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

Gildo Andreoni, Umberto Scarcia, Leonardo Vivarelli, Lorenzo Moriello, Gianluca Palli
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

Hand Description

- 5 fingers (3 DOF)
- 1 wrist (2 DOF)
- 17 DOF
- 24 servos
- Tendons actuation, pulleys driven
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)
Altera UB Hand

System Description

• 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
Altera UB Hand

Custom Hardware Description

- 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
## Altera UB Hand

- **CLK 50 MHz**
- **NIOS II**
- **SDRAM Controller**
- **2 UART (WiFi/USB)**
- **Jtag**
- **Parallel IO**
- **Interval timer**
- **Custom HDL components**

### Qsys System Description

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```
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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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- RTOS
- 1 Object Hand
- 5 Objects Finger
- 1 Object Wrist
- Control & Communication classes
- OSC Protocol implementation

NIOS II C++ SW Structure

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
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 OSC Protocol

• Originally intended for music management

• Easy data packet construction

• Large amount of ready to use tablets apps

• High customizability

 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
Altera UB Hand

- OSC Touch
- Customizable layout
- Send Joint reference
- Receive Motor current values
- Calibration

Tablet Interface
Altera
UB Hand

- Integration with existing control schemes
- Coordination with vision and arm
- Complex algorithms

Matlab & Simulink Interface
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- Flash memory integration for store data
- Learning algorithms embedded on the device
Grazie!