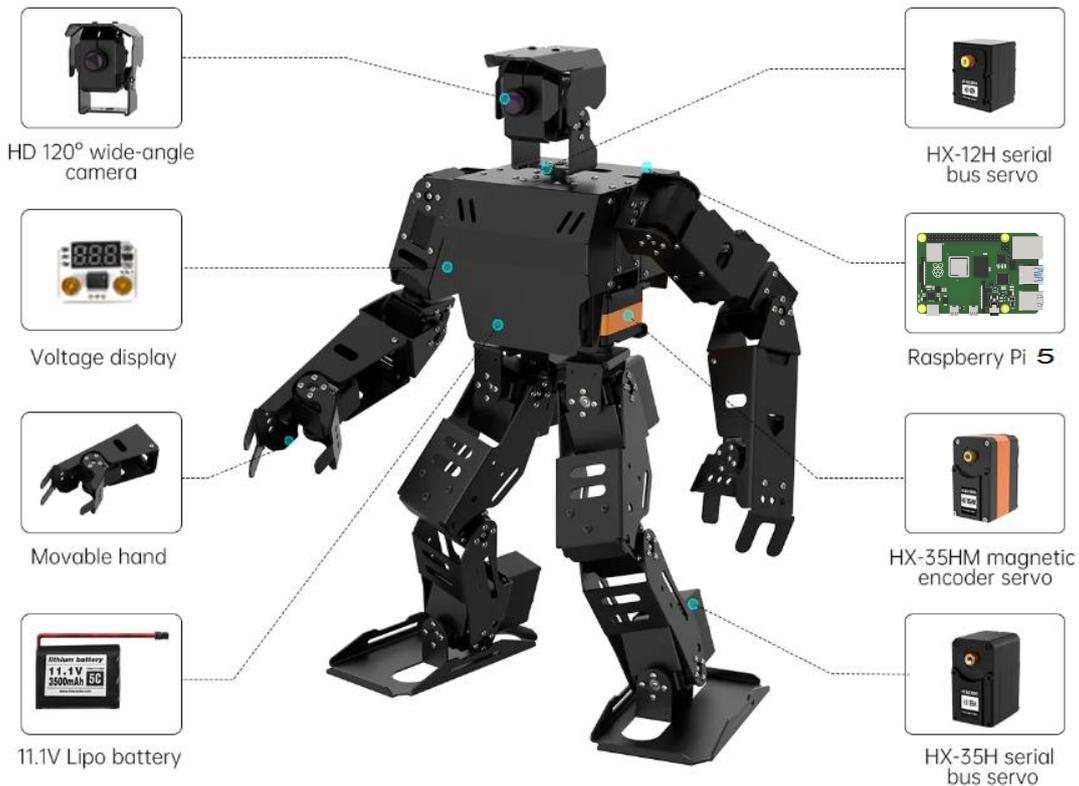# Lesson 1 Robot Hardware Structure

1. Introduction to Hardware

This section mainly introduces the robot's hardware, including the main control system, bus servos, high-definition camera, and voltage display module.

HD 120° wide-angle camera

Voltage display

Movable hand

11.1V Lipo battery

HX-12H serial bus servo

Raspberry Pi 5

HX-35HM magnetic encoder servo

HX-35H serial bus servo

1.1 Introduction to Main Controller

The Raspberry Pi 5 uses a 64-bit quad-core Arm Cortex-A76 processor with a clock frequency of 2.4GHz. It provides 2 to 3 times the CPU performance compared to the Raspberry Pi 4. In addition to a significantly improved 800MHz VideoCore VII GPU for graphics performance, it supports dual 4Kp60 display output via HDMI, as well as advanced camera support with a redesigned Raspberry Pi image signal processor. This can provide smooth desktop experience and open up new applications for you.

This is the first full-size Raspberry Pi computer using chips built internally by Raspberry Pi. RP1 provides most of the I/O functions for the Raspberry Pi 5 and achieves a leap in peripheral performance and functionality. The total USB

bandwidth has increased by more than twice, accelerating the transfer speed to external UAS drives and other high-speed peripherals. The dedicated dual-channel 1Gbps MIPI camera and display interfaces on early models have been replaced by a pair of four-channel 1.5Gbps MIPI transceivers, increasing the total bandwidth by three times and supporting any combination of up to two cameras or displays. The peak SD card performance is doubled by supporting SDR104 high-speed mode. For the first time, this platform introduces a single-channel PCIExpress 2.0 interface, providing support for high-bandwidth peripherals.

For more information about the Raspberry Pi mainboard, please refer to "**4. Raspberry Pi Baord and Expansion Board**".
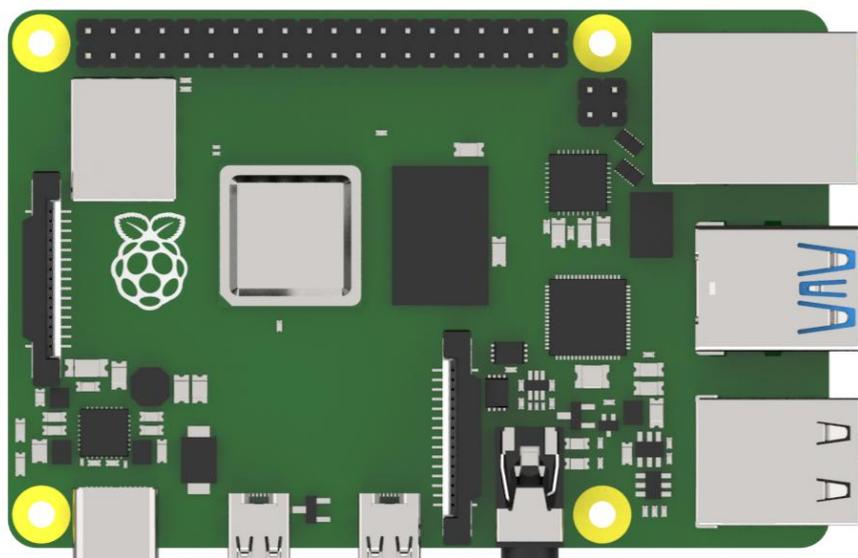
1.2 HD Camera

In daily life, cameras are generally used to perform basic functions such as taking photos and recording videos.

With the advent of artificial intelligence, there is a growing demand for obtaining more intelligent results from cameras. That is, by analyzing the changes in the environment through the camera's field of view, making judgments, and feeding the results back to the terminal or cloud processors, to serve richer applications.

Its advantages lie in its simple sensors, low cost, ease of calibration, and

recognition. Its disadvantage is that it cannot determine the real size of an object. It may be a large object far away or a small object nearby.

The specific parameters of the camera used in AiNex can be referred to in the following table:

Parameter	Description
FOV	170°
Focal length	3.2mm
Dimension（Unit：mm）	30*25*25.0 ±0.5mm
Storage temperature	-30℃~70℃
Operating temperature	0℃~50℃
Focus	Fixed
Focus	Manual lens focusing by twisting
Object Distance	30cm to infinity
Center Sharpness	600LW/PH（CENTER）
Data Transmission	USB2.0
Power Supply	USB bus end
Power Supply Voltage	DC 5V±5%
Maximum Power	40mW

Consumption	
System	Support Win XP/win 7、8 / vista /android 4.0/ mac /Linux with uvc
Maximum Effective Pixels	640（H）*480（V）
Sensitivity	2.5v / (lux-sec)
Pixel Size	3.4μm x 3.4μm
Resolutions and Frame Rates	YUY2 160x120 30FPS YUY2 176x144 30FPS YUY2 320x240 30FPS YUY2 352x288 30FPS YUY2 640x480 30FPS
Signal-to-Noise Ratio	42db
Dynamic Range	58db
Shutter Type	Electronic rolling shutter
Automatic Exposure Control (AEC)	Support
Automatic White Balance (AEB)	
Automatic Gain Control (AGC)	
Output Image Format	YUY2/MJPEG
Lens Structure	4E+IR
Aperture	2.4
Distortion	＜7.6%

1.3 HV Bus Servo

AiNex's body consists of 3 types of bus servos, totaling 24 in number, namely

HX-12H, HX-35H, and HX-35HM.

Bus servos utilize serial communication, connecting multiple servos to the control system via a single bus. Compared to digital servos, bus servos can be daisy-chained through a single I/O port, providing strong load capacity, high stability, and ease of maintenance and use. For more details, you can refer to " **Appendix/ 7. Servo Data**".

Regarding the pinout and explanation of the interface pins, taking the HX-35H servo as an example, it is illustrated in the following diagram:

Pin	Instruction
-	Power ground
+	Power input
S	Signal terminal (half-duplex UART asynchronous serial interface)

1.4 Digital Display Module

The digital display voltage module is an electronic device used for measuring and displaying voltage. It typically consists of a voltage sensor and a digital display. The voltage sensor converts the input voltage into a digital signal, which is then transmitted to the digital display by control circuitry to show the voltage value. This module is suitable for various occasions where voltage

measurement and display are needed, such as laboratories, industrial control, etc.