Fundamental field: Engineering Sciences
Specialisation: Mechanical Engineering

HABILITATION THESIS

– ABSTRACT –

MODELLING OF MEDICAL ROBOTS FOR CANCER TREATMENT AND HUMAN REHABILITATION…

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The thesis presents the main achievements of the author in his main research field, which is Medical Robotics. The achievements, regard especially the following:

- Minimally invasive robotic-assisted cancer treatment;
- Robotic-assisted physical rehabilitation for:
  - The upper limb;
  - The lower limb;

The thesis begins with a short chapter entitled "*ABBREVIATIONS*" and consists of a short list of the most used abbreviated terms within the paper.

Chapter 2, "*INTRODUCTION*", presents shortly the current trends regarding the development of robotic systems in medicine and their role in various medical fields, the most important being: Surgery, Delivery, Diagnostics and Rehabilitation. The chapter presents the main motivation behind his work, acknowledging that it is the result of a team effort.

Chapter 3 presents the main "*SCIENTIFIC, PROFESSIONAL AND ACADEMIC ACHIEVEMENTS*" of the author, which qualifies him to obtain the "habilitation" title to work with future PhD candidates.

Chapter 4, "MEDICAL ROBOTS FOR CANCER TREATMENT" presents the major achievements of the author in the modelling, simulation, and development of robotic systems for cancer treatment using brachytherapy. The achievements are mainly driven by the desire to develop a solution which is minimally invasive and non-surgical, since patients in the advanced cancer stages may not be able to withstand a classical open surgery procedure or the tumours are inoperable due to over-spreading (metastases) or location. The chapter presents the modelling of a parallel robotic architecture and a numerical method to determine the kinematic accuracy of the robot for needle placement accuracy and the development of a modular robotic system consisting of the collaborative robot KUKA iiwa LBR 7 R800 and a multiple needle insertion device used in conjunction with a CT for visual feedback. The system has been tested in medical environments using ballistic gel and pork liver.

Chapter 5, "*MEDICAL ROBOTS FOR THE UPPER LIMB HUMAN REHABILITATION*" presents the achievements of the author regarding the development of robotic systems for upper limb rehabilitation, especially the rehabilitation of the elbow and wrist motions: elbow flexion and pronation/supination and wrist flexion/extension and radial/ulnar deviation. Starting from an initial serial robot which has been modelled, the author has proposed a modular parallel robotic system consisting of two robots: ParReEx – elbow and ParReEx-wrist. There are some obvious advantages of the proposed system, such as: performing training with two patients at a time, easier maintenance and longer and high-intensity training exercises. The proposed robotic system has been developed and experimentally tested with patients within two sets of clinical trials, which have underlined both the strengths and weaknesses of the system, leading to an improved version.

Chapter 8, "*MEDICAL ROBOTS FOR THE LOWER LIMB HUMAN REHABILITATION*" highlights the modelling and development of RECOVER, a parallel robotic system for the rehabilitation of the lower limb for bed-ridden patients. RECOVER consists of two modules: the hip-knee module, targeting the rehabilitation of the hip (flexion/extension) and the knee (flexion) and the ankle module, targeting the rehabilitation of the ankle flexion/extension and plantar eversion/inversion. The two modules can work independently or together, for the gait training of the patients.

Chapters: 7, "*PLANS FOR EVOLUTION AND CAREER DEVELOPMENT*" presents the career plans of the author; 8, "*REFERENCES*" of the paper, 11 and 12 the "*LIST OF FIGURES*" and "*LIST OF TABLES*"; 13 the "*APPENDICES*", while 14 the "*LIST OF PUBLICATIONS*" of the author.