Lecture Series on

Intelligent Control

Lecture 1

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About Prof. Kwang Lee

- Professional
  - BSEE from Seoul National University, MSEE from North Dakota State, Ph.D. from Michigan State
  - ROTC & Army Signal Corps for 2 years
  - Electric Industry (Han Young) for 1 year
  - Faculty at MSU, OSU, UH, Penn State doing teaching and research in electric power systems
  - Have been at Baylor since 2007 as ECE Chair
  - Doing research in power systems, power plants, fuel cell, intelligent systems
  - Teaching power systems, linear systems, optimal control, intelligent control

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About Prof. Kwang Lee

- Personal
  - Have two sons & 6 grandchildren
    - Jonathan, age 26
    - Owen, age 23
    - Franziska, age 20
    - Esme, age 18
    - Jesse, age 15
    - Teddy, age 12

  - Live near campus on Hackberry Ave
  - Member of Fellowship Bible Church on Speegleville Road
  - Attend Bible Study Fellowship on Monday evenings

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Intelligent Systems

General characterization:

An intelligent system has the ability to act appropriately in an uncertain environment,

where an appropriate action is that which increases the probability of success, and success is the achievement of behavioral subgoals that support the system's ultimate goal [Antsaklis, 1994].

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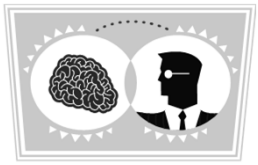
Intelligent Systems

In order for a man-made intelligent system to act appropriately, it may emulate functions of created beings:

living creatures and human mental faculties.



There are degrees or levels of intelligence that can be measured along the various dimensions of intelligence.

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Alternative Definitions

1. ***Man-made systems and intelligent machines:***

Machine intelligence is the process of analyzing, organizing and converting data into knowledge,

where (machine) knowledge is defined to be the *structured information* acquired and applied to remove ignorance or uncertainty about a specific task pertaining to the intelligent machine.

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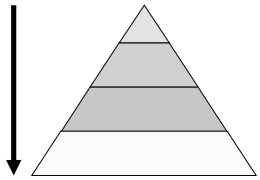
Alternative Definitions

This definition leads to *"the principle of increasing precision with decreasing intelligence."*

Applying machine intelligence to a data base generates a flow of knowledge, lending an analytic form to facilitate modeling of the process.



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Alternative Definitions

2. Ability to dynamically assign subgoals and control actions in an internal or autonomous fashion:

Many adaptive or learning control systems can be thought of as designing a control law to meet well-defined control objectives.

This activity represents the system's attempt to organize or order its "knowledge" of its own dynamical behavior, so as to meet a control objective.

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Alternative Definitions

The organization of knowledge can be seen as one important attribute of intelligence.

If this organization is done autonomously by the system, then intelligence becomes a property of the system, rather than of the system's designer.

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Alternative Definitions

3. A procedural characterization:

Intelligence is a property of a system that emerges when the procedures of focusing attention, combinatorial search, and generalization are applied to the input information in order to produce the output.

Once a string of the above procedures is defined, the other levels of resolution of the structure of intelligence are growing as a result of the recursion.

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Control and Intelligent Systems

The concepts of *intelligence* and *control* are closely related and the term "intelligent control" has a unique meaning.

An intelligent system must define and use goals.

Control is then required to move the system to these goals and to define such goals. *Consequently, any intelligent system will be a control system.*

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Control and Intelligent Systems

Conversely, intelligence is necessary to provide desirable functioning of systems under changing conditions, and it is necessary to achieve a high degree of autonomous behavior in a control system.

Since control is an essential part of any intelligent system, the term *"intelligent control systems"* is sometimes used in engineering literature instead of "intelligent systems" or “intelligent machines.”

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Control and Intelligent Systems

One more alternative characterization of *intelligent (control) systems* is the following:

An intelligent control system is designed so that it can autonomously achieve a high-level goal,

while its components, control goals, plant models and control laws are not completely defined, either because they were not known at the design time or because they changed unexpectedly.

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Dimensions of Intelligent Systems

There are several essential properties present in different degrees in intelligent systems.

Adaptation and Learning. The ability to adapt to changing conditions is necessary in an intelligent system.

Although adaptation does not necessarily require the ability to learn, for systems to be able to adapt to a wide variety of unexpected changes, learning is essential.

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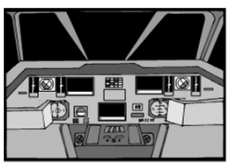
Dimensions of Intelligent Systems

Autonomy and Intelligence.

The autonomy in setting and achieving goals is an important characteristic of intelligent control.

When a system has the ability to act appropriately in an uncertain environment for extended periods of time without external intervention, it is considered to be highly autonomous.



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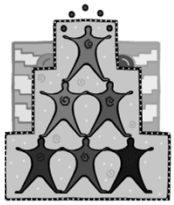
Dimensions of Intelligent Systems

Structures and Hierarchies.

In order to cope with complexity,

an intelligent system must have an appropriate functional architecture or structure for efficient analysis and evaluation of control strategies.



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Working Definition

In view of the above, a working characterization of intelligent systems, or of (highly) intelligent (control) systems or machines, that capture the essential characteristics present in any such system is:

- An ***intelligent system*** must be highly adaptable to significant unanticipated changes, and so learning is essential.
- It must exhibit a high degree of autonomy in dealing with changes.
- It must be able to deal with significant complexity, and this leads to certain sparse types of functional architectures such as hierarchies.

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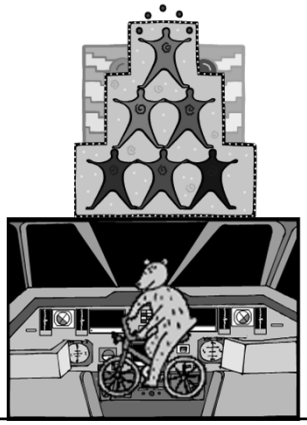

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