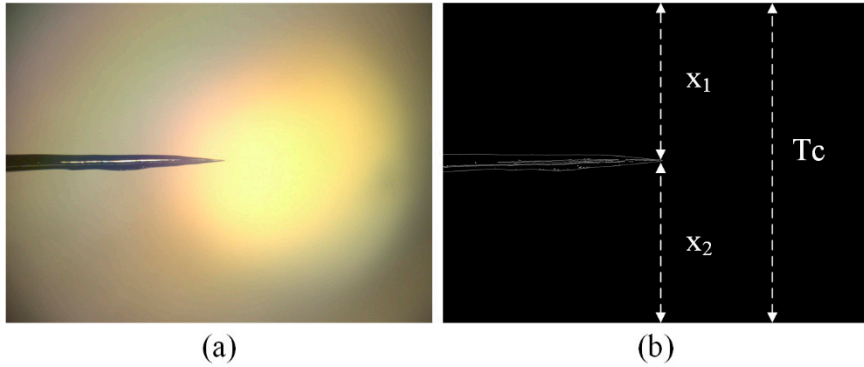


# Supplementary Materials: Multidirectional Image Sensing for Microscopy Based on a Rotatable Robot

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## 1. Alignment Experiment Demonstration

We took a tungsten needle as the sample and implemented the sample alignment based on the method proposed in Section 2.2 (main text). During this process, the to-be-aligned point at different rotation angle was recognized automatically by a Canny detection approach (Figure S1). The coordinate of the tip along the microscope image's vertical side was calculated by  $x_2 + \frac{Tc - x_1 - x_2}{2}$ .



**Figure S1.** (a) The microscope image for tungsten microneedle, and (b) processed microscope image with Canny detection method. The coordinates of the microneedle's tip are calculated as  $x_2 + \frac{Tc - x_1 - x_2}{2}$ .

## 2. Alignment Error Justification

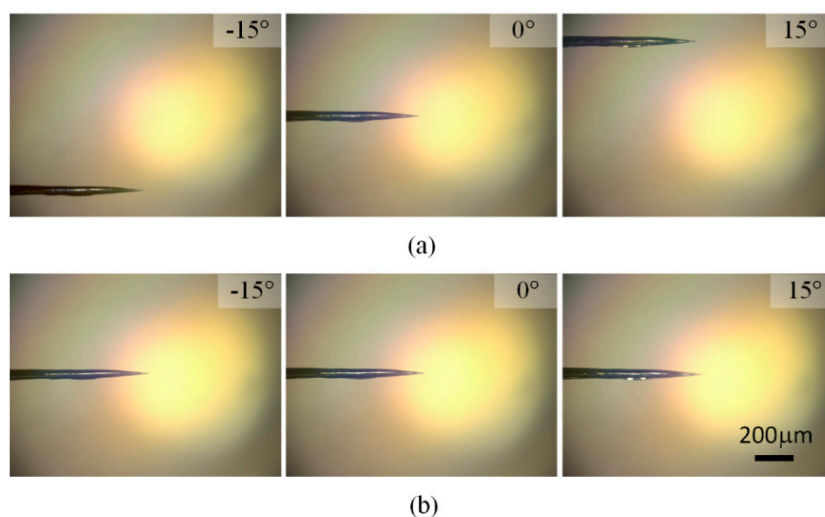
Figure S2a shows the microneedle's position at rotation angle  $-15^\circ$ ,  $0^\circ$  and  $15^\circ$  before alignment, and Figure S2b shows the microneedle's position at rotation angle  $-15^\circ$ ,  $0^\circ$  and  $15^\circ$  after alignment with magnification 200 and alignment angle  $15^\circ$ .

Before alignment, tungsten microneedle's position shift for the three images in Figure S2a is  $906 \mu\text{m}$ , while after alignment, tungsten microneedle's position shift for the three images in Figure S2b has dropped largely to  $8 \mu\text{m}$ . The decreasing position shift justifies the proposed method.

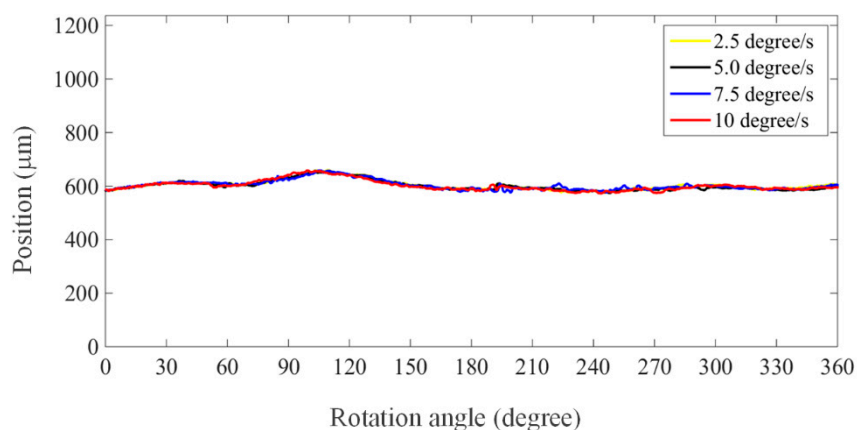
After that, the robot was rotated  $360^\circ$  at a series of rotation speed, *i.e.*,  $2.5^\circ/\text{s}$ ,  $5.0^\circ/\text{s}$ ,  $7.5^\circ/\text{s}$  and  $10.0^\circ/\text{s}$ , respectively, and the sample was imaged dynamically from different orientation. As the results shown in the Figure S3, sample's position at different rotation angle for different speed are almost the same, which demonstrates the high repeatability of the robot.

During the  $360^\circ$  rotation, the maximum position shift is  $84 \mu\text{m}$ . For the multidirectional imaging experiment, images of samples are taken every  $30^\circ$ , the maximum position shift in the  $30^\circ$  rotation range is  $45 \mu\text{m}$ , which is much smaller than the field of view (FOV) we adopted during our multidirectional imaging experiments. Therefore, during rotation, samples would always remain in the FOV and we don't need to spend much time finding samples and adjusting samples' positions.

In conclusion, this alignment has high repeatability regardless of the rotation speed, and the alignment accuracy can meet the requirements for multidirectional imaging.



**Figure S2.** Microscope images at rotation angle  $-15^\circ$ ,  $0^\circ$  and  $15^\circ$  (a) before and (b) after alignment. The position shift in the three images of (a) before alignment is  $906 \mu\text{m}$ , while the position shift in the three images of (b) after alignment becomes  $8 \mu\text{m}$ .



**Figure S3.** Sample's position at different rotation angle after alignment for various rotation speed. During the  $360^\circ$  rotation, the maximum position shift is  $84 \mu\text{m}$ . This makes sure that samples would always keep in the field of view, and therefore avoids spending much time finding samples and adjusting samples' positions.