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ABSOLUTE SCALING MEASUREMENT OF PRINTED IMAGE USING HIGH SPEED LINE SCAN CAMERA

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Absolute Scaling Measurement of Printed Image Using High Speed Line Scan Camera

Abstract: The size of a printed image in an absolute scale is precisely measured during print movement using a high-speed line-scan camera.

This disclosure relates to the field of printers.

A technique is disclosed that measures the size of a printed image in an absolute scale, i.e., to get a measurement in real length units

One of the challenges of precise printing is the scaling, such that the size of the resulting printed image size is precisely the design size in the digital image. Absolute scaling measurement means that the measurement done by a printing press gives a correct measurement in physical units such as, for example, millimeters (mm). Relative scaling measurement means that the measurement is done by a system that gives a size measurement in arbitrary units. For example, encoder units that are not calibrated to physical units, or have an unknown bias to the physical measurement, provide relative scaling measurements.

Relative scaling control means one measures the print length in arbitrary units, and keeps it fixed during the print session without verifying or controlling the absolute length itself. In most cases in the commercial market, relative scaling does not provide sufficient accuracy for the printed sheet to be cut into the desired size using a fixed-size die. To do so requires the precision of absolute image scaling. Every deviation in absolute image length can result in either cutting into the part of the image the customer wishes to use or leaving an unprinted white margin around the cut image.

The main challenge of absolute scaling is precision. The required precision is ±70 micrometers (um) over a print of 500 mm. Because this precision should include all errors in the system, the measurement error itself must be even smaller.

One prior approach is manual calibration, in which the operator measures the printed image using a ruler and manually adjusts the image size accordingly. However, this is insufficiently precise, requires a skilled operator, and takes a long time to perform. Another prior approach for scaling measurement in web presses utilizes a sensor for reading eye-marks and an encoder mounted on the one of the web cylinders. The eye-mark sensor marks the time the printed eye-marks goes under it, and the encoder position (in angles or encoder units) is recorded. When a second eye-mark passes under the sensor the encoder is read again to get the distance between eye-marks in encoder revolution units. To get an absolute distance measurement, the encoder units are translating to normal distance units to get the um/encoder ratio, which is set by the circumference of the roller on top of which the encoder is mounted. However, knowing the circumference in high accuracy is difficult, and the cylinder changes its dimensions with temperature. Manufacturing a cylinder with sufficiently tight tolerances is highly expensive, while applying a temperature control system is both expensive and problematic.

According to the present disclosure, and as understood with reference to the Figure, a high-speed line-scan camera 10 is utilized in an unorthodox manner: rotated by 90 degrees to be parallel to the printing direction 20. This allows the capture of numerous images of eye-marks 30, and measurement of the distances 40 between the marks 30. The large number of images significantly reduces the signal-to-noise level, and thus provides a highly accurate measurement of the absolute scaling with a reasonably priced system that does not require an expensive, high-resolution high-speed camera.

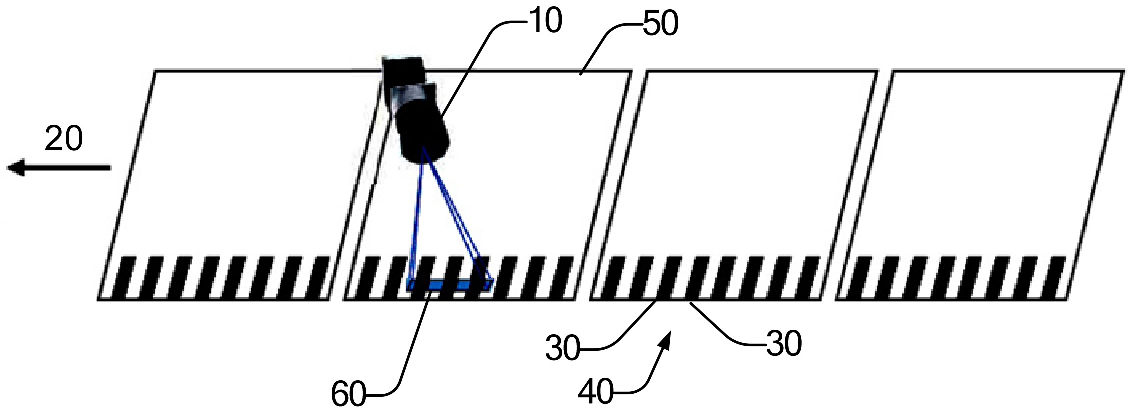
The line-scan camera 10 has an imaging sensor composed of a single line of pixels (e.g., 1*2048 pixels). This allows an extremely high rate of image captures on the order of magnitude of 10^4 images per second. The resolution along the longer axis is high enough to get a pixel size of ~20 um, with 2048 pixels and a field of view of 5 cm. Contrary to the normal use of line-scan cameras, the camera 10 is positioned parallel to the movement direction 20 of the print substrate 50. This unorthodox use of the line-scan camera obtains measurements of unprecedented accuracy, and thus measurement of the absolute scaling.

For example, assume a print substrate 50 that has a mark width of 2 mm and a distance between eye-marks of 2 mm, and a print system that has a substrate movement speed of 2000 mm/sec. The system also includes a line-scan camera with a field of view 60 of 50 mm, a frame rate of 10000 frames/sec (fps), and a line resolution of 1000 pixels. Each pixel in the image represents 50 um. Each eye-mark (and its adjacent gap, a total of 4 mm) passes the 50 mm field of view in 0.025 sec. That means that with a frame rate of 10000 fps, each eye-mark 30 and gap 40 will be captured ~250 times, which allows the signal-to-noise ratio of the eye-mark-gap measurement to be reduced by a factor of about sqrt(250), or approximately 16. This yields an effective pixel size of approximately 3 um.

In operation, as the substrate 50 moves, the line-scan camera 10 acquires images of the moving eye-marks 30 and performs the absolute scaling measurements. Summing all the measurements gives the total measurement of the print. This technique results in an accurate measure of the total absolute scaling of the page at the desired precision.

The disclosed technique is advantageously more accurate and faster than a manual method, and less expensive and more reliable than an encoder-based method.

Disclosed by Avi Malki, Tsafrir Yedid Am, and Ram Dagan, HP Inc.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