CPS: Synergy: Sensor Network-Based Lower-Limb Prosthetic Optimization and Control

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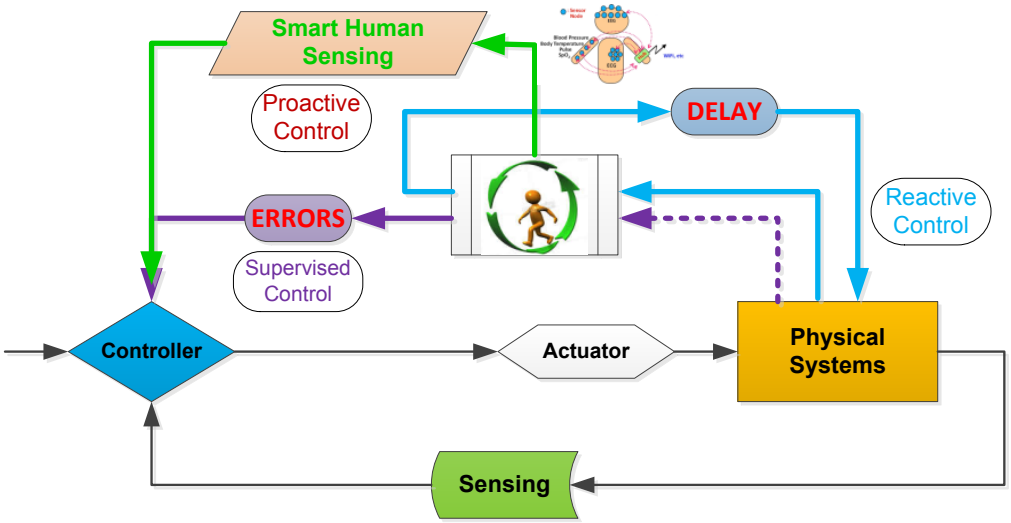
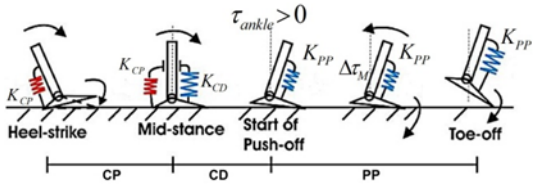
Human Estimation and CPS Control

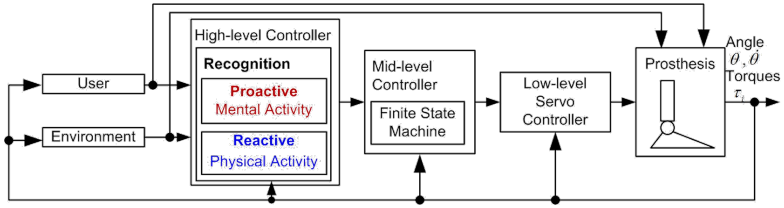
- Challenges in **Cyber-Physical Systems** with **H**uman-**i**n-the-**L**oop
  - Supervised Control: Prone to human errors and inaccuracies
  - Reactive Control: Delay in human reaction to physical systems
  - **Proactive Control: Faster, more accurate, and adaptive**



- HiL-CPS Application: *Powered Prosthetic Optimization and Control*
  - Challenge: Visual-based prosthesis fitting by experts results in inaccurate control – causing more energy expenditure and imbalance
  - Solution: Body-area sensor-based prosthetic control optimization

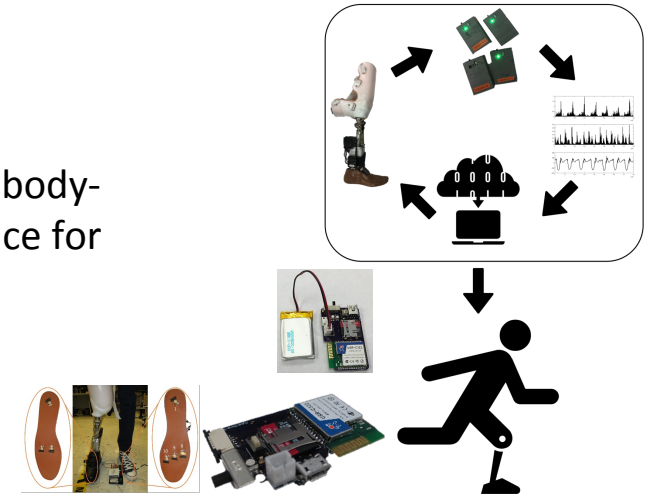


  - Challenge: Mechanical sensors embedded in prosthesis are unable to provide real-time adaptive control
  - Solution: Smart sensing of the user's volition to provide proactive control of the prosthesis before the transition of gait locomotion modes

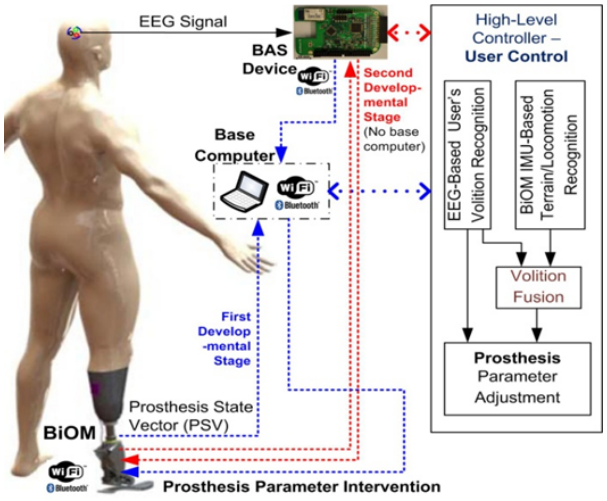


Findings

- Physiological activities measured by body-area sensors provided critical evidence for prosthetic tuning/optimization on amputees
  - Electromyography (EMG)
  - In-sole ground reaction force
  - Clinical evaluation
  - Automatic tuning of control parameters



- Brain-computer interface (BCI) method of motor imagery provided above 80% accuracy for user's volitional control of knee lock; Results showed that it is feasible for proactive control of prosthesis before the transition of gait locomotion modes
  - Preliminary test on single amputee subject
  - Received five hours of mental training with electroencephalography (EEG) feedback



Please visit our demonstration!