

Computer system for the segmentation of the urinary bladder in computed tomography, for the processing and classification of the pathology presented by the bladder

1st Brenda Samantha Pérez Bedolla

*Dept. Systems Engineering
Computational
ESCOM-IPN
México City*

2nd Jaime Hugo Puebla Lomas

*Dept. Systems Engineering
Computational
ESCOM-IPN
México City*

3rd José Félix Serrano Talamantes

*Virtual Reality Lab
CIDETEC- IPN
México City*

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SUMMARY.

The proposal aims to develop a prototype system to segment the bladder organ. The system will use image processing, computer vision, segmentation and pattern recognition techniques. The prototype will load images of axial sections where the urinary bladder (hollow and distensible muscular organ) is observed and will obtain a segmentation of the bladder organ for the subsequent classification of possible tumors in the organ.

Keywords: Urinary bladder, Image processing and Segmentation

I. INTRODUCTION

The urinary bladder is a hollow, distensible muscular organ whose function is to temporarily store urine. When empty, the urinary bladder is pyramidal in shape and lies entirely within the lesser pelvis. When it begins to fill, it becomes ovoid and expands upward to occupy part of the greater pelvis.

In this article with the title Prototype of a system to assist the urologist in the recognition of tumors in the urinary bladder in MRI images, where a real case of a 52 year old male patient from Mexico City is being presented, with the presence of a tumor, the detection of the tumor was achieved through the interpretation of magnetic resonance images of the urinary bladder by the urologist, Dr. Efigenio Antonio Garcia Ramiro.

For the case study the specialist gave us his support to label the images where the tumor and some other pathologies, such as the inflamed bladder that corresponds to cystitis, were present.

Since the patient's image bank was not enough for the training of our convolutional neural network, a dataset with the same characteristics of the patient under study was downloaded, and thanks to the specialist (Urologist) we were able to label all the images in the dataset.

II. DEVELOPMENT

2.1 PRESENCE OF TUMOR IN THE URINARY BLADDER



Figure 1.- Image showing the tumor in the urinary bladder.

Within the overarching context of our research endeavor, it became imperative to engage the valuable collaboration of a highly specialized urologist. The urologist's expertise and proficiency were instrumental in the meticulous task of annotating and labeling the images derived from magnetic resonance imaging (MRI). Their involvement was pivotal in the accurate identification and demarcation of specific regions of urinary bladder, a task that demanded a discerning eye and a profound understanding of the intricacies of the human anatomy.

To successfully delineate the specific areas of the urinary bladder, the seasoned urologist adeptly discerned and highlighted the pertinent regions characterized by discernible alterations in the bladder's morphology. This alteration typically manifested as a transition from the bladder's natural circular shape to a non-circular configuration in the MRI images.

This precise identification of regions of interest is nothing short of indispensable, as it forms the bedrock of our subsequent analytical processes and the correct interpretation of the results derived from the MRI scans. It provides the essential foundation upon which our research findings are based, making the urologist's contribution an integral and irreplaceable component of our study's success. Their expertise in this aspect significantly enriches the quality and reliability of the results, lending depth and credibility to the research outcomes.

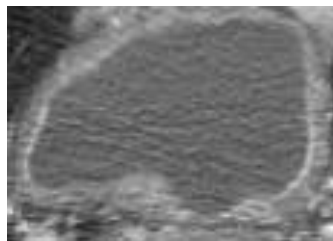


Figure 2.- Image showing the presence of anomalies in the urinary bladder

2.2 Segmentation

Image segmentation is a fundamental and indispensable technique within the realm of image processing. As elucidated by the National Autonomous University of Mexico [4], the concept of segmentation revolves around the extraction of pertinent and significant information from a given visual scene, demarcating the elements of interest from the surrounding background. This delineation significantly eases the process of scrutinizing and analyzing the image, especially in the context of our research article, where image segmentation takes on a pivotal role.

Our research particularly focuses on isolating and analyzing the region containing the urinary bladder. This specialized attention enables us to obviate the unnecessary computational overhead associated with processing extraneous information and, instead, concentrate our efforts on a thorough examination of the urinary bladder. This strategic approach proves to be instrumental in the early detection of potential anomalies and the subsequent in-depth exploration of their distinctive characteristics.

To initiate the segmentation of the bladder, the foremost step entails the identification of the urinary bladder's contours or boundaries. This is accomplished by applying various filters and employing algorithms to detect and isolate the figure with the largest area, which typically corresponds to the urinary bladder.

Once the urinary bladder region has been successfully identified, it is further refined by trimming away any extraneous details or artifacts that might have been captured during the initial identification process. This ensures that the segmented region is precise and corresponds accurately to the anatomical boundaries of the urinary bladder.



Figure 3.- Approximation of the segmentation of the urinary bladder.

The final segmented image is presented below, exhibiting dimensions of 300x300 pixels. It's important to note that this dimension, although reduced, is estimated and justified within the scope of our research project since we are concurrently performing segmentation of the prostate gland, for which a consistent 500x500-pixel dimension was utilized for segmentation.

In less ideal scenarios, segmentation of the urinary bladder can pose a more intricate challenge, particularly when the bladder lacks a clearly defined shape. In such instances, the accurate identification of its borders becomes notably convoluted, compounding the complexity of the segmentation process.

To offer a comprehensive understanding of the segmentation process in an ideal setting, we have included a detailed diagram that elucidates the various stages and steps involved in achieving a successful segmentation under optimal conditions. This diagram provides a visual roadmap of the methodology used when conditions are favorable, aiding in the grasp of the segmentation process's intricacies.

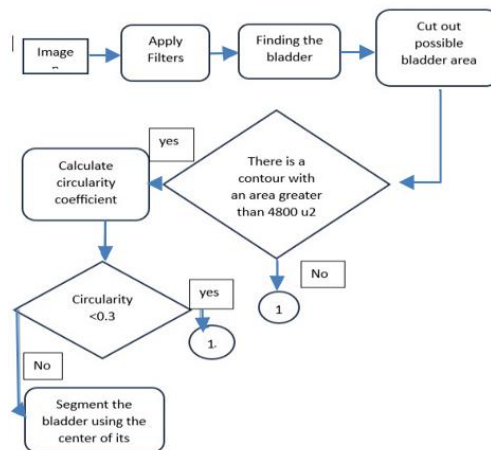


Figure 4.- Flowchart for image segmentation

Open CV is a pivotal tool for image segmentation due to its specialized functions and algorithms crafted for computer vision tasks. Its extensive array of segmentation techniques, such as contour detection, coupled with seamless integration with Python, efficiency in execution speed, and versatility in handling different image formats, empowers developers to address various segmentation challenges. The library's reliability in real-world applications, supported by an active community and integration with machine learning frameworks, further solidifies its significance in computer vision. In the pursuit of image segmentation, a pivotal criterion employed was the circularity coefficient, which served as a decisive factor in determining the shape of the figure during the segmentation process. This coefficient stands as a robust and objective metric for assessing the degree of similarity of a given shape to that of a perfect circle, thus facilitating a highly precise and dependable identification of the target figure.

To enhance the comprehension of the segmentation process, particularly in challenging scenarios where the figure's shape lacks definition, a graphical representation is provided in the following image.

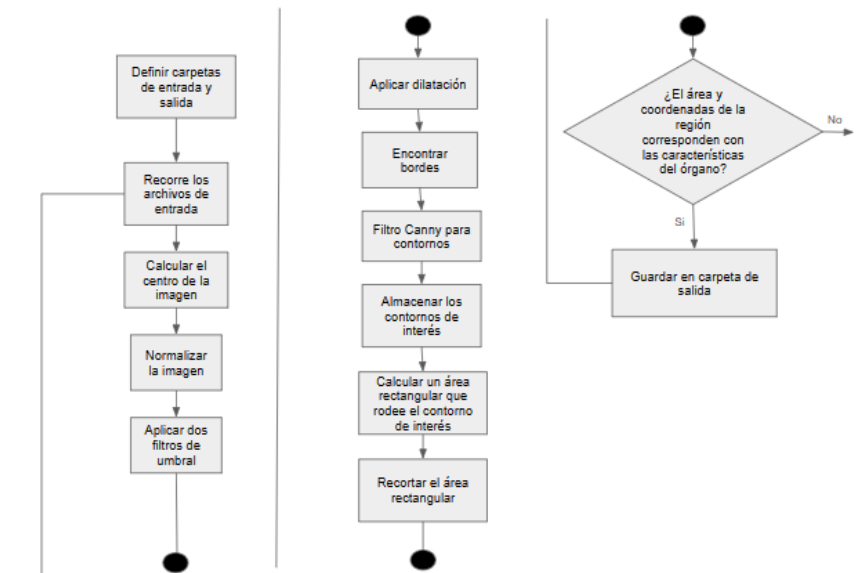


Figure 5.- Code diagram of segmentation



Figure 6.- Worst-case bladder segmentation

The resultant image, displayed below, provides a visual representation of the segmentation process by skillfully identifying and isolating the region containing the most prominent circles. This strategic approach is instrumental in simplifying the visual complexity within the image and ensuring a more focused analysis.

As a part of this segmentation process, the final image's dimensions have been set at 300x300 pixels, which is a notable reduction from the original image's size. This choice is made based on careful consideration and is aligned with the broader research objectives. This standardized image dimension facilitates uniformity and comparability with other segments of our research, particularly when dealing with the segmentation of the prostate gland, for which a consistent 500x500-pixel dimension has been utilized.

By adopting a consistent image size, our research endeavors maintain a cohesive and standardized approach, thereby enhancing the precision and reliability of our comparative analyses. This well-thought-out decision is crucial for streamlining the research process and ensuring that our findings are not skewed or distorted by variations in image sizes.

It not only offers a clear visual representation of our methodology but also underscores the importance of standardized image dimensions for cohesive and robust research outcomes.

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