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Basic guidelines for image analysis measurements

Scope

This TIP provides guidance on using image analysis to measure various visual properties of pulp, paper, board and the corresponding products that have been printed or coated.

Safety precautions

Specific safety precautions are not applicable. Users of image analysis technology must become familiar with the safety requirements of their particular application

Introduction

Image analysis systems have been available to the pulp and paper industry since the mid-nineteen seventies. There have been many publications dealing with applications ranging from dirt counting to print quality measurements. The image analysis equipment has evolved from complicated and expensive research-class devices and now covers a large number of camera-based two-dimensional charge-coupled diode arrays (CCD's), along with an increasing number of systems based on 'page-scanners' that use linear CCD's and scanning mirror systems to build up the scanned image in the computer. This guide attempts to provide an overview of some of the important issues, but it is not intended as an all-encompassing guide to this complex field. Anyone new to the field of image analysis should refer to the published literature for more detailed guidance on specific measurement applications

Technical information

The following information provides an overview and guidance in the application of image analysis technology.

Documentation

Every image analysis method should be thoroughly documented to ensure reproducibility of all steps, ranging from sample preparation through to equipment and lighting set-up to the final data collection and analysis steps.

Sample preparation

The apparent simplicity of image analysis measurements may lead users to ignore the possible impact of effects arising from variable sample preparation or from sample aging effects that introduce significant changes into the measurement. Ensure that samples and reference samples are prepared in a repeatable manner and are stable. Sample preparation is often identified as the greatest source of error in image analysis measurements.

Lighting

Lighting differences can drastically alter image analysis measurements. Differences can arise from numerous sources, including intensity, angular incidence, light source temperature and variable light intensity when an image analyzer is subject to ambient light variations. Even the light reflected from an operator's clothing can influence the measurement. Diffuse light is the preferred illumination for paper and paperboard surfaces. Ensure that the wavelength spectrum of the illuminant matches the spectral response of the detector. Camera response must be linear and with no autogain. Care must be taken when selecting a light source for detecting colored features. A brown dot will have a much lower contrast in a red light than in a blue light. Choose a light source that does not vary in spectral emission with changing voltage. Many CCD cameras are extremely sensitive to near infrared light, which can result in greater image contrast relative to visible light. A broadband green filter or a filter that excludes near infrared light may be installed in front of the detector. It is best to locate image analysis equipment in a windowless room.

Calibration

Almost all image analysis systems are delivered with some form of "calibration standard" that allows the conversion of measurements into meaningful units. However, these standards may not be suitable for all applications, and they are often difficult to confirm in relation to primary standards. When possible, buy a calibration standard that is traceable to a primary standard.

Reference Samples

Because of the complexity of overall system set-up for some applications, it is often advisable to retain one or more "reference samples" whenever this is possible. The reference sample is measured as a quick check to confirm that the current set-up produces reasonable values. This implies not only that the reference sample is stable, but also that it permits repeat scans with acceptable precision. It is advisable to ensure that a number of system operators obtain the same result, and that the method is operator-independent.

Pixel Resolution

At the heart of every image analyzer is a linear or two-dimensional detector array of picture elements (pixels). The optical image is converted into an array of pixels, each with an individual intensity in a computer memory. The resolution and accuracy of image analysis measurements are determined by the number of pixels that make up a discrete feature in an image. Electronic coupling between detector pixels can cause the effective resolution of the detector to be much lower than might be expected from pixel spacing. If it is essential to obtain high resolution of feature size or shape, then the feature magnification level must be set at an appropriate level.

Optical Resolution

The quality of image analysis measurements is limited by the optical limitations of the viewing system that feeds the image to the detector. The possible effects are potentially numerous and complex - alignment, flatness of field, chromatic aberration, etc. In general, finer detail will be resolved with high quality lenses, shorter wavelength light, and lenses with higher numerical apertures (and shorter working distances). When practical considerations require working a longer distance from the specimen and stopping down the lens to get greater depth of focus, detail on the scale of a few microns may be degraded and no amount of empty magnification will recover it. Beginners to image analysis should take some time to learn about their specific optical systems and applications before finalizing their image analysis methods. A minimum of 4 pixels is suggested for the smallest feature to be measured and magnification should not exceed 1 micron per pixel. Zoom lenses should be avoided.

Grey level resolution

The gray level, GL, is the intensity number assigned to each pixel where a lower number corresponds to a darker pixel. A resolution scale with a minimum of 256 GL is recommended (8-bit sensor). A range of 256 GL contributes 0.5% digitizing uncertainty to the total intensity uncertainty. If electronic noise is on the order of 0.5%,