



**USING INERTIA MEASUREMENT UNIT (IMU)  
FOR EXERCISE ANALYSIS.**

BORIS JIDOVTSSEFF<sup>1</sup> · OLIVIER BRULS<sup>1</sup> · FRANÇOIS TUBEZ<sup>1</sup> ·  
LAETITIA MONFORT<sup>1</sup> · NIGEL HARRIS<sup>2</sup> · JOHN B. CRONIN<sup>2</sup>

<sup>1</sup>UNIVERSITY OF LIEGE, BELGIUM  
<sup>2</sup>AUCKLAND UNIVERSITY OF TECHNOLOGY, NEW-ZEALAND






28th - 30th October 2010, Bratislava, Slovakia

IMU & EXERCISE ANALYSIS (Jidovtseff et al.)

## INTRODUCTION

- **Accelerometry**
  - Widely used in sport science
  - Measure physical activity (estimation of energy expenditure)
  - Motion analysis (gait, running, vertical jumps)
    - ▶ Locometrix => Gait and running
    - ▶ Myotest => resistance exercises (squat and bench press), vertical jumps, running
  - 3D accelerometer BUT no gyro
  - Impossible to analyse movement in 3D

28th - 30th October 2010, Bratislava, Slovakia

## INTRODUCTION

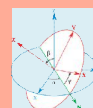
### ● Inertia measurement unit (IMU)

- 3D accelerometer
- 3D Gyro
- Wireless technology

Vertical Acc (Az)  
Horizontal Acc (Ax)  
Lateral Acc (Ay)



- Theoretically => 3D exercise analysis in the field and weight -room based environment



- Relatively untested !

↪ Aim of the study : Investigate relevance of IMU system in exercise analysis

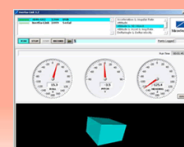


28th - 30th October 2010, Bratislava, Slovakia

IMU & EXERCISE ANALYSIS (Jidovtseff et al.)

## METHODS

- IMU = Inertia link (Microstrain, USA)
- Triaxial accelerometer (range :  $\pm 5g$ )
- Triaxial gyro (range :  $\pm 300^\circ/\text{sec}$ )
- Wireless (range :  $\pm 70\text{m}$ )
- Recording frequency = 100hz
- Attached on an elastic belt in the back (close CM)
- Data recorded with Microstrain software and analysed with Labview



28th - 30th October 2010, Bratislava, Slovakia



IMU & EXERCISE ANALYSIS (Jidovtseff et al.)

## METHODS

● Signal analysis

➔ Customized Exercises Labview Applications

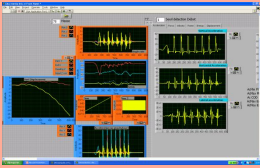

● Common part : orientation matrix

$$M = \begin{bmatrix} \cos(\psi) \cos(\theta) & \sin(\psi) \cos(\theta) & -\sin(\theta) \\ \cos(\psi) \sin(\theta) \sin(\phi) - \sin(\psi) \cos(\phi) & \sin(\psi) \sin(\theta) \sin(\phi) + \cos(\psi) \cos(\phi) & \cos(\theta) \sin(\phi) \\ \cos(\psi) \sin(\theta) \cos(\phi) + \sin(\psi) \sin(\phi) & \sin(\psi) \sin(\theta) \cos(\phi) - \cos(\psi) \sin(\phi) & \cos(\theta) \cos(\phi) \end{bmatrix}$$



where Pitch =  $\theta$ , Roll =  $\phi$ , Yaw =  $\psi$

● Specific part adapted to exercise specifications

- Split exercises in differents phases
- Quantify parameters of interest

- Vertical Acc (z)
- Lateral Acc (y)
- Horizontal Acc (x)





28th - 30th October 2010, Bratislava, Slovakia



IMU & EXERCISE ANALYSIS (Jidovtseff et al.)

## METHODS

- 16 healthy male subjects (22±3yr ; 1.76±0.12m ; 72±13kg)
- 2 identical sessions 1 week apart



Tests	Trials Nb	
	Familiarization	Test
VERTICAL JUMPS	SJ	3
	CMJ	3
	DJ (30 cm)	3
	6CJ	2
HORIZONTAL JUMPS	SBJ	3
	5AB	2
	5Hops (left+right)	2+2
Sprint (20m)		2
Change of direction	QCD (left+right)	2+2
	DCD (left+right)	2+2



28th - 30th October 2010, Bratislava, Slovakia

*IMU & EXERCISE ANALYSIS (Jidovtseff et al.)*

# METHODS

## Three investigations

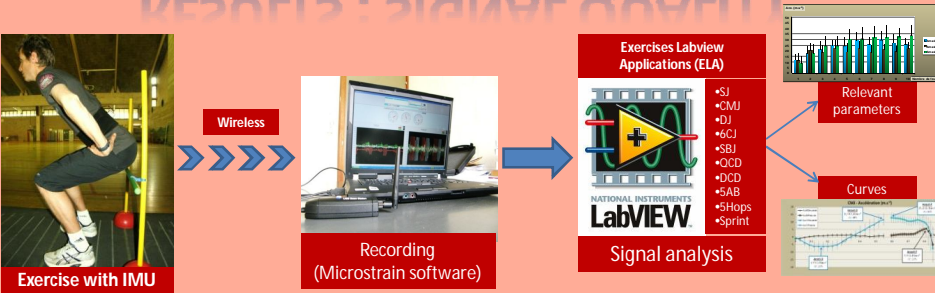
1. Signal quality
2. Ability of IMU to analyse exercise
3. Inter-session reliability

28th - 30th October 2010, Bratislava, Slovakia

*IMU & EXERCISE ANALYSIS (Jidovtseff et al.)*

# RESULTS : SIGNAL QUALITY



The flowchart illustrates the process: **Exercise with IMU** (a person performing a squat) is connected via **Wireless** transmission to **Recording (Microtrain software)** (a laptop displaying data). This leads to **Signal analysis** using **Exercises Labview Applications (ELA)** (a LabVIEW interface). The analysis produces **Relevant parameters** (a bar chart) and **Curves** (a line graph).



LIMITS & TROUBLES

100hz is not enough...

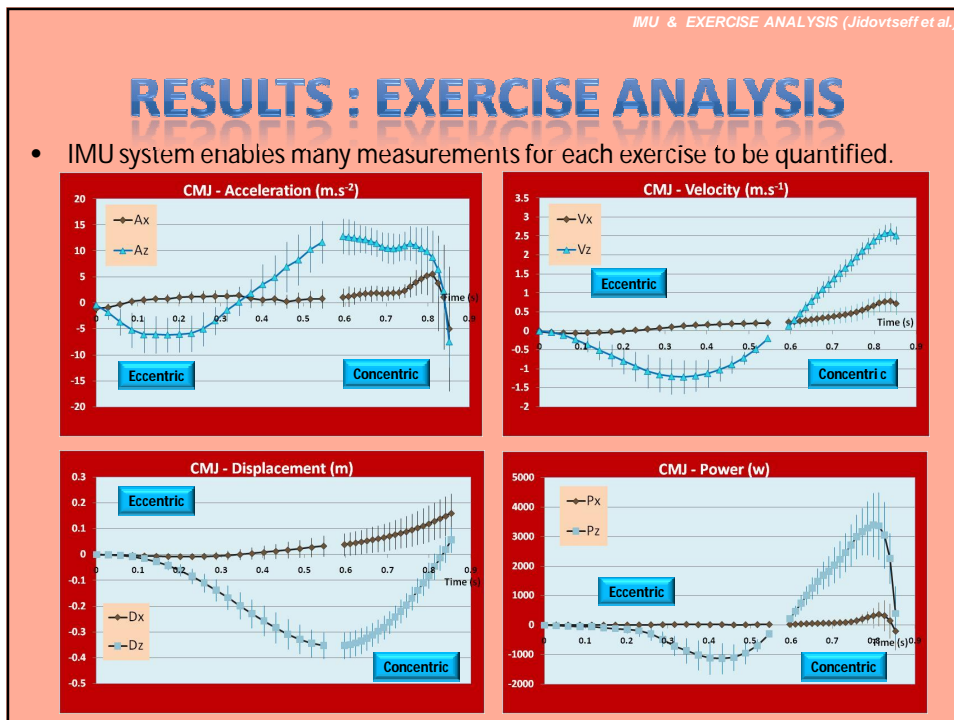
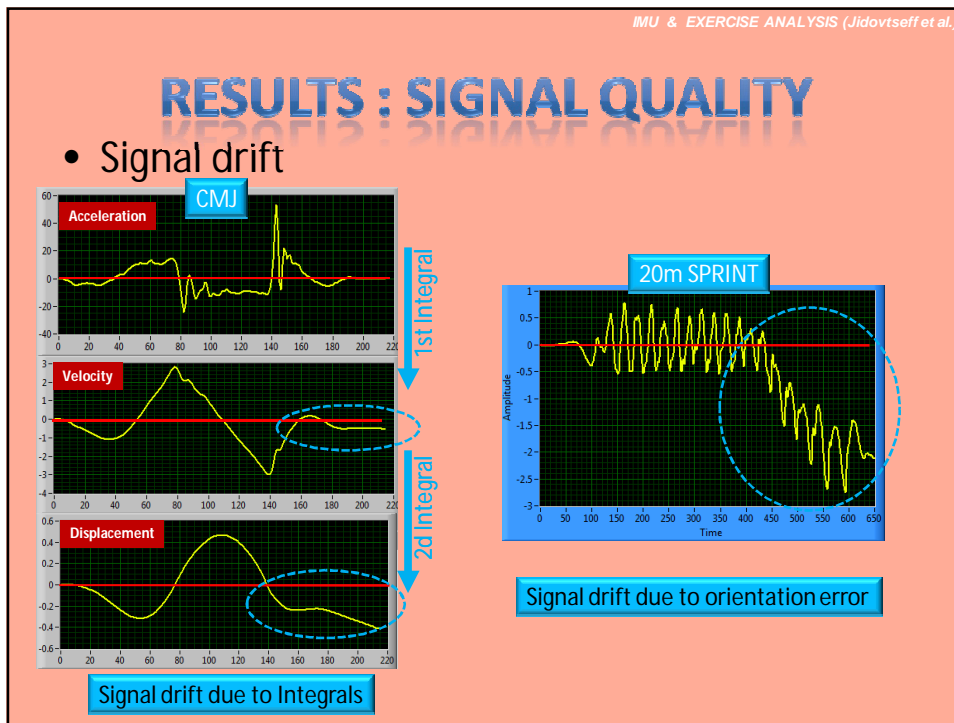
Antenna position

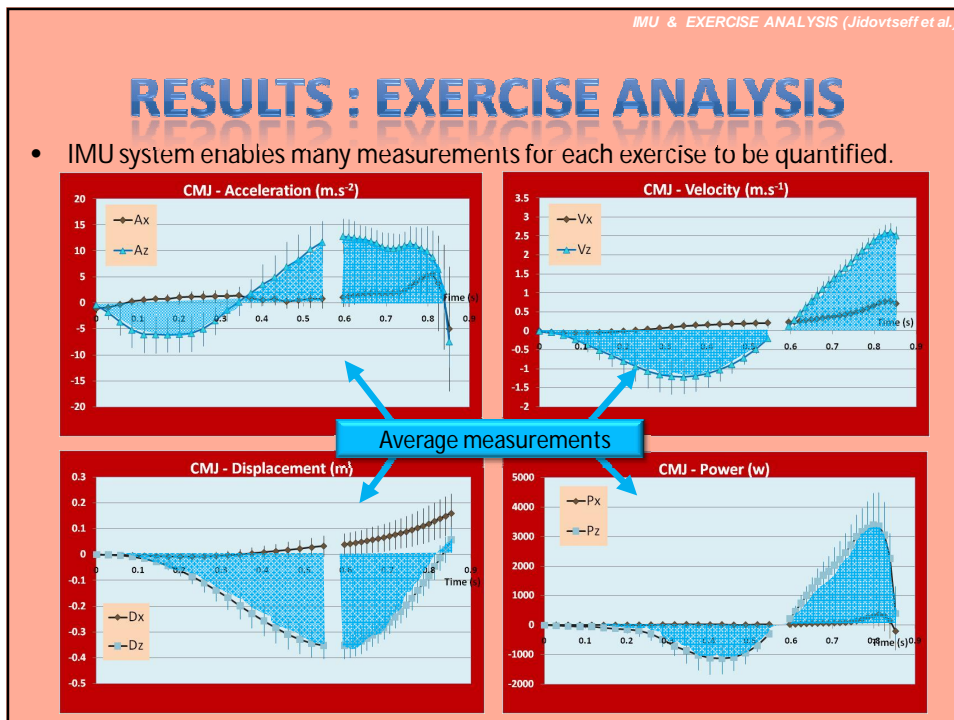
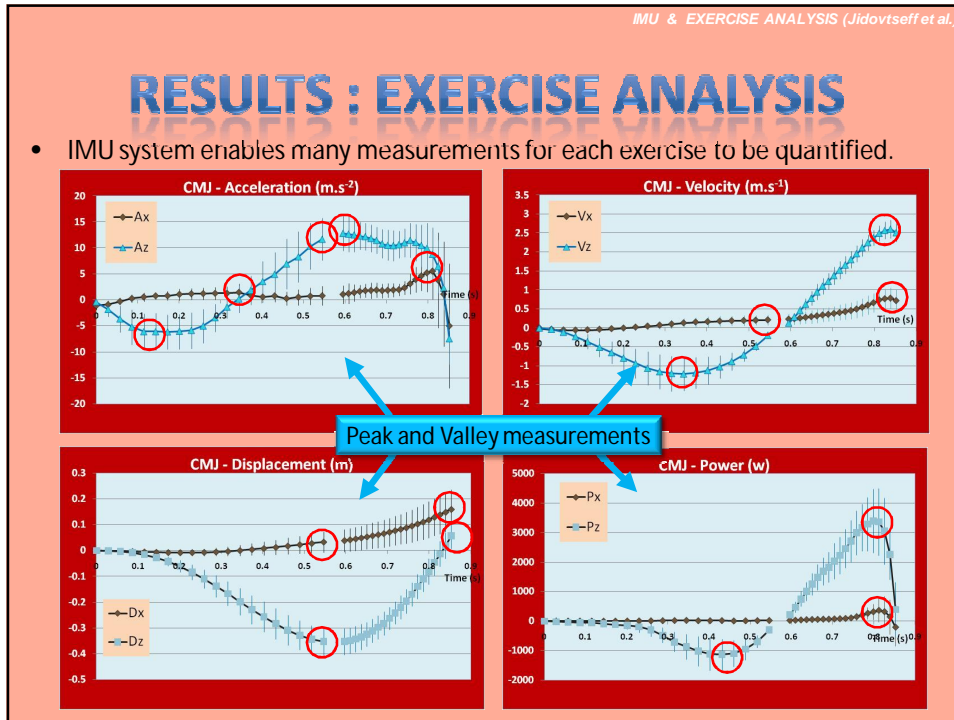
Laptop performance

} **Influence wireless transmission & could favour data lost**

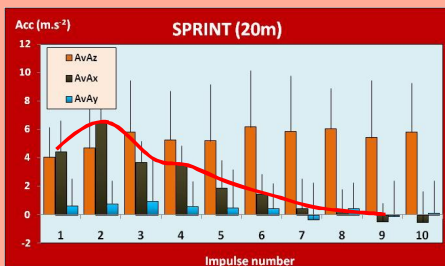
28th - 30th October 2010, Bratislava, Slovakia



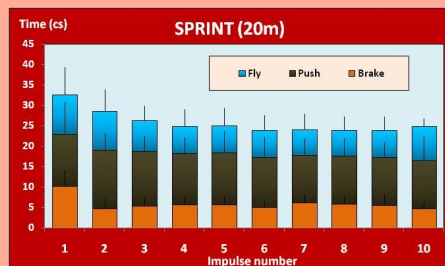


# RESULTS : EXERCISE ANALYSIS

- For multi-jump (5AB, 5hops, 6CJ) and Sprint exercises
- Analyse impulse by impulse

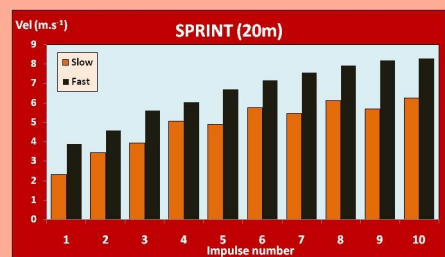


IMU is able to analyse variation in horizontal acceleration during SPRINT

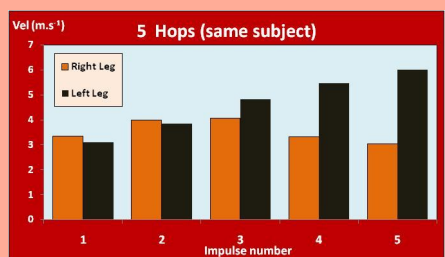


IMU is able to measure time variation of different phases during SPRINT

# RESULTS : EXERCISE ANALYSIS



Investigate differences between subjects



Investigate lower limbs imbalance



28th - 30th October 2010, Bratislava, Slovakia

## RESULTS : RELIABILITY

- Reliability is inconsistent
  - **Good to Acceptable** ( $CV < 20\%$ )
    - Exercise and phases duration,
    - Impulse frequency
    - Velocity in the main axis
  - **Moderate to weak** ( $6\% < CV < 97\%$ )
    - Acceleration
    - Power
    - Displacement

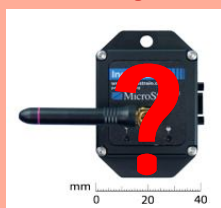


icst2010

28th - 30th October 2010, Bratislava, Slovakia

## CONCLUSION

### IMU



- Many perspectives for IMU in exercise analysis
- Fairly cheap, very light, field utilization
- Afford 3D exercise analysis
- Signal quality and reliability are insufficient

=> Technological improvements are still needed



icst2010

28th - 30th October 2010, Bratislava, Slovakia



*IMU & EXERCISE ANALYSIS (Jidovtseff et al.)*



**THANK YOU FOR ATTENTION**

*b.jidovtseff@ulg.ac.be*



**icst2010**

**28th - 30th October 2010. Bratislava. Slovakia**