POLITECNICO DI TORINO

Dipartimento di Automatica e Informatica

PhD in Computer and Control Engineering

XXIX cycle

Advisor

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Vision-Based Assistive Technology

PhD Candidate: *Giuseppe Airò Farulla*

1. Motivations

"Assistive Technologies" (ATs) include assistive, adaptive, and rehabilitative devices for people with disabilities.

Researching on AT means to focus on the design and the development of technology to ease, or even improve, everyday life of disabled, elderly people and people who are following rehabilitative programs.

Research activities involve a strict and direct contact with associations and people who benefit from the research itself.

2. My Research

Design, modeling and development of a hand-tracking and gesture recognition algorithm from single markerless observation: generative and discriminative approaches.

Technology involved: Microsoft Kinect and Leap Motion.

Framework: eXtreme Model-Driven Development (XMDD).

3. Method

3.1 A Generative Approach

The first approach comprises:

- models of human hand and its skeletal structure;
- alignment algorithms (ICP);
- optimization techniques (PSO, CMA-ES).

Testing:

- 100+ fundamental hand movements and gestures;
- objective and subjective evaluation;
- on-line survey, 150+ answers collected.

Outcomes: reliable and accurate but not real-time!

3.2 A Discriminative Approach

The second approach comprises:

- hand tracking (OpenNi, RANSAC, background removal, Machine Learning);
- hand joints classification (Random Forest);
- static hand gesture recognition (Machine Learning);
- dynamic hand gesture recognition (HMM, Graph Models).

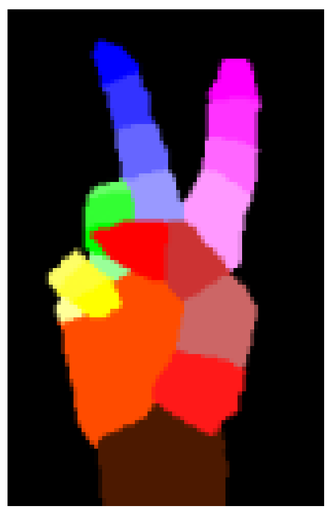
Testing:

- objective and subjective evaluation;
- application to two study cases.

Outcomes:

- accurate and real-time on consumer hardware;
- multi-technology integration.

Applied to: a Telephone for Deafblind People and a Novel Telerehabilitation Platform.



4. Applications

4.1 A Novel Telerehabilitation Platform

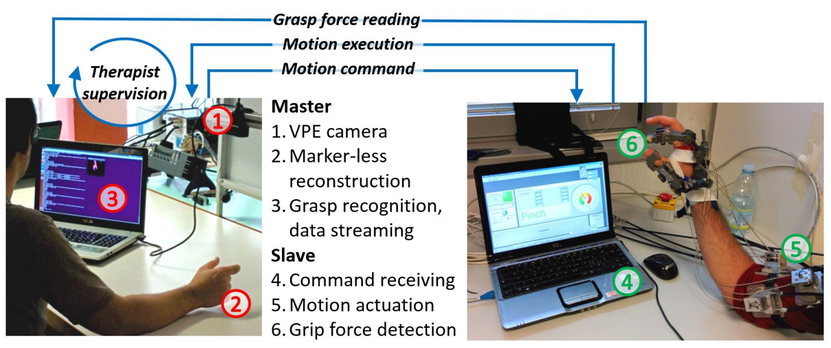
Post-stroke hand rehabilitation is performed in a one-to-one fashion: one therapist and one patient, leading to high personnel and management costs. Due to reduced National Health Services budgets, patients are returning to their homes when their rehabilitative program is not yet finished.

Idea: telerehabilitation equipment to provide remote assistance and relief without the burden of going to the clinic on a daily basis.

The project:

- identification: hand tracking and grasping exercise classification;
- transmission: UDP-based remote communication;
- synthesis: multi-joints robotic hand exoskeleton.

Testing: clinical protocol with 1 operator and 6 volunteers, 2 exercises.



4.2 A Telephone for Deafblind People

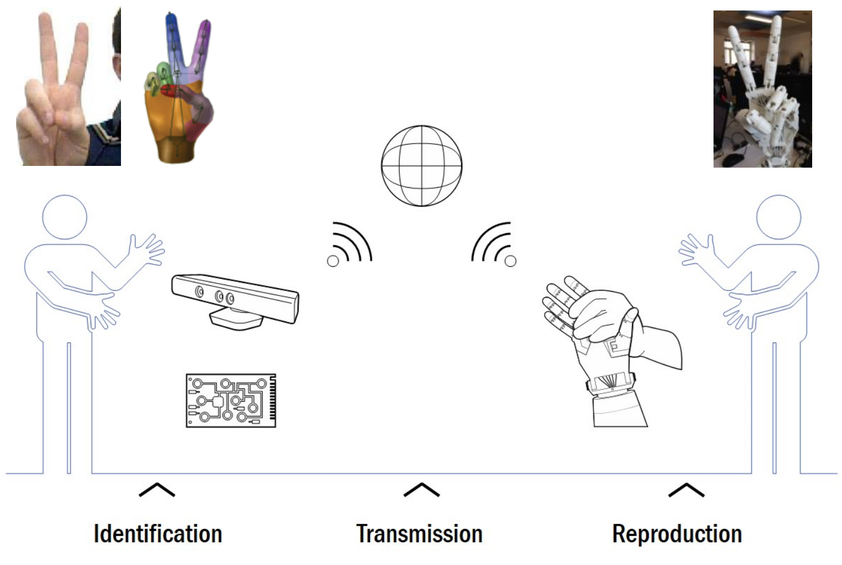
Deafblind people communicate through tactile Sign Languages (tSLs): no remote communication medium exists!

PARLOMA project:

- identification: static and dynamic hand gesture recognition;
- transmission: cloud robotics computation;
- synthesis: bioinspired anthropomorphic 3D-printed robotic hand and arm.

Testing: deafblind users and partner associations.

Formal verification: XMDD-based development of intrinsically secure systems to remotely control robotics actuators leveraging on intuitive vision-based input interfaces.



5. Most Relevant Publications

- Bulgarelli, A., Toscana, G., Russo, L. O., AIRÒ FARULLA, G., Indaco M., Bona, B. (2016). "A Low-cost Open Source 3D-Printable Dexterous Anthropomorphic Robotic Hand with a Parallel Spherical Joint Wrist for Sign Languages Reproduction". International Journal of Advanced Robotic Systems. 13:126.
- AIRÒ FARULLA, G., Pianu, D., Cempini, M., Cortese, M., Russo, L. O., Indaco, M., Nerino, R., Chimienti, A., Oddo, C. M., Vitiello, N. (2016). "Vision-Based Pose Estimation for Robot-Mediated Hand Telerehabilitation", Sensors. 16(2):208.
- Russo, L. O., AIRÒ FARULLA, G., Pianu, D., Salgarella, A. R., Controzzi, M., Cipriani, C., Oddo, C. M., Geraci, C., Rosa, S., Indaco, M. (2015). "PARLOMA-A Novel Human-Robot Interaction System for Deaf-blind Remote Communication". International journal of advanced robotic systems. 12:57.

6. Partners

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Scuola Superiore Sant'Anna Pisa

Lero The Irish Software Research Centre

Unione Italiana dei Ciechi onlus

lega del filo d'oro