

Phase Correlation Image Analysis System (PCIAS)

Robust Phase Correlation Based Subpixel Disparity Estimation

SEN001-PCIAS project of Sensor Exploitation Theme, SEAS DTC has developed a powerful phase correlation software package capable of measuring better than 1/50th pixels image feature shift together with many novel functionalities for both military and civil applications. The recent development of the PCIAS is focused on a robust compound phase correlation (CPC) based technique capable of measuring large range disparity at subpixel accuracy. This is achieved by a coarse-to-fine multi-resolution pyramid frame with the CPC technique enhanced by a "coefficient of determination" algorithm to more accurately locate and then refine the unreliable disparity estimates in areas of depth discontinuity. With this refinement scheme, we are able to greatly improve the accuracy of phase correlation based disparity estimation for DTM (Digital Terrain Model) generation from both narrow baseline and conventional wide baseline stereo image pairs.

Aim: Develop a phase correlation technique based, fast and robust image feature analysis system that can achieve subpixel accuracy image registration and produce subpixel accuracy optical flow for 3D vision.

Approach: Compound phase correlation (CPC) integrated with "coefficient of determination" algorithm and median shift propagation (MSP) technique within a multi-resolution pyramid frame.

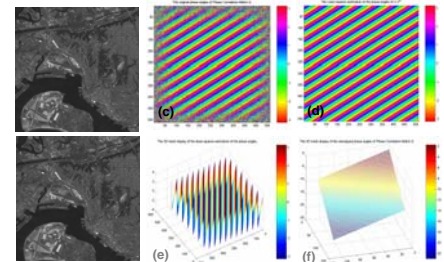
Outcomes: Subpixel image frame matching, moving object tracking and speed measurement, pixel-to-pixel precise image co-registration and high quality, low occlusion DTM generation.

Phase Correlation: disparity measurement

Given $g(x,y)$ and $h(x,y)$ representing two resemble images related by a simple translational shift a in horizontal and b in vertical directions, and the corresponding Fourier Transforms are denoted $G(u,v)$ and $H(u,v)$, the phase correlation between them is:

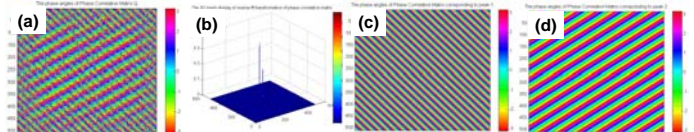
$$Q(u, v) = \frac{G(u, v)H(u, v)^*}{|G(u, v)H(u, v)^*|} = \exp\{-i(au + bv)\}$$

Right figure: (a)~(b) a pair of images with vertical and horizontal shifts. (c) Phase correlation matrix $Q(u,v)$. (d)~(e) 2D and 3D presentation of the rank one estimation of the phase correlation matrix; the direction and frequency of the fringes are decided by shift a and b . (f) Unwrapped phase correlation matrix data.

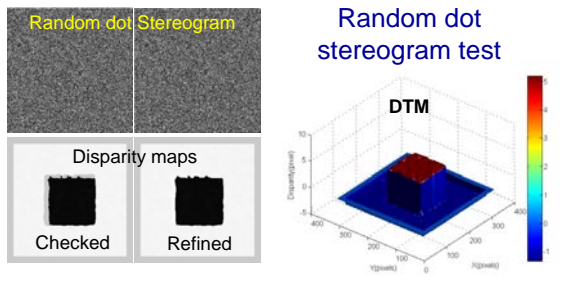


Compound Phase Correlation (CPC): multiple disparity separation

If there are two motions (disparity) of different direction and magnitude between two images, the phase correlation matrix illustrates interfered fringe patterns (a). The discrete Delta function via the IFT of $Q(u,v)$ presents two distinctive peaks corresponding to the two motions (b). Using the CPC, the original jumbled phase correlation matrix can be decomposed to two phase correlation matrices (c) and (d) each only represent a single motion.

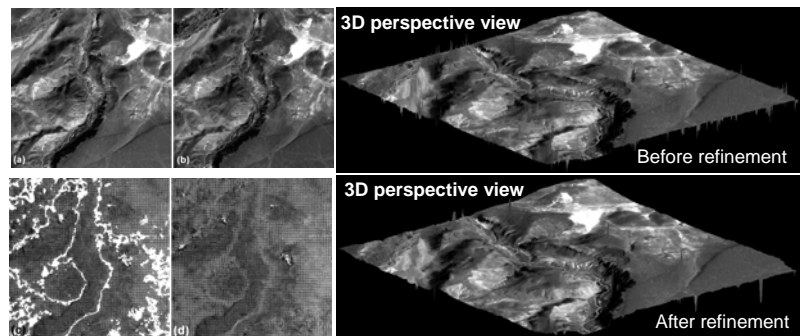


Narrow baseline (disparity < 10 pixels) DTM generation

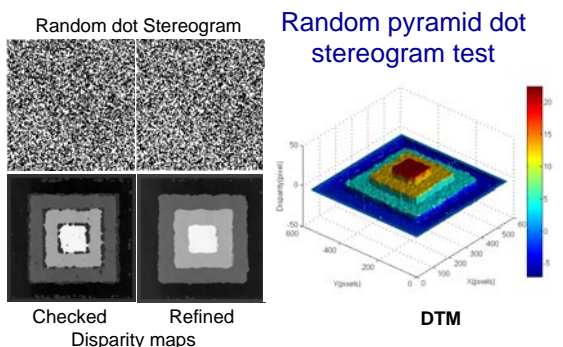


Right figure: (a)~(b) SPOT-5 very narrow baseline stereo pair images with 3.55° view angle difference < 1/10th of conventional. (c) Checked disparity map. (d) refined disparity map.

Narrow baseline DTM generation from SPOT images



Conventional wide baseline (disparity > 10 pixels) DTM generation



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An initial result of Mars DTM

