

Robot Design

Introduction

Design, are concerned with the design and modeling of the actual physical realizations of a robot. Some of the more obvious mechanical structures that come to mind are arms, legs and hands.

To this list we can add wheeled vehicles and platforms; snake-like and continuum robots; robots capable of swimming and flying; and robot structures at the micro- and nanoscales.

Even for that most basic robotic device, the arm, an incredibly diverse set of structures is possible, depending on the number and types of joints and actuators, and the presence of kinematic structure, or flexibility in the joints and links.

Constructing models, and planning and control algorithms for these diverse structures represents an even greater set of challenges.

General Robot Design Process

- **Step 1:** Determine the **topology of the kinematic chain** underlying the mechanical structure. Under this item we consider first the robot type: serial, parallel or hybrid.
- **Step 2:** Determine the **geometric dimensions** of the various links defining the robotic architecture, as required to fill a table of Denavit–Hartenberg (DH) parameters.
- **Step 3:** Determine the **structural dimensioning** of the various links and joints, as needed to meet **static load requirements**, where load includes both forces and moments – wrenches – under either the most demanding or the most likely operation conditions, depending on the design philosophy adopted at the outset.

General Robot Design Process

- **Step 4:** Determine the **structural dimensioning** of the various links and joints, as needed to meet **dynamic load requirements** where loads are inertia effects of links and manipulated object.
- **Step 5:** Determine the **elastodynamic dimensioning** of the overall mechanical structure. [Elastodynamic = The study of waves in an elastic material]
- **Step 6:** Select the actuators and their mechanical transmissions for the operation conditions adopted at the outset to cope with task uncertainty.

Robot Design Process: Limbed Systems

We refer a limbed system as a mobile robot which consists of a body, legs and arms.

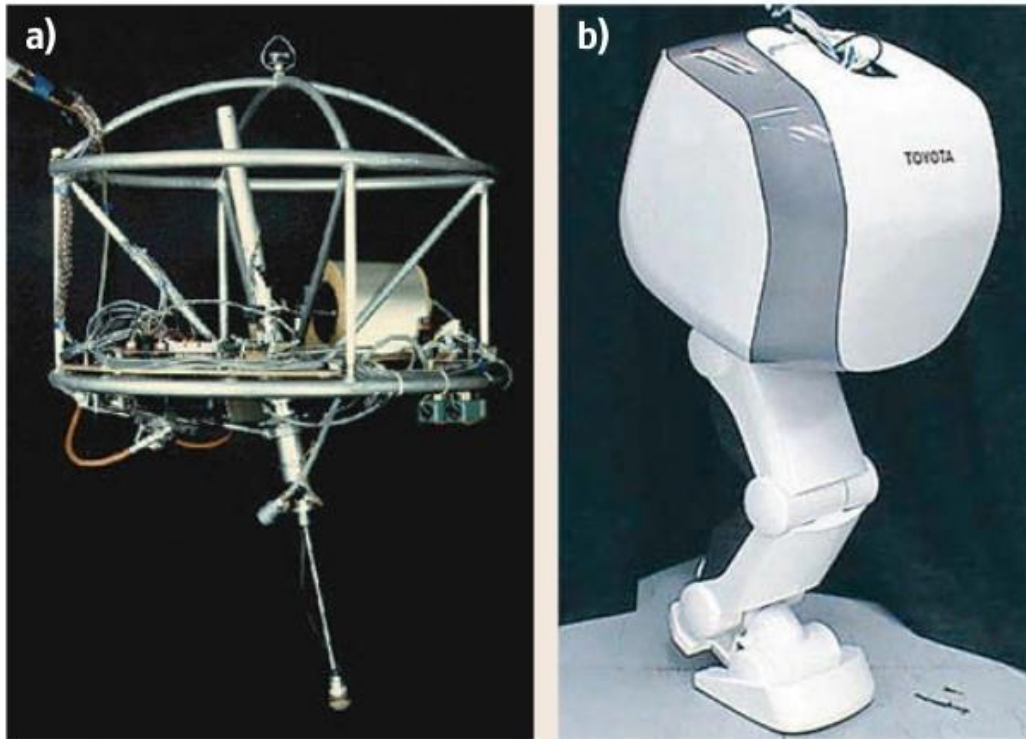


Fig.17.3a,b Monopod robot designs. (a) MIT 3-D One-Leg Hopper (1983); (b) Toyota monopod (2006)

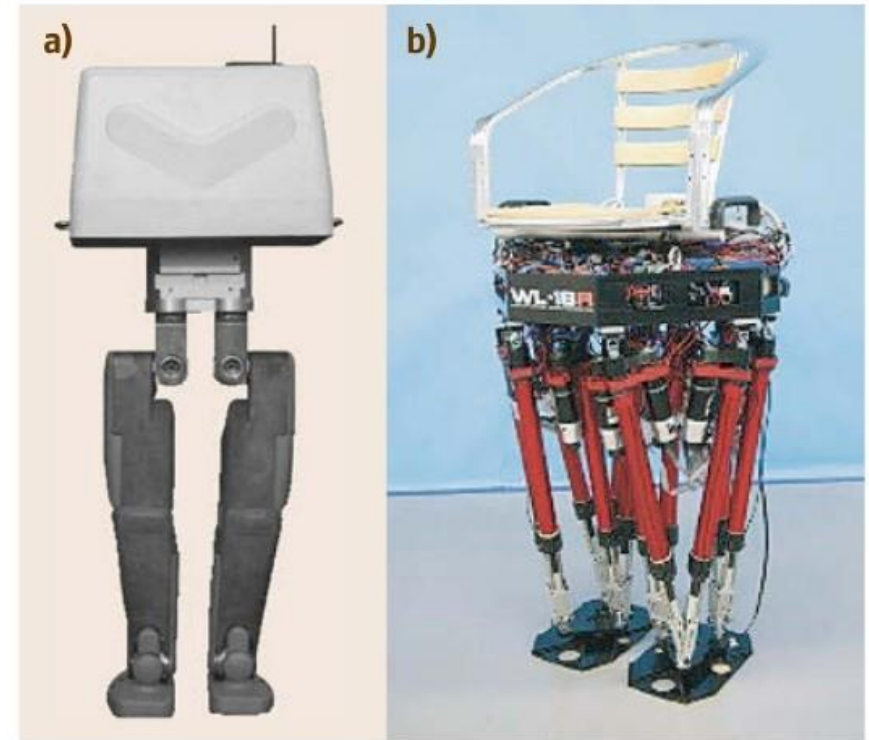


Fig.17.4a,b Biped robot designs. (a) HRP-2L (2001); (b) WL-16R (2003)

Robot Design Process: Limbed Systems

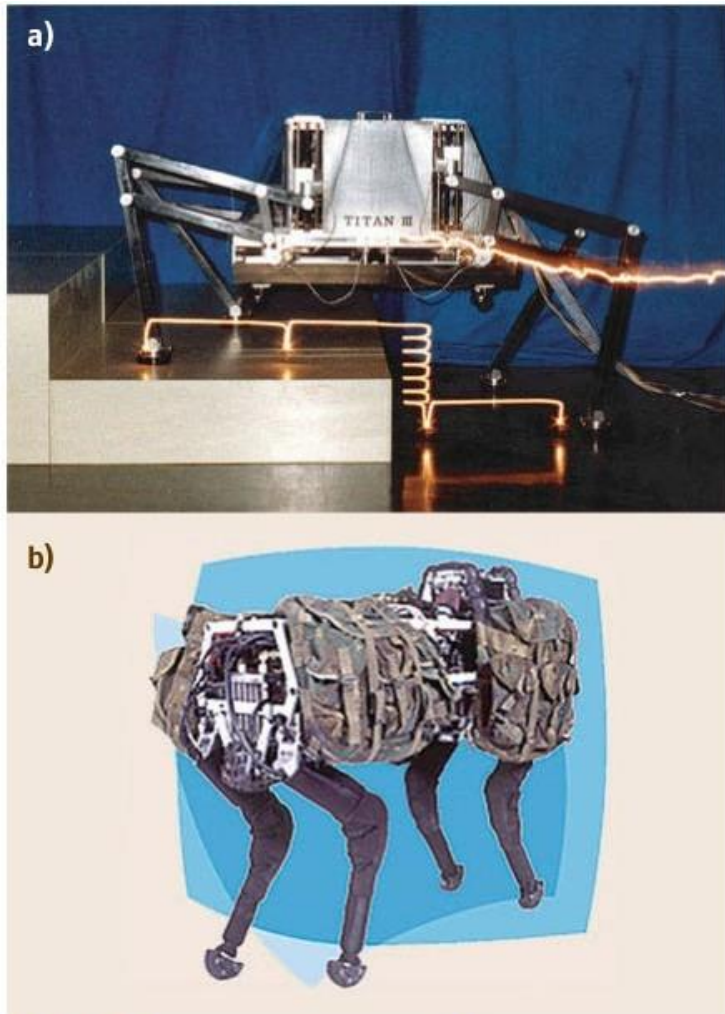


Fig.17.5a,b Quadruped designs. (a) TITAN III (1984); (b) BigDog (2005)

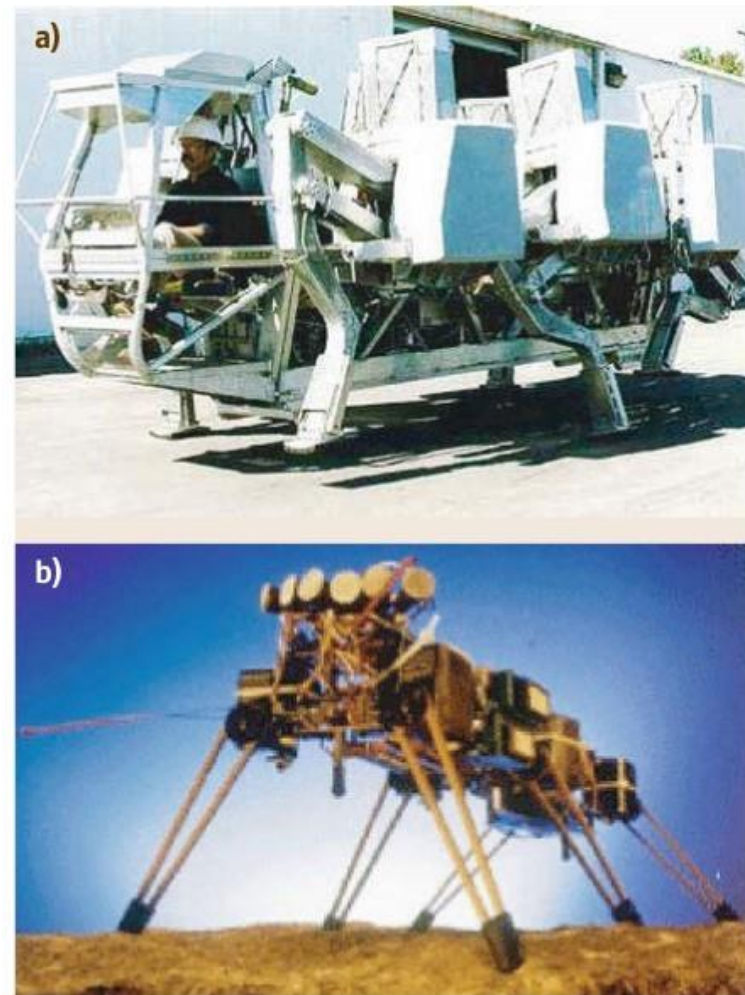


Fig.17.6a,b Hexapod designs. (a) ASV (1986); (b) Genghis (1989)

Design of Limbed Systems

General robot design process has already been discussed. A design process of actual limbed system's typical development process may takes the following steps:

Step 1: Basic requirements. A designer must specify the class of tasks performed by the limbed system and its requirements, target velocity, payload, expected environment, etc.

Step 2: Conceptual design. The number of legs and arms, their topology, and associated gait are decided simultaneously.

Step 3: Detailed design. A designer selects actuators, sensors, reduction gears, and other mechanical/electrical components to realize the conceptual design.

Design of Limbed Systems

Step 4: Evaluation. Evaluate the design by building a prototype model or performing computer simulations.

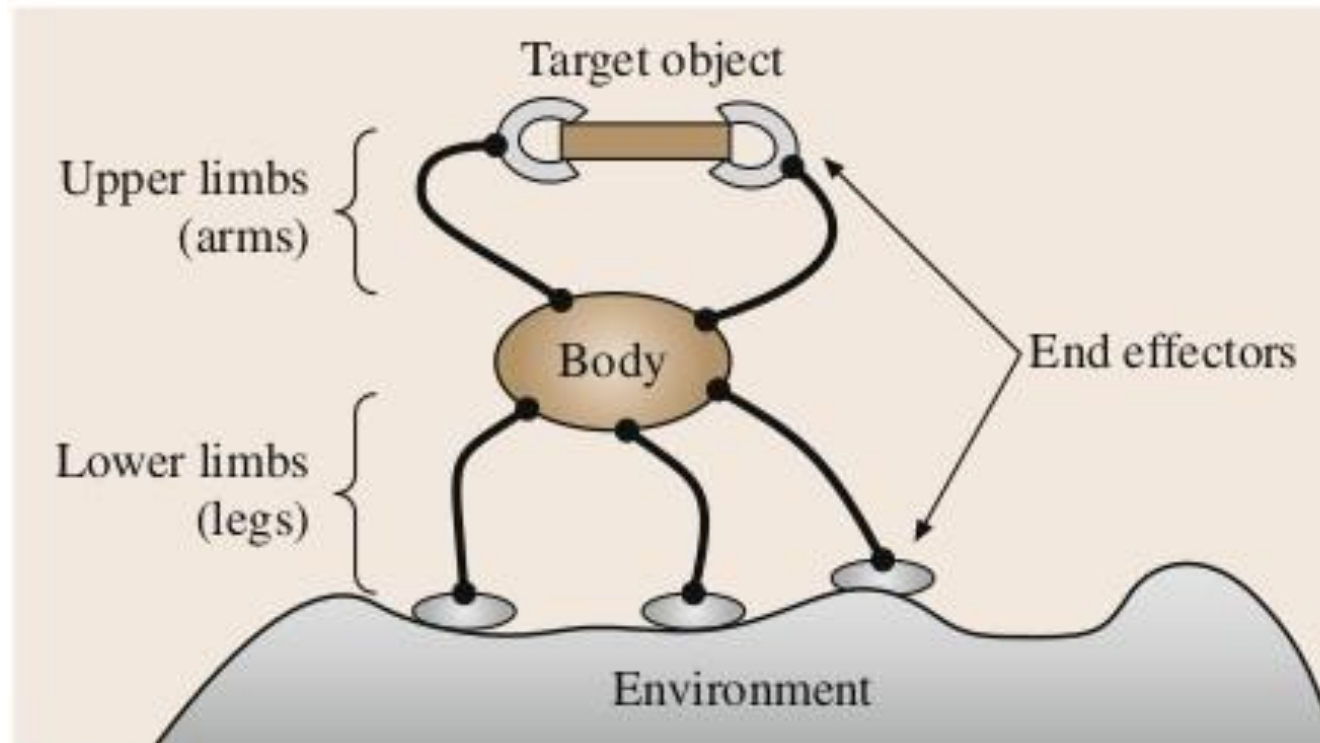


Fig. 17.1 General concept of a limbed system

Design of Limbed Systems

Figure 17.2 overviews the development process of a limbed system. Note that a development of a limbed system is an extremely dynamic process, rather than a static top-down development.

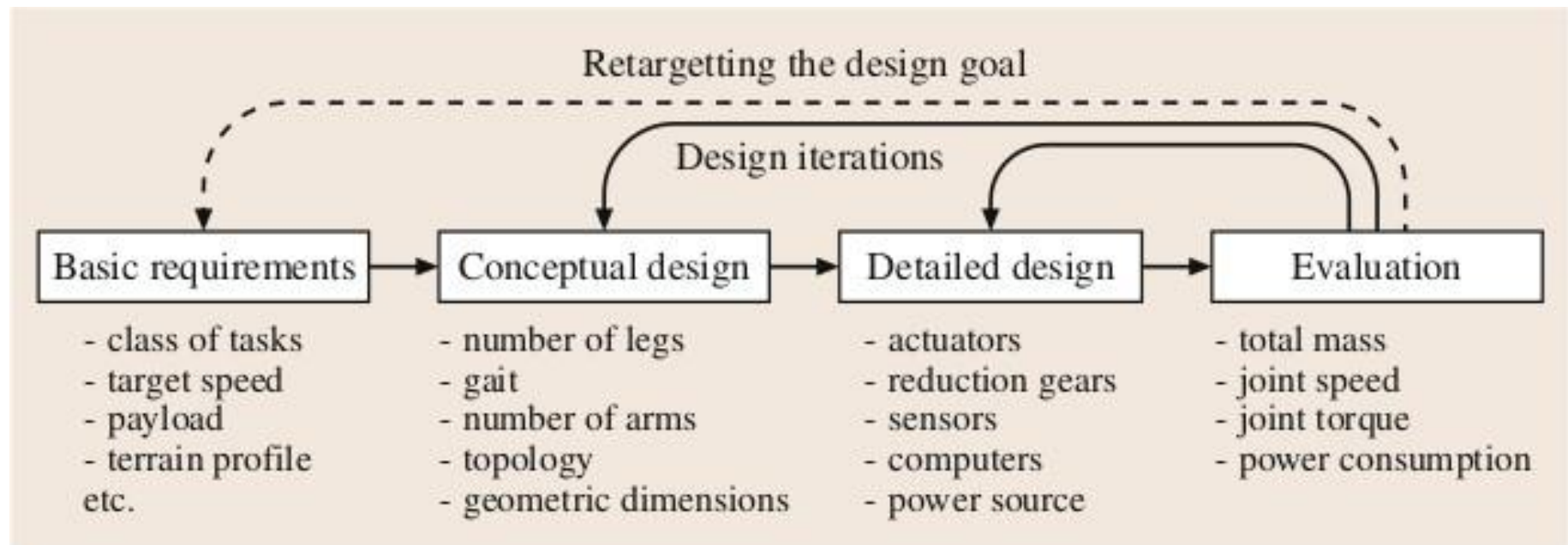


Fig. 17.2 Typical development process of a limbed system

Robot Design: Humanoid Robot HRP-4C

A cybernetic human as a humanoid robot have the following features:

1. Have the appearance and shape of a human being.
2. Can walk and move like a human being.
3. Can interact with humans using speech recognition and so forth.

Robot Design: Humanoid Robot HRP-4C

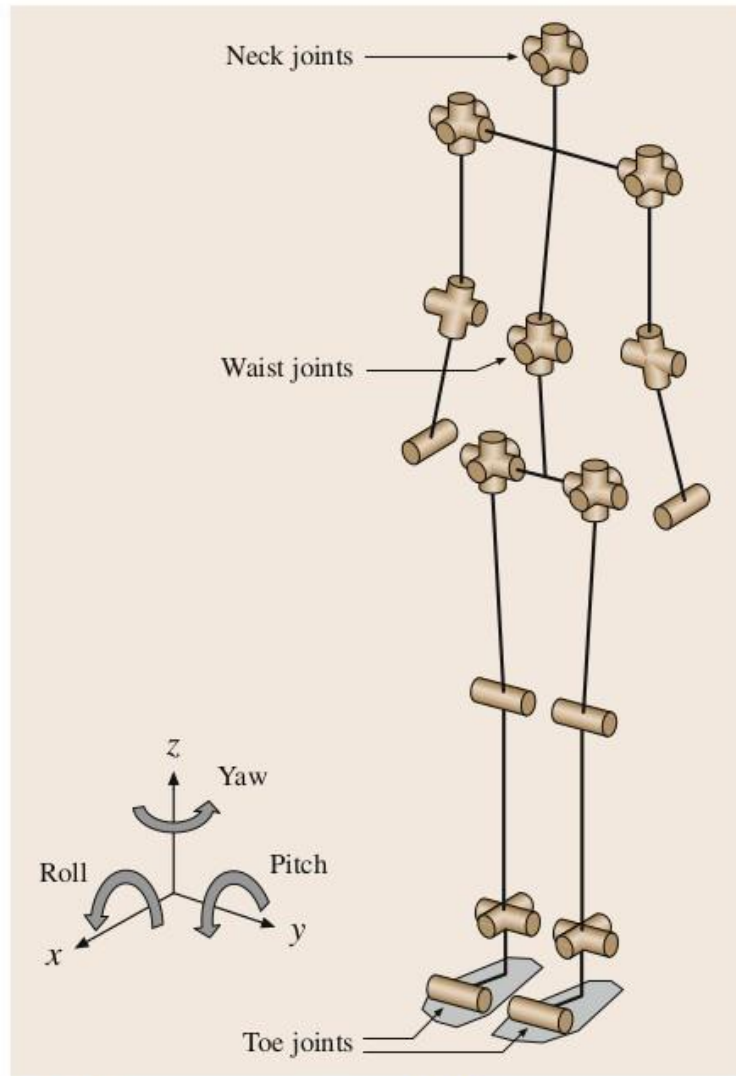
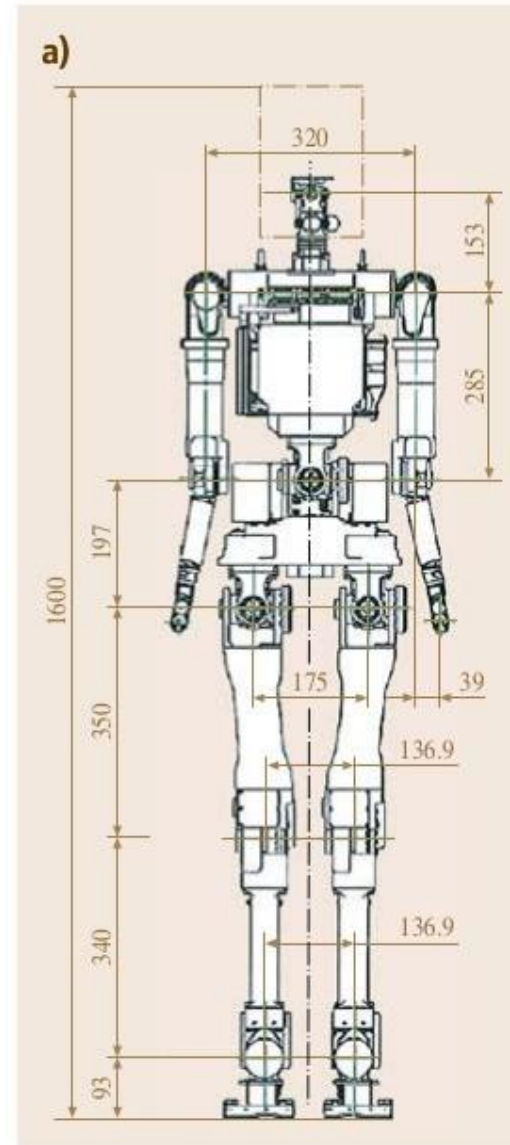


Fig. 17.9 Joint configuration of HRP-4C body (joints for the face and hands are omitted)



Robot Design: Humanoid Robot HRP-4C

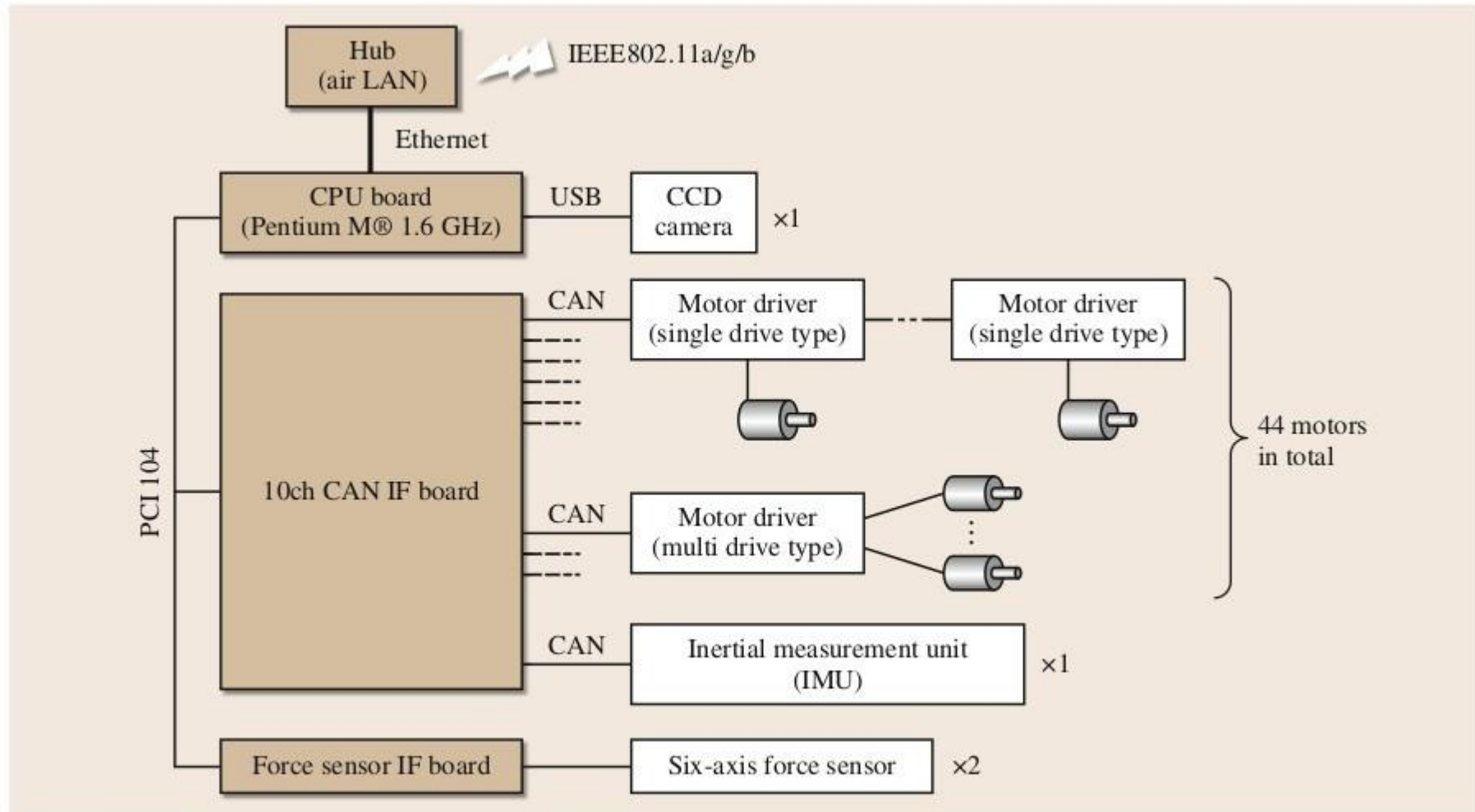


Fig. 17.14 Electronics architecture of HRP-4C