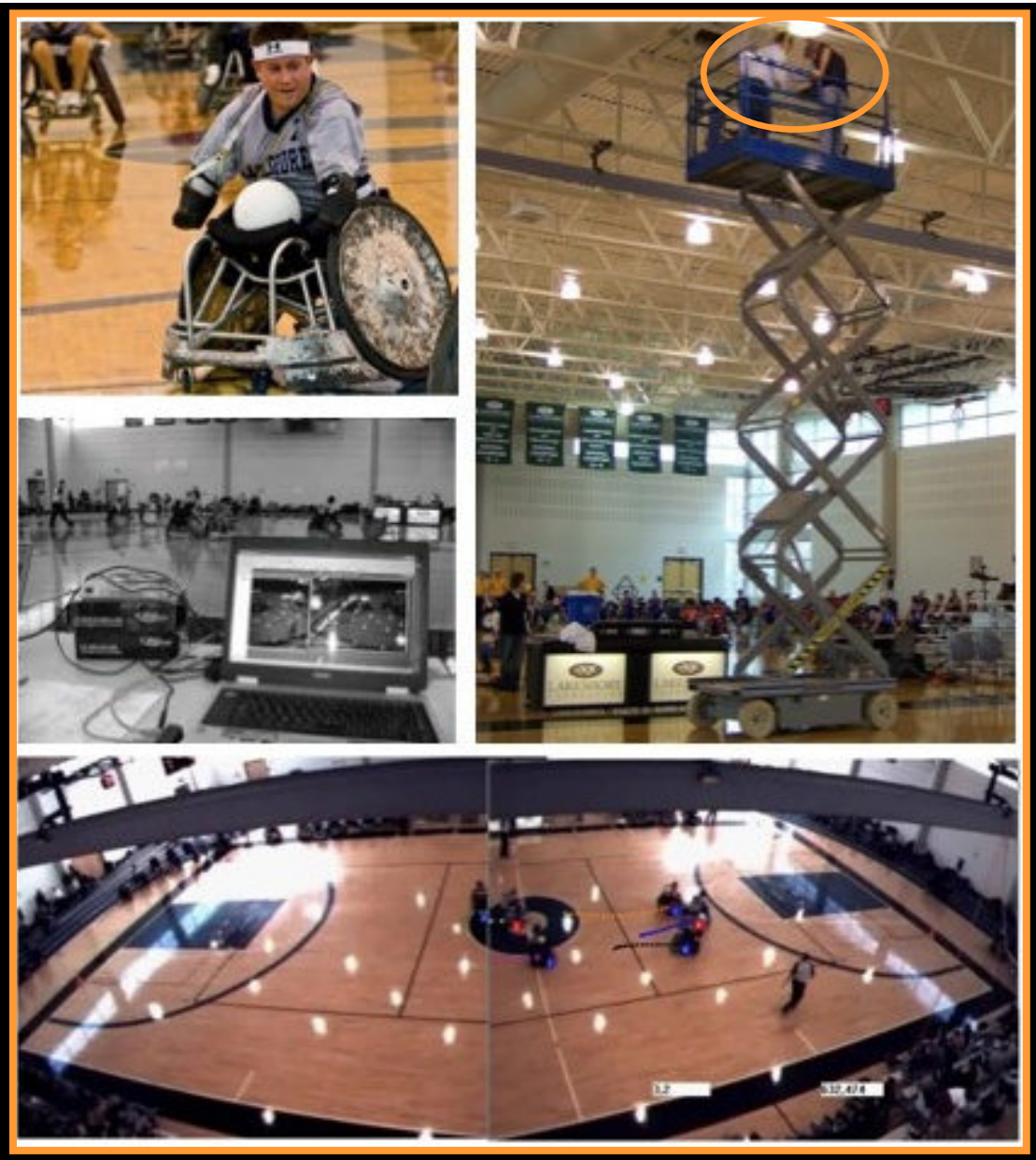

The Paralympic Athlete: Handbook of Sports Medicine and Science

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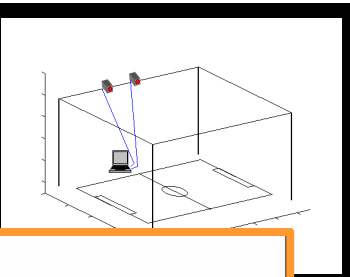
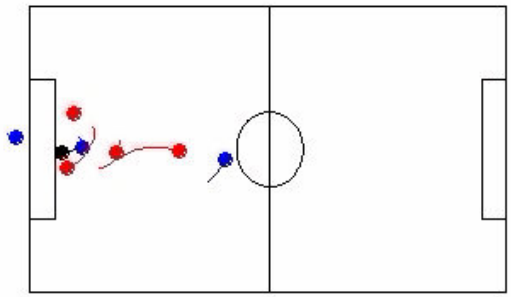
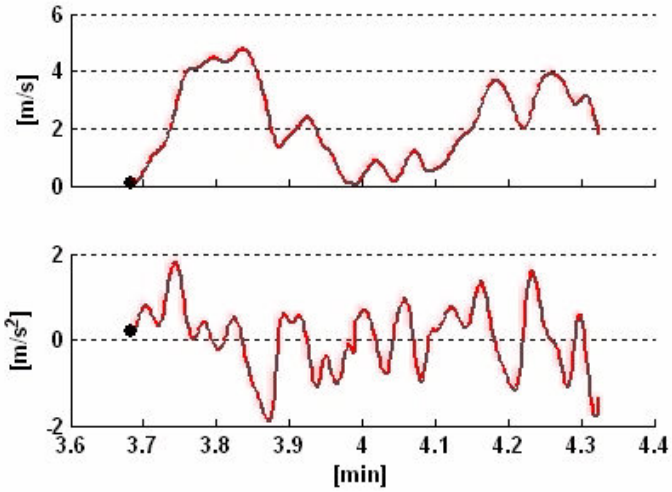
DVideo System LIB - Campinas Brasil

Methods





Distance: 0.0094[m]



Results

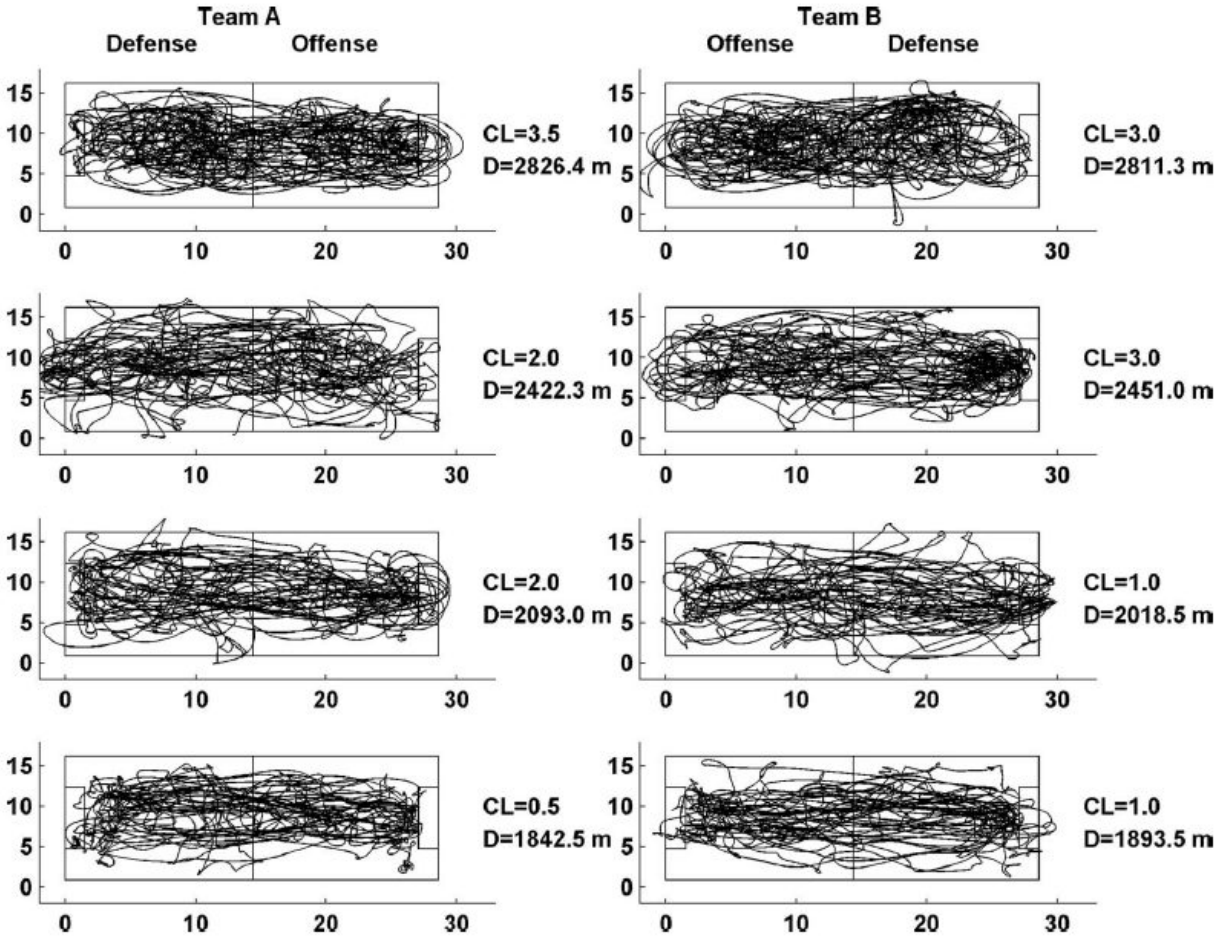


Figure 1. Visual representation of player trajectories on team A (left) and team B (right) during the first half of the game. CL = classification level of the player; D = distance covered by the player (m).

Results

Table I. IWRF classification level, distance covered during the first and second halves of the game, total distance covered, average speed in the first and second halves, and percent decrease in average speed from the first to second half for each player ($n = 8$) in the Demolition Derby final.

Player	IWRF class	Distance in first half (m)	Distance in second half (m)	Total distance (m)	Average speed in first half ($m \cdot s^{-1}$)	Average speed in second half ($m \cdot s^{-1}$)	Percent decrease
Team A							
1	3.5	2826.3	2708.0	5534.3	1.51	1.27	16.0
2	2.0	2422.2	2321.3	4743.5	1.29	1.09	16.0
3	2.0	2093.0	1982.9	4075.8	1.12	0.93	17.0
4	0.5	1842.3	1659.3	3501.6	0.98	0.78	21.1
Team B							
5	3.0	2811.4	2846.0	5657.3	1.50	1.33	11.3
6	3.0	2450.8	2546.6	4997.3	1.31	1.19	8.9
7	1.0	2018.4	2099.9	4118.3	1.08	0.98	8.8
8	1.0	1893.4	1799.5	3692.9	1.01	0.84	16.7
Mean $\pm$ s	–	2294.7 $\pm$ 391.5	2245.4 $\pm$ 431.5	4540.1 $\pm$ 817.4	1.22 $\pm$ 0.21	1.05 $\pm$ 0.20	14.5 $\pm$ 4.3

Note: The total duration of the first and second half was 31.2 min and 35.6 min respectively.

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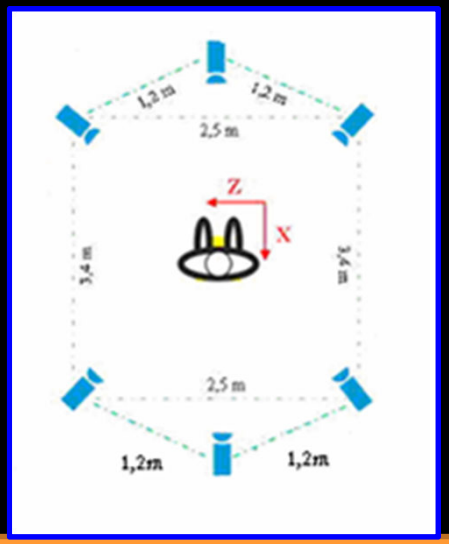
JULIANA VIANA PARIS.
Master, 2012.

Analysis of pulmonary function, thoraco-abdominal mobility and kinematics during matches of Wheelchair Rugby players before and after one years of training.



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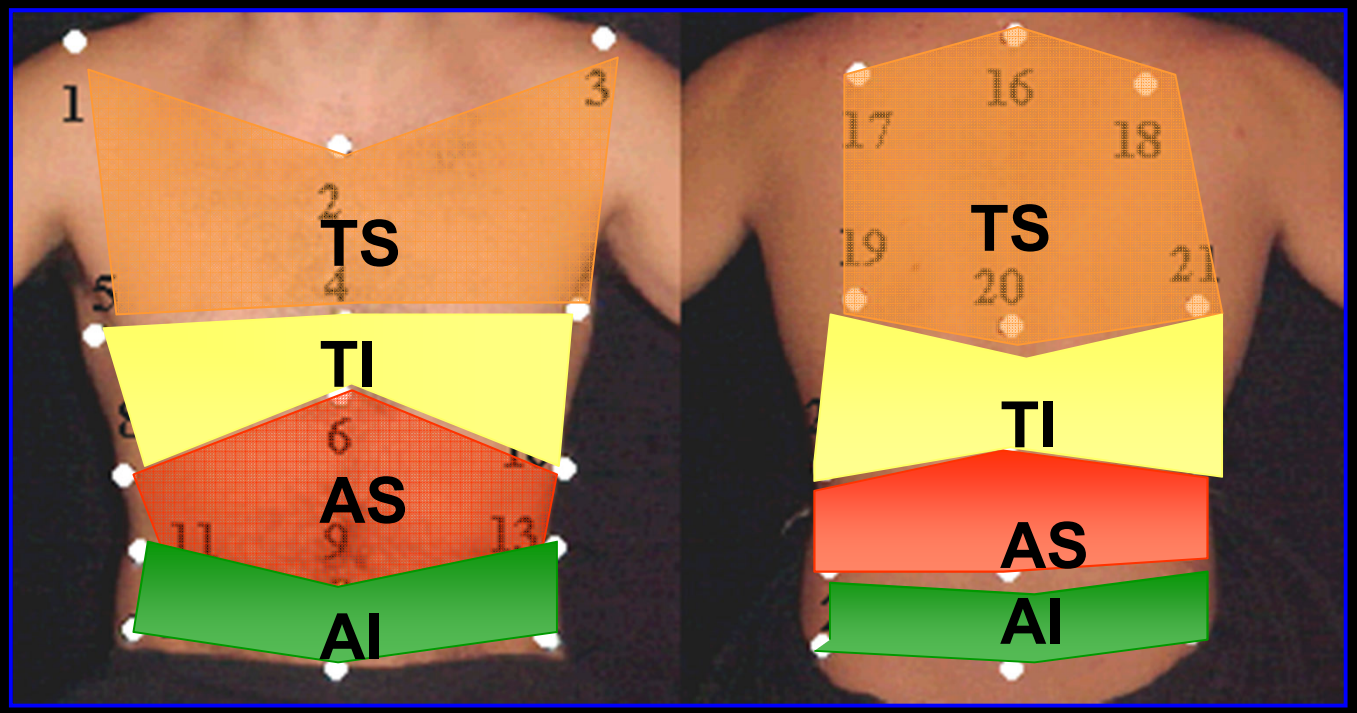
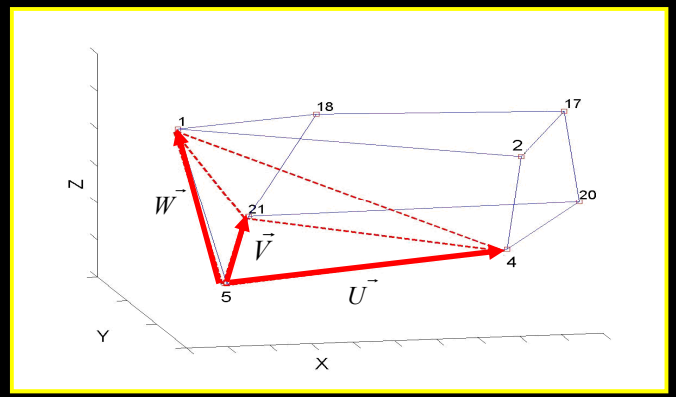
Chess Wall Kinematics



Loula et al (2004)



$$V = \sum_{n=1}^{6} \frac{\left| \vec{W}_i \times \vec{U}_i \cdot \vec{V}_i \right|}{6}$$

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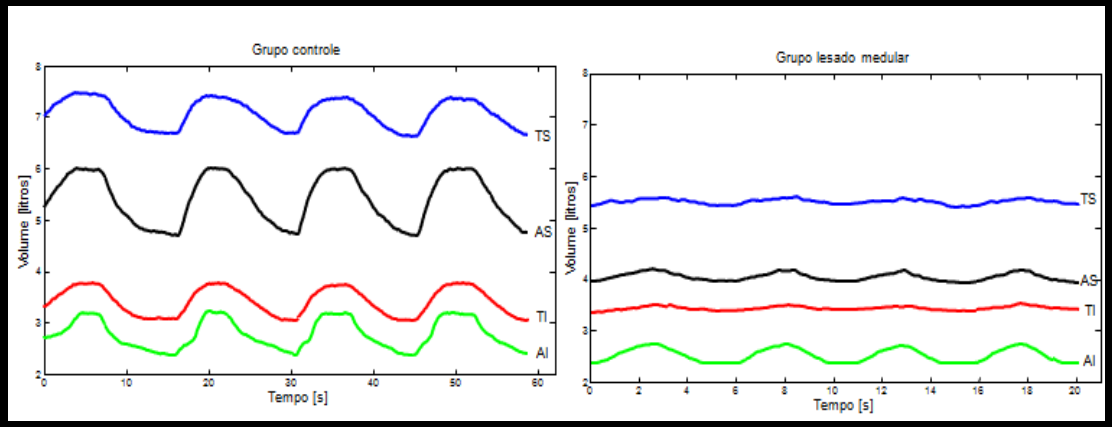
Results

Trunk Partial Volumes



Control Group **Rugby Player**

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Marlene Moreno
PosDoc – LIB 2010-2011

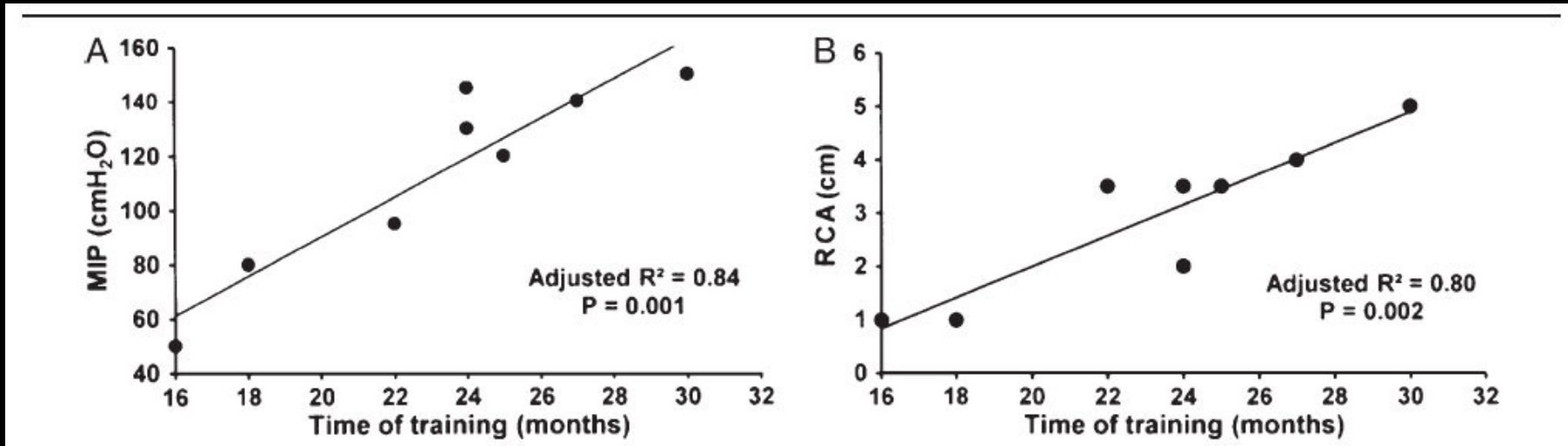

FIGURE 1 *Linear regression values between time of training and respiratory variables: MIP (A) and RCA (B) in the A-QUAD group. A-QUAD, active quadriplegic; MIP, maximal inspiratory pressure; RCA, respiratory coefficient at the axillary level.*

Moreno et al., Effects of Wheelchair Sports on Respiratory Muscle Strength and Thoracic Mobility of Individuals with Spinal Cord Injury. American Journal of Physical Medicine & Rehabilitation , 2012.

Marlene Moreno
PosDoc – LIB 2010-2011
Docente - Unimep

Marlene Moreno et al.

Wheelchair Rugby Improves Pulmonary Function in People With Tetraplegia After 1 Year of Training. Journal of Strength and Conditioning Research, v. 27, p. 50-56, 2013.

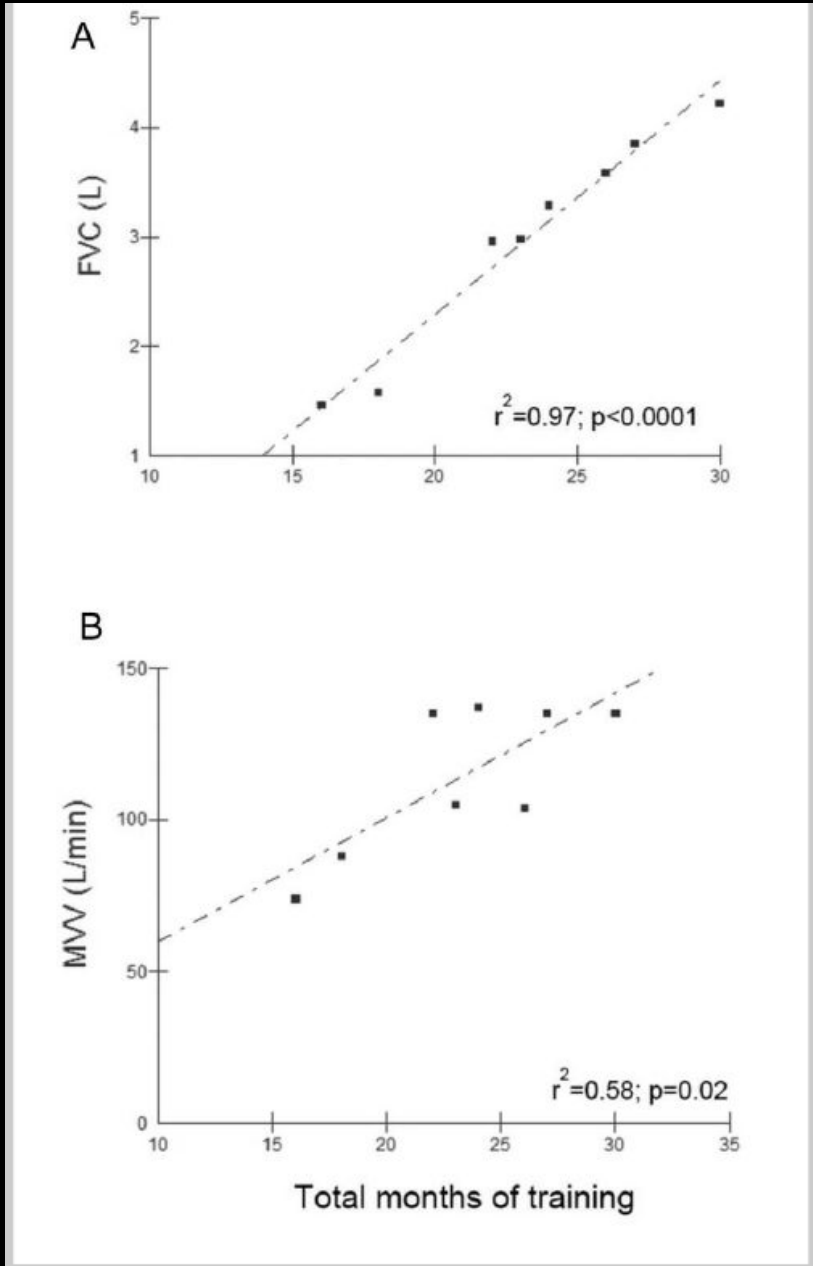

Figure 1. Regression between total months of training and respiratory variables: A) forced vital capacity (FVC) and B) maximal voluntary ventilation (MVV).

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Football 5-a-side
3rd IBSA Championship -2007

Final: Brazil x Argentina

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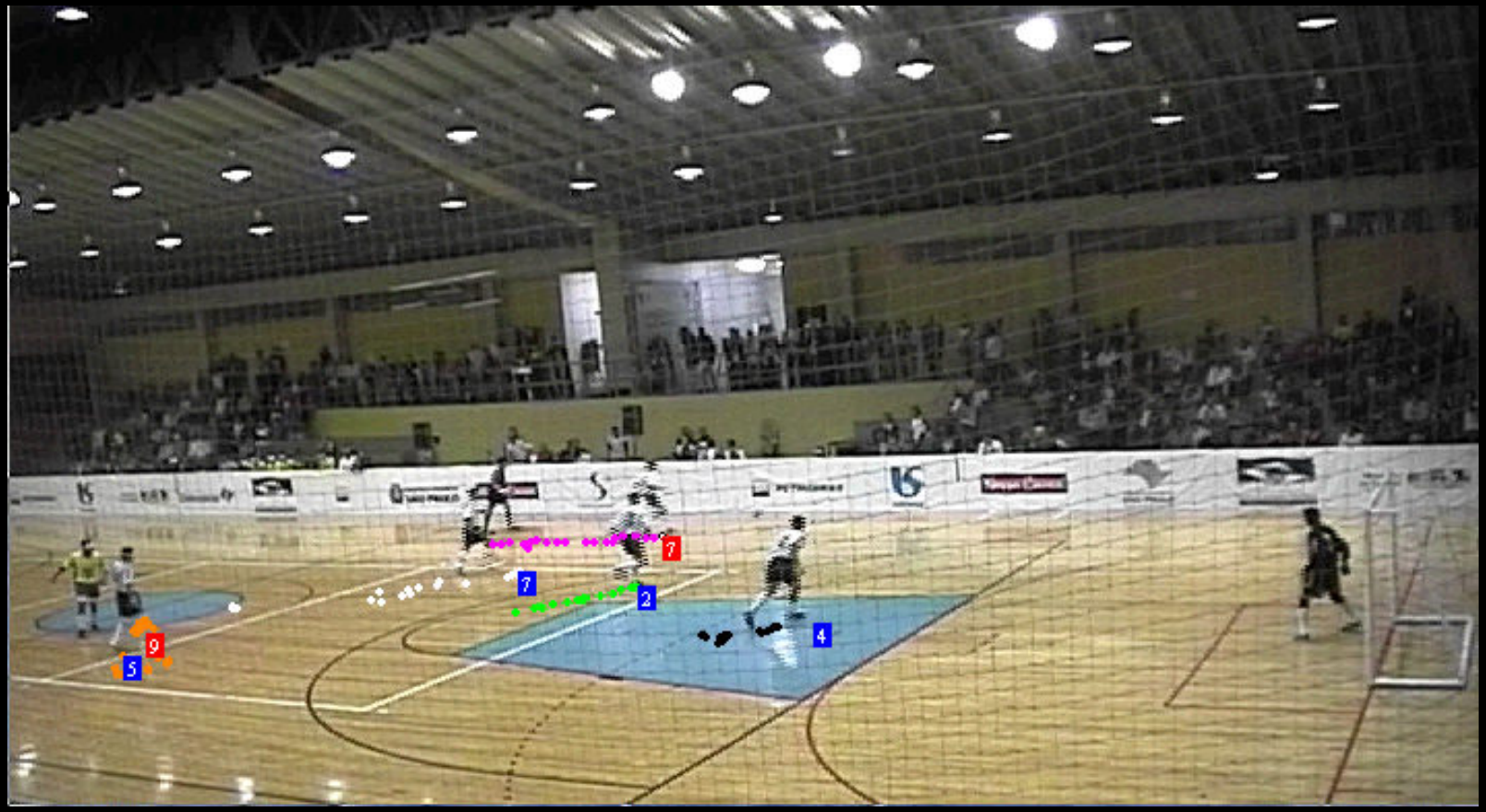
Tracking players



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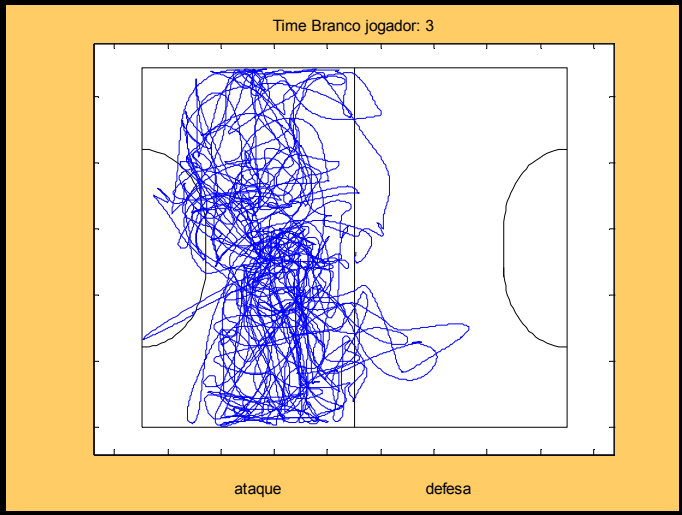
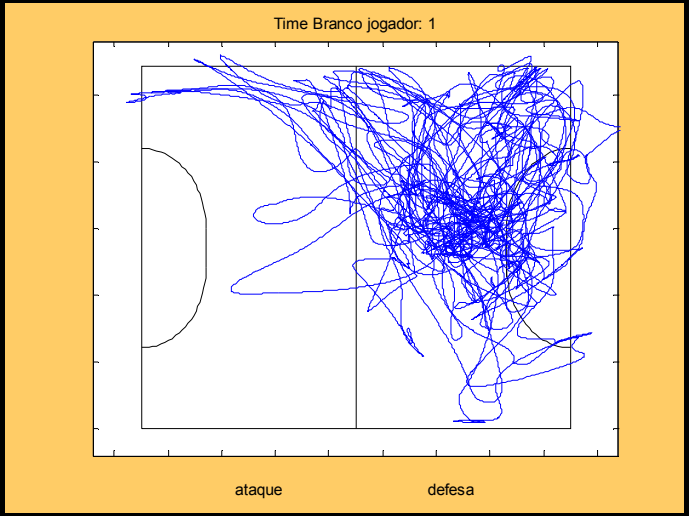
Distances Covered

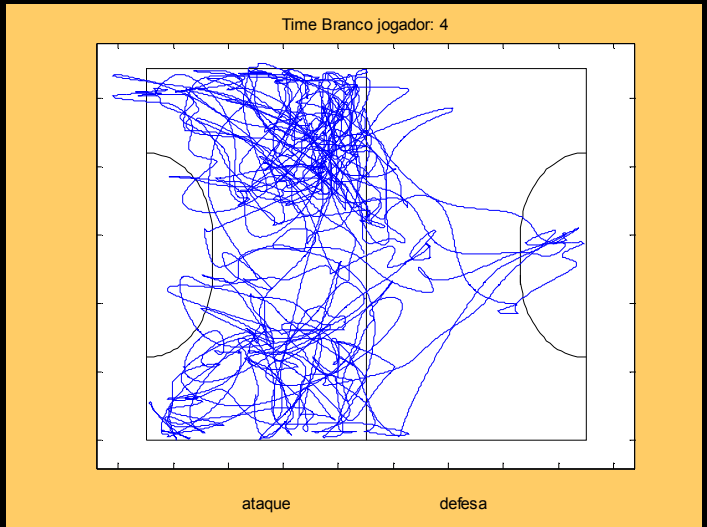
First Half



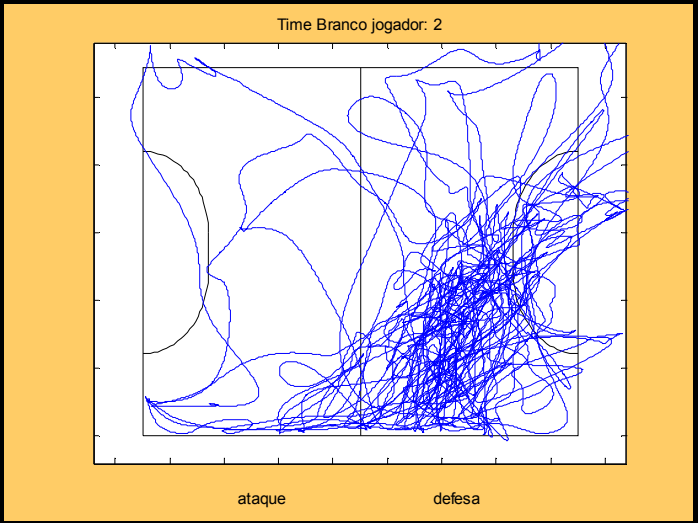
Distance covered: 2100 m



Distance covered: 2322 m



Distance covered: 2034 m



Distance covered: 2292 m

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Tracking systems: Current trends and challenges

Tracking Systems Based on TV Broadcast Images

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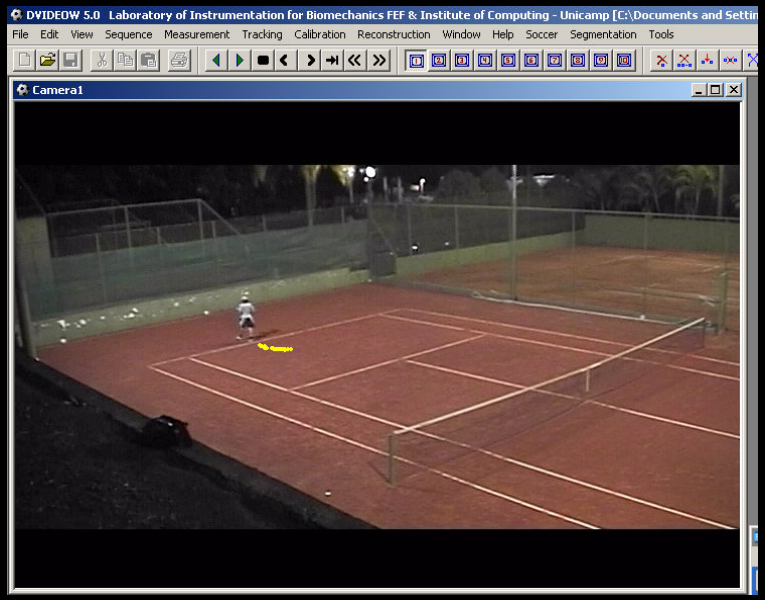
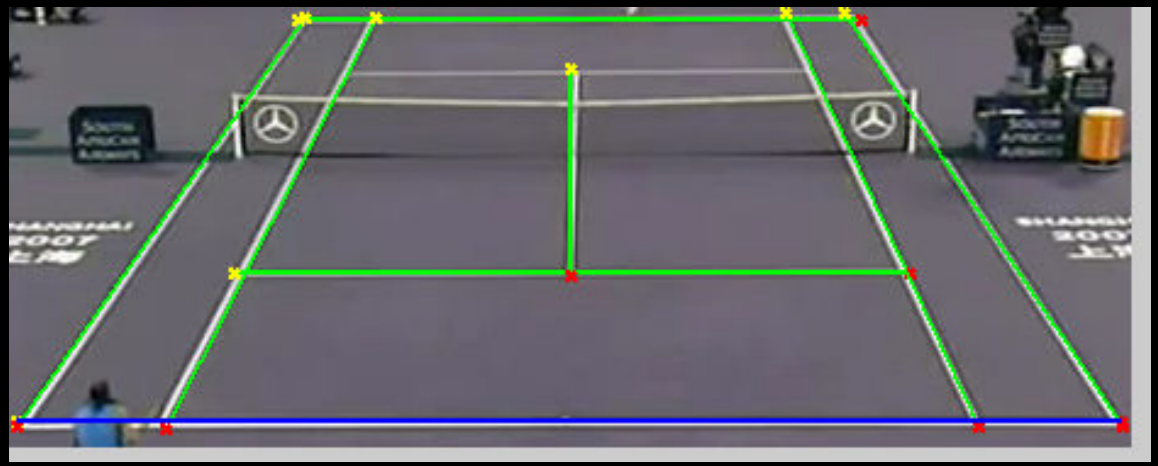
Cláudio Luis Roveri Vieira. Master`s Thesis. 2012.

PROPOSITION AND VALIDATION OF A NOVEL AUTOMATIC METHOD FOR TRACKING TENNIS PLAYERS



Tracking based on fixed cameras



Tracking based on broadcast TV cameras

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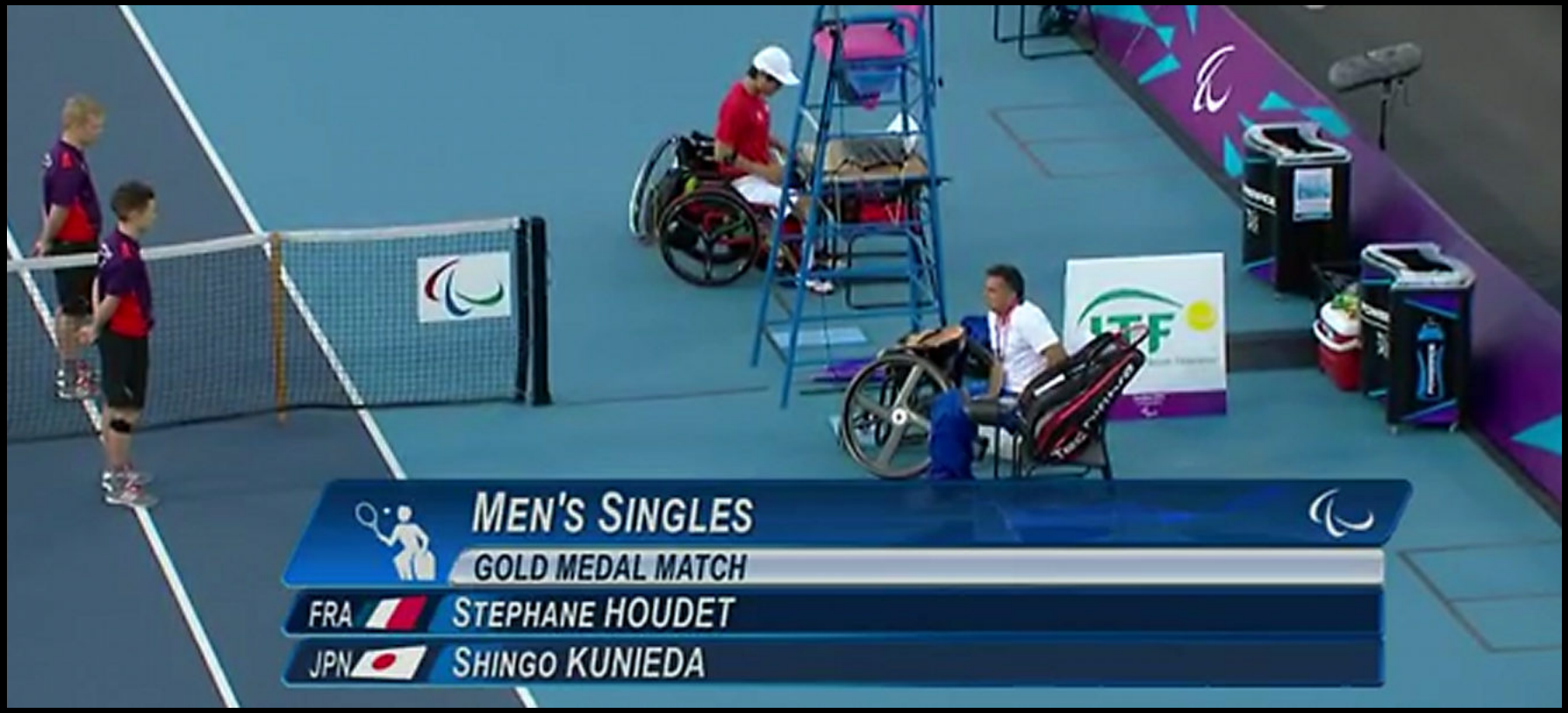
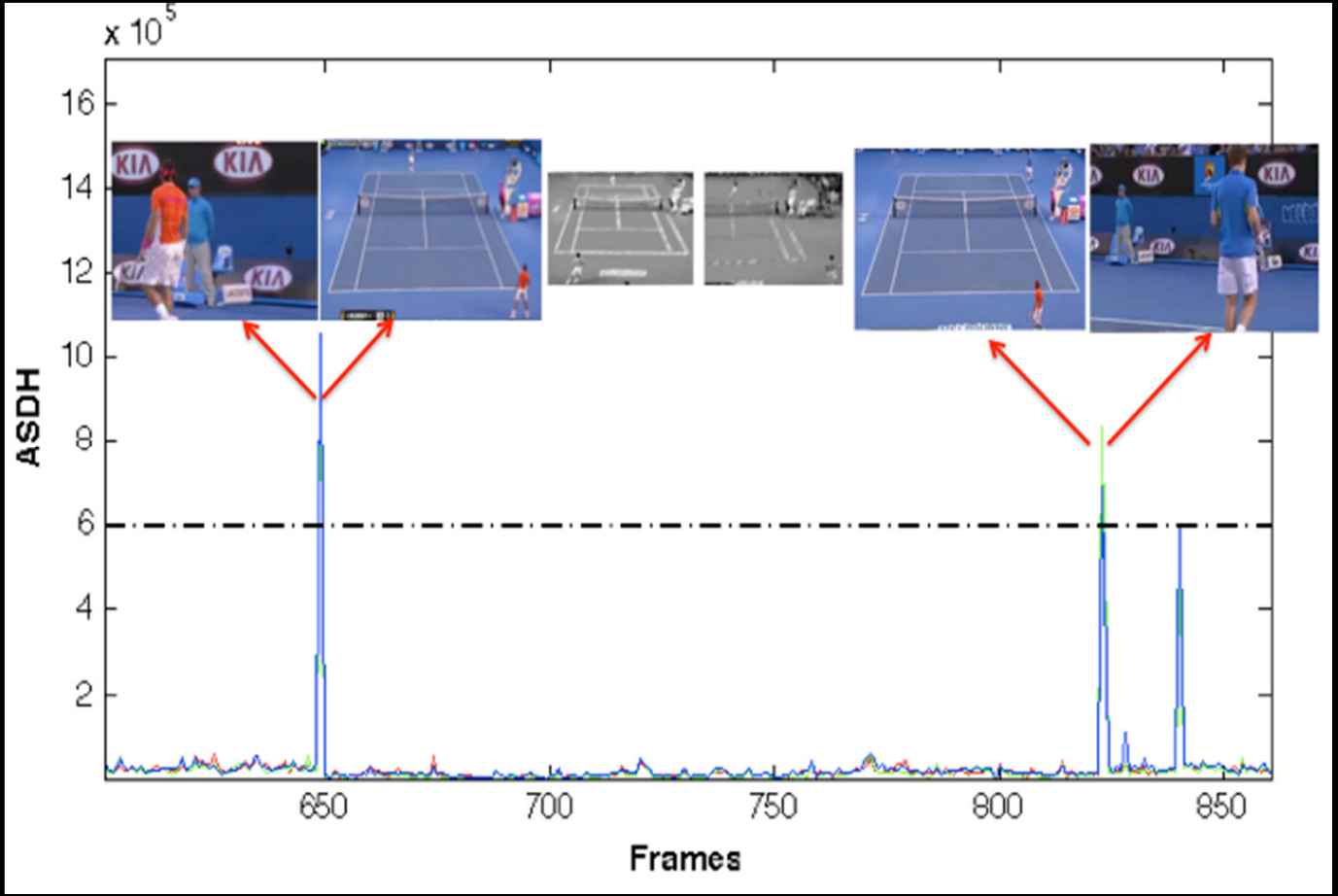
Wheelchair Tennis at the London 2012 Paralympic Games



Wheelchair Tennis at the London 2012 Paralympic Games

Automatic Scene Detection



Scene cuts detected in a video sequence based on Absolute sum of difference of histograms (ASDH).

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Dynamic Calibration

Processing

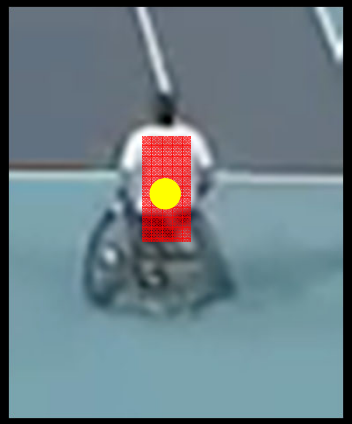
Model

Pearson Correlation

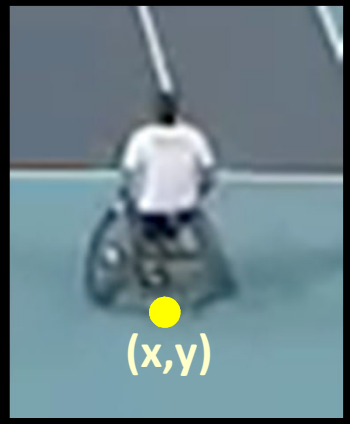
0,2	0,2	0,1	0,3	0,3	0,2	0,3
0,2	0,2	0,5	0,9	0,7	0,3	0,3
0,3	0,2	0,5	0,8	0,4	0,3	0,3
0,3	0,3	0,3	0,1	0,4	0,3	0,3

Matriz de correlações

ROI



Center



Projection

Tracking system:DVideo (Unicamp-Brazil)

Parameters

Frame
120015

Position File (P1)
posicao_para_1.txt

Position File (P2)
posicao_para_2.txt

Frame Range
120015 to 120125

View Tracking

Covered distances

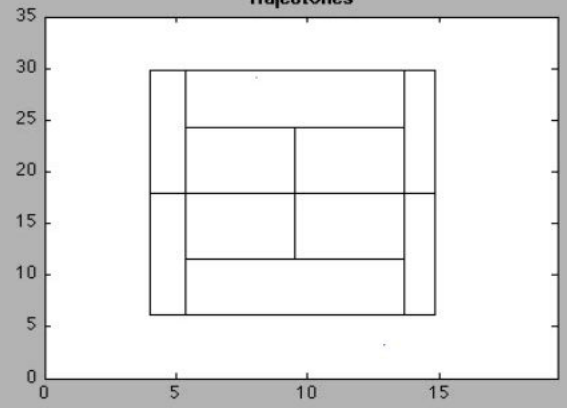
0m

0m

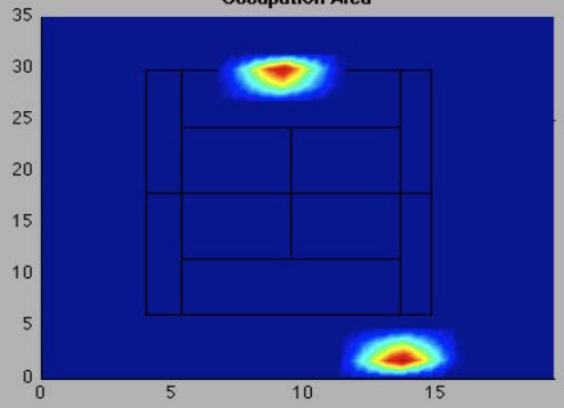
Video

Video Sequence

Trajectories



Occupation Area



Results

	Distance Covered (m)		Average Speed (Km/h)		
	Player 1	Player2	Player 1	Player 2	Winner
Game 1	62,15	41,73	5,49	3,69	1
Game 2	46,35	75,59	3,18	5,18	1
Game 3	171,75	196,70	4,77	5,46	2
Game 4	53,49	66,77	2,83	3,53	1
Game 5	61,08	30,15	4,92	2,43	2
Game 6	56,19	75,76	3,90	5,25	1
Game 7	136,96	115,55	5,91	4,98	1
Game 8	159,95	193,40	4,81	5,82	1
Mean	93,49	99,46	4,48	4,54	
Total	747,93	795,65			

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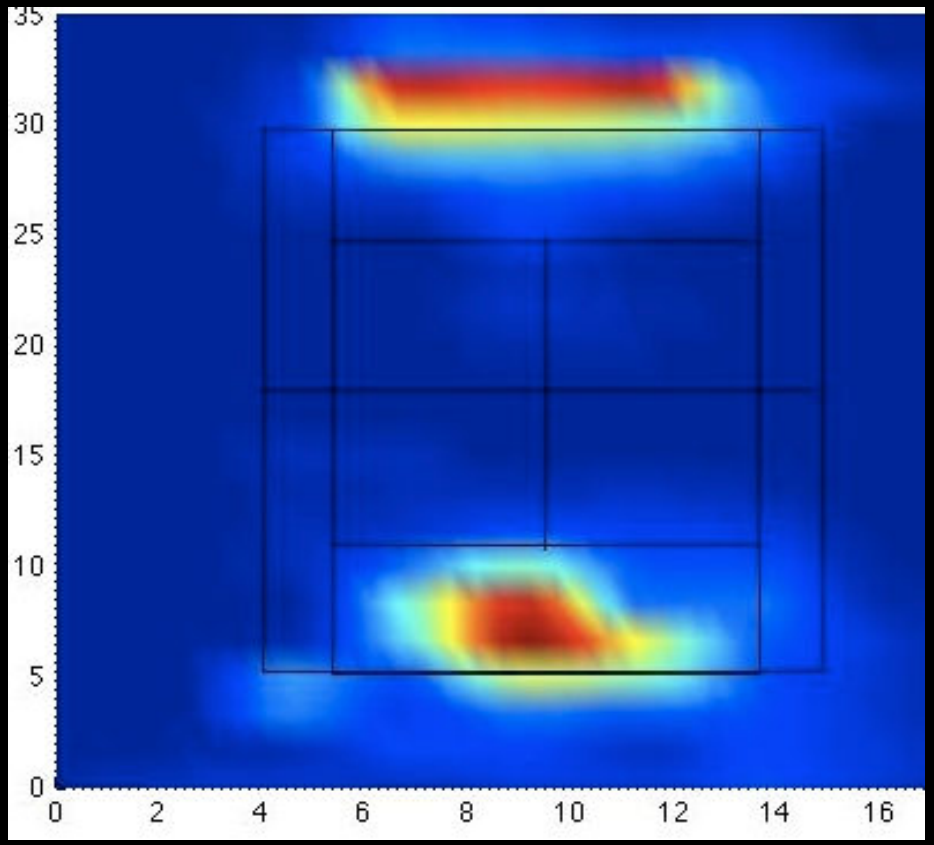
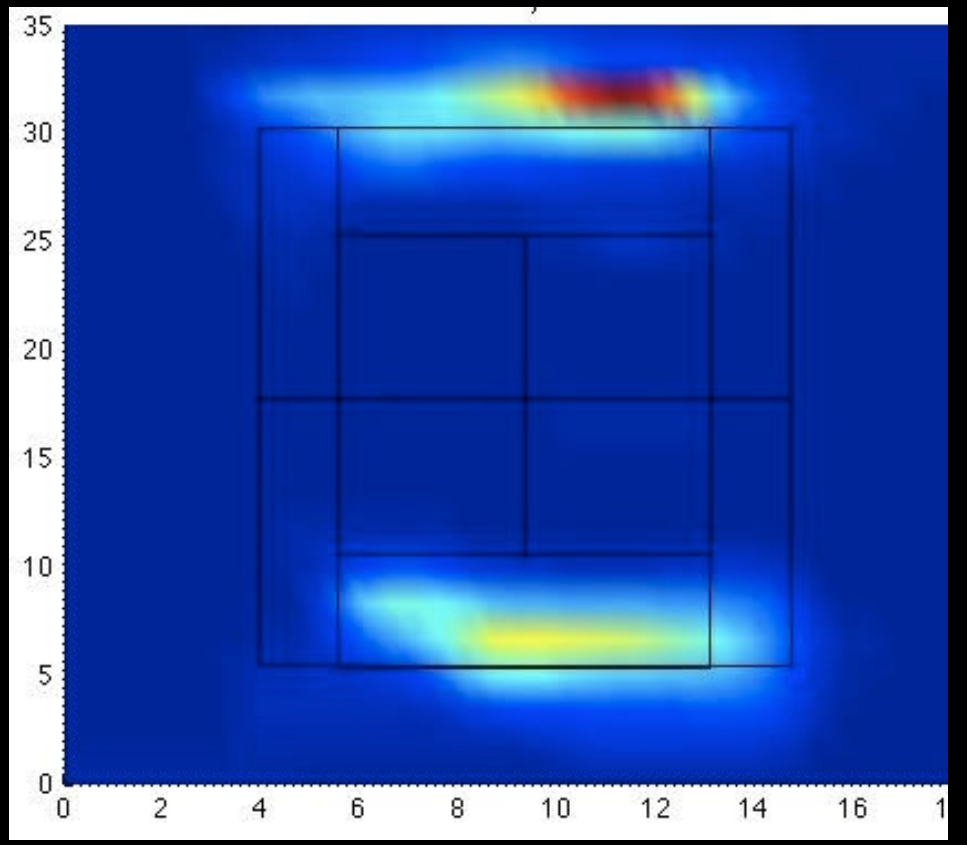
Results

PLAYER 1



PLAYER 2



Markerless analysis of front crawl swimming

Elena Ceseracciu [a], Zimi Sawacha [a], Silvia Fantozzi [b,c], Matteo Cortesi [b], Giorgio Gatta [b], Stefano Corazza [d], Claudio Cobelli [a,*]

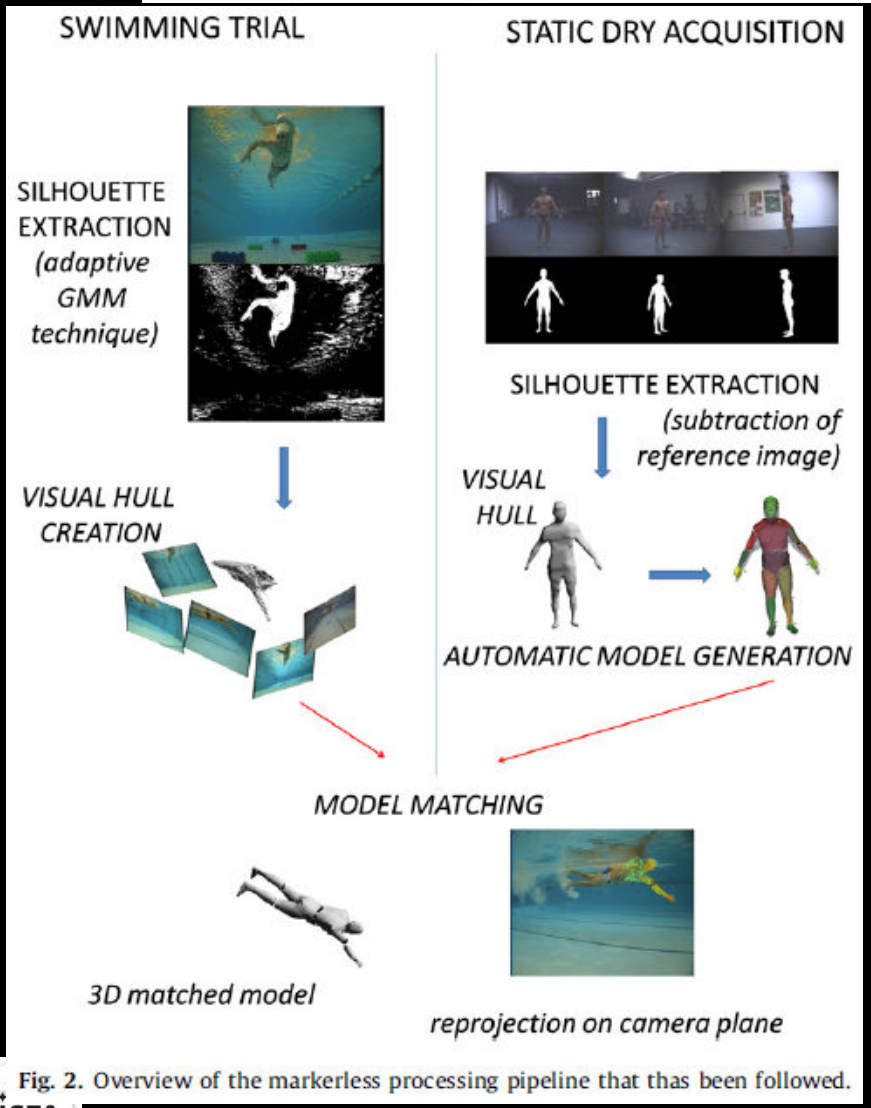
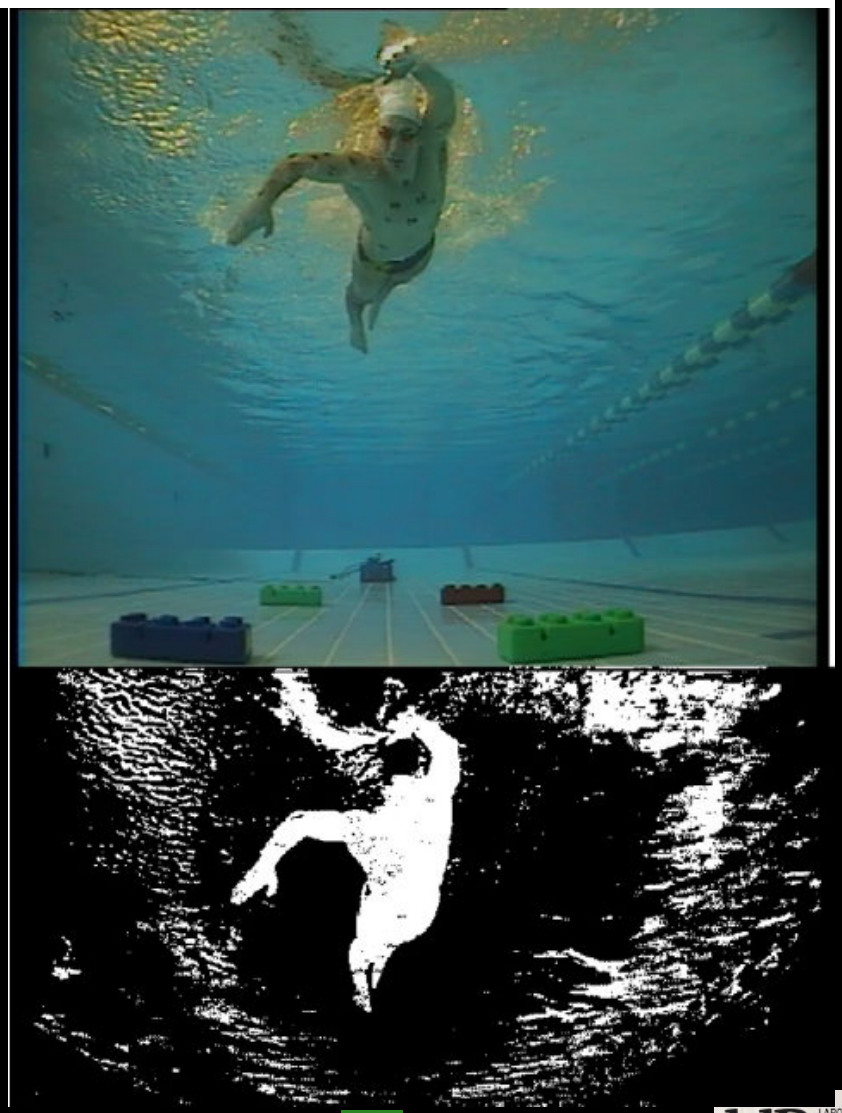


Fig. 2. Overview of the markerless processing pipeline that thas been followed.



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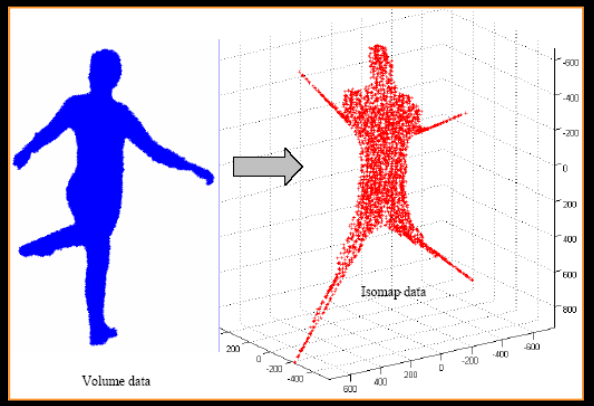
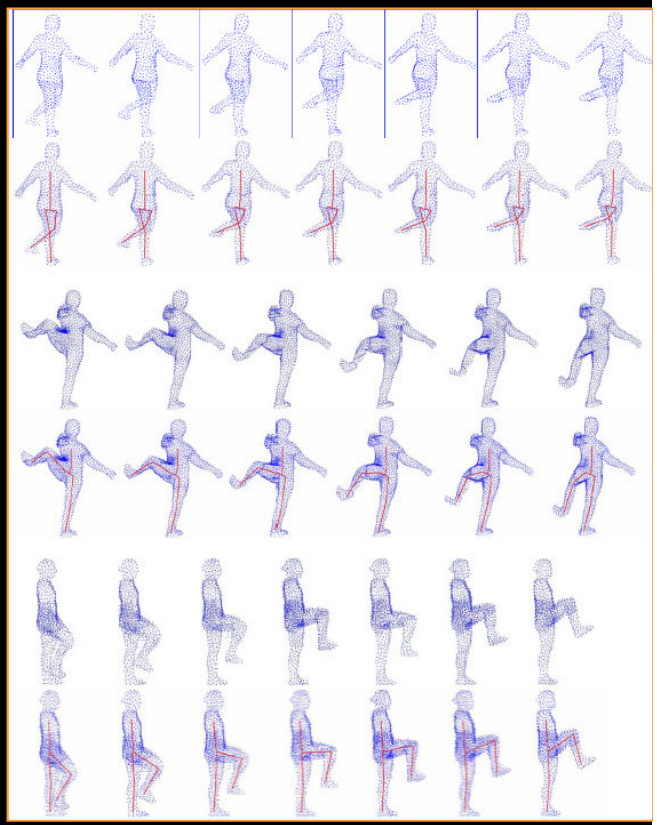
Pietro Cerveri.
Politecnico di Milano

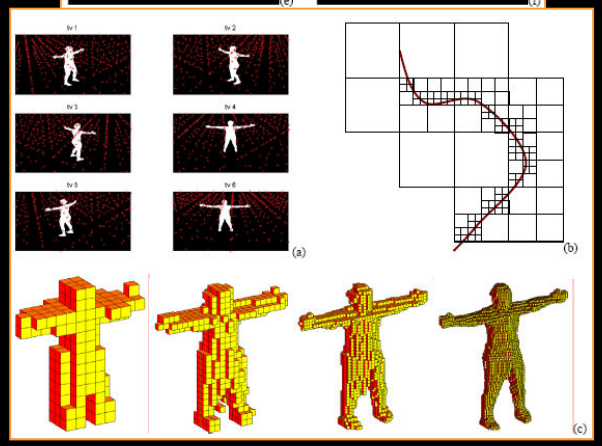
Academic Partner

Markerless motion analysis.

Cerveri, P., et al. Isomap transform for segmenting human body shapes. Computer Methods in Biomechanics and Biomedical Engineering, v. 14, p. 783-795, 2011.







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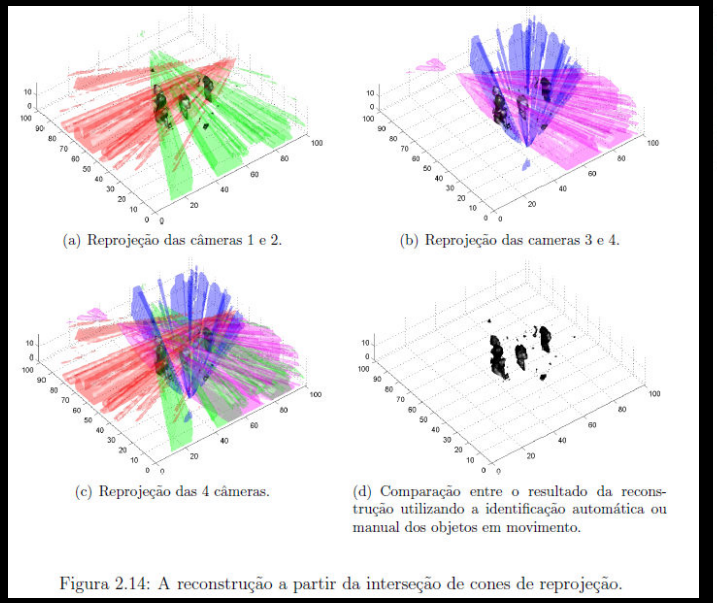
Fábio Augusto Salve Dias, PosDoc, 2013.

Visual Rhythm Generalization with application in Sports



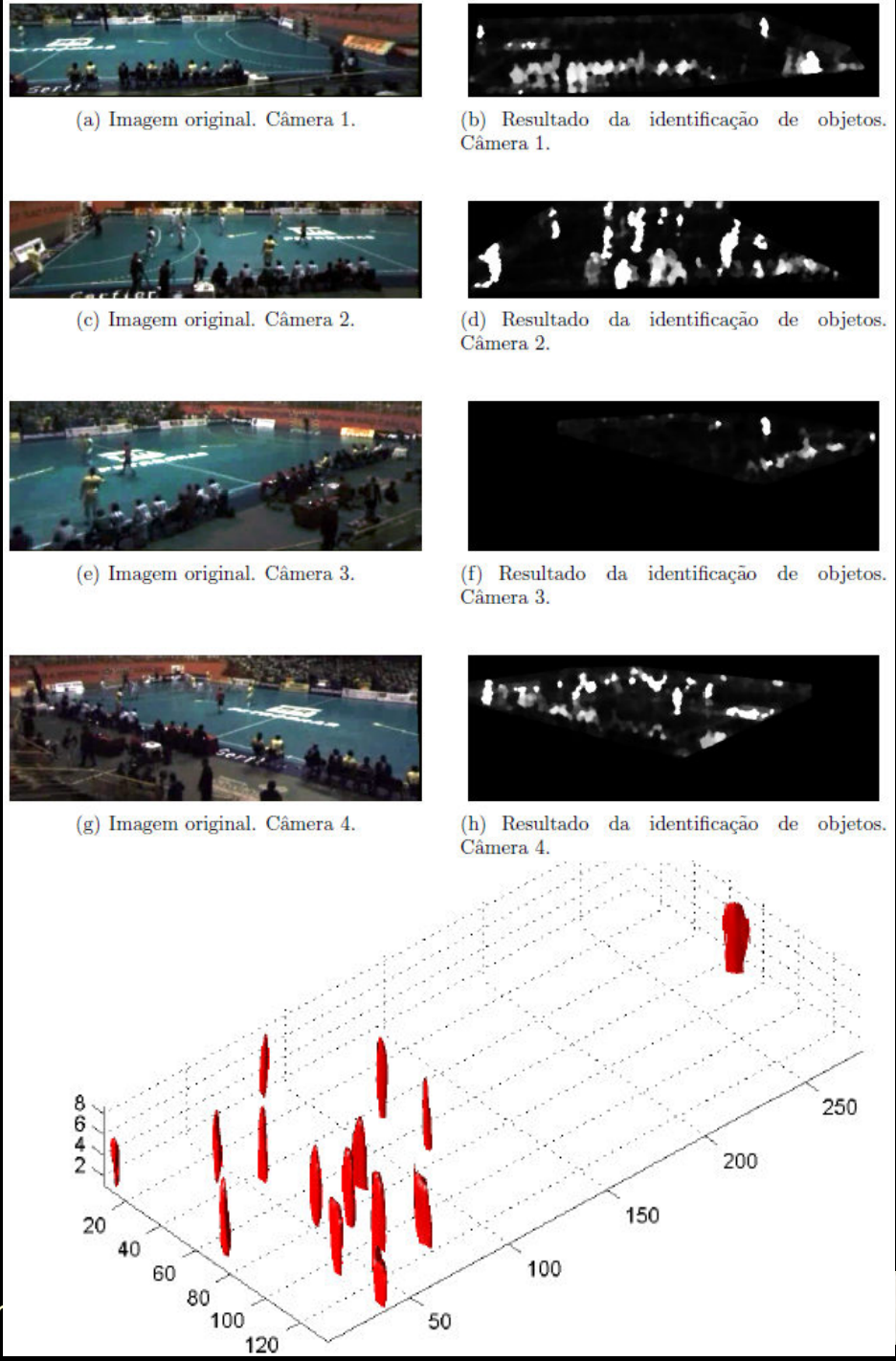
(a) Reprojeção das câmeras 1 e 2.

(b) Reprojeção das cameras 3 e 4.

(c) Reprojeção das 4 câmeras.

(d) Comparação entre o resultado da reconstrução utilizando a identificação automática ou manual dos objetos em movimento.

Figura 2.14: A reconstrução a partir da interseção de cones de reprojeção.



(a) Imagem original. Câmera 1.

(b) Resultado da identificação de objetos. Câmera 1.

(c) Imagem original. Câmera 2.

(d) Resultado da identificação de objetos. Câmera 2.

(e) Imagem original. Câmera 3.

(f) Resultado da identificação de objetos. Câmera 3.

(g) Imagem original. Câmera 4.

(h) Resultado da identificação de objetos. Câmera 4.

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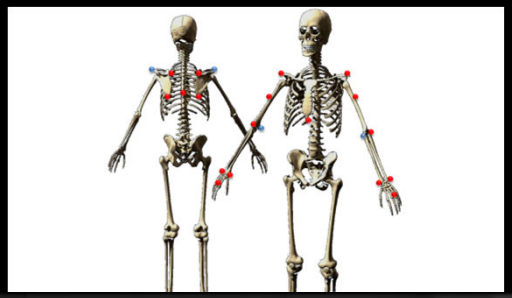
Vanessa Vargas Ferreira
Helga Tatiana Tucci
Jerusa Lara



3D Modeling of a Pass Motion in Wheelchair Rugby

Marker Tracking System– D V i d e o

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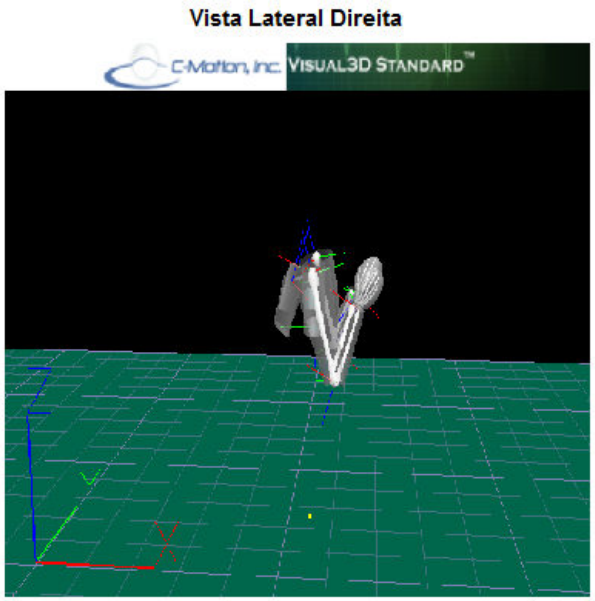
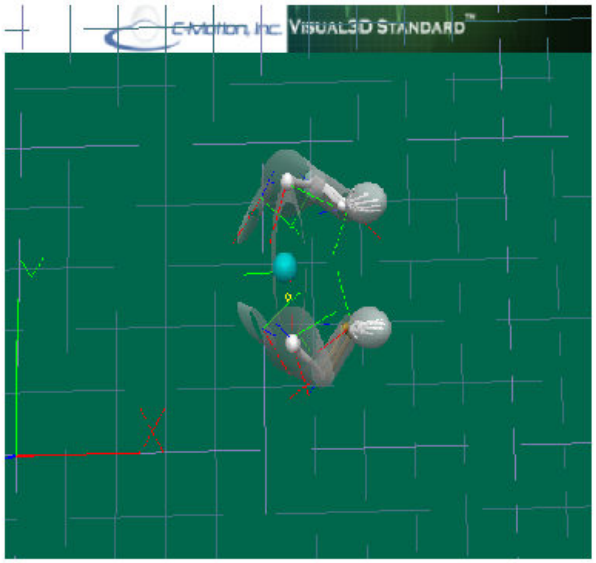
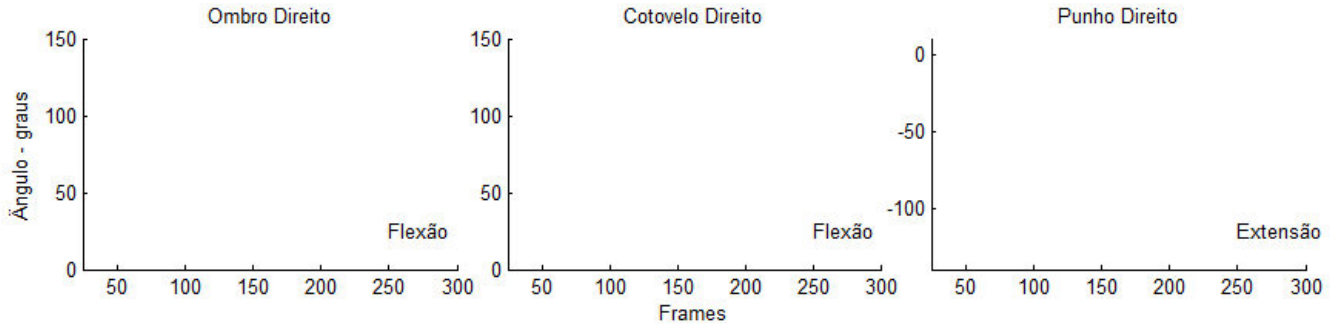
Results

Lateral View

Superior View







R-Shoulder R-Elbow R-Wrist

Tracking Systems: Advances

- Inprovement in temporal and spatial resolution compared to previous methods
- Acceptable accuracy in the measurement of distances covered and velocities
- Simultaneous capture and analysis of both teams
- Integrated analysis of physical, technical and tactical performance
- Results of great interest for academic and applied studies
- Analysis during real competitions.

Tracking systems for athlete/coach feedback

Summary of current trends

- Low cost sensors
- Broadcast TV analysis
- Volume reconstruction, modeling and simulation
- Markerless motion analysis

Conclusion

Tracking systems for Olympic sports such as tennis, handball, hockey, soccer among others have been proposed and successfully used.

In Paralympic sports, just a few sport specific studies were found in the literature.

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Faculty of Physical Education
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ricardo@fef.unicamp.br

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Felipe Moura., Ph.D.

Quantitative analysis of Brazilian football players' organisation on the pitch. Sports biomechanics, v. 11, p. 85-96, 2012.

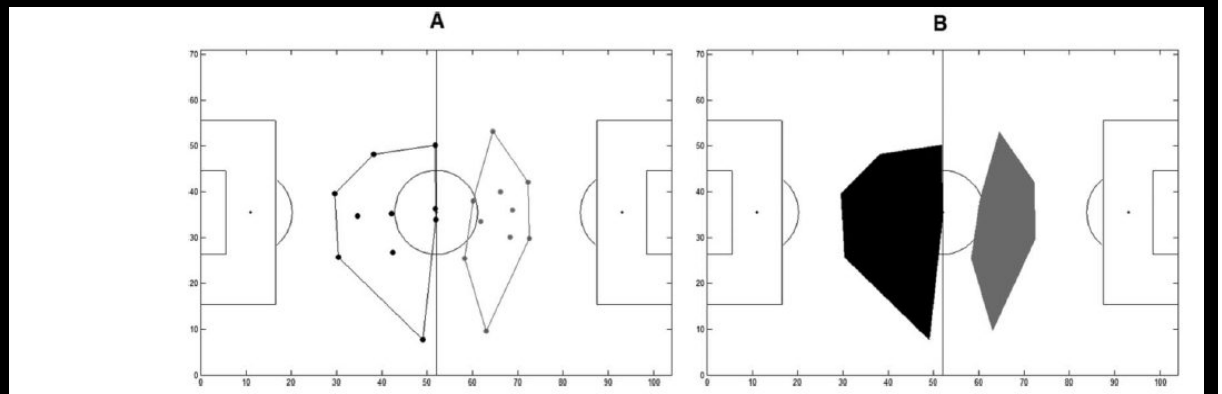

Figure 2. Teams convex hulls (A) and the representation of the surface areas (B).

A spectral analysis of team dynamics and tactics in Brazilian football. J. Sport Sciences, 2013

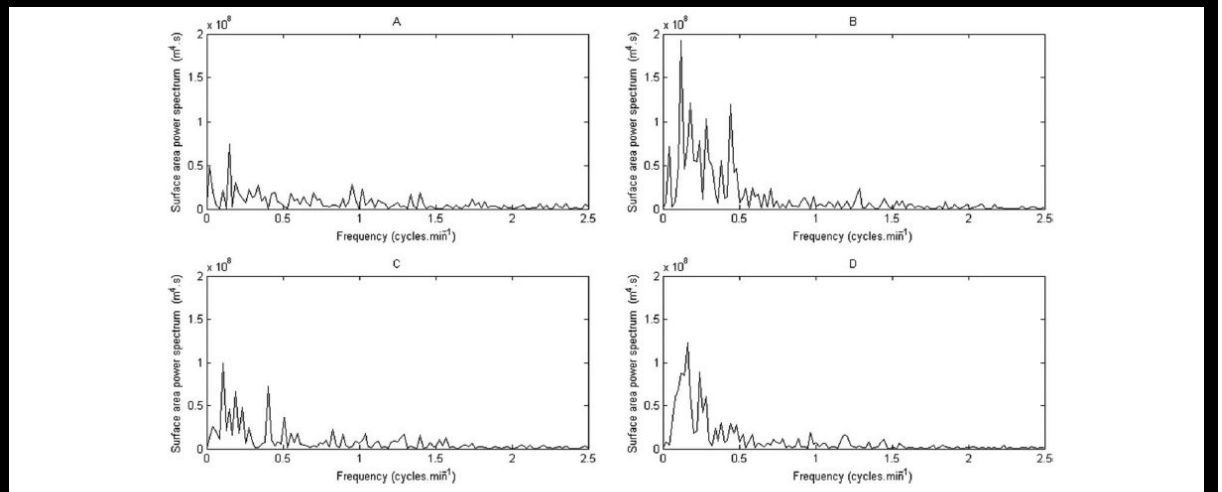

Figure 5. Results of the spectral analysis for the surface area time series of *tm3* (A – 1st half; B – 2nd half) and *tm4* (C – 1st half; D – 2nd half).

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DELLAL, Alexandre ; CHAMARI, Karim ; Wong, Del P. ; Ahmaidi, Said ; KELLER, Dominique ; **Barros, Ricardo M. L.** ; BISCIOTTI, Gian. N. ; CARLING, Christopher . Comparison of physical and technical performance in European soccer match-play: FA Premier League and LIGA. European Journal of Sport Science (Print), v. 11, p. 51-59, 2011.

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Tracking system: The human body modeled as a system of articulated bodies

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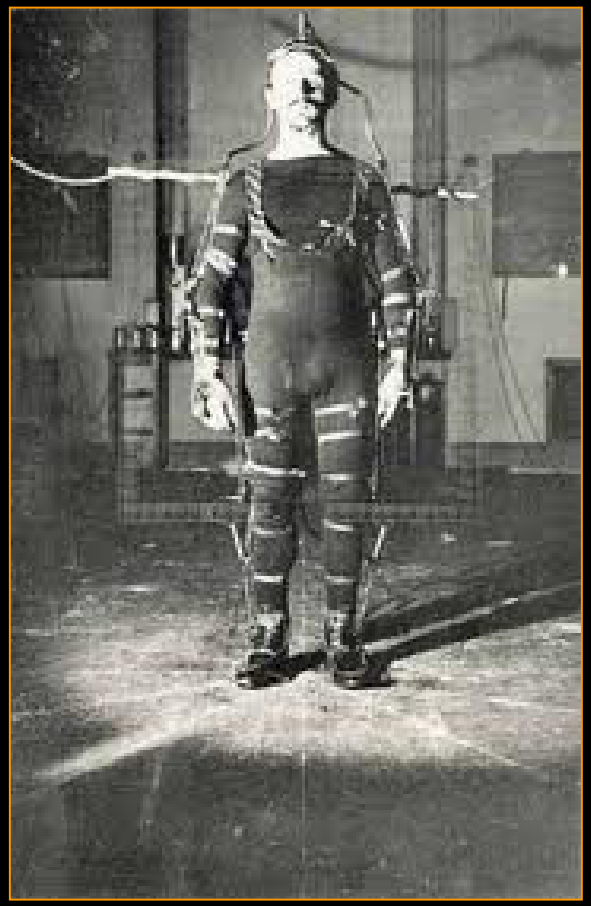
Evolution of the use of markers

Braune (1831-1892) & Fisher (1861-1917)



Nowadays

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Reconstrução de superfície e volume

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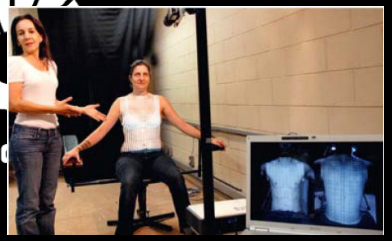
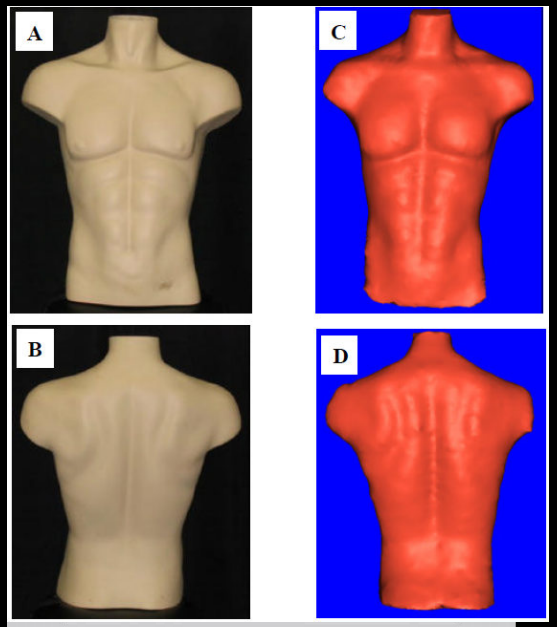
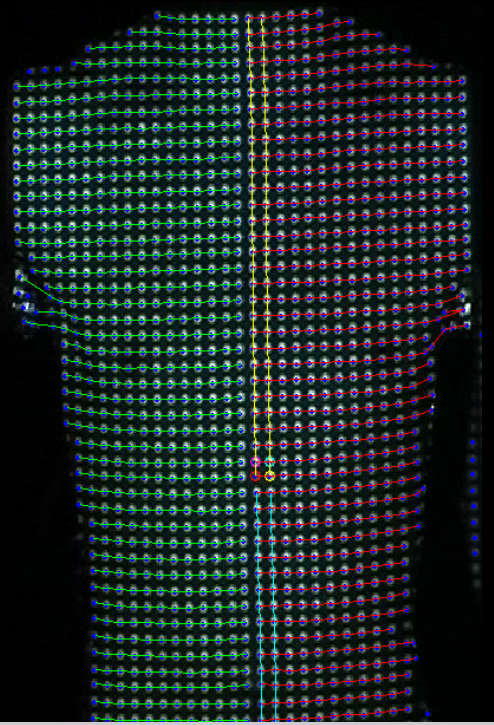
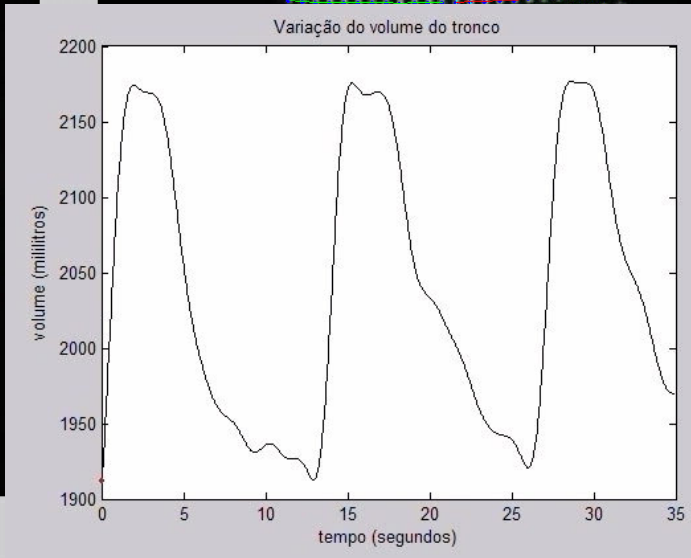


Angélica Lodovico .
Mestrado, 2006

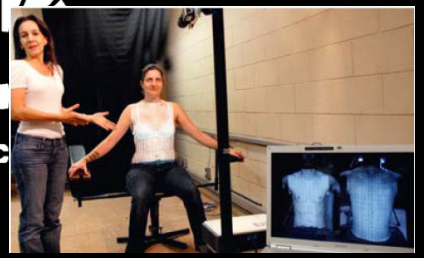
METODOLOGIA PARA DETERMINAÇÃO DOS VOLUMES DO TRONCO DURANTE A RESPIRAÇÃO.
2006.







3. Reconstrução e análise de superfícies e volumes do corpo

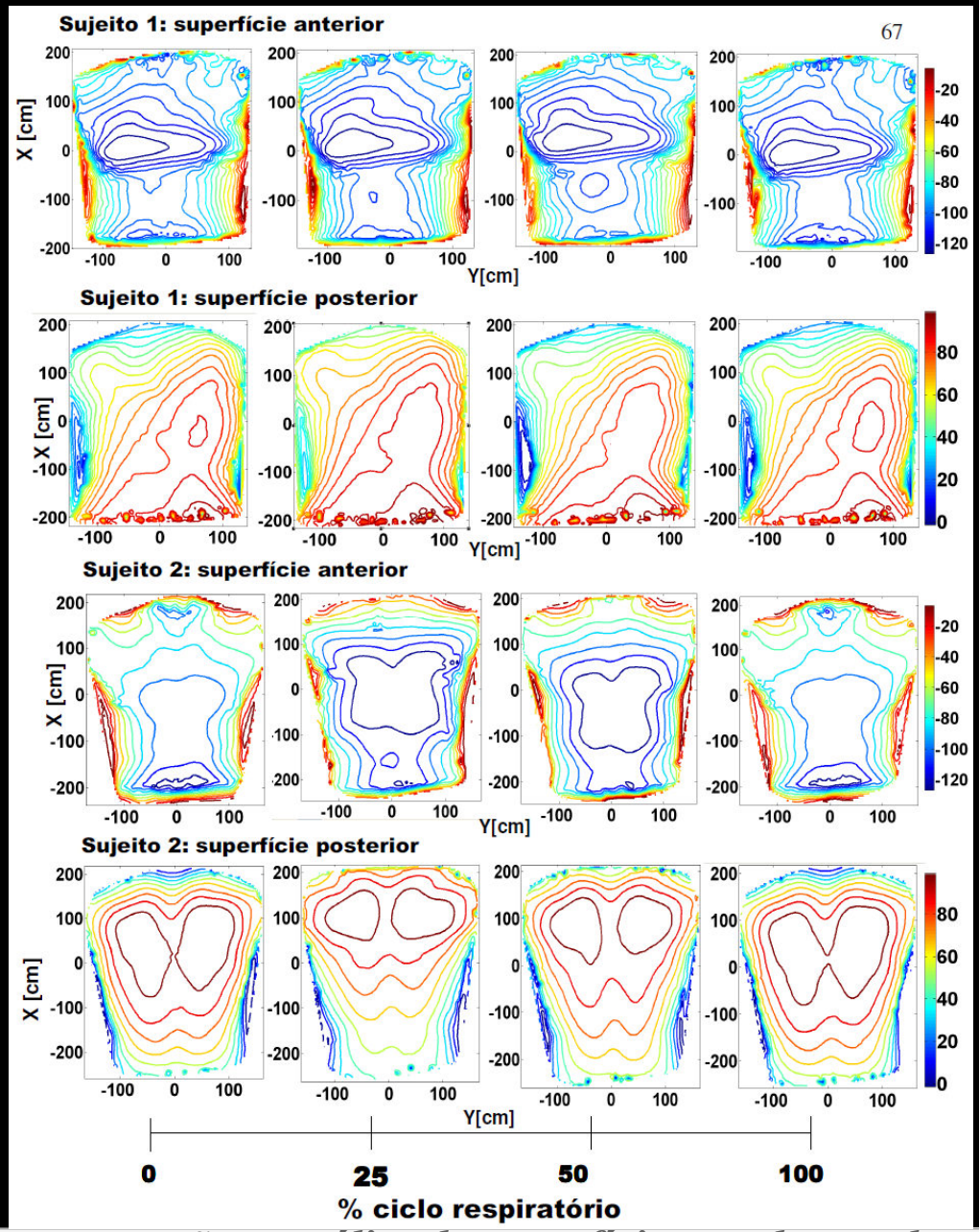


Angélica Lodovico.
Doutorado, 2011

PROPOSIÇÃO E AVALIAÇÃO DE UM MÉTODO BASEADO EM PROJEÇÃO DE LUZ PARA RECONSTRUÇÃO E ANÁLISE DA SUPERFÍCIE DO TRONCO DURANTE A RESPIRAÇÃO.

A novel video-based method using projected light to measure trunk volumes during respiration. Computer Methods in Biomechanics and Biomedical Engineering. First published on 01 December 2010.

Patente depositada.



3. Reconstrução e análise de superfícies e volumes do corpo

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Modelagem

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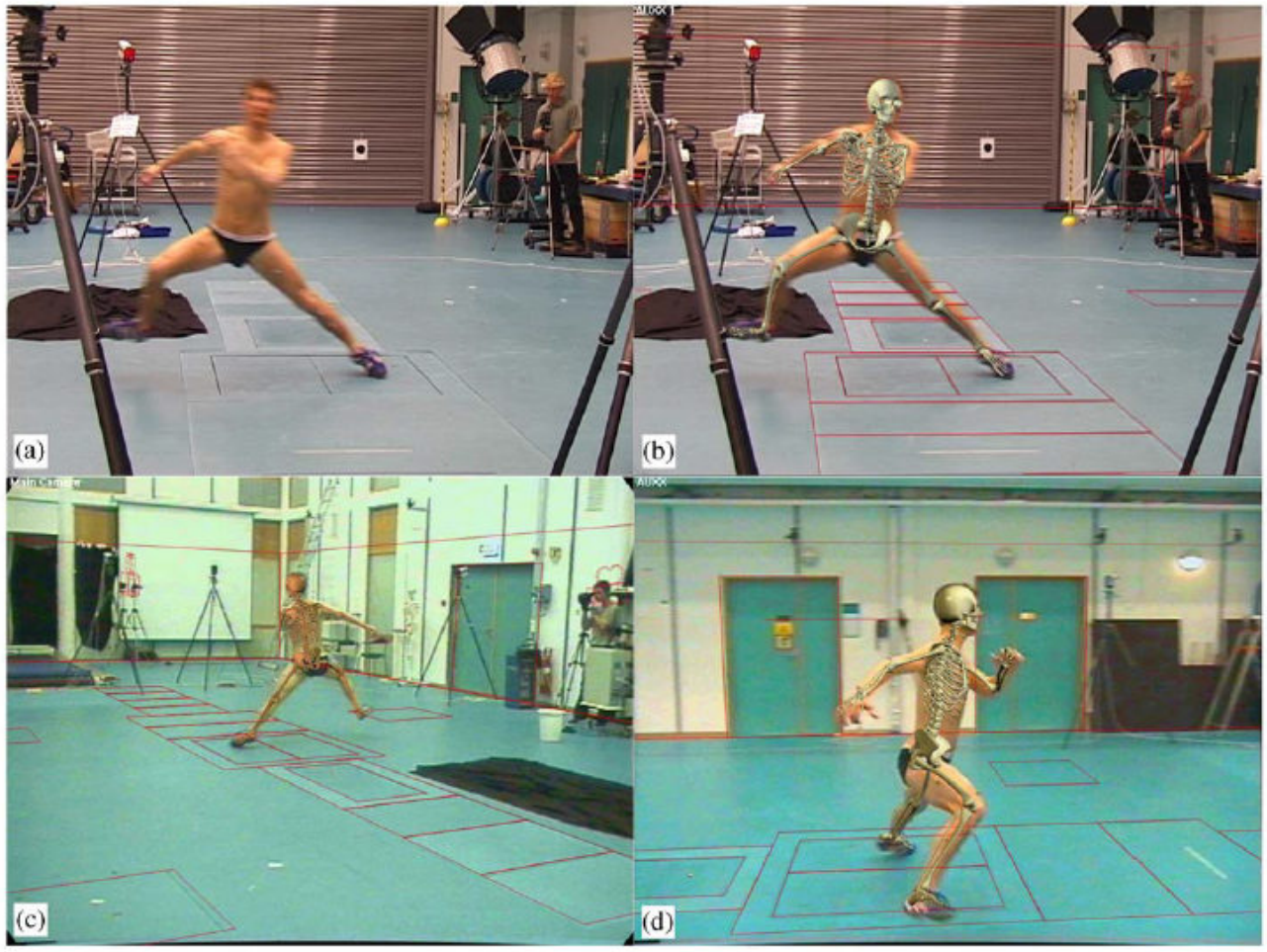
A model-based image-matching technique for three-dimensional reconstruction of human motion from uncalibrated video sequences

Tron Krosshaug*, Roald Bahr

Oslo Sports Trauma Research Center, University of Sport & Physical Education, PO Box 4014, Ullevaal Stadion, 0806, Oslo, Norway

Accepted 27 April 2004

T. Krosshaug, R. Bahr / Journal of Biomechanics 38 (2005) 919–929



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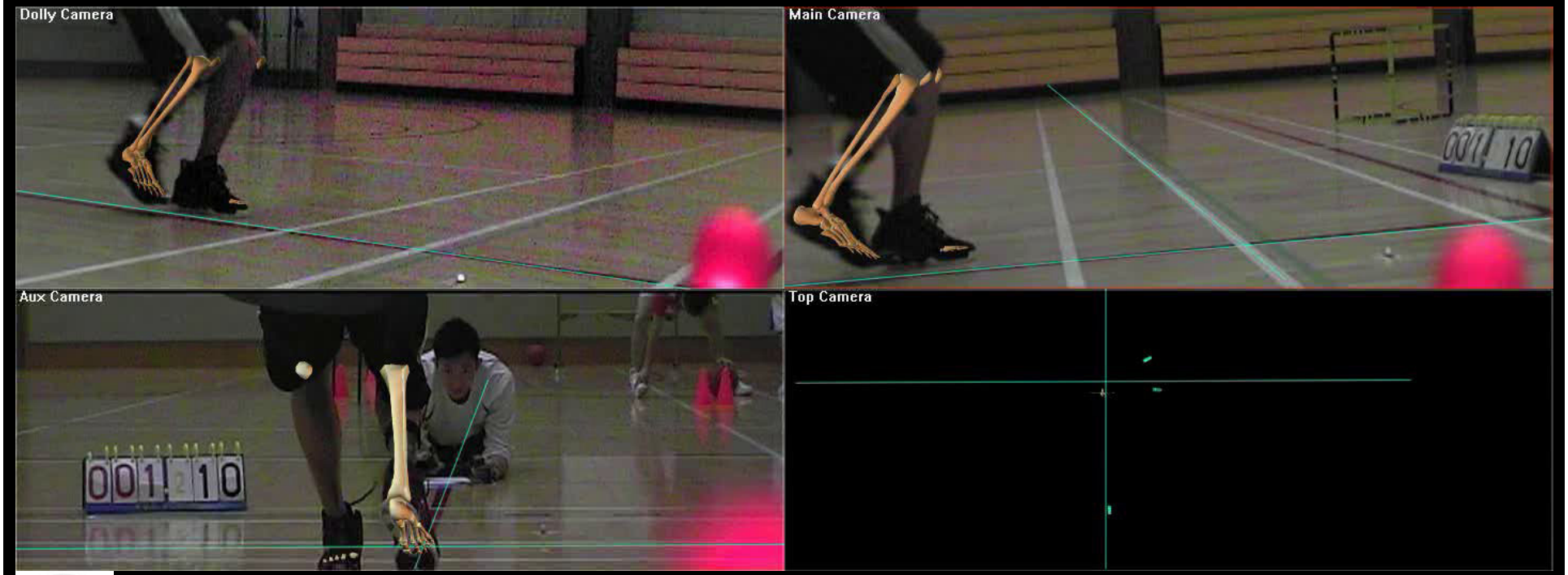
Biomechanics of Supination Ankle Sprain

A Case Report of an Accidental Injury Event in the Laboratory

Daniel Tik-Pui Fong,*† PhD, Youlian Hong,‡§ PhD, Yosuke Shima,‖ MD, Tron Krosshaug,‖ PhD, Patrick Shu-Hang Yung,*† FRCS Ed (Orth), and Kai-Ming Chan*†, FRCS Ed (Orth)



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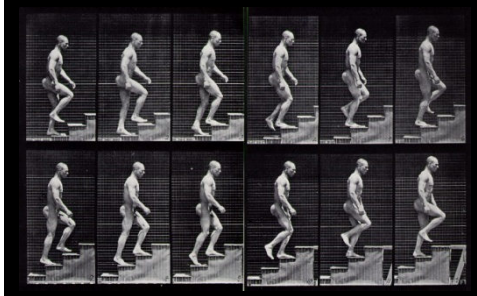
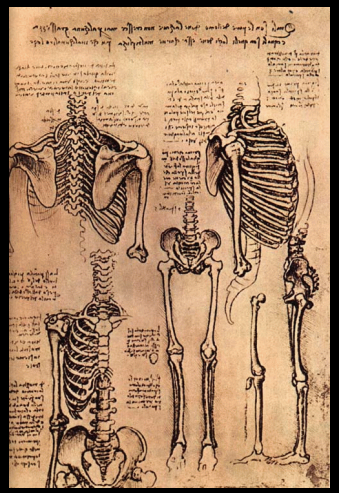
Métodos

A contribuição da biomecânica depende da aplicabilidade de seus modelos de representação da realidade e métodos de investigação.

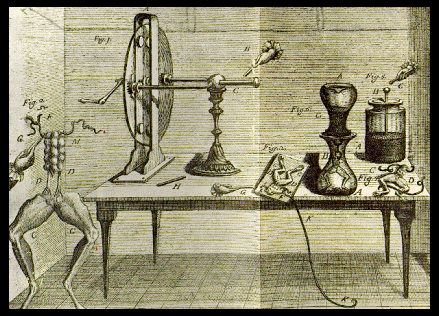
Cinemetria ⇩



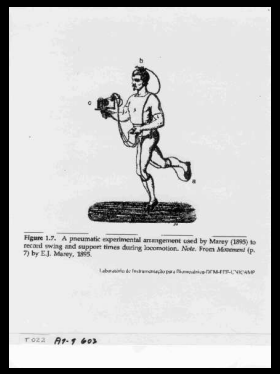
Antropometria ⇩



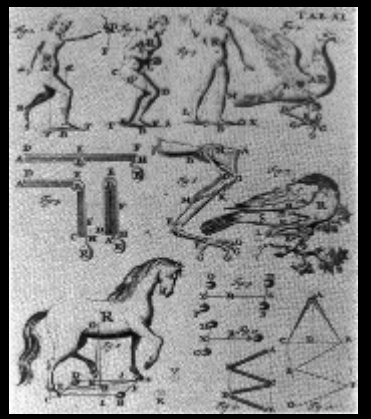
EMG ⇩



Dinamometria ⇩



Modelagem ⇩



Como atua a biomecânica

Contexto das análises

- Análises em laboratório
- Análises em situação real de competição
- Dados biomecânicos auxiliando as fases de planejamento / treinamento / competição
- Dados de interesse do público, arbitragem, imprensa e outros agentes

Aplicações das análises

- Análise individual de atletas/praticantes
- Análise de equipes
- Análise de competições

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Summary

I. Data Collection
   - From time motion to automatic tracking
   - Sensors x Images

II. Data Analysis/Interpretation
   - Physical, technical and tactical aspects

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Objetivos

Avaliação e/ou melhoria da performance esportiva

- Diretamente para um atleta pela otimização da sua performance
- Indiretamente por meio do acúmulo de conhecimentos

Compreensão dos benefícios do esporte para o atleta/praticante e seus mecanismos

Compreensão das alterações provocadas pela lesão/patologia

Prevenção de lesões

Desenvolvimento metodológico no esporte paralímpico

Desafios ao relacionamento entre as Universidades, Confederações e Comitês Olímpico e Paralímpico

Pesquisa básica, aplicada e metodológica
=>Prestação de Serviços

Rigor acadêmico

Excelência

Continuidade

Institucionalização

Articulação

Planejamento

Financiamento