

# What is Fuzzy Logic

Fuzzy logic is  
a *convenient way* to *map*  
an input space to an output space.

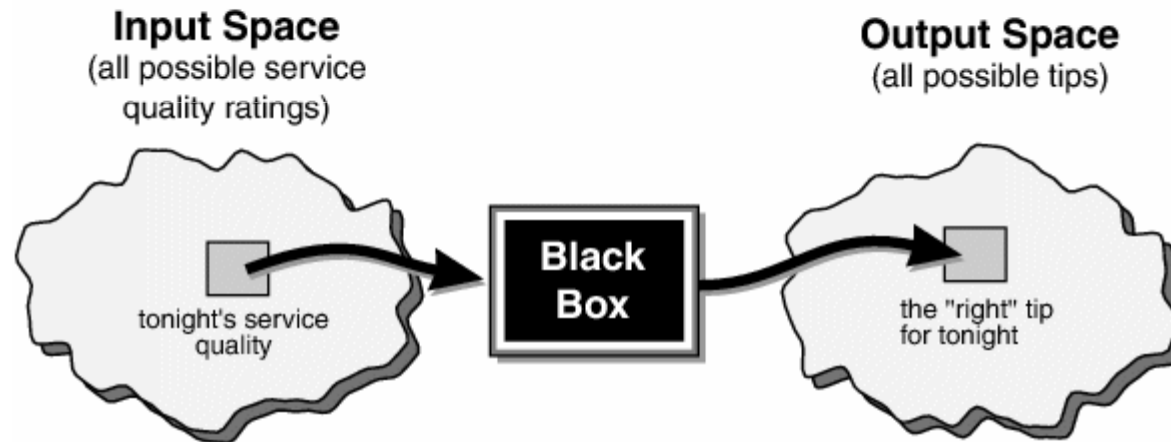
# What is Fuzzy Logic

**Fuzzy logic is a convenient way to map an input space to an output space.**

- \* With information about how good your service was at a restaurant, a fuzzy logic system can tell you what the tip should be.
- \* With your specification of how hot you want the water, a fuzzy logic system can adjust the faucet valve to the right setting.
- \* With information about how far away the subject of your photograph is, a fuzzy logic system can focus the lens for you.
- \* With information about how fast the car is going and how hard the motor is working, a fuzzy logic system can shift gears for you.

# What is Fuzzy Logic

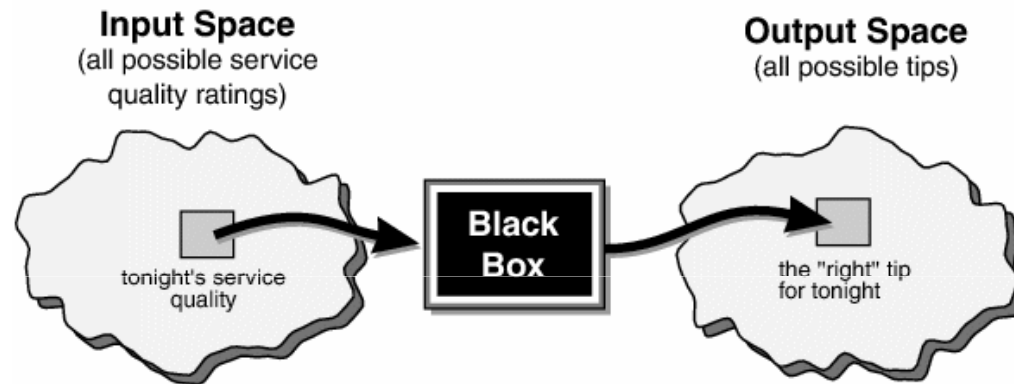
A graphical example of an input-output map



An input-output map for the tipping problem:  
"Given the quality of service, how much should I tip?"

# What is Fuzzy Logic

The black box can contain any number of things:



fuzzy systems,  
linear systems,  
neural networks,  
differential equations,  
interpolated multidimensional lookup tables,  
....

# Why use Fuzzy Logic

"In almost every case you can build the same product without fuzzy logic, but fuzzy is **faster** and **cheaper**."

-Lotfi Zadeh

# Why use Fuzzy Logic

Here is a list of general observations about fuzzy logic:

- Fuzzy logic is conceptually easy to understand.
- Fuzzy logic is flexible
- Fuzzy logic is tolerant of imprecise data.
- Fuzzy logic can model nonlinear functions of arbitrary complexity.
- Fuzzy logic can be blended with conventional control techniques.
- Fuzzy logic is based on natural language.

# When NOT to Use Fuzzy Logic

If you find Fuzzy Logic is not convenient, try something else.

If a simpler solution already exists, use it.

# An Introductory Example: Fuzzy vs. Non-Fuzzy

What is the right amount to tip your waitperson?

The Basic Tipping Problem. Given a number between 0 and 10 that represents the quality of service at a restaurant (where 10 is excellent),

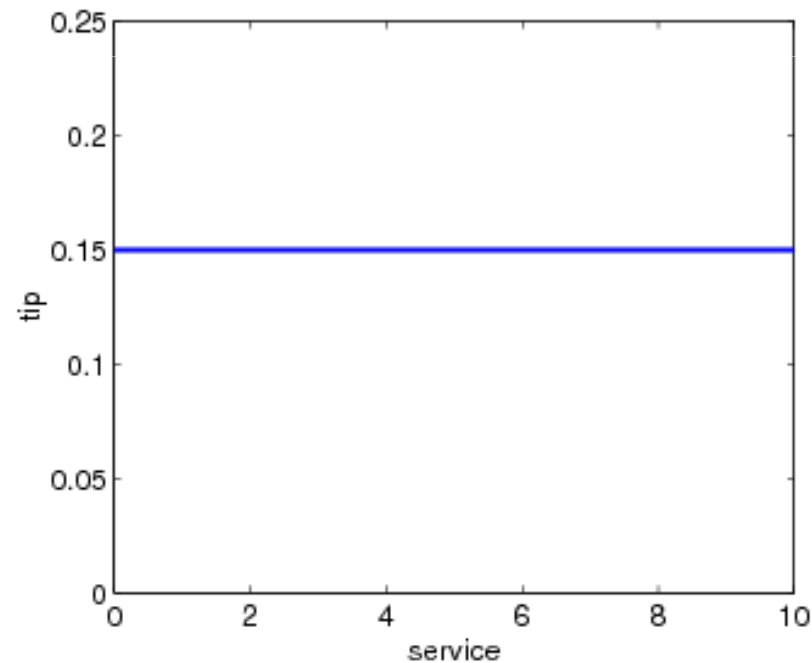
what should the tip be?



# An Introductory Example: Tipping Problem

## The Non-Fuzzy Approach

The tip always equals 15% of the total bill  
Tip=?

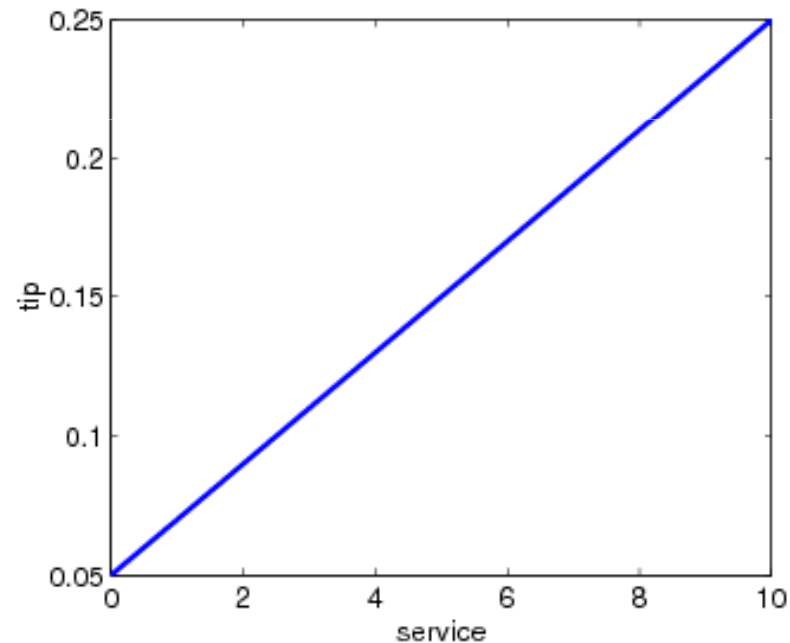


# An Introductory Example: Tipping Problem

## The Non-Fuzzy Approach

Because service is rated on a scale of 0 to 10, you might have the tip go linearly from 5% if the service is bad to 25% if the service is excellent.

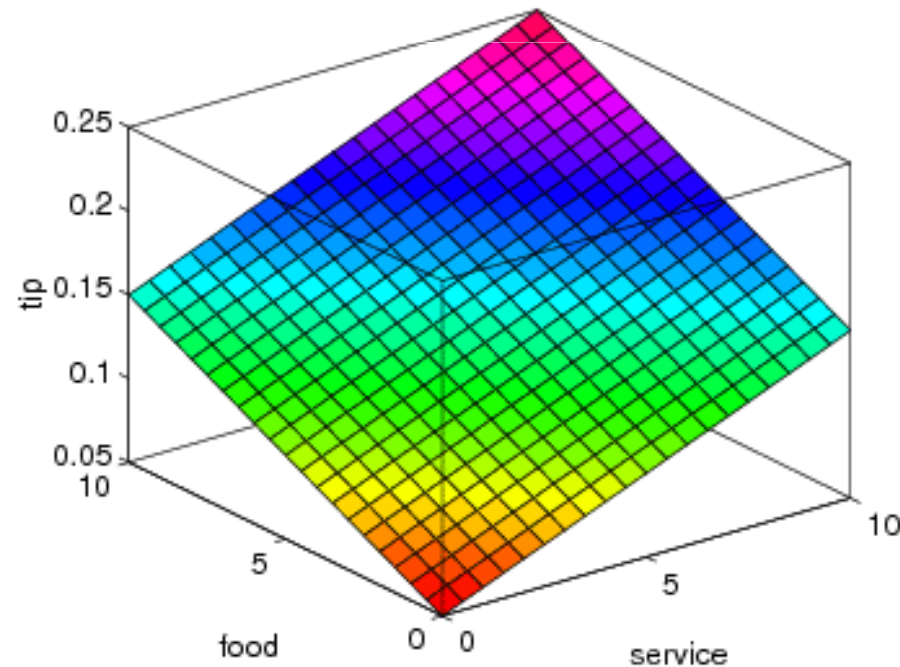
Tip=?



# An Introductory Example: Tipping Problem

## The Non-Fuzzy Approach

**The Extended Tipping Problem:** Given two sets of numbers between 0 and 10 (where 10 is excellent) that respectively represent **the quality of the service** and **the quality of the food** at a restaurant, what should the tip be?



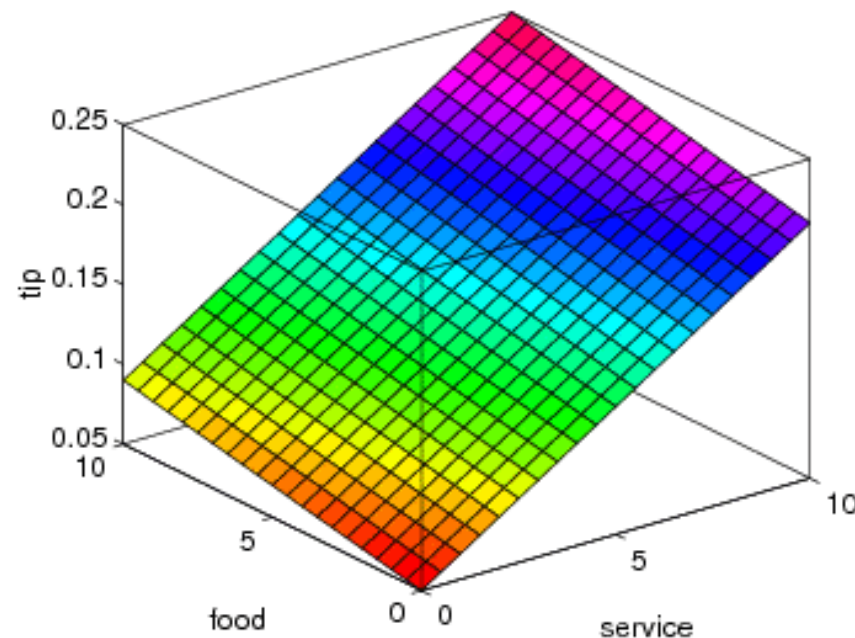
# An Introductory Example: Tipping Problem

## The Non-Fuzzy Approach

**The Extended Tipping Problem:** Given two sets of numbers between 0 and 10 (where 10 is excellent) that respectively represent **the quality of the service** and **the quality of the food** at a restaurant,

Suppose you want the service to be a more important factor than the food quality. Specify that service accounts for 80% of the overall tipping grade and the food makes up the other 20%.

what should the tip be?



# An Introductory Example: Tipping Problem

## The Fuzzy Approach

**The Extended Tipping Problem:** Given two sets of numbers between 0 and 10 (where 10 is excellent) that respectively represent **the quality of the service** and **the quality of the food** at a restaurant,

- **capture the essentials of this problem**
- **leave aside all the factors that could be arbitrary**
- **what really matters in this problem**

# An Introductory Example: Tipping Problem

## The Fuzzy Approach

**The Extended Tipping Problem:** Given two sets of numbers between 0 and 10 (where 10 is excellent) that respectively represent **the quality of the service** and **the quality of the food** at a restaurant,

### Tipping Problem Rules — Service Factor

If service is poor, then tip is cheap

If service is good, then tip is average

If service is excellent, then tip is generous

# An Introductory Example: Tipping Problem

## The Fuzzy Approach

**The Extended Tipping Problem:** Given two sets of numbers between 0 and 10 (where 10 is excellent) that respectively represent **the quality of the service** and **the quality of the food** at a restaurant,

### **Tipping Problem Rules — Service Factor**

If service is poor, then tip is cheap

If service is good, then tip is average

If service is excellent, then tip is generous

### **Tipping Problem Rules — Food Factor**

If food is rancid, then tip is cheap

If food is delicious, then tip is generous

# An Introductory Example: Tipping Problem

## The Fuzzy Approach

**The Extended Tipping Problem:** Given two sets of numbers between 0 and 10 (where 10 is excellent) that respectively represent **the quality of the service** and **the quality of the food** at a restaurant,

### **Tipping Problem Rules — Service Factor**

If service is poor, then tip is cheap

If service is good, then tip is average

If service is excellent, then tip is generous

### **Tipping Problem Rules — Food Factor**

If food is rancid, then tip is cheap

If food is delicious, then tip is generous

### **Tipping Problem — Both Service and Food Factors**

If service is poor OR the food is rancid, then tip is cheap

If service is good, then tip is average

If service is excellent OR food is delicious, then tip is generous



# An Introductory Example: Tipping Problem

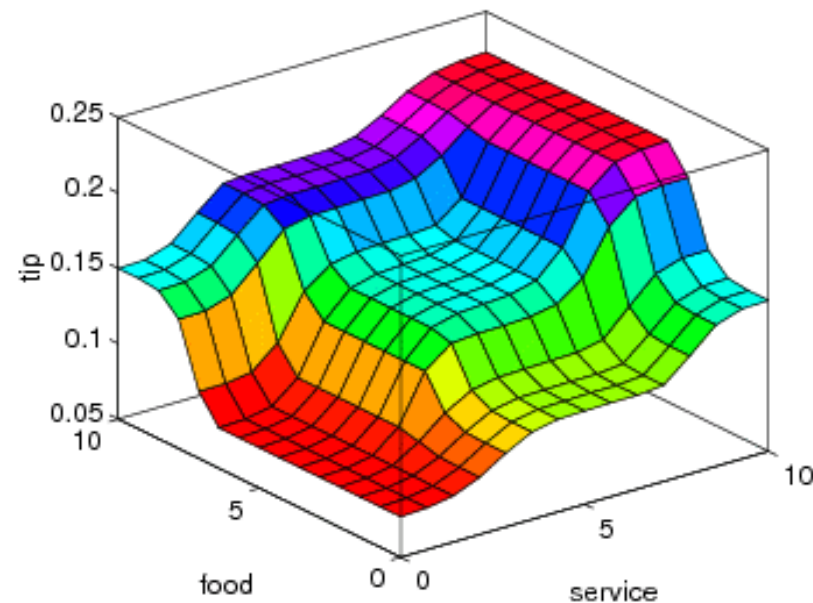
## The Fuzzy Approach

### Tipping Problem — Both Service and Food Factors

If service is poor or the food is rancid, then tip is cheap

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# An Introductory Example: Tipping Problem

## The Fuzzy Approach

### **Tipping Problem — Both Service and Food Factors**

If service is poor or the food is rancid, then tip is cheap

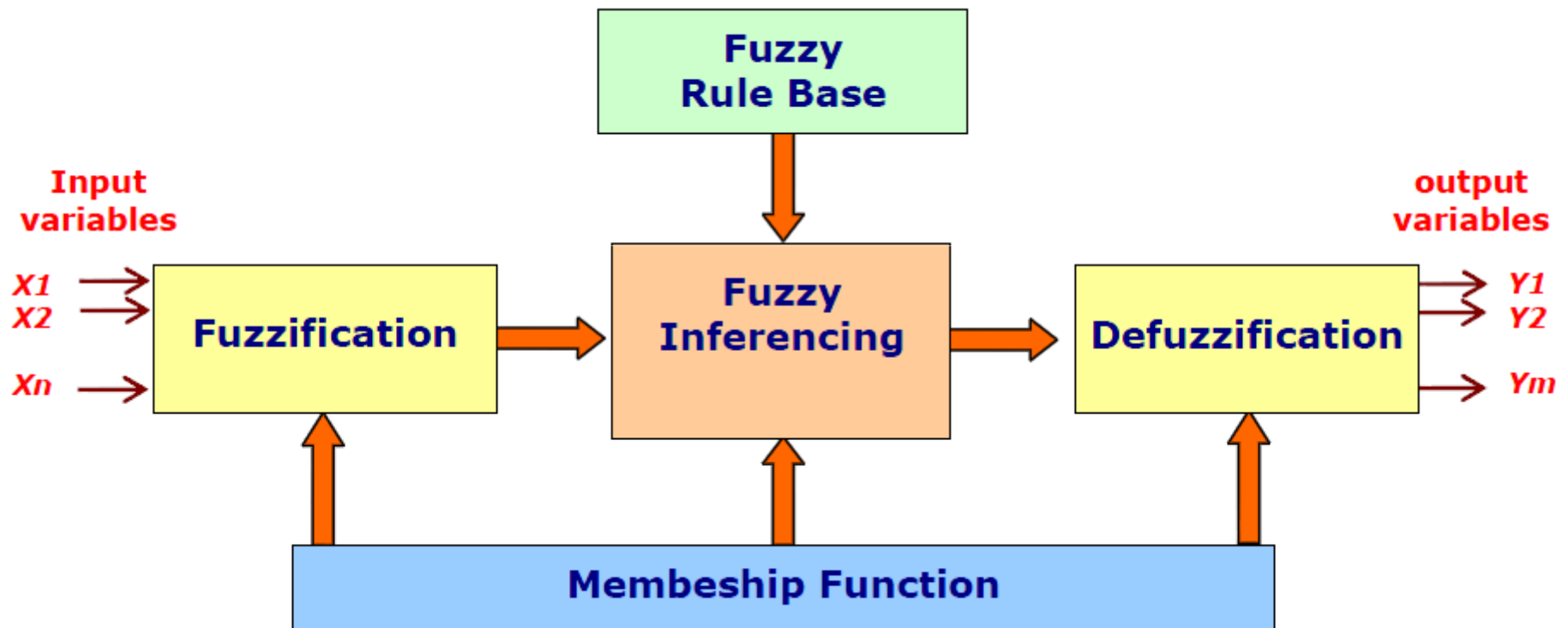
If service is good, then tip is average

If service is excellent or food is delicious, then tip is generous

# How are the rules all combined?

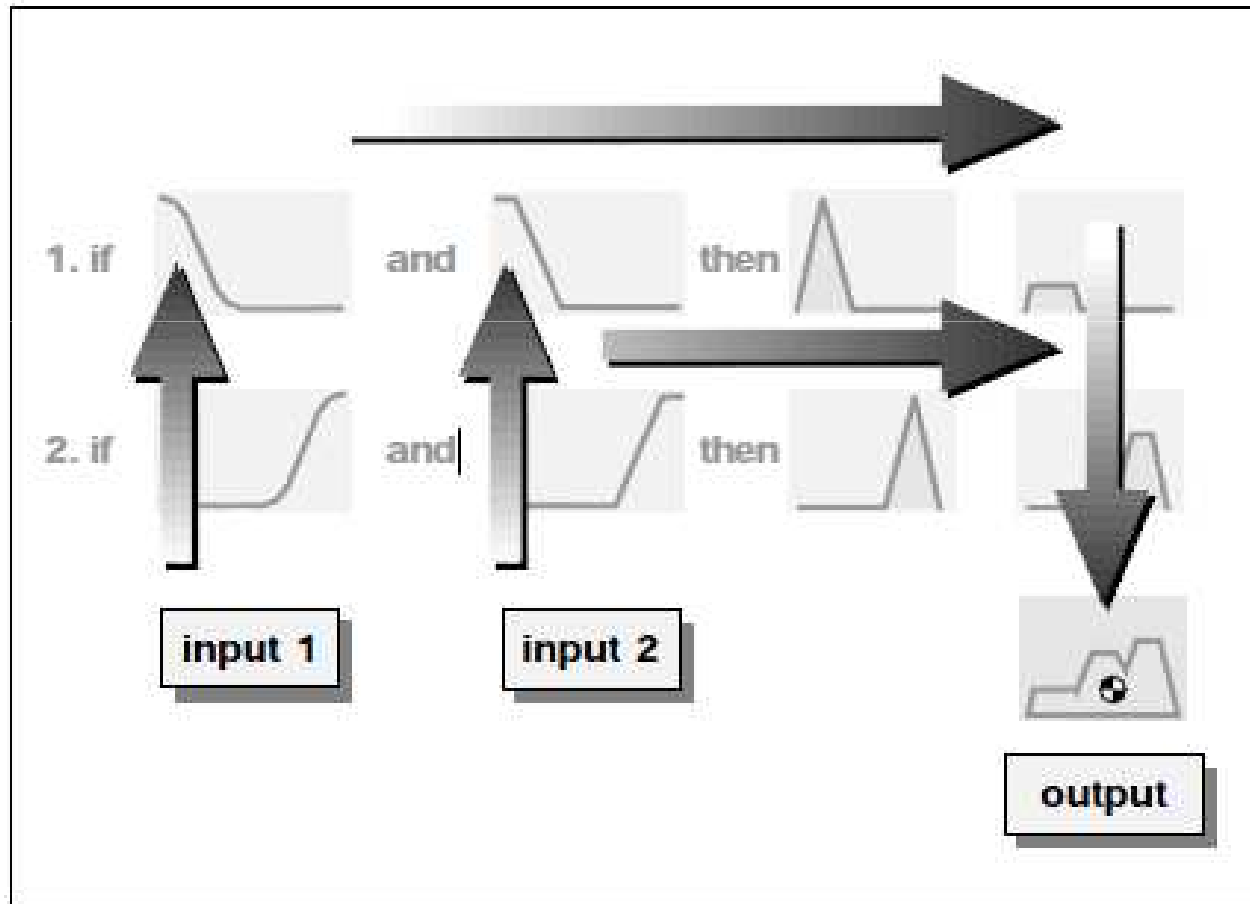
# How do I define mathematically what an average tip is?

# Fuzzy Logic System



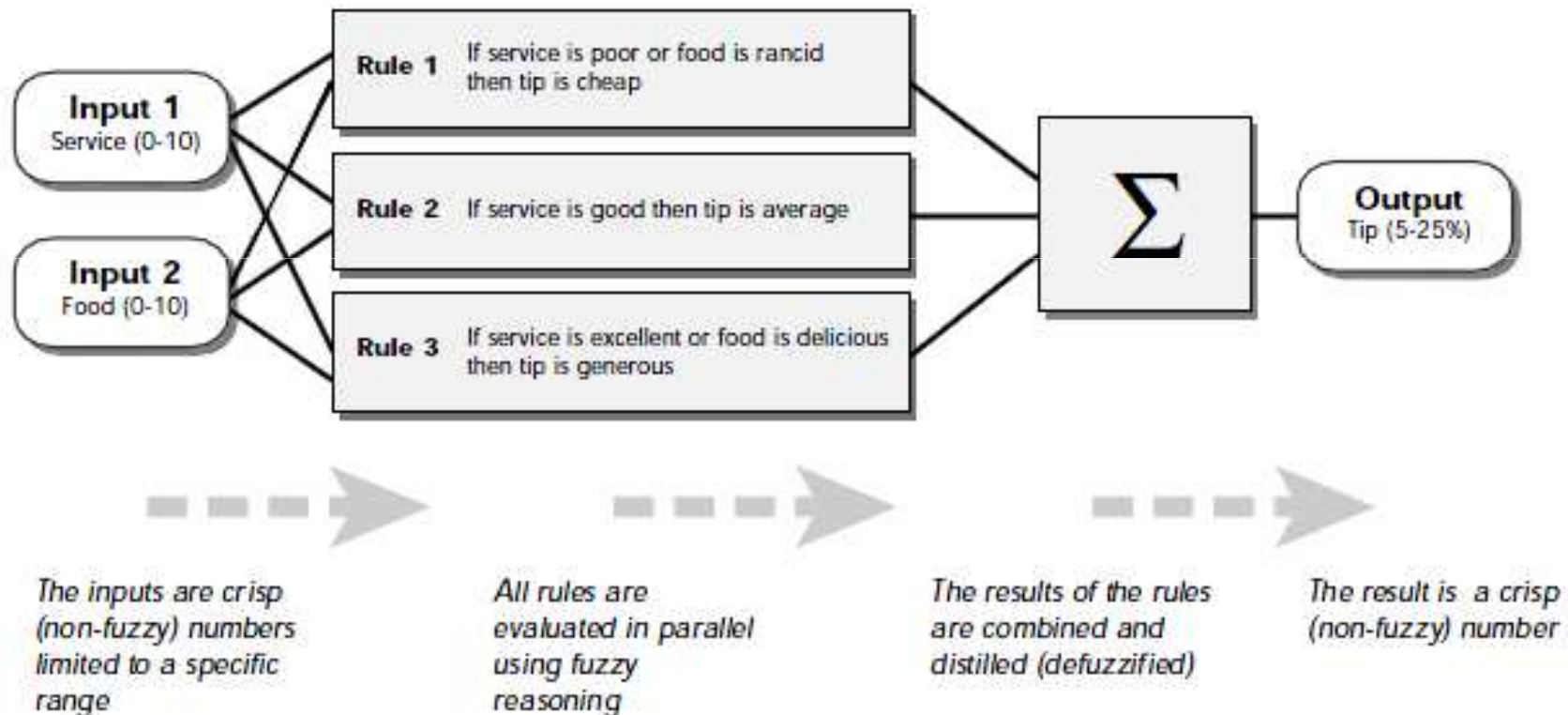
# Fuzzy Logic System

## Fuzzy Inference Diagram

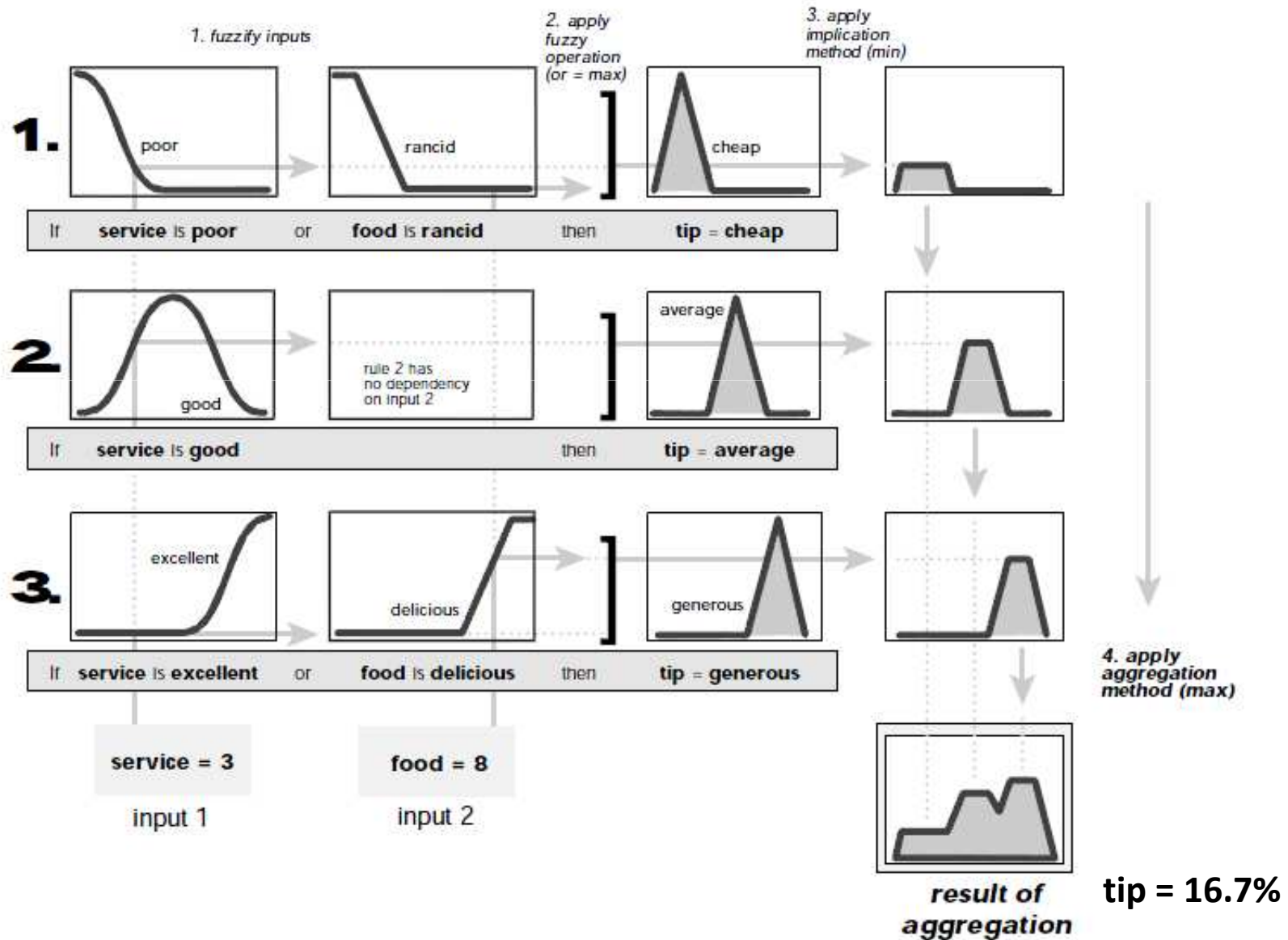


# Fuzzy Logic System

## A 2 input 1 output FLS



# Implementation of FLS



# Building System with the MATLAB Fuzzy Logic Toolbox

