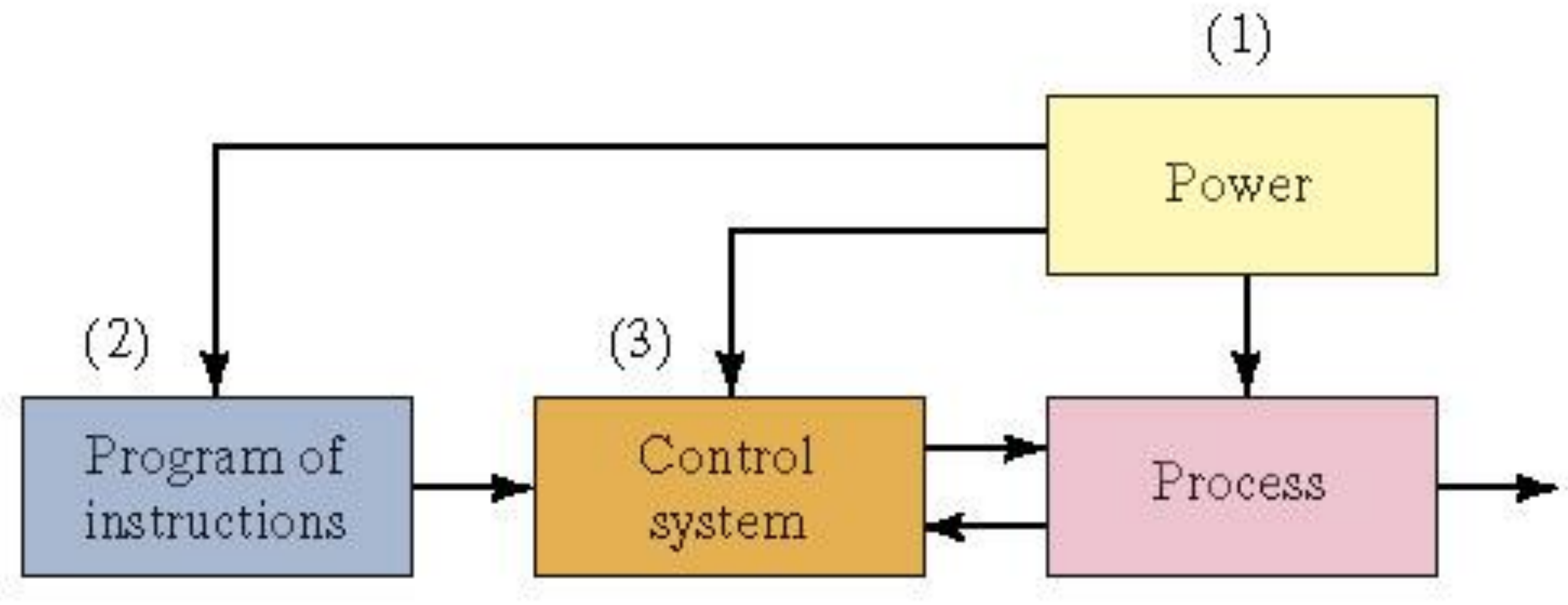
جلسه هشتم: اتوماسیون

Automation Defined

Automation is the technology by which a process or procedure is accomplished without human assistance.

- Basic elements of an automated system:
  1. *Power* - to accomplish the process and operate the automated system
  2. *Program of instructions* – to direct the process
  3. *Control system* – to actuate the instructions

Elements of an Automated System



Electricity - The Principal Power Source

- Widely available at moderate cost
- Can be readily converted to alternative forms, e.g., mechanical, thermal, light, etc.
- Low level power can be used for signal transmission, data processing, and communication
- Can be stored in long-life batteries

Power to Accomplish the Automated Process

- *Power for the process*
  - To drive the process itself
  - To load and unload the work unit
  - Transport between operations
- *Power for automation*
  - Controller unit
  - Power to actuate the control signals
  - Data acquisition and information processing

Common Manufacturing Processes and Their Power Requirements

Process	*Power Form*	*Action Accomplished*
Casting	Thermal	Melting the metal before pouring into a mold cavity where solidification occurs.
Electric discharge machining (EDM)	Electrical	Metal removal accomplished by a series of discrete electrical discharges between electrode (tool and work piece. The electric discharges cause very high localized temperatures that melt the metal.
Forging	Mechanical	Metal work part is deformed by opposing die(s). Work parts are often heated in advance deformation thus thermal power is also required.
Heat treating	Thermal	Metallic work unit is heated to temperature below melting point to effect rnicrostructural changes.
Injection molding	Thermal and mechanical	Heat is used to raise temperature of polymer to highly plastic consistency, and mechanical force is used to inject the polymer melt into a mold cavity.
Laser beam cutting	Light and thermal	A highly coherent light beam is used to cut material by vaporization and melting.
Machining	Mechanical	Cutting of metal is accomplished by relative motion between tool and work piece.
Sheet metal punching and blanking	Mechanical	Mechanical power is used to shear metal sheets and plates.
Welding	Thermal (maybe mechanical)	Most welding processes use heat to cause fusion and coalescence of two (or more) metal parts at their contacting surfaces. Some welding processes also apply mechanical pressure to the surfaces.

Program of Instructions

Definition: Set of commands that specify the sequence of steps in the work cycle and the details of each step.

- Example: CNC part program
- During each step, there are one or more activities involving changes in one or more process parameters
  - Examples:
    - Temperature setting of a furnace
    - Axis position in a positioning system
    - Motor on or off

EXAMPLE: An Automated Turning Operation

Consider an automated turning operation in which a cone-shaped geometry is generated. Assume the system is automated and that a robot is used to load and unload the work unit. The work cycle consists of the following steps: (1) load starting work piece (2) position cutting tool prior to turning (3) turn (4) reposition tool to a safe location at end of turning and (5) unload finished work piece. Identify the activities and process parameter(s) in each step of the operation.

EXAMPLE: An Automated Turning Operation

Solution: In step (1), the activities consist of the robot manipulator reaching for the raw work part. Lifting and positioning the part into the chuck jaws of the lathe, then removing the manipulator to a safe position to wait unloading. The process parameters for these activities are the axis values of the robot manipulator (which change continuously), the gripper value (open or closed).and the chuck jaw value (open or closed)

In step (2), the activity involves the movement of the cutting tool to a "ready' position. The process parameters associated with this activity are the r-and z-axis position of the tool

Step (3) is the turning operation. It requires the simultaneous control of three process parameters: rotational speed of the work piece (rev/min), feed (mm/rev), and radial distance of the cutting tool from the axis of rotation. To cut the conical shape, radial distance must be changed continuously at a constant rate for each revolution of the work piece. For a consistent finish on the surface, the rotational speed must be continuously adjusted to maintain a constant surface speed (m/min); and [or equal feed marks on the surface, the feed must be set at a constant value. Depending on the angle of the cone, multiple turning passes may be required to gradually generate the desired contour. Each pass represents an additional step in the sequence.

EXAMPLE: An Automated Turning Operation

Steps (4) and (5) involve the reverse activities as steps (2) and (1), respectively and the process parameters are the same.

Decision-Making in a Programmed Work Cycle

- The following are examples of automated work cycles in which decision making is required:
  - *Operator interaction*
    - Automated teller machine
  - *Different part or product styles processed by the system*
    - Robot welding cycle for two-door vs. four door car models
  - *Variations in the starting work units*
    - Additional machining pass for oversized sand casting

Features of a Work Cycle Program

- *Number of steps in the work cycle*
- *Manual participation in the work cycle* (e.g., loading and unloading workparts)
- *Process parameters* - how many must be controlled?
- *Operator interaction* - does the operator enter processing data?
- *Variations in part or product styles*
- *Variations in starting work units* - some adjustments in process parameters may be required to compensate for differences in starting units

Features of Work Cycle Programs Used in Automated Systems

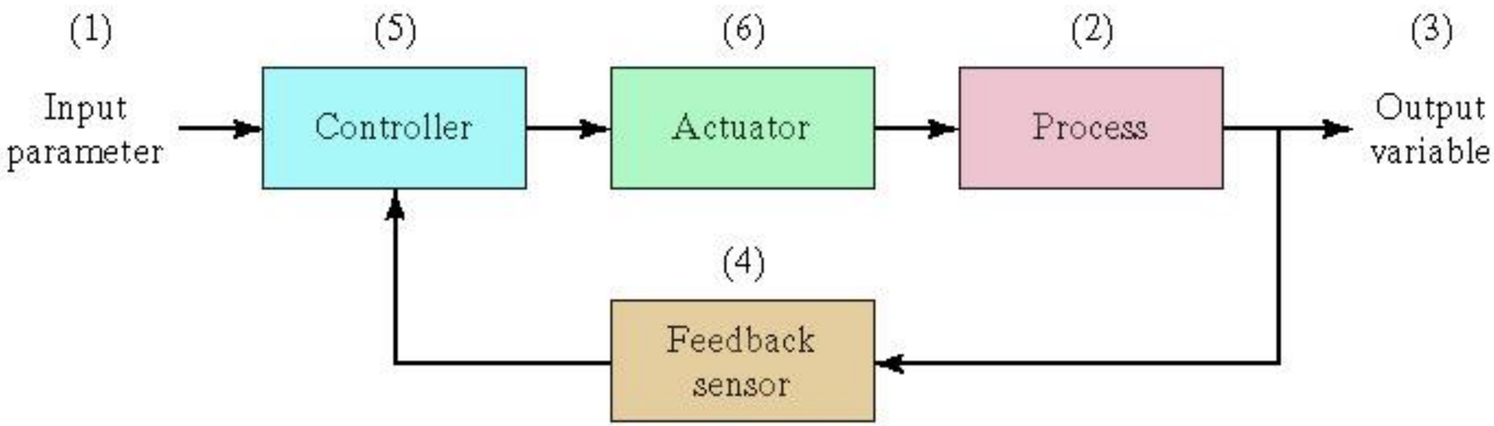
Program Feature	Examples or Alternatives
Steps in work cycle	Example • Typical sequence of steps: (1) load, (2), process, (3) unload
Process parameters (inputs) in each step	Alternatives: • One parameter versus multiple parameters that must be changed during the step • Continuous parameters versus discrete parameters • Parameters that change during the step; for example, a positioning system whose axes values change during the processing step
Manual steps in work cycle	Alternatives: • Manual steps versus no manual steps (completely automated work cycle Example • Operator loading and unloading parts to and from machine
Operator interaction	Alternatives: • Operator interaction versus completely automated work cycle Example: • Operator entering processing information for current work part
Different part or product styles	Alternatives: • Identical part or product style each cycle (mass or batch production) versus different part or product styles each cycle (flexible automation)
Variations in starting work units	Example • Variations in starting dimensions or part features

Control System – Two Types

1. *Closed-loop (feedback) control system* – a system in which the output variable is compared with an input parameter, and any difference between the two is used to drive the output into agreement with the input
2. *Open-loop control system* – operates without the feedback loop
   - Simpler and less expensive
   - Risk that the actuator will not have the intended effect

(a) Feedback Control System and (b) Open-Loop Control System

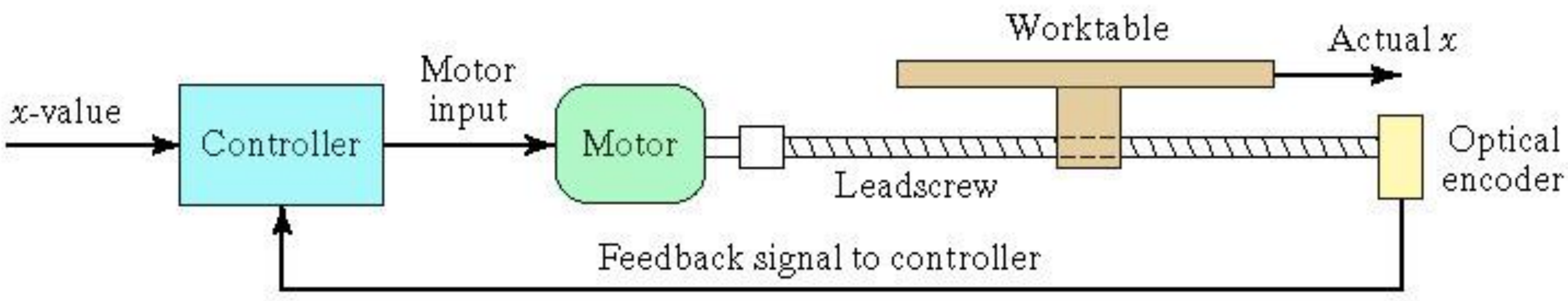
(a)



(b)

Positioning System Using Feedback Control

A one-axis position control system consisting of a leadscrew driven by a dc servomotor and using an optical encoder as the feedback sensor



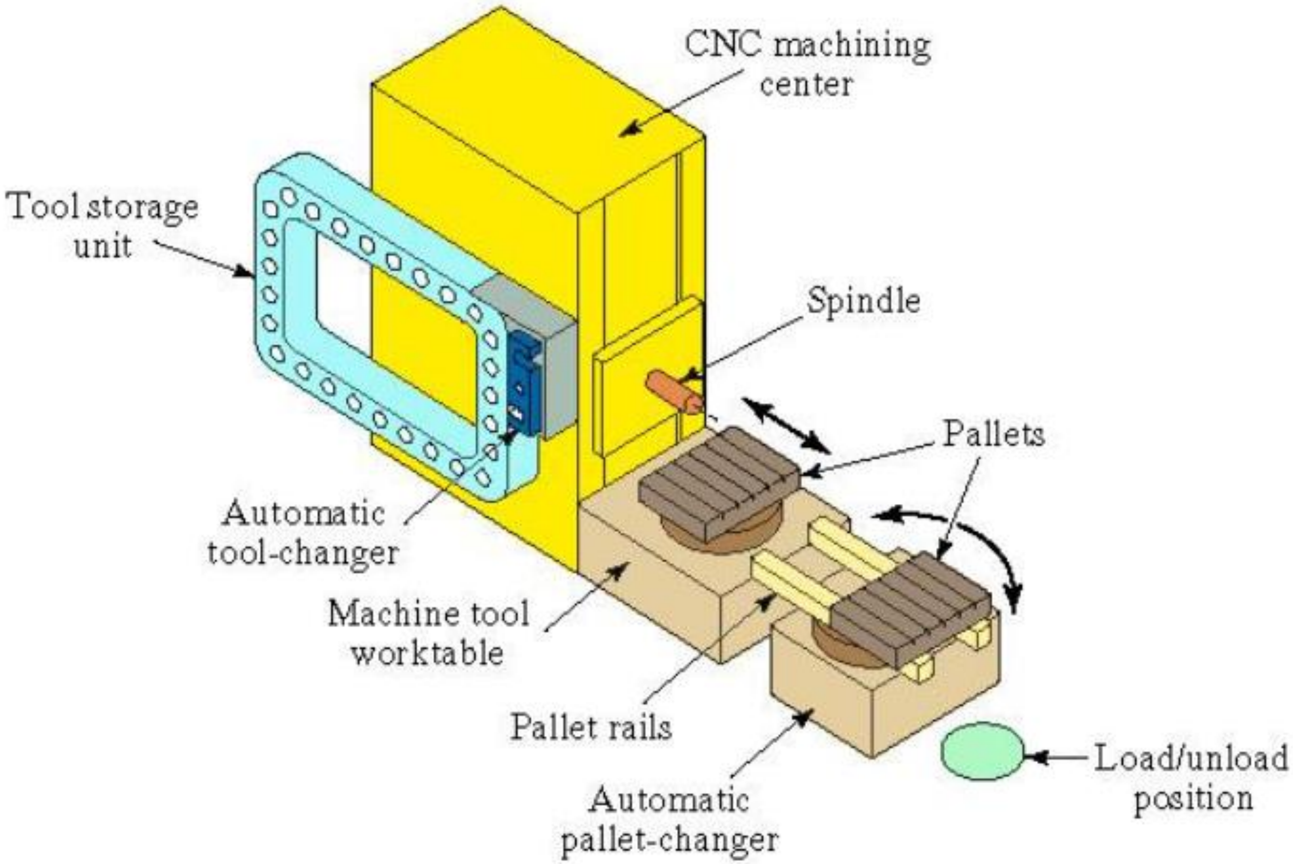
When to Use an Open-Loop Control System

- Actions performed by the control system are simple
- Actuating function is very reliable
- Any reaction forces opposing the actuation are small enough as to have no effect on the actuation
- If these conditions do not apply, then a closed-loop control system should be used

Advanced Automation Functions

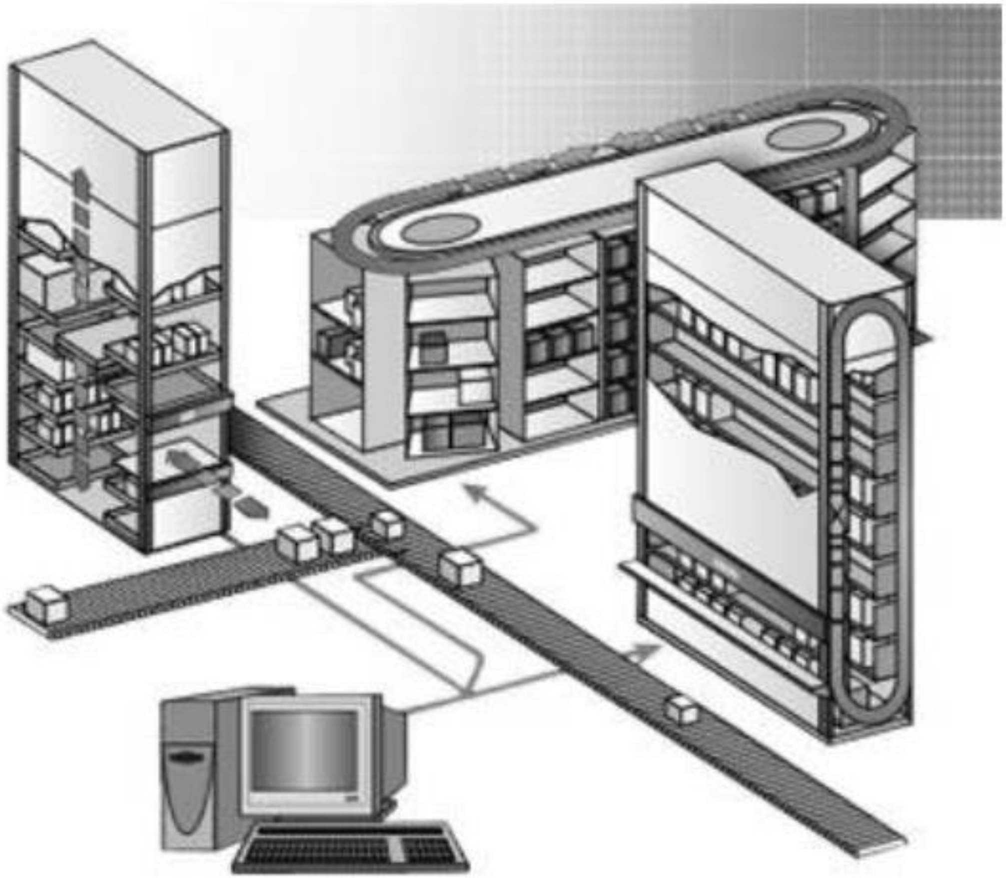
1. Safety monitoring
2. Maintenance and repair diagnostics
3. Error detection and recovery

Automation example



<u>Automatic pallet changer</u> integrated with a CNC machining center, set up for manual unloading and loading of work parts.

Automation example



Automated Storage and Retrieval System

Amazon automated storage system

Safety Monitoring

Use of sensors to track the system's operation and identify conditions that are unsafe or potentially unsafe

- Reasons for safety monitoring
  - To protect workers and equipment
- Possible responses to hazards:
  - Complete stoppage of the system
  - Sounding an alarm
  - Reducing operating speed of process
  - Taking corrective action to recover from the safety violation

List of sensors used for Safety Monitoring

- Limit switches
- Photoelectric
- Temperature
- Heat or smoke detectors.
- Pressure-sensitive floor pads
- Machine vision systems

Maintenance and Repair Diagnostics

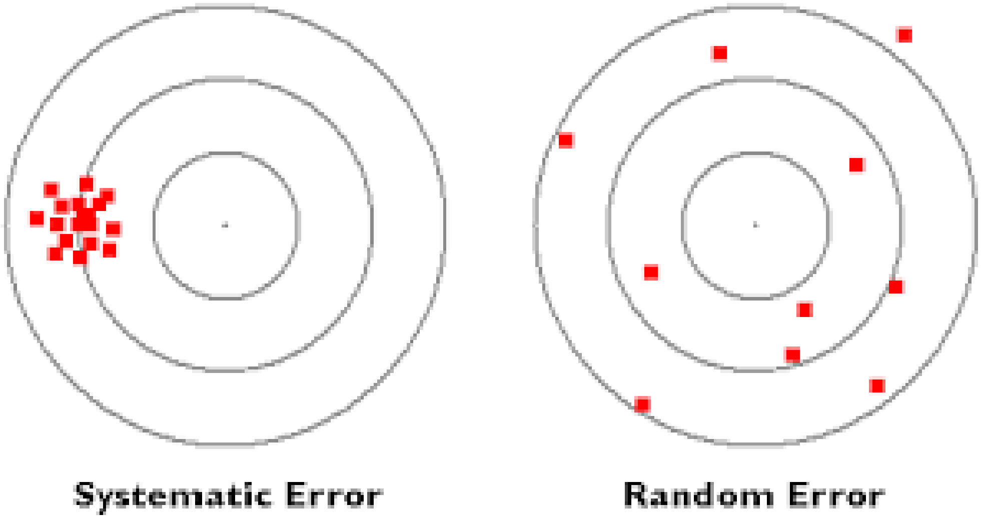
- *Status monitoring*
  - Monitors and records status of key sensors and parameters during system operation
- *Failure diagnostics*
  - Invoked when a malfunction occurs
  - Purpose: analyze recorded values so the cause of the malfunction can be identified
- *Recommendation of repair procedure*
  - Provides recommended procedure for the repair crew to effect repairs

Error Detection and Recovery

1. *Error detection* – functions:
   - Use the system's available sensors to determine when a deviation or malfunction has occurred
   - Correctly interpret the sensor signal
   - Classify the error
2. *Error recovery* – possible strategies:
   - Make adjustments at end of work cycle
   - Make adjustments during current work cycle
   - Stop the process to invoke corrective action
   - Stop the process and call for help

Error types

1. *Systematic error*
2. *Random error*
3. *Aberration error*



EXAMPLE :Error Detection in an Automated Machining Cell

- Consider an automated cell consisting of a CNC machine tool, a part storage unit, and a robot for loading and unloading the parts between the machine and the storage unit. Possible errors that might affect this system can be divided into the following categories: (1) machine and process, (2) cutting tools, (3) work holding fixture, (4) part storage unit, and (5) load/unload robot. Develop a list of possible errors (deviations and malfunctions) and corrective actions that might be included in each of these five categories.

Solution: 1. Errors

	Error Categories	Possible Malfunctions
1.	Machine and process	Loss of power, power overload, thermal deflection, cutting temperature too high, vibration, no coolant, chip fouling, wrong part program, defective part
2.	Cutting tools	Tool breakage, tool wear-out, vibration, tool not present, wrong tool
3.	Work holding fixture	Part not in fixture, clamps not actuated, and part dislodged during machining, part deflection during machining, part breakage, chips causing location problems
4.	Part storage unit	Work part not present, wrong work part, oversized or undersized work part
5.	Load/unload robot	Improper grasping of work part, robot drops work part, no part present at pickup

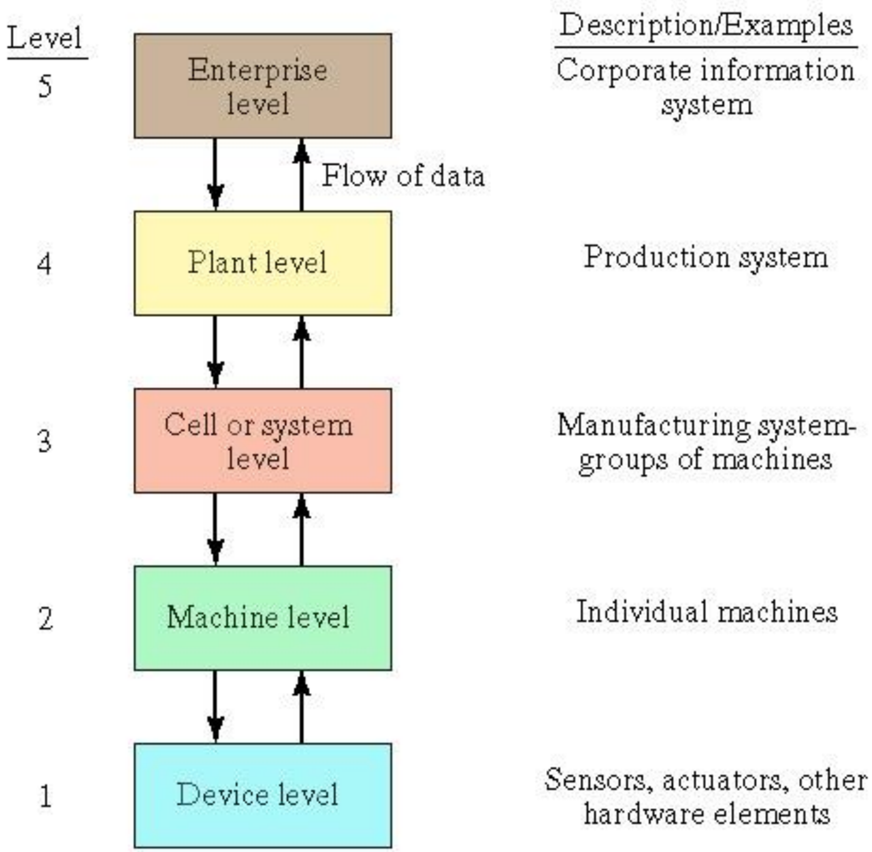
Solution: 2 Corrective Actions

Errors Detected	Possible Corrective Actions to Recover
Part dimensions deviating due to thermal deflection of machine tool	Adjust coordinates in part program to compensate (category 1 corrective action)
Part dropped by robot during pickup	Reach for another part (category 2 corrective action)
Part is dimensionally oversized	Adjust part program to take a preliminary machining pass across the work surface (category 2 corrective action)
Chatter (tool vibration)	Increase or decrease cutting speed to change harmonic frequency (category 2 corrective action)
Cutting temperature too high	Reduce cutting speed (category 2 corrective action)
Failure of cutting tool	Replace cutting tool with another sharp tool (category 3 corrective action).
No more parts in parts storage unit	Call operator to resupply starting work parts (category 4 corrective action)
Chips fouling machining operation	Call operator to clear chips from work area (category 4 corrective action)

Levels of Automation

1. *Device level* – actuators, sensors, and other hardware components to form individual control loops for the next level
2. *Machine level* – CNC machine tools and similar production equipment, industrial robots, material handling equipment
3. *Cell or system level* – manufacturing cell or system
4. *Plant level* – factory or production systems level
5. *Enterprise level* – corporate information system

Levels of Automation



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