20IS603 Architecture of Intelligent Systems

Systems for Interpretation and Diagnosis

Lecture #15

Diagnosis and Interpretation

- Diagnosis is the process of determining the nature of a fault or malfunction, based on a set of symptoms.
- Input data (symptoms) are interpreted and the underlying cause of these symptoms is the output.
- Diagnosis is a special case of the more general problem of interpretation.
- Interpreting data than diagnosing - x-ray, ultrasonic images; meters, gauges, and statistical data.
- With the inception of expert systems, diagnosis and interpretation have become preferred application areas

Deduction and Abduction For Diagnosis

- Deduction is used to predict an effect from a given cause.
- While deductive rules have an important role to play, they are inadequate on their own for problems of diagnosis and interpretation.
- Instead of determining an effect given a cause, diagnosis and interpretation involve finding a cause given an effect - termed as abduction.
- Three different approaches to tackling the uncertainty of abduction:
  - Exhaustive testing
  - Explicit modeling of uncertainty, and
  - Hypothesize-and-test

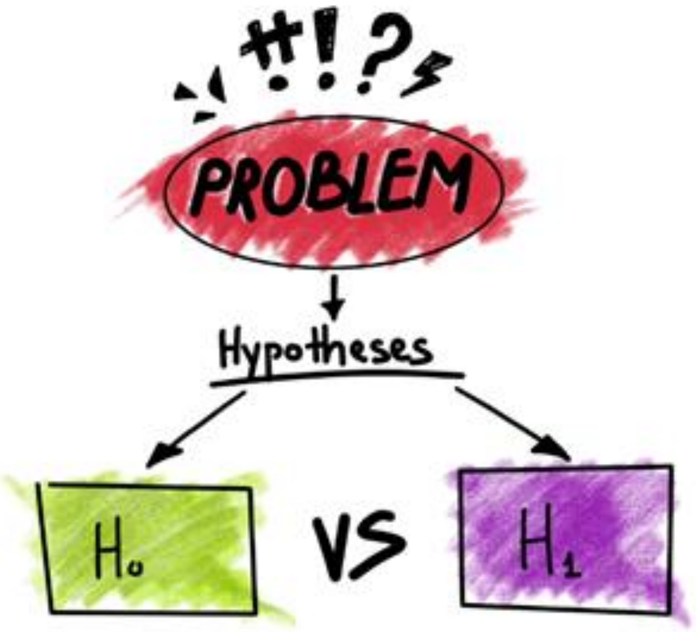
Deduction and Abduction For Diagnosis (2)

- Exhaustive testing
  - The conditions are exhaustively tested for every eventuality
  - Some rules can be used with confidence for both deduction and abduction describing a one-to-one mapping between cause and effect, such that no other causes can lead to the same effect – referred as reversible.

- Explicit modeling of uncertainty
  - Explicitly representing uncertainty.

Deduction and Abduction For Diagnosis (3)

- Hypothesize-and-test
  - A tentative hypothesis can be put forward for further investigation and may be subsequently confirmed or abandoned.
  - Nonmonotonic logic - an earlier conclusion may be withdrawn in the light of new evidence - termed as defeasible conclusion.
  - Hypothesize-and-test approach involves an active search for supporting evidence once a hypothesis has been drawn.
  - If sufficient evidence is found, the hypothesis becomes held as a conclusion.
  - If contrary evidence is found, then the hypothesis is rejected.
  - If insufficient evidence is found, the hypothesis remains unconfirmed.

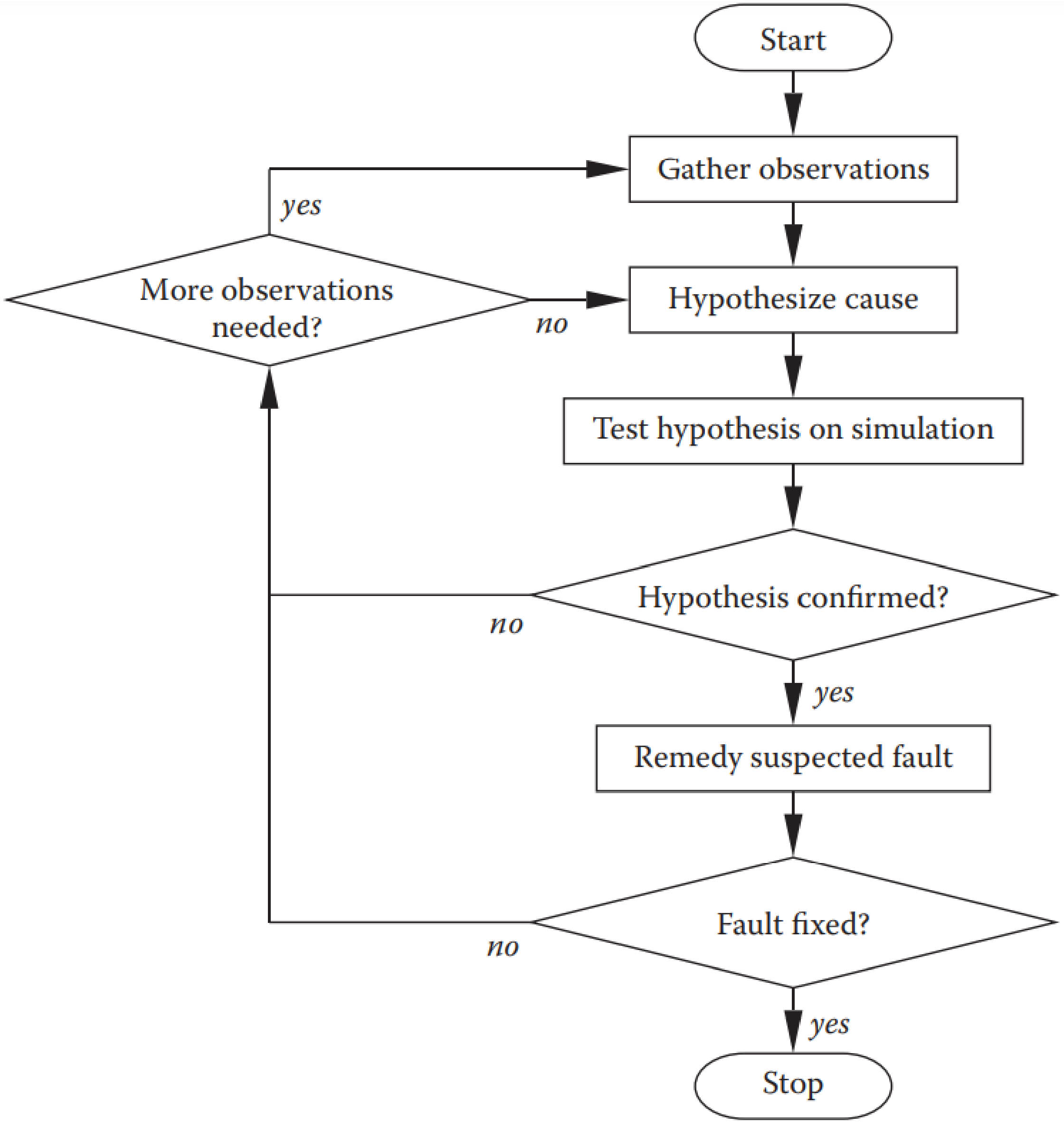


Model-based Reasoning

- Three major inadequacies of a purely rule-based diagnostic system:
  - Building a complete rule set is a massive task. For every possible failure, the rule-writer must predict a complete set of symptoms - in many cases, this information may not even be available because the failure may never have happened before.
  - Symptoms are often in the form of sensor readings, and a large number of rules is needed solely to verify the sensor data - related sensors must be checked.
  - Even supposing that a complete rule set could be built, it would rapidly become obsolete. As there is frequently an interdependence between rules, updating the rule base may require more thought than simply adding new rules.
- These difficulties can be avoided by a model of the physical system. Rather than storing a huge collection of symptom–cause pairs in the form of rules, these pairs can be generated by applying physical principles to the model.

Model-based Reasoning (2)

- Model to assist in diagnostic task:
  - Monitoring the device to check for malfunctions
  - Finding a suspect component, thereby forming a tentative diagnosis
  - Confirming or refuting the tentative diagnosis by simulation
- When a malfunction has been detected, the *single point of failure* assumption is often made - the malfunction has only one root cause

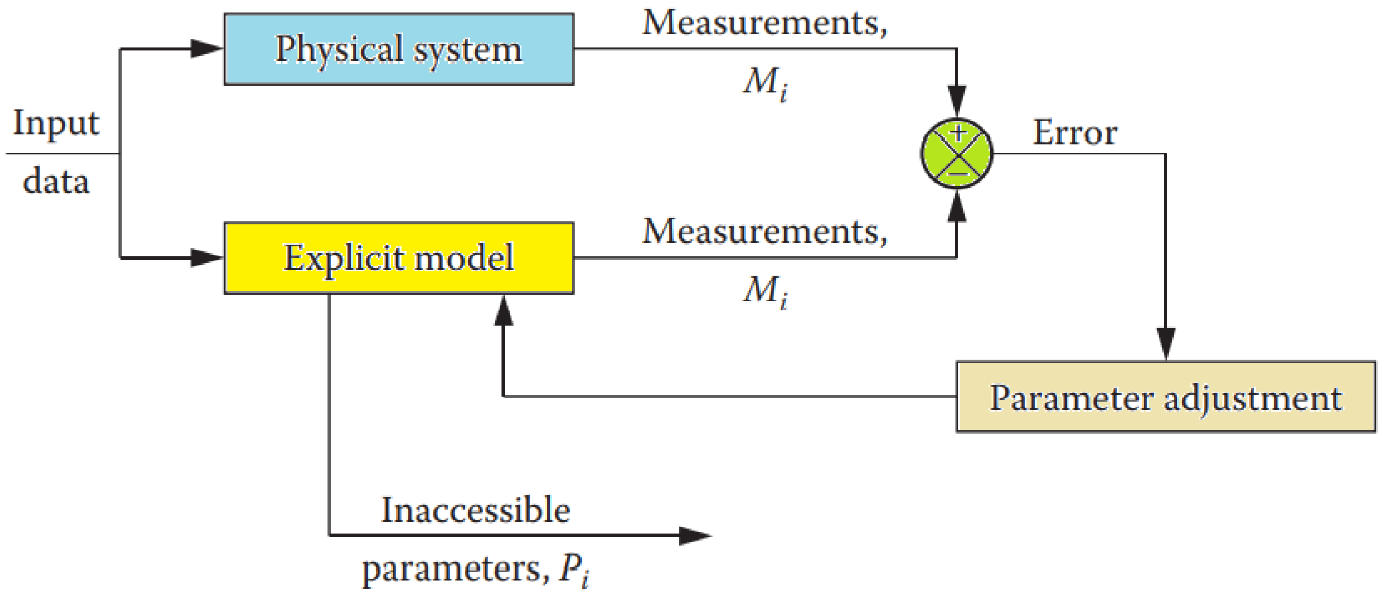


Model-based Reasoning (3)

- A model can be used to simulate the behavior of a device.
- The output (e.g., data, a substance, or a signal) from one component forms the input to another component.
- Rules or algorithms that can translate the available measurements (Mi) into the inaccessible parameters (Pi) are described as an implicit model.
- Obtaining a reliable implicit model is often difficult, and model-based reasoning normally refers to the use of explicit models

Model-based Reasoning (3)

- The real system and the explicit model are operated in parallel, the model generating values for the available measurements (*Mi*) and the inaccessible parameters (*Pi*).
- The model parameters (possibly including the parameters *Pi*) are adjusted to minimize the difference between the values of *Mi* generated by the model and the real system - called the *error*.
- If a critical parameter *Pi* in the model deviates from its expected value, it is assumed that the same has occurred in the physical system and an alarm is triggered.

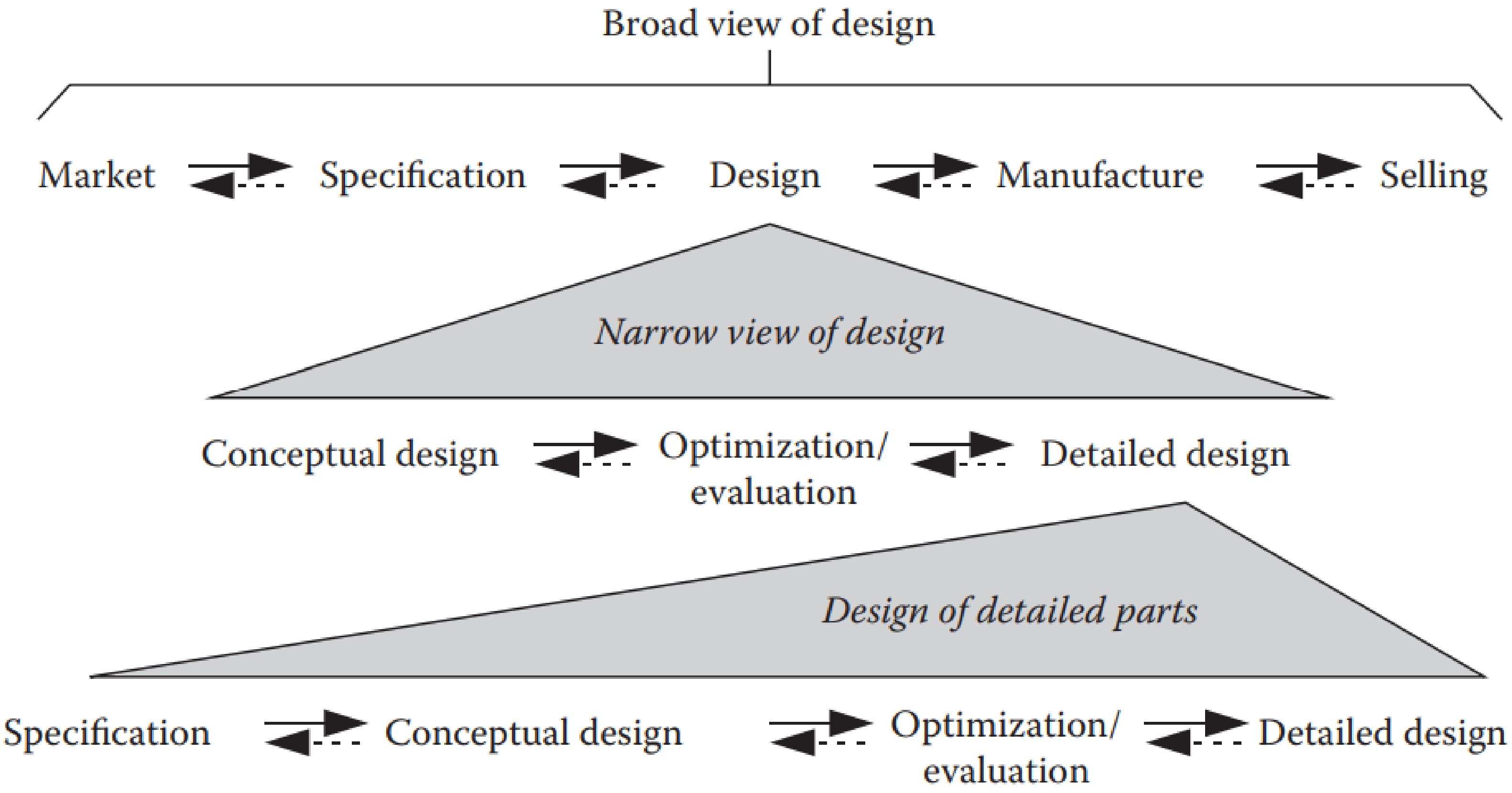


20IS603 Architecture of Intelligent Systems

Systems for Design and Selection

The Design Process

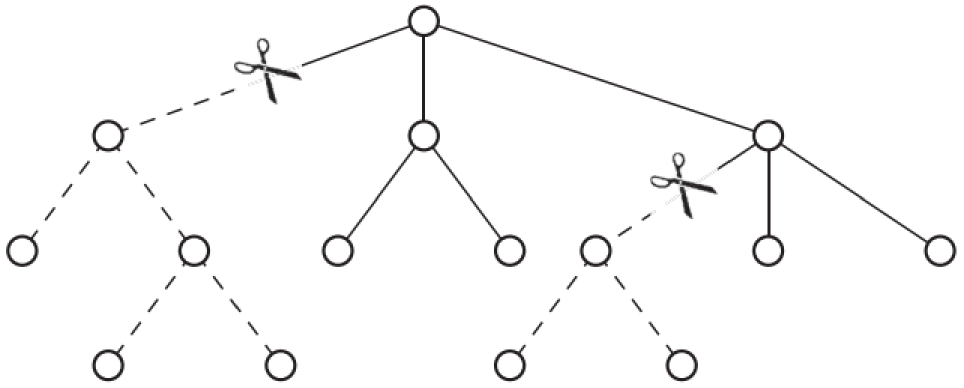
- Knowledge-based systems can be applied to design
- Design is the process of specifying a description of an artifact that satisfies constraints arising from a number of sources by using diverse sources of knowledge.



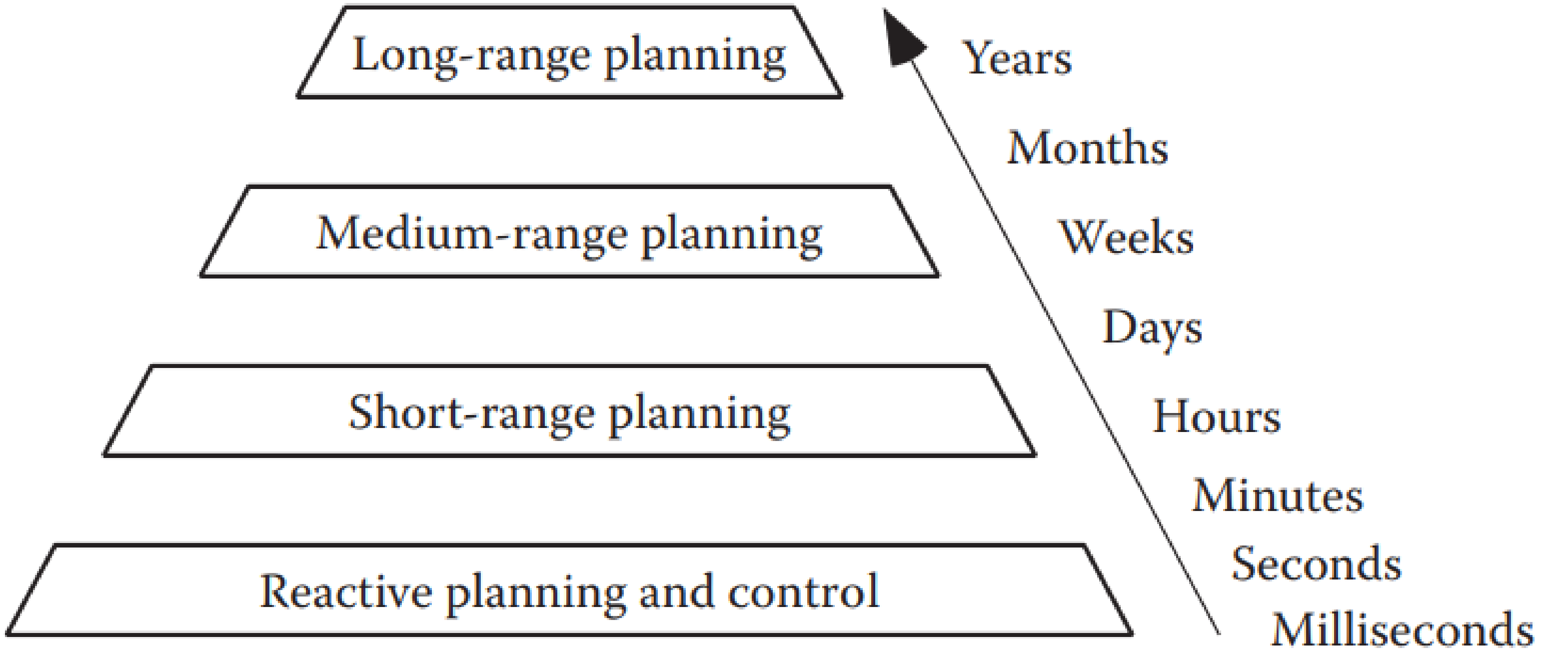
Design as a search problem

- Design can be viewed as a search problem, as it involves searching for an optimum or adequate design solution.
- Alternative solutions may be known in advance - derivation problems

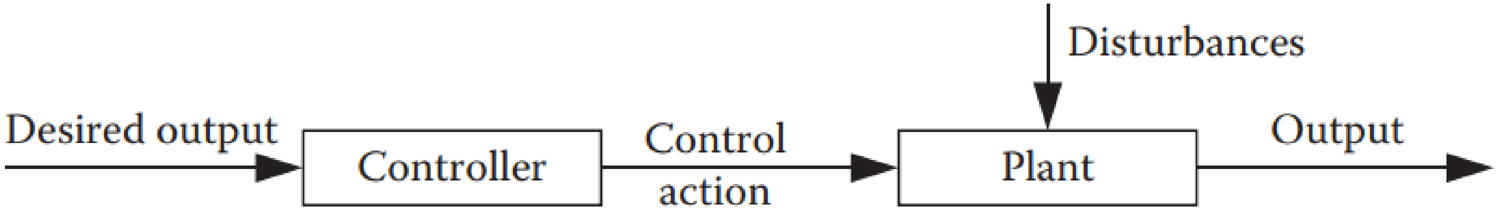
  or they may be generated automatically - formulation problems
- Designs may be tested as they are found in order to check whether they are feasible and meet the design requirements - generate and test method
- In design, there are likely to be many solutions, and required to find “the best” - search continue in order to find many feasible designs from which a selection can be made.



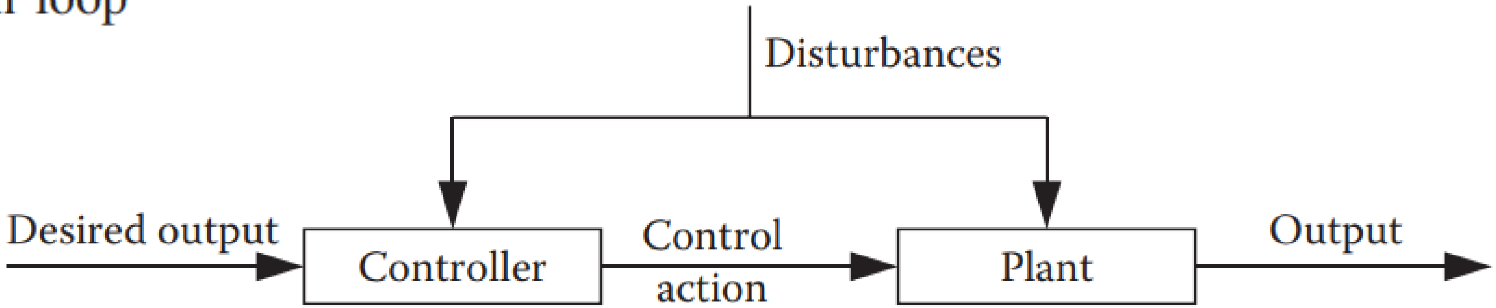
Systems for Planning



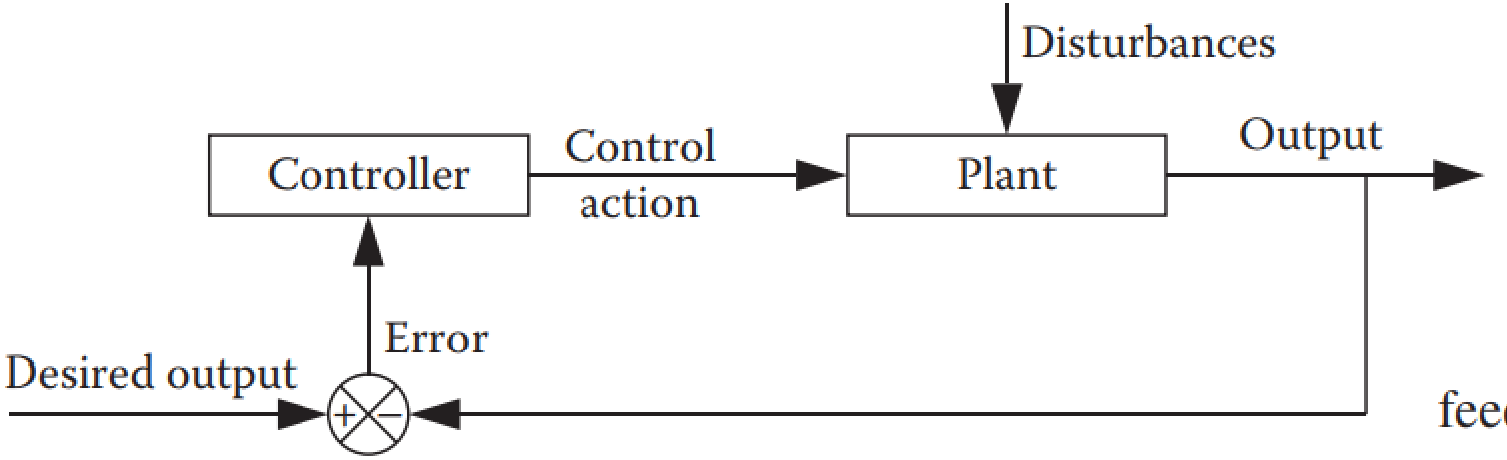
Systems for Control



open loop



feedforward



feedback (closed loop).

Systems for Control