Omnidirectional vision odometry for low power hardware on flying robots

Simon Reich[1], Maurice Seer[1], Lars Berscheid[1], Florentin Wörgötter[1], and Jan-Matthias Braun[1]

***Abstract*— In this work we will show a feature comparison in more detail than possible in the original submission. However, some steps are omitted as they refer to standard text book examples. They are noted as such. Images are enlarged to ease understanding. The referenced sources are the same as in the original submission; however, the numbering does not align.**

I. FEATURE ANALYSIS

Here, we will show a short comparison of several feature algorithms, which were tested on the quadrocopter. Since we are using very limited hardware, processing speed is a key feature. Furthermore, we are not interested in a huge amount of key points, but rather in few points of high quality, which can be tracked for several frames. The comparison includes FAST [1], GFTT [2], SIFT [3], and SURF [4]. As there are already numerous publications about feature comparisons, we are focusing here on the aspects, which are unique to our setup. That includes:

- Limited hardware,
- features are computed on a dewarped image, and
- features are computed on a reflected images, which dims light significantly.

Fig. 1 shows the original image as it is presented to the quadrocopter. First, we will look at the processing speed of the different sets. A comparison is given in table I. A visual representation of the same data is given in Fig. 2. The FAST implementation is at least a magnitude faster than all other tested sets.

Next, we will look at the quality of the features. Please note that a thorough data analysis would require ground truth information, different recording settings, and different light settings. All these have been tested numerous times and, furthermore, this is not the focus of this work. Therefore, we will analyze, which feature set meets our minimum requirements, which are (as stated above): Finding features

[1]Third Institute of Physics - Biophysics, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany
{sreich, mseer, lberscheid, worgott, jbraun}@phys.uni-goettingen.de
(The first two authors contributed equally to this paper.)

Feature Set	Time [s]
FAST	0.003 ± 0.001
GFTT	0.028 ± 0.001
SURF	0.060 ± 0.001
SIFT	0.550 ± 0.001

TABLE I: Processing speed of feature sets on out limited hardware setup.

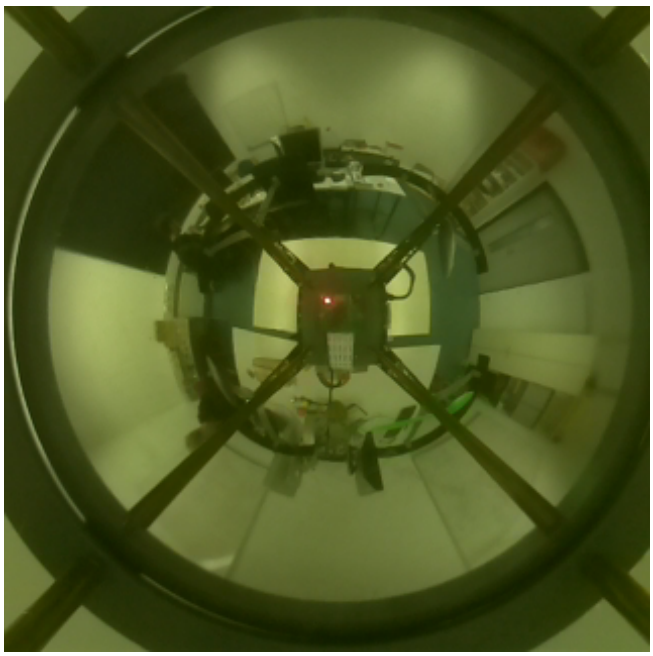


Fig. 1: Processed camera images with features and computed optical flow.

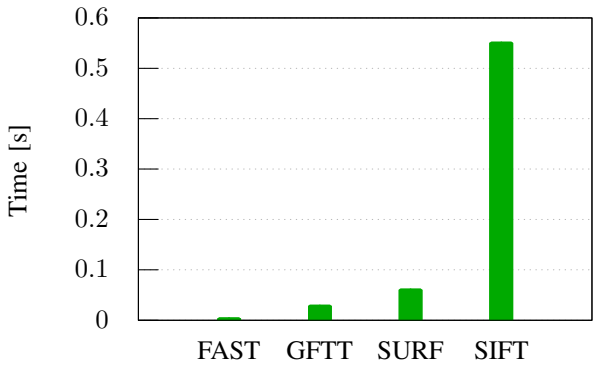


Fig. 2: Visual representation of table I. Shown is the processing speed of feature sets on out limited hardware setup.

in difficult light settings, which do not overlap, and which are stable to track.

Fig. 3 shows one example frame, on which feature sets were computed:

- FAST: All features found are on edges, which are rich on texture and easy to track through several frames. However, in areas with huge color gradient, e.g. the white desj in the upper middle, features tend to accumulate. This wastes computational power, as features on the same place does not add information.
- GFTT: In comparison to FAST features seem to be similar distributed, but better placed. Furthermore, all features are a minimum distance apart.
- SIFT: This sets finds a lot of good features, but is computational too expensive to run on limited hardware.
- SURF: Quiet a lot of features are on white areas. We did not spent much time "tuning" the algorithm, as the results on the dewarped image were of low quality throughout all trials.

II. CONCLUSION

As we are focusing on computational complexity, the FAST feature set outperforms all other. The quality of found key points is good enough for stable quadrocopter control.

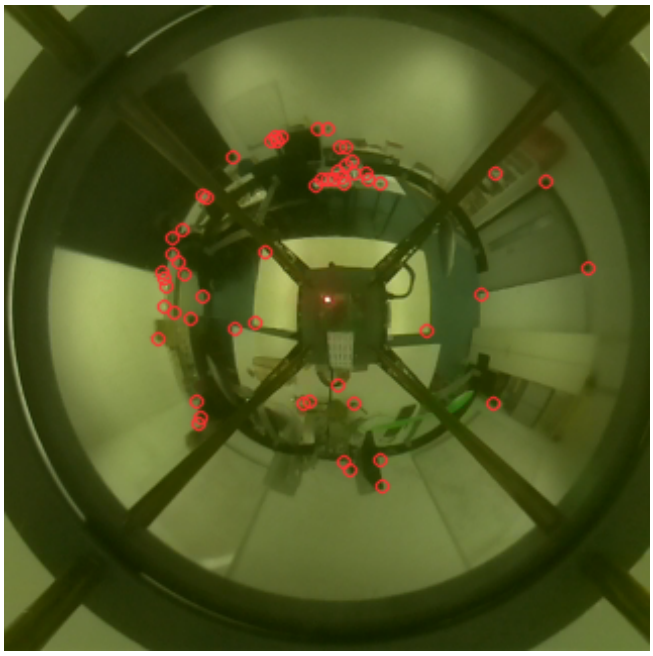
REFERENCES

[1] E. Rosten and T. Drummond, *Machine Learning for High-Speed Corner Detection*. Berlin, Heidelberg: Springer Berlin Heidelberg, 2006, pp. 430–443.

[2] J. Shi and C. Tomasi, "Good features to track," in *IEEE Computer Society Conference on Computer Vision and Pattern Recognition*. IEEE, 1994, pp. 593–600.

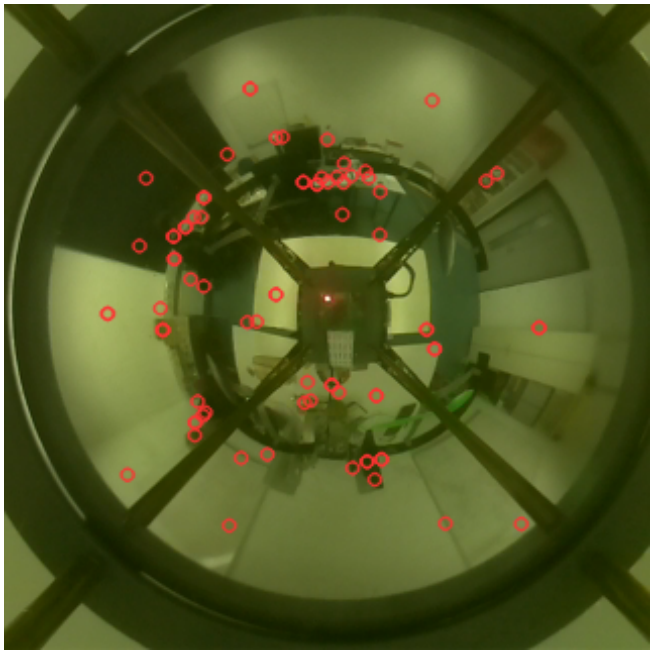
[3] D. G. Lowe, "Object recognition from local scale-invariant features," in *The proceedings of the seventh IEEE international conference on Computer vision*, vol. 2. IEEE, 1999, pp. 1150–1157.

[4] H. Bay, T. Tuytelaars, and L. Van Gool, "Surf: Speeded up robust features," in *European conference on computer vision*. Springer, 2006, pp. 404–417.

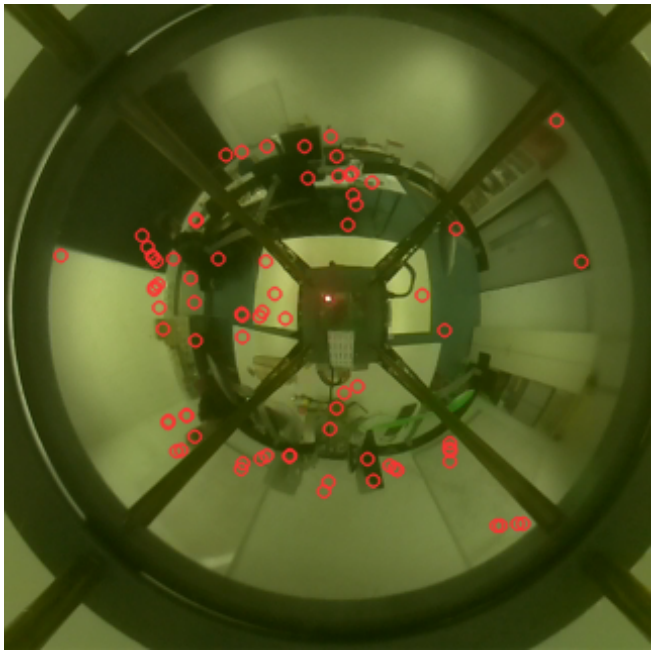


(a) FAST Feature Set

(b) GFTT Feature Set



(c) SIFT Feature Set



(d) SURF Feature Set

Fig. 3: Qualitative comparison of feature algorithms. The original image is shown in Fig. 1.