Novel Approaches in Image Processing (IP) and Human Centred Systems (HCSs)

Giuseppe Placidi, Danilo Avola, Andrea Petracca, Matteo Spezialetti
University of L’Aquila, Department of Life, Health and Environmental Sciences
Via Vetoio Coppito 2, 67100, L’Aquila, Italy
{danilo.avola, andrea.petracca, giuseppe.placidi, matteo.spezialetti}@univaq.it

Luigi Cinque, Stefano Levialdi
Sapienza University of Rome, Department of Computer Science
Via Salaria 113, 00198, Rome, Italy
{cinque, levialdi}@di.uniroma1.it

Abstract
The Image Processing (IP) and Human Centred Systems (HCSs) are attractive and current topics of the Computer Science (CS) field. This paper provides methods and algorithms to support these topics in everyday application environments (e.g., entrainment) as well as in specialistic contexts (e.g., rehabilitation). In particular, it is focused on the dissemination of our most recent results obtained in the following research areas:

Signal Processing: we show our advances in Image Processing (IP) with respect to the following matters: Adaptive Acquisition and reconstruction of biomedical images, 3D Reconstruction of dental models, and Analysis of brain images.

Human Centred Systems: we show our advances in Human-Computer Interaction (HCI) with respect to the following matters: Sketch Recognition, Gesture Recognition, and Handwriting Identification. We also present advances in Human Body Modelling (including hands) and Human Body Recognition (HB-R) and Tracking (HB-T) (including hands).

Keywords: Image Processing, Human-Centred Systems, Human-Computer Interaction, Recognition and Tracking of the Human Body

1. Introduction
The next three sub-sections summarizes recent works in IP, HCI, and HB-R & HB-T, respectively. Basic details and references are also given.
Figure 1. (a) reports the mask obtained as union of a set of adaptive masks, (b) a visual prospective during the implant design, (c) segmentation and labelling of an MRI brain slice.

**Image Processing (IP)**

As regards the acquisition of biomedical images (Fig. 1a) we demonstrated that, by using adaptive methods and $L_0$-homotopic minimization, we can reconstruct an image with a number of samples which is very close to the sparsity coefficient of the image without knowing a-priori the sparsity of the image. We highlighted two important aspects: 1) the width and the number of samples of the starting dataset that initiate the adaptive process, 2) how well the termination criteria allowed the acquisition of the optimal number of coefficients. The methods were tested on MRI cardiac images as well as other biomedical images [1][2][3]. Moreover, most acquisition strategies have been presented for MRI, in order to eliminate the distortion effects due to magnetic field inhomogeneity [3] [18].

As regards the 3D reconstruction of biomedical images (Fig. 1b) we have focused on developing a general purpose framework to support the 3D reconstruction, rendering and processing of biomedical images. Recently, we equipped the framework with a plug-in mechanism to process any kind of image. Moreover, we implemented the Implant plug-in, a structured component to model customised dental implants on a 3D representation of the oral cavity derived from diagnostic images [4][5].

As regards the analysis of biomedical images (Fig. 1c) we focused on developing the Texture based Computer Aided Diagnosis Framework (T-CAD Framework), a general purpose framework to support the texture analysis and the morphological reconstruction of brain MRI data. In particular, we have demonstrated that a set of customized first and second order statistics based operators can be used to provide a mathematical description of the brain tissues. The method can be applied on each tissue of the human body [6][7].
Figure 2. (a) reports the typical sketch components: freehand drawings and handwritten text. Each component is recognized as text or drawing, subsequently they are recognized and vectorized, (b) reports the working of a sketch-based interface able to recognize the movements of a led pen, (c) reports a typical off-line input provided to a trained system which will recognize the related writer.

Human-Computer Interaction (HCI)

As regards the sketch recognition (Fig. 2a) we have focused on developing Sketch SeParatiOn and REcognition Framework (SketchSPore Framework), a system designed both to automatically distinguish graphical from textual elements within the same sketch and to recognize freehand drawing as well as handwriting. Our recognition approach supports both on-line and off-line modes, moreover it has been implemented according to the XML policies to facilitate its integration with various applications [8][9].

As regards the gesture recognition (Fig. 2b) we have focused on developing different gesture-based interfaces. We have conceived various approaches to recognize tools, hands, and body gestures. We adopted different devices (e.g., Kinect, LEAP Motion) and designed ad-hoc algorithms according to the specific application context. Recently, we have focused on the recognition of the body, hands and fingers (without markers) to implement a set of Natural User Interfaces (NUIs) to support entrainment, icon browsing, data managing, and rehabilitation environments [10][11].

As regards the handwriting identification (Fig. 2c) we have focused on analysing the handwriting to study different personal characteristics of the human subjects, including identity, character, and neurological disabilities. Recently, we have conceived an handwriting identification approach based on the computation of the static and dynamic features of the strokes [12][13].
Recognition & Tracking of the Human Body (HB-R & HB-T)

As regards the human body modelling and the human body estimation and tracking (Fig. 3a and Fig. 3b) we have focused on developing different approaches to reconstruct and track the volumetric shape of the body as well as its skeleton. Recently, we have designed a framework supporting vision-based gesture recognition and virtual environments for fast prototyping of customized exercises for rehabilitation purposes. The goal was to provide skilled users with a tool for fast implementation and modification of specific rehabilitation exercises. We have also implemented a set of pilot examples [14][15].

As regards the hand modelling and the hand estimation and tracking (Fig. 3c) we have focused on developing different approaches to reconstruct and track the skeleton of the hands and its joints. Recently, we have developed a virtual glove system which can be adopted in different application contexts [16].

Patents

Some of the described approaches are subjects of patents [17][18][19][20].

References


