



Department of Information Engineering
University of Siena

Research Activities 2010

Research Areas



Computer Vision



Haptics & Virtual Reality



Medical Application



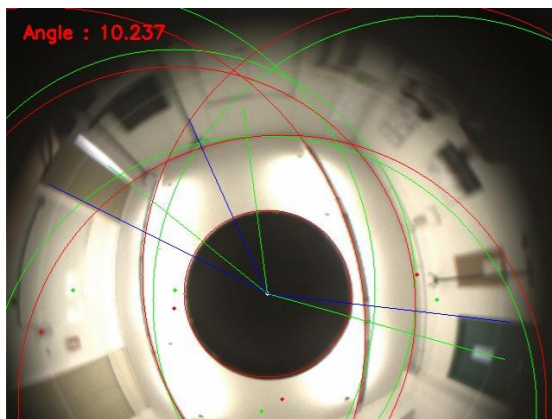
KUKA Control Toolbox

The KUKA Control Toolbox (KCT) is a collection of MATLAB functions developed at the University of Siena, for motion control of KUKA robot manipulators. The toolbox, which is compatible with all 6 DOF small and low payload KUKA robots that use the Eth.RSIXML, runs on a remote computer connected with the KUKA controller via TCP/IP.



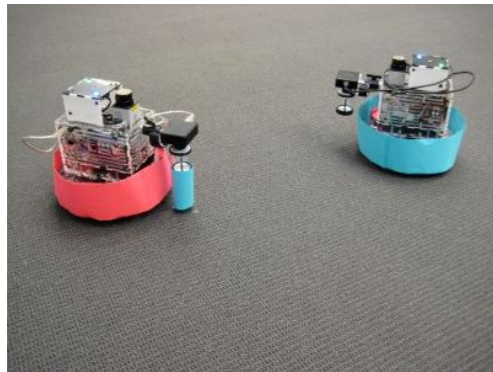
Planar Catadioptric Stereo Vision

Planar Catadioptric Stereo vision sensors (PCS) combine a pinhole camera with two or more planar mirrors. We propose new multi-view properties for PCS and address the image-based camera localization, mirror calibration and 3-D scene reconstruction problems.



Uncalibrated Paracatadioptric Visual Compass

Due to their panoramic field of view, paracatadioptric cameras are becoming ubiquitous in many robotics applications. We present new multi-view properties for paracatadioptric cameras that we use to design a visual compass algorithm for the estimation of the z-axis camera rotation angle. The proposed algorithm only needs the image projection of 3-D parallel lines, does not require any prior knowledge on the internal camera parameters, is robust to noise data and suitable for a real-time implementation.



Vision-based Localization and Control of Multi-Robot Formations*

We present a multi-robot (leader-follower) framework where each robot is equipped only with a panoramic camera addressing both the problems of vision-based observability (and localization) and control, also.

* In cooperation with Kostas Daniilidis and George J. Pappas (GRASP Lab, UPENN, USA)

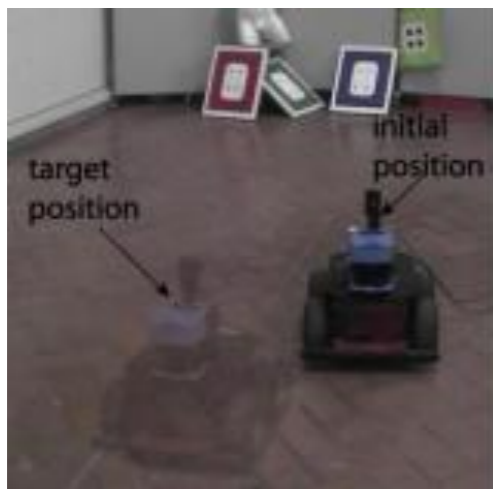


Image-based Visual Servoing for Mobile Robot Using Epipolar Geometry*

We present an image-based visual servoing strategy for asymptotically driving a mobile robot equipped with a partially uncalibrated pinhole camera toward a target position. Our approach uses the epipolar geometry and does not need any knowledge of the 3-D scene geometry.

* In cooperation with Giuseppe Oriolo ("La Sapienza", Rome, ITALY)

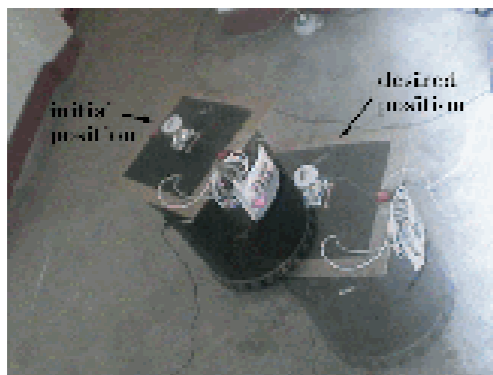


Image-based Visual Servoing for Central Catadioptric Cameras

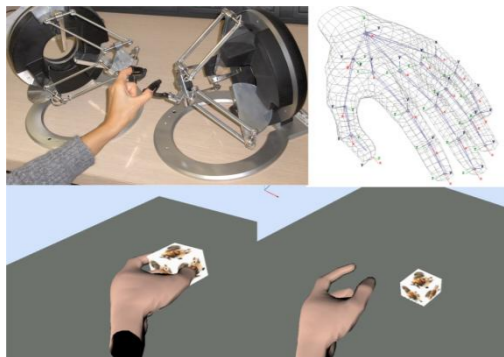
We present an image-based visual servoing strategy for a holonomic mobile robot equipped with a central catadioptric camera. This kind of vision sensor combines lens and mirrors to enlarge the field of view. The proposed visual servoing is mainly based on the auto-epipolar condition.

FP7 THE - The Hand Embodied



THE Hand Embodied refers to the “hand” as both a cognitive entity – standing for the sense of active touch – and as the physical embodiment of such sense, the organ, comprised of actuators and sensors that ultimately realize the link between perception and action. The general idea is to study how the embodied characteristics of the human hand and its sensors, the sensorimotor transformations, and the very constraints they impose, affect and determine the learning and control strategies we use for such fundamental cognitive functions as exploring, grasping and manipulating. The ultimate goal of the project is to learn from human data and hypotheses-driven simulations how to devise improved system architectures for the “hand” as a cognitive organ, and eventually how to better design and control robot hands and haptic interfaces. The project was supported by the European Commission in the context of the European project “The Hand Embodied” (THE), Grant Agreement n. 248587.

Animating a 3D biomechanics-based hand avatar in haptic grasping



In spite of the great deal of development, often Virtual Reality users complain they cannot see an avatar of their hands in the virtual simulation scenario, thus losing a relevant visual feedback commonly available in the real world. A 3D deformable hand avatar for virtual grasping using multiple single-contact-point haptic devices is presented. The proposed technique has two main advantages. First, the whole hand motion is reconstructed by measuring fingertips positions and using a biomechanical model of the hand along with the postural synergies characterizing grasping actions. Secondly, the computational performance of this method allow high-rate servo-loop for stable haptic interaction.

Remotouch



Technologies for remote touch have been typically used in robotic teleoperation and the used devices are very far from being portable, cheap or widely used in everyday life. The idea of RemoTouch consists of substituting the slave robot with a human operator and the exoskeleton with a simple tactile device. The device in charge of recording tactile perception is not a robot but a human avatar with a glove instrumented with force sensors. It is able to collect tactile, along with audio and video, signals used as feedback which is sent to the remote user. The force feedback is presented to the remote user by a simple and wearable tactile display.



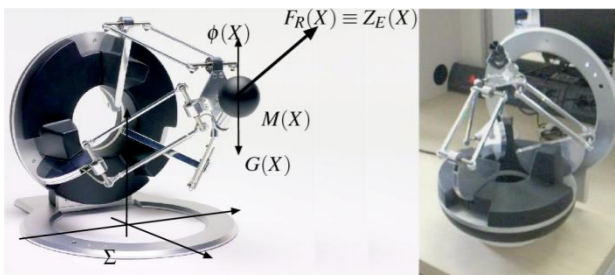
Shape and Weight Rendering for Haptic Augmented Reality

Haptic interfaces in Augmented Reality scenarios are an efficient way to enhance the interaction with a virtual world. We introduce a new system that involves both hands in virtual object experience. We render contemporary shape and weight of a virtual object, merged in a real world environment, using a commercial haptic interface and a new kind of finger-worn device.



Modular Robot: Application To Grasping

We are working on new applications for modular robots. Since now almost all the research in modular robot is on locomotion and self-reconstruction; we introduced two new tasks: Task Oriented modular grasping and Motion Oriented modular grasping.

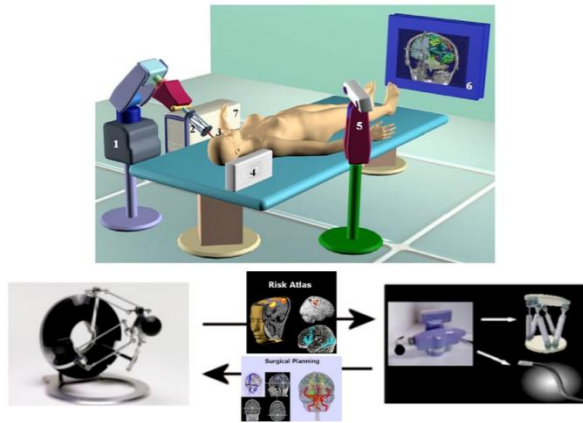


Libralis - Autocalibrated Gravity Compensation

In this research line, the target is studying general algorithms to setup an autocalibrated algorithm for gravity compensation. The algorithm is based on iterative estimations performed directly on the device of interest, then it is able to account for hardware customization and to work for any desired orientation in which the device has been displaced.

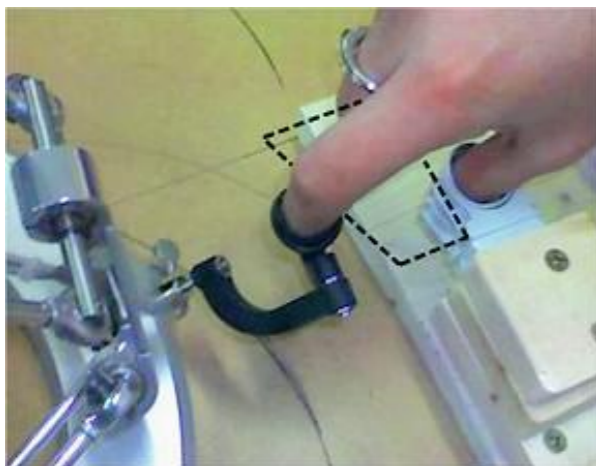
FP7 RoboCAST Project

The ROBOCAST project aims to develop ICT scientific methods and technologies which focus on robot assisted keyhole neurosurgery. A modular master-slave tele-manipulation system will be developed. The slave system will integrate 2 robots and one active bio-mimetic probe, able to cooperate among themselves in a biomimetic sensory-motor integrated framework. The master interface (SIRSLab WorkPackage) allows the surgeon to remotely control the probe motion and provides the force-feedback. The project is supported by the European Commission in the context of the European Project “The Hand Embodied” (THE), Grant Agreement n. 248587



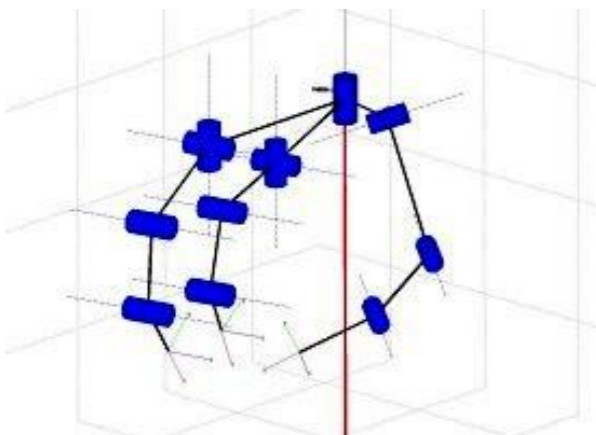
Augmented Kinesthetic feedback

Common single-contact-point force-feedback devices generally cannot convey local tactile feedback to the fingertip receptors, as it usually happens in real object manipulation. In this research, the target consists of designing new contact models for kinaesthetic stimulation in order to augment information that can be conveyed to user's sense of touch during virtual manipulation tasks.



Grasp Analysis

The grasp problem is a topic that has attracted considerable scientific attention, ranging from robotics, virtual reality, psychophysics and rehabilitation. The aim of this research, is the study of grasp stability, defining a set of contact forces that satisfy grasping constraints and formalizing grasp like a minimization problem.





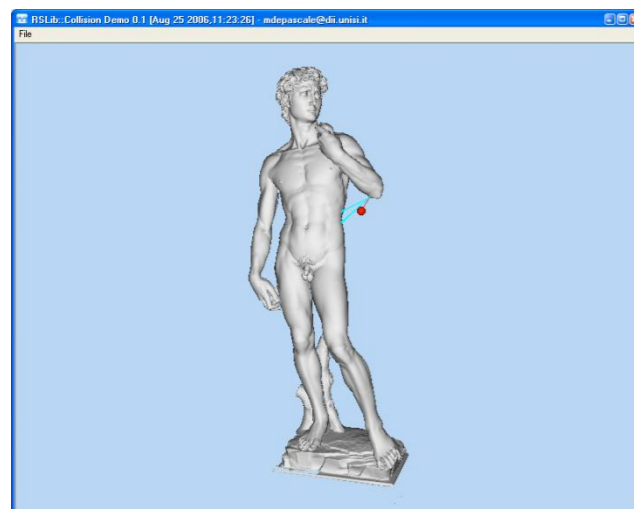
Bringing Haptics to Second Life

This project is aimed at exploring the possibilities that haptic technologies can offer to multiuser online virtual worlds, to provide users with an easier, more interactive and immersive experience. An haptics-enabled version of the Second Life Client, supporting major haptic devices, has been developed. Two main haptic-based input modes have been added to the original viewer which help visually impaired people to navigate and explore the simulated 3D environment by exploiting force feedback capabilities of these devices.



Establishing IEEE/RAS Points of Presence and Initiatives in Second Life

The project “Establishing IEEE/RAS Points of Presence and Initiatives in Second Life (SL)”, realized thanks to the contribution of the IEEE Robotics and Automation Society, consists of setting up a permanent location in this virtual environment, in the form of a building, with poster-like material and videos presenting the aim and services of the IEEE/RAS. A further objective of this project is that of reproducing in SL simplified behaviors of real world robots and auto-responding desk assistants.



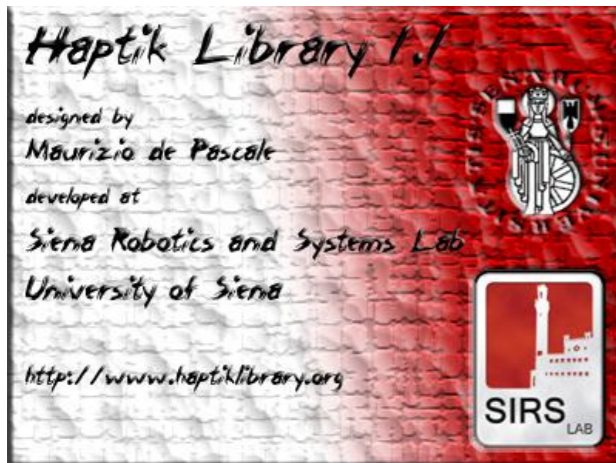
Voronoi Based Collision Detection for Haptics

The V-GRAPH is a framework for bounded time collision detection of point-like haptic interactions. It is based on an ad-hoc partitioning of space which makes its running time independent from mesh properties like number of vertices and triangles. The framework effectively works with haptic rendering of multimillion triangles meshes such as those used for virtual museum.



GPU-Friendly Local Deformations

This is a method for modeling realistic dynamic local deformations, which has been designed to be executable also on the GPU.



The Haptik Library

Haptik is a small opensource library providing a simple yet powerful API for low level access to haptic devices from multiple vendors. It also allows to use haptic devices within Matlab, Simulink and Java, as well as other scripting languages (like Python, for instance).



Haptic Digital Watermarking

Digital Watermarking is widely used to embed unperceptible signatures into media data such as audio files, images and also 3D meshes. The target of this study is that of embedding watermarks in data, triangular meshes, perceivable with haptic devices.



Mobile Haptic Interfaces

Mobile Haptic Interfaces consists of a force-feedback device mounted on a mobile robot. Mobile base allows to enlarge the limited workspaces of commercial haptic interfaces. The global effect of immersion inside virtual reality is highly enhanced by the possibility to indirectly stimulate vestibular apparatus, thus involving also user's sense of orientation in the simulation.



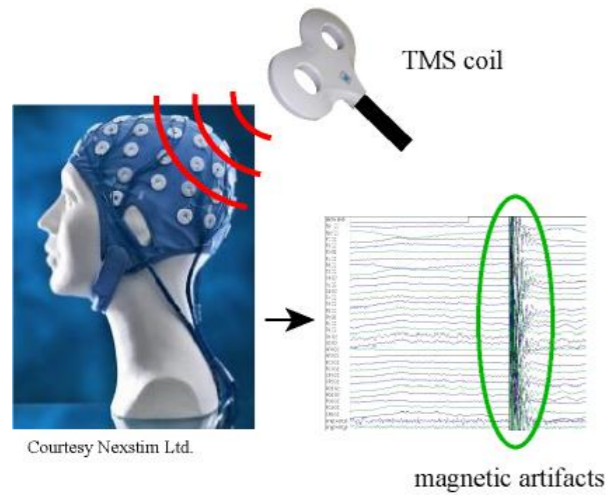
Virtual Grasping

In Virtual Grasping simulations, the human hand interacts with force-feedback systems composed by multiple 3DoF single-contact-point haptic devices, one per finger. This allows to simulate interaction via two contact points (pinch grasp) or three contact points (tripod grasp).



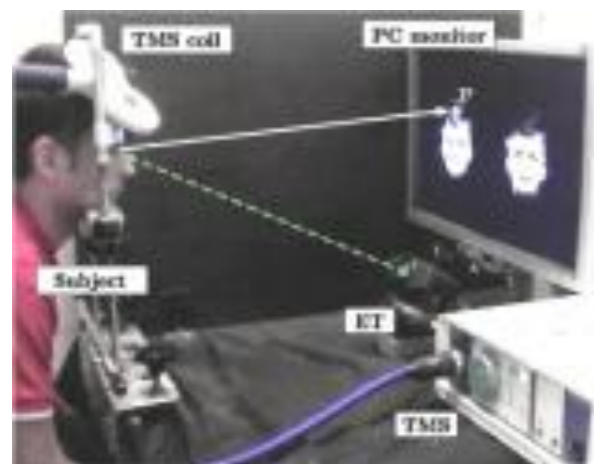
Interactive Fluid Simulation

Interaction with fluids is very frequent in our everyday lives (as an example, when we stir a cup of coffee in the morning). This research arises in order to allow users to interact with virtual fluids through an haptic device as well as an interaction with virtual rigid or deformable objects. An haptic simulation usually needs updating rates about 1 KHz. That's why it is necessary to find a method to make the computation of the force perceived by the human operator as fast as possible.



Suppression of TMS-induced artifacts from EEG by Kalman filtering

We present an off-line Kalman filter approach to remove transcranial magnetic stimulation (TMS) induced artifacts from electroencephalographic (EEG) recordings. This approach proved to be more effective than stationary filters (Wiener filter) for the problem under investigation.



Human-Robot Interaction for Active Rehabilitation in Cognitive and Emotional domains

We present here a new human-robot interface (HRI) for active interaction with the cognitive and emotional human domains with interesting applicability in the study and treatment of depression. This work has been realized in cooperation with the physicians of the Department of Neuroscience at the University of Siena.



ASTIDET software

ASTIDET v2.0 software, an important feature of our HRI, manages the integration and synchronization of ET (Eye-Tracker) and TMS (Transcranial Magnetic Stimulation).