Development of Portable Smart Robot Bomb for Uneven Territory

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Contents

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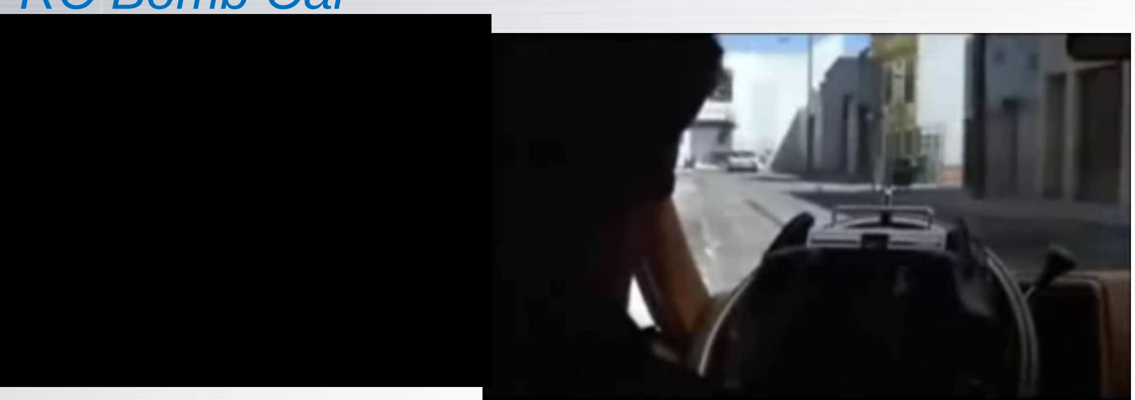
Introduction

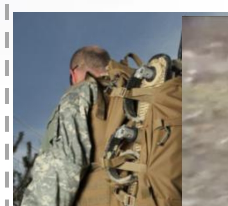
- **Remote controlled explosive device**
  - The radio-controlled car loaded with explosives
  - Wheel or caterpillar type
- **Reduced-DOF robots**
  - Legged transportation system for an uneven terrain
  - Inherently high mobility

  - Issues: *trajectory generation, mechanical design, link mechanism, high power (torque) capacity actuator, vision system, communication, durability, …*

RC Bomb Car



Reduced-DOF robot



Cheetaroid II: Concept Design

- **Cheetaroid-II :** a quadruped robot with one DOF actuation

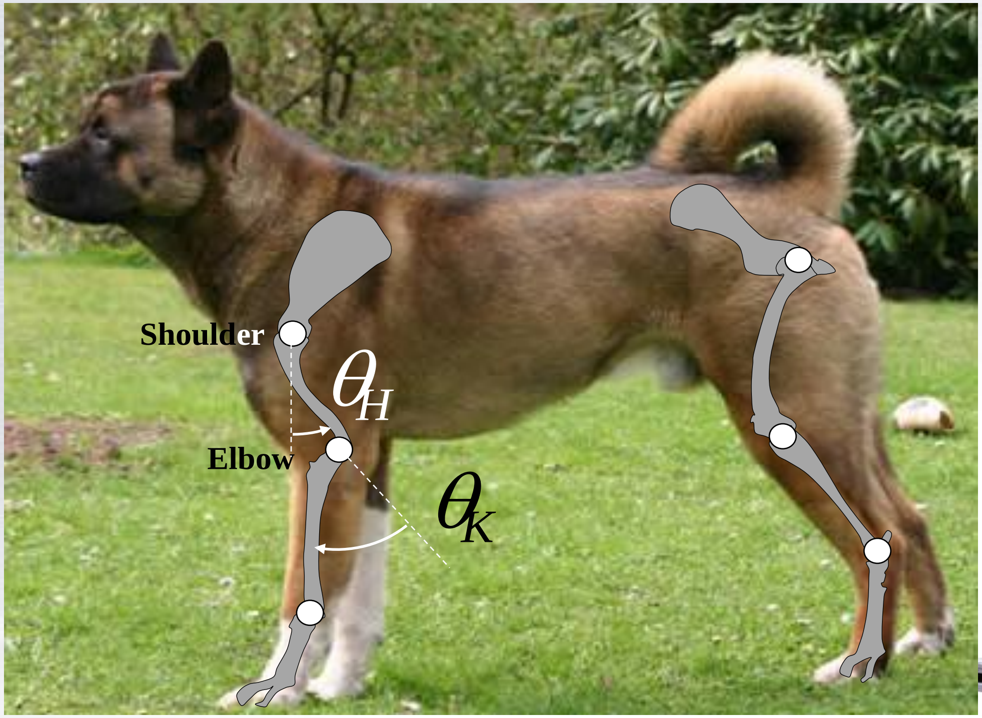
Mechanical drawing

Simulated motions

Desired Joint Angle Trajectory

❖ Experimental setting

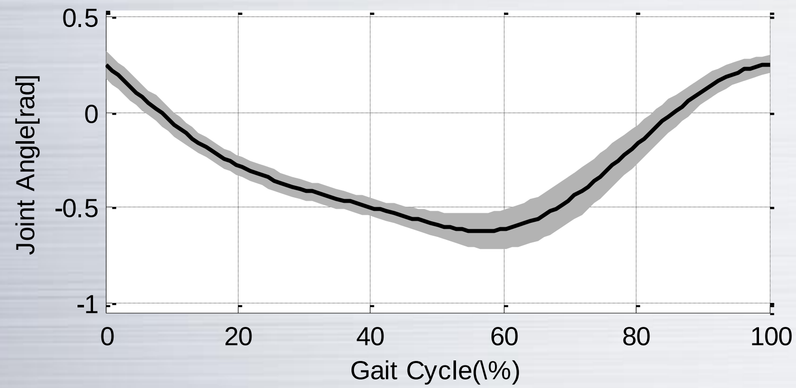
- In order to obtain the reference joint angles for the design of a link mechanism
- Obtained from the trotting motion of a dog
- A high-speed camera was utilized



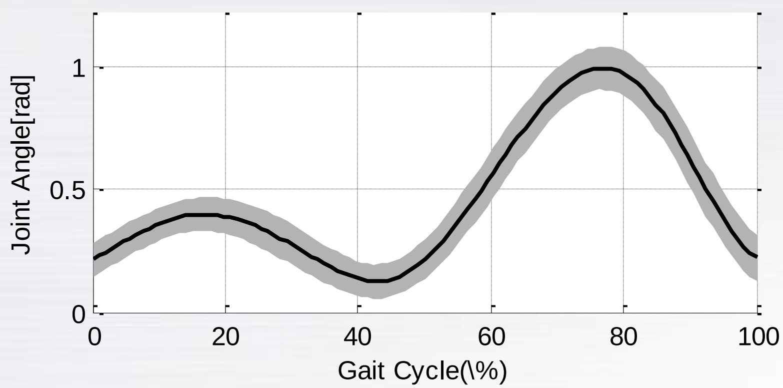
Desired Joint Angle Trajectory

❖ Desired Trajectories

- Shoulder joint



- Elbow joint



- The shoulder joint : as simple as an 1DOF pendulum system
- The elbow joint : major flexion occurs in the swing phase

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Parameter Optimization

❖ Design parameter optimization

- Cost function
  - $$J(\mathbf{X}) = \int_0^{2\pi} [\theta^*(\phi) - \theta(\phi+\alpha) - \beta]^2 d\phi + \lambda_H \left[\|T_y\|_\infty - \|T_y\|_{-\infty} \right]^{-1}$$
    - **X** : design variable
    - $\theta^*(\phi)$: Reference angle trajectory
    - α, β : Dummy variable
    - λ_H : Weighting factor
    - T_y : Height of the tiptoe

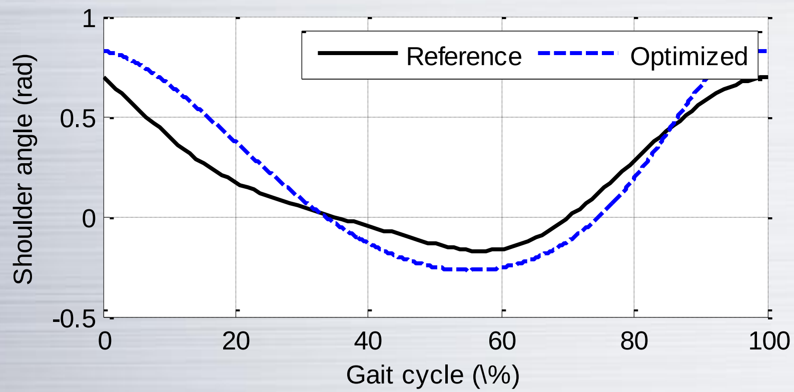
- Optimized design parameters

Variable	Value	Variable	Value
l_{HA}	0.065 m	l_{AC}	0.085 m
l_{HK}	0.1 m	l_{BC}	0.097 m
l_{KB}	0.027 m	l_R	0.030 m
D_x	0.067 m	D_y	-0.039 m

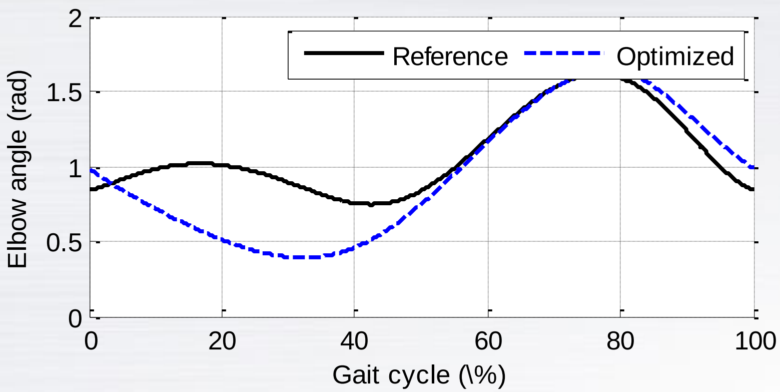
Simulated Motions(1/3)

❖ Optimized joint angle trajectories

- Shoulder joint



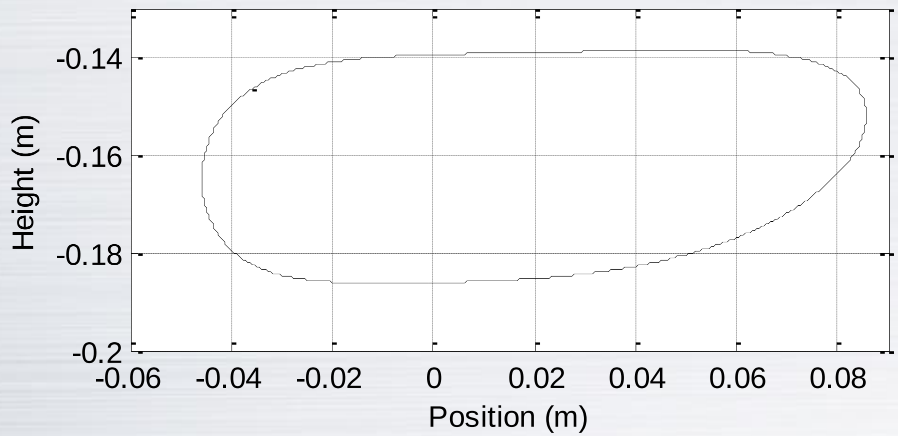
- Elbow joint



- The shoulder joint : similar to the reference motion
- The elbow joint : a large discrepancy caused by
  - Maximization of the clearance of the tiptoe
  - Engineering constraints for the torque arm length, and so on

Simulated Motions(2/3)

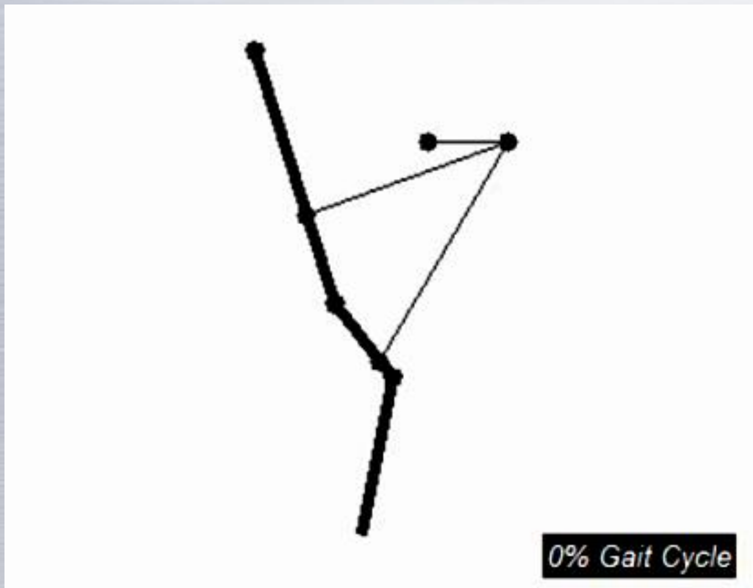
❖ Clearance of tiptoe

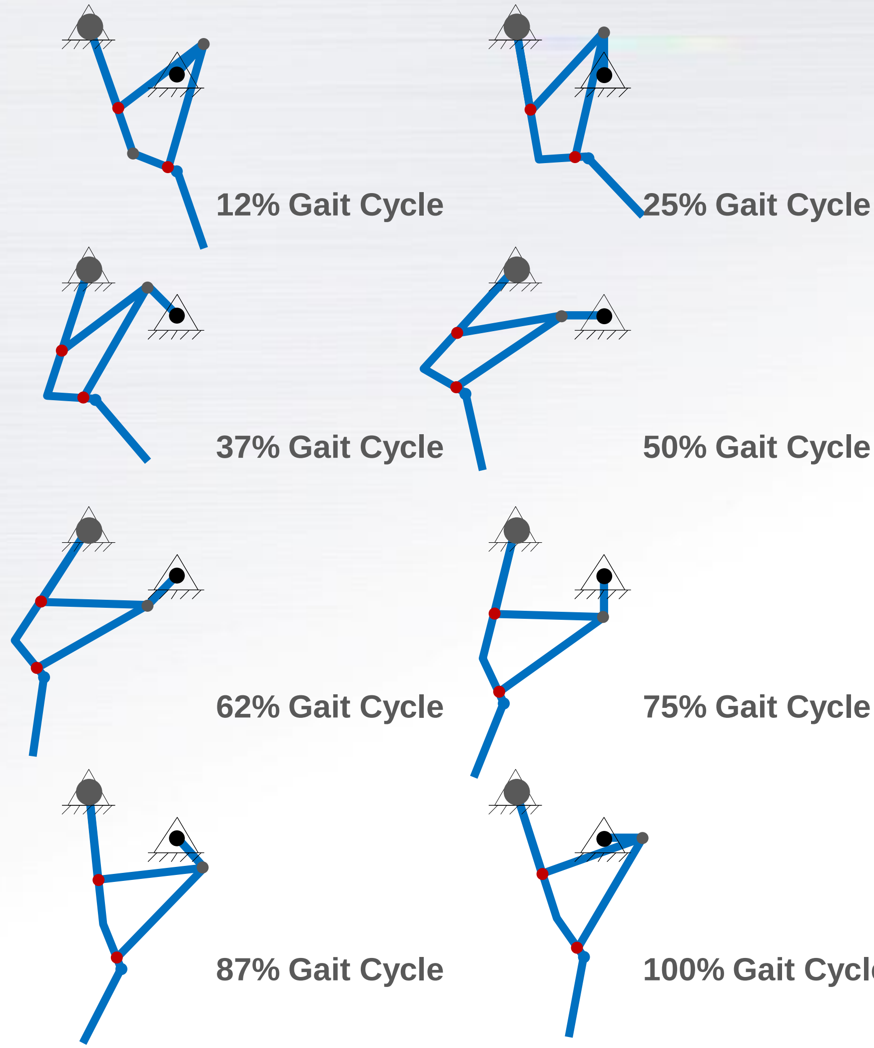


- The tiptoe follows an elliptical shape
- The clearance is about 0.048 [m] (26% of the total length of a leg)
- Large clearance of the tiptoe is important for gait stability

Simulated Motions(3/3)

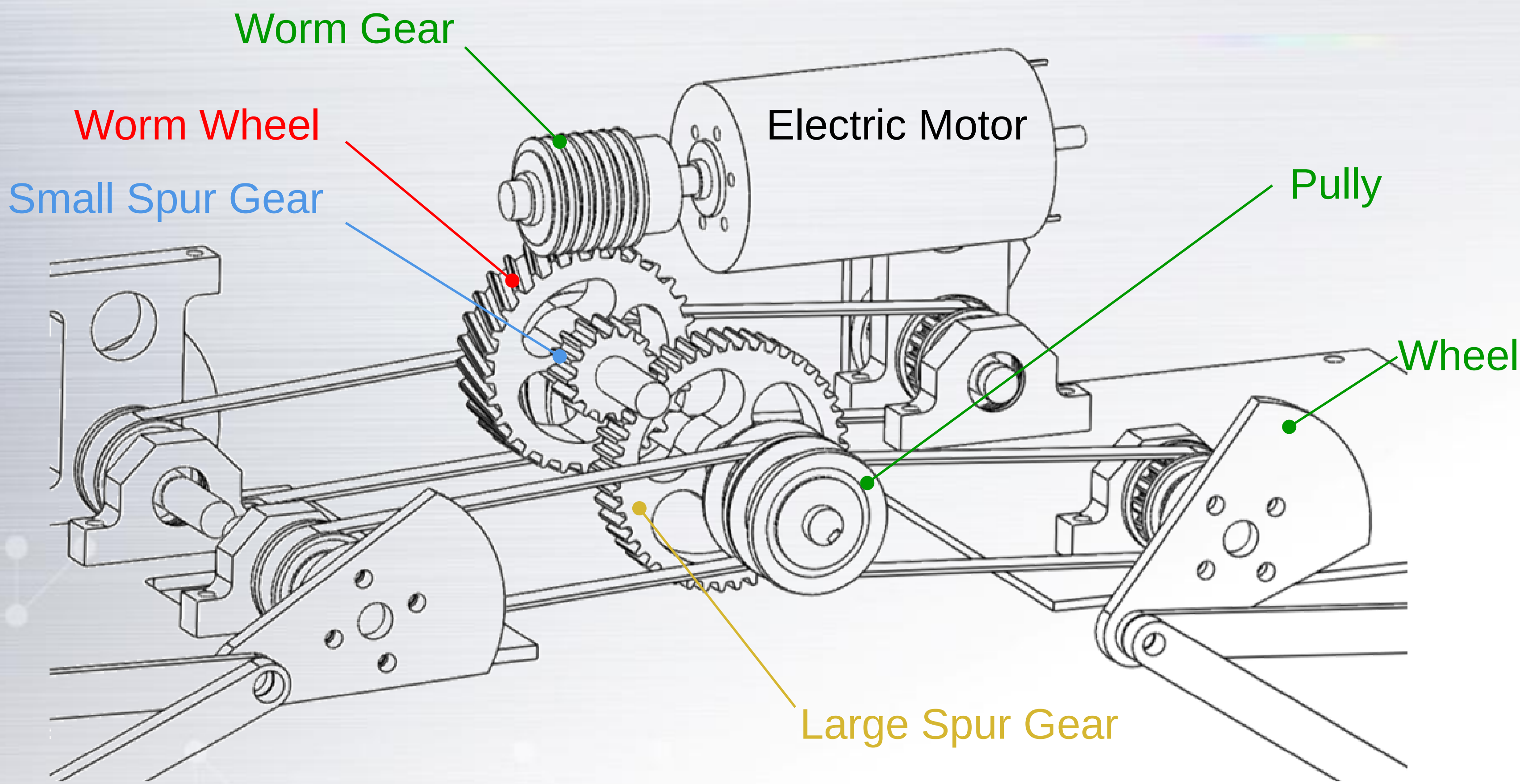
❖ Generated gait motion by link system





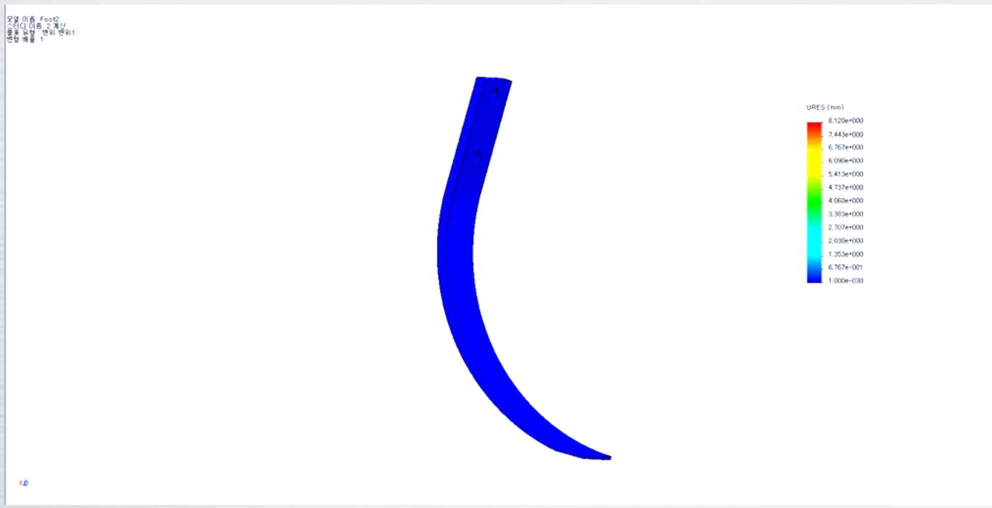
Mechanical Design(1/2)

❖ Power transmission system



Mechanical Design(2/2)

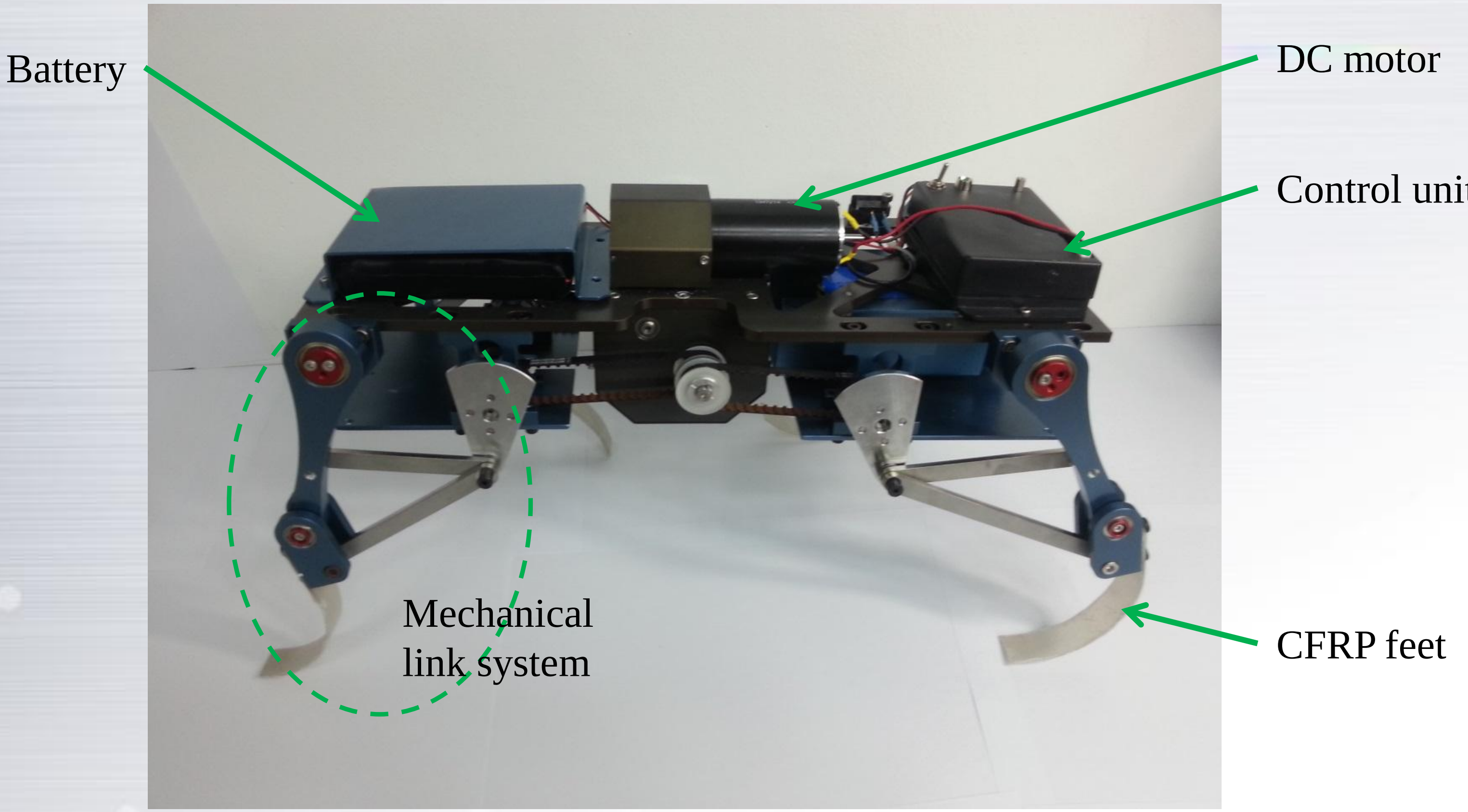
❖ Compliant foot



- To reduce the impulsive ground reaction force
- Designed to have J-shaped curvature
- Made of CFRP(Carbon Fiber Reinforced Plastic)

Cheetaroid II: Overall Design

❖ **Cheetaroid-II :** a quadruped robot with one DOF actuation



- Size : 500(W) x 200(D) x 300(H)
- Weight : 5kg

Experiments(1/2)

❖ On a treadmill

- Speed : 1 m/s

Experiments(2/2)

- Outdoor environment

Conclusions

- A quadruped robot actuated by only one actuator was proposed for Portable Smart Robot Bomb
- A mechanical link system was designed
- Design parameters were selected and optimized that considering the leg motion of a dog
- The robot successfully realized the desired gait motion
- Cheetaroid-II is a simple, cheap, and light robot system that is able to move fast

THANK YOU

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