GOOGLE'S RANDOM VIBRATION TESTING METHODOLOGY, OPEN TEST DATA

Part 3.1: 3D DISPLACEMENT DATA OF A MACHINE DURING RACK LEVEL VIBRATION TESTING
REVISION A

By Ken K.H. Leung
Email: openrandomvibe@ocproject.net

ASTM d4169-14 Forklift Truck Handling Drop, 6 inches Bottom Surface, 4000 Frames Per Second
Video link: https://youtu.be/0C2t9vNmBXU

Handling drop shock impact represents a whole different discipline in shock and vibration testing. Products are expected to experience a significantly higher level of stress - so much so that companies like Intel and Cisco historically dedicated tremendous resources toward the shock testing of chips and BGA solder joints, and published extensive papers and test standards on this subject.

We want to focus on the 3D measurement of test samples during drop testing, and see what we can learn from it. The structure of a fully populated rack is much more complicated than a single machine, so it's safe to assume things won't always follow between the two.

Lenovo SR650 V2 2D Rack Level Drop Test High Speed Cameras Setup

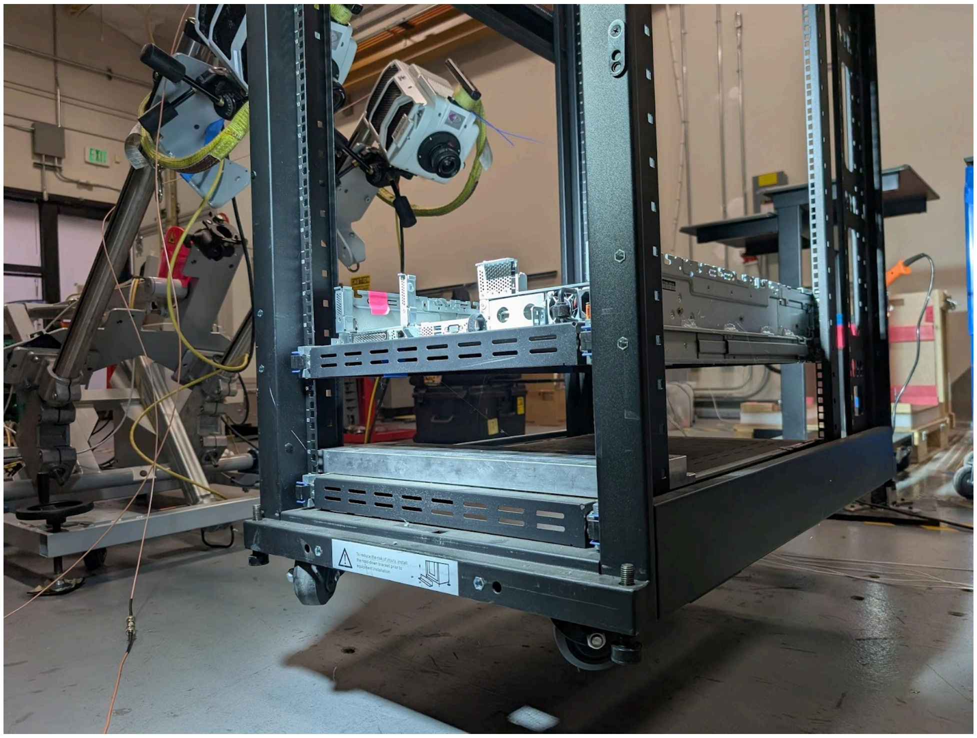


Figure 20.

Example Lenovo SR650 V2 2D Displacement Tracking During Rack Level Drop Test, Right Camera, 160 Frames

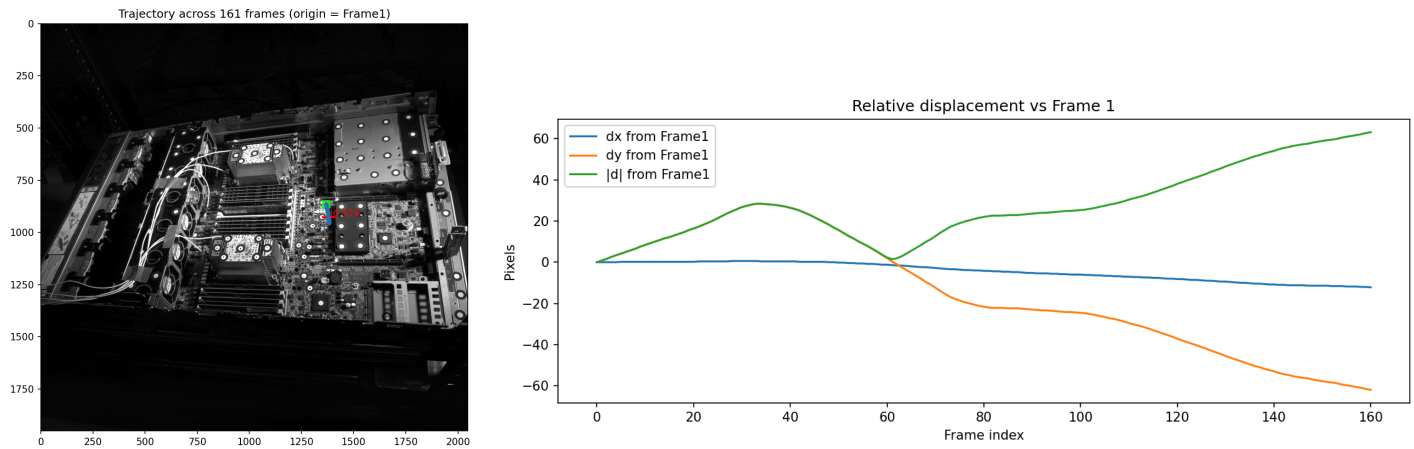
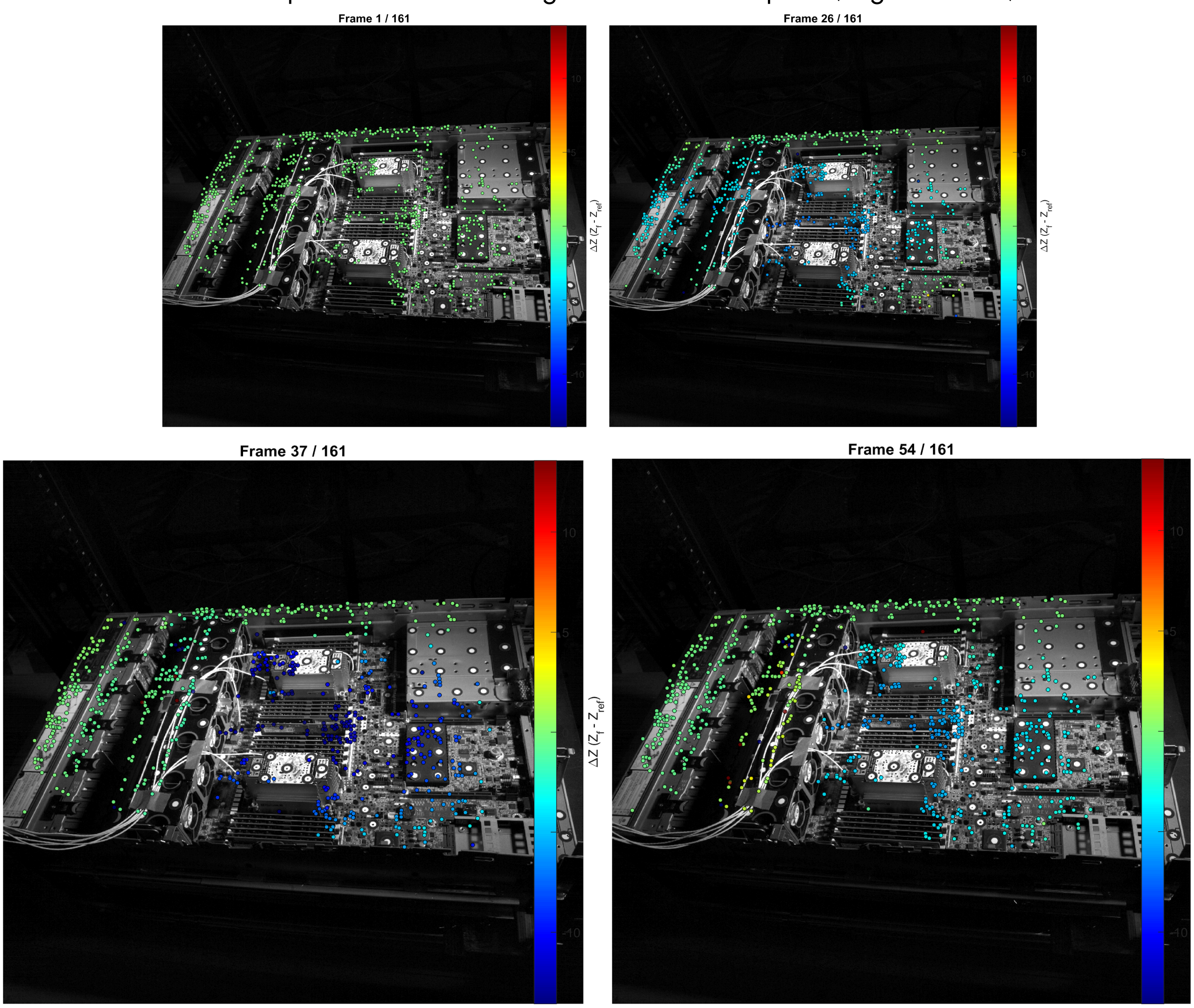


Figure 21.

Lenovo SR650 V2 3D Displacement Data During 6” Rack Level Drop Test, Right Camera, Frame 1 Thru 161



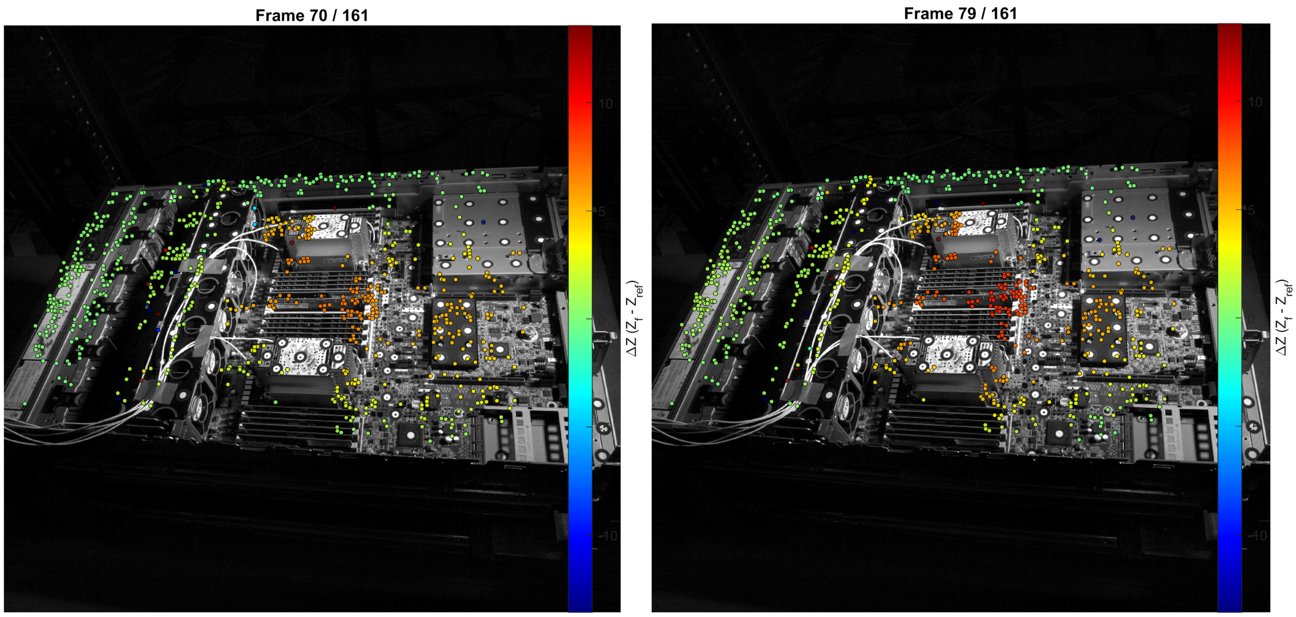


Figure 22.

The results are rather simple. +/- 15mm of relative displacement, concentrated near the center of the board and the heatsink toward the top. But when we look at the video, it's striking how much deformation occurs and how flimsy everything looks.

During product development, we want to compare this with tray level handling drop (3" free fall on bench top or the ground without packaging) and packaging level handling drop (up to 9" free fall on the ground with single corrugated cardboard box and foam packaging) and see how they compare. This is something we do daily during Google Cloud product testing to assess the risk of fully populated rack deployment.

The Bigger Picture

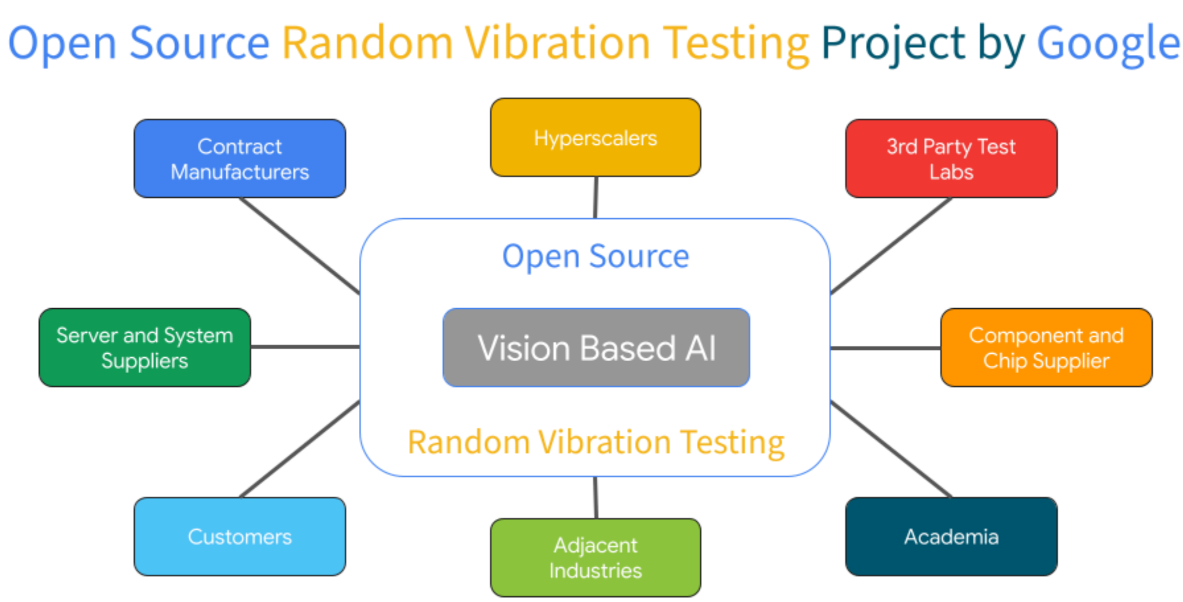


Figure 23.

With the advancement of computer vision and vision based AI, it is easier than ever to perform scientific measurements and complex motion analysis of day to day phenomena. The field of shock and vibration testing is ripe for the kind of revolutionary changes that are sweeping through the rest of the world, having relied on traditional acceleration and strain data for decades.

Traditional sensors and methods are used for a reason. There are many things that only accelerometers and strain gauges can do, many of which are described in Part 1.1 through 1.5. For example:

1. Accelerometers can produce highly accurate measurement of ultra high frequency movements and behaviors at minimal hardware and equipment cost.
2. Strain gauges can detect stretches and compressions of materials down to a fraction of a micrometer at locations deep inside a rack or a workstation.

These things are difficult for high speed cameras and 3D displacement measurements without jumping through a lot of hoops. But there are also things HS cameras and 3D displacement measurements can do that traditional sensors can't, such as capturing the macro dynamic behaviors of complex structures with a lot of parts and sub-assemblies in random vibration and shock scenarios that are historically challenging.

Vision based AI itself is also exploding in the era of AI, revolutionizing itself every 6 to 12 months, delivering solutions never thought possible before:

1. Meta's Segment Anything Model 3 (SAM 3) is now able to perform detection, segmentation, and tracking of objects in images and video using text, exemplar, and visual prompts.
2. State-of-the-art models from companies like NVIDIA, Apple can reconstruct detailed 3D geometry from a single 2D image or video sequence.
3. Foundation AI and LLM models can now easily analyze images and videos, understand context across multiple formats, and perform tasks like visual question answering or captioning.
4. Computer vision has grown far beyond algorithms that powered 3D DIC software. All the necessary functions that enabled 3D DIC are now available in open source libraries for free, including:
    a. Automated points matching of stereo images
    b. Automated calibration of stereo or multi camera setups
    c. Open scripts for Digital Image Correlation and sub-pixel points tracking
    d. Automated 3D depth estimation and dense mesh reconstruction

High speed videos themselves are informative even without any processing. Anyone can look at them and understand exactly what is being tested and what happened during testing, something difficult with traditional sensors, without tremendous engineering experience and resources for capital equipment (both of which struggle to scale with modern advancement of compute and AI hardware, and wide spread of AI chips in robotics, automation, autonomous vehicle, and edge computing).

Moving forward, particularly in Part 3, we will be releasing as much 3D data as possible to make everything simple to understand and easy to follow.