To be published in the ASTM Standardization News.

Video Based Metrology

Tsai Hong, Marilyn Abrams, Ted Doiron, and Michael Shneier
National Institute of Standards and Technology, Manufacturing Engineering Laboratory

Video based metrology is the method of obtaining measurements from video cameras. The North American market for video metrology is growing in electronics, machining, biological and biomedical work. In order to make video measurements, the camera used must first be calibrated. Calibration is the process of assigning a measurement to objects appearing in video images and is a basic requirement for video measurement. An improperly calibrated camera cannot be used for video measurements because the measurements will lack accuracy and traceability. Many of the problems faced by video based metrology are caused by a lack of understanding of camera and video display calibration.

Based on conversations and correspondences with the user community, we have learned that many companies are devoting time and money on individual efforts to develop calibration methods and targets to improve their own measurement capabilities. Their results are guarded as proprietary information. Not only does this prevent a sharing of results, it precludes a way of establishing the accuracy of measurements. A further consequence of the lack of accountability of video measurements is that it inhibits the widespread adoption of video measurement to other measurement applications. We would like to establish a dialog with users of video based measurements, to learn of their experiences.

Calibration is not a uniform operation: the results depend on the needs of the application, the scale of the required measurements, and the accuracy tolerances. In all applications, however, the calibration process needs a “calibration target” or “standard” to verify measurements. There

is little consensus as to what properties a calibration standard should have. For example, Figure 1 shows a linewidth calibration sold as a Standard Reference Material at NIST. It is used to standardize image-based linewidth measurements in the microelectronics industry. Figure 2 shows 4 patterns of different size shapes in various configurations designed at the National Physics Laboratory in Great Britain used for image analysis applications.

There are many unanswered questions related to the design of a uniform calibration target. Due to the number of different video measurement applications, there is probably no single target that can be used by all industries. For example, the type of target (or phantom) needed in bio-medical applications must be able to provide measurements of human or animal organs. This is very different from a semiconductor mask inspection. Further, measurement sizes in different applications range from tens of meters to nanometers.

There is no consensus on the type of patterns that should be placed on a target, on the size and distribution of the pattern, or even on the material used for the target. Different applications may use rulers, circles, squares, wire-frame squares, cross hairs, grids, or overlays. Due to the variation in measurement performance caused by a non-uniform calibration target, it is impossible to accurately compare measurements by different users. A customer who specifies an acceptable accuracy usually has no way of knowing whether that accuracy requirement will be met. Measurements made by one video system are likely to be very different from measurements made by another system. Machine inspection systems routinely claim sub-pixel accuracy (to 1/100 pixel). While they might be repeatable to this level, accuracy cannot easily be established.

There is no recognized standard method for determining if a video measurement system meets its specification tolerances. The sources of errors vary and affect measurement performance. In addition to errors caused by non-standard calibration targets, additional errors are introduced by the method or algorithm used to perform the calibration. Again, there is no widely accepted best way to do this. Other factors that influence the accuracy of video measurement include the quality and tolerance of the camera, the camera chip aspect ratio, the lens, the resolution of the camera, and the video monitor. For example, monitor characteristics such as resolution and asphericity affect the final monitor display, and the camera lens used influences the amount of distortion, and the field of view. It is not known to what extent calibration and better measurement programs can correct for these errors.

To address these issues in the context of real-world problems and applications, we would like to learn of your experiences. Would you benefit from a single calibration target or set of targets that could be used to understand measurement errors? Because the procedures involved in calibrating a camera system affect the validity of the measurements, would you be interested in defining these factors? Assuming an interest in a standard calibration targets and procedures, would you be interested in participating in a working group to support these efforts for video metrology? We would like to gather as much information on your needs relative to video measurement and your requirements for a calibration target. We look forward to your comments.

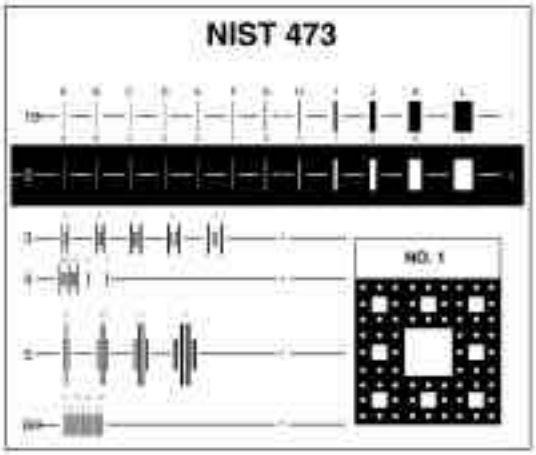

Figure 1. Linewidth Calibration

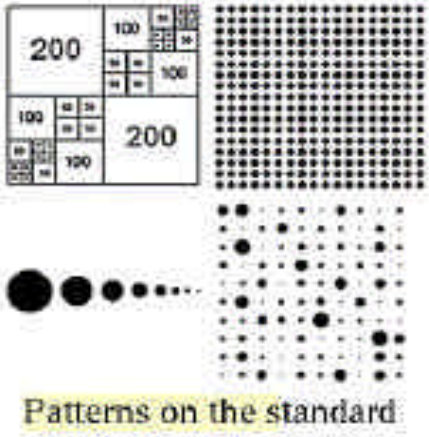

Figure 2. NPL Calibration Target