


**VIDEO AMPLIFICATION OF VIBRATION
FOR MACHINERY DIAGNOSIS**

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Vibration is often useful in determining whether or not a pump, turbine, or other rotating or reciprocating machine is operating properly. For diagnosis of problems, vibration levels and strategic frequencies can help determine if the operation appears improper, or provide important clues to reliability issues have been experienced (e.g. fatigue cracking, or premature wear of bearings and seals). It is also useful for diagnosing sources of noise.

For several decades, a visual method called Operating Deflection Shapes (ODS) has been an important tool in getting a complete and simultaneous view of the vibration of the machine and its system (e.g. piping, foundation, and driver or driven machine). The input for ODS is the phase-linked signal set from a group of accelerometers, moved over often hundreds of test points. The data is superimposed onto a CAD model, and then scaled-up vibrations are animated at frequencies of interest. This process is very useful, but is time-consuming (several days), is typically applied by expensive experts, and is error-prone.

This raises the thought, what if the investigator could truly *see* the actual vibration*?* To accomplish this, an exciting method has been developed by the author's organization as well as at least two others, that is based on evaluation of high resolution/ high speed videos. The method provides information equivalent to a high-sensor-count ODS, by treating each pixel as an accelerometer. In the case of the author's approach, each pixel's light intensity modulation is used to translate information embedded in the video, converting it into vibration motion able to be observed and interpreted by human investigators. From this information, realistic magnification of slow-motion video footage permits microscopic vibration to be amplified and thereby observed and interpreted.

One technique of accomplishing this analyzes the light modulation of each camera pixel, performing statistics, including signal vs. time as well as signal FFT frequency spectra, on the individual independent pixels. With this approach, much smaller vibration levels can be detected versus methods based on edge-tracking, and video amplification becomes practical at higher frequencies. For example, the author's system is able to display vibration at 640 Hz, without loss of screen size or resolution, making it of interest in high speed turbomachinery as well as numerous military applications. Using more expensive cameras and/ or reducing field-of-view, even higher frequencies are currently attainable, order of 3500 Hz.

The new video-based motion amplification process has advantages over the classic ODS method in most cases, and typically takes much less time and “logistics” to implement. Benefits include:

- It is a powerful and intuitive diagnostic tool
    - Realistically demonstrates modes and frequencies of vibration
    - Is the equivalent of millions of accelerometers, 1 per pixel
    - Is easy for non-experts to understand (management, etc.)
- It does not requires “contact” – perfect for restricted areas
    - Heat, radiation, accessibility/scaffolding requirements
- It is fast
    - Millions of data points ready to evaluate in minutes, not day

It is possible to develop custom software to accomplish video magnification in the manner discussed, using papers in the optics literature. It is also possible to buy a complete system off-the-shelf for roughly the cost of a multi-channel FFT analyzer.

Readers who find this new method of interest please feel free to contact the author for more information.