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Design of an enhanced visual odometry by building and matching compressive panoramic landmarks online

Key words: Visual odometry, Panoramic landmark, Landmark matching, Compressed sensing, Adaptive compressive feature

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Introduction

- Efficient and precise localization is a prerequisite for the intelligent navigation of mobile robots. Traditional visual localization systems, such as visual odometry (VO) and simultaneous localization and mapping (SLAM), suffer from two shortcomings:

1. A drift problem caused by accumulated localization error.
2. Erroneous motion estimation due to illumination variation and moving objects.

✓ We propose an enhanced VO by introducing a panoramic camera into the traditional stereo-only VO system.

Introduction (Con'd)

- Benefiting from the 360° field of view, the panoramic camera is responsible for three tasks:

1. Detecting road junctions and building a landmark library online.
2. Correcting the robot's position when the landmarks are revisited with any orientation.
3. Working as a panoramic compass when the stereo VO cannot provide reliable positioning results.

- To use the large-sized panoramic images efficiently, the concept of compressed sensing is introduced into the solution and an adaptive compressive feature is presented.

✓ Combined with our previous TLBBA stereo VO, the new system can obtain reliable positioning results in quasi-real time.

Framework of the enhanced visual odometry

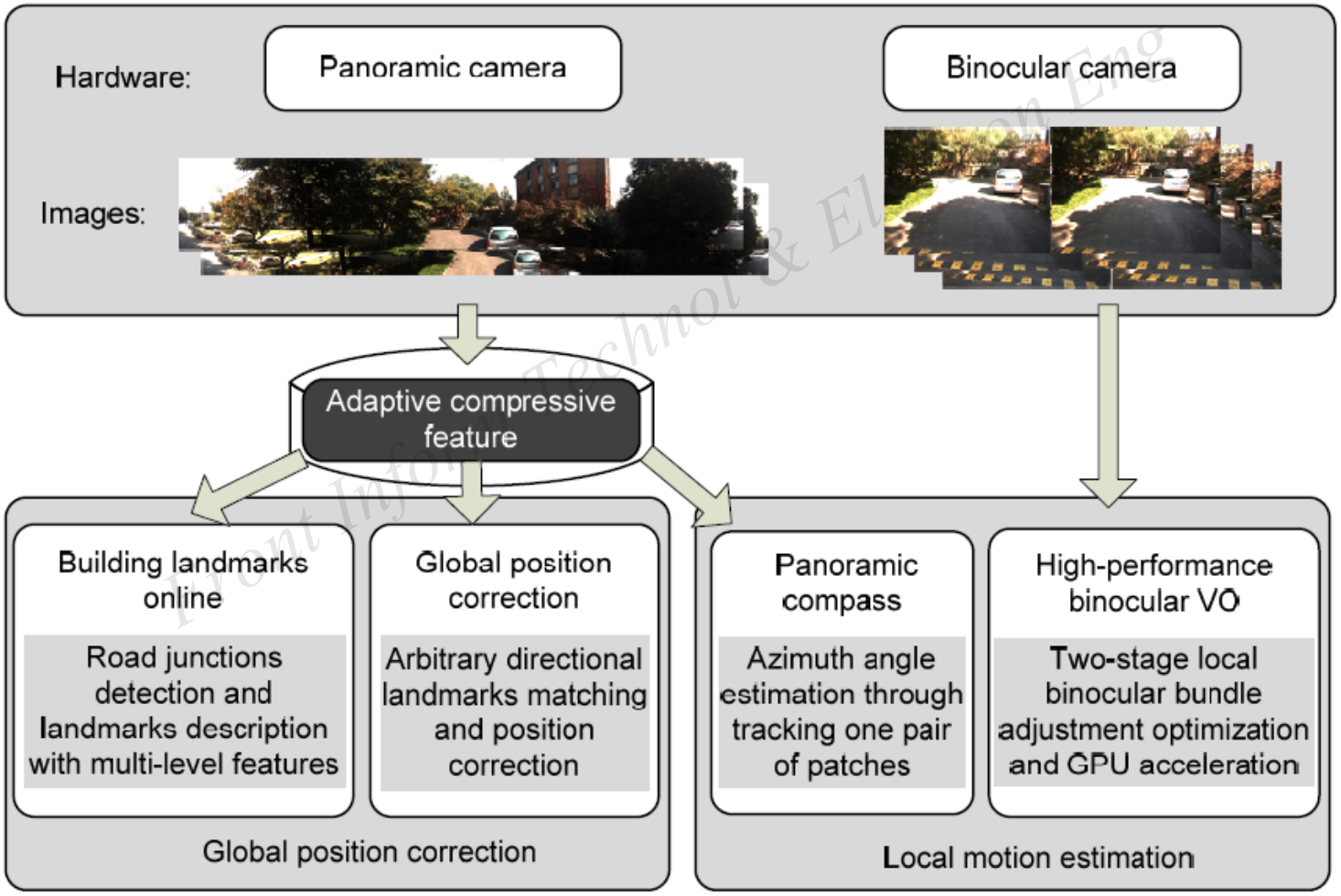


Illustration of the adaptive compressive feature

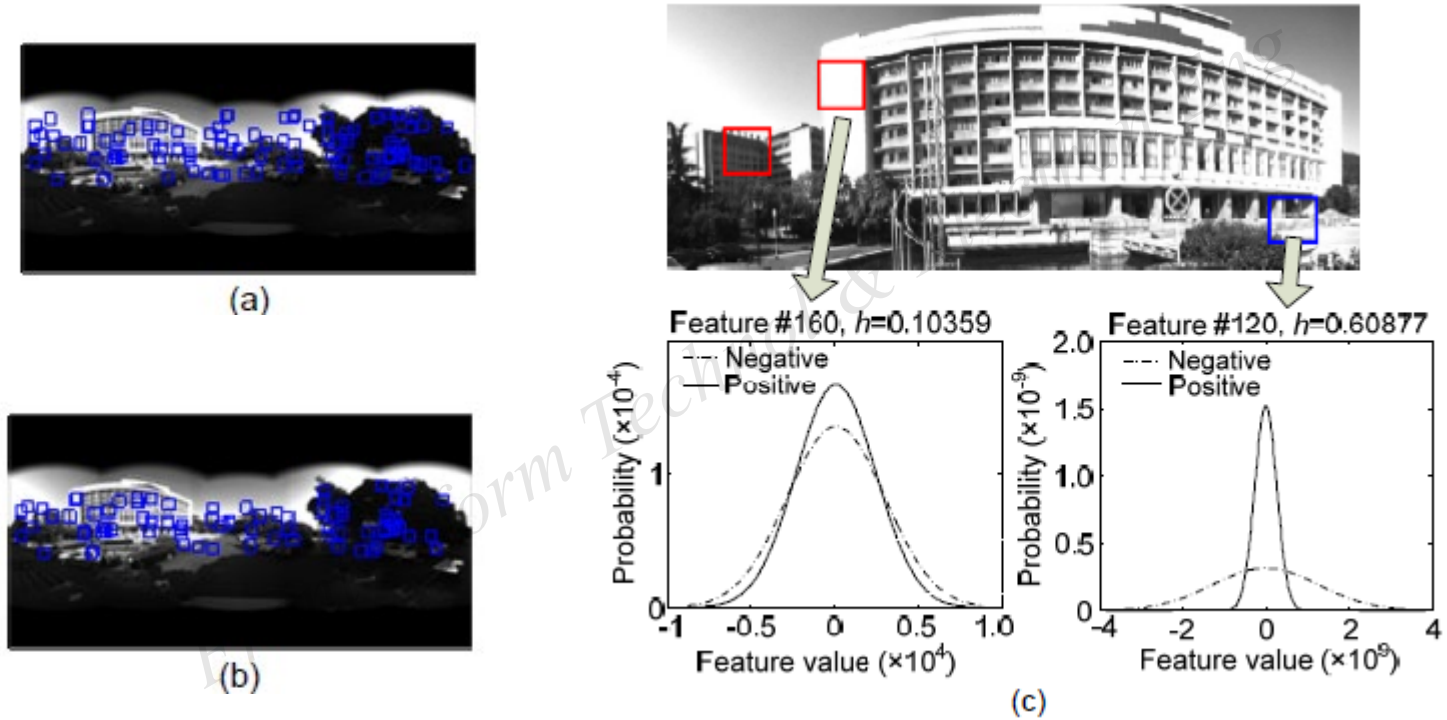
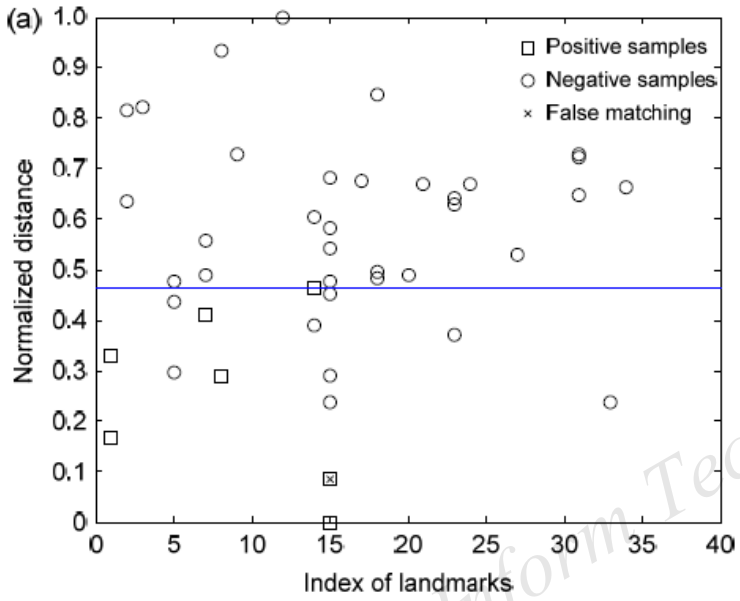
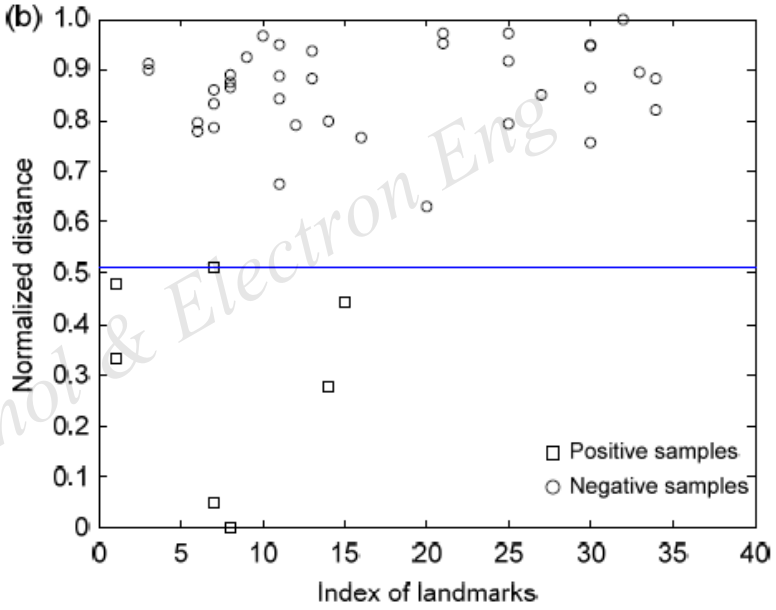


Fig. 2 Illustration of the adaptive compressive feature

(a) Randomly located rectangles in image ***I***; (b) Remove the features whose variances are too small; (c) Weight the features with the Hellinger distance

Global property of the features

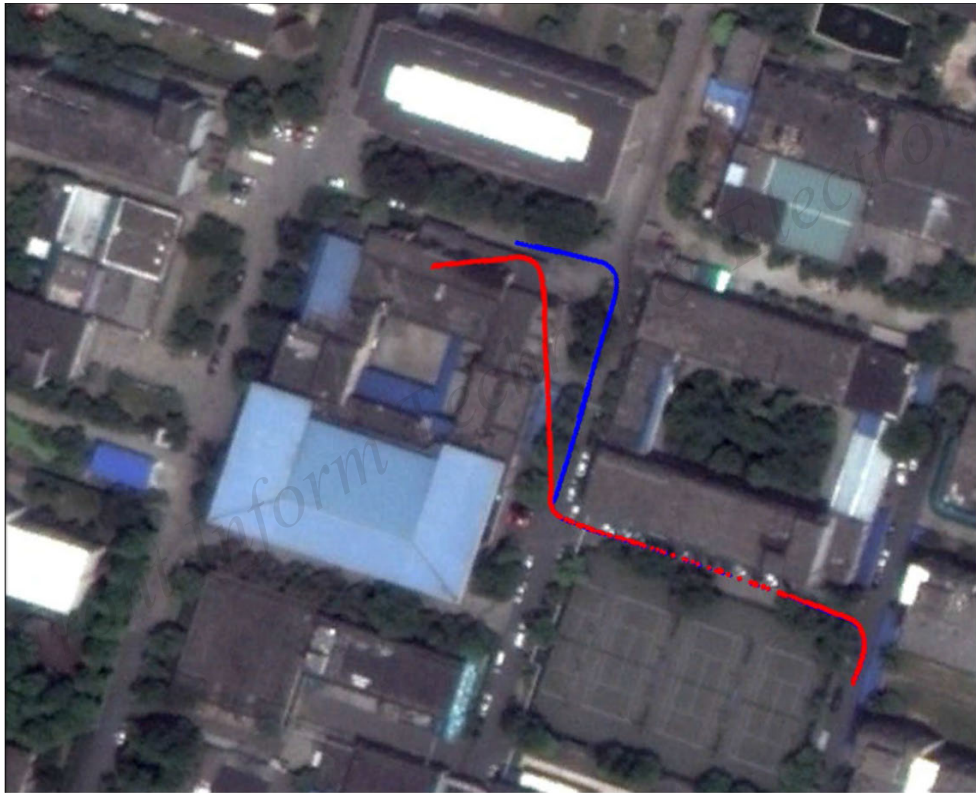




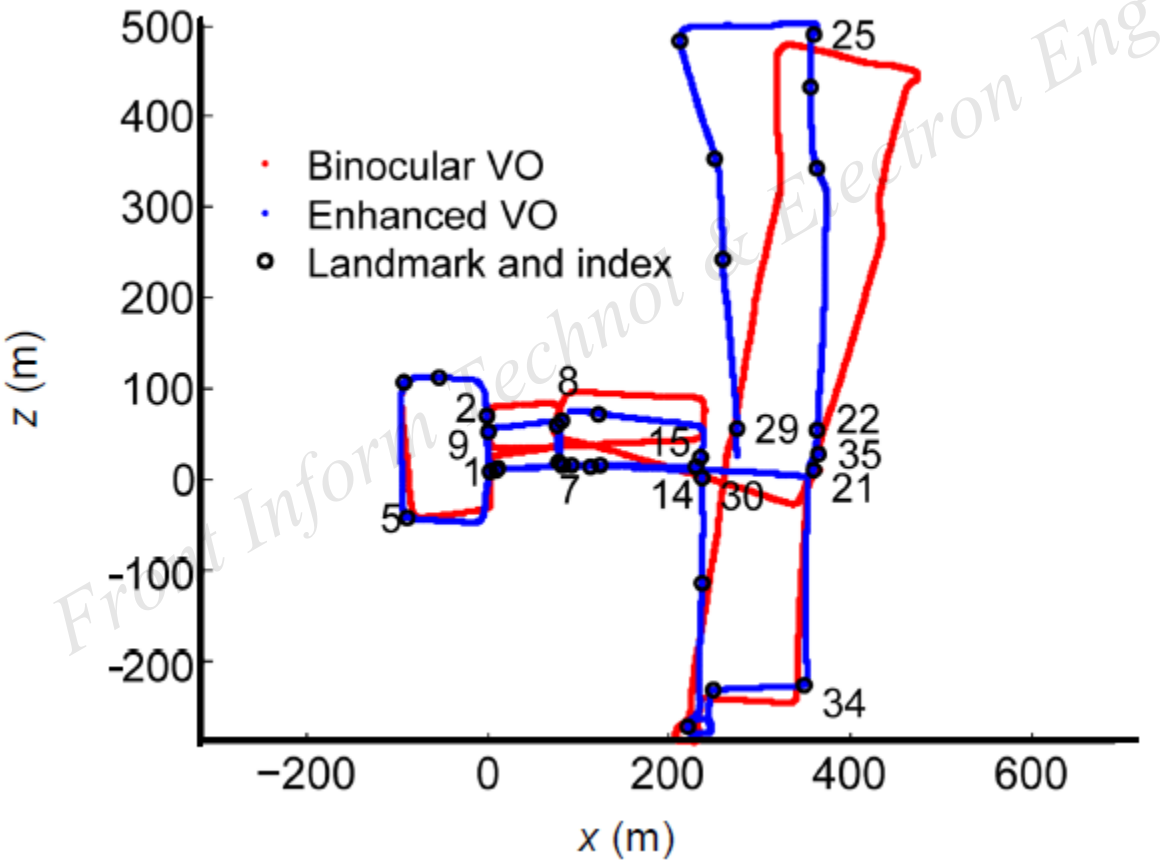
(a) The matching result of BRIEF-Gist (b) The matching result of our large scale ACF

Method	V_{sc}	TP	FP	Recall	Precision
BRIEF-Gist	0.33	6	8	0.86	0.43
Large-scale CF	0.54	7	0	1.00	1.00
Large-scale ACF	0.56	7	0	1.00	1.00
Small-scale CF	0.47	7	0	1.00	1.00
Small-scale ACF	0.37	7	14	1.00	0.33

Azimuth angle correction



Localization results of dataset-I



Localization results of dataset-II

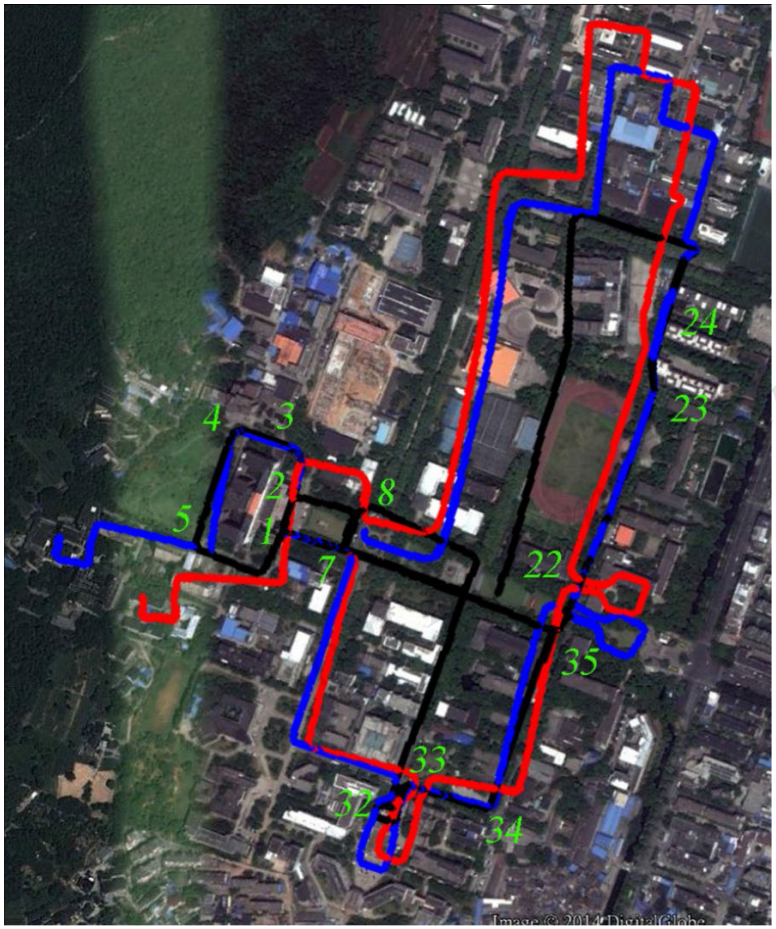


Table 3 Processing time of the enhanced VO

Item	Time (ms)
Building landmarks online	
Landmark detection	70
Landmark description	
Multi-level feature	80
SIFT	40
Global position correction	
Landmark matching	
h	3
f_l	8
f_s	7
Position correction	
SIFT matching	50
Five-point RanSaC	100
Panoramic compass	100
Binocular VO	35

Conclusions

- We proposed an enhanced VO solution composed of a panoramic camera and a stereo camera.

- Our enhanced VO is able to relieve the drift problem that plagues the traditional VO, and obtain better localization results in challenging environments.