Biological Motion for Gestural Communication by Social Robots

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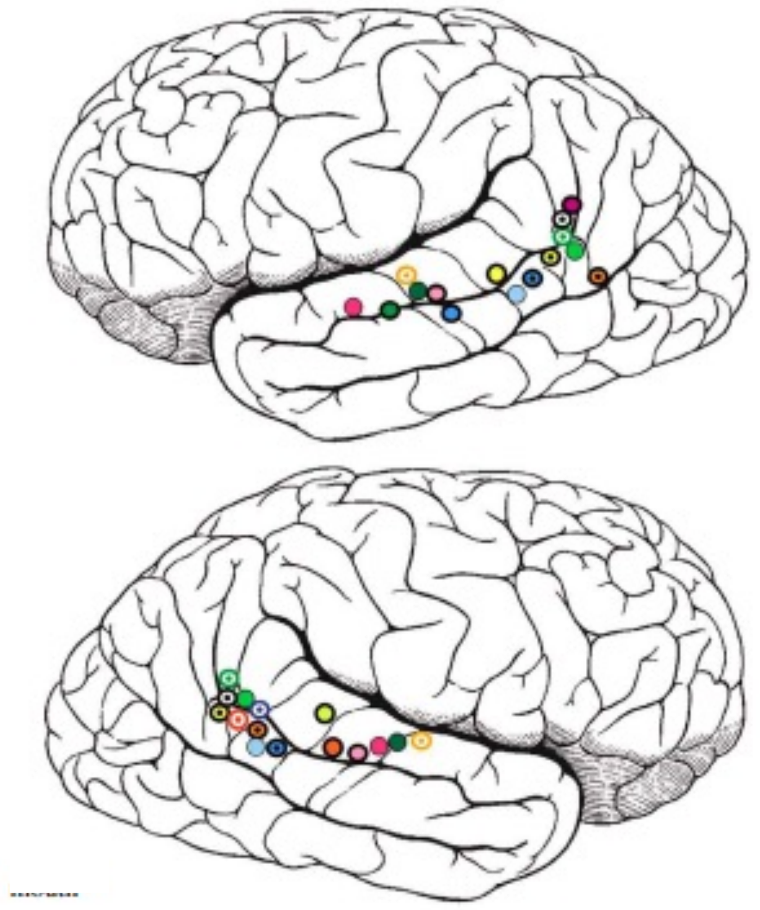
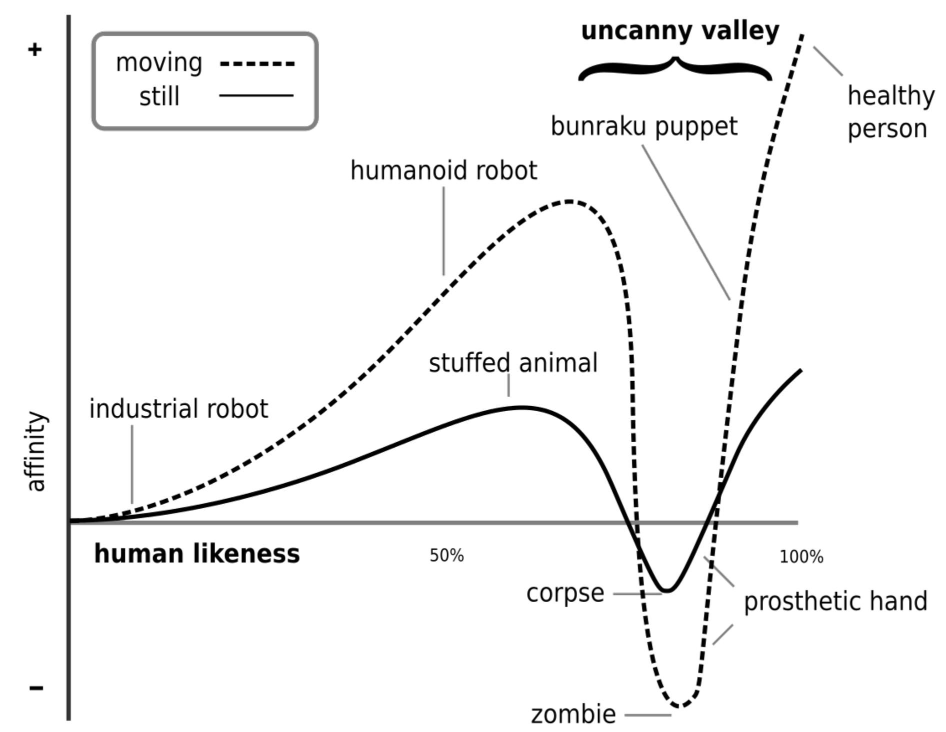
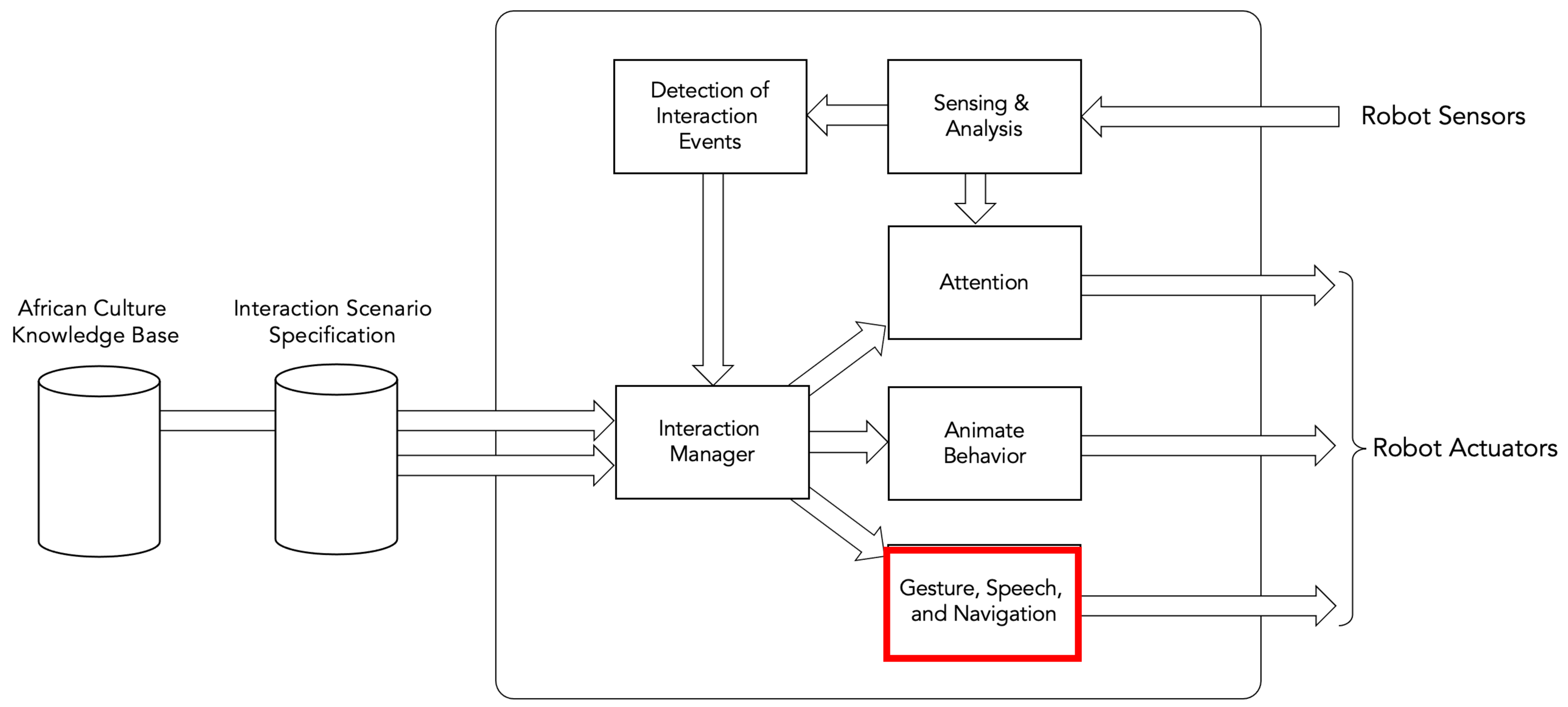
Significance of Biological Motion



Superior Temporal Sulcus activation
(Puce and Perret, 2003)



Uncanny Valley
(Bartneck et al., 2019)



CSSR4Africa System Architecture

Method

Models of Biological Motion

Minimum Jerk
(Chan et al., 2021)

$$\underbrace{CF = \frac{1}{2}\int_{t_1}^{t_2}\left[\left(\frac{d^3x}{dt^3}\right)^2 + \left(\frac{d^3y}{dt^3}\right)^2\right]dt}_{\text{Cost function being minimized}}$$

Two-thirds Power Law
(Viviani and Flash, 1995)

$$V(t) = K(t)\left(\frac{R(t)}{1+\alpha R(t)}\right)^{\beta}$$

Empirical value $\frac{2}{3}$

Velocity Gain Factor (> 0)

Tangential Velocity

Radius of Curvature

Decoupled Minimum-Jerk
(Huber et al., 2009)

$$r_z(t) = \sum_{k=0}^{5} a_{kz}t^k$$

Trajectory in z-direction

$$r_{xy}(t) = \sum_{k=0}^{5} a_{kxy}t^k$$

Trajectory in xy-direction

Trajectory Generation

Form of trajectory that minimizes jerk

$$\theta(t) = a_0 + a_1 t + a_2 t^2 + a_3 t^3 + a_4 t^4 + a_5 t^5$$

Boundary conditions

$$\theta(0) = p_s; \quad \dot{\theta}(0); \quad \ddot{\theta}(0) = 0$$

$$\theta(d) = p_f; \quad \dot{\theta}(d); \quad \ddot{\theta}(d) = 0$$

Joint positions

$$\theta(t) = p_s + k\left[10(t/d)^3 - 15(t/d)^4 + 6(t/d)^5\right]$$

Joint velocities

$$\dot{\theta}(t) = \frac{k}{d}\left[30(t/d)^2 - 60(t/d)^3 + 30(t/d)^4\right]$$

Joint accelerations

$$\ddot{\theta}(t) = \frac{k}{d^2}\left[60(t/d) - 180(t/d)^2 + 120(t/d)^3\right]$$

$$0 \le t \le d$$

Results

Impact Assessment

Non-biological (Control) gestures

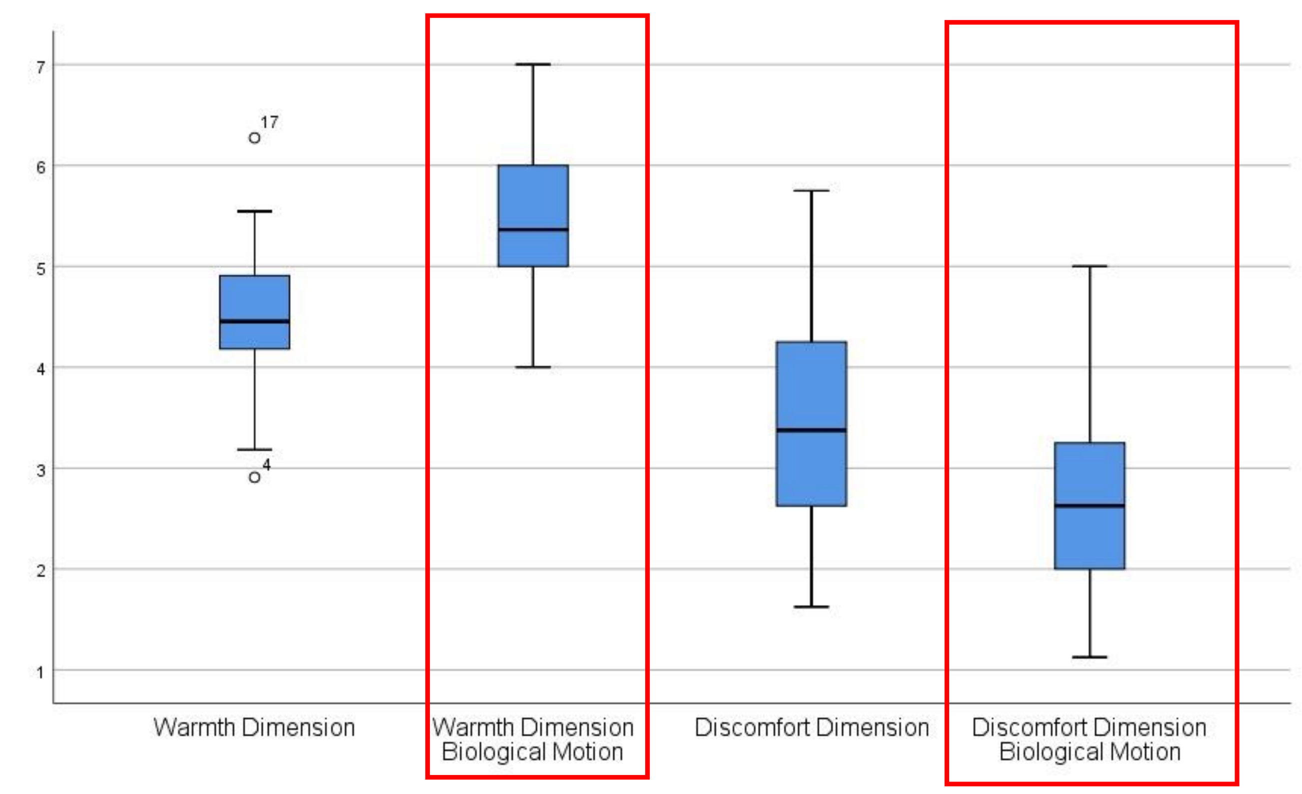
Condition 1

Biological motion profile

Condition 2

Warmth	Discomfort
Organic	Awkward
Sociable	Scary
Emotional	Strange
Compassionate	Awful
Happy	Dangerous
Feeling	Aggressive

RoSAS Assessment Variables
(Carpinella et al., 2017)



References

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