Electronic Supplementary Material (ESI) for Lab on a Chip.

Supporting Information

Intelligent nanoscope for rapid nanoparticle identification and classification

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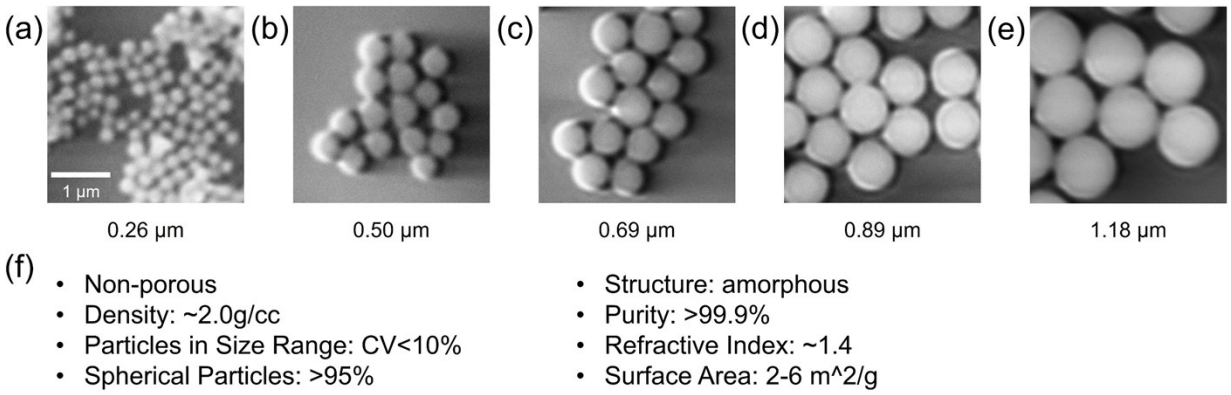
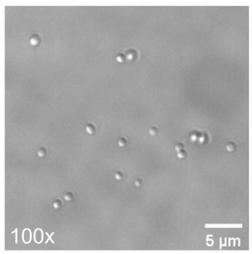


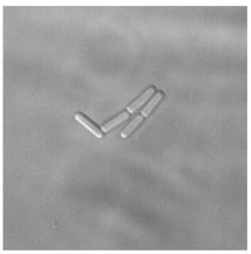
Fig. S1. Magnified images of SiO_2 nanoparticles are taken by SEM. (a) 0.26 µm, (b) 0.50 µm, (c) 0.69 µm, (d) 0.89 µm, (e) 1.18 µm. (f) Specification data of nanoparticles provided by the manufacturer (https://www.cospheric.com/SiO2MS_monodisperse_silica_spheres_beads_nm_microns.htm).

(a)



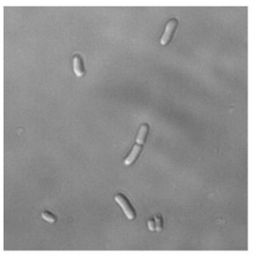
Staphylococcus aureus JE2 (Gram-positive)

(b)



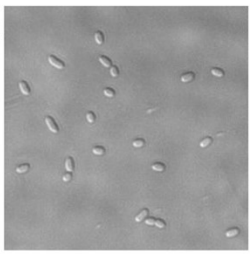
Bacillus subtilis 3610 (Gram-positive)

(c)



Escherichia coli BW25113 (Gram-negative)

(d)



Pseudomonas aeruginosa PA14 (Gram-negative)

(e)

(nm)	Round shape		Rod shape			
	S. aureus	Pseudomonas	Bacillus		E. coli	
	radius	radius	width	length	width	length
Average (N=5)	1,088	1,337	1178	4264	1346	3356
Standard deviation	62	68	71	367	79	496
Difference	249		168	908		

(f)

	Microscopic image based classification[1]	Electronic identification method[2]	Fluorescence staining method[3]	Intelligent nanoscope
System setup complexity	Simple	Complex	Complex	Simple
Number of categories of bacteria	2	5	5	4
Training data collection time	Long (> hours)	Short (≅ 75 seconds)	Long (≅ 8.9 hours)	Short (≅ 10 seconds)

Fig. S2. Magnified microscopic images of four different kinds of bacteria samples are taken with a 100x objective (NA:0.9, Nikon Ti-E, Japan): (a) Staphylococcus aureus JE2, (b) Bacillus subtilis 3610, (c) Escherichia coli BW25113, and (d) Pseudomonas aeruginosa. (e) Average size comparison in similar shape of bacteria cells. Round shape comparison for Staphylococcus aureus JE2 and Pseudomonas aeruginosa. Rod shape comparison for Bacillus subtilis 3610 and Escherichia coli BW25113. (f) Comparison table for other bacteria classification technologies based on machine learning.[1-3]

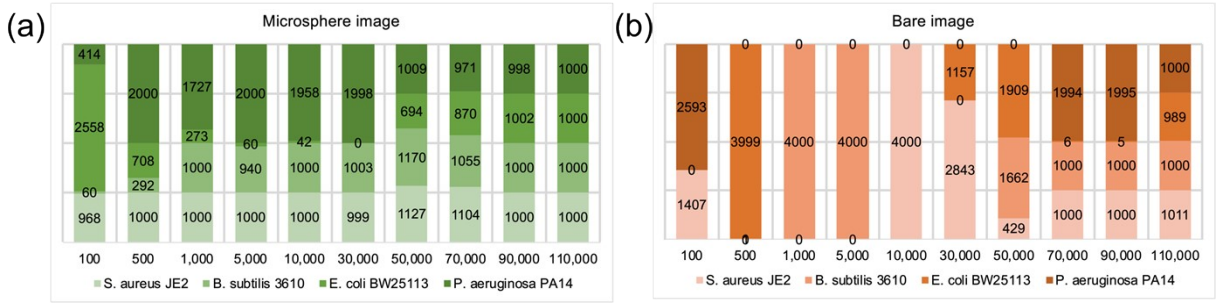


Fig. S3. Classification test results for each (a) microsphere image and (b) bare image of the four different kinds of bacteria for a given number of training images. 1,000 separately selected images from each category are inputted for the prediction test.

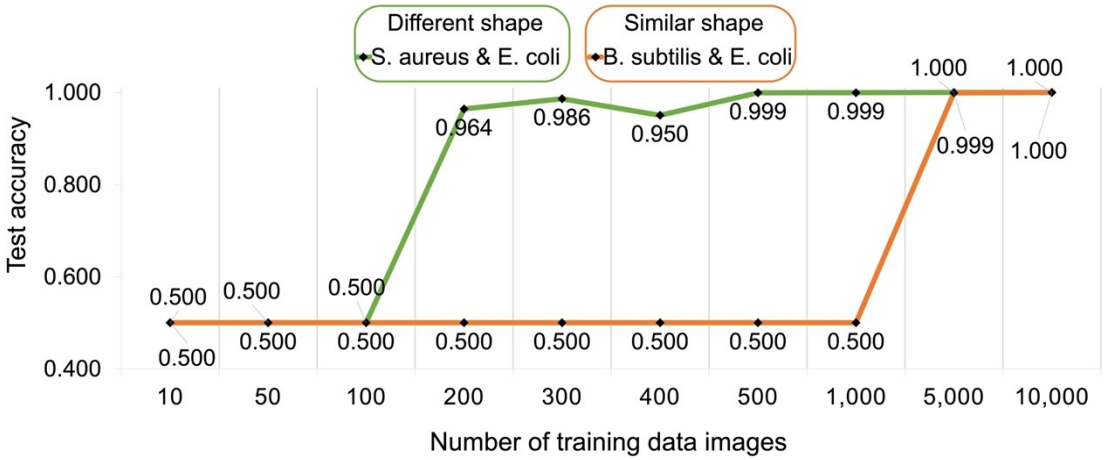


Fig. S4. Bacteria classification accuracy for the different shaped bacteria subsets with varying amounts of training data. The green graph represents the classification accuracy between the two different shaped bacteria samples (S.aureus (spherical) and E. coli (rod-like)) using the microsphere imaging method, and the orange graph represents the classification accuracy between the two similarly shaped bacteria samples (B. subtilis (rod-like) and E. coli (rod-like)) using the microsphere imaging method. 100 to 10,000 data images were used for the model training.

Objective (magnification/NA)	Field of view (μm)	Lateral resolution (μm)
10x/0.25	1,800	1.34
20x/0.40	900	0.84
40x/0.55	450	0.61
100x/0.95	180	0.35

Table. S1. Comparison of the field of view and resolutions of different objective lenses.[4]

References:

1. T. Treebupachatsakul and S. Poomrittigul, 2019 34th international technical conference on circuits/systems, computers and communications (ITC-CSCC), 2019, 1-3.
2. S. Hattori, R. Sekido, I. W. Leong, M. Tsutsui, A. Arima, M. Tanaka, K. Yokota, T. Washio, T. Kawai and M. Okochi, *Scientific reports*, 2020, **10**, 1-10.
3. Y. Seo, B. Park, A. Hinton, S.-C. Yoon and K. C. Lawrence, *Journal of Food Measurement and Characterization*, 2016, **10**, 253-263.
4. J. W. Ager III, *AIP Conference Proceedings*, 1998, **1**, 641-652.