CHAMP: Tree Climbing Robot
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Introduction
Observing wildlife, monitoring forest health, conducting research, and detecting invasive species and infections are just a few of the crucial tasks that currently require humans to climb trees. Putting people into trees is an expensive and potentially dangerous task. The CHAMP (Compliant Hook Arboreal Mobility Platform) is a tree climbing robot that carries and controls job-specific payloads to improve the safety and efficiency of many arboreal tasks.

Locomotion

- **Gripper**
  - Grips most common tree geometries
  - Passive anti-backdrive enables unpowered position holding

- **Individually Compliant Hooks**
  - Hooks use acupuncture needles to grip tree
  - Shallow penetration depth avoids damaging tree
  - Small constant force springs permit individual compliance and distributed loading

- **Symmetric Continuum Manipulator**
  - Supplies three DOFs of locomotion
  - Polycarbonate push-pull rods conform to organic tree geometries
  - Counter-rotating lead screws condense mechanism
  - Passive anti-backdrive enables unpowered position holding

- **Abdomen**
  - Supports multiple payloads via standard M3 bolt pattern
  - Manufactured with 3rd & 4th axis CNC machining

Sensing & Control

- **Distributed Computing Network**
  - Main processor handles passing commands between co-processors
  - Leaves CPU overhead for completing complex tasks
  - Co-processors set position control, process sensor data, and transmit high-level data
  - Multiple co-processors enable parallel task execution
  - Only 4 wires between co-processors
    - Battery +/-
    - RS485 High/Low

- **Abdomen Electronics**
  - BeagleBone Black
  - Atmel328p
  - Custom battery
  - Power regulation board
  - XBee Transceiver
  - RS485 Transceiver
  - 9 DOF IMU
  - Maxon DCX Motors (3)
  - EPOS4 position controllers (3)
  - Limit switches (6)
  - Communication logic level translator

- **End Effector Electronics**
  - Atmel328p
  - RS485 Transceiver
  - 9 DoF IMU
  - Maxon DCX Motors (2 per)
  - Limit switches (3 per)
  - Power regulation board
  - EPOS4 position controllers (2 per)
  - Time of flight proximity sensor

- **Specifications**
  - **Arboreal Mobility**
    - Moves up and down straight sections of tree
    - Moves through branches and tree complexities
  - **Payload Support**
    - 14.4V, 3A power connection off main robot system power
    - Serialized high-speed data interface with main system
  - **Portability**
    - System on tree is less than 2kg, without payload
    - Full CHAMP system, including robot, controller, and small payload, is under 5kg and can be comfortably carried

Inchworm Gait (left)
A slow and methodical form of locomotion used for navigating tree complexities. Push pull rods form a continuum manipulator actuating like an accordion.

Rotating Gait (right)
Used for navigating straight sections of tree. A fast form of locomotion. End effectors rotate the entire robot to move end-over-end up the tree.