Computational Analysis of Composite Fiber Diameter

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Introduction
The Advanced Materials and Nanosystems (AMN) group of Dynetics Technical Solutions (DTS) has a need to measure the diameter of fibers on the micro scale. Post-processing analysis informs the overall mechanical properties of the fibers.

The AMN group transitioned from using MATLAB to using Python because Python is free, easily portable, and has a wide-range of open-source libraries. Replacing a previously written MATLAB script, the Python diameter-measuring module is a portable application that calculates the diameter of a fiber based on an image.

Methods
The Old MATLAB Algorithm
1. Reads in an image in black and white
2. Detects and fills in holes in fiber
3. Calculates diameter
   a) Version 1: divides area of fiber by the length of fiber
   b) Version 2: calculates the distance between edges of fiber
4. Multiplies the diameter in pixels by micrometer/pixel ratio

The New Python Algorithm
1. Reads in an image of a fiber in greyscale
2. Denoises, smooths, and thresholds image
3. Reduces image size to decrease search window
4. For each column in image, counts number of black pixels
5. Multiplies the diameter in pixels by a micrometer/pixel ratio
6. Calculates diameter statistics: mean, maximum, minimum, and standard deviation

Results

<table>
<thead>
<tr>
<th>Image</th>
<th>Python 1 (µm)</th>
<th>MATLAB v1 (µm)</th>
<th>MATLAB v2 (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image0</td>
<td>10.96</td>
<td>10.14</td>
<td>10.17</td>
</tr>
<tr>
<td>Image1</td>
<td>10.96</td>
<td>10.15</td>
<td>10.18</td>
</tr>
<tr>
<td>Image2</td>
<td>11.03</td>
<td>10.69</td>
<td>10.72</td>
</tr>
<tr>
<td>Image3</td>
<td>11.29</td>
<td>83.10</td>
<td>389.72</td>
</tr>
<tr>
<td>Image4</td>
<td>11.17</td>
<td>10.95</td>
<td>11.03</td>
</tr>
<tr>
<td>Image5</td>
<td>11.44</td>
<td>14.32</td>
<td>24.10</td>
</tr>
<tr>
<td>Image6</td>
<td>11.15</td>
<td>11.10</td>
<td>11.16</td>
</tr>
</tbody>
</table>

±1% ±5% Outside ±5%

Impact
The methodology used to write the diameter module is vital to improving process efficiency and product quality. It automates a manual process that required a considerable amount of man hours while simultaneously improving data reliability. This information ultimately informs both current and future materials development efforts.

Acknowledgements
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