Mechanisms and Machine Science

Georg Rauter · Giuseppe Carbone ·
Philippe C. Cattin · Azhar Zam ·
Doina Pisla · Robert Riener *Editors*

New Trends in Medical and Service Robotics

MESROB 2021

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Mechanisms and Machine Science

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Preface

Medical and service robots face growing demands on their functionality and performance in a broad range of applications. Therefore, strengthening our community through interdisciplinary work is beneficial for all parties involved: researchers, technology providers, medical healthcare personnel, and most importantly patients. This and last year, methods from laser physics and virtual/augmented reality-based surgical planning have found their way to augment the functionality, possibilities, and safety of medical and service robots.

The last years, we had to face difficult circumstances due to the worldwide pandemic situation with COVID-19 that prevented us from realizing MESROB 2020, the 7th International Workshop on New Trends in Medical and Service Robotics, in Basel, Switzerland. Nevertheless, we published a first series of papers in 2020. In 2021, we could finally organize a successful MESROB 2021 conference in virtual format with and for our faithful community.

The entire story of MESROB conference events started with the first of its kind in 2012 in Cluj-Napoca, Romania. Following events were: MESROB 2013 at Institute "Mihailo Pupin" in Belgrade, Serbia; MESROB 2014 at EPFL in Lausanne, Switzerland; MESROB2014 at IRCCyN in Nantes, France; MESROB 2016 co-organized by University of Innsbruck and Joanneum Research in Graz, Austria; MESROB 2018 at the School of Engineering of the University of Cassino and South Latium in Cassino, Italy; and MESROB 2020 at University of Basel, Switzerland.

This workshop series is also sponsored by IFToMM, the "International Federation for the Promotion of Mechanism and Machine Science", and is one of the main conferences for the IFToMM Technical Committees on Biomechanical Engineering, Robotics and Mechatronics, and Computational Kinematics. The content of the MESROB 2021 book covers a wide range of aspects and topics such as: 1) rehabilitation robotics, 2) exoskeletons and prostheses, 3) surgical robotics and micromanipulation, and 4) nursing robotics and human performance evaluation. These contributions are provided as a collection of 17 papers that were selected among the 23 submitted contributions on the basis of a blind peer-review process. The MESROB 2021 book completes the collection of papers submitted to

MESROB 2020 (37 papers accepted, 49 submitted). So in total, MESROB in Basel successfully incorporates the published work of 54 accepted papers out of 72 submitted.

We wish to express our gratitude to the authors, the reviewers, and Scientific Committee for their valuable contribution to ensure the scientific quality of MESROB 2020 and 2021. Finally, we would like to thank our Gold Sponsor "Stäubli AG" and our Silver Sponsors "F. Hoffmann-La Roche Ltd.", "Stryker GmbH", and "Advanced Osteotomy Tools AG".

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Cyrill Bätscher

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Digitalization and automation represent nowadays in many aspects of our society not only the standard practice but are also expected and, in many instances, even considered as malpractice if not implemented as an integral structural backbone within the life cycle and at the core of services and products. Digitalization of analog processes has enabled their respective automation yielding more reliable, efficient, and efficacious digital enabled processes. In turn, automation has radically changed the status quo of how tasks get done and certainly the associated outcome expectations. Digitalization within the medical domain is starting to undergo an exponential transformational change which will allow for profound changes in the way medicine is practiced today by harnessing not only patient data but also device and process data in a holistic and continuous manner to establish data-driven processes and methods for efficient and efficacious personalized patient care and treatment delivery across the whole care continuum exploiting automation.

This scientific series is an important contribution that will decisively promote further growth and advance the status quo in medical and service robotics. Furthermore, this effort will also help enhance the interdisciplinary nature of the complex solutions needed which will certainly go far beyond the amalgamation of the digital and mechatronics domains to incorporate other technical and socio-economical aspects into future services and products.

José-Luis Moctezuma de la Barrera

Contents

Rehabilitation Robotics

Serious Games Strategies with Cable-Driven Robots for Rehabilitation Tasks

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Abstract. Rehabilitation training is the most effective way to reduce motor impairments in post-stroke patients. Cable-driven robots have ideal characteristics for stroke rehabilitation and bimanual rehabilitation can transfer training skills to the activities of daily living. However, rehabilitation often presents problems with motivation and patient involvement since the therapy exercises are often monotonous and repetitive. The serious games aim to provide an interactive experience and generate a high level of motivation in patients. Accordingly, this paper presents a serious games approach in combination with a cable-driven robot for unilateral and bilateral/bimanual rehabilitation. Experimental tests are reported with 15 healthy subjects. They use a specifically developed cable-driven robot in combination with a serious game approach for bimanual rehabilitation exercises. The performed tests are described and discussed to show the level of user acceptance and engagement that is achievable with the proposed solution.

1 Introduction

Stroke is a leading cause of disability and it leaves a significant number of individuals with motor and cognitive deficits [1]. The paralysis of the upper limb is the most frequent consequence of brain injury [2]. Rehabilitation training is the most effective way to reduce motor impairments in stroke patients [3]. Rehabilitation movements can be classified as unilateral when using only the affected limb (paretic side) or bilateral when using both sides of the body. Bimanual movements are a specific type of bilateral movements in which there is simultaneous use of both hands in a coupled way [4]. Most rehabilitation therapies, conventional or assisted by technology, focus on the most affected limb, neglecting bimanual activities. Sometimes bimanual training does not yield a superior primary outcome, but it shows benefits such as increased daily use of the paretic side and recovery from other activities [2,5,6].

Robotics is attracting significant interest with novel rehabilitation assistive solutions. Several innovative designs are proposed, for example, the cable driven

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