Robotic Systems Lab LSRO, EPFL Lausanne
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Robotics Laboratory, Institute Mihailo Pupin, Belgrad
Research Institute on Communications and Cybernetics (IRCCyN), Nantes, France, in cooperation with CEA and UPMC, sponsored by IFToMM

MESROB 2015 – 4th International Workshop on Medical and Service Robots

July 8 – 10 2015, IRCCyN, Nantes, France

Programme and abstracts

Wednesday, July 8 18:30 – 20:00 Welcome drink and registration Lieu Unique



Thursday, July 9 8:30 – 10:00 Registration

9:15 – 10:45 Morning session 1

9:15 – 9:55 **Keynote 1**: Improve the challenging postural control through musculo-tendinous adaptations and estimate the risk of the first fall through gait markers in elderly, C. Cornu

9:55 – 10:20 Effect of Non-Passive Operator on Enhanced Wave-Based Teleoperator for Robotic-Assisted, J. Guo, C. Liu, P. Poignet

10:20 – 10:45 Singularity Analysis of a Novel Minimally-Invasive-Surgery Hybrid Robot using Geometric Algebra, T. Tanev

Coffee Break

11:00 – 12:15 Morning session 2

11:00 – 11:25 **Invited Lecture 1**: Experience feedback of BA-System in medical robotics, Guy Caverot

11:25 – 11:50 ISO 13482:2014 and Its Confusing Categories. Building a Bridge between Law and Robotics, E. Fosch Villaronga

11:50 – 12:15 Variable stiffness for leaf springs mechanism, L. Esteveny , L. Barbe, B. Bayle

Lunch

13:45 – 15:25 Afternoon session 1

13:45 – 14:10 **Invited Lecture 2**: Gerontechnology: a new paradigm, G. Berrut

14:10 – 14:35 Application of Nonlinear Dynamics to Human Knee Movement on Plane Inclined Treadmill, D. Tarnita, D.N. Tarnita

14:35 – 15:00 Training of robot to assigned geometric and force trajectories, A. Leskov, V. Golovin, M. Arkhipov, L. Kocherevskaya

15:00– 15:25 Kinematic Analysis of an Innovative Medical Parallel Robot using Study parameters, C. Vaida, D. Pisla, J. Schadlbauer, M. Husty and N. Plitea

Coffee Break

15:40 – 17:55 Afternoon session 2

15:40 – 16:05 **Invited Lecture 3**: Atalante, the dynamical and autonomous exoskeleton, Nicolas Simon

16:05 – 16:30 Visuo-Vestibular Contributions to Vertical Selfmotion Perception in Healthy Adults, I. Giannopulu P. Leboucher, G. Ratureau, I. Israël, & R. Jouvent

16:30 – 16:55 Actuating the ankle in walking exoskeleton: a parallel linkage solution, C.Bidard, P.Garrec, A.Verney and J.-M. Jehanno

16:55 – 17:20 Series elastic actuation for assistive orthotic devices, A. Ortlieb, J. Oliver, M. Bouri, H. Bleuler

17:20 – 17:55 Sensory-motor Anticipation and Local Information Fusion for Reliable Humanoid Approach, H. F. Chame and C. Chevallereau

19:30 – 23:00 Cruise on the river Erdre and dinner

Friday, July 10

9:00 – 10:30 Morning session 3

9:00 – 9:40 **Keynote 2:** Using robotics methods for mobility and medical monitoring of frail people, J.P. Merlet

9:40 – 10:05 On the Design of the Exoskeleton Arm with Decoupled Dynamics, V. Arakelyan, Y. Aoustin, C. Chevallereau

10:05 – 10:30 Tactile and visual feedback for control of forces in laparoscopy, T. Howard, J. Szewczyk

Coffee Break **Demonstrations: exosqueletons, and humanoid robots**

11:20 – 12:25 Morning session 4

11:20– 11:45 A Dual-user Teleoperation System with Adaptive Authority Adjustement for Haptic Training, F. Liu, A. Lelevé, D. Eberard and T. Redarce

11:45 – 12:10 Strategy to lock the knee of exoskeleton stance leg: study in the framework of ballistic walking model, A. Formalsky and Y. Aoustin

12:10 – 12:35 Framework design for a Robotic Driven Handheld Laparoscopic Instrument for Non-Invasive Intraoperative Detection of Small Endoluminal Digestive Tumors, B. Mocan, V.V. Bintintan, S. Brad, C. Ciuce, M. Mocan, M. Murar

Lunch

14:00 – 15:15 Afternoon session 3

14:00 – 14:25 Modeling and dynamic identification of medical devices: theory, issues and example, A. Jubien and M. Gautier

14:25 – 14:50 A legged robotic system for remote monitoring, F. Tedeschi, G. Carbone

14:50 – 15:15 Development of home human-centered social robot for aged people care, A. Rodić, M. Jovanović, M. Vujović, I. Stevanović

Coffee Break

15:30 – 17:10 Afternoon session 4

15:30 – 15:55 Morphological optimization of prosthesis' finger for precision grasping of little objects, J. L. Ramirez, A. Rubiano, N. Jouandeau, L. Gallimard, O. Polit

15:55 – 16:20 Correction method for spine flexion tracking with markers, S. Butnariu, C. Antonya

16:20 – 16:45 Anthropomorphic underactuated hand with 15 joints, E. Matheson, Y. Aoustin, E. Le Carpentier, A. Leon and J. Perrin

16:45 – 17:10 Effects of the rolling mechanism of the human foot on the inverted pendulum representation for normal walking gait, S. Devie and S. Sakka

17:15 End of Workshop

Thursday, July 9

08:30 – 10:00 Registration

09:15 – 10:45 Morning session 1

09:15 – 09:55 Keynote 1

C. Cornu. **Improve the challenging postural control through musculo-tendinous adaptations and estimate the risk of the first fall through gait markers in elderly**

09:55 – 10:20 Effect of Non-Passive Operator on Enhanced Wave-Based Teleoperator for Robotic-Assisted Surgery.

Jing Guo, Chao Liu and Philippe Poignet

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Abstract. Minimally invasive surgery (MIS) has been advanced by new medical/surgical robotic technologies, aiming to achieve less invasiveness, smaller or even no scar procedures. Miniaturized surgical robot presents promising alternative to better benefit MIS, but considerable constraints including cables for power and communication may degrade the performance. Wireless communication possess great potential to be utilized, however time delay is inevitably introduced which challenges the design of teleoperation system from both stability and transparency point of view. Wave variable based teleoperation provides stable force reflecting teleoperation with arbitrary time delay, but with both compromised position and force tracking performance. Recently we proposed a wave variable compensated structure to improve the position and tracking performance together with energy reservoir based regulators for stability purpose [23], but with assumption of passive operator and environment. In this paper, several experiments are conduced to evaluate the passivity of operator using the enhanced wave variable compensated structure, and study the non-passivity of the operator to the teleoperation performance and overall system stability. The first case study shows that non-passive behavior (such as rigid grasp and trajectory tracking task) can inject extra energy into system and sometimes may cause stability issues for teleoperation system.

Key words. bilateral teleoperation, time delay, robotic-assisted surgery, telesurgery, non-passive operator.

10:20 – 10:45 Singularity Analysis of a Novel Minimally-Invasive-Surgery Hybrid Robot using Geometric Algebra, T. Tanev

T. K. Tanev

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Sciences, Bulgaria. tanev tk@hotmail.com

Abstract. The paper presents an analysis of the singularities of a novel type of medical robot for minimally invasive surgery using the language of the geometric algebra. The analysis is focuses on the parallel manipulator, which is the key component of the robot. The proposed new parallel manipulator provides remote centre of motion located at the incision point of the patient's body. The aim of the paper is to derive the geometric condition for singularity in term of the geometric algebra and thus to reveal the singular configurations in order to avoid them during the surgical procedure. The obtained geometric condition for singularity further leads to derivation of the algebraic formulation of the singularity surface, which is graphically presented.

Key words. Singularity, parallel robot, kinematics, minimally invasive surgery, geometric algebra.

10:45 – 11:00 Coffee Break

11:00 – 12:15 Morning session 2

11:00 – 11:25 Invited Lecture 1

Guy Caverot. Experience feedback of BA-System in medical robotics.

11:25 – 11:50 ISO 13482:2014 and Its Confusing Categories. Building a Bridge between Law and Robotics

E. Fosch Villaronga

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Abstract. Because of the fast technological development of the past few years, understandable bridges between the technical and the legal domains are urgently needed. In this respect, this paper pioneers the identification and examination of confusing categories among ISO 13482:2014 'Robots and Robotics Devices – Safety Requirements for Personal Care Robots'. It aims to make roboticists aware of the importance of clearer definitions for legal compliance purposes: although clarity may be missing in legal domain, robot creators still remain responsible for their creations and may be punished. Choosing under what category a robot should fall even if it is not really part of it is neither allowed and it could cause an abuse of the Law. A precise categorization is necessary, and based on the robot category specific regulations and laws should be taken into consideration and respected.

Key words. Personal Care Robot, Legal Compliance, Confusing Categories, Robotics, Law.

11:50 – 12:15 Variable stiffness for leaf springs mechanism.

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Abstract. The first issue in human-robot interactions is safety. In recent years, many variable stiffness actuators technologies have been proposed to absorb the energy transmitted to a human by a robot. In this paper we focus on leaf springs systems, whose stiffness variation is obtained by the modulation of the effective length of the leaf spring. In most literature solutions, the stiffness adjustment mechanism is not optimized. In this paper, the study is focused on the design of these mechanisms. A variable stiffness mechanism based on 4 leaf springs is first presented and modeled. The advantages of the proposed design are highlighted, while the remaining limitations due to backlashes are described. The system prototype is characterized experimentally to demonstrate the improvement brought to the design of such variable stiffness mechanisms.

Key words. Variable stiffness mechanism, compliant mechanism, leaf spring.

12:15 – 13:45 Lunch

13:45 – 15:25 Afternoon session 1

13:45 – 14:10 Invited Lecture 2

G. Berrut. Gerontechnology: a new paradigm.

14:10 – 14:35 Application of Nonlinear Dynamics to Human Knee Movement on Plane & Inclined Treadmill.

D. Tarnita[1] and D.N. Tarnita[2]

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Abstract. The objective of this study is to quantify and investigate nonlinear motion of the human knee joint on plane treadmill and inclined with 10o treadmill, using nonlinear dynamics stability analysis. The largest Lyapunov exponent (LLE) and correlation dimension will be calculated as a chaotic measures from the experimental time series of the flexion-extension angle of human knee joint. The mean LLE for human knee joint ranged from 0.042 to 0.082. Larger values of LLEs obtained on inclined treadmill are associated with more divergence and increase of knee flexion variability on inclined treadmill, while smaller values obtained for plane treadmill reflect increase of local stability, less divergence and variability, less sensitivity to perturbations and higher resistance to stride-to-stride variability. The use of nonlinear tools may provide additional insight on the nature of the step-to-

step fluctuations present in human and robotic locomotion.

Key words. human knee, treadmill, largest Lyapunov exponents, correlation dimension.

14:35 – 15:00 Training of robot to assigned geometric and force trajectories.

A. Leskov[1], V. Golovin[1], M. Arkhipov[1] and L. Kocherevskaya[2]

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[2]National University of Science and Technology MISIS, Russia.

Abstract. The features of training by demonstration in robotics for restorative medicine are considered in the article. They are caused by the fact that during training the robot interacts with patient's soft tissue. The regime of training by demonstration is more natural for physician than training of force points using the manual by physician. Also the training by demonstration is more precise method of input of assigned geometric and force trajectories.

Key words. Force trained points, training by demonstration, force sensors, soft tissue deforming, geometric and force trajectories.

15:00 – 15:25 Kinematic Analysis of an Innovative Medical Parallel Robot using Study parameters.

Calin Vaida[1], Doina Pisla[1], Josef Schadlbauer[2], Manfred Husty[2] and Nicolae Plitea[1]

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[2]Unit for Geometry and CAD, University of Innsbruck. {josef.schadlbauer, manfred.husty}@uibk.ac.at

Abstract. The paper investigates the kinematic analysis of an innovative 5-DOF parallel medical robot used for brachytherapy. Robotic assisted brachytherapy involves the targeted treatment of cancerous cells delivering high dosages of radiation inside the tumor, using as guiding tool a highly accurate robotic arm. The kinematic modeling of this mechanism is addressed using algebraic constraint varieties and the Study parametrization of the Euclidean displacement group. Algebraic methods in connection with classical multi-dimensional geometry have proven to be very efficient in the computation of direct and inverse kinematics of mechanisms as well as the explanation of strange, pathological behavior. The ideals belonging to mechanism constraints and methods to solve polynomial equations are the mathematical equivalents of the mechanism constraints. The obtained results are simulated and compared with the results obtained by the evaluation of the determinants of the A and B Jacobi matrices. This complete kinematic analysis of the robot will largely increase its safety during the medical procedure.

Key words. Parallel robot, Kinematics, Study parameters, Singularities analysis, Brachytherapy

15:25 – 15:40 Coffee Break

15:40 – 17:55 Afternoon session 2

15:40 – 16:05 Invited Lecture 3

Nicolas Simon Atalante, the dynamical and autonomous exoskeleton.

Abstract Exoskeletons are robotized devices which aim at giving back or enhancing physical abilities. They have generated expectations amongst disabled person. Indeed, they hope it will help improving their quality of life and autonomy - and those two concept are therefore key in exoskeletons' attractiveness. Users are thrilled with the feelings they get using current devices: they qualify for the first criterion. However, all exoskeletons do poorly on the second one - autonomy. This finding is core for Wandercraft and the reason why we develop a complete lower limb exoskeleton: the goal is to be able to move without crutches or otherwise external assistance, in a swift and stable movement. Doing so will require to use the latest theories of dynamical walking developed for humanoid robotics. Wandercraft is an all-out development phase, with a first prototype already designed, manufactured and assembled that is used as a test platform for implementing the control laws we are designing.

Key words. Exoskeleton, lower limb, dynamical walking, humanoid robotics

16:05 – 16:30 Visuo-Vestibular Contributions to Vertical Selfmotion Perception in Healthy Adults.

I. Giannopulu, P. Leboucher, G. Rautureau, I. Israël, & R. Jouvent

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Abstract. The intensity of the visuo-vestibular interaction, i.e., visuo-vestibular conflict, would influence upward self-motion and downward self-motion latencies and cardiovascular activity. In order to test this hypothesis, thirty five healthy adults aged 22 years in average have been immersed to a central visual motion via a HMD. During upward and downward self-motion perception, the engagement of vestibular saccular organs seems to contribute differently to latencies and cardiovascular activation depending on the direction of gravitational acceleration. Downward selfmotion latencies (same direction acceleration) are shorter than upward self-motion latencies (opposite direction acceleration). In the same vein, cardiovascular autonomic activation, reflecting by heart rate, is lower for downward self-motion than for upward self-motion. Our results provide evidence that

visuo-vestibular interaction would contribute to influence both latencies and cardiovascular variation in vertical self-motion perception.

Key words. visuo-vestibular interaction, vertical self-motion, cardiovascular activity, adults, HMD

16:30 – 16:55 Actuating the ankle in walking exoskeleton: a parallel linkage solution.

C.Bidard, P.Garrec, A.Verney and J.-M. Jehanno

CEA-LIST, Interactive Robotics Laboratory, France. catherine.bidard@cea.fr

Abstract. Lower-leg exoskeletons must transfer their own load to the floor and a possible additional load depending on the exoskeleton function. However most available exoskeleton are underactuated, such that not any wrench can be transferred by the exoskeleton structure and that some of the load components is transferred by the user body. The most common case is actuation of knee and hip flexion/extension of each leg where each leg can independently transfer a force passing at the passive ankle joint center. This paper presents a patented four-bar mechanism that allows to transfer the load in front of the ankle while using only two actuators per leg. The same mechanism is used to actuate independently knee and ankle flexion with the actuators placed at the thigh level minimizing the inertia of the leg during swing phase. The kinematic and static analysis and the current design of the exoskeleton using this mechanism will be presented.

Key words. Exoskeleton, locomotion.

16:55 – 17:20 Series elastic actuation for assistive orthotic devices.

A. Ortlieb, J. Olivier, M. Bouri and H. Bleuler

Laboratory of Robotic Systems, Swiss Federal Institute of Technology (EPFL). amalric.ortlieb@epfl.ch

Abstract. Wearable assistive robotics is a modern field where intelligent actuated systems work in collaboration with the body to replace a lost limb, to enhance performances (e.g. carrying load, walking, running, jumping) or to train or rehabilitate specific activities. Wearability (e.g. weight, bulkiness) and power are the two main competing characteristics of most assistive wearable devices. Actuation systems with high power density per mass and volume are thus preferred. Biologic muscle-tendon scheme are very interesting for their energy storage capacity and the generation of efficient cyclic patterns thanks to their series elastic power transmission. Different solutions using spring solid material in combination with electric motors have been explored in order to reproduce biologic performances. This study proposes to explore the properties of a technology of pneumatic cylinder as a series elastic actuator. Results present a systematic approach for the stiffness characterization of pneumatic cylinder. Finally, the properties of this solution are confronted with measured data of the human hip, knee and ankle joints in flexion during walking. Conclusion discuss the adequacy of pneumatic cylinder as a bioinspired energetically efficient

solution to assist walking.

Key words. Wearable assistive robotics, series elastic actuator, pneumatic cylinder, walking assistive Orthosis

17:20 – 17:55 Sensory-motor Anticipation and Local Information Fusion for Reliable Humanoid Approach.

H. F. Chame and C. Chevallereau

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Abstract. The possibility of developing increasingly sophisticated robots, and the availability of cloud-connected resources, have boosted the interest in the study of real world applications of service robotics. However, in order to operate under natural or less structured conditions, and given the information processing bottleneck and the reactivity required for a secure execution of the task, it is desirable that the agent can exploit more efficiently the local information available, so that being more autonomous, and relying less on remote computation. This study explores a strategy for obtaining reliable approach tasks. It considers the anticipation of perception, by taking into account the statistical regularities and the information redundancies induced in the sensorymotor coupling. From an initial perception of the object assisted by remote computation, contextual features are defined for capturing bodily sensations emerging in the task. The observations based on proprioceptive and visual data are fused in a Bayesian Network, which is in charge of assessing the saliency during the object approach, thus constituing a local discriminative processing of the object. The strategy proposed reduces dependency on context-free models of behavior, while providing an estimate on the degree of confidence in the progress of the task.

Key words. Cognitive robotics, Embodied cognition, Humanoid robotics, Ego-localization, Topdown visual attention, Robot Vision.

19:30 – 23:00 Cruise on the river Erdre and dinner

Friday, July 10

09:00 – 10:30 Morning session 3

09:00 – 09:40 Keynote 2

J.P. Merlet. Using robotics methods for mobility and medical monitoring of frail people,

09:40 – 10:05 On the Design of the Exoskeleton Arm with Decoupled Dynamics.

V. Arakelian[1,2], Y. Aoustin[1] and C. Chevallereau[1]

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[2]Dpt of Mechanical and Control Systems Engineering, INSA Rennes, France.

Abstract. This paper focuses on the design of a 2-DOF exoskeleton arm with decoupled dynamics. The goal is to simplify the controller design by reducing the effects of complicated manipulator dynamics. The added epicyclic gear train allows the optimal redistribution of kinetic energy, which leads to the linearization and decoupling of the dynamic equations. The determination of the parameters of the added links is based on eliminating coefficients of nonlinear terms in the manipulator's kinetic and potential energy equations. The suggested design methodology is illustrated by simulations carried out using the software ADAMS.

Key words. Exoskeleton arm, multibody system, dynamic equations, decoupling, balancing, epicyclic gear train

10:05 – 10:30 Tactile and visual feedback for control of forces in laparoscopy.

Thomas Howard[1] and Jérôme Szewczyk[2]

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Abstract. It is widely recognized that despite its many benefits, the ergonomics of laparoscopic surgery lead to severe perceptual distortions for the surgeon. In particular, interaction forces at the instrument tip are masked by interfering forces at the trocar and distorted due to a lever effect around the insertion point. This leads to improper control of tool-tip interaction forces, increasing the risk and occurrence of intra-operative injuries, unnecessary trauma to healthy tissue and suture breakage. Here, we propose an experiment aimed at determining the efficacy and usability of cutaneous vibrotactile and/or visual feedback of tool-tip interaction forces in assisting a surgeon in controlling fine interaction forces. 16 novice subjects performed force-reach and -hold tasks in a laparoscopic setting under provision of 9 forms of feedback (visual feedback, 4 variants of

vibrotactile feedback, and their combinations). Feedback increased precision (up to 85.8% reduction in error when aiming for a target force), repeatability (up to 84% reduction in spread of aiming errors), speed of reaching a target force (up to 18-fold increase in speed of reaching a target force at equal accuracy) and reduced force drift over time (>68% reduction in cumulative deviation from a target force over a 20s period). Results show best performance for visual feedback, with promising performance for pulsed vibrotactile feedback, allowing us to draw initial conclusions on the potential for using tactile feedback to represent interaction forces in laparoscopy and to gain insights into axes for its improvement.

Key words. haptics, laparoscopy, force feedback, sensory substitution, MIS

Coffee Break **Demonstrations:** ortheses, exosqueletons and humanoid robots

11:20 – 12:25 Morning session 4

11:20 – 11:45 A Dual-user Teleoperation System with Adaptive Authority Adjustement for Haptic Training.

Fei Liu, Arnaud Lelevé, Damien Eberard and Tanneguy Redarce

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Abstract. This paper presents a shared control based dual-user teleoperation haptic training system. The main contribution is an Adaptive Authority Adjustment (AAA). The authority is determined online according to the trainee's behavior performance. An evaluation method is introduced based on an adaptive virtual boundary, which results into a time-varing dominance factor. An overruling function is set upstream to solve some specific cases. The system is modeled and controlled in port-Hamiltonian form for passivity preserving. Experiments are conducted for validation.

Key words. Dual-user Teleoperation, Port-Hamiltonian, Adaptive Authority Adjustment (AAA), Shared Control

11:45 – 12:10 Strategy to lock the knee of exoskeleton stance leg: study in the framework of ballistic walking model.

Y. Aoustin[1] and A. M. Formalskii[2]

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[2]Institute of Mechanics, Lomonosov Moscow State University, Russia. formal@imec.msu.ru

Abstract. Human is modeled using a bipedal planar model of a five-link anthropomorphic mechanism. This mechanism consists of a trunk and two

identical legs. Each leg consists of a thigh and shin with point-foot. The biped is equipped with an exoskeleton. The exoskeleton is considered also as a five-link anthropomorphic mechanism. The shape and the degrees of freedom of the exoskeleton are identical to biped (to human). The links of the exoskeleton are attached to the corresponding links of the biped. The corresponding hip-, knee-, and ankle-joints coincide. We compare the walking of a biped alone and of a biped equipped with exoskeleton; both models are with a payload. A ballistic walking gait is designed for the biped alone and for the biped with the exoskeleton. During the ballistic walking of the biped with exoskeleton the knee of the stance leg of the exoskeleton (and as a consequence of the biped) is locked. The locking can be realized in the knee of each leg of the exoskeleton by any mechanical brake device with no energy consumption. There are not any actuators in our exoskeleton. Therefore, we call it passive exoskeleton. The walking of the biped (as of the human) consists of alternating single-support and double-support phases. In our study the double-support is assumed as instantaneous. During this instantaneous double- support phase, the knee of the previous swing leg (next stance leg) is locked and the knee of the previous stance leg is unlocked. Numerical results show that for a given time period T and a given length L of the walking gait step the human with the exoskeleton during the payload transport is more efficient to preserve the energy consumption than the human alone (without exoskeleton).

Key words. Human, Bipedal model, Passive Exoskeleton, Ballistic walking, Instantaneous double support, Impulsive torque, Optimization.

12:10 – 12:35 Framework design for a Robotic Driven Handheld Laparoscopic Instrument for Non-Invasive Intraoperative Detection of Small Endoluminal Digestive Tumors.

B. Mocan[1], V.V. Bintintan[2], S. Brad[1], C. Ciuce[2], M. Mocan[2] and M. Murar[1]

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Abstract. The present paper introduces a framework design for guiding decision-makers towards a superior balance between quality, efficiency and surgical procedure issues in medical instruments development. A prototype of the robotic handheld sensitive laparoscopic instrument for non-invasive intraoperative detection of small endoluminal digestive tumors was designed and developed. The developed prototype was evaluated by two surgeons in ex-vivo experimental conditions by different medical approaches – open and laparoscopic surgery. The surgeons found that the developed prototype is easy to use, satisfactory and useful in precise detection of small endoluminal digestive tumors in 85% of cases.

Key words. sensing laparoscopic instrument, robotic driven handheld

laparoscopic instrument, non-invasive intraoperative detection of small endoluminal digestive tumors, and precise detection of small endoluminal digestive tumors.

Lunch

14:00 – 15:15 Afternoon session 3

14:00 – 14:25 Modeling and dynamic identification of medical devices: theory, issues and example.

A. Jubien and M. Gautier

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Abstract. This paper deals with the dynamic identification of medical devices. The majority of medical devices are like serial robots. On robotic, the usual identification method is based on the Inverse Dynamic Identification Model and the Least Squares estimation (IDIM-LS method). This method was validated on rigid and flexible robots. However, the safety constraints applied on medical devices add some issues. Both typical examples are the use irreversible gearbox and the use of brakes during constant position level unlike conventional robot. Sometimes, the lightness constraint reduce the stiffness of the device and the flexible model of the device must be used instead of the rigid model. This paper presents the theory of identification and how to apply it on medical devices. A simple example of modeling of medical device is developed.

Key words. dynamic, identification, parameters, medical, medicine, robot

14:25 – 14:50 A legged robotic system for remote monitoring.

F. Tedeschi and G. Carbone

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Abstract. The paper outlines the evolution of the robotics series named “Cassino Hexapod”, highlight-ing main design issues and operational features. The Cassino Hexapod is an hybrid robot, equipped with legs and wheels, characterized by design solutions having low-cost and user-friendly features. Main task is aimed at monitoring and analysis of historical or archaeological sites.

Key words: Hexapod walking robot, leg-wheel, low-cost design, cultural heritage.

14:50 – 15:15 Development of home human-centered social robot for

aged people care.

Aleksandar Rodić, Miloš Jovanović, Milica Vujović and Ilija Stevanović

Mihajlo Pupin Institute, University of Belgrade. {aleksdandar.rodic, milos.jovanovic, milica.vujovic, ilija.stevanovic}@pupin.rs

Abstract. The paper is addressed to prototyping of technology platform aimed to develop of ambient-aware home human-centric indoor social robot with attributes of emotional intelligence, designed as an assistance device for care about aged people with various difficulties considering motion. The robot consists of a wheel-based mobile robot body, bi-manual manipulation system with grasper and robot head. Robot prototype was designed to see, hear, speak and use its multimodal interface for enhanced communication with humans. Robot is capable of demonstrating its affective and social behavior by using audio and video interface as well as body gestures. Robot is equipped with advanced perceptive system based on heterogeneous sensorial system, including laser range finder, ultrasonic distance sensors and proximity detectors, 3-axis inertial sensor (accelerometer and gyroscope), stereo vision system, wide-range microphones, and loudspeaker. The device is foreseen to operate autonomously but it may be also operated remotely from a host computer through wireless communication link as well as by use of a smart-phone based on advanced client-server architecture. Robot prototype has embedded attributes of artificial intelligence and utilizes advanced cognitive capabilities such as spatial reasoning, obstacle and collision avoidance, simultaneous localization and mapping, etc. Robot is designed in a manner to enable uploading of new or changing existing algorithms of emotional intelligence that should provide to robot human-like affective and social behavior. The key objective of the project presented in the paper regards to building advanced social robot aimed to use for different purpose, e.g. walking-assistance, health monitoring, rehabilitation and assistance, etc.

Key words. Human-centric robot, personal robot, medical robots, artificial emotional intelligence

Coffee Break

15:30 – 17:10 Afternoon session 4

15:30 – 15:55 Morphological optimization of prosthesis' finger for precision grasping of little objects.

J. L. Ramìrez[1], A. Rubiano[1,3], N. Jouandeau[2], L. Gallimard[1] and O. Polit[1]

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Abstract. In this paper, we present the morphological optimization of our tendon driven underactuated robotic hand prosthesis' finger, to improve precision grasping of little objects. The optimization process is performed with a black box optimizer that considers simultaneously kinematic and dynamic constraints. The kinematic is computed with the Denhavit-Hartenberg parameterization modified by Khalil and Kleinfinger and the dynamic is computed from the virtual displacements and the virtual works. All these constraints are considered as a fitness function to evaluate the best morphological configuration of the finger. This approach gives a way to introduce and improve soft and flexible considerations for the grasping robots such as hands and grippers. Theoretical and experimental results show that flexible links combined with morphological optimization, lead in more precise grasping. The results of the optimization, show us an important improvement related to size, torque and consequently energy consumption.

Key words. Morphological optimization, mechanisms prehension, precision grasping, soft robotic

15:55 – 16:20 Correction method for spine flexion tracking with markers.

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Abstract. The aim of the present paper is to accomplish a virtual model for testing the properties of the outer layers of the human body (skin, adipose tissue, muscle) in order to estimate and calculate the dis-placements of certain points on the skin surface in relation to the bones (which are considered fixed points). The proposed correction method will be used in the development of a device for tracking the human body postures and the spine movement by using different types of sensors for establishing a preliminary diagnosis of it. There is a major problem identified in this case of tracking the spine with markers: the skin sliding in connection with the bones. In order to obtain a precise calculus, it requires great knowledge of this phenomenon and the ability to establish a clear relationship between the position of bones and the position of the corresponding points on the skin, taking into account the different characteristics of material and measurement conditions.

Key words. lumped mass model, skin behavior, multi-point system, spine tracking.

16:20 – 16:45 Anthropomorphic underactuated hand with 15 joints.

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Abstract. Underactuated mechanisms are increasingly becoming popular in complex robotic designs where mass and size are yet limited, multiple degrees of movement are required. Such designs require a tradeoff between versatility and simplicity. This is the case for prosthetic robotic hands, which need to imitate the human hand both in functionality and dimensions as closely as possible in order to achieve a natural feeling solution for the patient. This paper presents the initial mechanical analysis of the design of an anthropomorphic hand with 15 degrees of freedom using six electric motor actuators. A transmission system of cables and pulleys is used as the underactuated mechanism in order to propagate the motor torque over the three joints of each finger, and springs are used to provide the passive return actuation. The design has been validated according to its ability to stably grasp different cylindrical objects. The stability of the grasp has been judged according to the criterion of positive or zero contact forces being present at all points of contact between the hand and the object in a static case. A simulation of the grasping procedure where the contact forces are modeled over time has been developed in Matlab R. It has been shown that the design process requires iterative steps, as multiple factors such as spring stiffness, pulley radii, and motor torques will affect the stability of grasping of the hand and its effectiveness as a prosthetic device.

Key words. Grasping, Anthropomorphic Underactuated Robotic Hand, Contact Effort, Stable Grasps.

16:45 – 17:10 Effects of the rolling mechanism of the human foot on the inverted pendulum representation for normal walking gait.

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Abstract. This paper addresses the way the rolling mechanism of the human foot influences the Generalized Inverted Pendulum (GIP) model during normal walking. A test on 6 subjects was performed, and two ways of modelling were used: the first one uses the filtered data of the Center of pressure (CoP) trajectory to rebuild the human inverted pendulum; the second one linearizes the CoP trajectory with time, which is equivalent to ignoring the effects of the rolling mechanism of the foot. The results show that the linearized model leads to an observable clear area of convergence of the dynamics support lines showing a neat inverted pendulum, while the non-linearized forces to make the distinction between the three sub-phases of single support: damping, stabilizing, propelling.

Key words. GIP, normal gait, walking, human beings, rolling mechanism, center of pressure.

17:15 End of Workshop