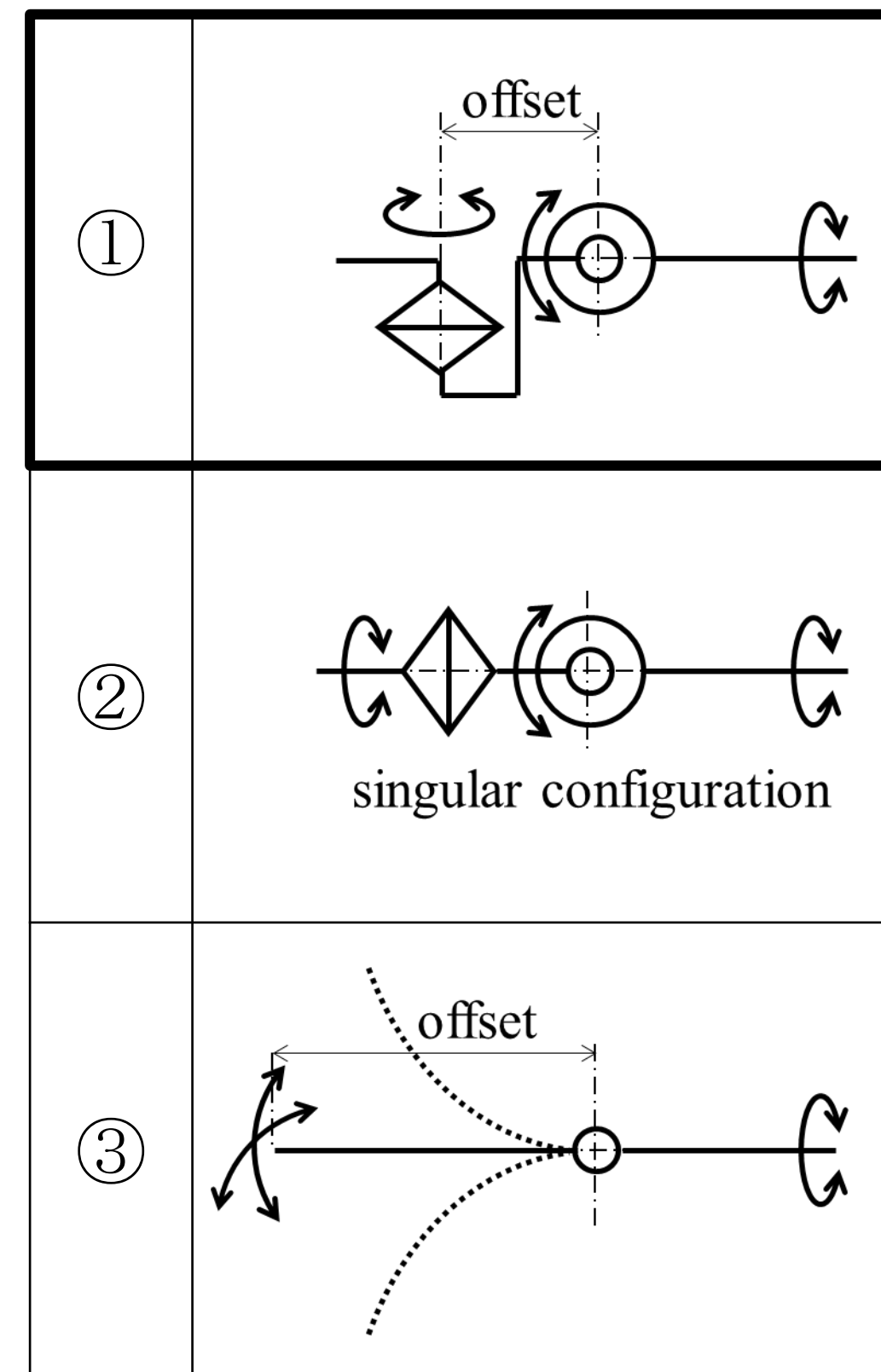


Novel wrist mechanism for articulated forceps for use in robot-assisted laparoscopic surgery

Basic specifications required for the wrist mechanism

- (1) Small offset distance between the pitch and yaw axes
- (2) Avoid singularity configurations near the standard working posture

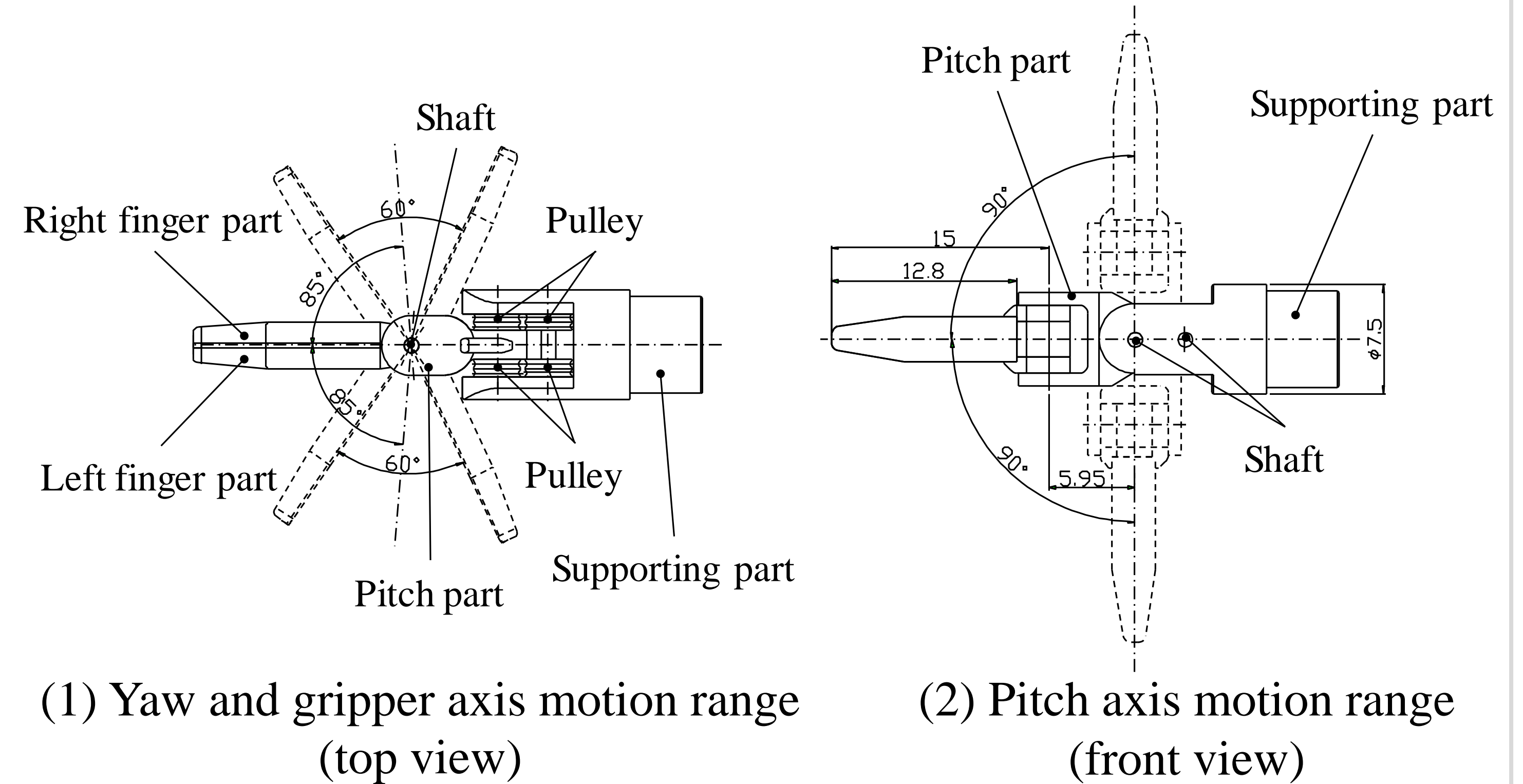
Axis configuration	(1) Offset between axes	(2) Distance from singular configuration
① Pitch and yaw axes	△	○
② Yaw and roll axes	○	×
③ 2 bending axes	×	○



Specifications of wrist mechanism

Items		Specification
Size	Maximum diameter	φ7.5 [mm]
	Offset from pitch axis to yaw axis	5.95 [mm]
	Offset from yaw axis to gripper axis	0 [mm]
	Radius from gripper axis to tip	15 [mm]
	Gripper face length	12.8 [mm]
Motion range	Pitch	±90 [deg]
	Yaw	±85 [deg] (±90 [deg])
	Gripper	60 [deg] (50 [deg])

Mechanical design

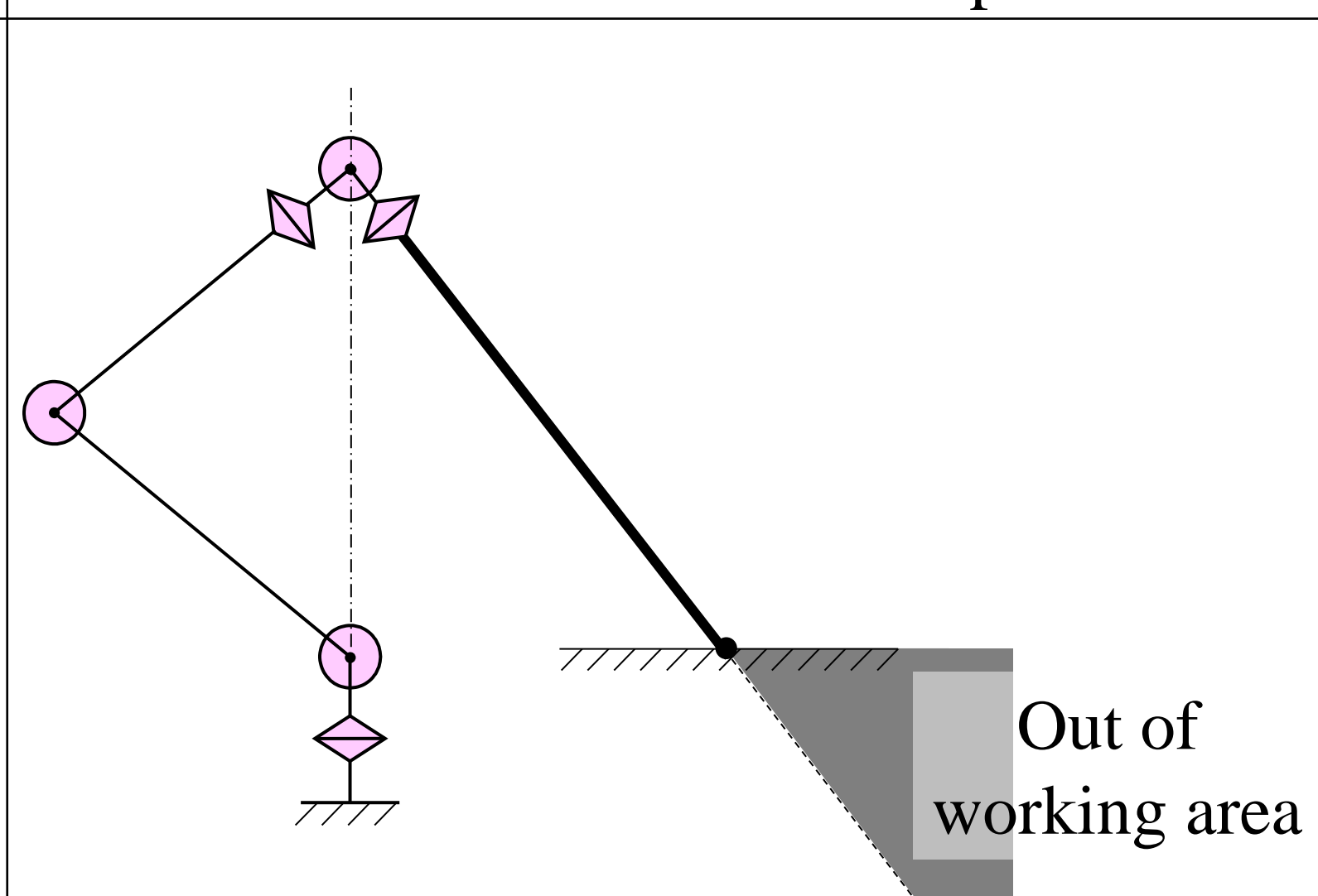
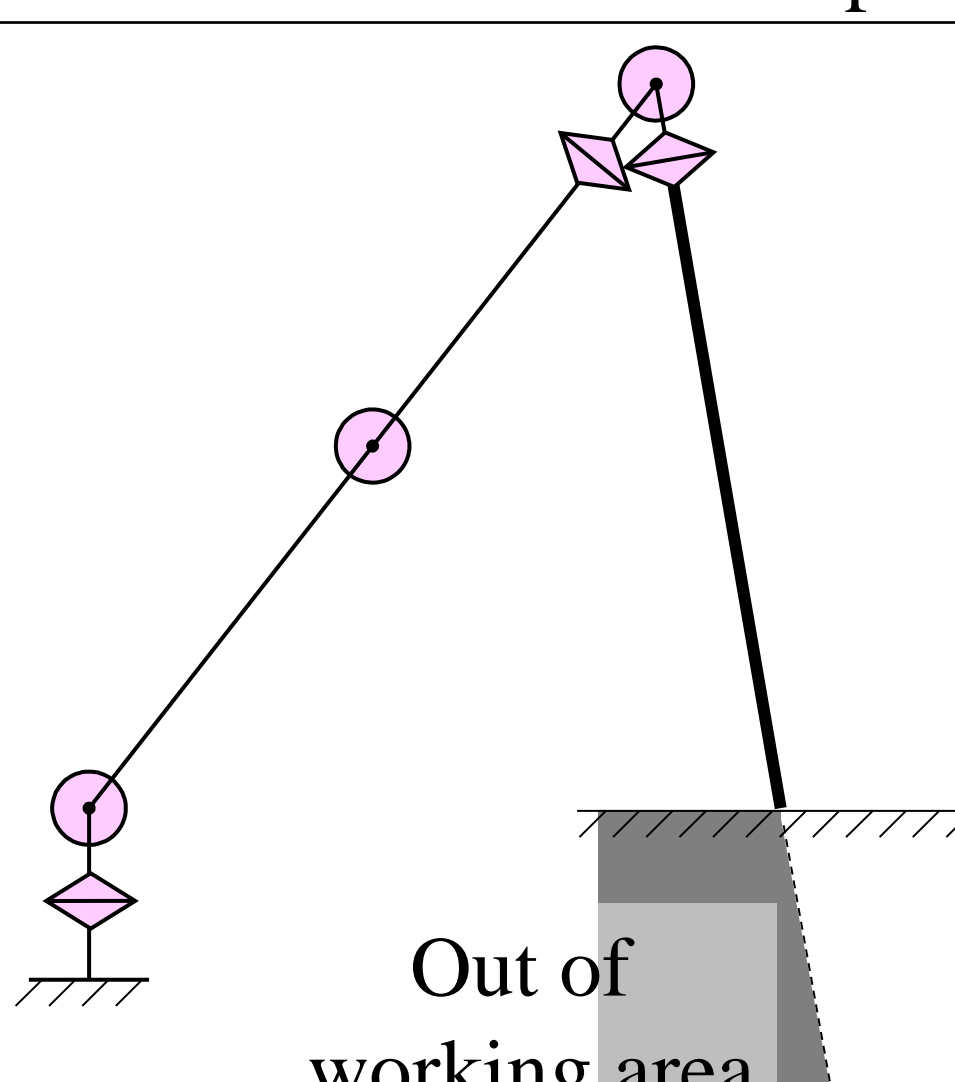
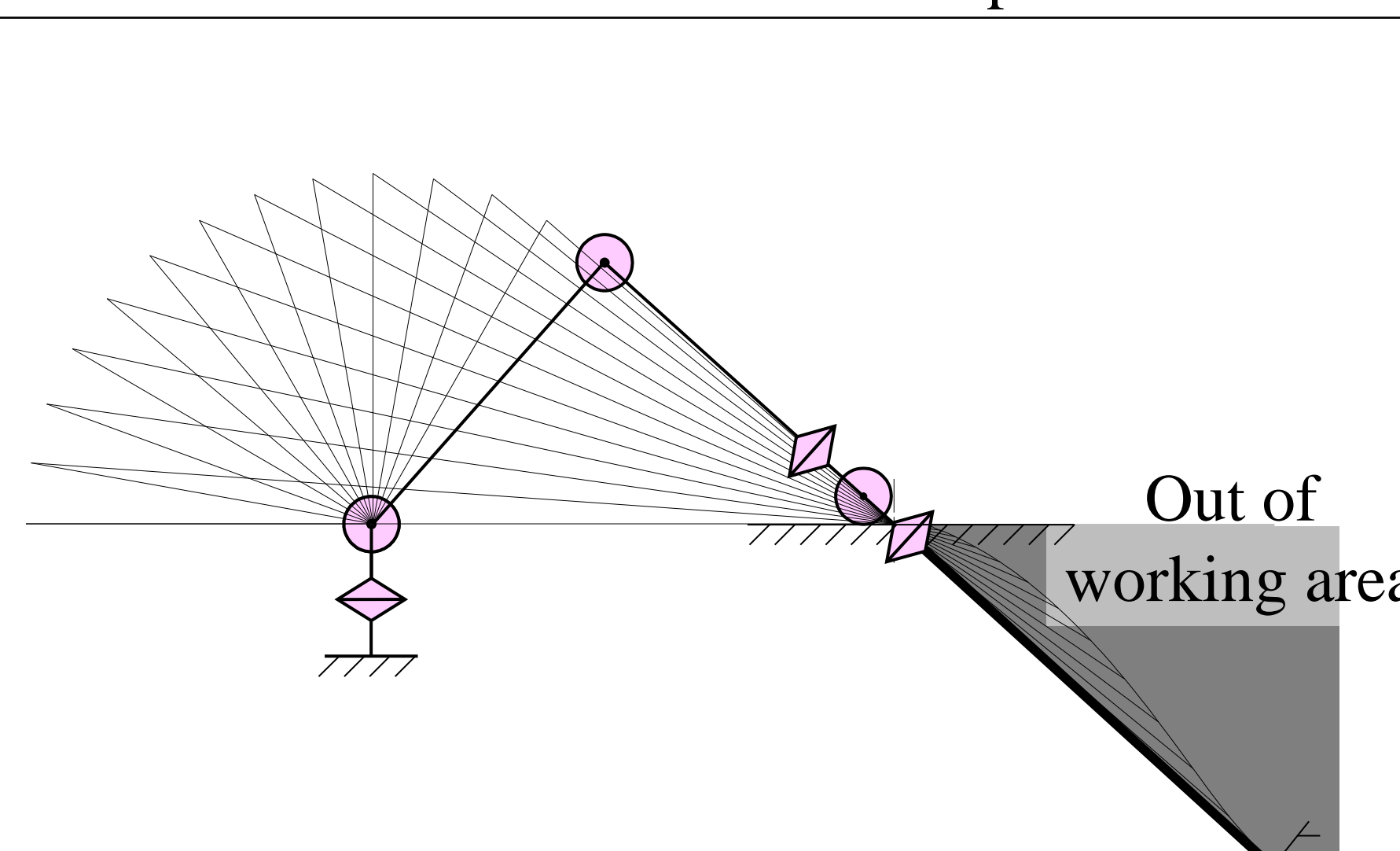


Component parts list of wrist mechanism

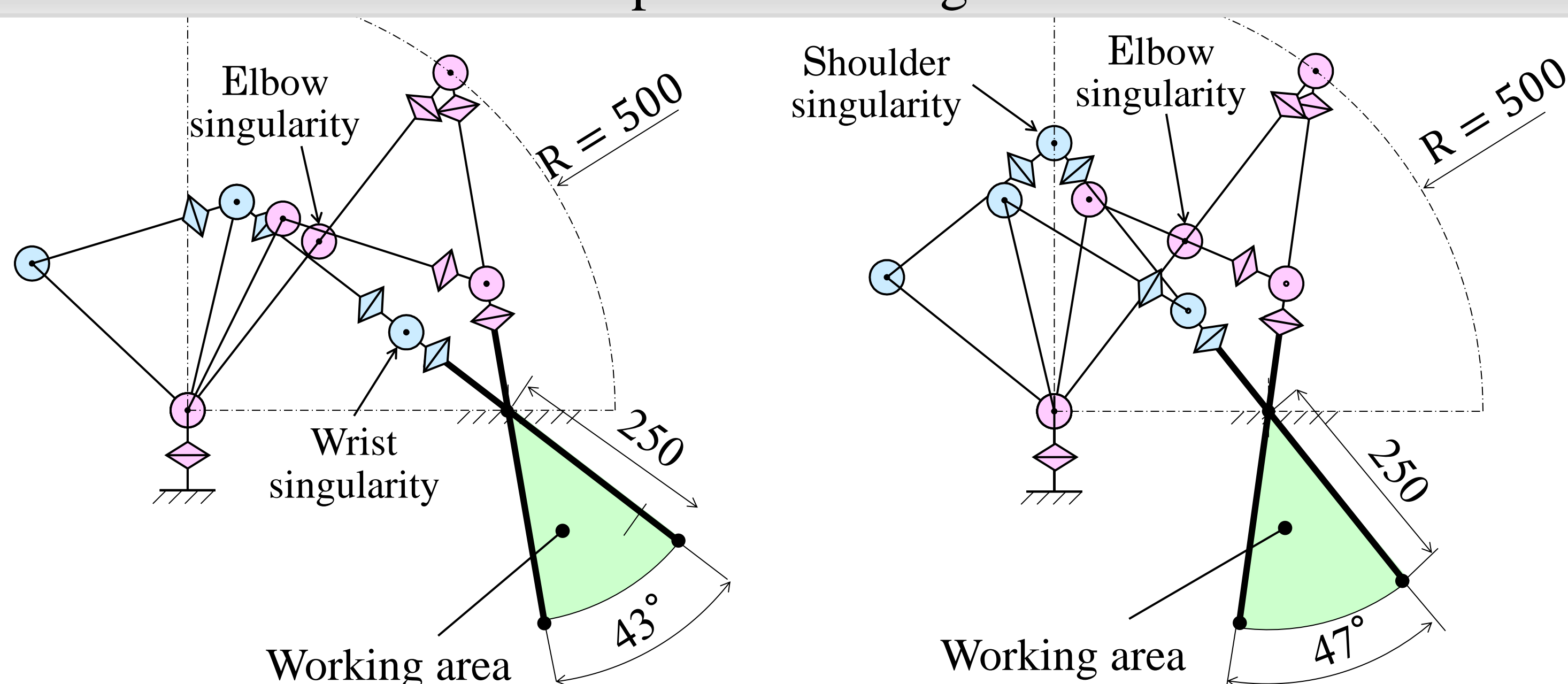
Part name		Quantity
Complex shape parts	Supporting part	1
	Pitch part	1
	Right finger part	1
	Left finger part	1
Simple shape parts	Supporting shaft	3
	Pulley (φ3 [mm])	8
	Stainless wire (φ0.45 [mm], 7 × 19)	3
Total		18

A robot to assist laparoscopic surgeries with optimized motion both inside and outside the abdominal cavity of a patient (JSPS KAKENHI Grant Number: 17K06271)

Relation of singularity type and working area

Singularity type	Shoulder singularity	Elbow singularity	Wrist singularity
Emergence time	Evulsion of forceps	Evulsion of forceps	Maximum insertion of forceps
Out of working area	Front side from insertion point	Rear side from insertion point	Front side from insertion point
Posture			

Example of working area



Future work toward the final robot system

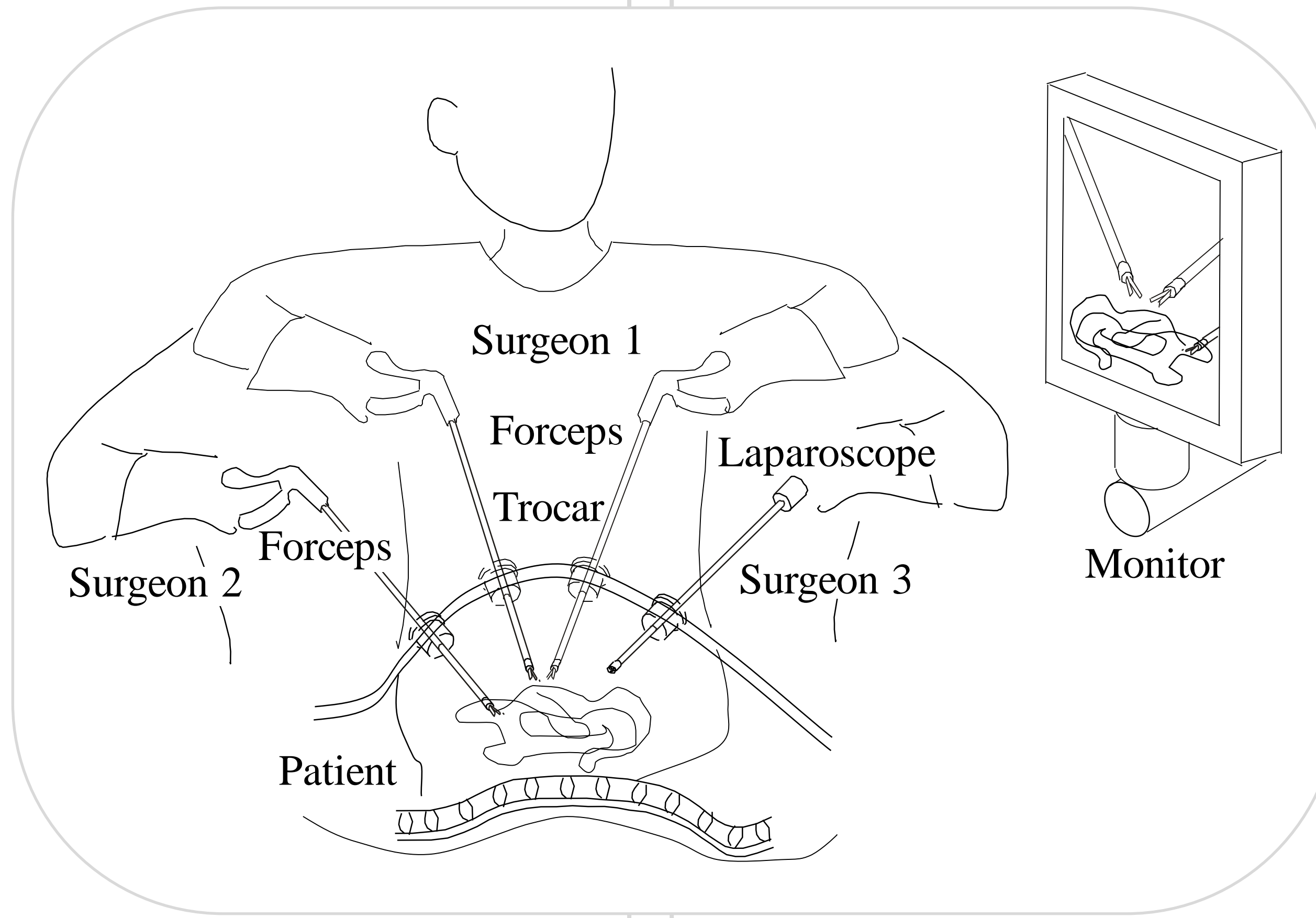
- (1) Implementation of the proposed wrist mechanism to slave manipulators while considering the clinical environment. A sealing mechanism for airtight structure, cleaning method of forceps, and attachment mechanism of forceps are very important.
- (2) Development of a master-slave manipulator for laparoscopic surgery using a vertical articulated robot.

Requirement from clinical site

Advantages of laparoscopic surgery

Improves quality of life (QOL)

- Ability to walk the day after surgery
- Early return to normal everyday activities
- Short hospital stay
- Small incision



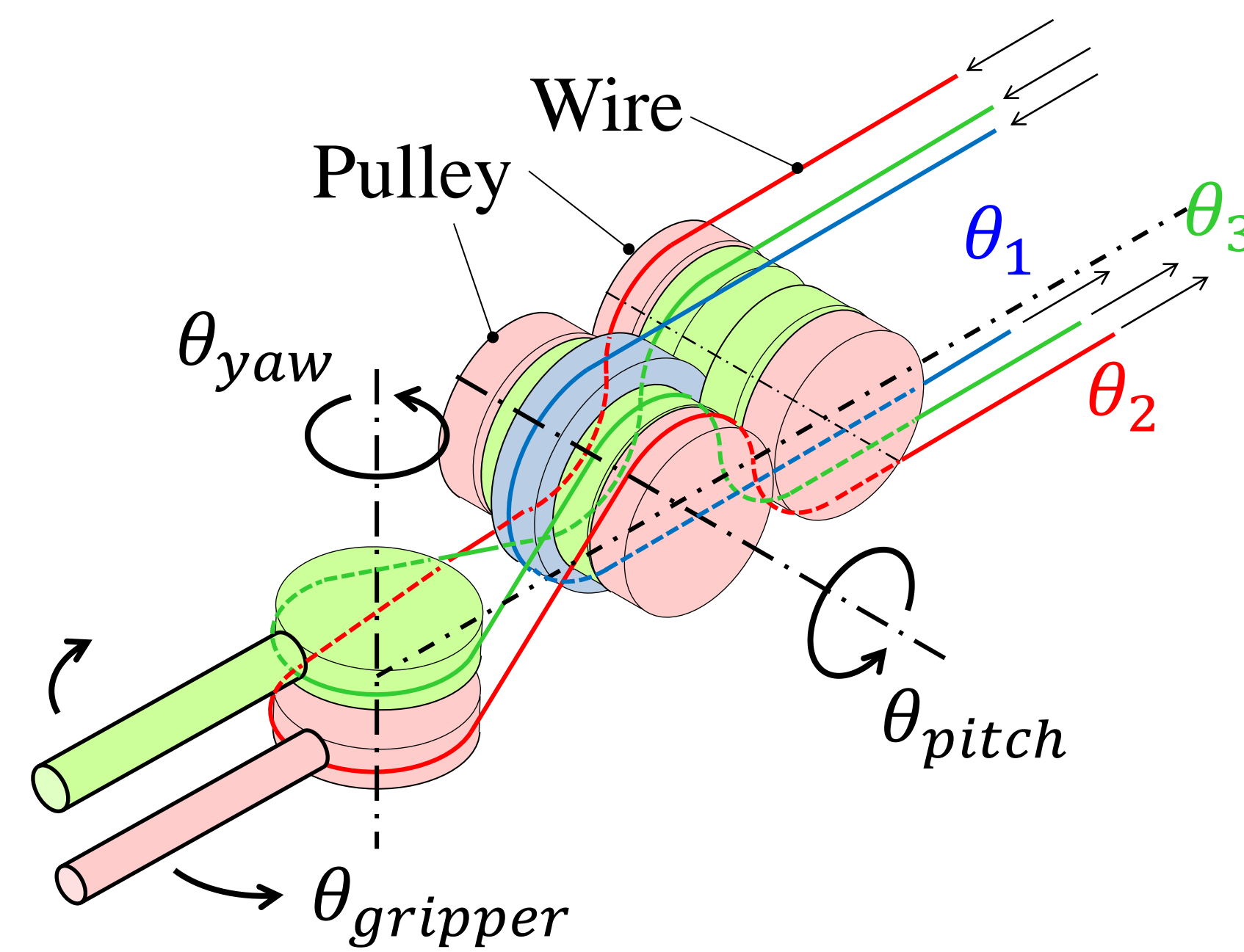
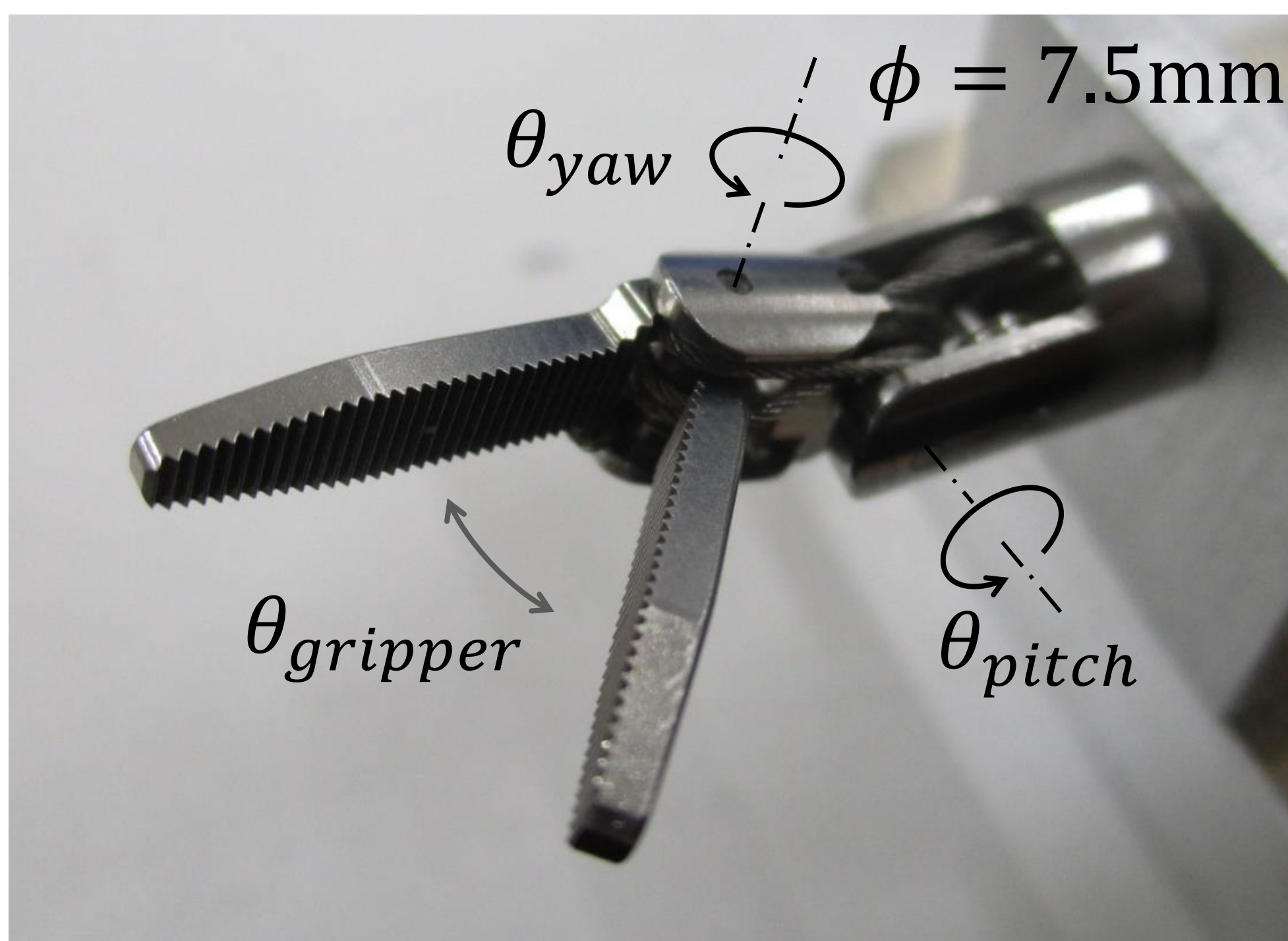
Challenges in laparoscopic surgery

Clinical site requirement

- Intuitive operability
- Reduce cost
- Reduce operation time
- Reduce hospital stay
- Improve clinical results

Expectation for development in new surgical instruments

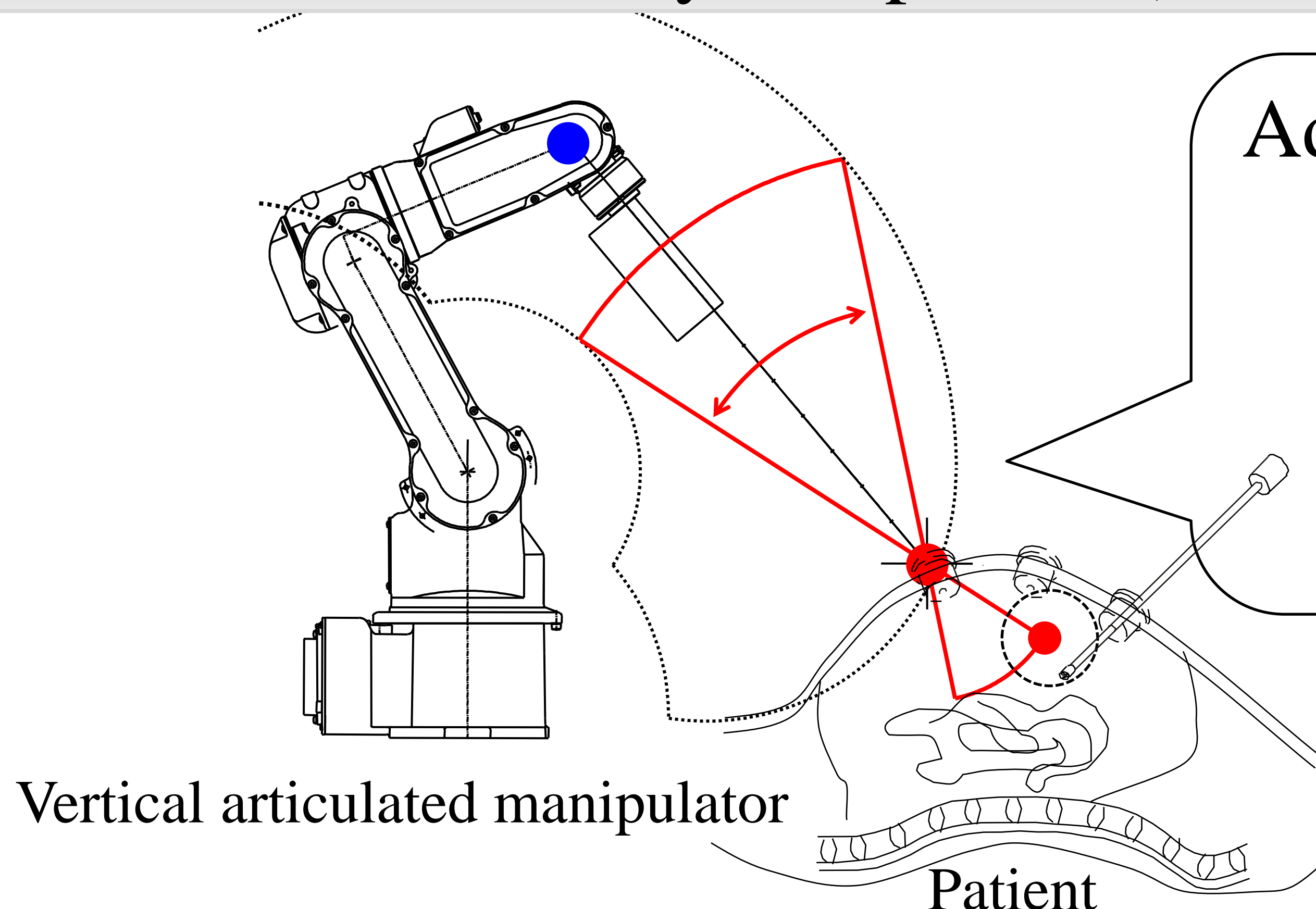
Novel wrist mechanism for articulated forceps for use in robot-assisted laparoscopic surgery



Features of the wrist mechanism

- (1) Small offset distance between the pitch and yaw axes
- (2) Avoids singularity configurations near the standard working posture
- (3) Few parts and simple mechanism

A robot to assist laparoscopic surgeries with optimized motion both inside and outside the abdominal cavity of a patient (JSPS KAKENHI Grant Number: 17K06271)



Advantages of vertical articulated manipulator

- (1) Any entry position in the working area
- (2) Wide working area outside the patient's abdominal cavity
- (3) Versatile and extensible system

Novel high-functioning wrist mechanism for articulated forceps