

Supplemental Materials

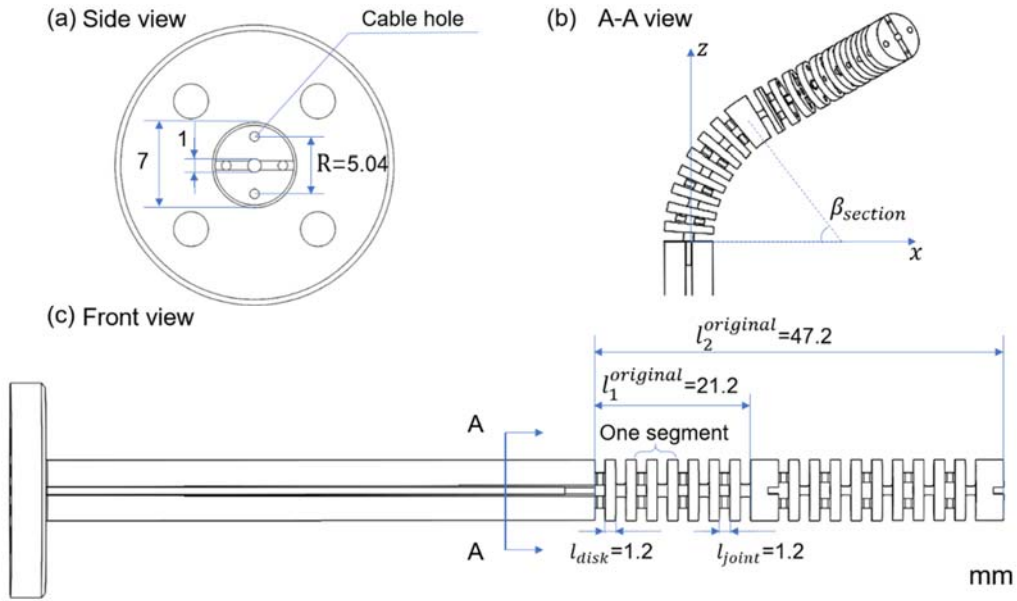
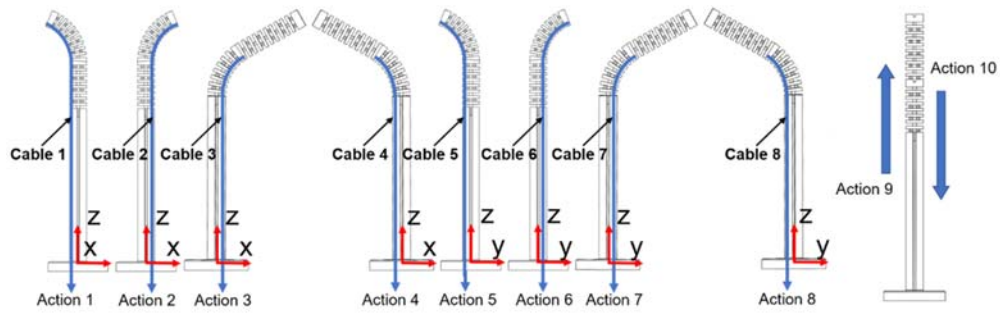


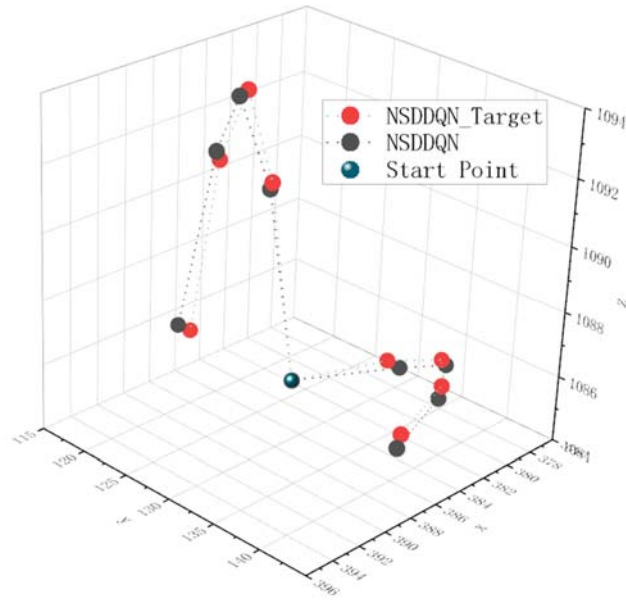
Figure S1. Robot arm overview. (a) Side view of the robot arm, the distance between the two cable holes is 5.04mm. (b) Bending status of the robot arm. (c) Front view of the robot arm.



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8 Figure S2. The relationship between the cables and actions. Action 1 represent cable
 9 1 is driven with length change 0.16 mm. So do action 2-8. Action 9 and Action 10
 10 represented the linear guide move upward and downward with 0.07 mm, respectively.

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13 Figure S3. Point Tracking (3D sine function shape) with NSDDQN controller (Start

14 Point at x=386mm, y=126mm, z=1086mm

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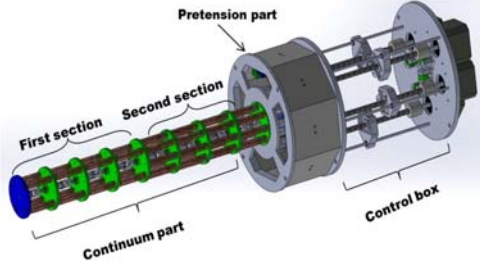
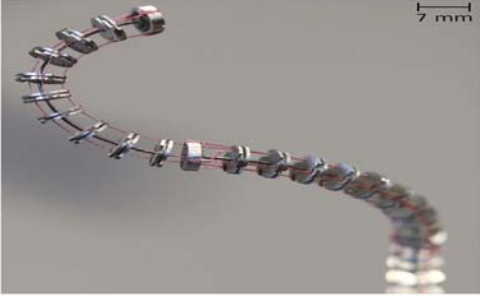
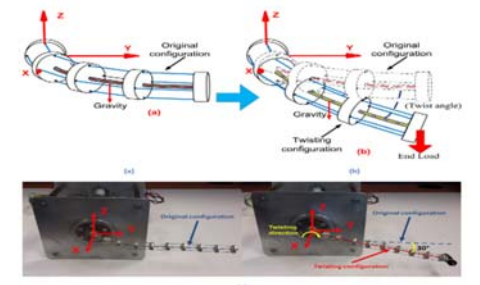
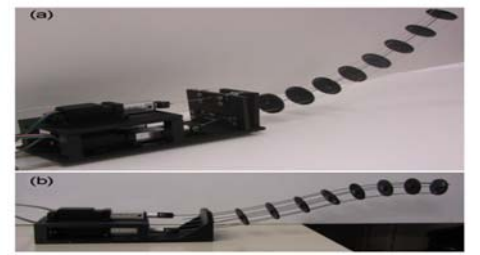
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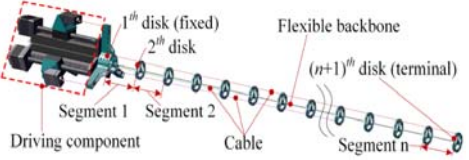
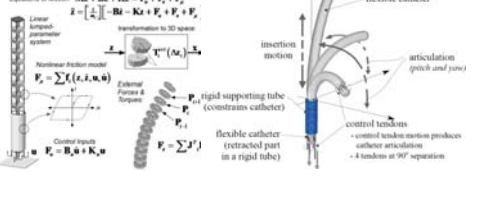
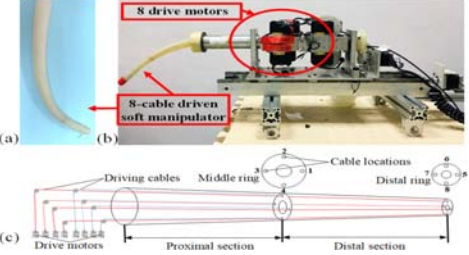
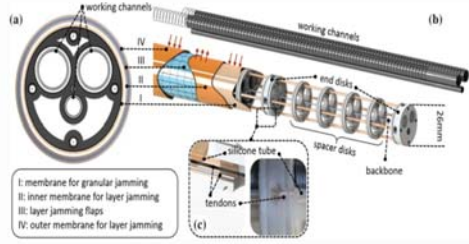
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23 Table S1. More cable driven soft continuum robots with four tendons per section

Picture	Tendon number per section	Flexible/ soft continuum robot	Cable driven or not	ref
	4	yes	yes	[1]
	4	yes	yes	[2]
	4	yes	yes	[3]
	4	yes	yes	[4]
	4	yes	yes	[5]

 1th disk (fixed) 2th disk Flexible backbone (n+1)th disk (terminal) Segment 1 Segment 2 Cable Segment n Driving component	4	yes	yes	[6]
 2.4 mm fiber	4	yes	yes	[7]
 Equations of Motion: $M\ddot{\mathbf{z}} + \mathbf{B}\dot{\mathbf{z}} + \mathbf{K}\mathbf{z} = \mathbf{F}_e + \mathbf{F}_p + \mathbf{F}_f$ $\ddot{\mathbf{z}} = \left[\frac{\ddot{\mathbf{z}}}{\ddot{\theta}} \right] - \mathbf{B}\dot{\mathbf{z}} - \mathbf{K}\mathbf{z} + \mathbf{F}_e + \mathbf{F}_p + \mathbf{F}_f$ $\mathbf{F}_e = \sum \mathbf{F}_e(\mathbf{r}, \mathbf{z}, \mathbf{u}, \mathbf{u})$ $\mathbf{F}_p = \mathbf{B}_p \dot{\mathbf{z}} + \mathbf{K}_p \mathbf{z}$ $\mathbf{F}_f = \sum \mathbf{F}_f(\mathbf{z})$ Linear lumped parameter system Nonlinear friction model External Forces & Torques Control input rigid supporting tube (constrains catheter) flexible catheter (retracted part in a rigid tube) flexible catheter insertion motion articulation (pitch and yaw) control tendons - control tendons motion produces catheter articulation - 4 tendons at 90° separation	4	yes	yes	[8]
 8 drive motors 8-cable driven soft manipulator (a) (b) (c) Driving cables Middle ring Cable locations Distal ring Drive motors Proximal section Distal section	4	yes	yes	[9]
 (a) working channels (b) working channels (c) silicone tube tendons end disk water disks backbone I: membrane for granular jamming II: inner membrane for layer jamming III: layer jamming flaps IV: outer membrane for layer jamming	4	yes	yes	[10]

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27 Table S2. Robot Parameters

l_{disk}	1.2mm
l_{joint}	1.2mm
$l_1^{original}$	21.2mm
$l_2^{original}$	47.2mm
N_1	4
N_2	5
R	2.52mm

28 where l_{disk} is the thickness of the disks, l_{joint} is the length of the compliant joints,
 29 $l_1^{original}$ is the original length of one pair of cables in first section, $l_2^{original}$ is length of
 30 one pair of cables in second section, N_1 is the quantity of segments in first single
 31 section, N_2 is the quantity of segment in second section, R is the distance from center
 32 of the disk to the cable anchor point, beta_segment is the bending angle of segment
 33 and beta_section is the bending angle of section.

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36 Supplemental Movie 1. Point tracking of robot arm with external payload (10 g)
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38 Supplemental Movie 2. The robot performs point tracking between the soft obstacle
39 (side view)
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41 Supplemental Movie 3. Explanation for cable driven control
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43 Supplemental Movie 4. The robot movement demonstration
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Supplementary Reference

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