Visualization for Fibroid Surgery applying Augmented Reality and Ultrasound Image Segmentation

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In the field of endoscopy, extraction of fibroid is suggested in some cases. These fibroids become infrequently lethal, but surgery is considered the least intrusive method of curing, thus making it the most popular technique. When performing a surgery like this, it is important to execute only one incision on the uterine wall. This kind of surgery can be extremely difficult to perform by only one incision, for the reason that the fibroid can be located in the deep tissues of the uterus to such a degree that it is barely visible by the unaided eye using only the feed of the endoscopic camera [1]. This complication is usually overcome by using preoperative sonography or magnetic resonance imaging. A scan like this is made preoperatively with the goal to get information about the precise location of the fibroid. Despite of it making the surgery relatively easier, medics are struggling to perform a well-placed incision on their first try, hence resulting in excess blood loss, higher complication rate and a longer recovery.

Considering the fact that sonography is much faster, cheaper and more widely available [2], we propose a method to solve the aforementioned problem. Using a suitable ultrasound system, we can extract the image slices and perform a segmentation in order to get the model of the uterus. An expert can then place a model of the fibroid in a precise location. This combined final model is then projected onto an endoscopic camera frame. As the first step we applied Otsu's thresholding algorithm [3]. This results a region of interest on the ultrasound image slice, which is then used to segment the uterus itself. A second thresholding stage is following in which our goal is to use the two-dimensional data in the slices to get an average segmentation mask for each case. This is determined based on the slices in the middle of the 3D capture. Regarding the three-dimensional information, our algorithm of choice was a version of the Active Contour Without Edges (ACWE) method [4]. The main technique of these kind of algorithms is to evolve a curve on a given image based on some constraints so that an object is detected. For the final segmentation of the model, we have used a morphological version of this algorithm, since it can reduce computational costs. Using the model achieved by executing these algorithms, we have managed to project the combined result (with the fibroid placed in the uterus) on a frame from the endoscopic camera flow. This has been done using a popular Augmented Reality development kit, called Vuforia, which is compatible with UWP (Universal Windows Product) [5], thus making it a suitable choice for us.

Our main contribution is the workflow process that is capable of making a three-dimensional model from a sonography capture. The application we made has the ability to form an accurate representation of an uterus. Although a working segmentation algorithm was made, we have yet to overcome some difficulties in order to reach our final goal. To be precise, we plan on making the insertion of the fibroid automatic, also the augmentation and projection process is planned to happen in real-time during surgery. In addition, neural networks are considered to perform the segmentation in case of a suitable dataset. With our contribution, doctors could perform the aforementioned surgery more precisely, thus making it more efficient and without unnecessary long recovery times for the patients.

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