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APPLICATION ORIENTED DESIGN AND SIMULATION OF AN INNOVATIVE PARALLEL ROBOT FOR BRACHYTHERAPY

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ABSTRACT

The paper presents the design and simulation of a new 5-DOF parallel robot named PARA-BRACHYROB used for brachytherapy. Brachytherapy (BT) is an advanced cancer treatment technique, where radioactive seeds are delivered directly in the tumor without damaging the proximal healthy tissues. Due to the tremendous therapeutic potential of brachytherapy, many researches are encouraged to provide solutions for enhanced placement of BT devices inside the patient body, thus further developing brachytherapy robotic systems. Therefore the paper presents an innovative CT-Scan compatible robotic device for this application. The PARA-BRACHYROB system consists of a parallel robot with five degrees of freedom (DOF) for needle positioning and orientation up to the insertion point in the patient body and a 1-DOF mechanism for the needle insertion. The kinematic models of PARA-BRACHYROB are presented and validated through a multi-body simulation including a short description of the numerical and simulation results for the developed model.

INTRODUCTION

The third millennium encounters a very provocative challenge: there are more and more cancer patients (as the world population increases, the average life span is higher and as we better treat competing co-morbidities). This makes cancer one of the main causes of death nowadays, due to a complex set of uncontrollable natural and artificial factors. Huge efforts have been made by the entire scientific community to provide better solutions and new techniques for the curative and palliative treatment of malignant tumors. In most cases, cancerous tumors require several types of treatment: chemotherapy, radiotherapy or surgery, each one with its side effects. In the recent years, studies have led to the development of local treatment of cancer tumors, namely brachytherapy (BT). This technique, also known as internal radiotherapy, sealed source radiotherapy, curietherapy or endocuritherapy, involves the placement of tiny radioactive miniaturized sources very precisely in the tumor area, delivering high dosage of radiation in the cancerous cells. Its effectiveness is clearly demonstrated, its side effects are reduced to a minimum, but it involves an important condition: the catheters delivering the radioactive sources must be placed precisely as the radiation dose decreases abruptly from the base and incorrect positioning causes the necrosis of healthy tissue without affecting the tumor. Brachytherapy is commonly used as an effective treatment for cervical, prostate, breast, and skin cancer and can also be used to treat tumors in many other body sites [1].

Most of the brachytherapy procedures are manually achieved, but robot-assisted brachytherapy proves to be a necessity in order to: improve accuracy of the needle placement and seed delivery; improve the consistency of the seed implant;