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High-speed visual target tracking with mixed rotation invariant description and skipping searching

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Abstract

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1 Introduction the most fundamental technologies in computer

Target tracking is one of the most fundamental technologies in computer vision. Many tracking systems have been designed for various applications such as industrial automation, autonomous robot navigation, intelligent video surveillance, activity analysis, classification and recognition from motion, and human-computer interfaces [1, 2]. However, (**??**) the respond speed of conventional tracking system is limited to less than 60 fps due to serial image processing. Some researchers adopt parallel single-instruction-multiple-data (SIMD) processors to speed up tracking algorithms [3–7]. However, these processors are Sect. 1 still unable to meet the needs of high-speed target tracking applications because they can only implement straightforward low-level and some simple middle-level image processing https://mc03.manuscriptcentral.com/scpma algorithms such as background subtraction, segmentation and motion detection.

In many applications such as robot navigation and automatic drive, the target moves at high speed in complex environment. In order to tracking a moving target constantly, not only real-time processing capacity but also robust algorithms are required. Image processing algorithms such as optical flow, self-window and moment tracking have been implemented on high-speed vision systems to realize fast tracking functions [**?**, 8, 9]. However, most of them can only be applied to certain scenarios with a clear background or constant illumination. Some other algorithms such as compressive tracking and tracking-learning-detection have better performance in robustness; however, their computation overhead constrains their real-time performance [11, 12]. Local binary pattern (LBP)-histogram of gradient (HOG) feature description is widely used in target detection and tracking [9, 10]. However, both of the HOG and LBP histogram are rotation variant. Hence, it would result in target shifting and tracking failing when the target moves in a complicated environment or rotates suddenly.

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Figure 1 Process of the proposed MRID.

Table 1 FPGA resource ultilization

FPGA device	ArriaV 5AGXFB3H4F35C4N
Logic utilization (in ALMs)	83845/136880 (61%)
Total registers	83534
Total pins	41/656 (6%)
Total block memory bits	2350280/17674240 (13%)
Total PLLs	2/36 (6%)[1)]

1) spacecraft will hit earth on way back since $r_p < r_{earth}$

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Conflict of interest The authors declare that they have no conflict of interest.

1 W. Pauli, *Die allgemeinen Prinzipien der Wellenmechanik* (Springer, Berlin, Heidelberg, 1933).
2 S. Weigert, Phys. Rev. A **45**, 7688 (1992).
3 J. P. Amiet, and S. Weigert, J. Phys. A-Math. Gen. **32**, 2777 (1999).
4 J. Chen, H. Dawkins, Z. Ji, N. Johnston, D. Kribs, F. Shultz, and B. Zeng, Phys. Rev. A **88**, 012109 (2013).
5 H. Y. Wang, W. Q. Zheng, N. K. Yu, K. R. Li, D. W. Lu, T. Xin, C. Li, Z. F. Ji, D. Kribs, B. Zeng, X. H. Peng, and J. F. Du, Sci. China-Phys. Mech. Astron. **59**, 100313 (2016).
6 T. Heinosaari, L. Mazzarella, and M. M. Wolf, Commun. Math. Phys. **318**, 355 (2013).
7 G. Gutoski, and N. Johnston, J. Math. Phys. **55**, 032201 (2014).
8 J. Finkelstein, Phys. Rev. A **70**, 052107 (2004).
9 C. H. Baldwin, I. H. Deutsch, and A. Kalev, Phys. Rev. A **93**, 052105 (2016).
10 C. H. Baldwin, A. Kalev, and I. H. Deutsch, Phys. Rev. A **90**, 012110 (2014).
11 Y. Long, G. R. Feng, J. Pearson, and G. L. Long, Sci. China-Phys. Mech. Astron. **57**, 1256 (2014).
12 F. Z. Jin, H. W. Chen, X. Rong, H. Zhou, M. J. Shi, Q. Zhang, C. Y. Ju, Y. F. Cai, S. L. Luo, X. H. Peng, and J. F. Du, Sci. China-Phys. Mech. Astron. **59**, 630302 (2016).
9 X. L. Zhen, T. Xin, F. H. Zhang, and G. L. Long, Sci. China-Phys. Mech. Astron. **59**, 690312 (2016).
10 M. A. Nielsen, I, L. Chuang, *Quantum Computation and Quantum Information* (Cambridge University Press, Cambridge, 2010).
11 D. G. Cory, A. F. Fahmy, and T. F. Havel, Proc. Natl. Acad. Sci. **94**, 1634 (1997).

Appendix