Chiba University

Outline

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Background

Assistance during hazardous operations

- Disaster-relief work
- Construction
- Mine detection and clearance etc.

The Expectation of robots is increasing!

http://www.yomiuri.co.jp/feature/20080614-2892868/news/20080616-OYT1T00506.htm

http://headlines.yahoo.co.jp/hl

Background

Sites of hazardous operations

- Disaster site
- Construction site
- Mine field

} **Rough terrain**

Utility of multi-legged robot

- Multi-legged robots have high ***stability*** and ***mobility*** in rough terrain.
- Multi-legged robots can enter areas where it is difficult for wheeled robots and crawler type robots to enter.

Development of COMET-IV

COMET-I

COMET-II

COMET-III

COMET-IV

Development goal

1. <u>Fully autonomous locomotion on outdoor rough terrain</u>
2. Assistance during various hazardous operations

Development Tasks

◆ **Autonomous Navigation System**

◆ **Teleoperation Assistant System**

◆ **Control System**

- Gait Planning
- Foot Trajectory Tracking
- Force Control
- Attitude Control

Design specification in locomotion

1. Walking speed: max 1 km/h
2. Vertical step: max 1 m
3. Gradient: max 20 deg
4. Omni-directional walking

Previous work (1)

The position/force and attitude control system have been proposed and implemented their algorithm to the COMET-IV [1]. Figure1 shows the pictures of 60 cm step test.

(a) (b) (c)

Figure 1. Overview of 60 cm step test

[1] M. Oku, K. Nonami, Force Control of Hydraulically Actuated Hexapod Robot, Master Thesis, Chiba University, 2008.

Previous work (2)

The way point walking test have succeeded [2].
A position controller with SAC (Simplify Adaptive Control) have designed by Harada.

(a)

(b)

Figure 2. Overview of way point navigation

[2] Y. Harada, K. Nonami, Rough Terrain Walking of Hydraulically Actuated Hexapod Robot with Impedance Control, Master Thesis, Chiba University, 2009.

Previous work (3)

The omni-directional gait have designed and implemented to the COMET-IV. Moreover, the obstacle avoidance walking test using a laser range finder (LRF) have succeeded [3].

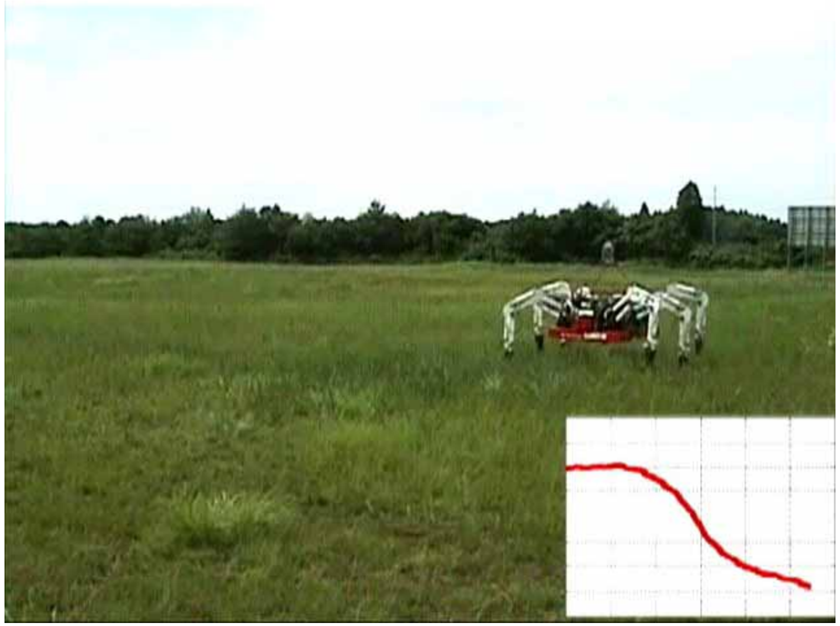

Figure 3. Photo of the lane change walking test

Figure 4. Photo of the obstacle avoidance navigation test

[3] K. Futagami, K. Nonami, Autonomous Obstacle Avoidance of Hydraulically Actuated Hexapod Robot, Master Thesis, Chiba University, 2009.

Previous work (5)

The tele-operation assistant system of COMET-IV have been developed and implemented. Moreover, the obstacle avoidance walking test by tele-operation have succeeded [4].

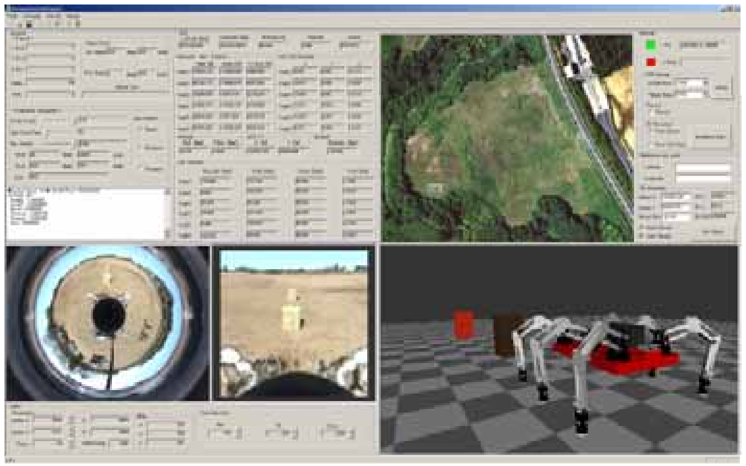

Figure 5. Display image of tele-operation assistant system

Figure 6. Photo of the obstacle avoidance test by tele-operation

[4] H. Ohroku, K. Nonami, Omni-directional Vision and 3D Animation Based Teleoperation of Hydraulically Actuated Hexapod Robot COMET-IV, ICGST-ARAS journal, 09(1), 2009

Motivation

The verification of the walking algorithm by a large-scale robot such COMET-IV is attended with danger and too risky!!

It is important to confirm the walking algorithm in the simulation before experiment.

Simulator System Configuration

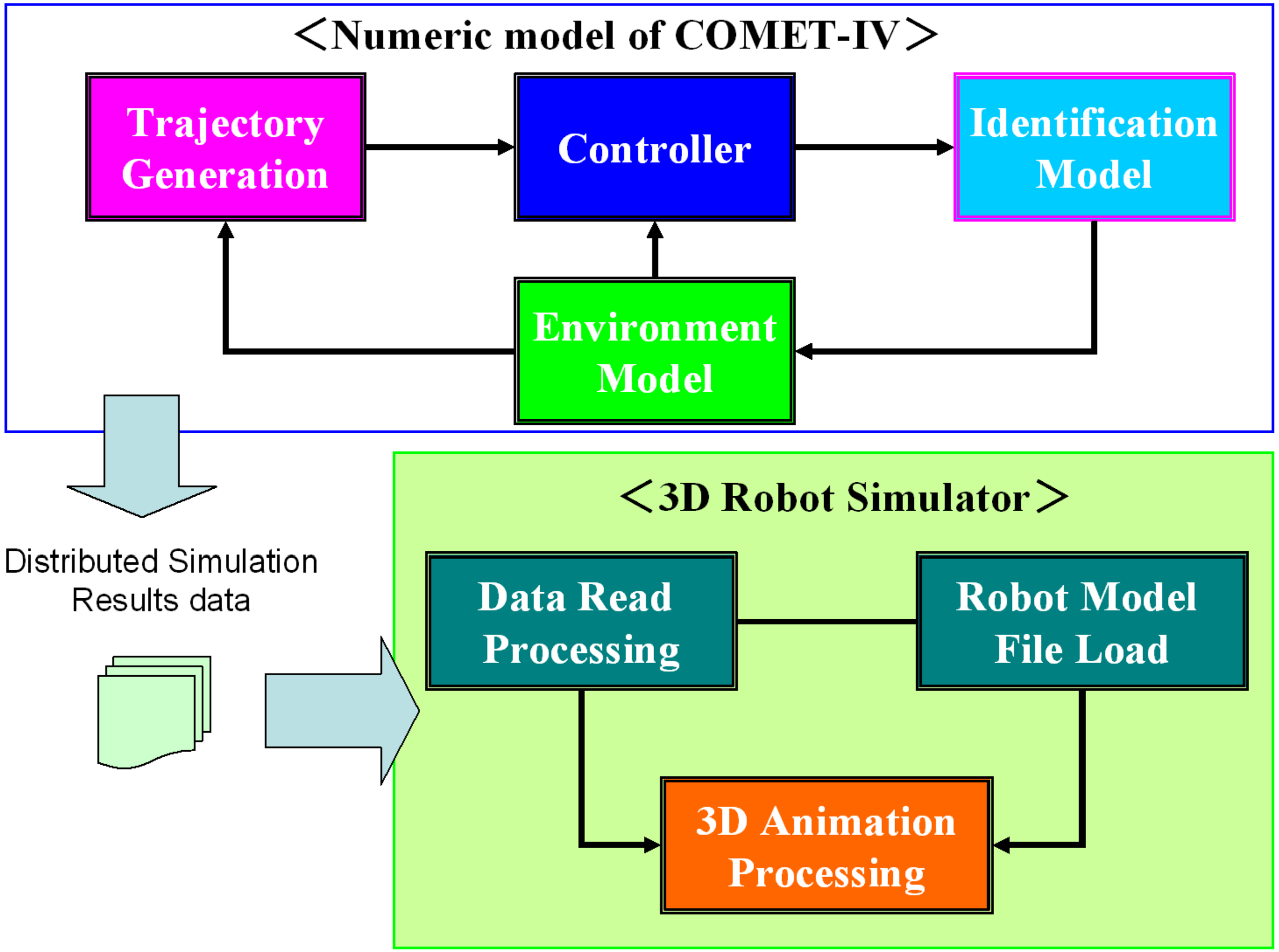

Figure 7. COMET-IV Simulator System Configuration

COMET-IV Controller Hierarchy

The impedance controller is applied to this system.

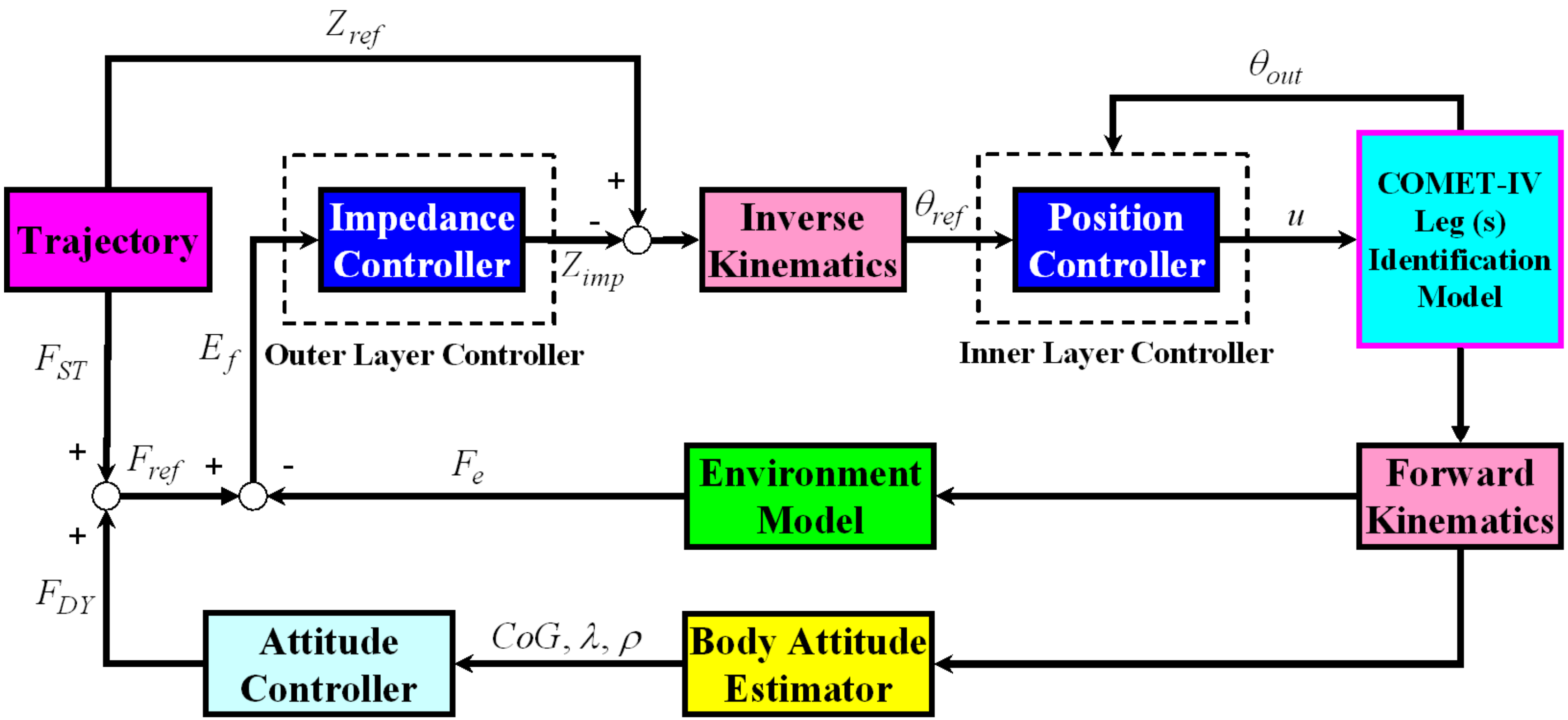

Figure 8. COMET-IV Controller Hierarchy

Data Flow

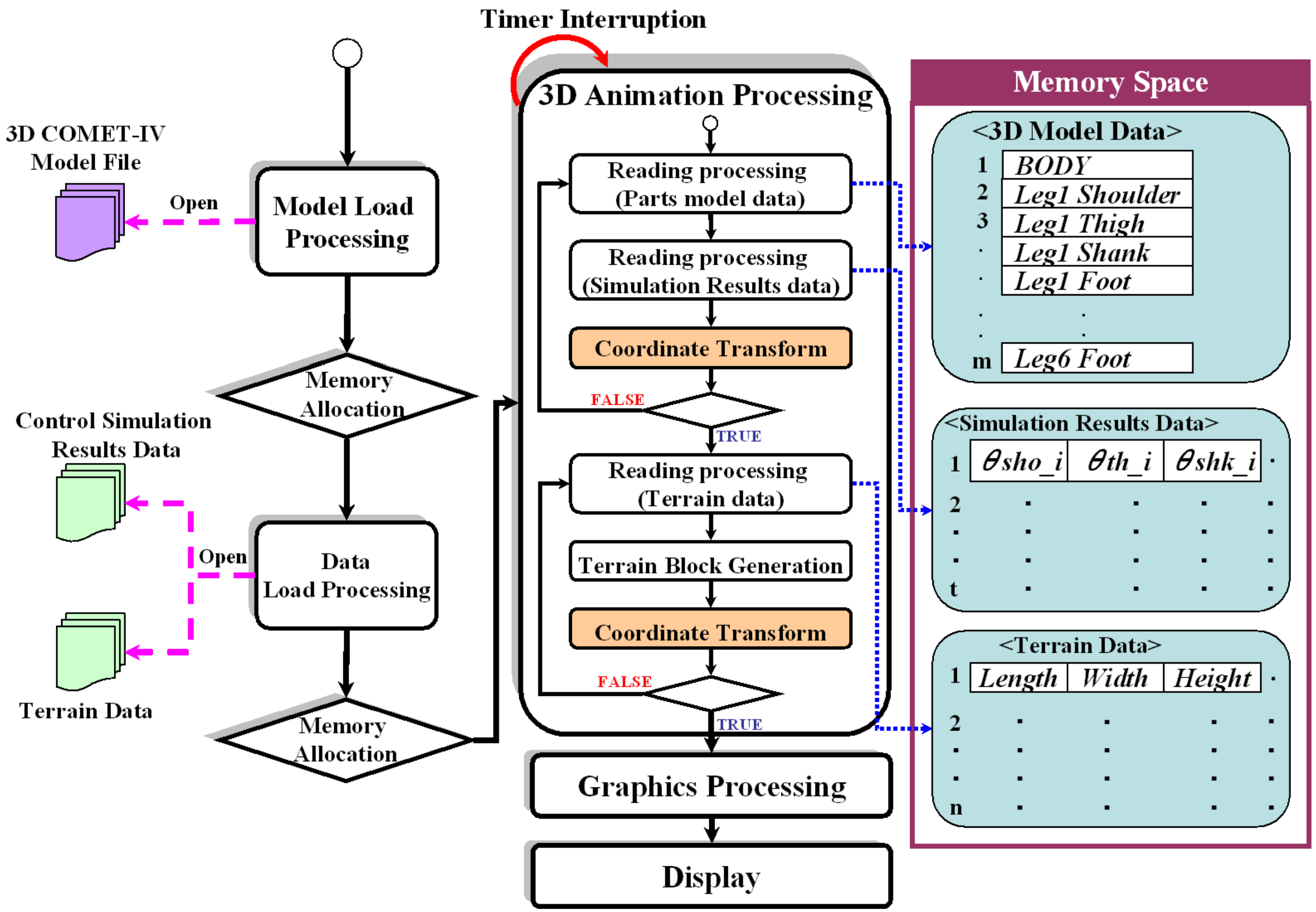

Figure 9. The detail flow of data processing in 3D robot simulator

3D Robot Simulator

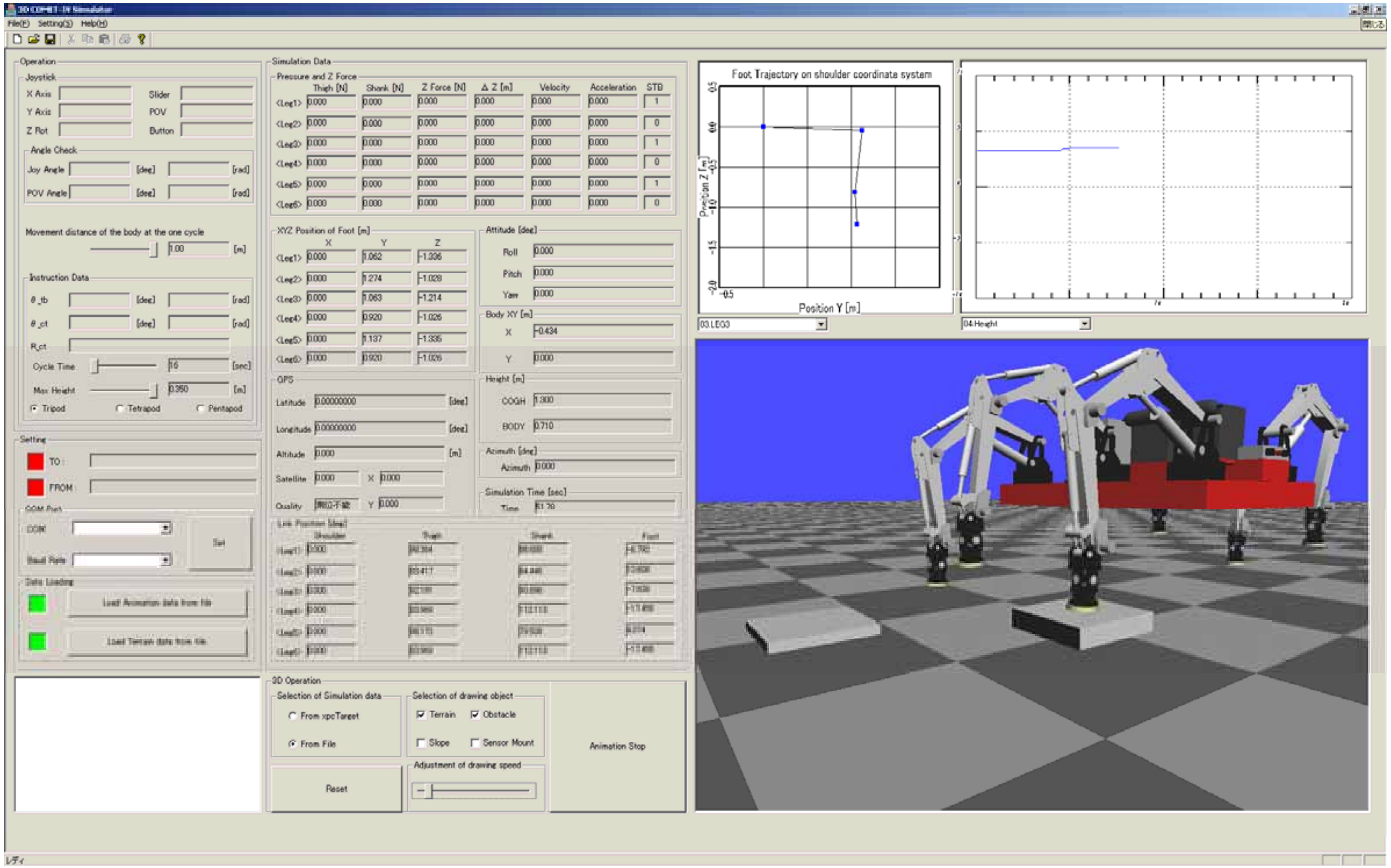

Figure 10. Display image of 3D robot simulation running

Modelling Verification

In order to verify the designed COMET-IV simulator, a simple experiment has Been done to match with the simulation results from numerical model and 3D Geometric model visualization.

Two blocks (Step1 : 6cm, Step2 : 12 cm) with different height arranged in the Environment in virtual environment as shown in Figure11.

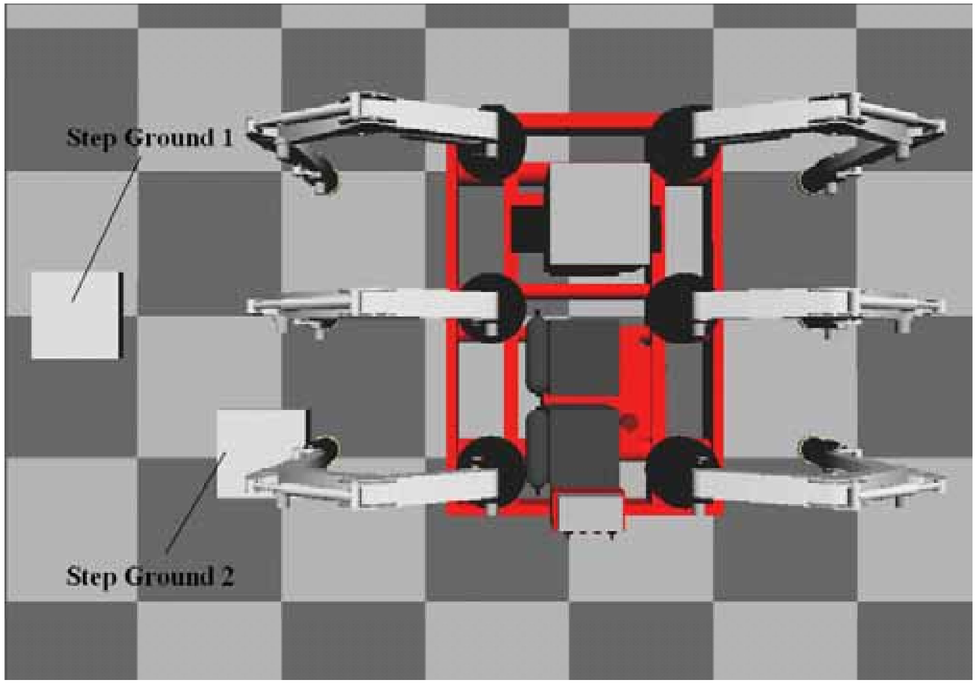

Figure 11. Terrain environment image in simulation

Modelling Verification

Each leg trajectory on world coordinate system (numerical model simulation results) and walking animation images in 3D robot simulator are shown in Figure12 and Figure13 respectively.

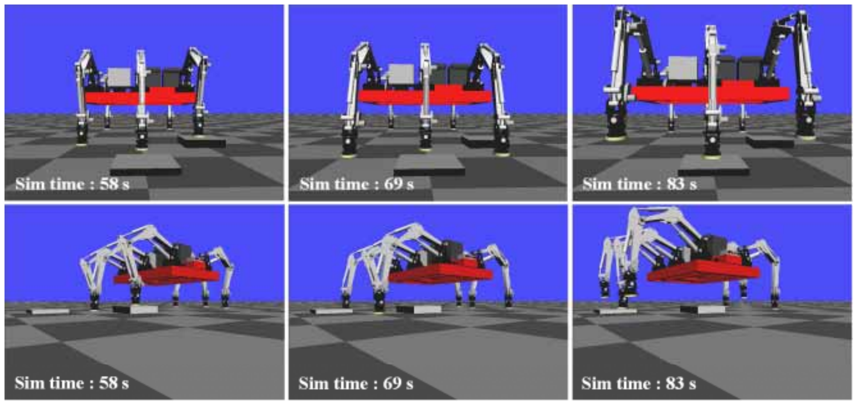

Figure 12. Walking animation images
in 3D robot simulation

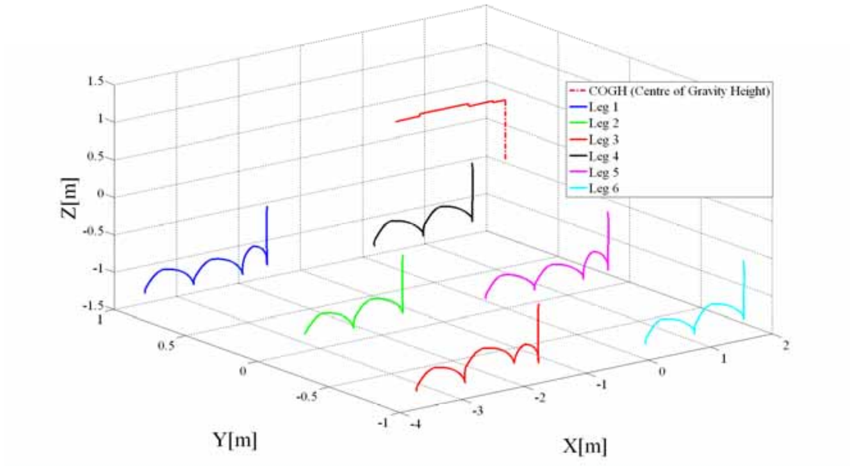

Figure 13. Each leg trajectory
on world coordinate system (Sim)

Modelling Verification

The same situation is set in the real experiment.
The movement and posture of COMET are nearly same as simulated in 3D geometric model. However, friction and slipping problem in experiment running were ignored. Moreover, currently a part of leg of the real robot has bending and the distortion.

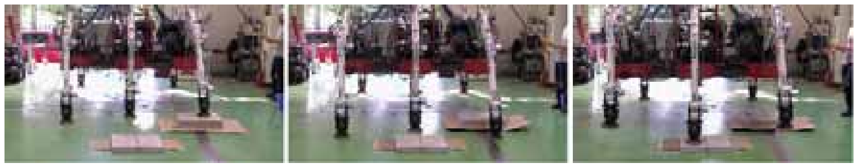

Figure 14. Overview of step walking experiment

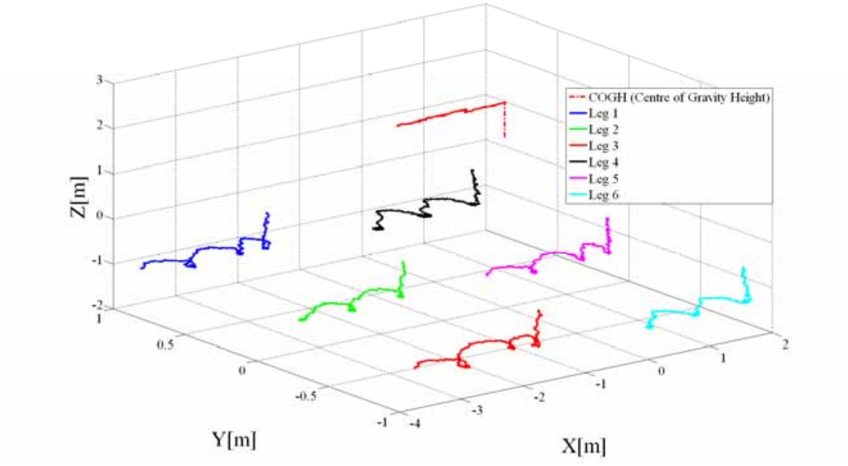

Figure 15. Each leg trajectory on world coordinate system (Exp)

Conclusion

- 3D Robot Simulator is developed.
  - -Simple system composition
  - -System of numeric model separation type

- Simple walking experiment has been done to verify this simulator and the results are nearly same as simulated.

Future work

- Control system design for stability walking
  - Force and Position Controller
  - Attitude Controller
- Accuracy improvement of self-localization estimation
- Design of environment recognition algorithm for autonomous walking
- Design of each leg identification model for control simulation
- Construction of walking simulation that uses the real environment positional data (e.g. acquired from the laser range finder)