



Introduction

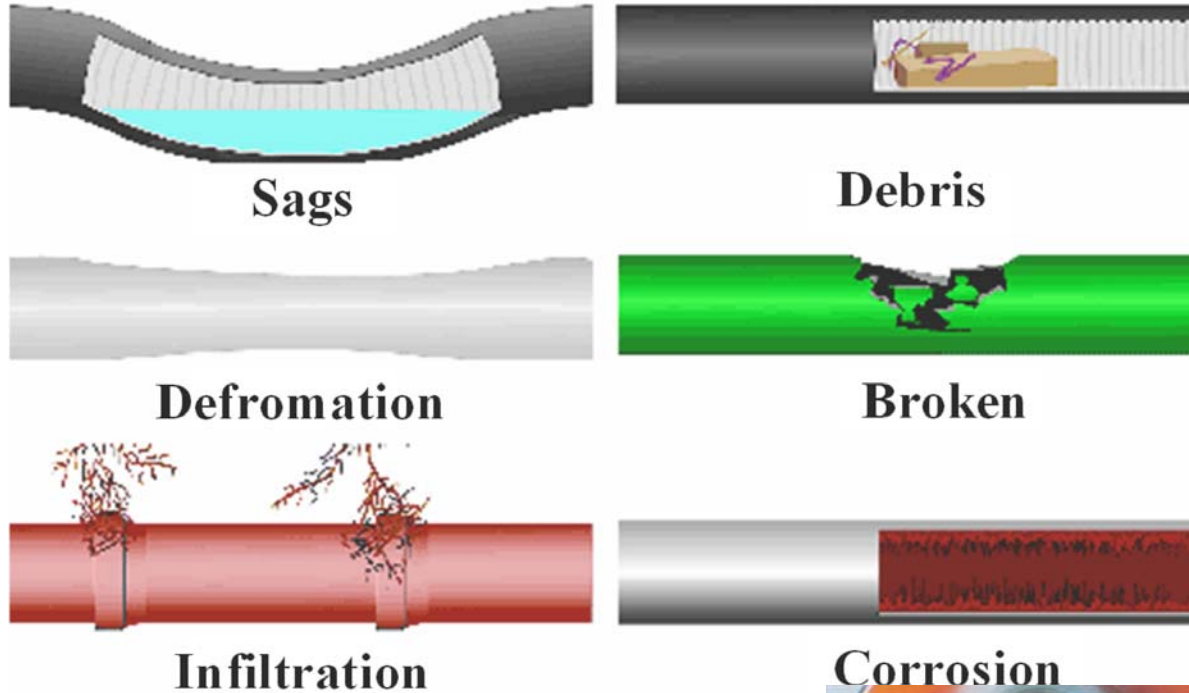
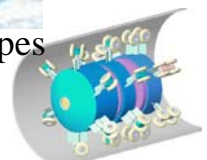


Fig. 1. Some cases of the pipelines



Fig. 2. Comparisons of the newly and corrosion pipes





Previously-developed In-pipe Robots



Fig. 3. Mutivehicle developed by Fujiwara *et al.*



Fig. 4. Toshiba Corporation pipe robot

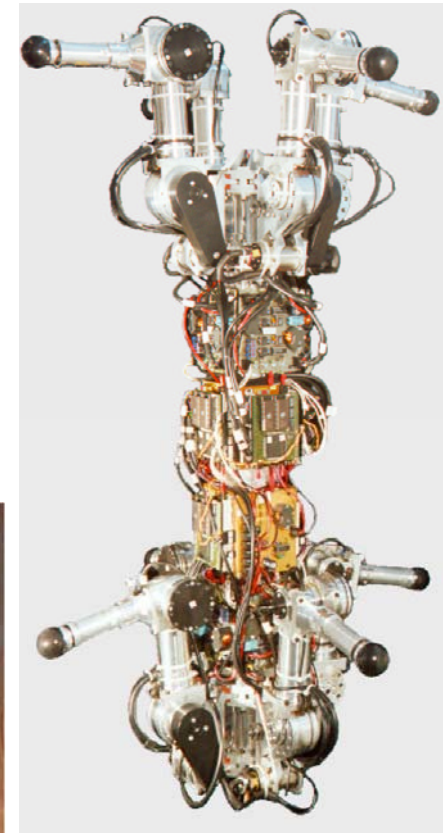


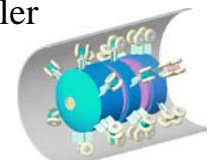
Fig. 7. “MORITZ”
by Zagler



Fig. 5. Inch worm robot—“MOCASIn” by NC state university



Fig. 6. Screw drive robot “HELIIPIPE”



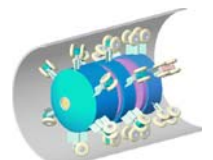


Problem's Statement

- These robot use **more actuators** that results in **highly cost** and too much **energy consumption**
- The robot's **mobility** is **poor** when it encounters the **obstacles**, while using less actuators

Our work aims to:

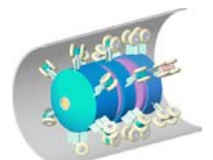
- **Reduce** the number of the driving actuators
- **Make full use of** the **capacity** of the actuators
- Acquire **extra mobility functions**, even small number actuators





Basic Consideration for In-Pipe Robot

- 1) **Adaptability**: Pipe robots designed for inspection should have **adaptability** to the **change of the environments**
- 2) **Multifunction**: The robots should have **more moving modes or forms**. This will enlarge the application range of the pipe robot
- 3) **Efficiency**: Due to the narrow space, robots should make **full use** of the **capacity** of the driving actuator





Screw Drive Principle

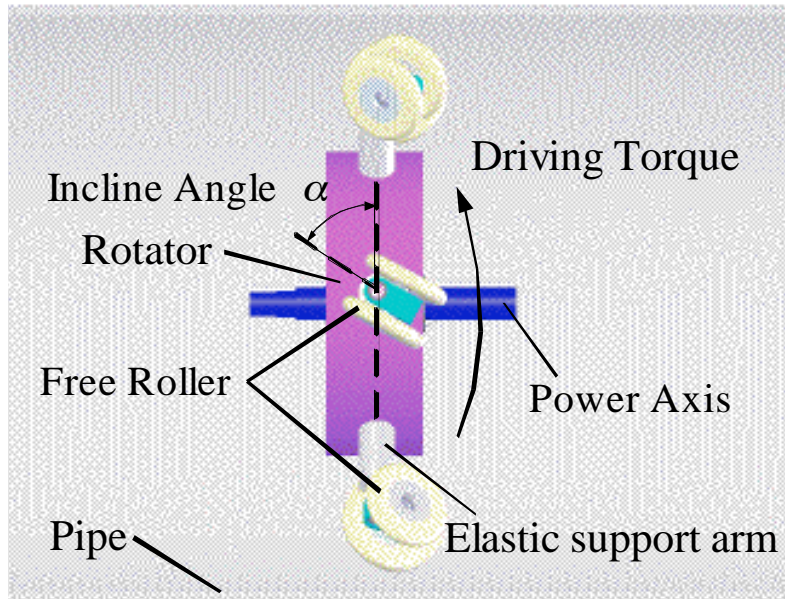
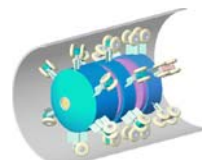


Fig. 8. Principle of screw drive wheel type robot

- It is composed of rotator, elastic support arm and free rollers
- The rollers have an **incline angle** with respect to the axis of the pipe
- The driving torque applied, the **trajectory** of the roller center displays a **helical line**





Concept of our In-Pipe Robot

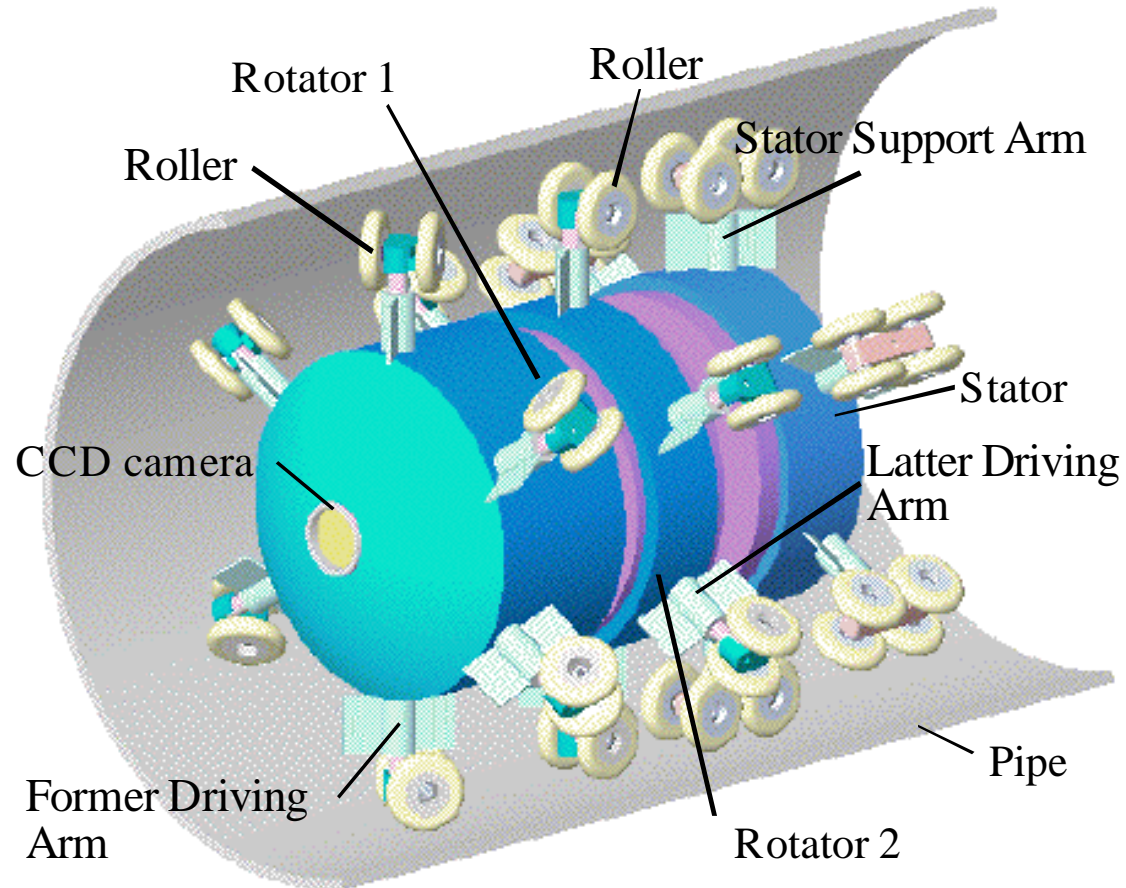


Fig. 9. Concept of the adaptive mobile mechanism

➤ Feature

Rotator 2 generally keeps still, while possible support to overcome the steps

➤ Advantage

- Classical screw drive robot is **Low Capacity** of surmounting obstacle
- Linked type configuration uses **More Actuators**



◆ This proposed mechanism

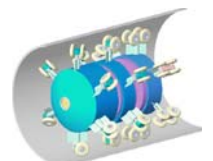
One module uses one actuator





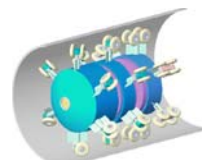
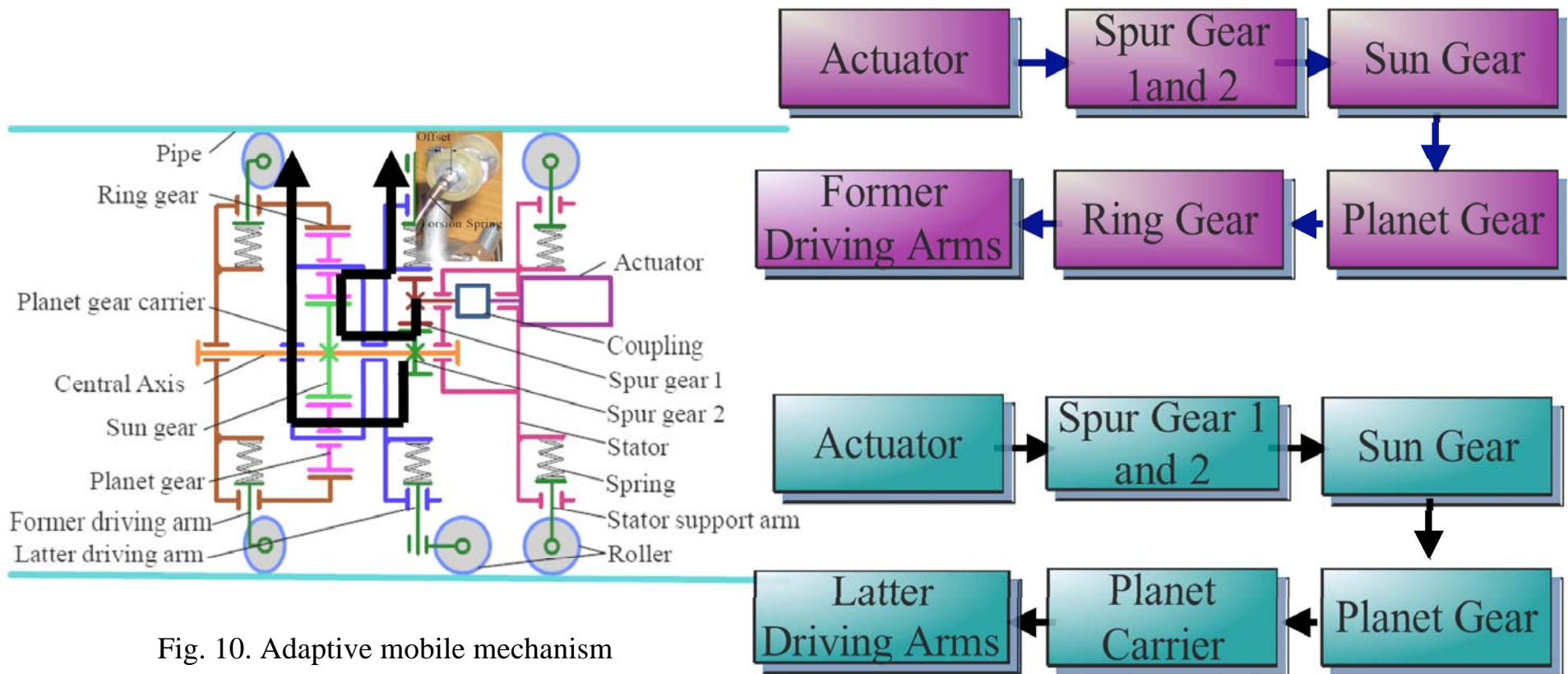
Requirements for Design

- The **axial length** of the robot should be as **SHORT** as possible, because of the pipe geometric constraints
- The mechanism should be **ONE actuator** to achieve **multifunction**





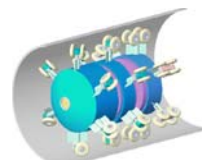
Mechanical Design





Possible Locomotion Modes

- 1. Normal Working Mode:* Because the resistance is not high in most of the time, the **former** driving **arms** thus **rotate** and the **latter** driving **arms** keeps **still**. The robot thus travels at a high speed in the pipe
- 2. Assistant Enhanced Mode:* When the robot encounters an obstacle, the **latter arms** produce **torque** to **help** the **former arms** **surmounting** the obstacle





Design of the Latter Driving Arm

- **Normal working mode:** Rollers should be parallel to the axis of the pipe, for **avoiding extra resistance**
- **Assistant enhanced mode:** Rollers should have an incline angle with respect to the axis of the pipe

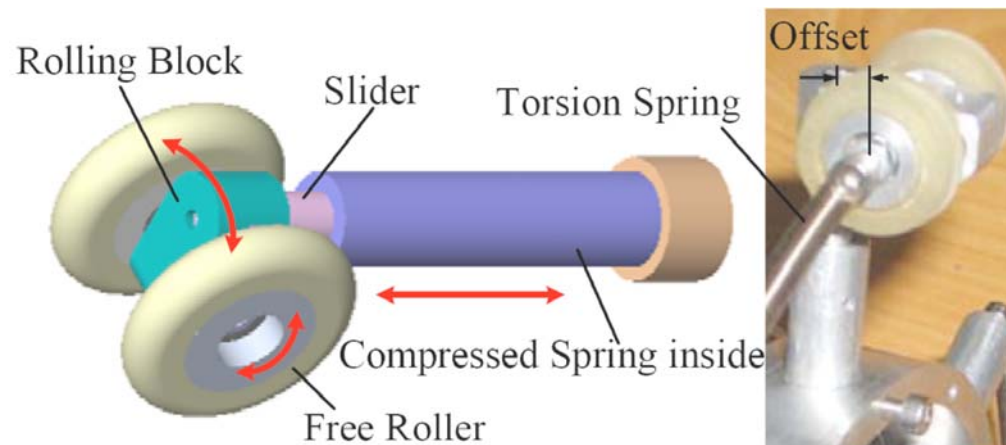
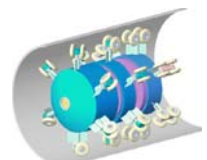


Fig. 11 Mechanism of the latter driving arm





Prototype

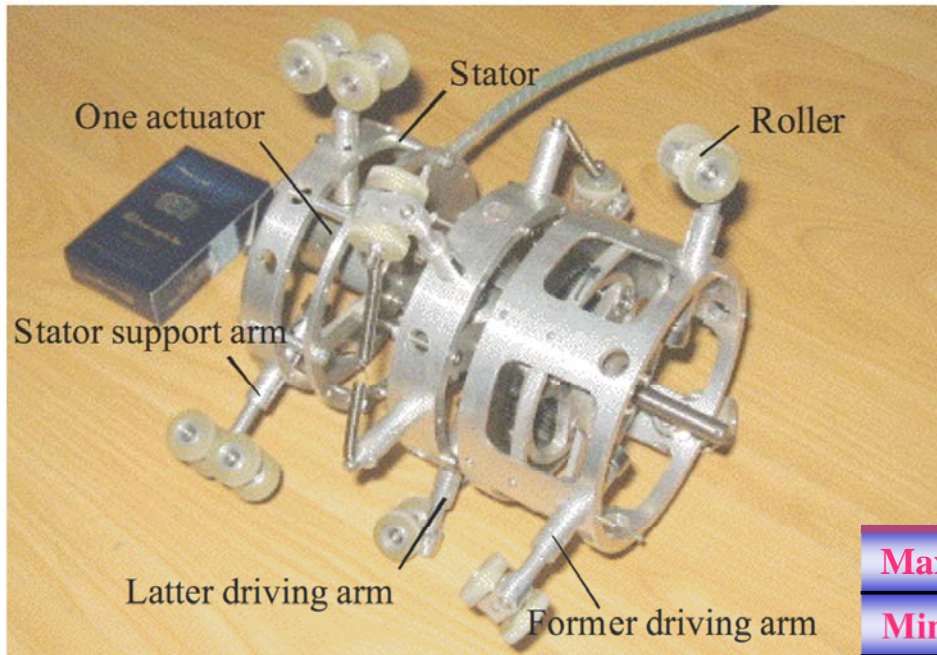


Fig. 12 The prototype of the robot

Specifications of The Pipe Robot

Max Diameter	205mm
Min Diameter	175mm
Axial Length	207mm
Total Weight	1.8Kg
Ratio of Transmission	2(normal mode),3(assistant mode)
Velocity in horizontal pipe	16.3cm/s

