Laser Speckle Photography for Surface Tampering Detection

YiChang Shih, Abe Davis, Samuel W. Hasinoff, Fredo Durand, William T. Freeman

CSAIL, M.I.T.

Accepted by IEEE Conference on Computer Vision and Pattern Recognition (CVPR), 2012

Abstract

It is often desirable to detect whether a surface has been touched, even when the changes made to that surface are too subtle to see in a pair of before and after images. To address this challenge, we introduce a new imaging technique that combines computational photography and laser speckle imaging.

Laser Speckle Photography

- When shine a coherent light (laser) on a surface, a camera will capture a granular pattern, which is called speckle.

The speckle is caused by the interference of the laser light reflected from the surface. The speckle pattern is determined by the surface micro-geometry.

Surface Tampering Detection

- When the surface is tampered (eg. touched), the surface micro-geometry is changed, and so the speckle image is changed, even the changes are very small.

We take before and after speckle images of the surface to detect subtle change. Someone touched the surface between the two speckles.

- We visualize the tampered region by correlating the two speckle images:

\[ S(i, j) = NCC(W(i, j)I_{tar}, W(i, j)I_{est, w}) \]

Rephotography

- Our system is portable, out-of-lab setting, and can be removed during the two speckle images.

- Speckle is very sensitive to camera viewpoint, so the alignment need to be very precise (about 1 mm)

- Our solution takes two stages, Feature-based localization by PTAM
  - Accuracy about 2-3mm
  - Not enough meet the requirement

  Speckle-based finer alignment
  - Utilize the speckle sensitivity to viewpoint

Works on Various Kinds of Materials

- Our system is portable, out-of-lab setting, and can be removed during the two speckle images.

- Speckle is very sensitive to camera viewpoint, so the alignment need to be very precise (about 1 mm)

Textured Surface

v.s. Forensic Technology

Acknowledgements

We thank MicroVision for donation of equipment, and acknowledge gifts from Microsoft Research and Texas Instruments, and funding from NSF GGV No.1111415. Thank Podo Chen and Dheera Venkatraman’s help in hardware design.