Factory Automation and Control Methods
Lecture 4: Introduction to Automation

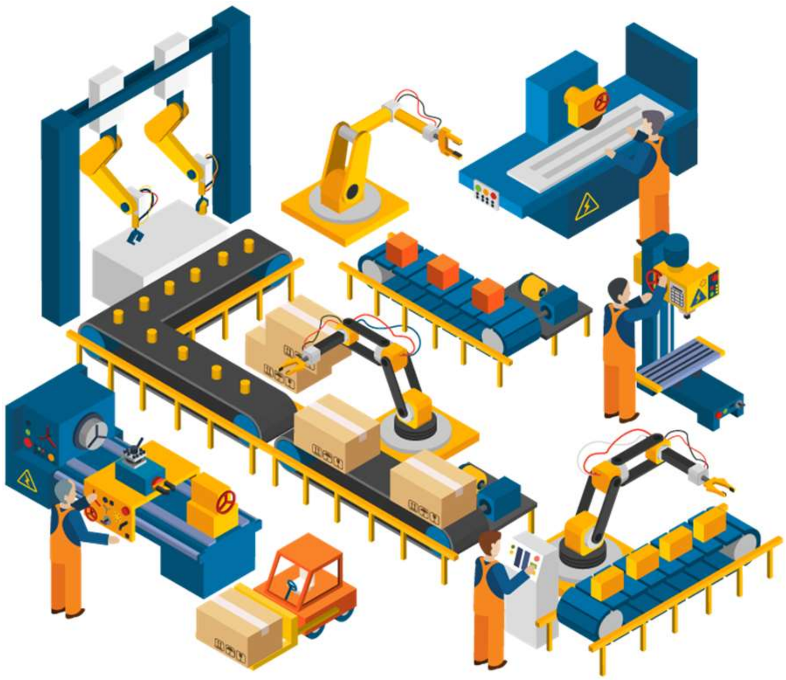
Daro VAN

Paragon International University
Faculty of Engineering
Department of Industrial Engineering

Outline

- Basic elements of an automated system
- Advanced automation functions
- Level of automation

Overview



Overview

Automation can be defined as the technology by which a process or procedure is accomplished without human assistance.

It is implemented using a program of instructions combined with control systems that execute the instructions.

To automate a process, power is required, both to drive the process itself and to operate the program and control systems.

Learning Objective

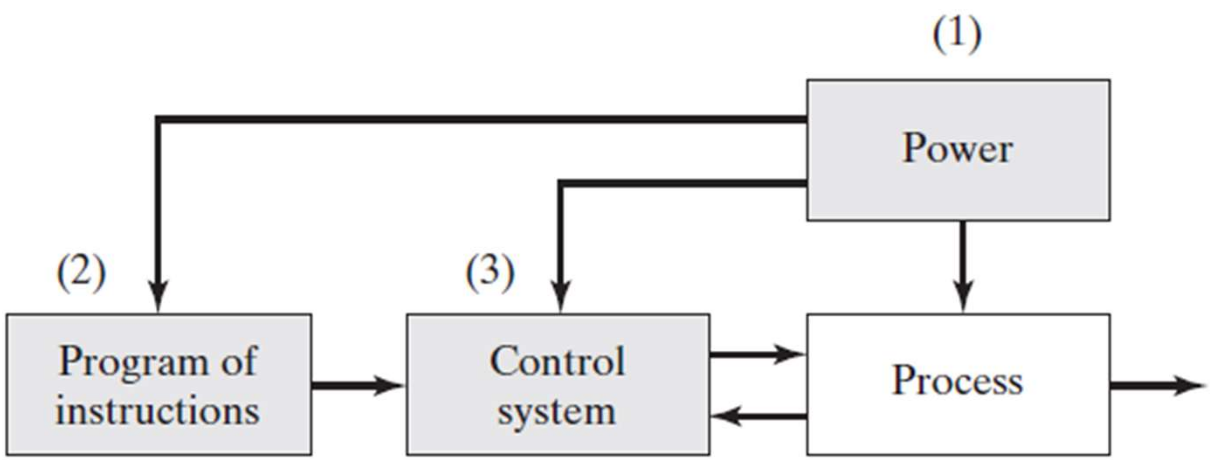
After completing this class, you will be able to understand

- the basic elements of an automated system from a high level perspective
- some of the advanced features beyond basic elements and
- the level of automation.

4.1 Basic Elements of Automated Systems

An automated system consists of three basic elements:

- Power to accomplish the process and operate the system
- Program of instructions to direct the process
- Control system to actuate the instructions.



4.1 Basic Elements of Automated Systems
4.1.1 Power to Accomplish the Automated Process

The principal source of power in automated systems is electricity

- Electric power is widely available at moderate cost
- Electric power can be readily converted to alternative energy forms: mechanical, thermal, light, acoustic, hydraulic, and pneumatic.
- Electric power at low levels can be used to accomplish functions such as signal transmission, information processing, and data storage and communication.
- Electric energy can be stored in long-life batteries for use in locations where an external source of electrical power is not conveniently available.

4.1 Basic Elements of Automated Systems

4.1.1 Power to Accomplish the Automated Process

Power for the Process

Process	Power Form	Action Accomplished
Casting	Thermal	Melting the metal before pouring into a mold cavity where solidification occurs.
Electric discharge machining	Mechanical	Metal removal is accomplished by a series of discrete electrical discharges between electrode (tool) and workpiece. The electric discharges cause very high localized temperatures that melt the metal.
Forging	Mechanical	Metal work part is deformed by opposing dies. Work parts are often heated in advance of deformation, thus thermal power is also required.
Welding	Thermal , 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.

4.1 Basic Elements of Automated Systems
4.1.1 Power to Accomplish the Automated Process

Power for the Process (cont.)

Process	Power Form	Action Accomplished
Heat-treating	Thermal	Metallic work unit is heated to temperature below melting point to effect microstructural 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 machining	Light, thermal and mechanical	A highly coherent light beam is used to cut material by vaporization and melting.
Sheet metal punching and blanking	Mechanical	Mechanical power is used to shear metal sheets and plates.

4.1 Basic Elements of Automated Systems
4.1.1 Power to Accomplish the Automated Process

Power for the Process

power is also required for the following material handling functions:

- Loading and unloading the work unit
- Material transport between operation

4.1 Basic Elements of Automated Systems
4.1.1 Power to Accomplish the Automated Process

Power for the Automation

power is also required for the following material handling functions:

- Controller unit
- Power to actuate the control signals
- Data acquisition and information processing

4.1 Basic Elements of Automated Systems
4.1.2 Program of Instructions

Work cycle program

In the simplest automated processes, the work cycle consists of essentially one step, which is to maintain a single process parameter at a defined level.

Ex. Maintain the temperature of a furnace at a designed value for the duration of the heat treatment cycle

Note that here a **process parameter** is an **input to the process**, such as the temperature dial setting, whereas **a process variable** is the corresponding **output of the process** which is the actual temperature of the furnace.

4.1 Basic Elements of Automated Systems
4.1.2 Program of Instructions

Work cycle program

- Set-point control : the process parameter value is constant during the work cycle.
- Logic control : the process parameter value depends on the values of other variables in the process.
- Sequence control : the value of the process parameter changes as a function of time. Ex. Load the part, then perform the process, and then unload the part.
- Interactive program : interaction occurs between a human operator and the control system during the work cycle.
- Intelligent program : the control system exhibits aspects of human intelligence (e.g., logic, decision making, cognition, learning) as a result of the work cycle program.

4.1 Basic Elements of Automated Systems
4.1.2 Program of Instructions

Decision making in the programmed work cycle

- Operator interaction: the controller unit may require input data from a human operator in order to function.
- Different part or product styles processed by the system: the automated system is programmed to perform different work cycles on different part or product styles.
- Variations in the starting work units : In some manufacturing operations, the starting work units are not consistent.

4.1 Basic Elements of Automated Systems
4.1.2 Control Systems

Control is everywhere in industrial applications, in nature and also in life

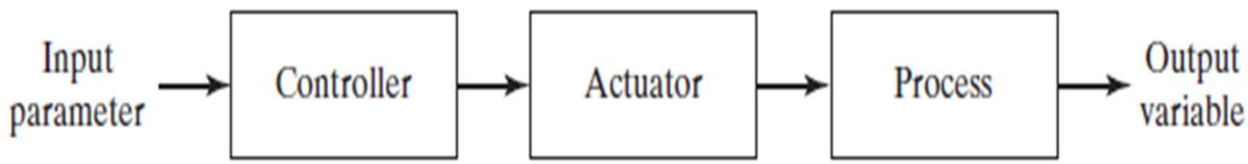
"No Control, No Life!"


And feedback is the key to success…

4.1 Basic Elements of Automated Systems
4.1.2 Control Systems

Control is an automated system that can be either closed loop or open loop.

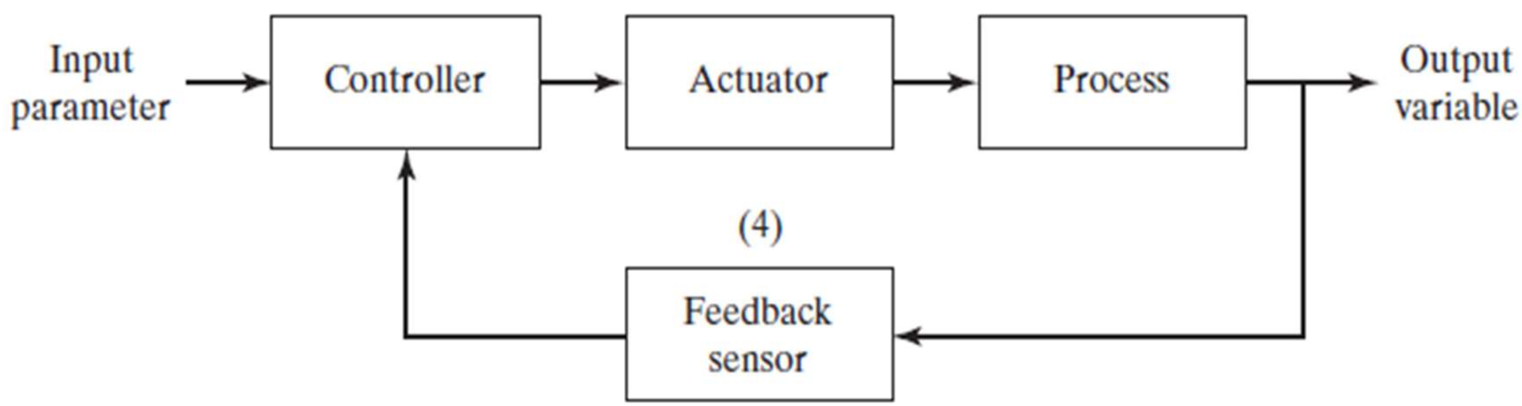
Open-loop control systems



4.1 Basic Elements of Automated Systems
4.1.2 Control Systems

Control is an automated system that can be either closed loop or open loop.

Closed-loop control systems



4.2 Advanced Automation Functions

In addition to executing work cycle programs, an automated system may be capable of executing advanced functions that concerned with enhancing the safety and performance of the equipment.

Advanced automation functions include the following:

- Safety monitoring
- Maintenance and repair diagnostics
- Error detection and recovery.

4.2 Advanced Automation Functions
4.2.1 Safety Monitoring

There are two reasons for providing an automated system with a safety monitoring capability:

- To protect human workers in the vicinity of the system,
- To protect the equipment comprising the system.

4.2 Advanced Automation Functions
4.2.1 Safety Monitoring

Conventional safety measures taken in manufacturing operation: protective shields, safety boot, glove …or the kinds of manual devices that might be utilized by workers

4.2 Advanced Automation Functions
4.2.1 Safety Monitoring

Safety monitoring in an automated system involves the use of sensors

- To track the system's operation
- To identify conditions and events that are unsafe or potentially unsafe.

The safety monitoring systems (commonly use sensor)is programmed to respond to unsafe conditions in some appropriate way. Possible responses to various hazards include one or more of the following:

(1) Completely stopping the automated system,
(2) Sounding an alarm,
(3) Reducing the operating speed of the process, and
(4) Taking corrective actions to recover from the safety violation.

4.2 Advanced Automation Functions
4.2.1 Safety Monitoring

Some sensors for safety monitoring:

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

4.2 Advanced Automation Functions

4.2.2 Maintenance and Repair Diagnostics

Three modes of operation are typical of a modern maintenance and repair
diagnostics subsystem:

1. Status monitoring : the diagnostic subsystem monitors and records the status of key sensors and parameters of the system during normal operation. It can be used
   - Provide information for diagnosing a current failure
   - Provide data to predict the future malfunction or failure.
   - …..

4.2 Advanced Automation Functions
4.2.2 Maintenance and Repair Diagnostics

2. Failure diagnostics : invoke when a malfunction or failure occurs. Its purpose is to interpret the current values of the monitored variables and to analyze the recorded values preceding the failure so that its cause can be identified.

3. Recommendation of repair procedure: the subsystem recommends to the repair crew the steps that should be taken to effect repairs.

4.2 Advanced Automation Functions
4.2.2 Error Detection and Recovery

Error Detection

In analyzing a given production operation, the possible errors can be classified into one of three general categories:

- Random errors: occurs due to the stochastic nature of the process
- Systematic errors: results from some assignable cause such a change in raw materials or drift in an equipment setting
- Aberrations: results from either an equipment failure or a human mistake.

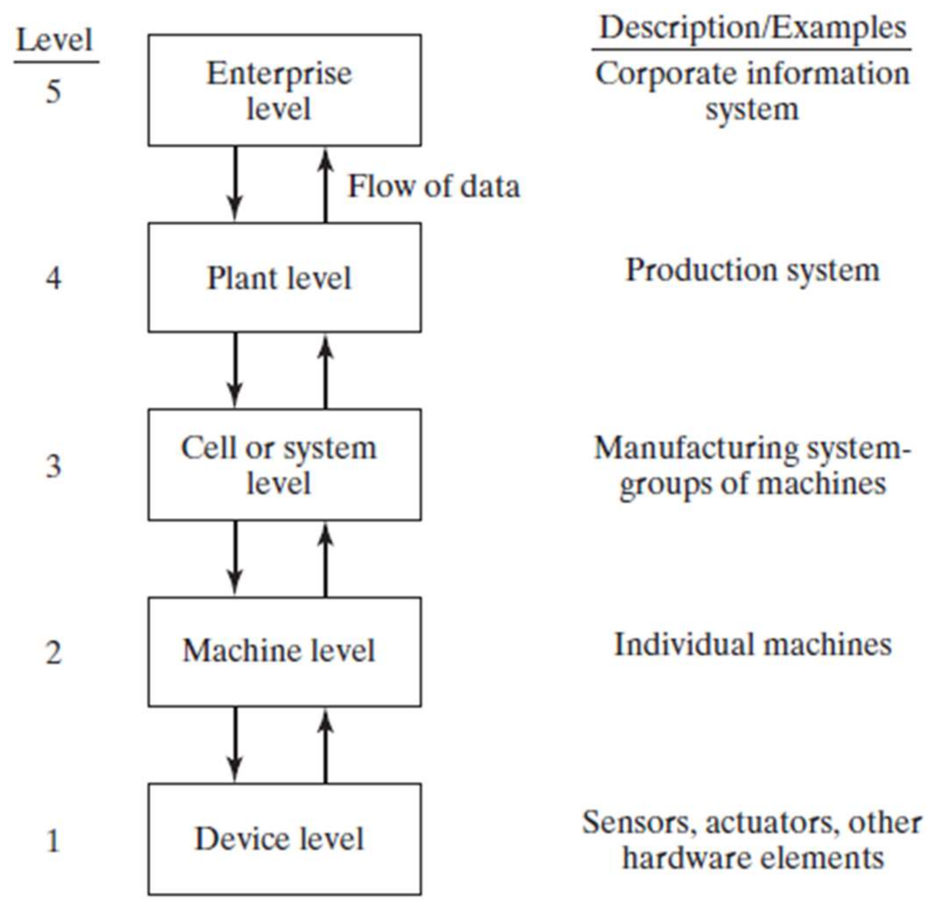
4.2 Advanced Automation Functions
4.2.2 Error Detection and Recovery

Error Recovery

Generally, a specific recovery strategy and procedure must be designed for each different error. The types of strategies can be classified as follows:

1. Make adjustments at the end of the current work cycle.
2. Make adjustments during the current cycle.
3. Stop the process to invoke corrective action.
4. Stop the process and call for help.

4.3 Levels of Automation



References

Mikell P. Groover, “Automation, Production Systems and Computer-integrated Manufacturing” , 4th edition, Pearson, chapter 2