FPGA-based Control and Interface System for an Anthropomorphic Robotic Hand

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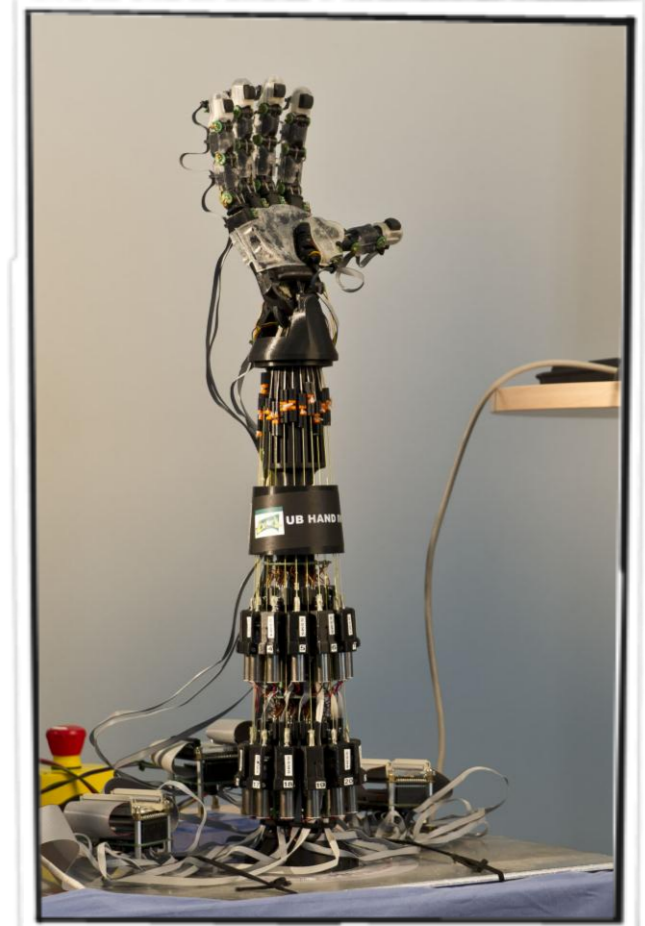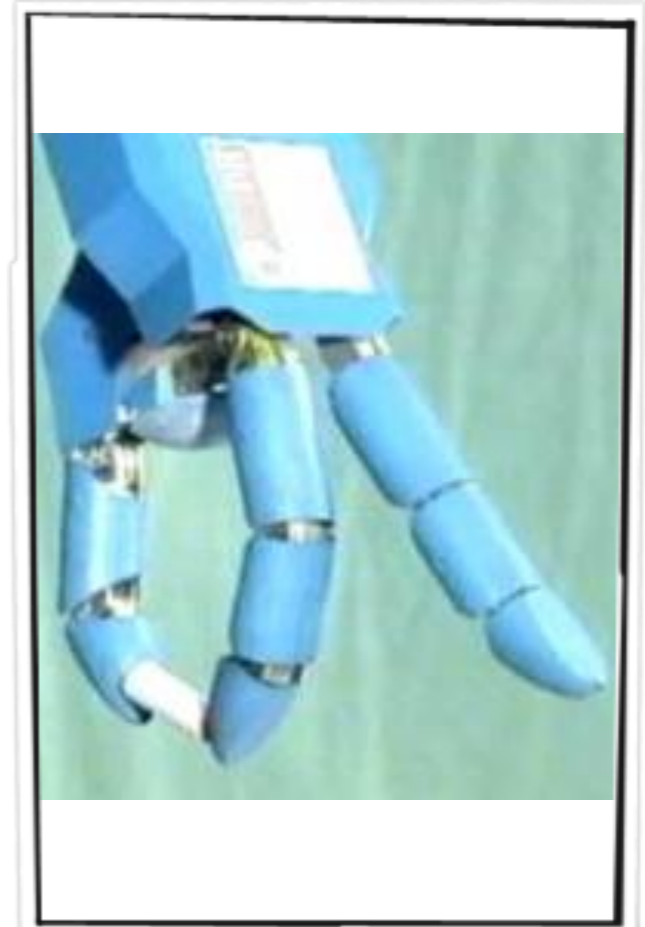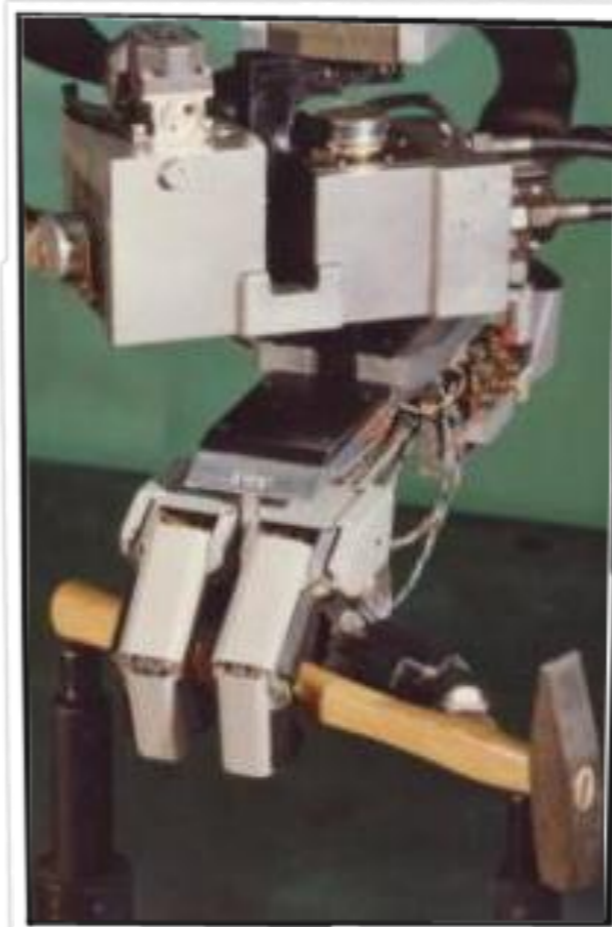Prof. Claudio Melchiorri

Alma Mater Studiorum Università di Bologna

UB Hands

Anthropomorphic robotic hands

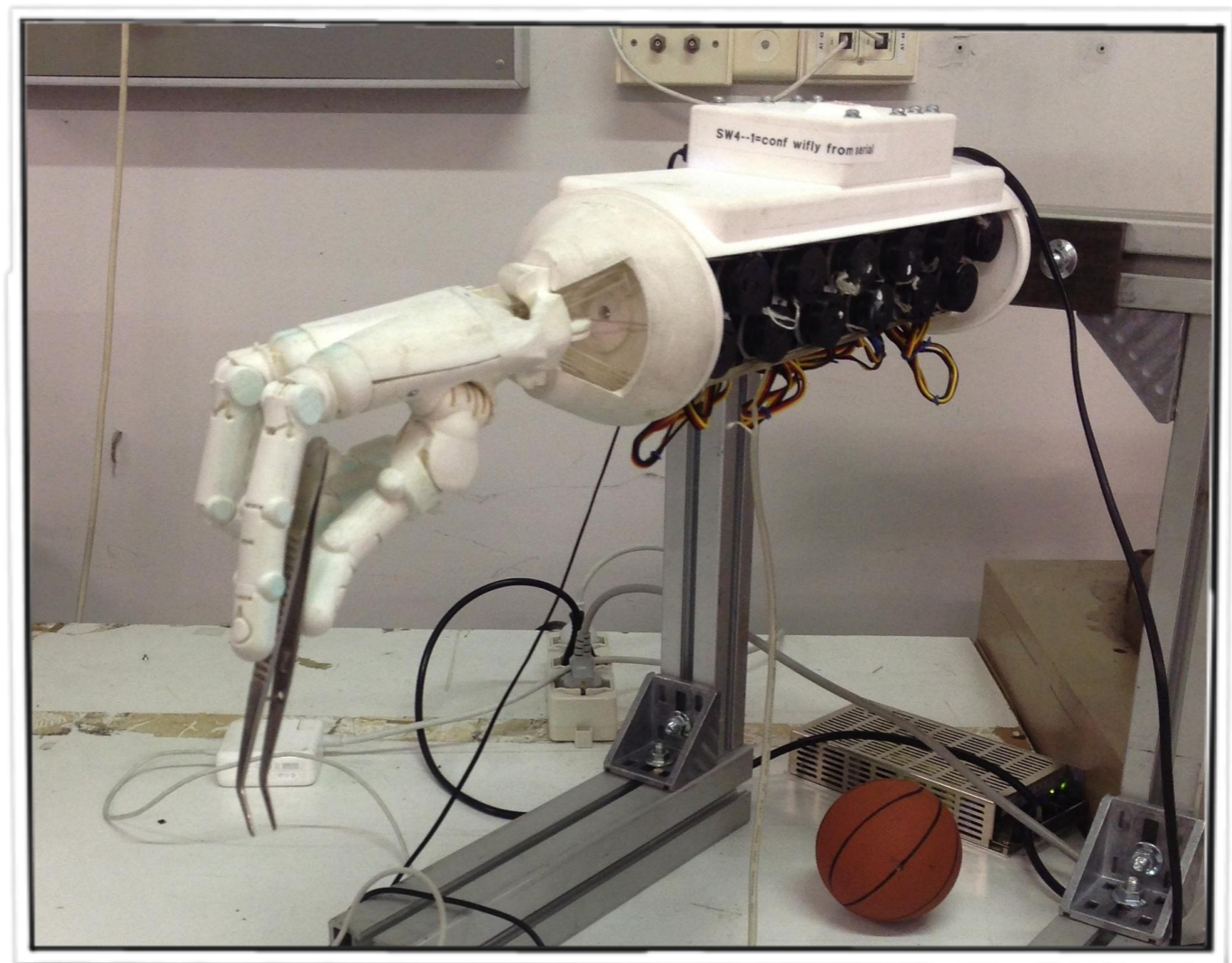- First prototype built in 1986

- Industrial/service applications

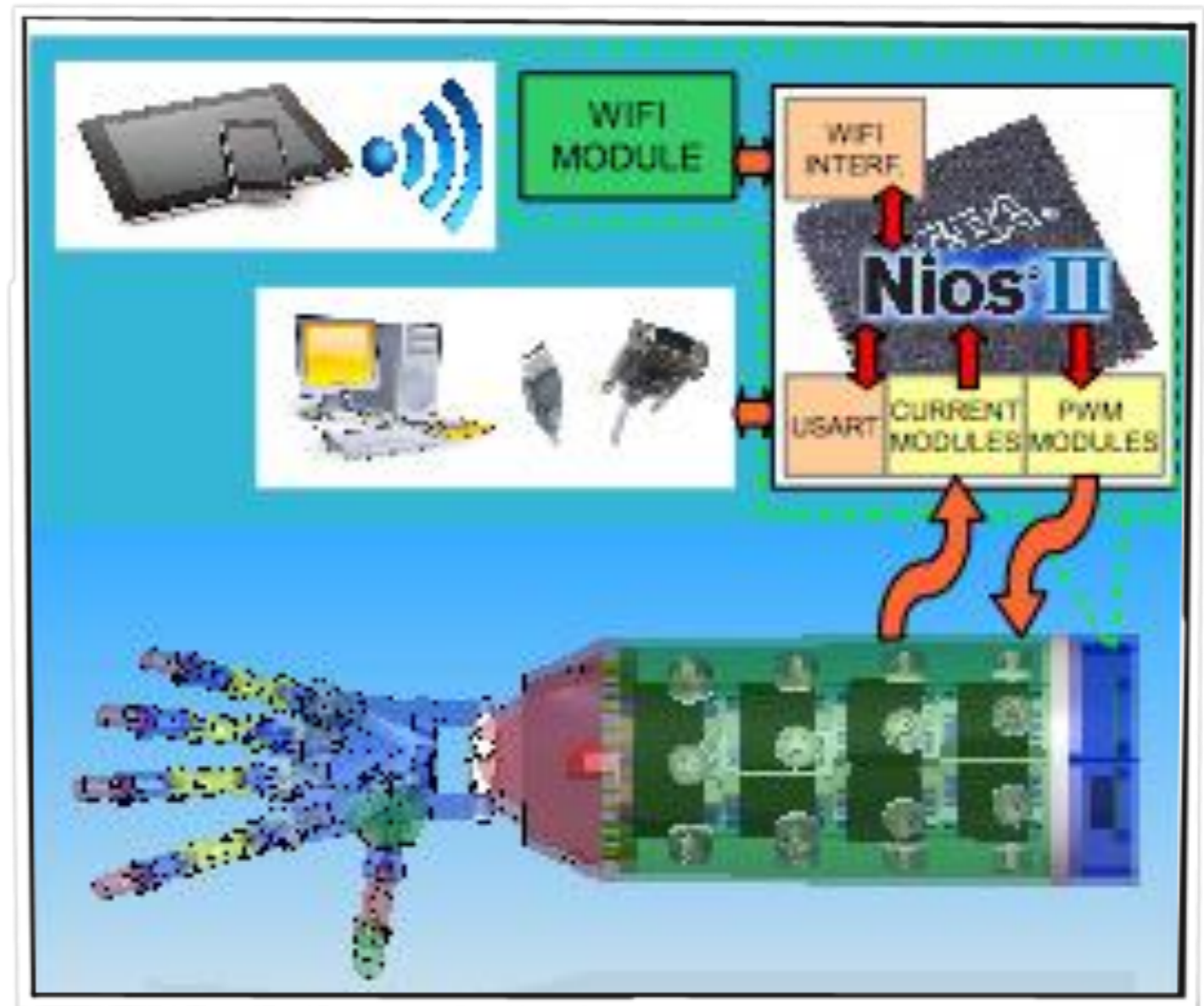- Endoskeletal tendons actuation

Altera UB Hand

- 5 fingers (3 DOF)

- 1 wrist (2 DOF)

- 17 DOF

- 24 servos

- Tendons actuation, pulleys driven

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Why an ALTERA FPGA?
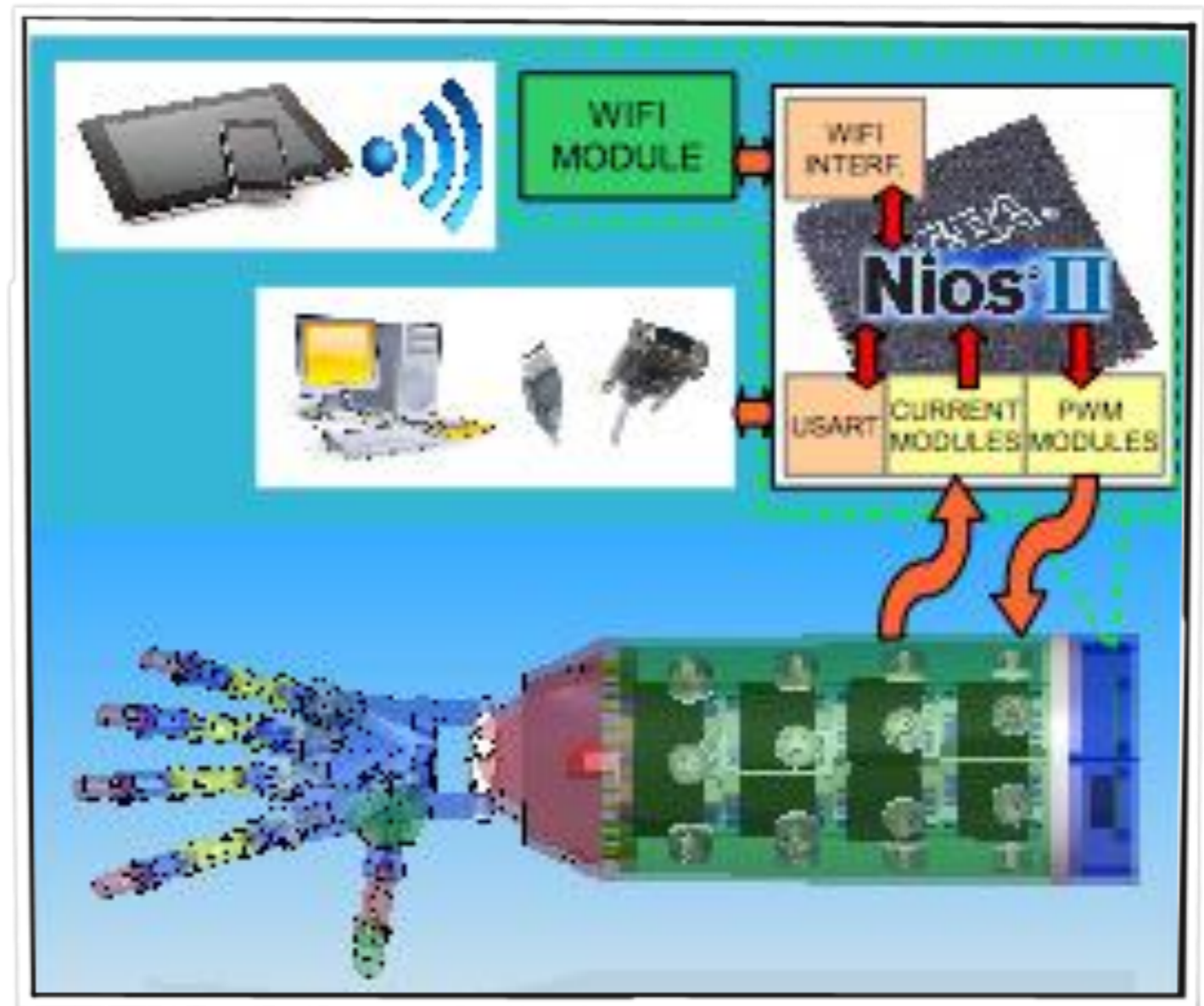
- High size/performance ratio

- Easy integration of custom hardware (motor control, sensor acquisition & communication)

- HDL peripherals

- On-board low level control software (Nios II)

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- Ready to use stand alone device

- DE0 NANO Altera FPGA

- 24 Hitec Hs-775MG servos

- Communication interfaces (WiFi & USB)

- Custom currents measurement board
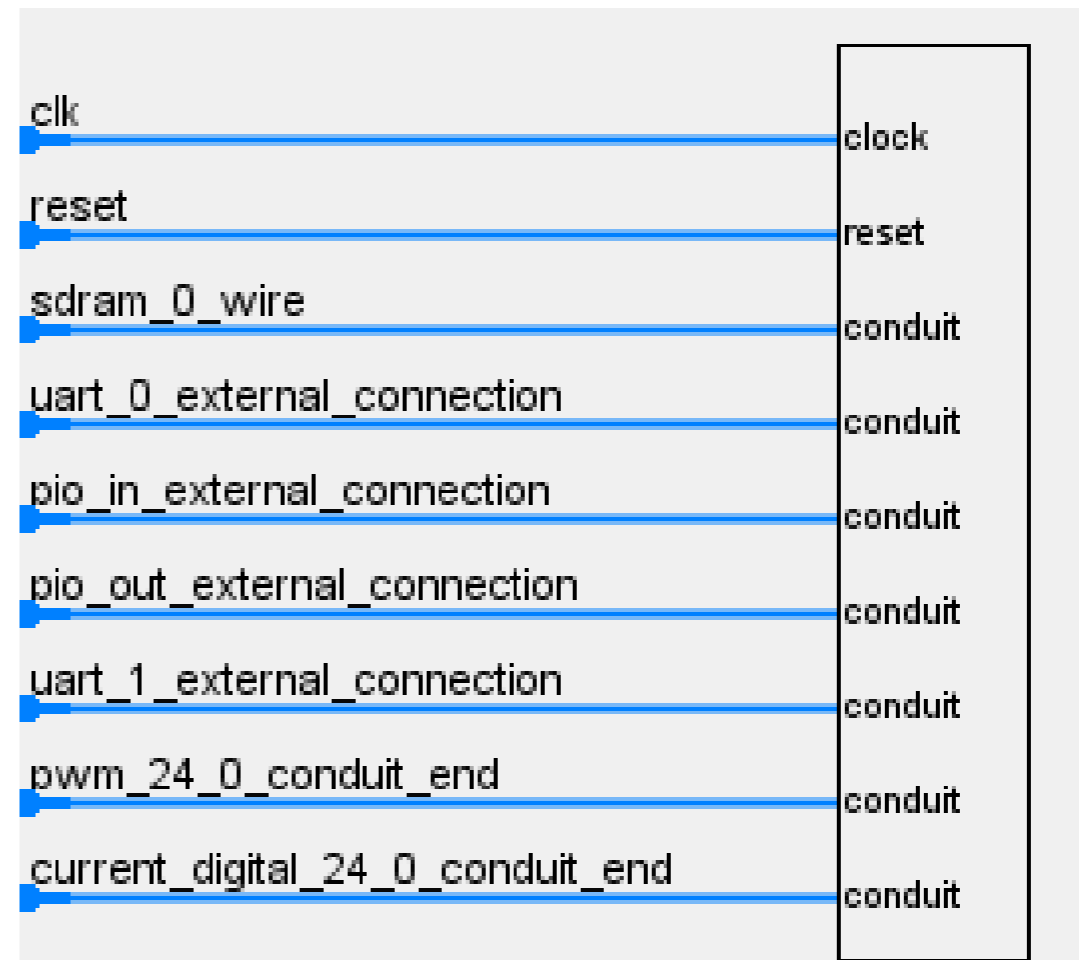
- Switches & Led

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- Motor connection breakout board

- 24 digital pin to PWM

- 24 digital pin for current sensors

- Currents are measured digitally (squared wave currents) (ZXCT1008)

- WiFi adaptor

- Access point mode

- Serial communication

- Serial TTL to USB converter

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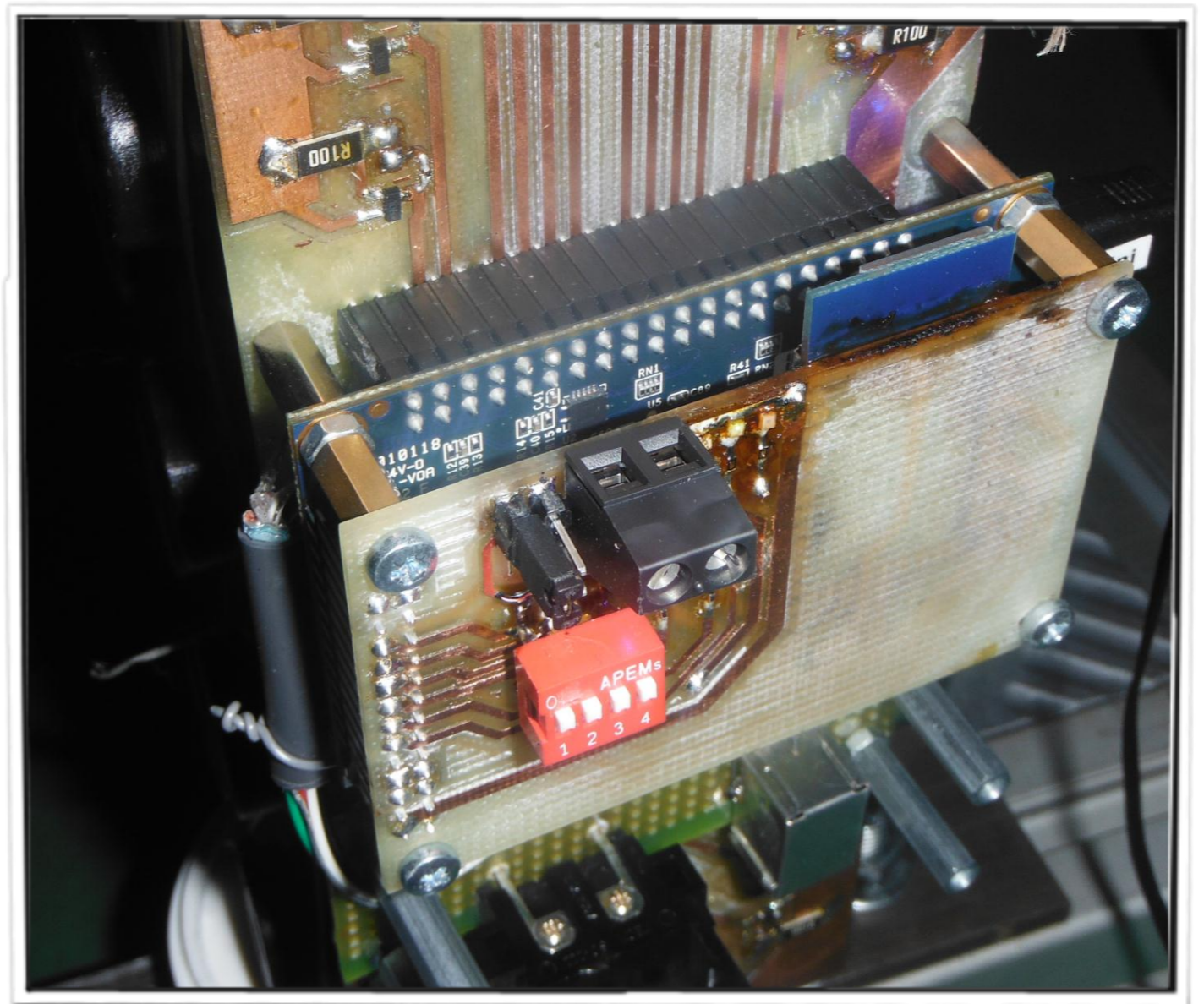
Qsys System Description

- CLK 50 MHz

- NIOS II

- SDRAM Controller

- 2 UART (WiFi/USB)

- Jtag

- Parallel IO

- Interval timer

- Custom HDL components

clk — clock

reset — reset

sdram_0_wire — conduit

uart_0_external_connection — conduit

pio_in_external_connection — conduit

pio_out_external_connection — conduit

uart_1_external_connection — conduit

pwm_24_0_conduit_end — conduit

current_digital_24_0_conduit_end — conduit
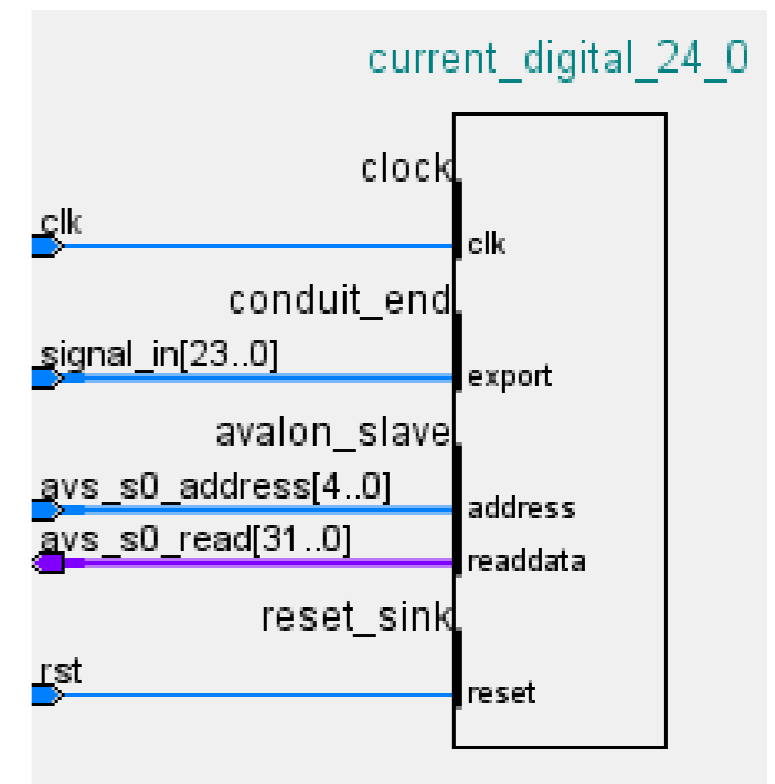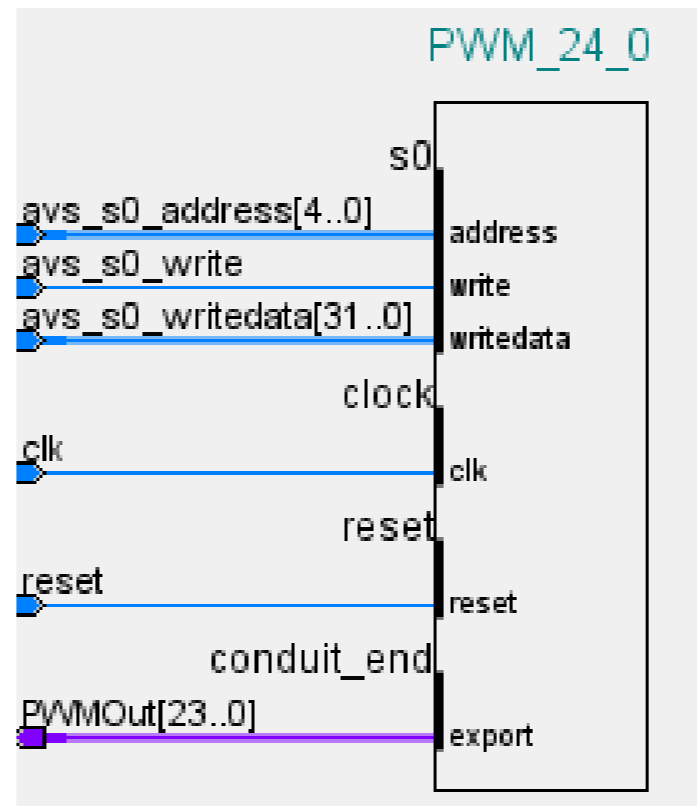
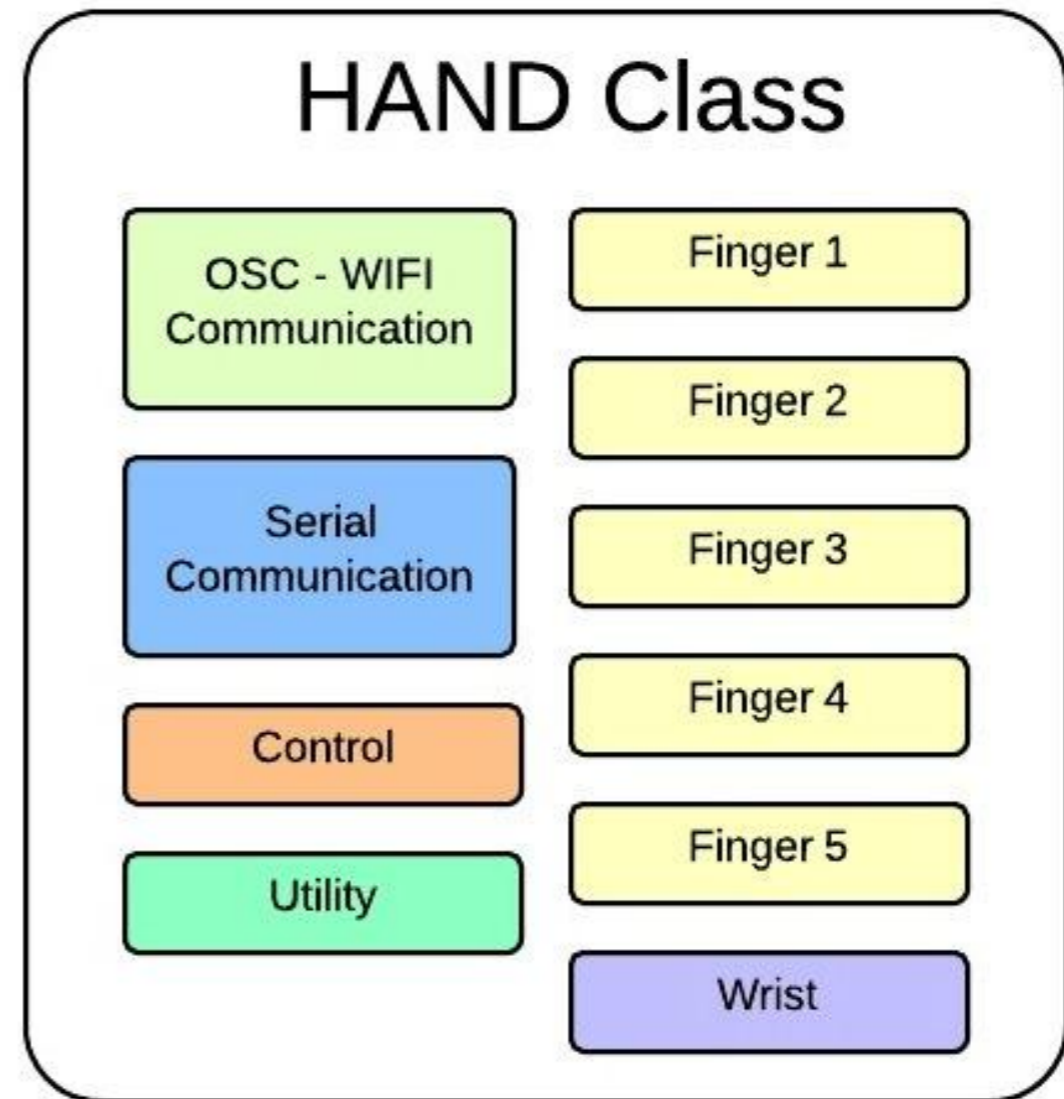# Altera UB Hand

Custom HDL Components Description

- Memory mapped interfaces

- Digital current absorption measurement (24 channels)

- PWM module (24 Channels)(for position set-points)
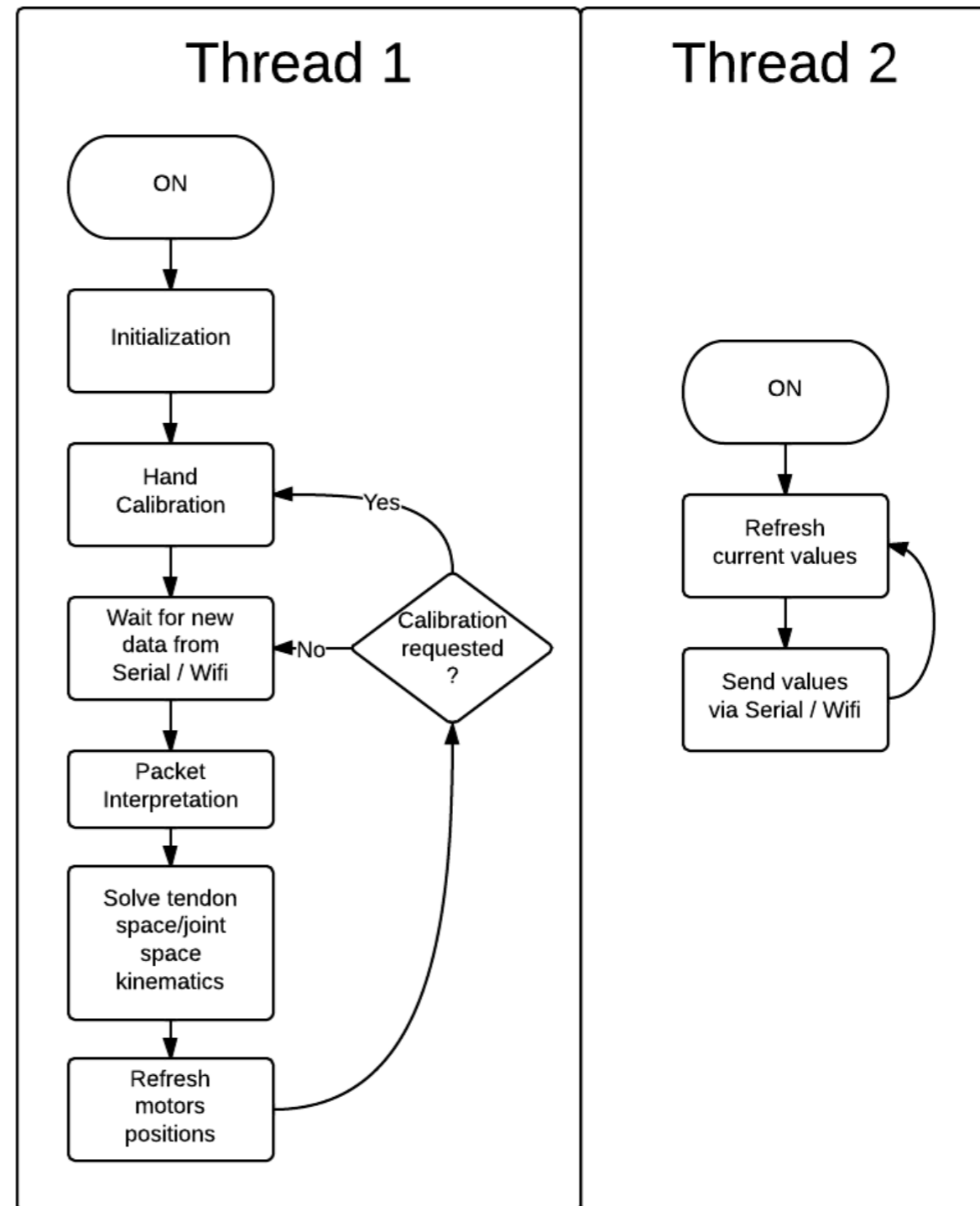
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NIOS II C++ SW Structure

- RTOS

- 1 Object Hand

- 5 Objects Finger

- 1Object Wrist

- Control & Communication classes

- OSC Protocol implementation

HAND Class

OSC - WIFI Communication

Serial Communication

Control

Utility

Finger 1

Finger 2

Finger 3

Finger 4

Finger 5

Wrist

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- Automatic Tendon Tensioning and Initialization

- Motor Current Control

- Kinematic transformation from Joints Space to Motors Space

- Implementation of agonistic/antagonistic behavior

Control Routines

Thread 1

ON

Initialization

Hand Calibration

Wait for new data from Serial / Wifi

Packet Interpretation

Solve tendon space/joint space kinematics

Refresh motors positions

Calibration requested ? — Yes / No

Thread 2

ON

Refresh current values

Send values via Serial / Wifi
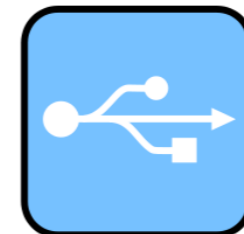
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Communication

OSC Protocol

- Originally intended for music management

- Easy data packet construction

- Large amount of ready to use tablets apps

- High customizability

OSC
open sound control

Serial Protocol

- For more complex scenarios

- Compatible with a large number of PC applications (Matlab, Labview ecc)

- Real time capability

- Custom packets and overhead reduction

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Tablet Interface

- OSC Touch

- Customizable layout

- Send Joint reference

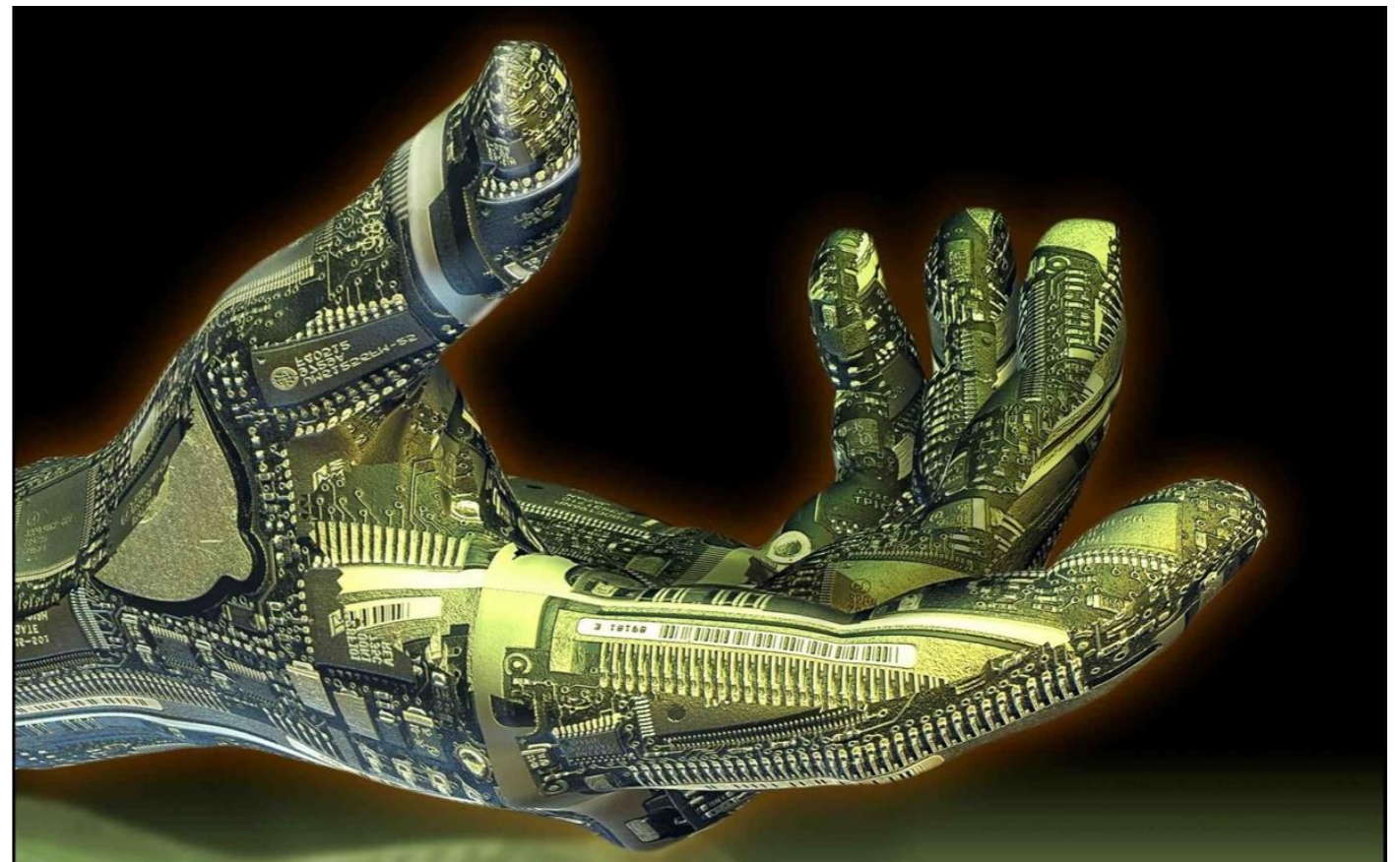- Receive Motor current values

- Calibration

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- Integration with existing control schemes

- Coordination with vision and arm

- Complex algorithms

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What's next?

- Flash memory integration for store data

- Learning algorithms embedded on the device

Grazie!