



IEEE-RAS
Humanoids09

Developing CPG based periodic motions using tactile interaction

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Concept

CPGs have numerous parameters

Manually set

- ✓ Control over the resultant motion
- ✗ change-effect relationship often unintuitive
- development is time consuming



Automatically set

- ✓ Little user effort
- ✗ Difficult to provide a good evaluation function
- Awkward motions



Tactile interaction

- Tradeoff:
- ✓ Intuitive, limited effort
 - ✓ Control over the result



Oscillator Model

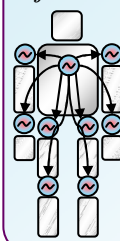
Similar touches must lead to similar changes → CPG must be very predictable

$$\dot{z}_j = \gamma (\mu_j - |z_j|)^2 z_j + i\omega_j z_j + F_j(t)$$

$$\omega_j = p_j \omega_0$$

$$m_j = \Re\{z_j\} + o_j$$

$$F_j(t) = w e^{i\phi_j} z_0^{p_j} \phi_j \in \mathbb{R}$$

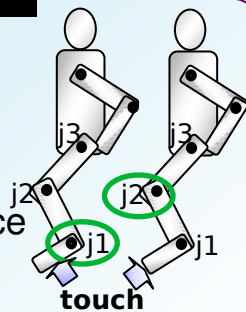


- $m_j \in \mathbb{C}$ signal sent to the actuator
- $\Re\{\cdot\}$ real part
- $o_j \in \mathbb{R}$ oscillation center parameter
- $w \in \mathbb{C}$ oscillator coupling coefficient
- $\phi_j \in \mathbb{R}$ phase parameter
- $z_j \in \mathbb{C}$ state variable
- $z_0 \in \mathbb{C}$ state variable of the reference oscillator
- $\gamma \in \mathbb{R}$ recovery speed after perturbation
- $\mu_j \in \mathbb{R}$ oscillation amplitude parameter
- $\omega_0 \in \mathbb{R}$ reference frequency parameter
- $p_j \in \mathbb{N}$ frequency parameter
- $F_j \in \mathbb{C}$ external perturbation

Touch protocol

Determination of the oscillator:

Most distal joint generating movement in the direction normal to the sensor surface



Determination of the parameter:

- Offset variation → very long push
 - Amplitude variation → long push
 - Phase variation → single tap
 - Frequency increase → double tap, both short
 - Frequency decrease → double tap, second long
- phase change time reference [radians]
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Experiment



motion	Development Time (min)	Changes (offset, amplitude, frequency, phase)
crawling	56	22,57,2,39
sidestep	29	56,31,4,18
walking	34	132,60,15,28

Humans implicitly control many aspects: ex. in crawling pitch&roll range smaller than GA