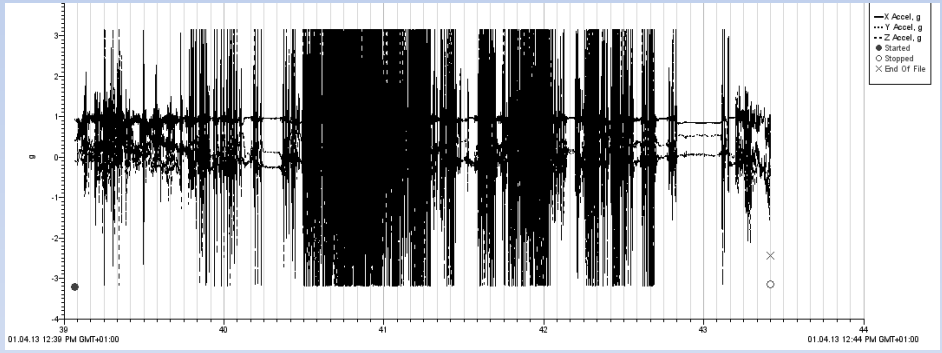
USAGE OF TRI-AXIAL ACCELERATION OF THE HIND LEG FOR RECOGNIZING SHEEP BEHAVIOR



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Skopje, R. Macedonia

Varieties of hind leg position and locomotion:

POSTURE

LAYING

STANDING

Varieties of hind leg position and locomotion:

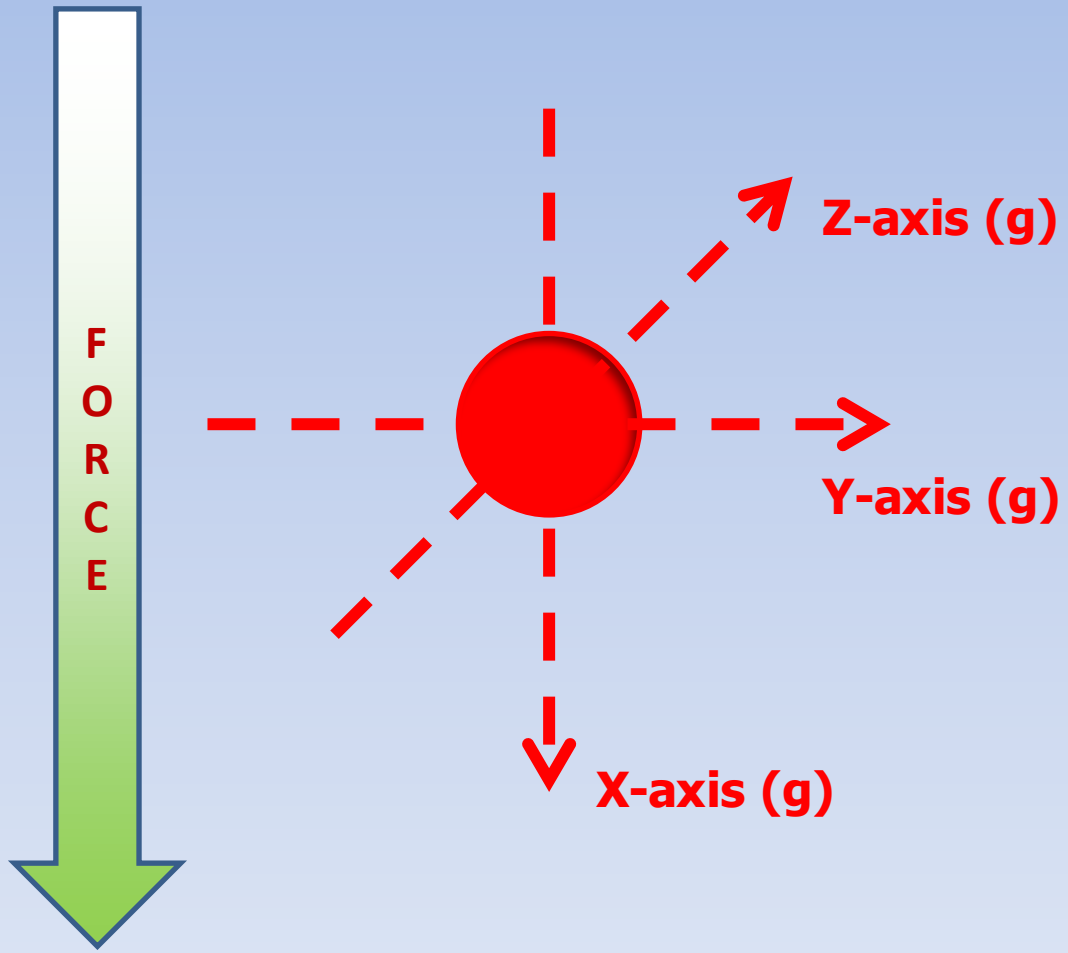
GAIT TYPES

WALKING

TROTTING

RUNNING

Tri-axial accelerometers – Operating principles



Axis acceleration equation:

$$x=\cos(180-x)$$

Sum vector acceleration:

Sum vector= $\sqrt{x^2+y^2+z^2}$

Accel erom eter

x=1g; y=0

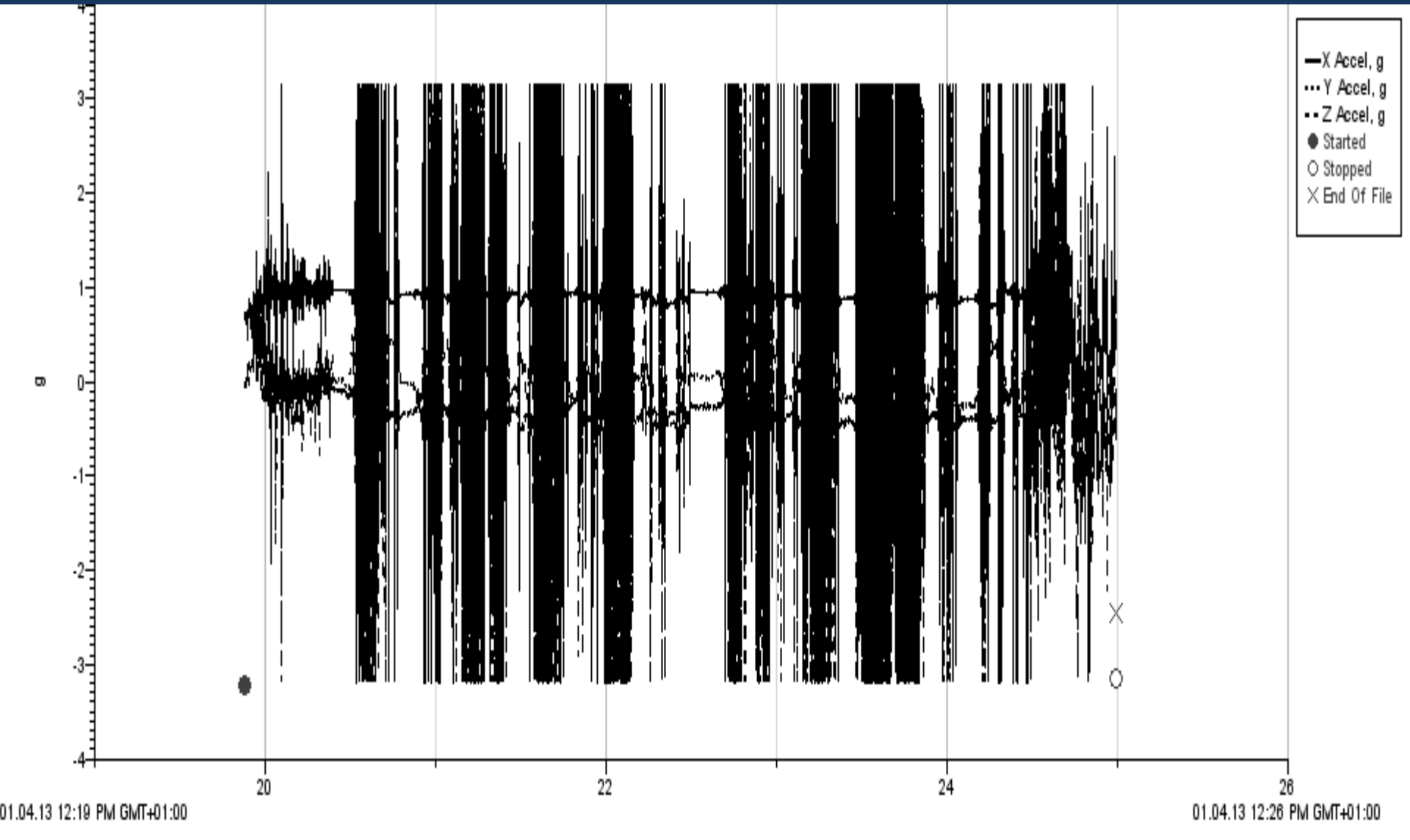
x=-1g; y=0

Accelerometer

x=0g; y=1

x=0g; y=-1

Attaching accelerometer on the animal:

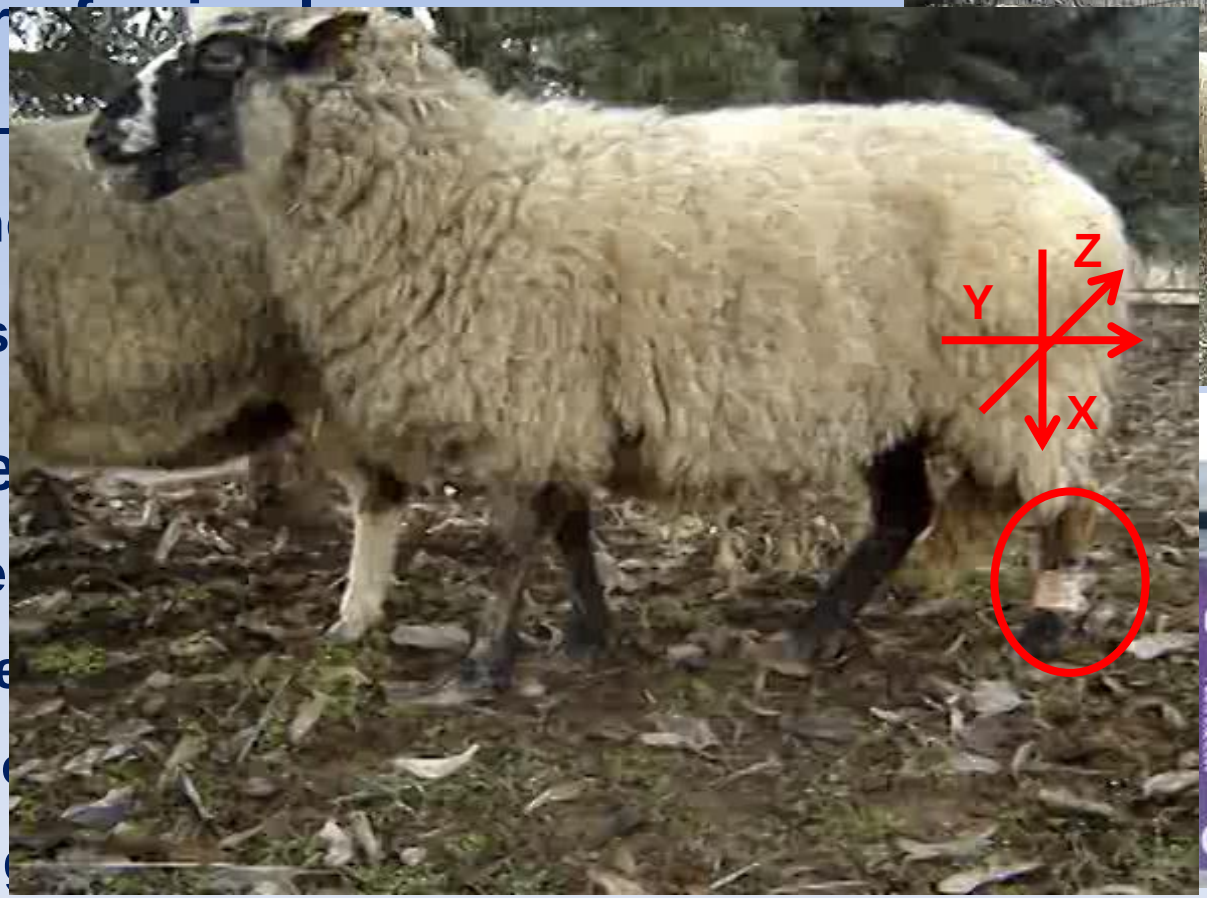


Objectives

- Interpretation of gathered data from the accelerometer attached on the hind leg of sheep
- Optimized method for discrimination of:
  - Posture (standing & lying)
  - Gait type (walking, trotting & running)
- Stride models and kinematic parameters for walking & running

Animals & Accelerometers

- **Number**
  - Standing –
  - Gait – 6 sh
  - Lying – 7 s
- **Accele**
  - HOBO Pe
  - Logger se
    - rec
    - log



0.03s(33Hz) ≈ 100 readings/3 seconds (max. duration of 10 min.)

Video & Software

- **Video recording:**

  SONY DSC – S90 camera 25 frames/ s

- **Software:**

  HOBOware Lite® 3.3.3– reading out logger data

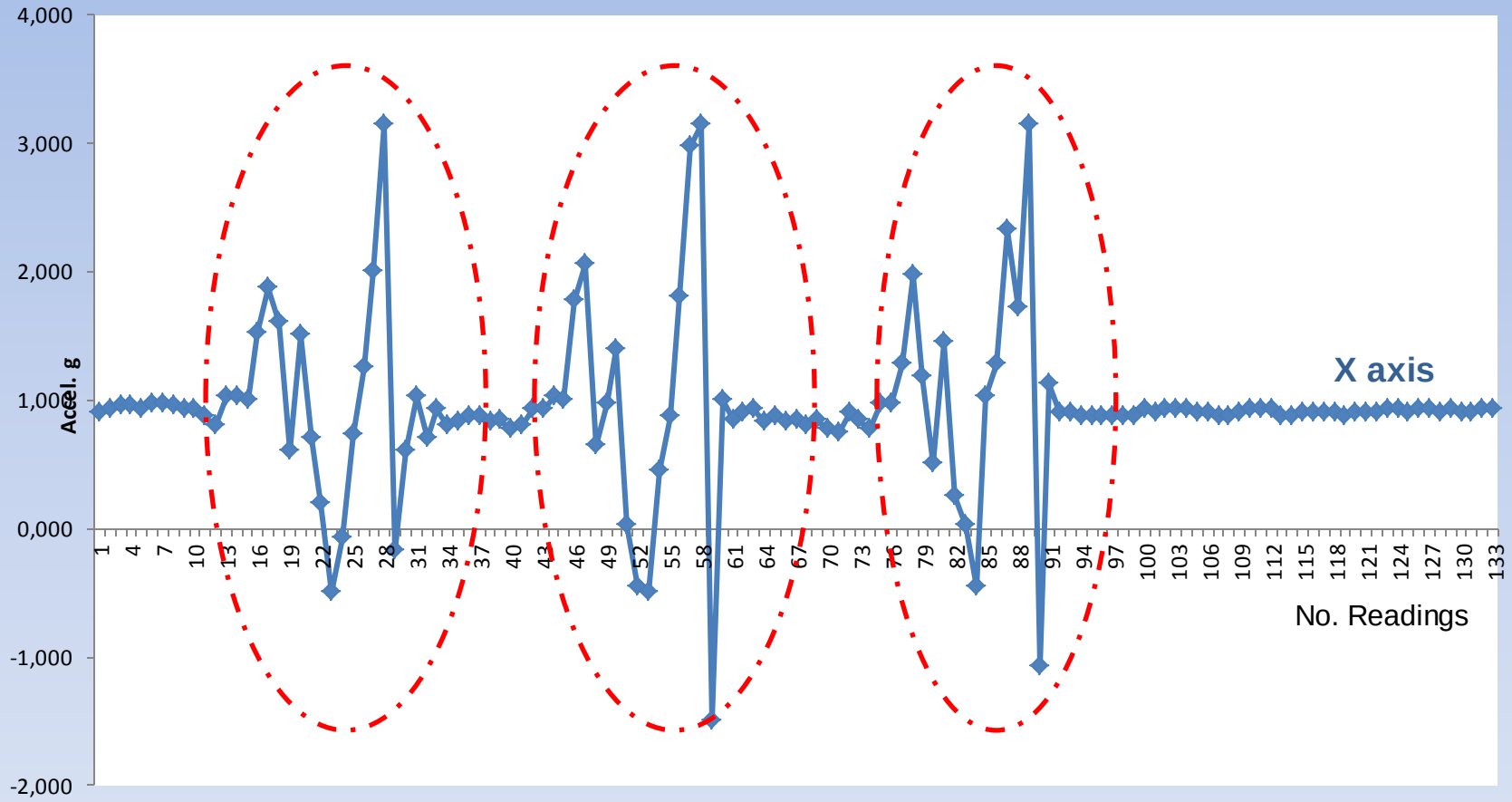
  Adobe Premiere Pro CS5.5 ® - video analysis

  MS Excel 2010 & STATISTICA 8.0 - data processing

Summary of gathered data

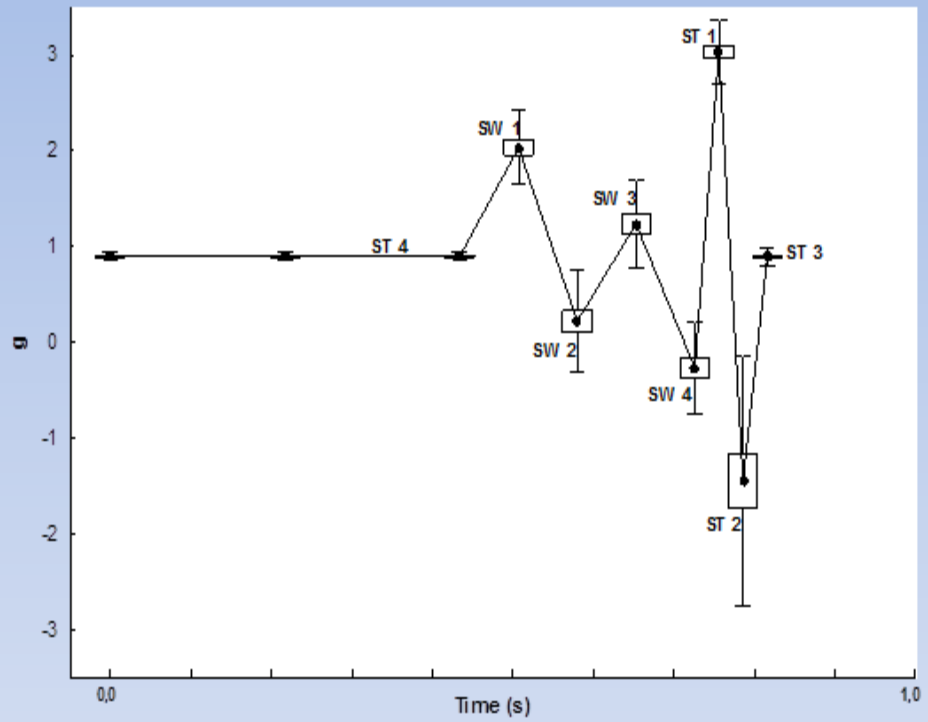
	Total time (s)	Acc. readings	No. of sequences	Mean ± SD time (s) /sequence
Lying	1,800	7,784	6	637.8 ± 511.8
Standing	268.9	8,872	6	44.8 ± 20.60
Walking	102.4	3,402	13	7.9 ± 5.9
Trotting	78.0	2,595	19	4.1 ± 1.39
Running	83.8	2,787	18	4.7 ± 3.78

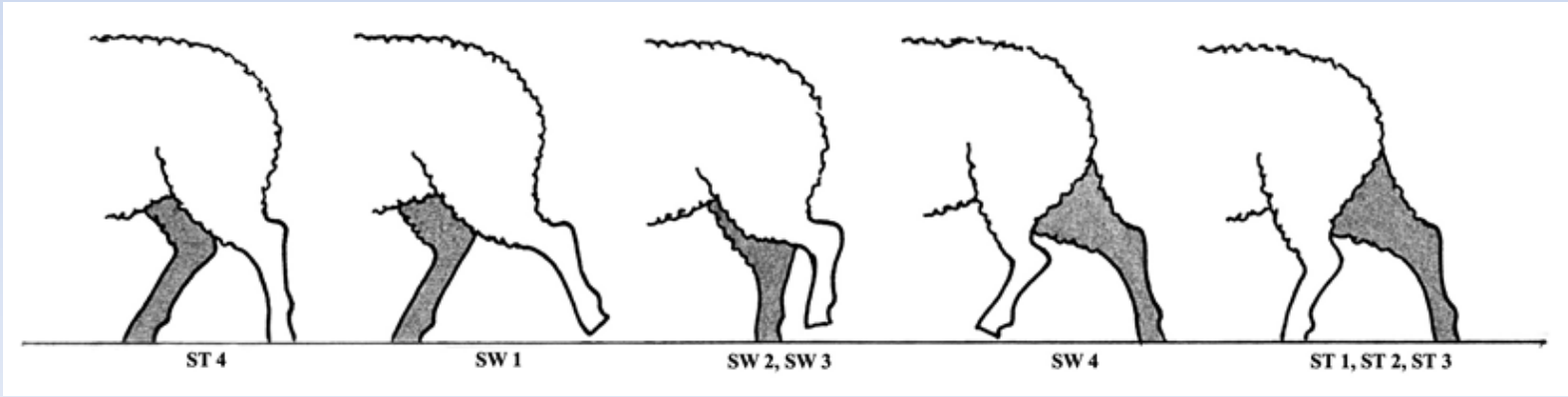
Single Stride analysis - WALKING



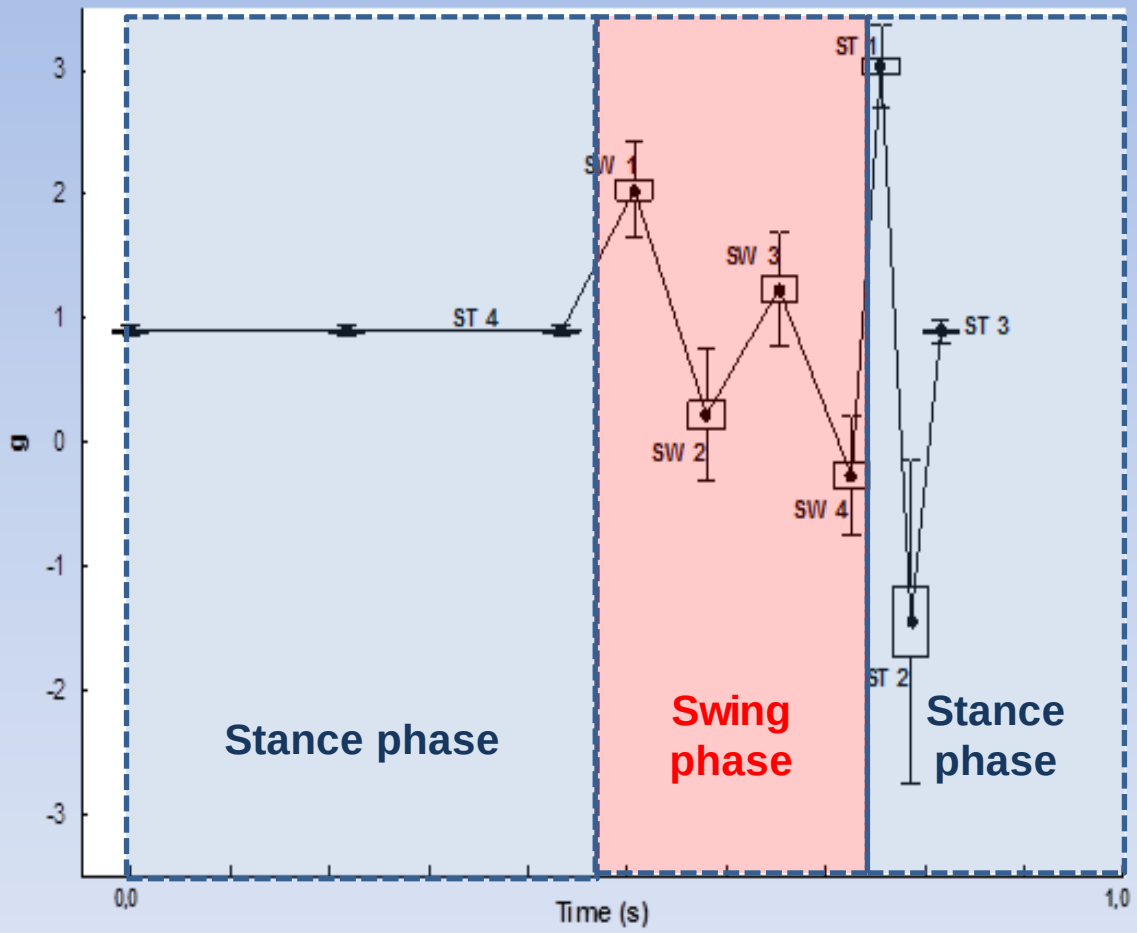
- 94 stride patterns on the vertical (x) axis
- 8 key acceleration points (KAP)

Single Stride analysis – WALKING
Stride Acceleration Model





Single Stride analysis – WALKING
Kinematic stride parameters



$$ST_{(tw)} = ST4_{(ts)} - SW4_{(ts-1)}; ST_{(tw)} = ST4_{(ts)} - (SW4_{(ts-1)} + 0.03) \text{ ,if } SW4_{(ts-1)} + 0.03 \neq ST1_{(ts-1)}$$

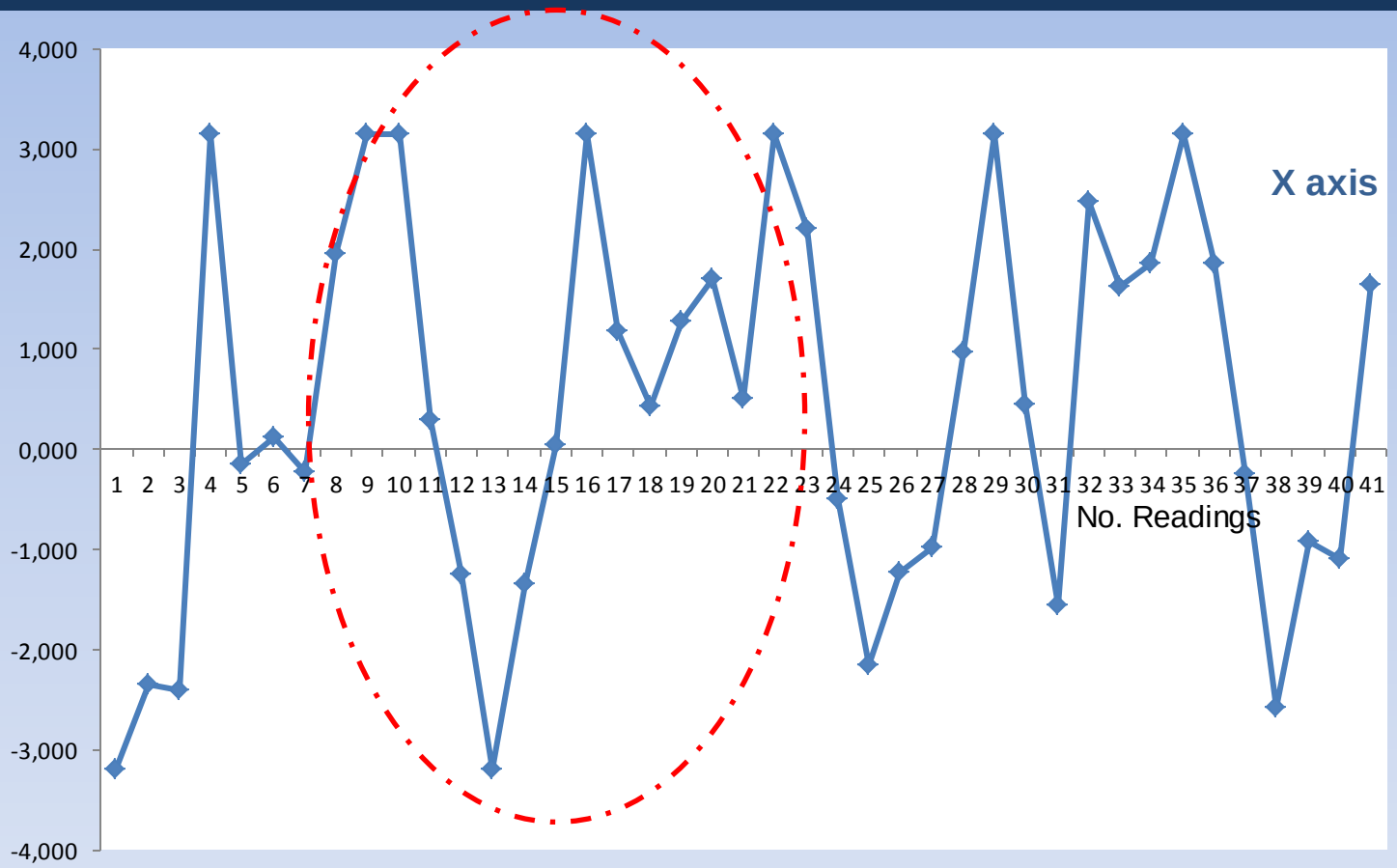
$$SW_{(tw)} = SW4_{(ts)} - ST4_{(ts)}; SW_{(tw)} = (SW4_{(ts)} + 0.03) - ST4_{(ts)} \text{ ,if } SW4_{(ts)} + 0.03 \neq ST1_{(ts)}$$

Single Stride analysis – WALKING
Kinematic stride parameters

	Walking			
	Total strides (n)	Mean ± SD	Range	CI 95%
Stance phase (s)	77	0.52 ± 0.17	0.24 – 1.20	0.48 – 0.56
Swing phase (s)	77	0.29 ± 0.06	0.18 – 0.45	0.28 – 0.31
Stride duration (s)	77	0.81 ± 0.19	0.42 – 1.53	0.77 – 0.86
Duty factor (%)	77	63.30 ± 6.98	44.44 – 80.00	61.71 – 64.88

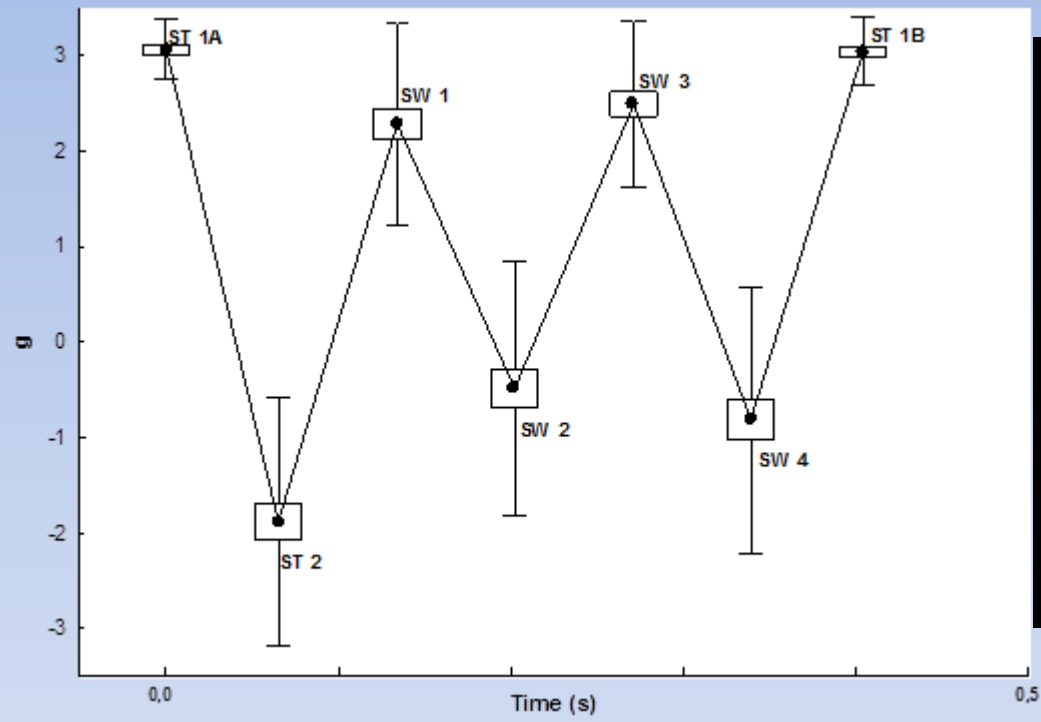
- **% error of number of strides comparing with the video of 2%(7% - 33%)**

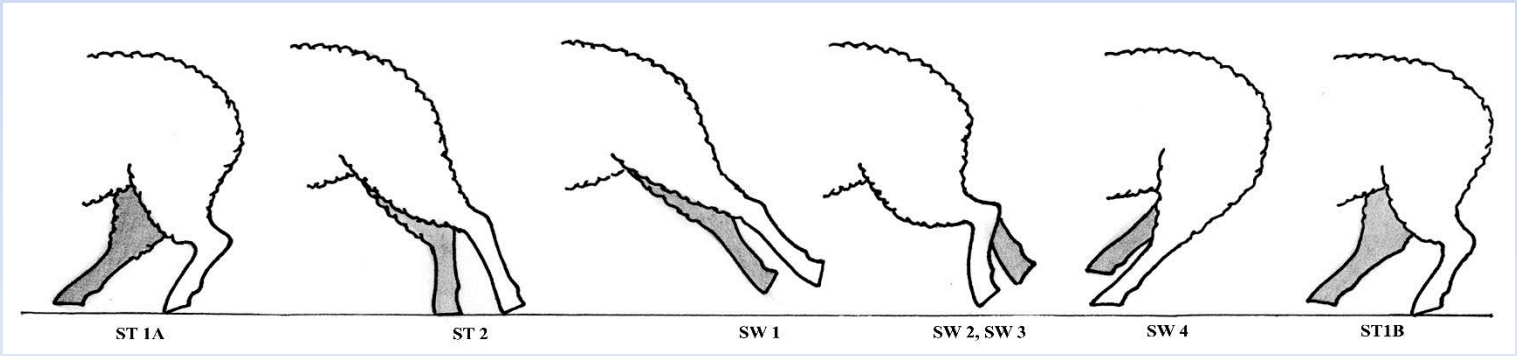
Single Stride analysis - RUNNING



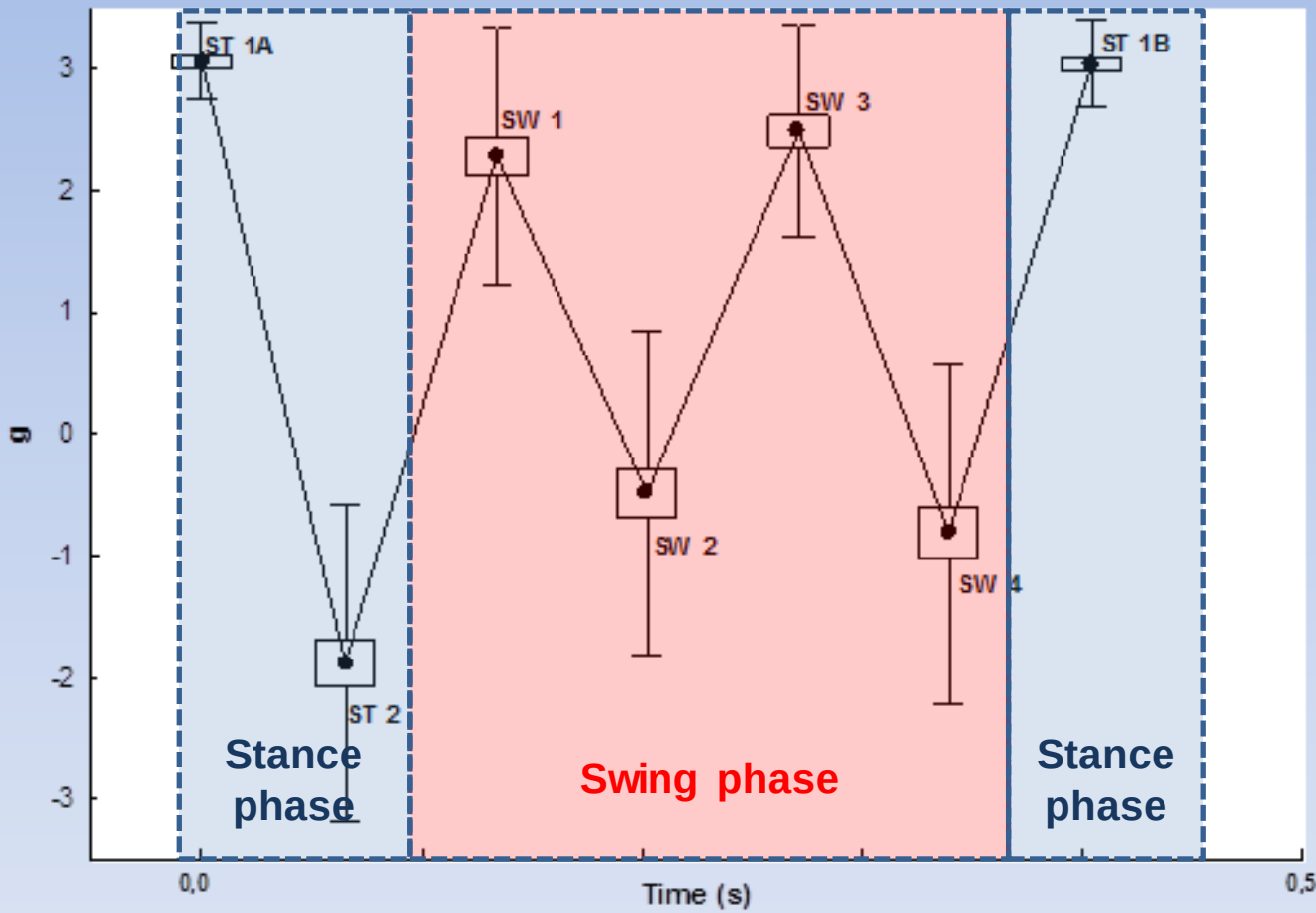
- 180 stride patterns on the vertical (x) axis
- 7 key acceleration points (KAP)

Single Stride analysis – RUNNING
Stride Acceleration Model





Single Stride analysis – RUNNING
Kinematic stride parameters



$$ST_{(tr)} = ST2_{(ts)} - SW4_{(ts-1)}\text{;}\quad ST_{(tr)} = ST2_{(ts)} - (SW4_{(ts-1)} + 0.03)\ \textbf{,if}\ SW4_{(ts-1)} + 0.03 \neq ST1A_{(ts)}$$

$$SW_{(tr)} = SW4_{(ts)} - ST2_{(ts)}\text{;}\ SW_{(tr)} = (SW4_{(ts)} + 0.03) - ST2\ \textbf{,if}\ SW4_{(ts)} + 0.03 \neq ST1B_{(ts)}$$

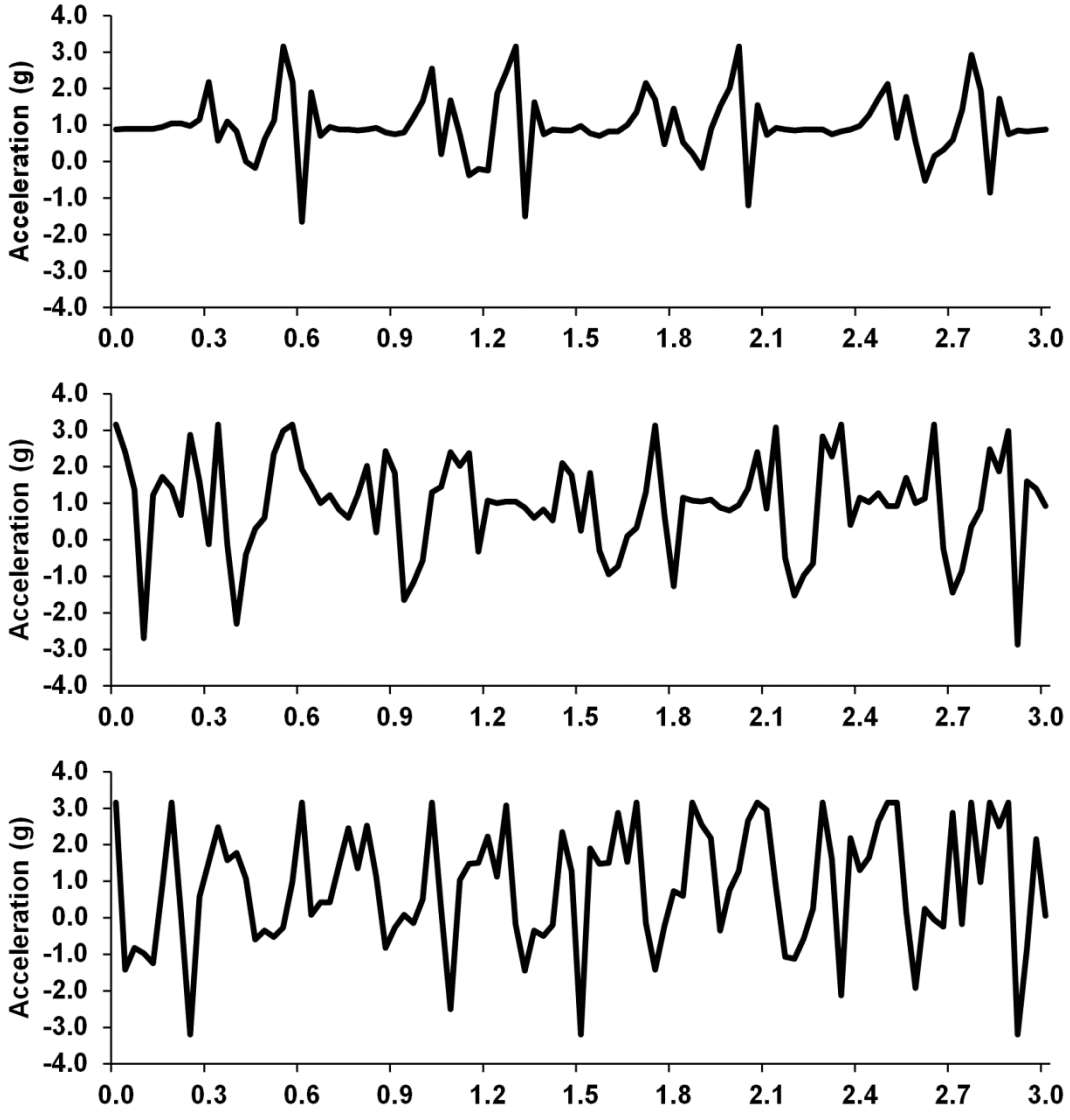
Single Stride analysis – RUNNING
Kinematic stride parameters

	Running			
	Total strides (n)	Mean ± SD	Range	CI 95%
Stance phase (s)	161	0.13 ± 0.05	0.06 – 0.27	0.12 – 0.14
Swing phase (s)	161	0.27 ± 0.08	0.12 – 0.48	0.26 – 0.29
Stride duration (s)	161	0.40 ± 0.08	0.21 – 0.69	0.39 – 0.42
Duty factor (%)	161	32.51 ± 10.42	12.50 – 66.67	30.89 – 34.13

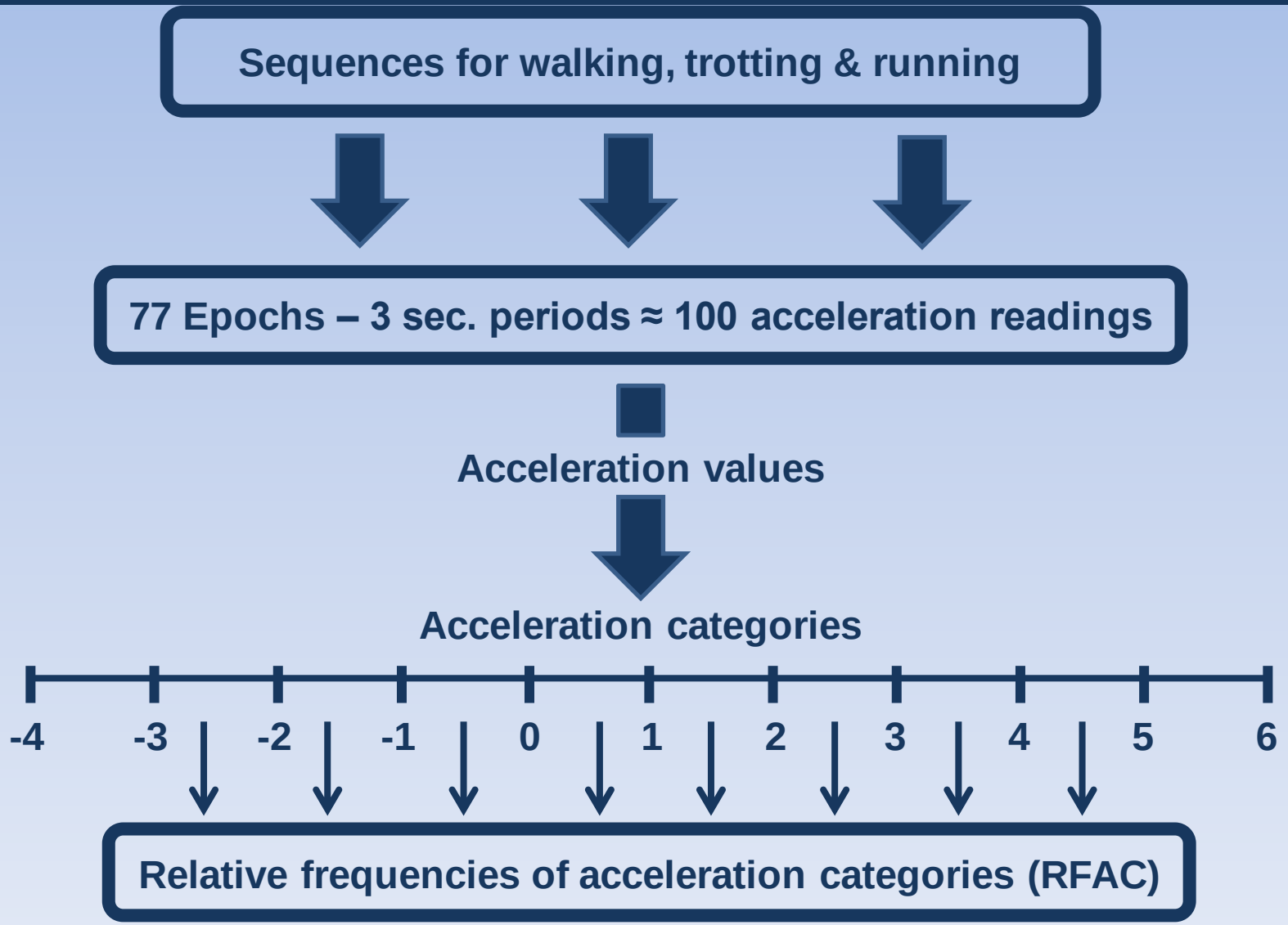
- **% error of number of strides comparing with the video of 1%(9% - 33%)**

Gait discrimination

- Walking
- Trotting
- Running



Gait discrimination



Gait discrimination

- **Discriminant function of RFAC for the vertical, horizontal axes & Sum vector**

	Acceleration Categories				
Vertical (x) axis	0 - 1	1 - 2	2 - 3	-3 – (-2)	
Horizontal (y) axis	3 - 4	2 - 3	-4 – (-3)	-2 – (-1)	-2 – (-1)
Sum Vector	0-1	2 - 3	5 - 6	1 - 2	3 - 4

Gait discrimination

- **Classification function**

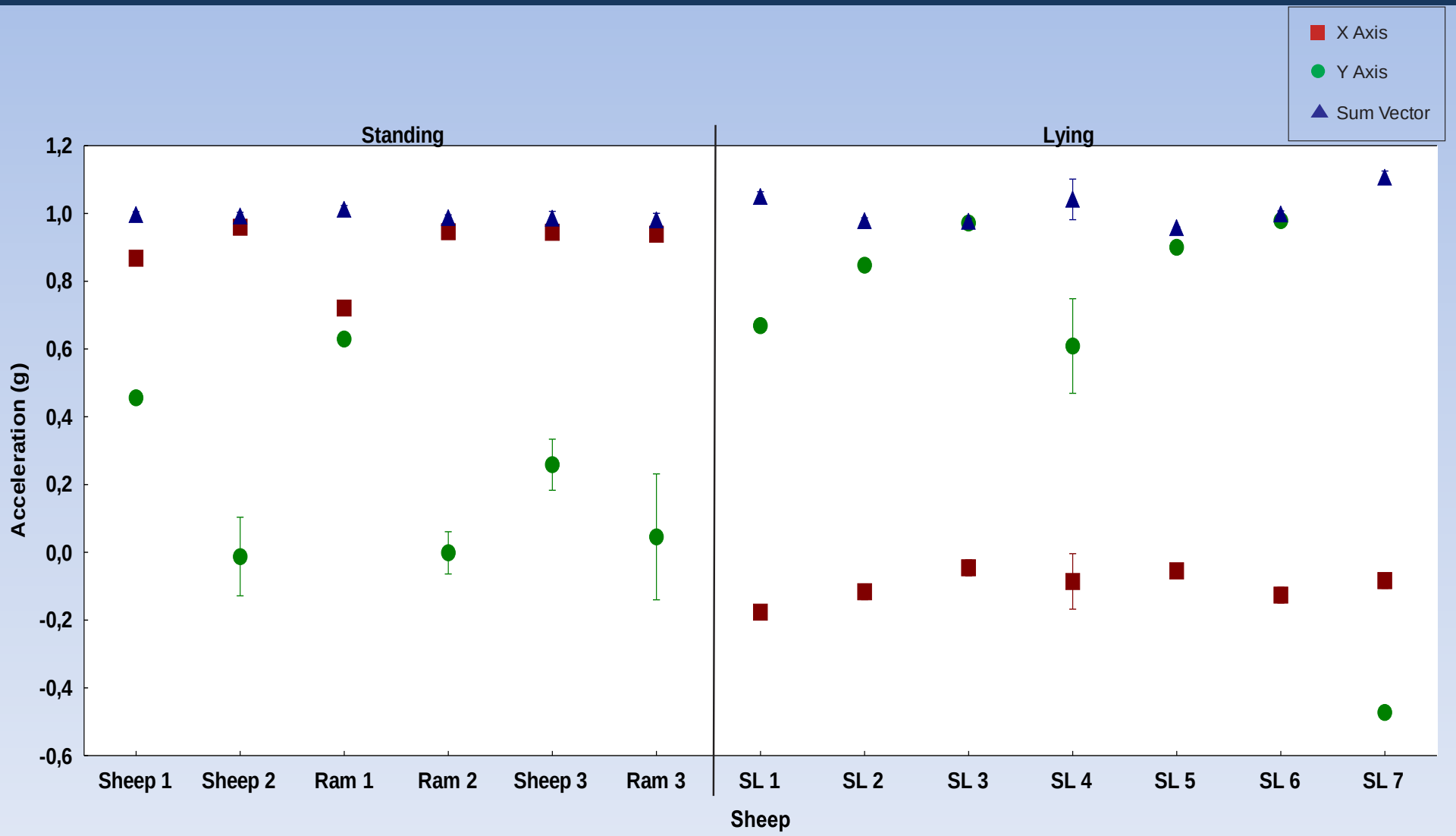
$$S_g = c_g + w_{gAC1} * rf_{AC1} + w_{gAC2} * rf_{AC2} + ...w_{gACm} * rf_{ACm}$$

- **Post hock classification matrix**
  - **Vertical axis – correct cases 89.6%**
  - **Horizontal axis – correct cases 90.9%**
  - **Sum vector – correct cases 87.0%**
  - **Trotting - least ; Walking – most accurate**

- **Optimized method for gait discrimination:**

  - using one axis and 4 or 5 AC identifies the gait type

Standing vs Lying



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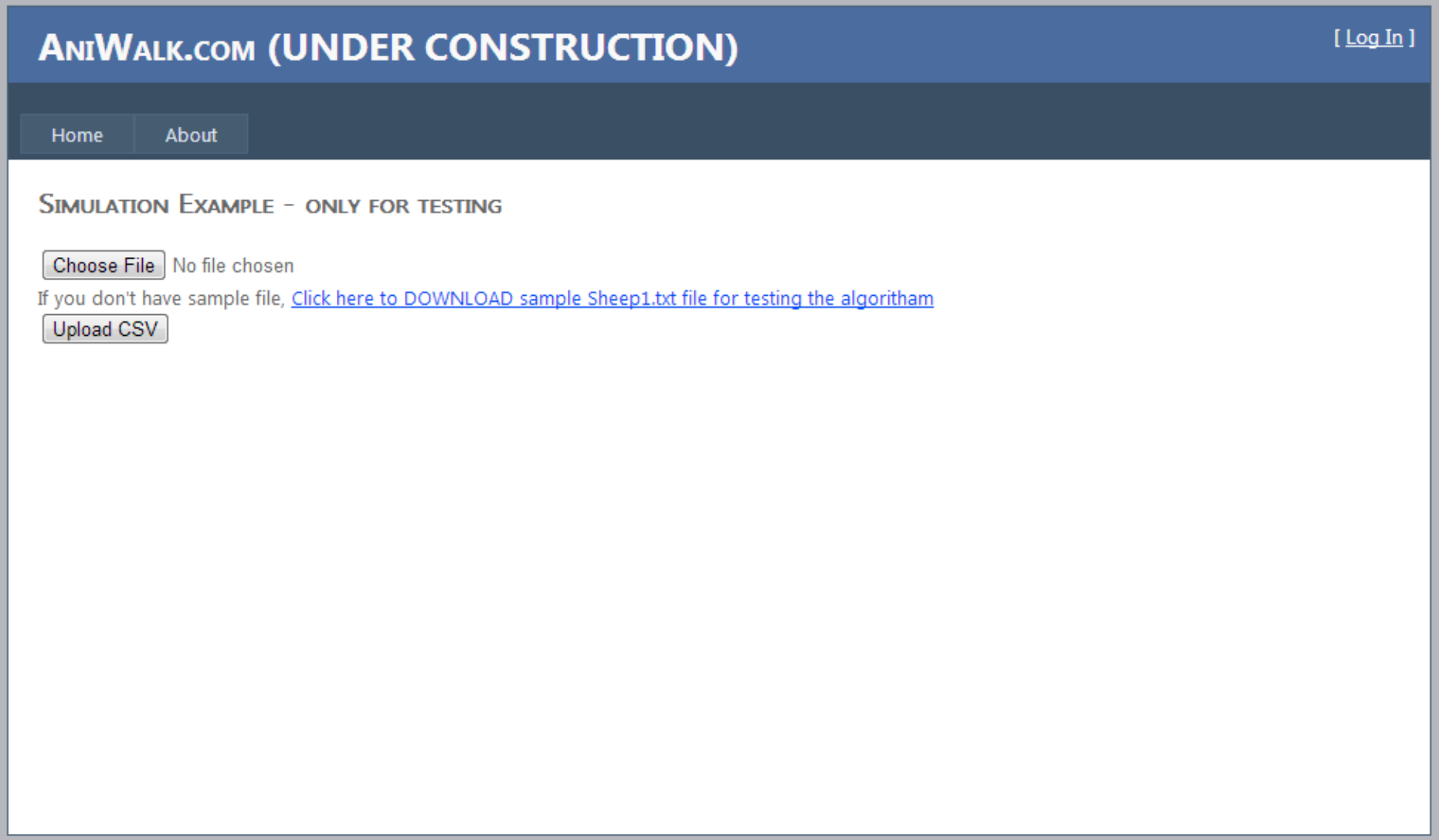

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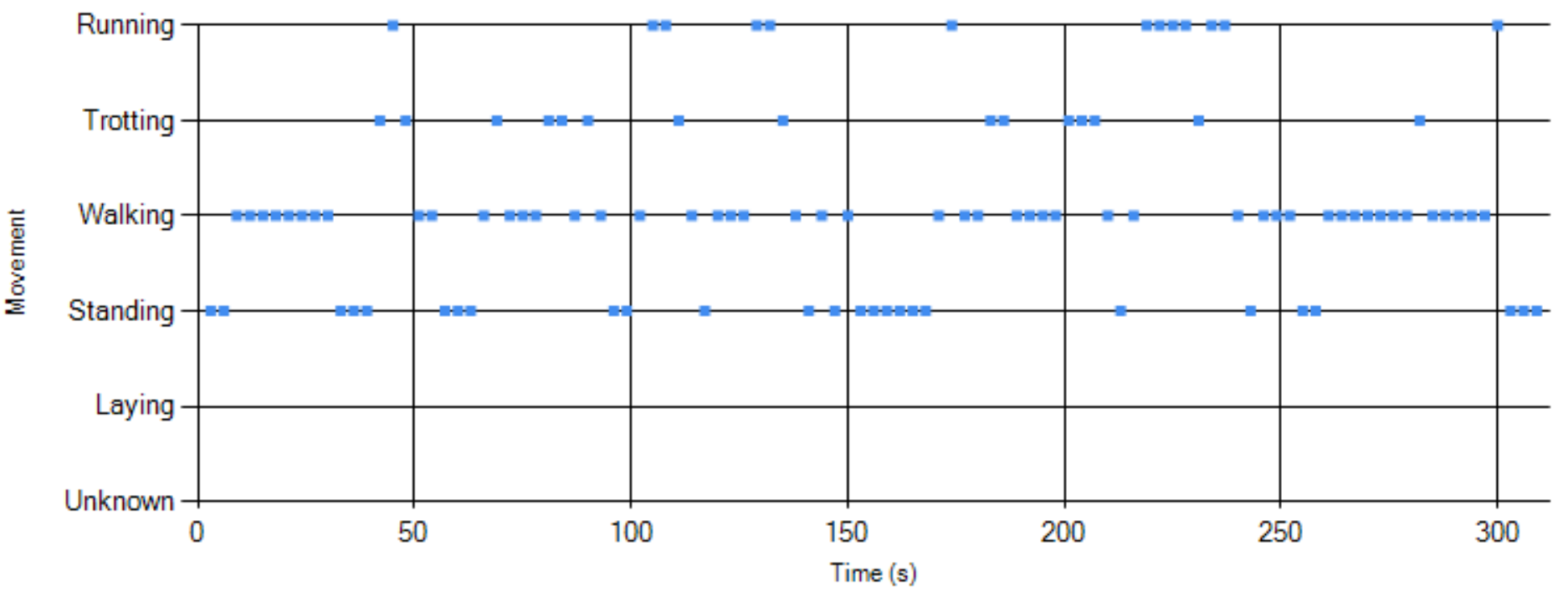


THANK YOU FOR YOUR ATTENTION