Investigation of Speckle Image Correction Technique Based on Coding Assistance

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Abstract. The effect of image correction on digital speckle correlation method (DSCM) is researched. And the error caused by differences in attitude is analyzed. Then the theoretical model of image correction based on coding assistance is established. According to the model, computer simulation is conducted. The error of corrected image is significantly reduced after correlation calculation. The relationship between the angle of distortion and matching rate is studied in physical experiment, the error is obviously stabilized, so the accuracy is guaranteed basically. The result showed that speckle image correction technique based on coding assistance will be conductive to improve the measurement accuracy and sensitivity, and the measurement error will decrease from 0.05pixel to 0.01pixel.

Introduction

Digital speckle correlation method is a way to measure the displacement of the object based on the correlation of random speckle gray field on the surface [1], the key step of which is to collect images of objects. In this process, the camera axis and the surface of the object cannot be guaranteed absolutely vertical, which will result in deforming of image attitude and it is not conducive to the subsequent processing. Therefore, it is essential to correct images which have been collected.

At the present, the most frequently used image correction techniques mainly include the angle correction method, projective transformations correction method and cluster correction method [2]. However, due to many factors limit, as well as the random distribution of the speckle image, these methods cannot achieve distortion correction in DSCM measurement. This paper has proposed an image correction technique based on coding assistance [3]. With the advantages of large capacity, high recognition rate, sufficient contrast and high positioning accuracy, we can use the coded target to solve image’s attitude information, then we could correct the image by perspective projection invariants. Finally, correlation calculation is carried by using corrected images to obtain positioning information and the deformation [4] is obtained.

Theoretical Model

Vision Measuring camera perspective projection and coordinate transformation relations are based on ideal pinhole imaging linear model, while the ideal state of actual imaging system does not exist, so the images collected must be processed in order to achieve precise positioning. In actual measuring system, the coded points are attached to the surface of the measured speckle and then we solve the attitude according to encoded information. Speckle image correction model is established based on perspective invariant principles in visual measurements in order to achieve speckle image correction [5]. Fig. °1a shows the measurement schematic diagram of the camera in elevation and perturbation circumstances. When the optical axis of the camera is perpendicular to the surface to be measured, the initial collected speckle pattern is showed as Fig °1b. When the next time lead to an angle α between the optical axis of the camera and the normal of the surface due to the perturbation and other factors, the collected speckle image is showed as Fig °1c. Obviously, attitude differences exist between Fig. 1c and Fig. 1b. The difference will introduce errors in relevant calculations, which will result in the decrease of measuring accuracy and reliability, so it is necessary to correct distorted speckle images.

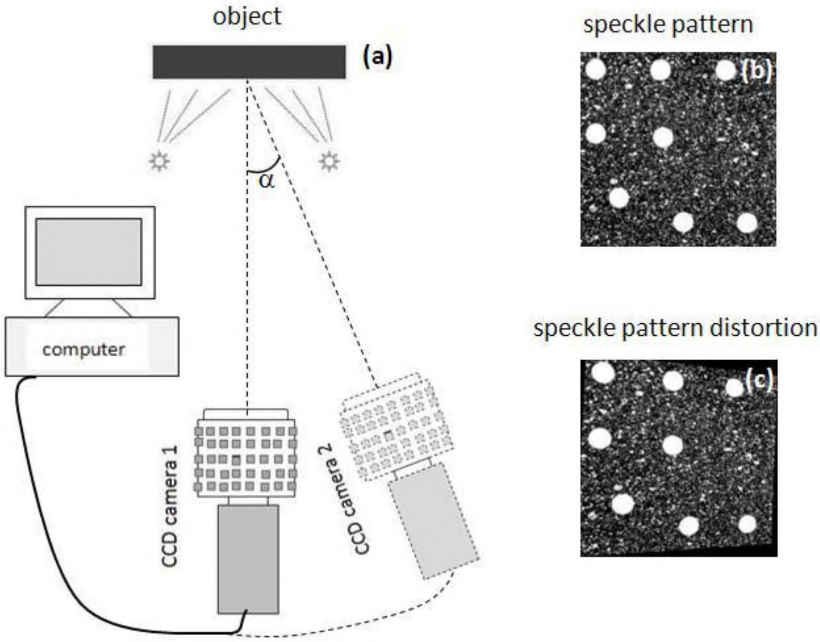

Fig. 1 DSCM measuring system and speckle gray distribution.

Computer Simulation

We get simulated speckle images according to Peng Zhou's method [6], and in accordance with the CCD imaging process, the camera's internal and external parameters are confirmed by establish the conversion relationship between the image coordinate system and the world coordinate system reversely. At the same time, the external parameter α is introduced so that we can precisely control the angle.

The simulated speckle is 128*128 pixel, the random number is 400, and the size of the speckle is 3pixel, in which the objective speckle moves 0.4*N pixel(N=1~10) respectively in x, y directions, meanwhile a range of simulated speckle is generated as α changes from 1° to 10° according to the displacement. As is showed below, Fig.°2a shows the initial speckle image, Fig.°2b is the distorted speckle image after 10pixel displacement in x and y direction, and Fig.°2c is the target image after correction processing from Fig.°2b.

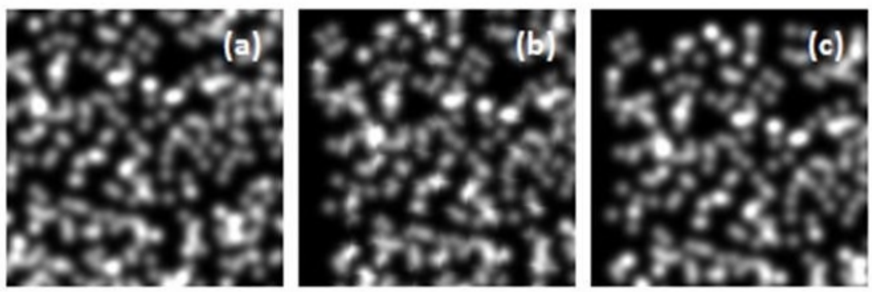

Fig. 2 Speckle images by computer simulation.

Physical Experiment

Experiments based on the DSCM system are showed in Fig.°3, the measured object with coded points is rigidly fixed on the stage which can move three-dimensional translation and rotation, then put a tunable light source and the calibration plate in the right position, we have to adjust the distance between the camera and the object during the experiment, as well as select the appropriate size of the coded points.

Fig. 3 The measurement system.

During the collection process of image, the size of the aperture is set according to environmental conditions, and the light intensity and angle should be reasonably adjusted in order to the feature points information and image information would be accessed with high quality. Compared a distorted image with the corrected image based on coded points, and the result is showed as Fig. 4. The distorted speckle image with coded points is showed in Fig.°4a, and the corrected image is in Fig.°4b.

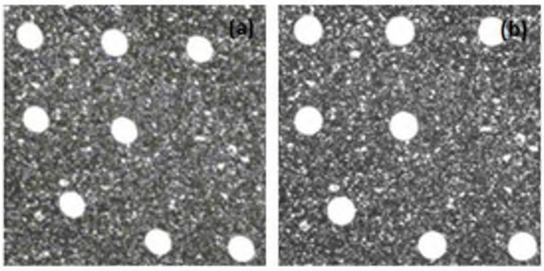

Fig. 4 Speckle image before and after correction.

The experimental data shows that the attitude estimation based on coded points is highly more accurate, and it is reliable to carry out the follow-up calculations. The accuracy and reliability of DSCM depend on the quality of speckle image and the parameters. False mismatch and location may come up because of distortion in position and gray, we define mismatch when the error is more than 5%.The mismatching rate before and after correction is showed in Fig.°5.

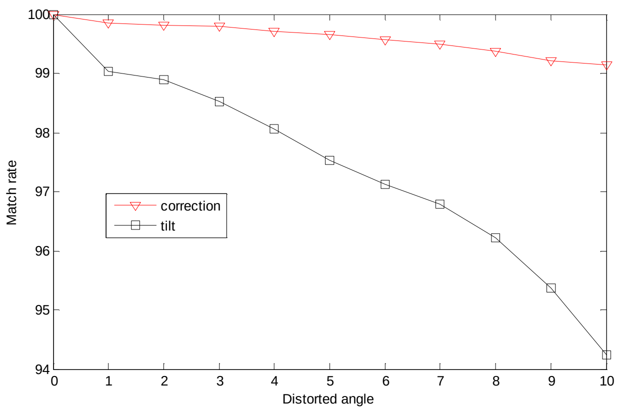

Fig.°5 Match rate graph.

As is showed above, Fig.°6a is the correlation distribution of the distorted image, Fig.°6b is the corrected image. Obviously, the corrected image only has one peak, so its locating accuracy and efficiency are very high. Then we have done some related experiments.

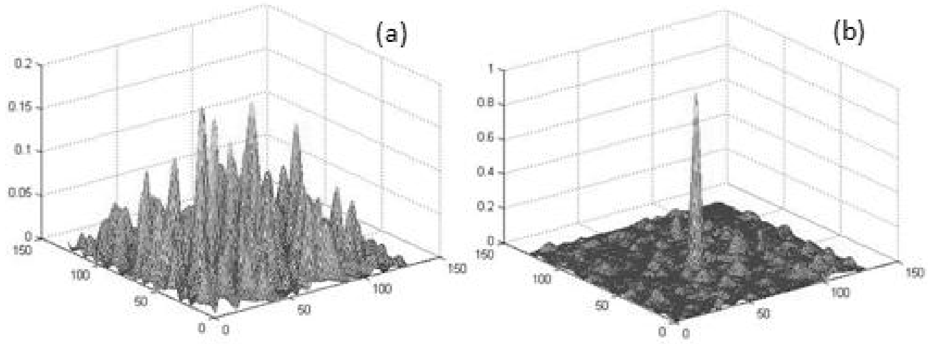

Fig. 6 The correlation coefficient distribution diagram.

Firstly, collect the initial speckle image, and keep the surface of object perpendicular to the optical axis of the camera; secondly, adjust the 3-D turntable to make the object plane and the optical axis of camera into an angle of 10°, 5° and 1°, then collect some images respectively; finally, make the correlation calculations before correcting the image, then calculate the corrected images at a movement of 10 pixel each time. The results are in Table 1.

Table 1. Different distorted angles and corrected results.

Step/[pixel]	10	20	30	40	50	60	70	80	90	100
10°	9.78	20.26	29.85	39.91	50.36	59.87	69.63	80.36	90.14	99.85
correction	9.86	20.18	29.92	40.13	50.18	59.96	69.87	80.16	90.07	99.89
5°	9.83	19.89	29.91	40.18	50.16	59.93	69.84	80.18	89.83	99.91
correction	9.89	19.92	29.96	40.11	50.08	59.94	69.89	80.06	90.08	99.96
1°	10.08	19.93	30.07	39.94	49.96	60.05	70.08	79.93	90.07	99.92
correction	10.02	20.03	30.01	40.01	50.02	60.01	70.03	79.98	89.97	99.98
ideal	10.01	19.99	30.009	39.993	49.986	60.01	69.996	80.016	90.01	99.98

Then we draw the curve in Fig.°7 according the results in Table 1.

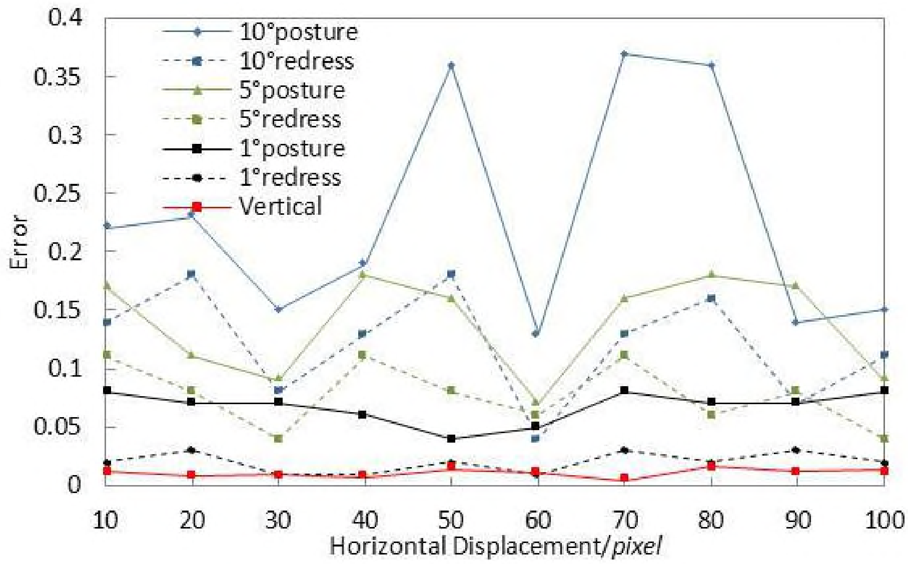

Fig.°7 The error curve in distorted and corrected situation.

Apparently, the error increases as the distorted angle expending, and the measurement accuracy significantly increased after correction.

Conclusion

In this paper, coded points have been used in the DSCM measurement creatively, with the advantages of easy to recognize, anti-interference and lower false recognition rate, coded points have greatly improve the precision and speed in the calculation: The relationship between the error and the distorted angle is found after computer simulation. A typical experiment has verified the advantages of coded points, the result showed that speckle image correction technique based on coding assistance is beneficial to improve the measurement accuracy and sensitivity, measurement error decreases from 0.05pixel to 0.01pixel.

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