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Computer integrated Surgery 2

3/11/2018

Critical Review

The article in review is titled "Multi-Modal Imaging, Imaged Based Tracking, and Mixed Reality Visualization for Orthopaedic Surgery" written by Sing Chun Lee, Bernhard Fuerst, Keisuke Tateno, Alex Johnson, Javad Fotouhi, Greg Osgood, Frederico Tombari, and Nassir Navab. The article in review was published in Healthcare Technology Letters, having been received on June26, 2017 and accepted on August 2, 2017. Two of the authors of this paper, Sing Chun Lee and Javad Fotouhi, are mentors for our project as well, so they informed me of this paper to better my understanding of how to go about the project. The paper first starts off with an introduction to explain the problem. The problem they set out to solve was that of the technical challenges orthopedic surgery. Currently it is a difficult surgery to perform for reasons such as complex anatomy, limitations in screw starting point and trajectory, and the limited margin of error in some cases. They then summarize the process of obtaining the imaging during the procedure. The surgery uses a camC arms to which they can attached RGBD cameras to in order to obtain imaging data. This process in particular is relevant to my project because that is how we plan to get the osteotom position. Currently most of the surgery navigation is done by the pre-operative imaging from the C-arm camera. However, by attaching a RGBD camera to the C-arm images of the tools position can be received intra-operatively without the risk of extra radiation to the patient and without increasing the operation time. Alternative solutions to their problem are also given in the introduction along with the downfalls of each of them. An example that they included was that of attaching cameras near the x-ray source so that they can be co-registered with the fluoroscopic images, however this alternative required introduction of large spherical markers and positioning the X-ray above the patient instead of below, causing radiation to affect the surgeons in addition to giving them a smaller workspace. Their analysis tin this portion seemed pretty thorough. They made sure that in each alternative they showed the pros and cons that were evident. They then talked about their actual solution. This solution used a live point cloud received from the RGBD attached the C-arm to track the tool and display it in a mixed reality environment so that the surgeon can match the actual orientation and trajectory to the planned trajectory and orientation for fast entry point localization to which would speed up the operation. They did mention that their solution would have minute tracking errors, but the fluoroscopic images from different viewpoints would help ensure correct alignment. In the next section, the methods and materials used to achieve their goal were discussed. Each algorithm that they used was explained in how it works and what part of the project it accomplished. This helps readers of this paper to better understand the process of how the parts fit together and how to go about achieving something similar. They also stated the advantages of the processes that were used as well as the ways that they got around the inherent disadvantages that come with each method, such as dealing with occlusions. This section was a really useful section, however, the mixed reality portion of this section was not as detailed as the others in terms of explaining how it works. I find that this section should probably have been the most detailed since this seems like the section that would be the hardest concept to understand on a first read through. Other than that critique, the section was well written and useful. Next was the experimental portion. This section came complete with pictures of the experimental setups and charts of the results that accompanied the written description of the process they used to test their solution. The data showed that high occlusion produced results that deviated by 20.68 ± 4.54 mm from the actual pose of the tool being tracked, but low occlusion resulted in variation of 1.36 ± 1.12 mm. The section that follows is the discussion and conclusion of these results. They discovered that their tracking on average had a margin of error of about 3 mm, but can reduce radiation dosage and operation time by 63% and 59% respectively. This accuracy can't help with procedure with very small margins of error such as k-wire screw placements, but can drastically improve the speed of procedures that have insertion sights with more wiggle room due to helping the surgeon visualize where their trajectory would lead and help them line up the tool to the pose of the pre-operative plan. I would have liked the discussion and conclusion to talk a bit more on how they could improve their design in the future. The only input given was that more cameras can help improve accuracy. Although, that is one way to improve, there should be more than one way to improve accuracy, like maybe changing an algorithm, or using a different type of camera, etc. Regardless, this paper is quite relevant in terms of my project, and very informative to read. We have their algorithms in segmentation and calibration that we can use for are project, or at least a starting place to think about implementing. For possible next steps, this project could work either on new ways of improving accuracy or transitioning to intra-operative tracking as well and not just pre-operative tracking.