Alvus Modeling in Gazebo

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Abstract

Insufficient testing of medical robots can lead to accidents during a surgery and damage an expensive equipment. A simulated 3D patient permits a preliminary checking of robotics-based medical scenarios without threatening a real patient's health. This article presents a 3D model of a human abdomen, which contains vital organs: intestine, liver, stomach, and kidneys. There are 3 layers of an abdominal wall: skin, adipose, and muscle. Blender modeling software was used to create realistic 3D models of organs with their distinctive features for Gazebo simulator. The model is presented as a ROS package with necessary configuration files and can be used by other researchers to simulate medical operations in Gazebo environment.

Keywords: 3D Modeling, Blender, Medical Robotics, Gazebo.

1. Introduction

Over the last two decades, robot-assisted procedures have become popular in many surgical scenarios[1]. Robots are used in various aspects of medicine – from surgical intervention and palpation to therapy and rehabilitation. This avoids the risk of wound infection, postoperative pain and reduces the need for blood transfusions[2]. But despite the many positive aspects, there are also disadvantages: the high cost of operations, limitation of the surgeon's movement and the absence of a three-dimensional image that interferes with coordination and reduces maneuverability[3]. Robots are used only for auxiliary tasks, e.g., Da Vinci, which is widely used for laparoscopic surgery, and ARTAS, which is used for hair transplant operations.

An increasing number of robots are being used in a wide variety of medical fields. These operations are not ubiquitous due to their high cost[4]. Surgical operations require special technical equipment and qualified personnel. An example of such an operation is laparoscopic surgery. Laparoscopic surgery is an operation on the internal organs that is performed through small holes, while traditional surgery requires large incisions.

Simulation avoids these difficulties because the medical environment, which includes the patient and special medical equipment, is emulated on a computer. This emulation approach is most effective when testing medical algorithms, since the simulation is close to real medical tests, which allows get reliable results of testing the developed medical algorithms. It is possible to work out all the outcomes and scenarios without compromising expensive equipment.

The ROS/Gazebo environment was chosen as the environment for simulating the medical environment, which includes the patient and medical equipment[5]. This choice is due to the fact that most of the real medical robotic systems are developed on the basis of the ROS framework[6]. This allows effortlessly transfer the simulation code to a real robot, thereby reducing the time required to adapt the design for use in real conditions.

Our analysis of scientific sources and publications showed that at the moment there is no full-fledged medical robotic complex in the ROS/Gazebo environment, and there are also no developments related to modeling the human body: head or body. There is no high-quality assembly of a complex model of the abdominal cavity in the Gazebo simulator, so it is impossible to find a world or sdf file, which will allow run ready-made modules or models in a complex.

This article presents a medical software package for the ROS/Gazebo environment, which allows to simulate a complex model of the abdominal. The package includes 7 3D models of organs and tissues. Each model of organs and tissues has unique structure: shape, color, location and quantity.

2. Complex Abdomen Model

The 3D model of abdomen is divided into two main parts: tissues (skin, muscles and adipose tissue) and organs (stomach, kidneys, liver and intestines).

2.1. *Tissues*

For the complex model tissues were modeled, differing in their shape, structure and color. Fig 1 shows the skin. The main features of our model are the beige color and the shape of the prelum. Human skin color is determined by the brown pigment melanin[7]. The prelum perform functions: twisting the lumbar spine, rotating the torso, stabilizing the movement of the chest and participating in the breathing process.

Fig. 2 shows adipose tissue models. For the reliability of the model, the relief was modeled, imitation of adipocytes. Adipocytes are cells of adipose tissue.

Muscle tissue has pronounced muscle fibers, colored red. The color is due to the pigment[8]. These features have been demonstrated in our model. In Fig. 3 depicts muscle tissue models.

Fig. 1. Human skin: real human abdomen (left) and simplified 3D model skin of a human with a waist outline and prelum (right). The left image is borrowed from ocalaplasticsurgery.com.

Fig. 2. Adipose tissue: exemplary adipose with adipocyte samples (left) and 3D adipose model with relief and pronounced adipocytes simulated in Gazebo (right). The left image source: science.org.

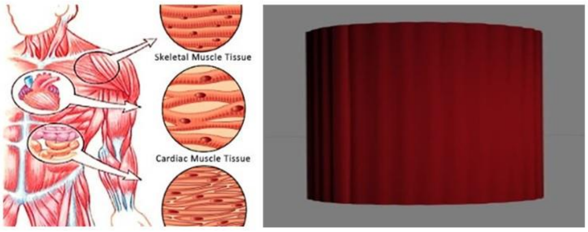

Fig. 3. Muscle tissue: standard muscle tissue 3D model with specified fiber direction (left) and created muscle tissue 3D model with pronounced fibers (right). The left image source: lifelinecelltech.com.

2.2. *Organs*

Fig. 4. Human intestine: original intestines 3D model location taking into account the location of other organs (left) and simplified intestine 3D model of small and large intestines (right). The left image is borrowed from webmd.com.

For the abdominal complex, 4 models of organs were modeled in the Blender modeling toolset, with their different peculiarities. Fig. 4 shows models of intestine. The intestine consists of the small intestine, the large intestine and rectum. The intestines are pink in color due to the very dense network of blood vessels[9].

Fig. 5 shows models of liver. The liver has 2 brown lobes. To create a more believable model, each lobe was modeled separately and fastened with connective tissue.

Fig. 6 shows models of stomach. A hollow muscular organ, part of the digestive tract. The model was created in red due to the network of blood vessels. The reliefs of the gastric mucosa with characteristic longitudinal folds, fields, dimples were modeled[10].

Fig. 7 shows models of kidneys. The kidneys are paired bean organs. This model demonstrates not only the kidneys organs, but also the adrenal glands, simulated with imitation of adipocytes, made in yellow. Arteries and ureter are also modeled.

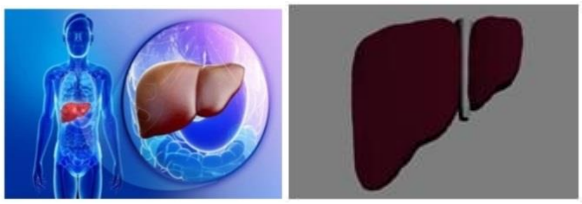

Fig. 5. Liver organ: sample liver 3D model with structure and location (left) and designed liver 3D model with two lobes (right). The left image is appropriate from webmd.com.

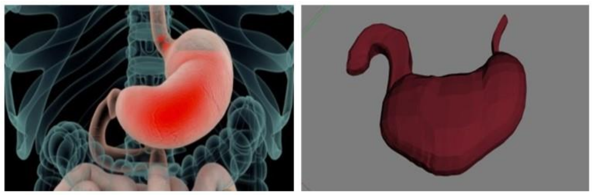

Fig. 6. Human stomach: exemplary stomach 3D model with location features (left) and created stomach 3D model taking into account the structure and shape (right). The left image is borrowed from webmd.com.

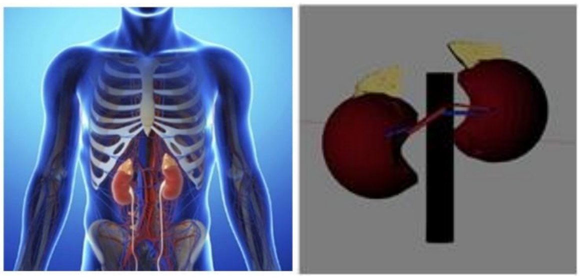

Fig. 7. Models of kidneys: a paradigmatic kidneys 3D model taking into account the structure and location (left) and simplified kidneys 3D model with adrenal glands (right). The image is imported from intermountainhealthcare.org.

3. Conclusions

This article presents a 3D model of a human abdomen, which contains the following organs: intestine, liver, stomach, and kidneys. There are 3 panniculus of an abdominal wall: skin, adipose, and muscle. The model is implemented as a ROS/Gazebo package with necessary configuration files and can be used to simulate medical operations in Gazebo environment.

Acknowledgements

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Authors Introduction

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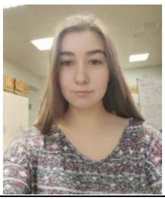

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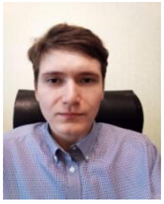

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