Stereo Vision with RGB and Time of Flight Camera

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Assumptions:

- Only brief explanation of mentioned simplifications is present.
- Complexities such as finding optimal centers, finding correct translation parameter, etc. [1], are ignored, clearly focusing on value additions.

Classical stereo vision suffers from two major problems – i) The Correspondence Problem and ii) The (3D) Reconstruction Problem [2]. Many systems try to solve these, including the methodologies of combining ToF camera with stereo vision, most of these use three cameras, keeping classical stereo systems intact [7], but the root causes are still present. I think these are solvable by this new fusion method.

1. Mismatched correspondence in the areas of very homogenous intensity or high distortion regions [3]: Due to ToF camera, depth information will be inherently available and hence correspondence will improve. The calibration equations will simplify. In turn, problem of 3D reconstruction, including barriers like textureless region, will be solved to the great extent.
2. Disparities are only estimated to a certain precision [3]: ToF cameras are fast, the error is 10-15mm/m [1]. For classical stereo vision systems it is 30-100mm/m [4]. Hence, higher precision can be attained.

With respect to stereo vision, above two problems give rise to other problems such as finding ROI, dealing with lighting conditions, etc., as mentioned in [1]. So those will also be taken care of to some extent.

Due to ambiguous Fundamental matrix, even when converted to Essential Matrix [5], calibrating stereo camera is a tough. As presented in [1] intrinsic calibration is fast, accurate and straightforward. So, stereo camera calibration is natural because we just need to map the disparity to RGB camera. Also, improved correspondence will help the calibration of the entire system is far more accurate.

A method to calibrate this particular setting is briefly mentioned in [1]. Recent advances in this field will ease the calibration overall. The presence of color map will help in minimizing the intricacies of the ToF cameras, such as flying pixels. While working in real time, a common problem of losing the correspondence occurs quite often. A solution to restore the calibration would be using a single ToF frame [6] is quite interesting.

Essentially, we could gain a lot of things in this new fusion. The New system will have its own set of problems, for e.g. The mismatch between the resolutions of ToF and RGB camera but I think it's worth investing time to yield those, as this seems very promising way.

[1] Topograpy, Time of Flight cameras (3D vision), March 2013, *Luc Mertens* [1,] *Rudi Penne* [1.2] *and Bart Ribbens* [1,3,4]
[2] Stereo Vision – A brief introduction Feb-2007 *Máté István* Lecture notes, MSc Informatics
[3] Disparity estimation and reconstruction in stereo vision, *Salvador Gutiérrez and José Luis Marroquín*, Comunicación Técnica No I-03-07/7-042003(CC/CIMAT)
[4] A comparison of PMD-cameras and stereo-vision for the task of surface reconstruction using patchlets, Jun 2007, *Christian Beder, Bogumil Bartczak, Reinhard Koch*
[5] Youtube video on Stereo Camera Calibration - https://www.youtube.com/watch?v=DDjfhYxqp3w
[6]An Incremental Procedure for the Lateral Calibration of a Time-of-Flight Camera by One Image of a Flat Surface, Jun 2013, *Rudi Penne · Bart Ribbens · Luc Mertens*
[7] Fusion of stereo vision and Time-Of-Flight imaging for improved 3D estimation, Jun 2013, *Sigurjón Árni Guðmundsson*, Henrik Aanæsand Rasmus Larsen*