Kinematic Synthesis in the Design of Continuum Robots

Yucheng Li

Advisors: Andrew Murray, Ph.D. & David Myszka, Ph.D.

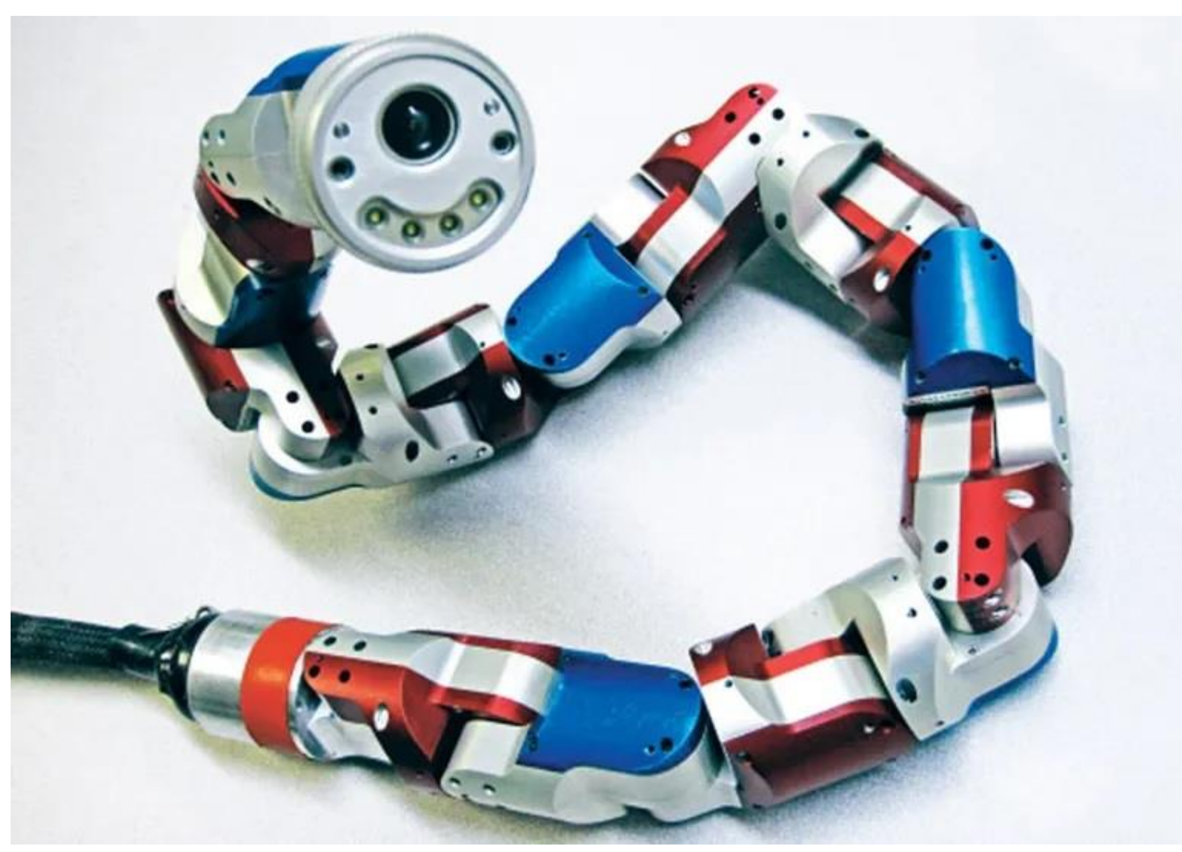
Department of Mechanical & Aerospace Engineering

UNIVERSITY of DAYTON

Research objective: To develop a novel and fast inverse kinematics methodology for continuum and hyper-redundant robots by exploiting the snake-like curve, called the backbone, described by a configuration of the robot.

Motivation

- Flexibility, maneuverability, and compliance of continuum robots.
- Minimally invasive surgery, search and rescue operations, and a variety of inspection tasks.
- Additional complexity introduces new synthesis challenges.

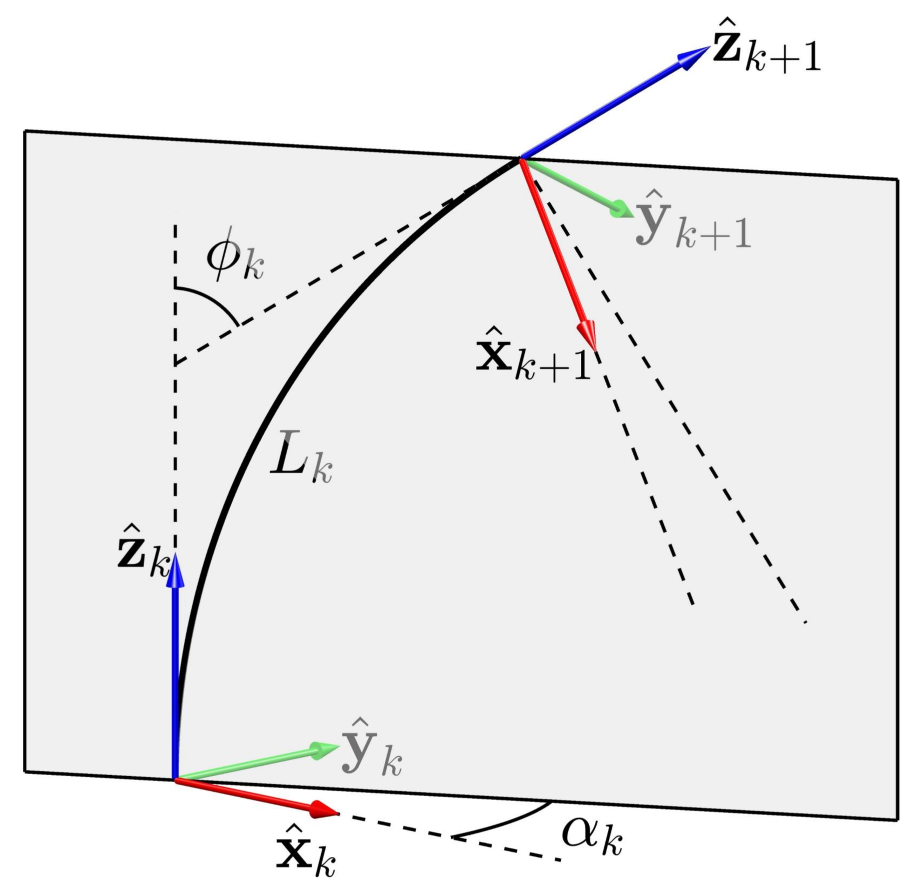


Unified Modular Snake Robot (Wright et al., 2012)

Festo's Bionic Handling Assistant (source: Festo AG & Co. KG)

Kinematic Analysis

Three variables to determine the pose of each segment: segment length, bending direction, and bending angle.



Kinematic nomenclature for one-segment of the continuum robot.

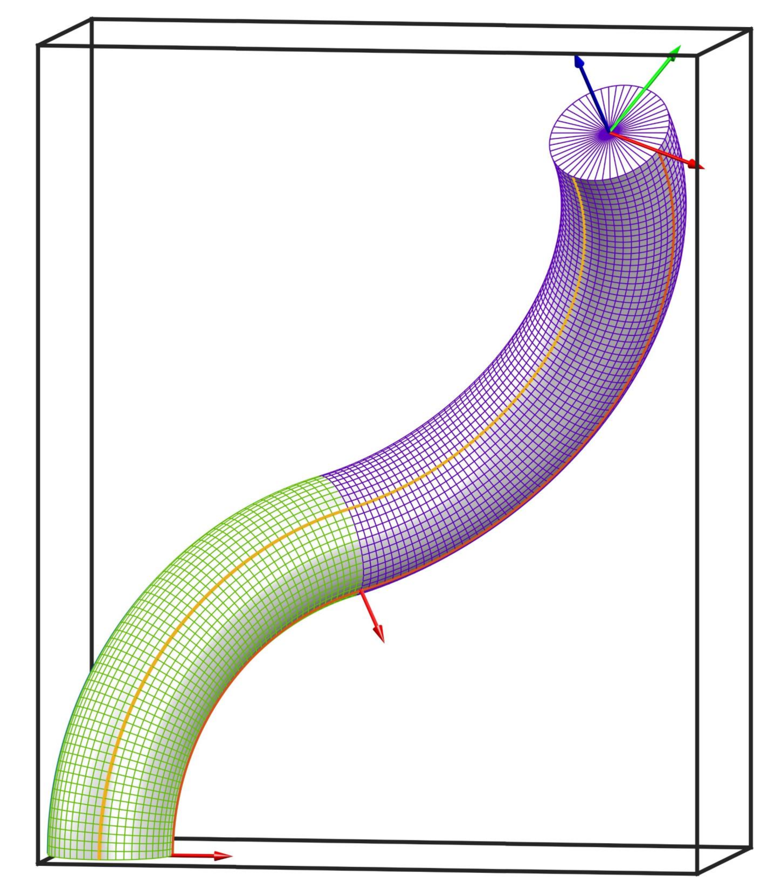
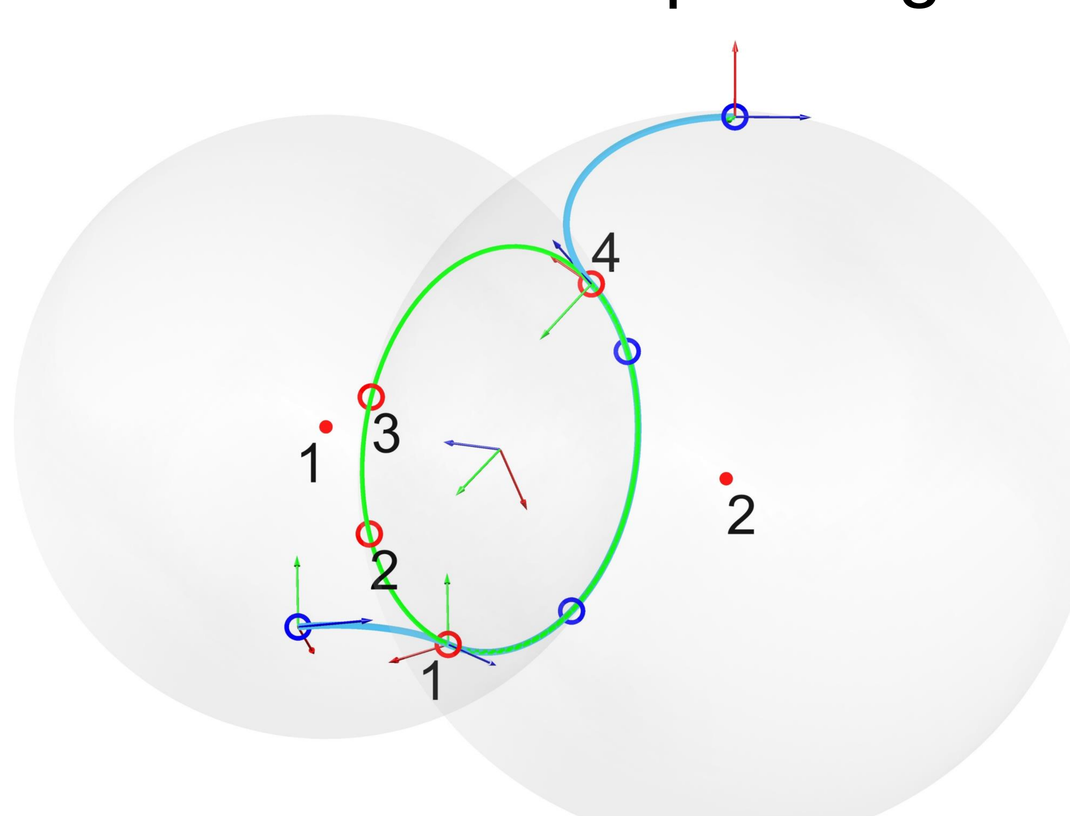


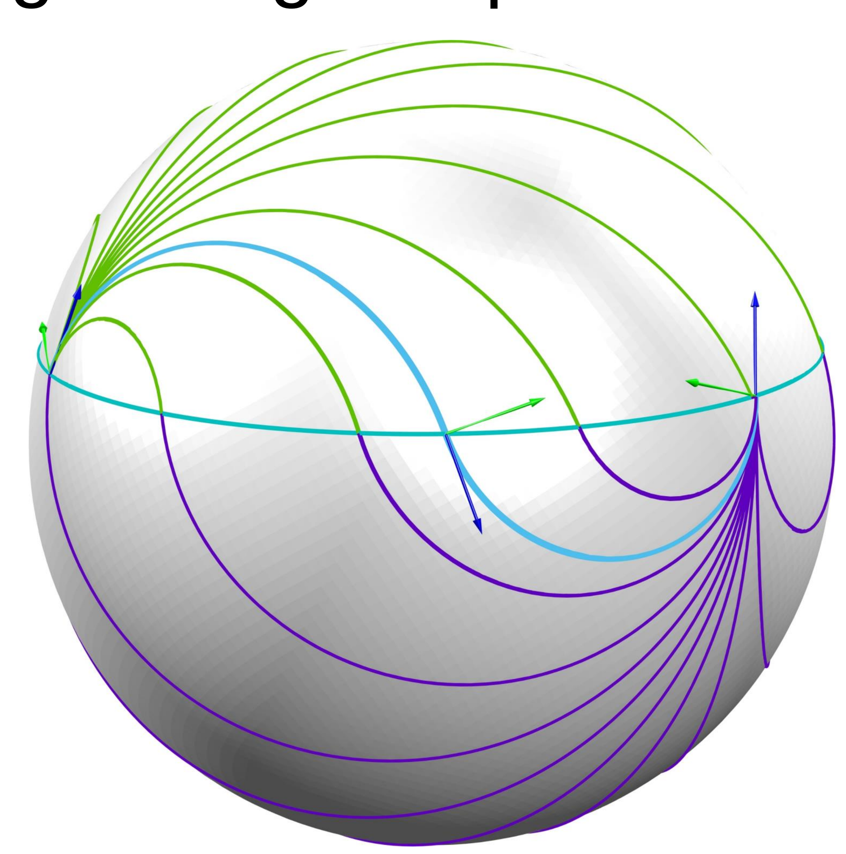
Illustration of a two-segment robot configuration.

Closed-Form 5-DoF Solutions

- For two-segment robots, capable of matching positions and tangential directions at both ends.
- For three-segment robots, capable of matching 5-DoF and passing through two given points.



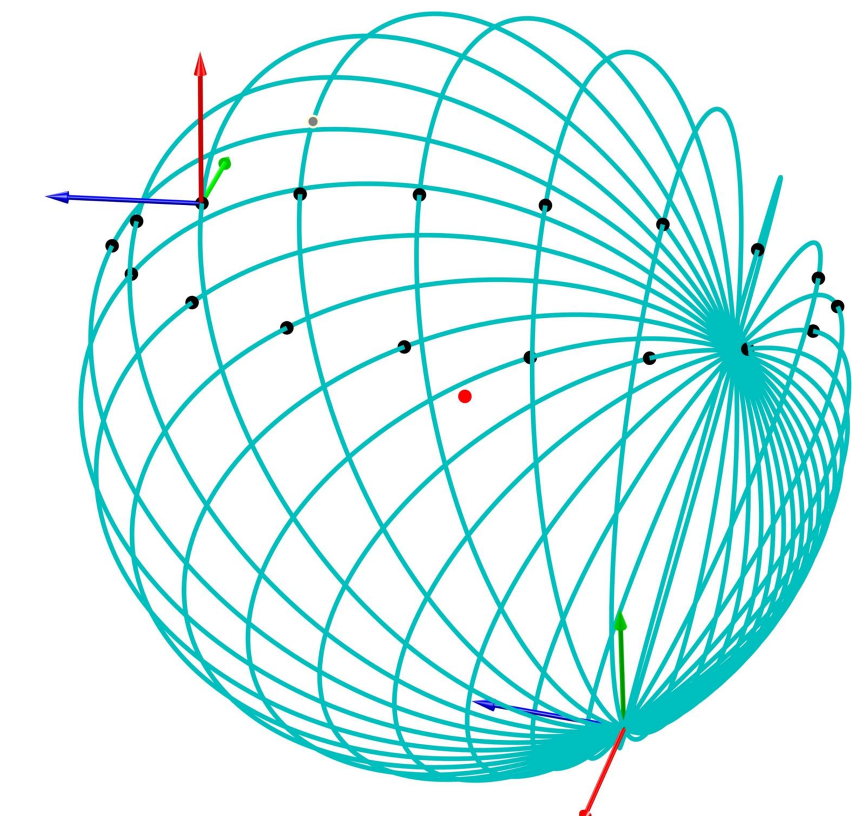
Move the junctions to ensure the backbone passes through given points.



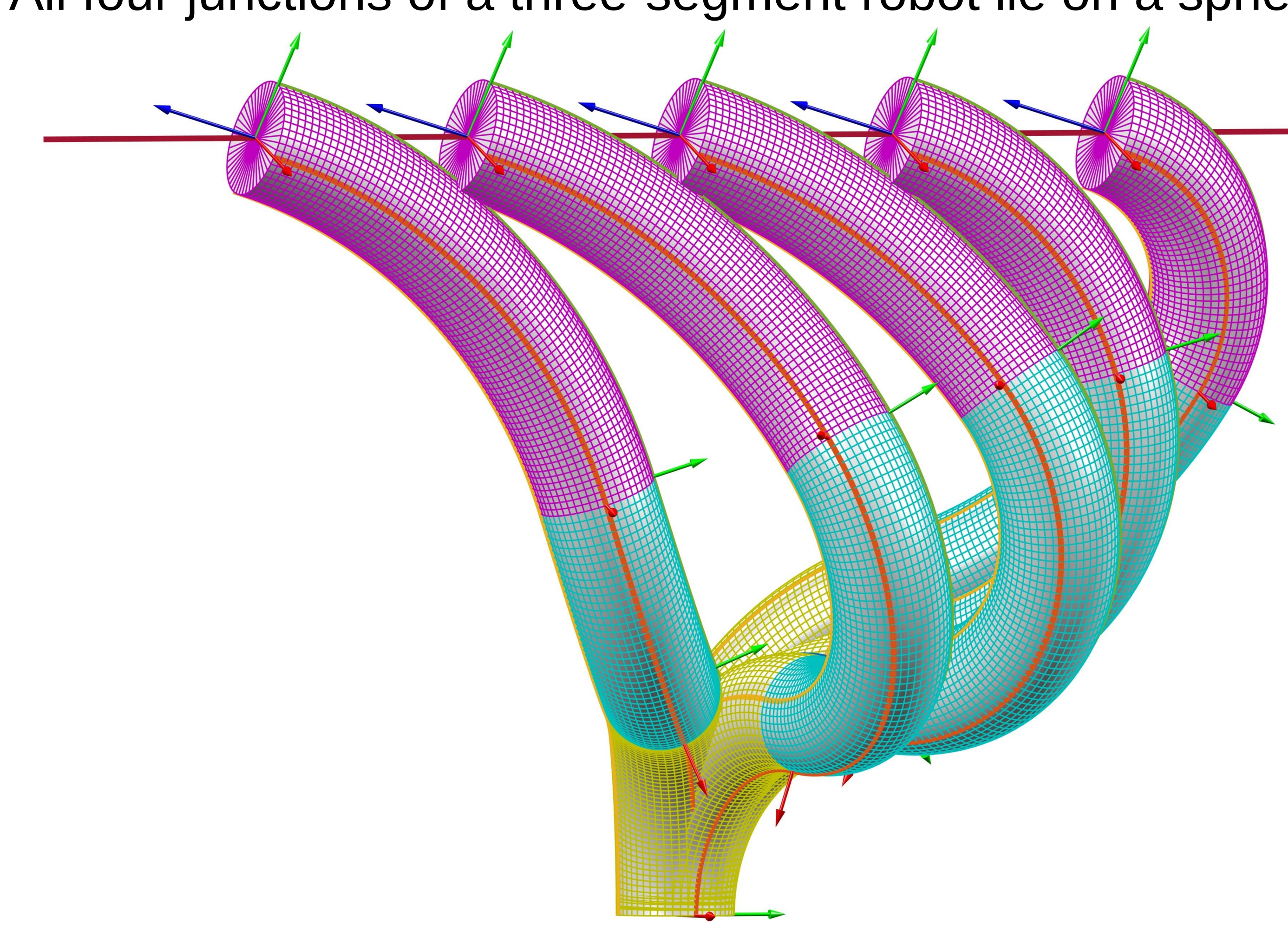
The continuous backbone of adjacent segments lies on a sphere.

Closed-Form 6-DoF Solutions

- For three-segment robots, capable of matching positions and orientations of the frames at both ends.



All four junctions of a three-segment robot lie on a sphere.



A set of robot poses that match the given 6-DoF trajectory of the end-effector.

Future Work

- Investigate the capability of matching 6-DoF and ensuring given points.
- Implement the design process to synthesize robots with given constraints.