MeSRob 2013 International Exploratory Workshop
NEW TRENDS in MEDICAL and SERVICE ROBOTICS

Date: 11th to 13th July, 2013

Venue: Mihailo Pupin Institute - Belgrade, Serbia

Organized by: Robotics Laboratory**,** Mihailo Pupin Institute, University of Belgrade, Serbia;

Swiss National Scientific Foundation, Switzerland

Scope:

The 2nd International Exploratory Workshop on new trends in medical and service robotics will be held in the Mihailo Pupin Institute, Belgrade, Serbia. The workshop is envisaged to bring together in a collegial and stimulating atmosphere invited reputed speakers dealing with multi-disciplinary aspects of medical and service robotics and applications. In accordance with the objectives, the MESROB 2013 will cover the main areas of robotics research, medical and service robotics and applications, etc. Presentations are focused on topics related to one of the following general and particular areas of interest but not limited to:

- Robot kinematics and dynamics
- Parallel robots and mechanisms
- Design, modeling, system identification and simulation
- Bio-inspired robotics and bio-mimetic systems
- Medical robots, active prosthesis and exoskeletons
- Remote diagnosis and surgery
- Elderly assistive robots
- Service robots (indoor and outdoor)
- Robotic vision and sensing
- Navigation, motion planning and control
- Cognitive robotics
- Social and behavioral robotics
- Robot learning and intelligent handling
- Dual-arm systems, anthropomorphic hands, manipulation
- Human-robot interfaces, etc.

Pre-Program

Tuesday, July 9, 2013

TIME	PLENARY LECTURE
09:00 - 11:00	› From Recent Studies of Humanoid Robotics *Yoshihuko Nakamura (Department of Mechano Infromatics, University of Tokyo, Tokyo, Japan)*

Workshop Program

Thursday, July 11, 2013

TIME	EVENT
09:00 - 09:30	**Registration**
09:30 - 10:20	**Opening ceremony**
10:20 - 12:00	**Session 1 –** ***Hannes Bleuler***
10:20 - 10:40	› Robotic Assistance for Senior People *Klaus Schilling (Julius-Maximilians-University Wuerzburg Am Hubland, Wuerzburg, Germany)*
10:40 - 11:00	› Robot as Assistive Technology in Treatment of Children with Developmental Disorders *Branislav Borovac (University of Novi Sad, Novi Sad, Serbia)*
11:00 - 11:20	› Control of robot assistant for the training of upper extremities movements *Dejan B. Popović* **, Miloš Kostić*, Maša Popović** **(University of Belgrade, Belgrade, Serbia)* ***(Aalborg University, Denmark)*
11:20 - 11:40	› Advanced Medical and Rehabilitation Robots *Huosheng Hu (University of Essex, Colchester, United Kingdom)*
11:40 - 12:00	› Rehabilitation Robotics for lower limbs - A case study with clinical trials *Mohamed Bouri*, Elahe Abdi*, Hannes Bleuler*, Olivier Deriaz** and Fabienne Reynard*** **(Laboratoire De Systèmes Robotiques Ecole Polytechnique Fédérale de Lausanne (EPFL) Lausanne – Switzerland)* ***(Institut de Recherche en Réadaptation, Réinsertion (IRR) Sion – Switzerland)*
12:00 - 15:00	**Lunch pause**
15:00 - 16:20	**Session 2 –** ***Doina Pisla***

15:00 - 15:20	› The Role of Haptics in Biomedical Human-Robot Interface *Hannes Bleuler, Mohamed Bouri, Simon Gallo, Jeremy Olivier, Solaiman Shokur and Ali Sengül (EPFL, Lausanne, Switzerland)*
15:20 - 15:40	› Towards haptic-based teleoperation by FPGA *Aleš Hace, Marko Franc (University of Maribor, Slovenia)*
15:40 - 16:00	› Generalized Backdrive and Compliant Motion Control of Multi Joint Robot Arm in Medical Physical Interaction with Humans *Petar B. Petrović, Nikola Lukić and Ivan Danliov (University of Belgrade, Belgrade, Serbia)*
16:00 - 16:20	› Robot skill acquisition by demonstration and explorative learning *Bojan Nemec, Aleš Ude (Jozef Stefan Institute, Ljubljana, Slovenia)*
16:20 - 16:40	**Coffee break**
16:40 - 18:20	**Session 3 – *Klaus Schilling***
16:40 - 17:00	› Control of an Autonomous Bucket Excavator for typical Construction Tasks *Karsten Berns, D. Schmidt and G. Zolynski (University of Kaiserslautern, Kaiserslautern, Germany)*
17:00 - 17:20	› Dynamic and control of quadrotors and some considerations related to service operations *Amit Aillon (Dept. of Electrical and Computer Engineering, Ben Gurion University of the Negev, Israel)*
17:20 - 17:40	› Learning motor skills on the iCub *Giorgio Metta (Istituto Italiano di Tecnologia, Genoa, Italy)*
17:40 - 18:00	› Moving from 'how to go there?' to 'where to go?': Towards increased autonomy of mobile robots *Francesco Amigoni (Politecnico di Milano, Milano, Italy)*
18:00 - 18:20	› Two faces of human-robot interaction: service and field robots *Rodrigo Ventura (Instituto Superior Técnico, Lisbon, Portugal)*
20:00	**Dinner**

Friday, July 12, 2013

TIME	EVENT
9:00 - 10:40	**Session 4 – *Karsten Berns***
09:00 - 09:20	› ZMP-based biped walking control of a humanoid robot for entertainment *Shuuji Kajita, Morisawa, Kanako Miura, Shin'ichiro Nakaoka, Kenji Kaneko, Fumio Kanehiro, Kazuhito Yokoi (Intelligent Systems Research Institute, AIST, Tsukuba, Japan)*
09:20 - 09:40	› Imitation of human motion by a humanoid while preserving dynamic equilibrium *Christine Chevallereau, K. Munirathinam, S. Sakka (Institut de Recherche en Communications et Cybernetique de Nantes, Nantes, France)*

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09:40 - 10:00	› Experiences on service robots at LARM in Cassino *Giuseppe Carbone, Marco Ceccarelli (University of Cassino and South Latium, Cassino, Italy)*
10:00 - 10:20	› How to Control Anthropomimetic Robots – Engineering and Cognitive Approach *Veljko Potkonjak, Kosta Jovanović and Predrag Milosavljević (University of Belgrade, Belgrade, Serbia)*
10:20 - 10:40	› Contributions on the modelling and simulation of the human joints with applications to the robotic structures *Daniela Tarnita*, M. Catana*, C. Berceanu* and D.N. Tarnita*** **(University of Craiova, Romania)* ***(University of Medicine and Pharmacy, Craiova, Romania)*
10:40 - 11:00	**Coffee break**
11:00 - 12:20	**Session 5 –** ***Dejan Popović***
11:00 - 11:20	› Robotics in restorative medicine *Vladim Golovin (Moscow State Industrial University, Moscow, Russia)*
11:20 - 11:40	› Dependable System Design for Medical Robots *Achim Wagner (Heidelberg University, Mannheim, Germany)*
11:40 - 12:00	› New results on classifying EMG signals for interfacing patients and mechanical devices *Giuseppina C. Gini, Flavio Mutti, Paolo Belluco, Alessandro Mauri (Politecnico di Milano, Milano, Italy)*
12:00 - 12:20	› Building of Emotional Intelligence with Service Robots *Aleksandar Rodić (Mihailo Pupin Institute, University of Belgrade, Belgrade, Serbia)*
12:20 - 15:20	**Lunch break**
15:20 - 16:40	**Session 6 –** ***Veljko Potkonjak***
15:20 - 15:40	› Innovative Approaches regarding Robots for Brachytherapy *Doina Pisla, Nicolae Plitea (Technical University of Cluj-Napoca, Romania)*
15:40 - 16:00	› Design of a parallel manipulator with variable actuation *Philippe Wenger (Institut de Recherche en Communications et Cybernetique de Nantes, Nantes, France)*
16:00 - 16:20	› Some Applications of Biomimetics and Fractional Calculus in Control and Modeling of (Bio)robotic Systems *Mihailo Lazarević (University of Belgrade, Belgrade, Serbia)*
16:20 - 16:40	› The dynamic behaviour of a 3-RPS manipulator in the neighborhood of a transition pose between operation modes *Josef Schadlbauer*, CalinVaida**, Andras Szilaghyi**, Manfred Husty*, DoinaPisla*** **(University of Innsbruck, Austria)* ***(Technical University of Cluj-Napoca, Romania)*
16:40 - 17:00	**Coffee break**

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17:00 - 17:40		**Session 7 – *Aleksandar Rodić***
	17:00 - 17:20	› Testing Capacity for Space Technology Suppliers *Adrian Pisla, CalinVaida (Technical University of Cluj-Napoca, Romania)*
	17:20 - 17:40	› Advanced Gesture and Pose Recognition Algorithms using Computational Intelligence Paradigms and Microsoft KINECT Sensor *Duško Katić*, Petar Radulović**, Sofija Spasojević*, Željko Đurović**,Aleksandar Rodić** **(Mihailo Pupin Institute, University of Belgrade, Belgrade, Serbia)* ***(University of Belgrade, Belgrade, Serbia)*
20:00		**Dinner**

Saturday, July 13, 2013

TIME	EVENT
08:00	**Excursion (bus departure from the hotel)**
12:00	**Lunch**
14:00	**Visit to Park of nature "Wet Mountain"**
19:00	**Dinner**
21:00	**Back to hotel**

Contents

SE1.1 Klaus Schilling (Julius-Maximilians-University Wuerzburg Am Hubland, Wuerzburg, Germany)

Robotic Assistance for Senior People

The aging societies worldwide raise challenging tasks for robotic assistance systems. In a large scale research effort of industry and academia, the project “Fit4Age”focused on technologies to support senior people in a self-determined, independent life. In this context, robotic assistance systems supported mobility aspects and industrial work places. Demonstrators were developed and tested by senior users in typical environments.

Safe mobility is a key requirement to participate in social life. For this demand, a robotic vehicle for robust short range mobility in a city environment was realized. Navigation equipment was adapted for a pedestrian environment with highlighting safety aspects. So preferences for route planning emphasize inclusion of park areas, pedestrian zones and safe street crossings at traffic lights or cross-walks, but also avoid difficult paths including stairs or barriers. The navigation system and ranging sensors to provide related functions are addressed in this presentation.

Industrial production is confronted with an increasing age average of personnel, too. While the experience of the senior workers is appreciated, robotic assistance systems are in demand to relieve workers from carrying heavy loads, as well as sensor systems to support appropriate reactions in safety critical situations. Robotic arms should act as a “third hand” near to the worker respecting the high safety requirements, which is realized by sensor and control approaches. For an intuitive interface to the worker augmented reality and projective methods were used to visualize to the future robot movements.

Extensive tests of the demonstrators by a senior user community of about 160 retired people provided direct feedback to the development process and encouraged future activities.

SE1.2 Branislav Borovac (University of Novi Sad, Novi Sad, Serbia)

Robot as Assistive Technology in Treatment of Children with Developmental Disorders

This presentation is aimed to give brief overview of the project “Design of Robot as Assistive Technology in Treatment of Children with Developmental Disorders” funded by Ministry of education, science and technological development, Republic of Serbia.

The project aim is to develop an assistive technology aid to improve the work with children with developmental disorders (impaired motor and disharmonious development, cerebral palsy, hearing and emotional disorders, etc.). The main goal of the application of these means of assistive technology is to ensure long-lasting motivation for acquiring new skills, creation of the conditions for an easier application of treatment procedures, and achieving faster treatment effects. The intention is to take

advantage of the child's existing capabilities with the aim of developing its maximum potentials through play and entertainment. The application areas are: mastering of basic life skills, communication, visual, auditory and tactile reception of information, cognitive abilities, social interactions, mobility, and child's emotional functioning.

To define basic robot's characteristics the entire research team was jointly engaged. On the basis of developmental characteristics of children to whom robot is dedicated we arrived at the concrete conclusions about the shape, appearance and other basic characteristics of the robot.

The main requirement is safety. The robot has to be safe for the work in the intrinsically human environment, and this requirement must be unconditionally fulfilled.

Very important is task to be achieved is the child-robot communication: gestural reaction to the touch, voice (understanding and synthesis of speech) and visual stimuli. Stimulation by speech may be very efficient in the sense of encouraging the efforts to perform a given exercise. Also, robot must exhibit appropriate behavior and reaction during the work with children. All the robot's reactions have to be based on the corresponding sensory information: visual perception, identification of what was uttered and the synthesis of the appropriate response, and on tactile information. Besides, the synthesized robot's movements have to be by their dynamic characteristics as close as possible to those of human, i.e. they should be anthropomorphic to the highest possible extent.

The appropriateness of the realization of the robot is subject of constant critical re-examination and improvement during all the time of the project realization.

SE1.3 Dejan B. Popović* **, Miloš Kostić*, Maša Popović*, *(University of Belgrade, Belgrade, Serbia), **(Aalborg University, Denmark)

Control of robot assistant for the training of upper extremities movements

Recent results in the rehabilitation of stroke and other patients with central nervous system related paralysis of upper extremities suggest that intensive assisted training is beneficial for the recovery of functioning. The intensive exercise consists of the repetitive task related training which contributes to the modification in the excitability and due to cortical plasticity allow carry over effects. We are addressing the use of 3D robot assistants that interface the patient at the hand. The research aims at improving the setup of the tasks that are suitable for patients and allow progressive learning. Our design integrates the robot assistant into a gaming that is essential for increasing the motivation for the training. The basis of the design is the movement representation of the end of the 3D robot assistant in form that can be created easily to match the abilities of the patient. The movement representation, termed Probability Tube, considers the end point trajectory as a stochastic process and uses probability methods to generate the space in which the velocity belongs to the surrounding of the preferred trajectory that has been recorded in healthy persons. The developed system is robot assistant with haptic interface to the user. The haptics is realized by means of a special handle with multiple force sensors. The new approach has been demonstrated to work effectively in the clinical trials with stroke patients.

SE1.4 Huosheng Hu (University of Essex, Colchester, United Kingdom)

Advanced Medical and Rehabilitation Robots

As the level of intelligence and robustness in robotics technologies advances and computers become more powerful, robots are gradually doing formerly human manual work in the operating theatre and hospitals. Currently, there are three new trends in advanced medical and rehabilitation robots. The 1st new trend is the application of surgical and implantable robots to improve consistency and reliability, promote minimum invasive for fast patient recovery, as well as reduce the time of surgery operations. The 2nd new trend is the application of wearable and assistive robots to support mobility and independent living of patients and elderly. The 3rd new trend is the use of network technology and tele-operated robots for home-based healthcare and rehabilitation at a reduced cost. This talk will focus on these trends and uncover what they tell us about the future of the field. Some successful systems are demonstrated via video clips.

SE1.5 Mohamed Bouri*, Elahe Abdi*, Hannes Bleuler*, Olivier Deriaz** and Fabienne Reynard**, *(Laboratoire De Systèmes Robotiques Ecole Polytechnique Fédérale de Lausanne (EPFL) Lausanne –Switzerland), **(Institut de Recherche en Réadaptation, Réinsertion (IRR) Sion – Switzerland)

Rehabilitation Robotics for lower limbs - A case study with clinical trials

Robotics is increasingly used in rehabilitation therapies for paraplegics, tetraplegics and post stroke suffering subjects. This is mainly due to the opportunity to take advantages of the motorized mobilization providing controlled movements and the possibility to implement different sensory motor feedback strategies. Furthermore, the intelligence of such devices also allows the measurement of the progress of the patient during the therapy and interacts with it. The exercises may have different objectives depending on the pathology. They may seek to reduce hypertonia, increase the joint range of motion, improve the plasticity behavior of the limb, increase muscular forces, decrease spasms or reach various other objectives. Robotized devices provide repetitive, precise and totally instrumented mobilization of the limbs.

The work concerned with this presentation will focus on the MotionMaker Rehabilitation device developed in the Laboratoire de Sytèmes Robotiques. It provides the mobilization of the entire joints of the legs (Hip / Knee and Ankle of each Leg). The original (and patented) adopted therapy associates mobilization and closed loop muscle electro stimulation.

In this presentation, the MotionMaker and its components will be introduced. The rehabilitation strategy combining mobilization and the sensory feedback through force sensors will be presented and the clinical progress of 10 subjects of the CRR (Clinique Romande de Réadaptation, Sion, Suisse) will be discussed. The rehabilitation protocol will also be presented with its evaluation and exercise phases.

SE2.1 Hannes Bleuler, Mohamed Bouri, Simon Gallo, Jeremy Olivier, Solaiman Shokur and Ali Sengül (EPFL, Lausanne, Switzerland)

The Role of Haptics in Biomedical Human-Robot Interface

Although in recent years the visibility and the number of reported research projects on haptics has significantly increased, there are still few practical realizations of closed loop haptics. ("Open-loop haptics" is since a long time practiced under other keywords, such as e.g. ergonomics. Think of how a car manufacturer tunes the "feel" of his product). In this talk, we focus on biomedical application of haptics, where there are two rapidly developing fields:

1) Rehabilitation
2) Instrumentation with force feedback
3) Cognitive Neuroscience

In rehabilitation, the potential of haptics in combining both, motion and force control is of absolutely central interest and the outlook for the future, both short and longer term, is brilliant. We will illustrate one example from the "walk-again project"

In instrumentation, we will mainly focus on teleoperators with force feedback and we will also address the issue of multi-modal haptic feedback. The link of haptics with cognitive neuroscience will be illustrated by a research project, which had implications on both, neuroscience and design of new surgical tools.

SE2.2 Aleš Hace, Marko Franc (University of Maribor, Slovenia)

Towards haptic-based teleoperation by FPGA

This presentation covers approach that leads towards haptic-based performance in bilateral teleoperation. For cutting-edge performance of various mechatronic systems high control rate was recognized as a significant system design parameter. Therefore, FPGA-based controller that allows high-speed and parallel signal processing can present an advanced solution though it offers only limited resources. The bilateral control algorithm is derived using the chattering-free sliding mode control based design approach. Such algorithm retains practical robustness to the disturbances, and provides easy model-free implementation. We propose an FPGA implementation of the bilateral control algorithm in order to achieve improved haptic fidelity. The teleoperator information such as position, velocity, and external force, are obtained pseudo-sensorless, i.e. without an external sensor; this simplifies the system design and also significantly contributes to high-haptic fidelity. The presented algorithms were validated by a laboratory master-slave experimental system. Recent experimental results confirm that high control rate significantly improve the haptic performance of bilateral teleoperator.

SE2.3 Petar B. Petrović, Nikola Lukić and Ivan Danliov (University of Belgrade, Belgrade, Serbia)

Generalized Backdrive and Compliant Motion Control of Multi Joint Robot Arm in Physical Interaction with Humans

This presentation regards to a new conceptual framework for effective application of light-weight and soft anthropomorphic robot arm in the fields of noninvasive medical diagnostics, ultrasound guided biopsy, and precise minimally invasive surgery, based on interactive ultrasound digital acquisition of anatomical structures of the patient (human body), and generation of precisely located 2d anatomical sections in real time as well as generation of spatial images for human-friendly anatomical visualization (3d sonograms obtained through volume and surface rendering) that can be used for servoing / navigation of a surgical instrument, or specific diagnostics and intraoperative quantitative measurements or analysis. Within this context, robot behaves as an intelligent co-worker that operates the ultrasound transducer with machine precision and assists sonographer or surgeon in performing ultrasound examination, and/or ultrasound feedback generation, by addressing common limitation of conventional manual 2d sonography (first of all numerous drawbacks related to human dependency, including the lack of clinical reproducibility, but also the physical fatigue that normally arise during the examination). Contrary to the free hand ultrasound scanning technique, collaborative robotic ultrasound scanning provides radically new possibilities that significantly raise medical value of ultrasonography. In this way, new imaging technology can be developed, which is simple in use, cheap in comparison to other imaging technologies (like computerized tomography or magnetic resonance imaging), and up to now has no known negative consequences to human health. Collaborative robotic ultrasound scanning can integrate three basic acquisition modes: float, haptic and autonomous, with several submodes, especially in the haptic and the autonomous mode of operation. To achieve these, the robot should be guided by a new collaborative control concept that enables robot to generate wide variety of behaviors in a complex human-robot-human interaction, which will allow human operator, i.e., sonographer, to freely drive the ultrasound transducer attached to the robot tip over the patient body (perfect backdriving behavior), or to precisely execute specified motion of the transducer, following the required position/angle/speed and/or force trajectories in a haptic or completely autonomous mode, commanded by the sonographer. This also includes automatic compensation of patient body motions like those induced by breathing, without losing the specified contact force and orientation of the ultrasound transducer, relative to the patient body. In addition to the complex multimode control system, robot should be equipped with bidirectional force-feedback human-machine interface, capable to simultaneously acquire interacting forces between the robot and sonographer and between the robot and patient. This kind of redundancy is not present in industrial applications of the soft robots. The paper presents details of the proposed concept of collaborative robotic ultrasound medical scanning system, basic analytical formulations of the multimode control system which is capable to produce specific behavior of the robot arm in complex human-robot-human interaction (various kinds of generalized backdrive and compliant behaviors), and shows experimental results in the domain of the soft robotic joint design and practical implementation of the developed analytical formulations of the robot control system to Yaskawa SIA 10F 7dof robot arm, which are carried out in the Cybernetics and Mechatronics System Laboratory.

SE2.4 Bojan Nemec, Aleš Ude (Jozef Stefan Institute, Ljubljana, Slovenia)

Robot skill acquisition by demonstration and explorative learning

The paper presents our approach to the robot skill acquisition and self-improvement of the learned skill. Initial demonstration are parameterized as Dynamic Motion Primitives and stored into a data base of actions. Whenever needed, the robot retrieves previous learned skill form the data-base and generalizes it to a new situation. If the generalization itself cannot generate an appropriate action for the given situation, the robot refines its skill by means of the reinforcement or iterative learning. In order to speed up the learning process, the algorithm searches first in the constrained manifold of demonstrated movements. For final tuning, it explores also the full dimensional space of a parameterized policy. The approach is validated with illustrative examples, taken from everyday life as well as from industrial applications.

SE3.1 Karsten Berns, D. Schmidt and G. Zolynski (University of Kaiserslautern, Kaiserslautern, Germany)

Control of an Autonomous Bucket Excavator for typical Construction Tasks

In typical construction scenarios excavators are often use e.g. for transportation, excavation, landscaping or demolition. The operational environment is mainly unstructured and rough. Due changing weather and soil conditions, the sensor reliability as well as the precision of the control is very restricted. Therefore, two main problems have to be solved for the development of an autonomous or semi-autonomous excavator: 1) the detection and scene analysis of a highly dynamical environment, and 2) navigation and manipulation under high disturbances.

In the presentation first the mechatronics of the autonomous excavator THOR (Terraforming Heavy Outdoor Robot) will be presented. Main focus of the presentation is the highly reactive control approach as well as the perception and classification of the operational environment. Often control of such typical manipulation tasks is done using finite state machines. Because of high disturbances during the excavation process a complete mapping of all system states to an automaton is almost impossible to realize. In the presentation a behavior based control approach will be discussed, which is capable of combining cyclic motion tasks with reactive adaptions to disturbances. Furthermore, it will be shown, in which way the highly dynamical environment can be modeled for supporting the excavation tasks. Components of the perception system are surface and object detection based on gathered Laser Point Clouds and landscape modeling. Based on common excavation tasks the performance of the system will be demonstrated.

SE3.2 Amit Aillon (Dept. of Electrical and Computer Engineering, Ben Gurion University of the Negev, Israel)

Dynamic and control of quadrotors and some considerations related to service operations

The first part of this talk is devoted to some kinematic and dynamic issues and basic control problems in the quadrotor (QUAD) type helicopter. A simple and robust output-based stabilizing controller is presented for the attitude and the attitude/altitude subsystems. A closed-form feedback controller is demonstrated for solving the set-point and the trajectory tracking control problems in the considered nonlinear model of the autonomous QUAD system. Next, we will evaluate the potential of this particular aerial vehicle to contribute to the emerging area of Assisting Robotics and review some possible applications. In this regard the QUAD establishes grower expectations of new technologies for applications in precision agriculture and becomes a useful tool for farmers who practices advanced agricultural technology. Fleet of QUADs could provide efficient delivery services of goods such as medicine and critical supplies to remote areas and communities. Another possible application of a small-scale QUAD system relates to rehabilitation and associated therapies fields. This considered option is based on some recent advances in rehabilitation science which show that the QUADs might be useful in encouraging patients with limited mobility to improve their range of motion and new kinect-based QUAD controllers allow users to control complex maneuvers by gestures and body postures.

SE3.3 Giorgio Metta (Istituto Italiano di Tecnologia, Genoa, Italy)

Learning motor skills on the iCub

In this talk, I will cover some recent work that uses the iCub to learn object recognition on the fly, exploit binocular vision to plan approximate grasping of the recognized object and combine it with affordance estimation in tool use tasks. The typical scenario includes a benevolent teacher that interacts with the robot by showing objects and naming them. We employ state of the art machine learning and analyze online performance of various techniques.

SE3.4 Francesco Amigoni (Politecnico di Milano, Milano, Italy)

Moving from 'how to go there?' to 'where to go?': Towards increased autonomy of mobile robots

Autonomous mobile robots have seen a wide spread development in recent years, due to their possible applications (e.g., surveillance and exploration). Several techniques have been proposed for solving the path planning problem, in which a user specifies spatial targets and the robots autonomously decide

how to go there. In contrast, the problem of where to go next, in which the targets themselves are autonomously decided by the robots, is largely unexplored. In this talk, we make a step toward a framework for casting and solving this problem. The framework includes the following dimensions: the amount of knowledge about the environment the robots have, the kind of that knowledge, the number of decision makers, and the possible adversarial nature of the setting. We focus on applications relative to search and rescue and to patrolling.

SE3.5 Rodrigo Ventura (Instituto Superior Técnico, Lisbon, Portugal)

Two faces of human-robot interaction: service and field robots

In this talk I will present a summary of our research activities at Institute for Systems and Robotics (ISR) on service and field robots. I will address the problem of effective Human-Robot Interaction applied in several application areas.

Concerning service robots, we have been collaborating with Carnegie Mellon University on the problem of deploying service mobile robots in real office environments, exploring the concept of symbiotic interaction. This concept embraces the idea that robots are aware of their own physical limitations, e.g., lack of an arm to pick up and transport objects, while being capable of asking humans for help on these kinds of tasks, for which the robot is physically incapable of performing autonomously.
We are also involved on the EU project MOnarCH, which goal is to research mixed human-robot societies targeting the deployment of a heterogeneous network of robot and sensors in the pediatric area of an oncological hospital. The main research problems here are how to handle uncertainties introduced by people and robots, generate natural interactions, and engage in edutainment activities.
In the area of field robots we have targeted the problem of employing semi-autonomous field robots in Urban Search and Rescue (USAR) scenarios. In particular, we have been involved in the design and construction of the RAPOSA robot, a tracked wheel platform for USAR scenarios, as well as in the use of quadrotor aerial platforms. Our research has been focused in two problems: (i) adjustable autonomy, where particular tasks area autonomously performed by the robots, being otherwise teleoperated, e.g., autonomous docking or autonomous stair climbing, and (ii) immersive teleoperation in order to effectively provide human operators with the best possible situation awareness during USAR operations.

SE4.1 Shuuji Kajita, Morisawa, Kanako Miura, Shin'ichiro Nakaoka, Kenji Kaneko, Fumio Kanehiro, Kazuhito Yokoi (Intelligent Systems Research Institute, AIST, Tsukuba, Japan)

ZMP-based biped walking control of a humanoid robot for entertainment

Cybernetic human HRP-4C is a biped humanoid robot which has a body dimension based on an average Japanese young female (Fig.1). One of the purposes is to explore possibilities of biped robots in the entertainment industries. For this purpose, it is demanding to realize reliable biped walking with the

human-like feet whose size is relatively small compared with conventional biped robots. This problem was solved by using the Zero-Moment Point (ZMP) proposed by Miomir Vukobratović. We discuss ZMP based walking pattern generation and stabilization developed for HRP-4C. Finally, we show several examples of HRP-4C's entertainment application performance including a dance performance with professional human dancers.

SE4.2 Christine Chevallereau, K. Munirathinam, S. Sakka (Institut de Recherche en Communications et Cybernetique de Nantes, Nantes, France)

Imitation of human motion by a humanoid while preserving dynamic equilibrium

This paper analyzes the off-line imitation of a reference human motion, or performer, by a humanoid robot meeting a balance constraint. Human body and humanoid robots may have the same appearance, but are very different in terms of mass distribution and kinematics (among others). Classically, imitation under balance constraint reproduces the human joint motion, and then modifies it to meet the robot balance constraint. When performing such modification, the gesture coordination may not be respected.

In this framework, we first set a reference imitation by means of joint trajectory parameterized optimization. Then a novel approach is explored, based on motion time-scaling instead of joint modification. In such case, the motion coordination is respected as the joint trajectories remain the same as the human performer, but the motion acceleration is increased or decreased to influence the ZMP trajectory and meet the robot balance constraint. A hybrid approach based on a simultaneous time-scaling and joint trajectory optimization is also proposed to take advantage of the two approaches and overcome the respective limitations of each approach. Two techniques are developed and compared for off-line imitation. The first one is based on optimization as previously mentioned. We have framed the optimization problem with the constraints on balance (ZMP) and the physical limits of the humanoid robot. The joint motion is described as a spline function whose parameters are optimized. As a result, we have obtained the feasible joint trajectories for the humanoid robot, which can track the human reference trajectory to achieve a natural-looking imitation of the human actor motion with optimum time delay and joint angle error.

The second technique consists in avoiding the restriction of the search of optimal motion in a set of spline functions. A control approach for the time scaling process is developed. The second derivative of the scaling factor is derived from the dynamics equations. This factor is a control variable that constraints the ZMP within the support polygon while being as close as possible to the motion of the performer. As the constraints on the ZMP act on the sagittal and frontal plane, one control input (second derivative of scaling factor) may be insufficient, thus the use of the acceleration of the center of mass as supplementary input is also proposed.

These approaches were validated with the NAO humanoid robot with a kick motion in a single-support phase of stance.

SE4.3 Giuseppe Carbone, Marco Ceccarelli (University of Cassino and South Latium, Cassino, Italy)

Experiences on service robots at LARM in Cassino

Service robots are presented in this paper from the authors' perspective as based on experiences at LARM in Cassino. Peculiarities of service robots can be challenge for their wide diffusion in terms of low-cost user-oriented features both in design and operation. Comments on direct author's experiences help to outline possibilities for developing service robots with low-cost user-oriented features with design activity without large resources.

SE4.4 Veljko Potkonjak, Kosta Jovanović and Predrag Milosavljević (University of Belgrade, Belgrade, Serbia)

How to Control Anthropomimetic Robots – Engineering and Cognitive Approach

Anthropomimetics is a new field of robotics that tends to go one step further than copying human shape and functionality. In order to fully transfer some human behavior patterns to the robots working in a human adapted environment, we need to fully copy human body and structure. However, the emerging issue in the field is how to control such a mechanism. This paper presents concepts in control of human like drives. Firstly, biologically inspired and energy efficient puller-follower control concept for the antagonistically coupled compliant drives is presented. Although the concept follows its biological paragon, it is still realizable in a conventional engineering way. Beside the antagonistically coupled muscles, we need to deal with control of muscles crossing several joints or even multi-DOF joints, where conventional control techniques can hardly offer solution. The second part of the paper suggests approaches to deal with these issues, exploiting cognition and heuristics. The control algorithm involves two levels: feedforward and feedback, both relaying on the experience. Based on prior knowledge of human-like motions, feedforward control is obtained using neural networks or heuristic approach. Regardless of the antagonistic drive structure both methods are applicable to wider class of robots. The paper suggests these methods as an efficient tool to evade the exact mathematical modeling and conventional control of the nonlinear and redundant mechanical system. The feedback control is introduced through fuzzy logic. It presents a novel solution to problems that emerge as a result of combining the experience-based learning and a "black-box" model of the system.

SE4.5 Daniela Tarnita*, M. Catana*, C. Berceanu* and D.N. Tarnita**, *(University of Craiova, Romania), **(University of Medicine and Pharmacy, Craiova, Romania)

Contributions on the modelling and simulation of the human joints with applications to the robotic structures

This paper presents advanced modeling and simulation methods, using the latest generation of CAD-CAE applications. For the geometric modeling of human joint there had been used embedded applications as DesignModeler, SpaceClaim under Ansys Workbench software package. The objective of this study is to present our contributions on the modeling, simulations and finite element analysis of the human joints in order to quantify and investigate the biomechanical behavior. The biomechanical behavior of human joints is important in order to design robotic structures inspired by human systems. To investigate the role of human joints components and to analyze and simulate their biomechanical behavior, a finite element analysis was performed. For each analysis there were extracted values for the maximum Von Mises stress, strains and displacements. The process of behavior simulation of the human joints requires:

a) three-dimensional modeling of the joint components

In order to obtain the transversal sections of the bones we employed CT scanner. In order to properly define the virtual components of the bones, CT images were processed using Space Claim integrated application and to obtain the 3D virtual model the integrated application DesignModeler was used. The 3D virtual models are completely parameterized and can be imported in order to perform kinematic of FEA simulation with dedicated software.

b) mesh generation of the geometrical model in finite elements.

In this stage we used ANSYS software, a software for finite element analysis (FEA). The splitting is made using 3D elements which takes account from the composite like structure of the natural bones (compact and spongy), by introducing the corresponding elastic constants for both materials.

c) the establishment of the contour conditions

d) gathering the results

By solving the system of equations one can find the nodal displacements over three directions in each nod of the finite elements. The displacements are used to determine the mechanical deformations and stress found in the analyzed structure. The biomechanical systems of the human joints are studied from the kinematical and dynamical point of view.

SE5.1 Vladim Golovin (Moscow State Industrial University, Moscow, Russia)

Robotics in restorative medicine

The overview of development of restorative medicine apparatus is given. The manipulation robots for

restorative medicine are considered mainly. They are robots for various massage and extremities movements in joints. These means can be particularly effective for preventive restorative medicine, for increasing of health reserves and working capacity people.

At the present in the world the simplest robots are known more and more. But they specialize on some body parts and some techniques only and they are not adapted to various patients. The universal robots can be adapted to individual patient's features using position/force and biotechnical control. The position/force control is necessary to support assigned forces complying on assigned trajectory. Method force teaching for position/force control is proposed. In order to estimate procedure efficiency objectively the biotechnical control using electric-skin resistance measurement is proposed. The constructive variants, safety, social and economic aspects are submitted too.

SE5.2 Achim Wagner (Heidelberg University, Mannheim, Germany)

Dependable System Design for Medical Robots

Medical systems such as medical and rehabilitation robots need to be highly safe and dependable since they directly influence health and live of patients. Furthermore, modern assistance technology allows the design of highly sophisticated medical devices and the use of medical systems in a more flexible and interactive way. Thus, dependability of human behavior in close interaction with a medical system has to be considered additionally to the basic system behavior and functions. A unique view on the overall system can be achieved by modeling the technical system and the human operator on a behavioral description level and its realization as functional descriptions. A methodology for designing dependable medical systems is proposed, which is based on a behavioral modeling of the user and the technical part of the system in the closed control loop. Decomposing the system recursively into behavioral levels leads to well-defined interfaces between the operator and the corresponding subsystem. The closed loop behavior is evaluated using an integrated measure that combines safety and performance acceptance functions in a unique dependability functional. Defining dynamic safety margins, system behavior and interface parameters can be adopted in order to ensure the safe operation of the interactive system. The methodology is demonstrated on examples of surgical robots and assistance wheelchairs.

SE5.3 Giuseppina C. Gini, Flavio Mutti, Paolo Belluco, Alessandro Mauri (Politecnico di Milano, Milano, Italy)

New results on classifying EMG signals for interfacing patients and mechanical devices

We review current uses of sEMG signals to control devices such as orthoses and prostheses. We justify why they are an important input both to control the devices and to understand the human contribution

during a rehabilitation therapy assisted with exoskeletons.

Then we present the general tools (3-channel hardware and software) we have developed for acquisition and processing of sEMG signals. In particular we show our Matlab/C application software and its use for classification. We also discuss how the acquired signals can be used to predict the force using a muscle-skeletal model.

Finally we focus on a few cases that we have approached through our system, considering in particular, an upper limb prosthesis. We show that multiple classes' classifiers can be used to extend the range of movements.

SE5.4 Aleksandar Rodić (Institute Mihailo Pupin, University of Belgrade, Belgrade, Serbia)

Building of Emotional Intelligence with Service Robots

The presentation concerns with building of some basic functions of the emotional intelligence (EI) with service robots. The research objectives of this project are addressed to development of EI model, i.e. to building of emotion-based and social behavior attributes with intelligent service robots. The basic model of personal and inter-personal (social) behavior is developed based on the widely accepted Myers & Briggs (followers of the Carl Gustav Jung) theory of personality well known in human sciences (psychology). The importance of building EI with new generation of service robots, together with building of artificial intelligence (AI) that assumes cognitive behavior capabilities, is considered in presentation. Different factors influence human psychological and social behavior. These are: a) personal factors such as type of personality, character of personality and personality temperament, b) external, i.e. social factors that assume influence of family, education institutions, companions, social communities and politic parties, religion, etc., and c) inner factors such as condition of physical and emotional health, feelings (happiness, depression, infatuation, frustration), etc. The previously mentioned factors are taken into account in building of the basic model of a human EI. In the presentation, it will be discussed if possible and in which way to map (make appropriate model) the main human emotion-based and social attributes of behavior to the service humanoids of new generation. In that sense, a complex multi-input and multi-output fuzzy inference system will be designed that is capable to acquire basic EI functions of human beings. On-line tests of the personality type and personality temperament with human examinees are accomplished and used for model development and verification. Some characteristic real-life scenarios that emulate different events (cases) are assumed in order to test functionality and accuracy of the model developed. Simulation tests as well as experimental behavior of the examinees (their written reports on behavior) will be compared to validate the model quality. Simple graphical user interface developed for testing model will be presented, too. It will demonstrate different types and levels of emotion-based behavior depending on various types of events and types of personality and temperament. Some concluding remarks and future research plans will be stressed.

SE6.1 Doina Pisla, Nicolae Plitea (Technical University of Cluj-Napoca, Romania)

Innovative Approaches regarding Robots for Brachytherapy

This paper presents an overview of the most important innovative approaches concerning robots for brachytherapy. The third millennium encounters a very provocative challenge: there are more and more cancer patients mainly because the increase of the average life span of the population and the curative treatments discovered for other diseases. This makes cancer one of the main causes of death nowadays, due to a complex set of uncontrollable natural and artificial factors.

Starting with some important concepts regarding the cancer, a classification of the modern cancer therapies is made. Brachytherapy is an advanced form of radiation therapy enabling the concentration of high doses in specific target points, enabling the direct treatment of tumors without damaging the proximal healthy tissues. Brachytherapy usage is limited by the insufficient accuracy of radioactive seeds placement in the body.

The latest innovative achievements in robotics for brachytherapy are presented followed by the main current challenges emphasizing the performed researches at the Technical University of Cluj-Napoca regarding the development of an innovative family of modular parallel robots together with some ethical issues.

SE6.2 Philippe Wenger (Institut de Recherche en Communications et Cybernetique de Nantes, Nantes, France)

Design of a parallel manipulator with variable actuation

This presentation introduces a new planar 3-dof parallel manipulator with multiple actuation schemes: the NaVARo (Nantes Variable Actuation Robot). Parallel manipulators have singularities in their workspace that reduce drastically the possible ranges of motions. Attempts to eliminate the singularities at the design stage generally results in a robot with a very limited workspace. The locus of singularities depends on choice of the actuated joints. Most existing planar 3-DOF parallel manipulators are composed of a triangle moving platform connected by three identical legs to a fixed base. The legs are kinematic chains composed of three joints. Most often, the first joint of each leg is actuated. The idea of the NaVARo project is to allow the selection of an optimal actuation scheme for a given prescribed trajectory. The NaVARo was designed on the basis of 3 identical RRR legs, where the first or the second R joint of each leg can be actuated according to the task. A device composed of a clutch and a break makes it possible to select the joint to be actuated and only one motor per leg is necessary. First experiments conducted on a prototype will be presented to demonstrate the performances of NaVAro.

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SE6.3 Mihailo Lazarević (University of Belgrade, Belgrade, Serbia)

Some Applications of Biomimetics and Fractional Calculus in Control and Modeling of (Bio)robotic Systems

Rapid development of biological science and technologies will further improve the active applications of control engineering by advanced biomimetic and biologically inspired research. In this paper, first, it is promoted a biologically inspired control synergy approach that allows the resolution of redundancy of a given robotized system. Particularly, the actuator redundancy control problem has been stated and solved using Pontryagin's maximum principle, where control synergy is established at the coordination level. The effectiveness of the suggested approach will be demonstrated with a suitable robot with redundant control variables.

Besides, it is well known, fractional calculus (FC) is a mathematical topic with more than 300 years old history, and in recent years, there have been extensive research activities related to applications of FC in many areas of science and engineering. The fractional integro-differential operators present a generalization of integration and derivation to non-integer order (fractional) operators. Here, they are presented the new algorithms of PID control based on FC tuned by genetic algorithms in the position control of robotic system with 3 DOFs driven by DC motors. The effectiveness of suggested optimal fractional PID control is demonstrated with a suitable robot as the illustrative example. Also, it is suggested and obtained a chattering-free fractional PD sliding-mode controller in the control of a given robotic system. Simulations also include comparison fractional-order PD sliding mode controller with standard PD sliding-mode controller. Finally, it will be shown that one can obtain analytical expressions for generalized forces of the damping element (viscoelastic element of fractional order) which are used to obtain mathematical model of robotic system in symbolic form.

SE6.4 Josef Schadlbauer*, CalinVaida**, Andras Szilaghyi**, Manfred Husty*, DoinaPisla**, *(University of Innsbruck, Austria), **(Technical University of Cluj-Napoca, Romania)

The dynamic behavior of a 3-RPS manipulator in the neighborhood of a transition poses between operation modes

The dynamic analysis of parallel hybrid robots requires a great deal of computing regarding the formulation of the generally nonlinear equations of motion and their solutions. The dynamic model for complex parallel structures raises a big challenge as the model has to be detailed enough but also to have a low computational time in order to be suitable for the implementation in the control system of the robot.

The paper investigates the dynamic behavior of a 3-RPS parallel manipulator in the neighborhood of transition poses, in which the manipulator can switch operation modes by applying its kinematic

equations. The 3-RPS parallel manipulator is a three degree of freedom parallel manipulator, introduced by K. Hunt in 1983 as one of the lower mobility parallel manipulators. It consists of an equilateral triangular fixed platform and a similar moving platform connected by three identical RPS legs. The first joint (R-joint) is connected to the base and the last joint (S-joint) is connected to the moving platform. The legs are extensible, changing lengths via prismatic joints (P-joints), thereby moving the platform with three highly coupled DOFs. The 3-RPS manipulator is actually a special case of the 6-3 Stewart-Gough platform.

Recently, the complete kinematic behavior of the 3-RPS manipulator, including singularities, operation modes and transitions between the operation modes has been revealed using algebraic equations. Furthermore it is shown that a transition from one operation mode into the other is possible. The new inverse dynamic model of 3-RPS parallel manipulator is obtained by using the virtual work method on the basis of dynamically equivalent lumped masses. A comparison between the simulation data obtained in Matlab (IDM) with the simulation data through a Multi-body Simulation software (MBS), namely Siemens NX™ Motion Simulation-RecurDyn, has been performed.

SE7.1 Adrian Pisla, CalinVaida (Technical University of Cluj-Napoca, Romania)

Testing Capacity for Space Technology Suppliers

This paper presents an overview of the most important milestones concerning space robotics as long as outstanding studies of parallel kinematics start from the beginnings with applications for aerospace industry.

The third millennium encounters very provocative challenges like outerspace mining, outerspace manufacturing, outerspace medicine, and astrosociology.

The latest innovative achievements and strategies within space robotics at Technical University of Cluj-Napoca are following the general trend and challenges. After entertainment and industrial painting applications, for a long time parallel kinematics is strongly associated with flight simulators. For over 20 years, remarkable results are obtained at the TU Cluj-Napoca. After the overview, in the MeSRob 2012 regarding some results oriented on the Medical & Service robots, in the paper now is considered the opening for the space robotics for companies that are or will be prepared to become European suppliers in the next space era.

In the beginning, a parallel between the necessary research instruments and the available ones, including the human resources and the link with industry is considered. Within the topic, the training aspects are becoming secondary elements as long as more and more companies focused over this type of activity. Similar consideration is also for the applications oriented on the service robots within space robotics, the companies looking for testing technical devices, extreme conditions biological experiments simulation, and solutions for a versatile facilitator and ergonomic “partner” in aerospace.

SE7.2 Duško Katić*, Petar Radulović**, Sofija Spasojević*, Željko Đurović**, Aleksandar Rodić*, *(Institute Mihailo Pupin, University of Belgrade, Serbia), **(University of Belgrade, Belgrade, Serbia)

Advanced Gesture and Pose Recognition Algorithms using Computational Intelligence Paradigms and Microsoft KINECT Sensor

This research work suggests one kind of approach in developing a natural human-robot interface that will be used for control of four wheels differentially steered (4WD) mobile robot. The designed system is capable of extracting, understanding and learning a sequence of full body gestures and poses, that were previously captured in standard RGB and IC DEPTH videos. The starting set of robot commands includes the following 5 gestures: START, TURN RIGHT, TURN LEFT, SPEED UP and SLOW, while command STOP is realized as pose. The special feature of proposed classifier system is fact that human user is always in visual domain of camera but without fixation for defined position or orientation. Two different kinds of classifiers were implemented: first, support vector machine (SVM) classifier and second, based on multiple interconnected FUZZY Logic systems. The research showed satisfactory results in small classification error, simple human operator training and user comfort. The presentation contains state of the art of contemporary Human Robot Interface, some basic information about the KINECT camera that was being used, details of classifier design process itself, and a short review of the results that were obtained by testing of the algorithm.