KARLSRUHE ICRA 2013

Motion Tracking for portable biomechanic measures

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The ERGANE Project

- Ecological detection of work related pathologies
  - Workers in unstructured environments:
    - Construction
    - Craftsmanship
    - Farmers

The ERGANE Project

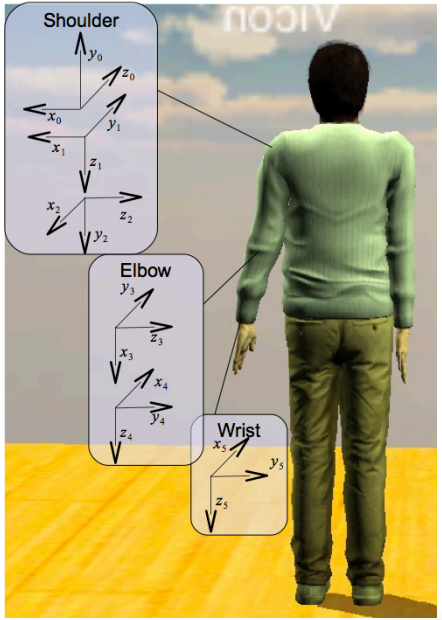
- Pathologies caused by repetitive actions with dangerous postures and loads: high impact on health and economy
- System for tracking and analysis of workers in ecological conditions
- Motion capture aided by wearable technologies
- Grasp force estimation by surface EMG matrix

MoCap: background

- Wearable sensors based motion reconstruction
  - Inertial sensor units
  - Models of human kinematics
  - Sensor fusion

MoCap: Kinematics

- Model of the human upper limb



Frame	a_i	α_i	d_i	ϑ_i
1	0	$\pi/2$	0	ϑ_1
2	0	$\pi/2$	0	$\vartheta_2 - \pi/2$
3	l_{ua}	0	0	$\vartheta_3 + \pi/2$
4	0	$\pi/2$	0	$\vartheta_4 + \pi/2$
5	0	0	l_{fa}	ϑ_5

MoCap: UKF

- Process model

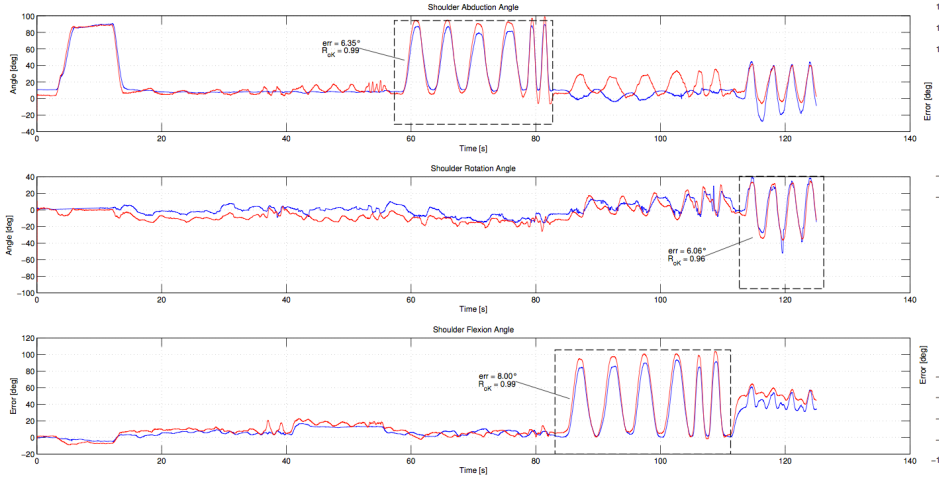
$$\vartheta_i(k+1) = \vartheta_i(k) + T_s\dot{\vartheta}_i(k) + \tfrac{1}{2}T_s^2(\ddot{\vartheta}_i(k) + \nu_k)$$
$$\dot{\vartheta}_i(k+1) = \dot{\vartheta}_i(k) + T_s(\ddot{\vartheta}_i(k) + \nu_k)$$
$$\ddot{\vartheta}_i(k+1) = \ddot{\vartheta}_i(k) + \nu_k$$

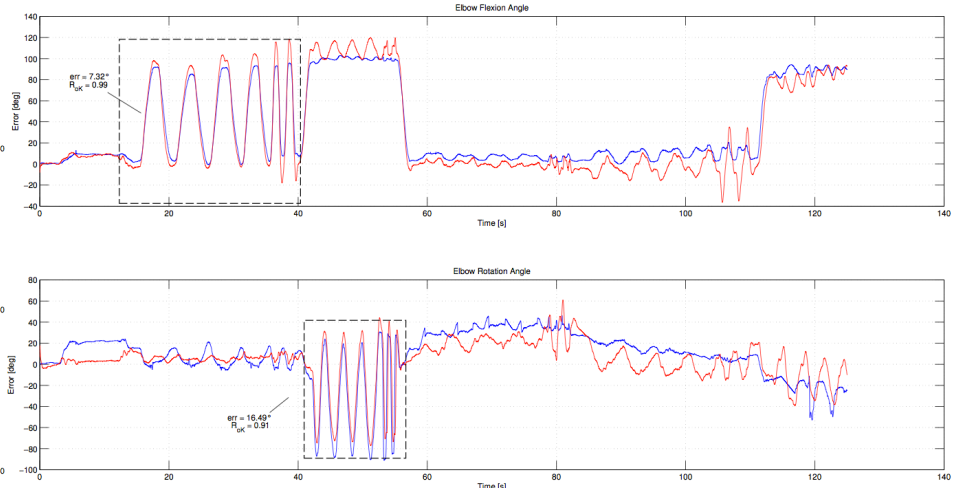
- Measurement model

$$\omega_s^s = R_p^s(\omega_p^p + \dot{\vartheta}_{p+1}z_0)$$
$$\ddot{x}_s^s = R_p^s\ddot{x}_p^p + S(\dot{\omega}_s^s)r_{p,s}^s + S(\omega_s^s)^2 r_{p,s}^s + R_0^s g^0$$
$$m_s^s = R_0^s m^0$$

MoCap: Results

- Joint variables estimation





MoCap: Results

- RMSE and Correlation

Joint	E_{ϑ_i} $[deg]$	C_{ϑ_i}
ϑ_1	7.03	0.95
ϑ_2	6.03	0.87
ϑ_3	4.95	0.99
ϑ_4	9.93	0.98
ϑ_5	11.29	0.85

$$C_{\vartheta_i} = \frac{\sum_{j=1}^{N} (\vartheta_i - \bar{\vartheta}_i)(\tilde{\vartheta}_i - \bar{\tilde{\vartheta}}_i)}{\sum_N (\vartheta_i - \bar{\vartheta}_i)^2 \sum_{j=1}^{N} (\tilde{\vartheta}_i - \bar{\tilde{\vartheta}}_i)^2}$$

$$E_{\vartheta_i} = \frac{1}{N} \sqrt{\sum_{j=1}^{N} (\vartheta_i - \tilde{\vartheta}_i)^2}$$

MoCap: Results

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ERGANE: Directions

- Refinement of online tracking
  - 7 DOF (submitted)
  - Position calibration (submitted)
  - Improved performance
- Integration of EMG
- Test on workers

MoCap: Further Implementations