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An Active Stereo Vision Method to Measure Distensibility of a Compliant Tube

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ABSTRACT

Ex-vivo heart perfusion (EVHP) is a donor heart preservation method that mimics physiological conditions by pumping blood and supplements through the heart in cardiac cycles. Conventionally, EVHP uses rigid tubing for the flow loop. However, it has been shown that compliant tubing requires less pumping energy and dampens the fluctuations in the pulsatile pressure as suggested by the Windkessel effect. This more closely approximates in-vivo conditions and is beneficial to the donor heart during EVHP. To investigate the relationship between compliant tubing distensibility and its damping effects, an active stereo vision system is used to develop a measurement methodology. The imaging device consists of a pair of infrared cameras in a stereo configuration that are used to image the compliant tube with a speckle light pattern generated by an infrared emitter. Pairs of infrared images are used to generate a synthetic image, called a depth map, that measures the distance between the scene and imaging system. The compliant tube is isolated in the depth maps using image segmentation methods. A collection of 3D points, called a point cloud, along the surface of the compliant tube are generated from the segmented depth maps. Point clouds from multiple stereo vision systems, with different views of the compliant tube, can be aligned and combined to provide a complete surface map of the tube. A custom algorithm is used to monitor the distention of the compliant body. In this study, data was collected from a custom pulsatile flow loop in which a compliant tube, mimicking an aorta, is downstream from the simulated heart. The tube distension with respects to time and the pump cycle are found, which are validated using shadowgraph. The compliant tubes are cast from different silicone elastomer materials such as dragon skin. This method can evaluate the distensibility of different compliant tubes to help determine geometry and material that would be favorable for an EVHP. Additionally, this methodology could be applied to other compliant sections of an EVHP with irregular geometry. The presentation will discuss the methodology in detail.