

**File Name: Supplementary Movie 1**

Description: Two basic types of motion modes. The left video shows the multi-legged millirobot with flexible tapered feet locomotion with discontinuous flap-wave mode (DFW). This motion mode is generated by an “O” trajectory of magnet with surface magnetic field intensity 80 mT on  $y$ - $z$  plane. This multi-legged millirobot with flexible tapered feet moves 8 mm in 36 s with frequency 1 Hz. The right video shows the multi-legged millirobot with flexible tapered feet locomotion with continuous inverted-pendulum mode (CIP). This motion mode is generated by an “S” trajectory of magnet with surface magnetic field intensity 80 mT on  $x$ - $y$  plane. This multi-legged millirobot with flexible tapered feet moves 12 mm in 20 s with frequency 1 Hz. The video is at  $1\times$  playback speed.

**File Name: Supplementary Movie 2**

Description: An individual foot motion in one gait circle. The video shows the continuous motion of an individual foot in each gait cycle with frequency 1 Hz, as the results given in Fig. 3a and Fig. 3b, including the robot body’s displacement along  $y$  axis (pink line), the foot’s displacement along  $y$  axis (green line), the robot body’s displacement along  $z$  axis (light blue line) and the foot’s deformation (dark blue line). The video is at  $0.1\times$  playback speed.

**File Name: Supplementary Movie 3**

Description: Over-obstacle ability comparison between the flexible foot and the rigid foot. The video shows when multi-legged millirobot with flexible tapered feet comes to an obstacle (height  $160\ \mu\text{m}$   $\times$  width 1 mm) on the way forward, the robot could stride it via foot deformation after head lifting with an angle approximate  $20^\circ$  by changing the magnetic flux direction. By contrast, the robot with rigid foot gets stuck to the obstacle no matter how magnetic flux direction changes.

**File Name: Supplementary Movie 4**

Description: Robot locomotion on liquid film. The video shows the difference when footless robot and multiple tapered feet robot contact to liquid membrane. The video is at  $4\times$  playback speed. When the multiple tapered feet millirobot occurred to a humidity environment (liquid film approximate  $150\ \mu\text{m}$ ), it moves 10 mm with an average speed of 0.5 mm/s with frequency 1 Hz. The video is at  $1\times$  playback speed.

**File Name: Supplementary Movie 5**

Description: Robot locomotion with a loading approximate 100 times of its own weight. The video shows the multi-legged millirobot with flexible tapered feet motion when it is loaded a capsule weight 3980.6 mg with self-weighted 39.4 mg, moves 8 mm in 45.3 s with frequency 1 Hz. The video is at 8× playback speed.

**File Name: Supplementary Movie 6**

Description: Robot cross an obstacle with height approximate 10 times higher of its own foot. The video shows the multi-legged millirobot with flexible tapered feet climbs two obstacles with height 6.5 mm, and slop angle 60° in 113 s within 40 mm distance. The beginning of the video emphasizes the “soft” property. The video is at 8× playback speed.

**File Name: Supplementary Movie 7**

Description: Robot motion demonstration with swing frequency at 0.5 Hz, 4 Hz and 16 Hz. The video shows the multi-legged millirobot with flexible tapered feet is actuated by a permanent magnet with surface magnetic field intensity 200 mT at frequency 0.5 Hz, 4 Hz and 16 Hz. The robot moves with velocity around 0.98 mm/s at 0.5 Hz, 8.3 mm/s at 4 Hz frequency and 25.2 mm/s at 16 Hz frequency.

**File Name: Supplementary Movie 8**

Description: Robot demonstration of locomotion ability in harsh environment. The video shows the complex stomach model’s internal structure and humidity environment, which demonstrates the multi-legged millirobot with flexible tapered feet potential locomotion ability in-vivo environment. The video is at 4× playback speed.

**File Name: Supplementary Movie 9**

Description: Bionic starfish millirobot locomotion demonstration. The video shows the beach environment with sand, tiny stone and dry leaves on a piece of white sheet. The starfish millirobot walks 10 cm across the beach-like region in 123 s. The video is at 8× playback speed.