Decision Making Using Fuzzy Logic

Lecture 8

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Background

- Decision making in multi parameters systems
- Example: degree of damage in system
- Take into account the **condition of component** and **importance of the component**

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Fuzzy Weighted Expression

$$Y = \frac{\sum_{i=1}^{n} W_i X_i}{\sum_{i=1}^{n} W_i}$$

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Take Home Problem

	[Xia, Xib]	*[Wia, Wib]*
Attribute 1	[0.4, 0.6]	[0.8,1.0]
Attribute 2	[0.7,0.96]	[0.5,0.9]
Attribute 3	[0.1,0.3]	[0.8,1.0]
Attribute 4	[0.0,0.2]	[0.5,0.9]

Find Y

4

Take Home Problem

	[Xia, Xib]	*[Wia, Wib]*
Attribute 1	[0.4, 0.6]	[0.8,1.0]
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Attribute 4	[0.0,0.2]	[0.5,0.9]

Y = [0.241,0.561]

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Fuzzy Control System

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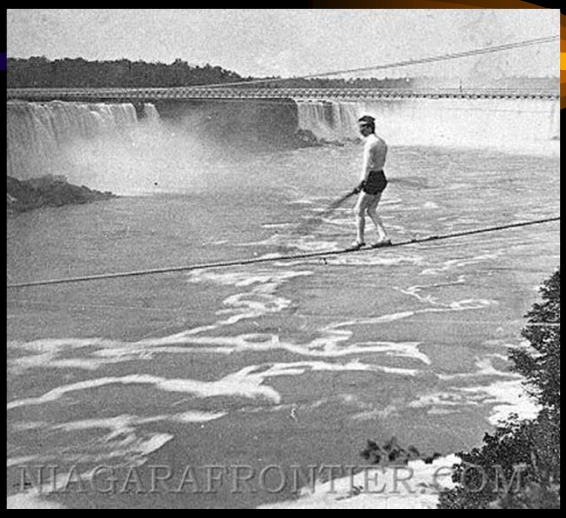
Niagara Falls
DAREDEVILS OF NIAGARA FALLS
a history



http://www.niagarafrontier.com/devil_frame.html

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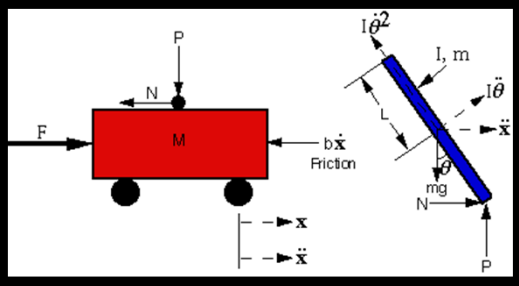
Inverted Pendulum



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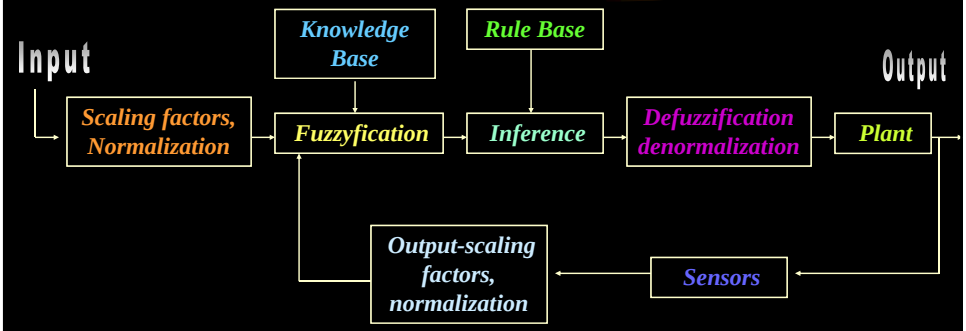
Simple Fuzzy Logic Control System block diagram



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Design Steps

- Step 1: Identify the variables (Inputs, states, and outputs) of the plant
- Step 2: Partition the universe of discourse or the interval spanned by each variable into a number of fuzzy subsets, assigning each a linguistic label (subsets include all the elements in the universe)
- Step 3: Assign or determine a membership function for each fuzzy subset
- Step 4: Assign the fuzzy relationships between the inputs' or states' fuzzy subsets on the one hand and the outputs' fuzzy subsets on the other hand, thus forming the rule-base

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Design Steps

- Step 5: Choose appropriate scaling factors for the input and output variables in order to normalize the variables to the [0,1] or the [-1,1] interval
- Step 6: Fuzzify the inputs to controller
- Step 7: Use fuzzy approximate reasoning to infer the output contributed from each rule.
- Step 8: Aggregate the fuzzy outputs recommended by each rule
- Step 9: Apply defuzzification to form a crisp output

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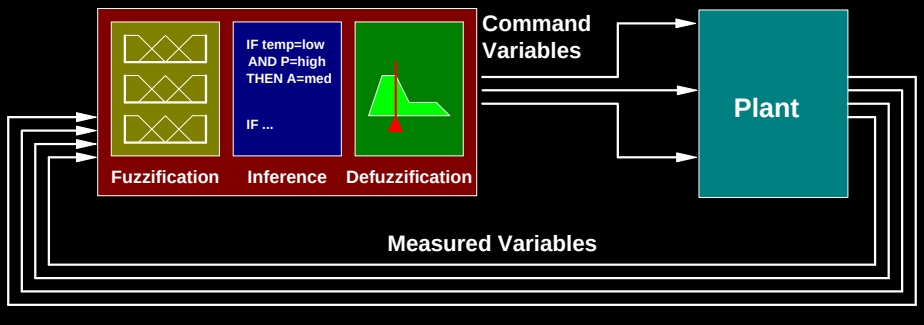
Types of Fuzzy Controllers: - Direct Controller -

The Outputs of the Fuzzy Logic System Are the Command Variables of the Plant:



Fuzzy Rules Output Absolute Values !

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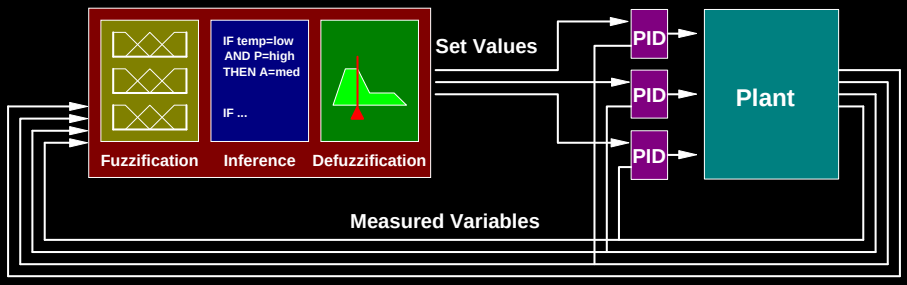
Types of Fuzzy Controllers: - Supervisory Control -

Fuzzy Logic Controller Outputs Set Values for Underlying PID Controllers:



PID → Proportional-Integral-Derivative

Human Operator Type Control !

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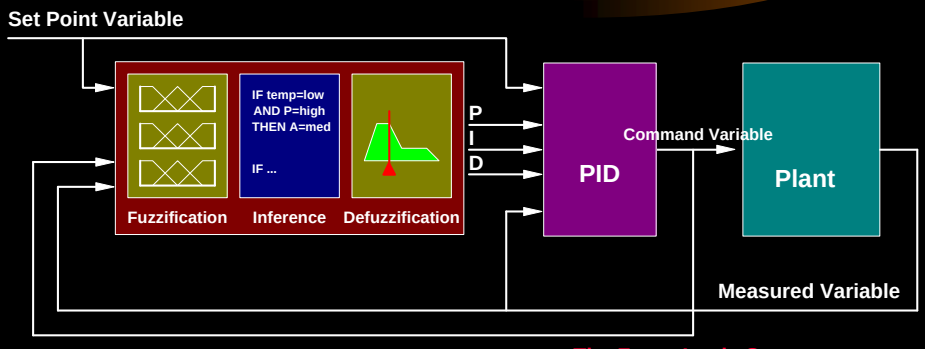
Types of Fuzzy Controllers: - PID Adaptation -

Fuzzy Logic Controller Adapts the P, I, and D Parameter of a Conventional PID Controller:



PID → Proportional-Integral-Derivative

The Fuzzy Logic System Analyzes the Performance of the PID Controller and Optimizes It !

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Fuzzy Control

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Simplified Examples of Applications

- Washing Machine
- Vacuum Cleaner
- Traffic Control

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Washing Machine

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Washing Machine

- Washing Parameters
- **Inputs – The actual weight, fabric types and amount of dirt**
- **Output – Amount of detergent, washing time, agitation, water level, and temperature**
- Controlling above parameters – Leads to a cleaner laundry, conservation of water, savings in detergent, electricity, time and money

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Simplified Model – Washing Machine

- Inputs – The dirtiness of the load as measured by the opacity of the washing water using an optical sensor system
- The weight of the laundry load as measured by the pressure sensor system
- Output – The amount of detergent dispensed.

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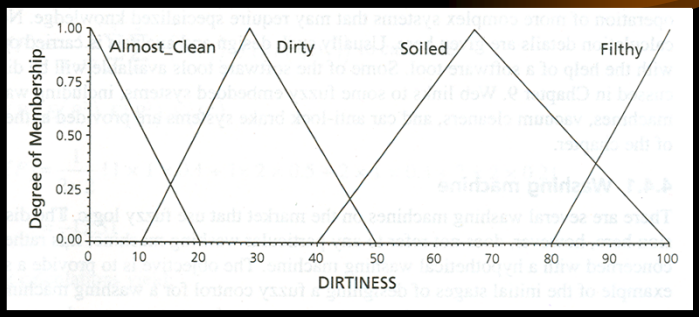
Dirtiness



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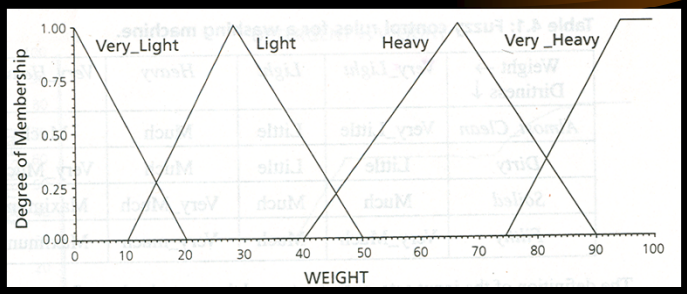
Weight



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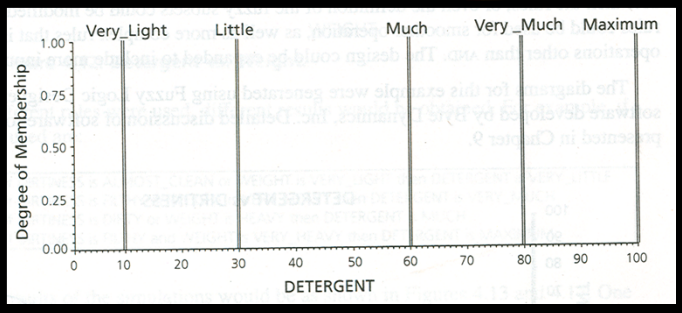
Detergent



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Suggested Rules

if DIRTINESS is ALMOST_CLEAN and WEIGHT is VERY_LIGHT then DETERGENT is VERY_LITTLE
if DIRTINESS is DIRTY and WEIGHT is VERY_LIGHT then DETERGENT is LITTLE
if DIRTINESS is SOILED and WEIGHT is VERY_LIGHT then DETERGENT is MUCH
if DIRTINESS is FILTHY and WEIGHT is VERY_LIGHT then DETERGENT is VERY MUCH
if DIRTINESS is ALMOST_CLEAN and WEIGHT is LIGHT then DETERGENT is VERY_LITTLE
if DIRTINESS is DIRTY and WEIGHT is LIGHT then DETERGENT is LITTLE
if DIRTINESS is SOILED and WEIGHT is LIGHT then DETERGENT is MUCH
if DIRTINESS is FILTHY and WEIGHT is LIGHT then DETERGENT is MUCH
if DIRTINESS is ALMOST_CLEAN and WEIGHT is HEAVY then DETERGENT is MUCH
if DIRTINESS is DIRTY and WEIGHT is HEAVY then DETERGENT is MUCH
if DIRTINESS is SOILED and WEIGHT is VERY_HEAVY then DETERGENT is VERY_MUCH
if DIRTINESS is FILTHY and WEIGHT is HEAVY then DETERGENT is MAXIMUM
if DIRTINESS is ALMOST_CLEAN and WEIGHT is VERY_HEAVY then DETERGENT is MUCH
if DIRTINESS is DIRTY and WEIGHT is VERY_HEAVY then DETERGENT is VERY_MUCH
if DIRTINESS is SOILED and WEIGHT is VERY_HEAVY then DETERGENT is MAXIMUM
if DIRTINESS is FILTHY and WEIGHT is VERY_HEAVY then DETERGENT is MAXIMUM

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Fuzzy Control Rules

Weight → Dirtiness ↓	*Very_Light*	*Light*	*Heavy*	*Very_Heavy*
Almost_Clean	Very_Little	Little	Much	Much
Dirty	Little	Little	Much	Very_Much
Soiled	Much	Much	Very_Much	Maximum
Filthy	Very_Much	Much	Very_much	Maximum

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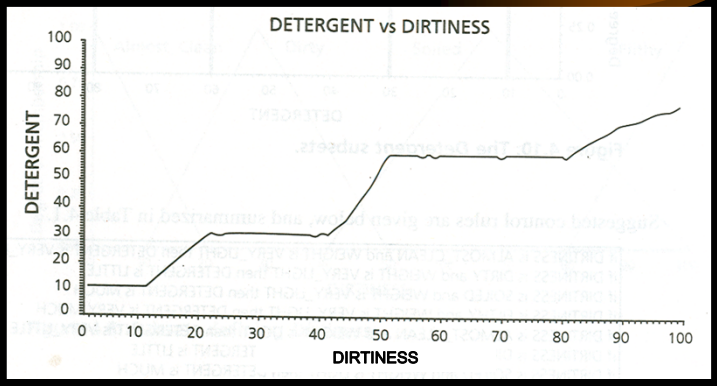
Detergent Vs Dirtiness



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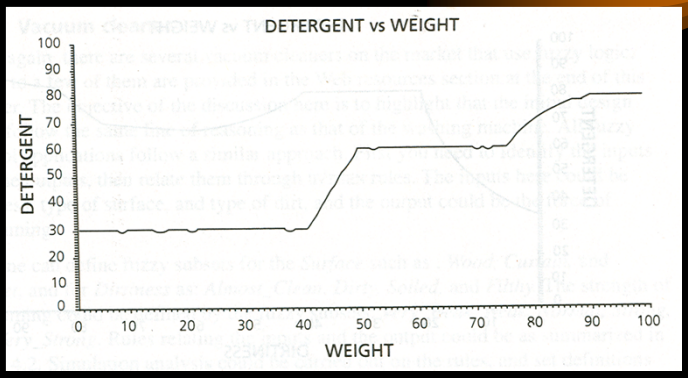
Detergent Vs Weight



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Vacuum Cleaner

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Vacuum Cleaner – Fuzzy Control Rules

Dirtiness → Surface ↓	*Almost_Clean*	*Dirty*	*Soiled*	*Filthy*
Wood	Very_Week	Week	Normal	Strong
Curtain	Very_Week	Normal	Strong	Very_Strong
Carpet	Week	Normal	Strong	Very_Strong

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