

The goal of this project is to develop a novel set of non-photorealistic rendering (NPR) techniques for displaying thyroid cartilage images for medialization laryngoplasty surgical procedures that will help surgeons better visualize the unique geometry of the patients vocal cords and thyroid cartilage. Non-photorealistic rendering techniques do not create exact photorealistic renderings, but rather renderings that will enhance visual comprehension. By abstracting some of the complexities of the 3D CT data and rendering them similar to the highly comprehensible images found in medical textbooks or technical manuals, we can greatly enhance comprehension. The objective is to provide the tools for the surgeon to better understand his patient's unique thyroid geometry and help increase the success rate of this geometrically difficult procedure.

Vocal cord paralysis and paresis are a group of disorders that occur when one or both vocal cords are unable to open or close properly. This debilitating condition may lead to difficulty speaking, eating, and coughing for the patient. Two vocal cords are located bilaterally in the larynx (voice box) above the trachea and are basically a muscle covered by a mucous membrane. The pair vibrates to produce voice, and close to protect the lungs.

Under paralysis, the vocal cord muscle will naturally atrophy, and the resultant vocal cord will be weak and bow shaped and unable to effectively close in the middle to protect the lungs or produce the high-pitched sounds associated with voice. In order to correct this deviation, an implant is surgically placed in the trachea to provide lateral support to the weak vocal cord and move it into the medial position. This way the other vocal cord can effectively open and close uninhibited. Medialization laryngoplasty is the surgical procedure to place an implant that pushes the weak vocal cord into the midline (medial) position so that the other vocal cord will better meet it.

During medialization laryngoplasty, the uniquely configured implant is placed lateral to the paretic vocal cord through a window cut in the thyroid cartilage. Because the surgeon has limited detail of the geometry of the patient's thyroid cartilage, the surgeon must rely on experience and intuition to place the implant. This procedure is subject to a significant level of uncertainty and the failure rate is as high as 24% even for experienced surgeons.

The motivation behind this research is to provide the surgeon with the tools necessary to improve the outcome of this procedure and to reduce the revision rate. The goal is to provide an intraoperative image guided system that will enable the surgeon to effectively understand and coordinate the insertion of the implant, allowing the surgeon to accurately place the implant at the desired location. The surgeon is provided with a stylus that he may use to manipulate the image-guided system. The location of the stylus is registered with 2D cameras against the 3D CT dataset and as the surgeon moves the stylus around the area of interest, the system updates a graphical view of the patient. Utilizing a simple graphical interface system, the surgeon will be able to seamlessly integrate the system into his surgical practices.

During the interactive visualization, the preoperative 3D CT data will be rendered using the GPU (graphics hardware) acceleration. An opacity transfer function is used to simultaneously visualize the laryngeal

cartilage surface and the airway lumens. The goal of this proposal is to develop rendering techniques that will best convey the form and shape of the thyroid cartilage. These techniques should abstract some of the confusing elements of the realistic image, without losing too much detail. The NPR methods will automatically render the 3D geometric datasets into simpler, yet more effective renderings of the patient's data. NPR techniques greatly assist in showing the geometric details of parts of a complex 3D system.

Non-photorealistic rendering techniques produce 3D images with enhanced visual comprehensibility. By enhancing certain geometric properties and abstracting other irrelevant information, shape features and geometry become easier to understand and visualize. Specifically, the goal is to create NPR methods for our preoperative CT data that render images similar to the hand drawn images found in technical illustrations or in medical textbooks, where the communication of shape and form is valued above realism.

There are a number of common themes in medical illustrations: Edge lines are drawn with black curves to enhance visual comprehensibility of the geometry detail. Matte objects are shaded with intensities with warmth or coolness of color indicative of the surface normal. Shadowing is not shown. The edge lines and highlights provide a great detail of shape information and our goal is to develop a simple and automatic system that imitates these methods for line and color found in medical textbooks and technical manuals. The aspiration is to develop rendering techniques that will best convey the form and shape of our thyroid cartilage. These techniques should abstract some of the confusing elements of realistic image, without losing too much detail. Abstraction simplifies the elements of 3D images.

Non-photorealistic rendering employs abstraction techniques to convey the relevant information, whilst disregarding the more confusing elements of photorealistic renderings. Our aim is that by providing a more comprehensible view to the surgeon, we will significantly improve the success rate of the medialization laryngoplasty procedure.