A Smart Wireless Glove for Gesture Interaction

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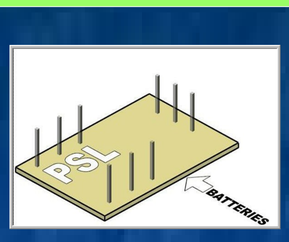
Introduction

Embedded electronics enables future scenarios where different kinds of objects can be enhanced with computing power and connectivity. This process naturally leads to "intelligent systems" composed of a variety of networked, sensor enriched, intelligent devices able to sense and react to the environment, as well as aware of users' location, activity and behavior with the purpose of anticipating their needs and intentions. Moreover, in this scenario, each smart device can be aware of the physical environment and of the other smart objects in reach and decide how to behave according to the context, e.g. to which other smart object interact with.
In particular, sensory augmented smart objects can enable natural interaction techniques, such as use of gestures and movements.

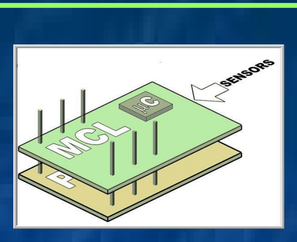
The Smart Wireless Glove (SWG) is not only an input device, but a smart sensorized object, that can be used alone, but also as part of a body area network or even of a broader wireless sensor network. In particular, it can recognize the proximity of other Bluetooth devices and exploit inertial as well as bend sensors to extract complex information regarding the user.

Architecture



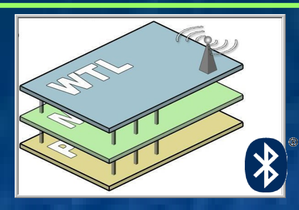
Power Supply Layer (PSL)

- Connected to NiMh rechargeable 4.2V batteries
- Power stabilizer
- Battery-charge



MicroController & Sensors Layer (MCL)

- Equipped with *ATMega8* microcontroller:
  - SPI interface (used by the *Triaxial Digital Accelerometer*)
  - Analog inputs hooked to 5 bend sensors.



Wireless Transmission Layer (WTL)

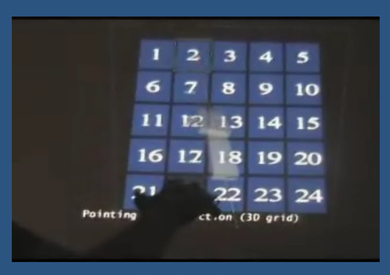
- Based on a Bluetooth® 2.0 transceiver (operating in the 2.4Ghz worldwide bandwidth)
- Serial Port Profile to transfer and receive data

Main Features

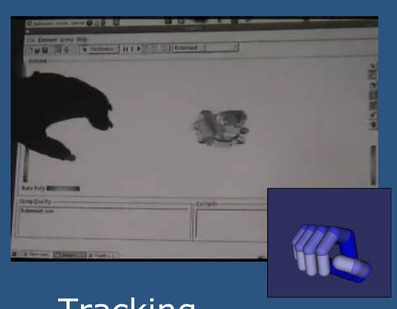
- Detect finger position (resolution: 10 bit)
- Inertial tracking with a tri-axial accelerometer (resolution:12 bit; range: +-2g)
- Bluetooth® 2.0 transmission (customizable packet-rate)
- Proximity-aware algorithm
- Battery-charge on board
- Support to wireless programming

Applications

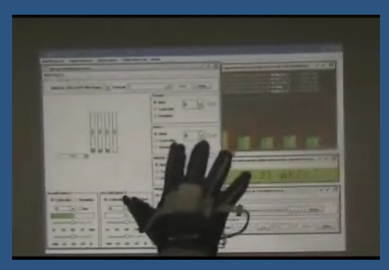
Gaming
Gestures for navigation & shooting



Pointing
Using Tilt and "non-idealities" in hand positioning



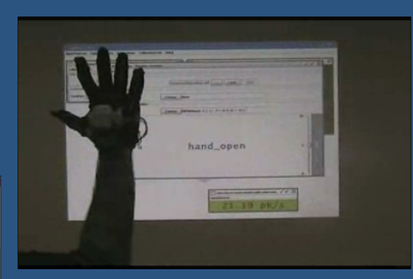
Tracking
Real-time Hand movements mapping on a 3D virtual hand



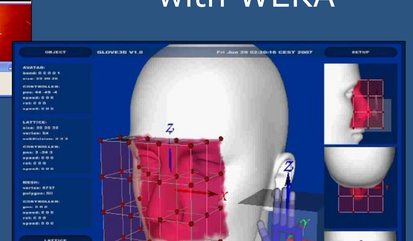
Playing music
Midi Interaction and control through gestures

Cultural Heritage
2D contents navigation in the Memorial Wall in Bologna

One-handed & Two-handed HMM-based gesture classification



Gesture Recognition with WEKA

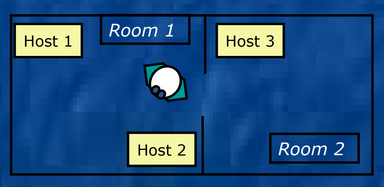


Free-Form Deformation Gesture driven

The system has been tested in a number of challenging applications: 3D game environments, interaction with 3D graphical shapes, music in a MIDI application, as a pointing device in a cultural heritage application.

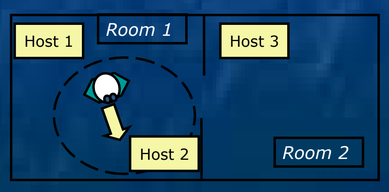
The smart wireless glove enables one and two-handed gesture recognition to implement natural interaction with CAD tools. In the project IT4CAD, gestures are used to manipulate meshes and 3D volumes and to perform free-form deformation. With two gloves the application is able to recognize combined gestures.

Proximity-aware algorithm

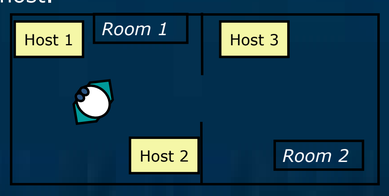


We exploit Bluetooth protocol ability to discover BT neighbors and their identity. The inquiry procedure obtains the RSSI referred to a certain device and the glove can decide to automatically associate to the selected host to interact with the application. The inquiry procedure can be repeated periodically to check the proximity of other BT devices. Similarly, the glove can be disconnected if moved far from the system, since the RSSI connection value decreases under a certain threshold.

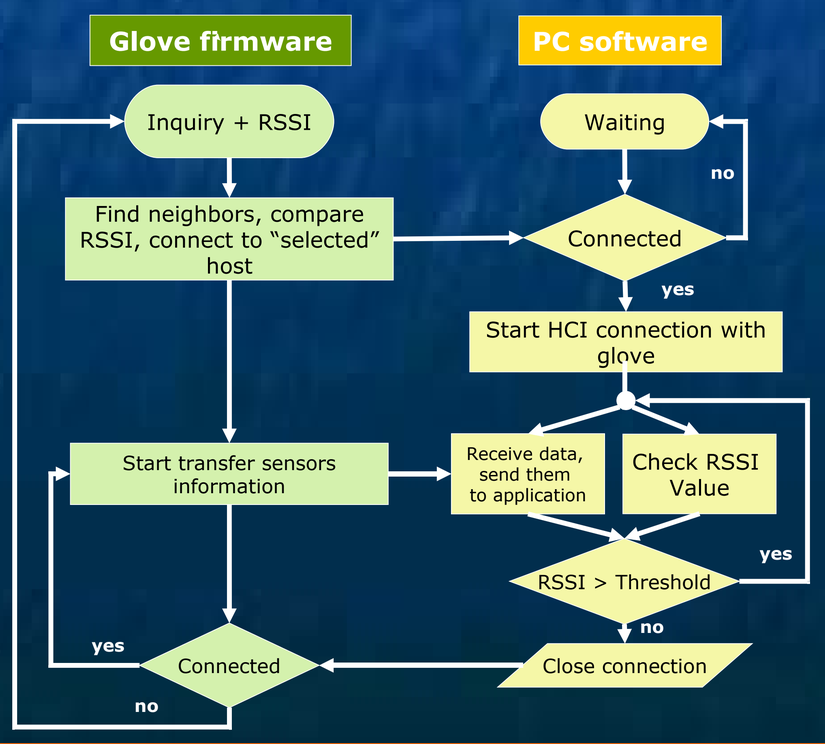
- **Inquiry**. When the driver is initialized, it performs Bluetooth Inquiry + RSSI procedure.



- **Interaction**. Bluetooth link is established and data exchange with the Smart Wireless Glove can start. The link is maintained as long as the glove is in the range and faces the host.

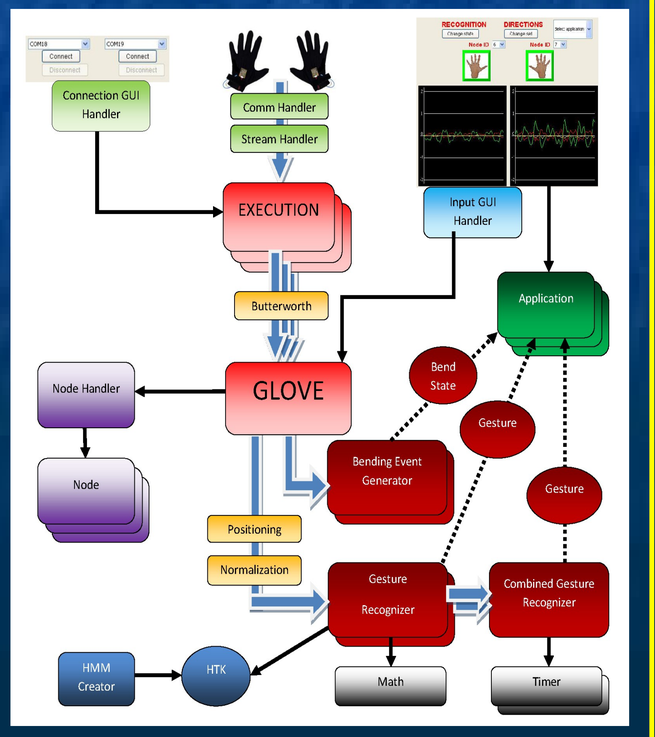


- **Disconnect**. When the user moves away and doesn't face at the host the link is closed.



Gesture Recognition

Java based application (*Glove interface*) to collect and analyze the data stream from the glove. The output of the *Glove interface* is used to control other sample applications. The Algorithm is based on **Hidden Markov Model** (GART toolkit). The application recognizes a gesture for each glove and combines them to identify a two-hands gesture. Preliminary usability test have been performed showing a fast learning curve.



Engineered prototype done in cooperation with DGTech Engineering Solutions
http://www.dg-tech.it/vhand/index.html