Constructing a Single Camera Triangulation System for Capturing 3D Point Clouds with Color

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Triangulation has been a popular choice for mapping 3D positions because of its speed and cost. However, it is constrained by the correspondence problem and limited to almost zero inter-frame motion. The purpose of this experiment is to improve the typical triangulation systems in terms of accuracy and number of false matches, allowing for a real-time 3D camera. The first proposed idea is to split the image RGB layers into different perspectives, yielding three different geometry views for a single frame, instead of the traditional two. Thus, only one camera is required instead of many, saving cost and increasing speed. The second idea is to project a pattern composed of distinct predefined symbols, instead of the traditional vertical line(s). Combining these two innovations not only improves the accuracy but also mitigates the false matching of corresponding points. The experiment system was constructed using optical splitter, color filters, and mirrors to effectively capture three perspectives with a single shot. The pixel and real world spaces are related using vector geometry and optics. The three perspectives yield six linear equations for each real world coordinate. This over-constrained system is then solved using the least-squares method from linear algebra to optimally recover the (x,y,z) position coordinate and to ensure geometric consistency. The results of the experiment demonstrate that the unique pattern symbols, together with the extra perspectives, greatly reduce the number of false matches. However, the accuracy did not improve proportionally; perhaps the calibration and/or systematic errors were masking the enhancement.