Measuring yarn diameter using inexpensive optical sensors

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Abstract

In this paper, the inexpensive optical sensor of a common computer mouse is proposed to measure yarn diameter. This measurement allows a progressive control of the yarn production processes in the textile industry. The optical mouse sensor is an inexpensive sensor that includes all parts of a complete vision system compacted together in a reduced size: illumination, lens, and CMOS optical sensor. The selected CMOS sensor has a two dimensional array of 30x30 pixels that can be used to obtain the diameter at different positions of the yarn with a resolution of 60 μm. Additionally, the sensor can work at very high frame rates allowing the development of real-time monitoring applications.

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1. Introduction

The control of the quality and parameters of the yarns is essential in the textile process production. Due to natural and mad-made yarns, there are a varieties of characteristics, such as hairiness, diameter, mass, twist or snarls that determine the textile yarn quality. Currently, visual inspection is commonly used for the determination of these characteristics. The inclusion of automatic procedures will contribute to increase the quality and efficiency of the processes used in the textile industry.

There are many researches that propose different alternatives to estimate these parameters of the yarn. In [1] the twist of the yarn was obtained by high resolution image processing. The recognition of yarn wet snarls from an image by means of pattern recognition was presented in [2]. A procedure for measure the yarn mass of the yarn in real time using capacitive sensors was developed in [3]. Recently, in [4] the yarn diameter is also correlated with other interesting parameters such as his mass and hairiness with a significant statistical relationship.

The yarn hairiness densities can be obtained using image processing techniques [5-6] and also the yarn core or yarn diameter. In [6] a vision system was proposed to estimate yarn hairiness and diameter using a CMOS linear array with an error in the estimation of 9.1%. However, a complex high-cost optical setup was needed to obtain these estimates precluding its industrial application.

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In this work, a new vision based approach is proposed to estimate the yarn quality by means of the automatic measurement of the yarn diameter. The approach is based on the image acquisition capabilities of the optical mouse sensor originally designed as a displacement sensor. The optical mouse sensor is optimized for the acquisition of images in a very short distance range with an array of 30x30 pixels (depending on the sensor used). In [7-9] the optical mouse sensor was used as an image acquisition system. In [8] the mouse sensor was used to build an absolute encoder reading printed patterns on an inner rotating disc. And recently, in [9] the image acquisition capabilities of the mouse sensor was applied to measure differences in the roughness of common side two Euro coins and develop counterfeit algorithms.

2. The Optical mouse sensor

The optical mouse sensor used in this work is the LED-based sensor ADNS-3080 from Avago Technologies [10]. The optical sensor is based on a very compact image acquisition system which is made up with the main optical sensor. The sensor includes a digital signal processor (DSP), a CMOS camera (30x30 pixels) with a view area of 1.82x1.82 mm (60µm/pixel) [8], a single light emitting diode (LED) that illuminates the surface at an angle, and plastic convex lenses to focus the reflected light into the CMOS camera with the device very close to the displacement surface (Fig 1).

Fig. 1. Sectional view of assembly components for the ADNS-3088 sensor (courtesy of Agilent).

The ADNS-3080 has a standard SPI bus to control the common actions of the sensor. The displacement of the sensor is obtained reading the registers DELTA_Y and DELTA_X that returns the relative movement detected with the internal control loop. In addition, the optical mouse sensor has the PIXEL_BURST register that allows a sequential access, pixel by pixel (with intensity values from 0 to 255), to the entire raw data of the image captured with the internal CMOS sensor. The time spent in the SPI communication to read one complete image was 130 µs.

3. Yarn diameter detection

To use the optical mouse sensor capabilities the yarn is placed horizontally at focal distance recommended by the sensor manufacturer (about 2.4 mm) obtaining an orthogonal yarn view. A black cardboard is used as background located at 20 mm of the yarn to avoid reflections in the images. The yarn analyzed in this work is a standard white textile yarn from Presencia Hilaturas manufacturer made by 100% mercerized cotton with three twisted fibers.

Fig. 2 shows some images of the textile yarn captured by the optical mouse sensor (left) and with a Bresser BioDiscover optical microscope (right) using a 4x objective and 640x480 VGA electronic eyepiece with 10x optical lens. In both cases the yarn diameter core and the hairiness are clearly identified by visual inspection.

Fig. 2. Left: some images of the yarn captured by the ADNS-3080 optical sensor. Right: image of the yarn obtained with an optical microscope.
The image resolution and speed limitations are the most important factors of a vision system. The procedure of yarn diameter estimation in the image of the optical sensor is performed by the follows steps: 1) Sum of the intensity values of the rows of the image to find the center of the yarn position (Fig 3-b); 2) Image segmentation with a fixed threshold of 0.45 (Fig 3-c); 3) Search for the boundaries of the yarn in each column of the image (consecutive white pixels) (Fig 3-c, red points); 4) The mean of the diameters obtained in all columns of the image is considered as the average diameter of the yarn. The maximum, minimum and deviation values of the diameters detected in one capture can be used to detect some yarn evenness as a yarn break point or hairiness presence.

4. Experimental results

In order to test the proposed system, a set of 20 images of the yarn were captured with an approximate distance of 2 mm between images. The images were acquired with the optical mouse sensor and with the Bresser BioDiscover optical microscope with the same setup described before. Fig. 4-left shows the average values obtained in each image of the yarn with the using the optical mouse sensor. The mean value of the diameter was 4.078 pixels (0.24 mm) and the maximum absolute deviation was 17.69% (originated by the hairiness). Fig. 4-right presents the relative error of the average yarn diameter value obtained with the optical sensor compared with the diameter measured manually with the microscope. Results show a standard deviation of 11.5% in the diameter of the yarn measured with the optical sensor relative to manual measurements.

The next experiment was performed using the same yarn with two different qualities: good (brand new yarn) and poor conditions (used yarn, with heavy hairiness presence). Table 1 shows the minimum, maximum and average values of the yarn diameter estimated analyzing a set of 30 different captures with the optical sensor and the microscope for the different conditions proposed. The error between the estimate of the yarn diameter using the proposed optical system and using the microscope was 4.33% and 17.71% for the cases of good and poor yarn.
conditions. In the case of the proposed automatic system the hairiness has large effect in the automatic measurement of the diameter (increasing the standard deviation) whereas in manual measurement this effect was filtered by the manual procedure used.

Table 1. Measurement results obtained with the proposed automatic system and with manual measurements.

<table>
<thead>
<tr>
<th></th>
<th>Diameter using the proposed system (mm)</th>
<th>Diameter using a manual measurement (mm)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
<td>Normal yarn condition</td>
<td>0.196</td>
<td>0.366</td>
</tr>
<tr>
<td>Poor yarn condition</td>
<td>0.343</td>
<td>0.584</td>
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</tbody>
</table>

5. Conclusions

A new automatic yarn diameter detection system using an inexpensive optical mouse sensor is presented. The system uses the image acquisition capabilities of an optical mouse sensor to estimate the yarn diameter. The main advantage of the optical sensor is the short focal distance that enables the development of very compact measurement systems. The results obtained with the proposed measurement system were compared with manual measurements using a microscope obtaining an error of 4.33% in the measurement of the yarn diameter and 17.71% in the case of poor conditions due to the effect of the hairiness. The experimental results obtained confirm that the inexpensive optical mouse sensor can be applied for automatic yarn diameter detection as a way to increase the efficiency of a textile production process.

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References