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Intelligent assembly platform architecture for complex products

复杂产品智能装配平台体系架构

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Table of Contents

6.1 Structural Subsystem

6.1.1 Overview The structural subsystem consists of five functional modules and three types of module interfaces. The functional modules mainly include the basic support module and the positioning clamp. The system includes a support module, a motion execution module, a logistics conveying module, and auxiliary modules. Module interfaces are divided into fixed connection interfaces and detachable connection interfaces. And motion connection interfaces. Each functional module is organically integrated through module interfaces to achieve complete assembly functionality from static support to dynamic execution. The specific components of the structural subsystem are shown in Figure 3. Figure

6.1.2 Functional Modules

6.1.2.1 Basic Support Module The basic support module is the foundation of the intelligent assembly platform for complex products, providing a stable and reliable basic framework and mounting base for the entire system. Accuracy. Other modules should be mounted directly or indirectly on top of this module to ensure that geometric accuracy and stability are maintained under static/dynamic loads. The design of this module must fully consider static/dynamic stiffness, natural frequency matching, and thermal stability, including the frame, base, housing, and moving platform. Qualitative properties and vibration reduction/isolation factors directly determine the upper limit of the platform's accuracy and long-term stability.

6.1.2.2 Positioning and clamping module The positioning and clamping module is responsible for determining and maintaining the precise spatial pose of components during the assembly process, providing consistent positioning for all assembly operations. Repeatable references. This includes flexible fixtures, fixed fixtures, and fixture families adapted to hold a variety of parts with varying specifications. This module requires... It can adapt to the production needs of multiple varieties and variable batches, and achieve flexibility in the assembly process through rapid model changeover.

6.1.2.3 Motion Execution Module The motion execution module provides the components needed to perform assembly actions, enabling precise execution of physical assembly actions according to predetermined paths and methods. This includes serial and parallel robots, running modules, slides, transmission mechanisms, and end effectors. The performance of this module directly determines the assembly speed. Precision and flexibility.

6.1.2.4 Logistics Conveying Module The logistics and conveying module performs the transfer, loading, and unloading of materials, components, and finished products between workstations and warehouses according to the assembly process, forming a continuous flow. The production flow includes conveyor lines, elevators, rotary tables, etc. This module typically integrates automatic identification technologies such as RFID and barcodes, and can communicate with upper-level management systems. Real-time interaction with the management system ensures the accuracy, efficiency, and traceability of material flow, which is key to forming a continuous and efficient production flow.

6.1.2.5 Auxiliary Supporting Modules Auxiliary modules should provide necessary support functions for the assembly process, such as energy transmission and safety protection, including cables and conduits. Safety fences, protective nets, safety gates, etc. The design of this module directly affects the reliability, ease of maintenance, and operational safety of the entire system.

6.1.3 Module Interface

6.1.3.1 Fixed connection interface Used for permanent or rigid connections between modules, requiring little or no disassembly between modules. Includes welding, bolted connections, and standard flanges. Connection methods such as linking.

6.1.3.2 Detachable connection interface Interface patterns used to achieve flexibility and modularity should ensure both rapid disassembly and high-precision reinstallation. This includes machine... Quick-change disc interface for end effectors, quick-change docking interface for tooling, modular slot positioning interface, etc.

6.1.3.3 Motion Connection Interface It provides precise relative motion while ensuring connectivity between functional modules. This includes precision linear guide pairs, precision ball screw pairs, and precision... Rotating shaft systems, etc.

6.2 Control Subsystem

6.2.1 Overview The control subsystem consists of three parts. hardware modules, software modules, and module interfaces. The hardware modules enable communication with the structural subsystem. Connection and control, including the main control computer, controller, driver, electrical components, motor, and data conversion module; software modules can realize the structure. The execution and coordination of the subsystem, data interaction with the sensing subsystem, the intelligent process decision-making and optimization subsystem, and the basic information subsystem, including the use of User management, multithreaded programming, control algorithms, human-computer interaction interfaces, etc.; module interfaces enable communication between the control subsystem and various subsystems and peripherals. Signal, data, and command transmission, including input interfaces, output interfaces, communication interfaces, debugging interfaces, special interfaces, and interface protocols. Control subsystem. The specific components of the system are shown in Figure 4. Figure

6.2.2 Hardware Module

6.2.2.1 Main Control Computer The main control computer is the brain of the entire system, providing interfaces for the control system hardware modules, processing various sensor data, and operating... Interface display screen and software operating environment.

6.2.2.2 Controller The controller is a hardware and software system with the main control computer as its core. By integrating it into a network, it can realize motion control and input/output. Signal control and sensor control, etc., and the control module can be reconfigured through the combination of different controllers. The controller interacts with various devices via communication protocols. sending precise position, speed, or torque commands to the actuators; and communicating via data... The digital/analog input/output module connects to control solenoid valves, relays, and other switching electrical components, or reads status signals from buttons, limit switches, etc. The system can control the switching or brightness adjustment of machine vision lighting; and collect feedback signals from force sensors, temperature sensors, displacement sensors, etc. in real time. The system performs data processing, logical judgment, and closed-loop control.

6.2.2.3 Driver Based on the signals sent by the controller, power amplification and feedback control are performed, enabling control of the motor's position, speed, and torque. It can monitor the status, faults, and abnormalities of equipment, and perform diagnosis and handling. It can also monitor the position, speed, load, and other parameters of actuators in real time. The system counts data and performs fault detection and anomaly handling based on set rules and algorithms.

6.2.2.4 Electrical Components Electrical components mainly include power supplies, switches, relays, capacitors, resistors, fuses, circuit breakers, connectors, and plugs.

6.2.2.5 Motor It serves as the power source for the motion execution module within the structural subsystem.

6.2.2.6 Data Conversion Module Tools used for converting between different data formats.

6.2.3 Software Modules

6.2.3.1 User Management Responsible for managing user permissions and authentication, including user registration, login, and access control functions.

6.2.3.2 Multithreaded Programming Parallel control of the structured subsystem is achieved through multithreaded programming, including thread management, thread synchronization, message passing, event handling, and data processing. Shared and shared memory, as well as error handling and exception handling, etc. This parallel framework is the core operating mechanism of the controller system software, which can efficiently coordinate and schedule multiple critical tasks.

a) Allocate high-priority real-time threads to motion control algorithms with extremely high real-time requirements to ensure precise timing control;

b) Create dedicated threads or thread pools for image processing algorithms to fully utilize multi-core processor resources and avoid blocking the main control loop;

c) Through a carefully designed thread synchronization and message passing mechanism, ensure smooth communication between motion control, image processing, and the main logic of the controller. It can exchange data securely, efficiently, and in real time and work collaboratively.

6.2.3.3 Motion Control Algorithm The control algorithms include path planning algorithms, multi-axis interpolation algorithms, and servo loop control algorithms. The control algorithm is the core of the control subsystem, which can transform target position, velocity profile, and process requirements into precise, coordinated, and real-time shaft systems. Motion commands. It comprises three levels. path planning algorithm, multi-axis interpolation algorithm, and servo control algorithm. Path planning algorithm. In a Cartesian coordinate system, it can generate paths based on the starting point, ending point, obstacle avoidance constraints, speed/acceleration limits, process requirements, etc. To achieve the desired spatial motion trajectory. This includes point-to-point movement, generation and optimization of continuous paths (such as straight lines, arcs, and spline curves), and speed... Proactive control is used to reduce impact and improve efficiency. Multi-axis interpolation algorithm. It can decompose the spatial trajectory and velocity profile