Electronic Supplementary Information

QR-on-a-chip: Computer-recognizable micro-pattern engraved microfluidic device for high-throughput image acquisition

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Materials and Methods

Microfluidic device design

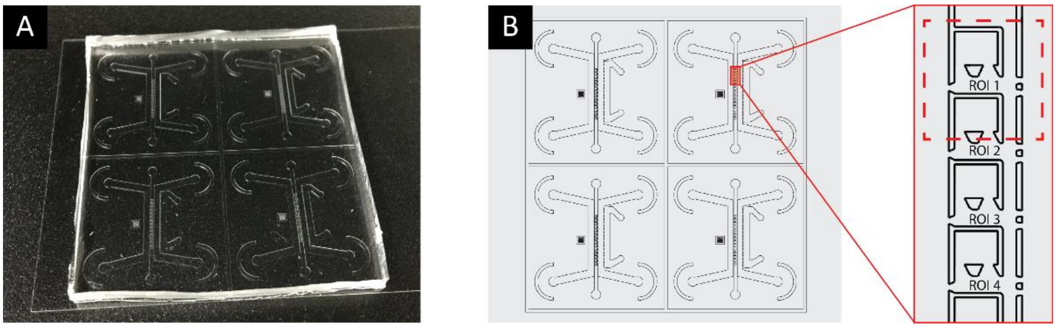

Fig. s1. The image of the microfluidic device used in this study. (A) The fabricated device. (B) The design of the device in the computer-aided-design(CAD) software. The ROIs were located along the centre channel of each device.

The design of the microfluidic device used in this work was designed for engineering an array of blood vessels for vascular permeability measurements[1]. The above figure shows 4 identical devices integrated on a single substrate. Each device has 13 separate regions (ROIs) where a single perfusable vessel is formed in each ROI. To test the permeability of multiple vessels, fluorescent dye solution is introduced into the device and time-lapse image of each ROI is taken for upto 30 min. When manually performing the experiment, it takes approximately 10 min per device to locate and store the x,y position values for each ROI. When using the QR Code, it takes 1-2 minutes to locate the two QR Codes and the multi-position time-lapse images can be taken automatically. (**Fig. s1**).

Results and Discussion

Rotational angle of microfluidic device observed in microscope camera's field of view

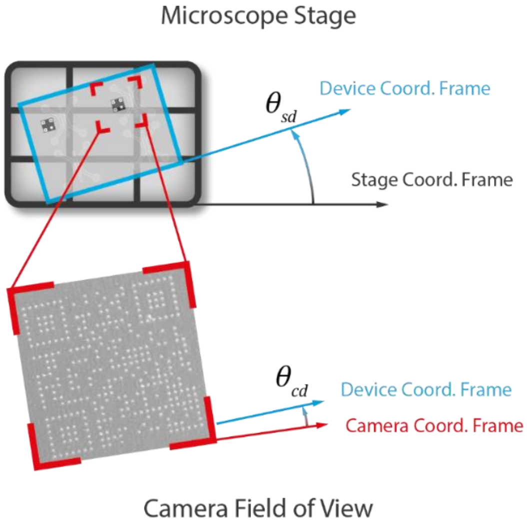

Fig. s2. Schematic diagram of device angle of rotation, with respect to the microscopic stage θ_{sd} and the microscopic camera's field of view θ_{cd}.

When observed through the microscopic camera's field of view, the angle of rotation of the device θ_{cd} is presented with respect to the microscopic field of view. Since there may be the rotational misfit of the microscope camera, the observed angle is generally different from the rotational angle of the device with respect to the microscopic stage, θ_{sd} (**Fig. s2**). Letting the rotational misfit of the microscopic camera with respect to the microscope stage to be θ_{sc}, the relationship between these angles is then

$$\theta_{sc} = \theta_{sd} - \theta_{cd}$$

Reconstruction of QR Code image from PDMS integrated QR Code structure

To virtually reconstruct the image of original QR Code, the software also inherently recognizes θ_{cd} and minimum spacing between the databits, *f*. The process is performed via 2D-FFT image of the captured image of QR Code structure (**Fig. s3**). Since the image of QR code contains highly repetitive circles, its 2D-FFT image contains intensity peaks representing the repeated intensities from the original QR Code image. From location of the closest intensity peak from the centre, represented in r-θ coordinate frame, the software recognizes *f* and θ_{cd}.

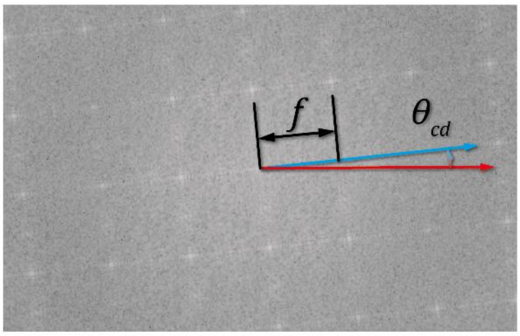

Fig. s3. 2D-FFT processed image of captured microscopic QR Code image. In 2D-FFT image, Intensity peaks are presented due to the highly repetitive features in the original QR Code image. By finding the intensity peaks near the center, the software can find the rotation of the device with respect to the imaging frame, θ_{cd}, and the frequency of the databits, *f*, which is the same as the width of databits in captured QR Code image (**Fig. 2B**).

Calibration of θ_{sd} for various device positions

We verified the performance of the $\boldsymbol{\theta_{sd}}$ calibration for five sample pivot angles. Reference device pivot angle was acquired via referencing the stage positions of same structural features in the two different arranged devices, located 22.4 mm away (**Fig. s4a**). After acquiring the reference pivot angle, the calibration procedure was performed, recognizing the position of two separately located QR Code's centre. Each calibration was repeated five times, and the result is presented in **Fig. s4b**. The results show that the device pivot angle is successfully acquired via QR recognition, with the errors less than 0.05°.

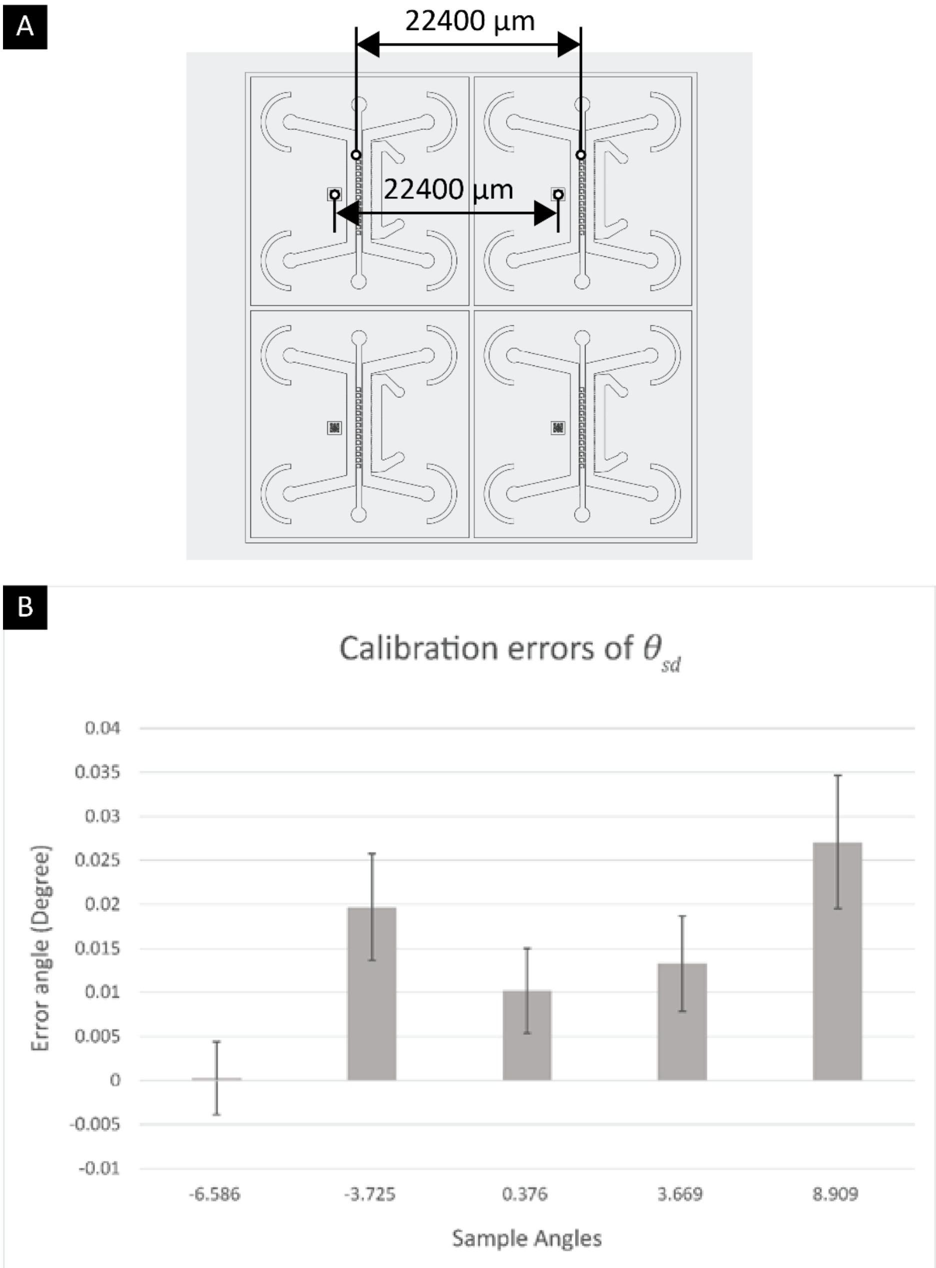

Fig. s4 (A) Reference points for device pivot angle calibration. (B) $\boldsymbol{\theta_{sd}}$ Calibration errors for five sample angles.

References

1. H. Lee, S. Kim, M. Chung, J. H. Kim and N. L. Jeon, *Microvascular research*, 2014, **91**, 90-98.