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

Supplementary Information for

Biologically inspired micro-robotic swimmers remotely controlled by ultrasound waves

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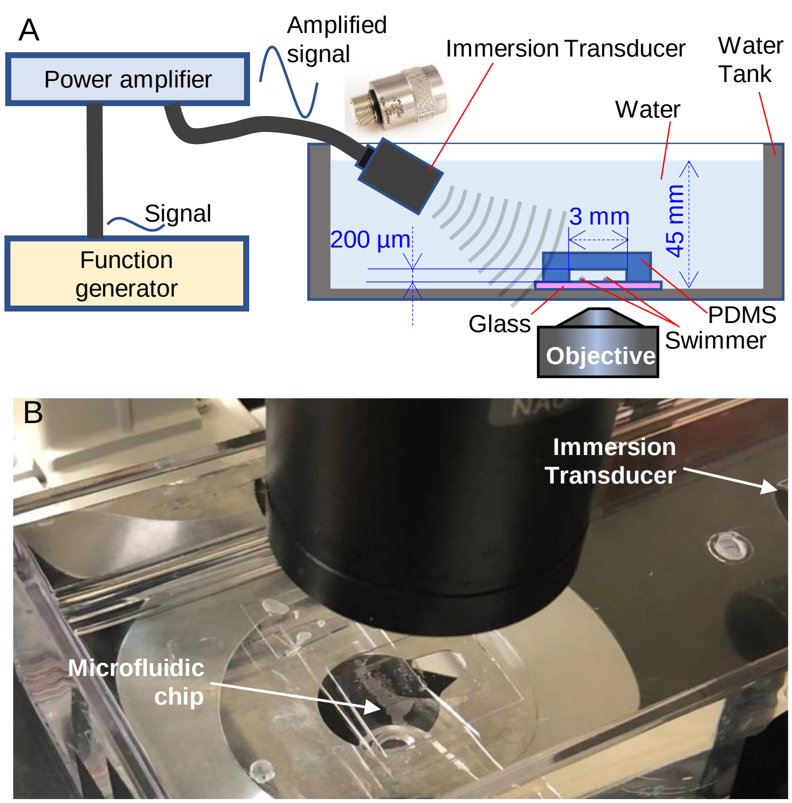

Fig. S1. Experimental setup. (A) A schematic of the experimental setup. A function generator together with a power amplifier (with fixed amplification of 50 dB) are used to power the transducer. The immersion transducer was submerged in the water in a 4 x 2 x 12 inch^3 rectangular cuboid tank, and a PDMS microfluidic channel 3 mm in width, 200 µm in height, and ~4 cm in length is bonded on a 1 mm-thick and 1 inch x 3 inch glass slide. The micro-swimmers are seeded within the microfluidic channel. (B) A photo of the experimental setup with the immersion transducer and microfluidic chip on the stage of a microscope.

Movie S1 (separate file). Selective excitation of microbubbles with different sizes of air-fluid interface. Movies of two one-bubble swimmers with opening d= 8 µm and 10 µm respectively, each anchored on a substrate. The acoustic streaming flows are generated by the oscillating microbubbles and visualized by fluorescence marker beads. At ultrasound frequency f = 300 kHz, strong streaming flow is observed for swimmer with an opening of diameter *d* = 10 μm; and at f = 396 kHz, strong streaming flow is observed for swimmer with opening diameter of d = 8 μm. The movies are taken at 20 fps, and sped up 2x.

Movie S2 (separate file). Movies showing initial attitude adjustment. A time series of the microscopic images taken by an inverted microscope (10X Objective), showing the attitude adjustment process from a bottom view. The size of the image is 215 x 215 μm, and the time between consecutive images is 50 ms. t = 0 is defined as when the ultrasound is turned on.

Movie S3 (separate file). A microswimmer swims close to a substrate. A movie taken by an inverted microscope (10X Objective) shows that a micro-swimmer is always in focus during the 16 s filming time indicating that they always stay close to the substrate. The movie is taken at 20 fps, and sped up 3x. t = 0 is defined as when the ultrasound is turned on.

Movie S4 (separate file). Robotic microswimmer moves along the wall of the microfluidic channel. A movie taken by an inverted microscope (10X Objective) shows that a swimmer swims along the wall of a microfluidic channel. The movie is taken at 20 fps, and sped up 3x. t = 0 is defined as when the ultrasound is turned on.

Movie S5 (separate file). Locomotion of micro-swimmer controlled by ultrasound waves. At ultrasound frequency 301 kHz, the micro-swimmer follows a linear trajectory, and increases its speed with the input voltage to the ultrasound transducer. At ultrasound frequency 234 kHz, the micro-swimmer swims in circles, its speed also increases with the input voltage to the ultrasound. The yellow line shows the trajectories of the swimmer. The real-time movie is taken by an inverted microscope (10X Objective) at 20 fps, and sped up 3x. t = 0 is defined as when the ultrasound is turned on.

Movie S6 (separate file). Making a left turn. The left turn is controlled by switching the ultrasound frequency from 342 to 218 kHz at t =20.8 s and switching it back at t =43 s. The duration of the movie is 60 s. The movie is taken at 20 fps, and sped up 4x. t = 0 is defined as when the ultrasound is turned on.

Movie S7 (separate file). Making a right turn. The right turn is controlled by switching ultrasound frequency from 328 to 234 kHz at t = 7.5 s, and switching it back at t =15 s. The duration of the movie is 20 s. The movie is taken at 20 fps, and sped up 4x. t = 0 is defined as when the ultrasound is turned on.