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The World is a Fuzzy Place
A Beginners Guide To Fuzzy Logic

Brought to you by the
IEEE Computational Intelligence Society
Pre-College Subcommittee

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Tutorial Summary

- Engineering the world…….
- The world is not just BLACK and WHITE.
- What does it really mean to be tall ?
- Fuzzy sets and how you create them.
- So you think you can boil a perfect egg ?

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How Engineers Make a World of Difference

You can change the World !

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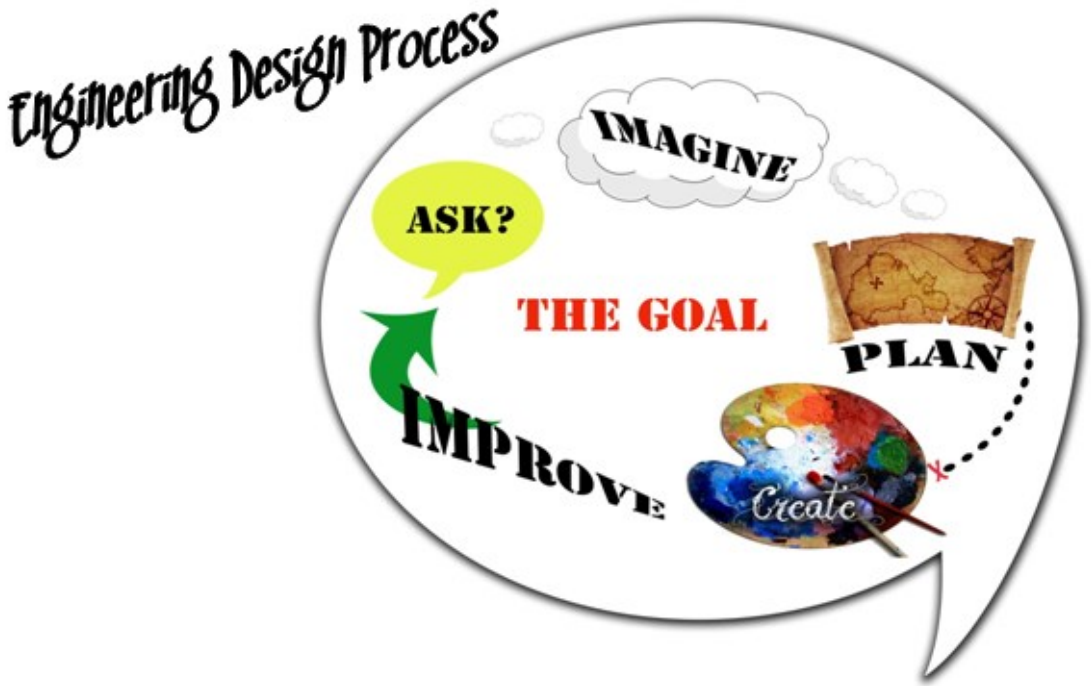
Engineering Design Process



ASK	IMAGINE	PLAN	CREATE	IMPROVE
Whats the problem?	What could be some solutions?	Draw a diagram.	Follow your plan and create it	Make your design
What have others done?	Brainstorm ideas.	Make a list of materials	Test it out!	even better!
What are the constraints?	Choose the best one!	you'll need		Test it out!

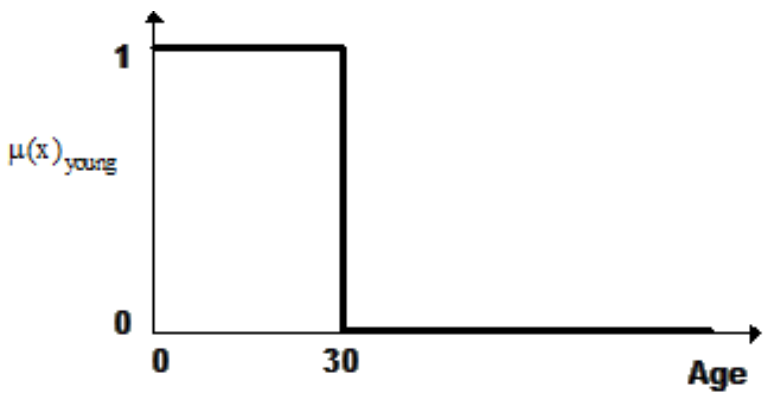
Engineers are Creative

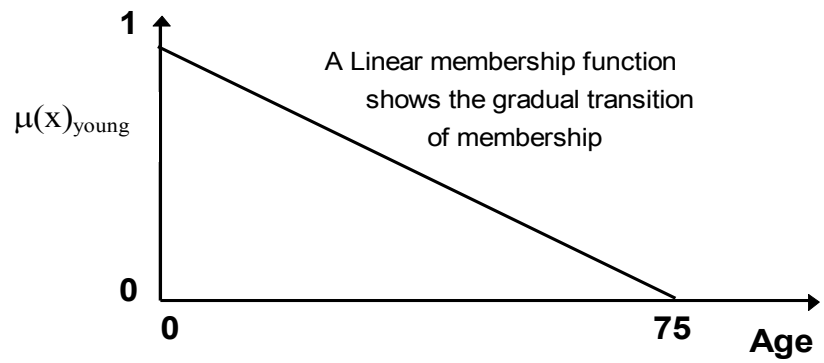
Human Dialog is Fuzzy

- Experts rely on common sense when they solve problems.
- How can we represent expert knowledge that uses vague and ambiguous terms in a computer?
- Does a computer understand the difference between a **young** person and an **old** person ?
- If we store age as a numeric value then this is quite precise e.g. age is between 0 and 115
- However if in our data, age has values like **old**, **medium,** and **young** then this is fuzzy.

Systems are Fuzzy

- We need to be able to create systems that can cope with fuzzy data
- Fuzzy logic is logic that is used to describe fuzziness and uses fuzzy sets





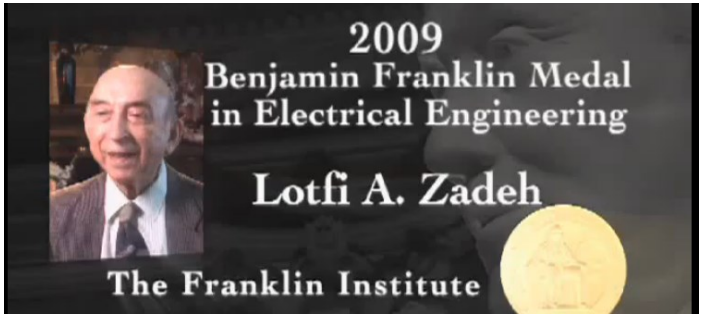
$\therefore$ The membership function, μ_A defines the fuzzy set, A

$$\mu_A : X \rightarrow [0,1]$$

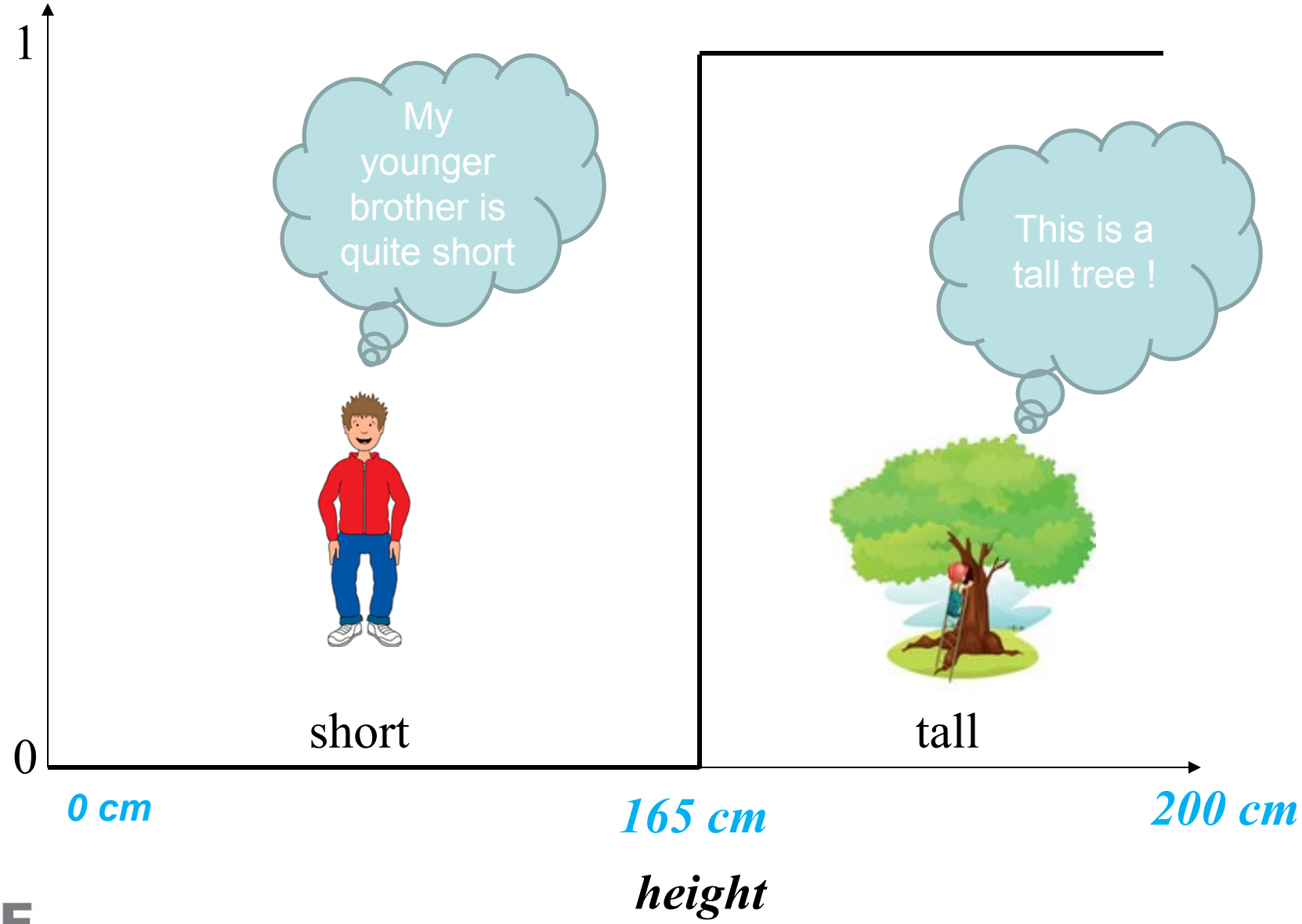
Professor Lofti Zadeh

- In 1965 Lotfi Zadeh, published his famous paper “Fuzzy sets”.

- Meet Professor Lofti Zadeh in a short interview when he was awarded the Benjamin Franklin Medal of Electrical Engineering.



What is Short and Tall ?



Activity: Creating Fuzzy Sets

- All stand up and make a line from smallest to tallest in terms of height
  - Record the height of everyone in your class
  - Who is the tallest and the shortest?
  - Assuming you have three labels “Tall”, “Medium” and “Short” assign each person in the class a label ?
    - How did you decided on who goes where ? i.e. determined the boundaries ?
    - Could you agree ?

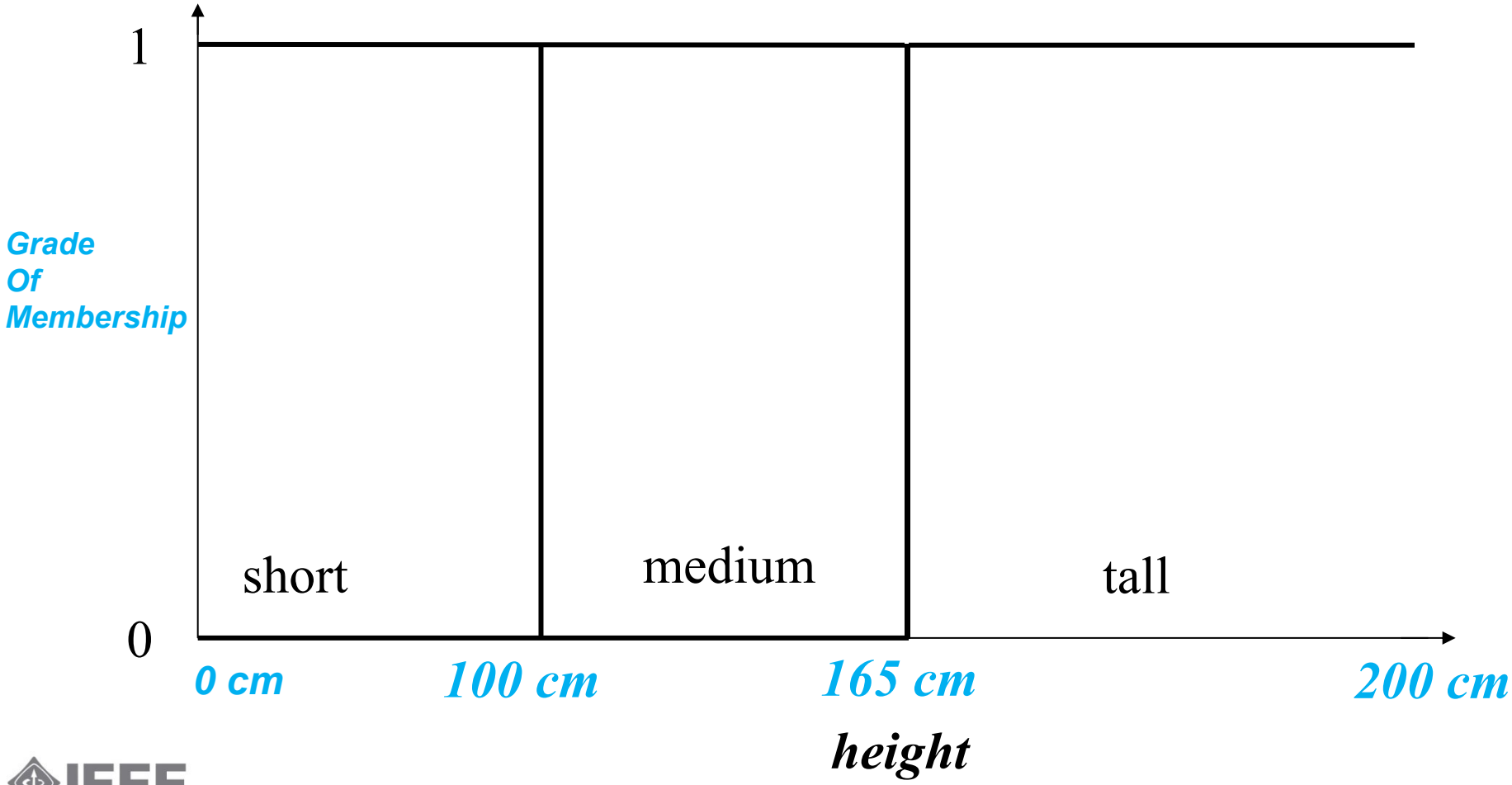
Example of Pupils

Name	Height (cm)	SHORT	MEDIUM	TALL
Jane	180			√
Alex	177			√
Haider	175			√
Surni	165		√	√
Max	142		√	
Jo-ellen	142		√	
Kaprisa	140		√	
Stephen	139		√	
Jo	100	√	√	
Pei	98	√		

So who is Short ? Medium ? Tall ?

Drawing Crisp Sets

- First draw some crisp sets



How much do pupils belong in the fuzzy sets ?

- We need to know the **degree** in which each person belongs to the fuzzy sets short, medium and tall.
- Assume we decide short is any heights between 0 and 100 cm then the fuzzy set **short** is defined as:

$$Short(0,100,height) = \begin{bmatrix} 1 \rightarrow height \leq 0 \\ 1 - \dfrac{height}{100} \rightarrow 0 \leq height < 100 \\ 0 \rightarrow height \geq 100 \end{bmatrix}$$

How much do pupils belong in the fuzzy sets ?

- Assume we decide **tall** is any heights greater that 165cm then the fuzzy set **tall** is defined as:

$$Tall(0,100,height) = \begin{bmatrix} 0 \rightarrow height \leq 165 \\ \dfrac{height - 165}{35} \rightarrow 165 \leq height < 200 \\ 1 \rightarrow height \geq 200 \end{bmatrix}$$

This example shows that anyone over 200cm is always definitely Tall !

So what about Medium ?

- A medium height person may be someone between 80 cm and 185 cm so we need to create a triangular fuzzy set to cover this range.

$$\mu Medium(height) = \begin{cases} 0 & if\ height \le 80 \\ \dfrac{height - 80}{53} & if\ 80 \le height \le 133 \\ \dfrac{185 - height}{52} & if\ 133 \le height \le 185 \\ 0 & if\ height \ge 185 \end{cases}$$

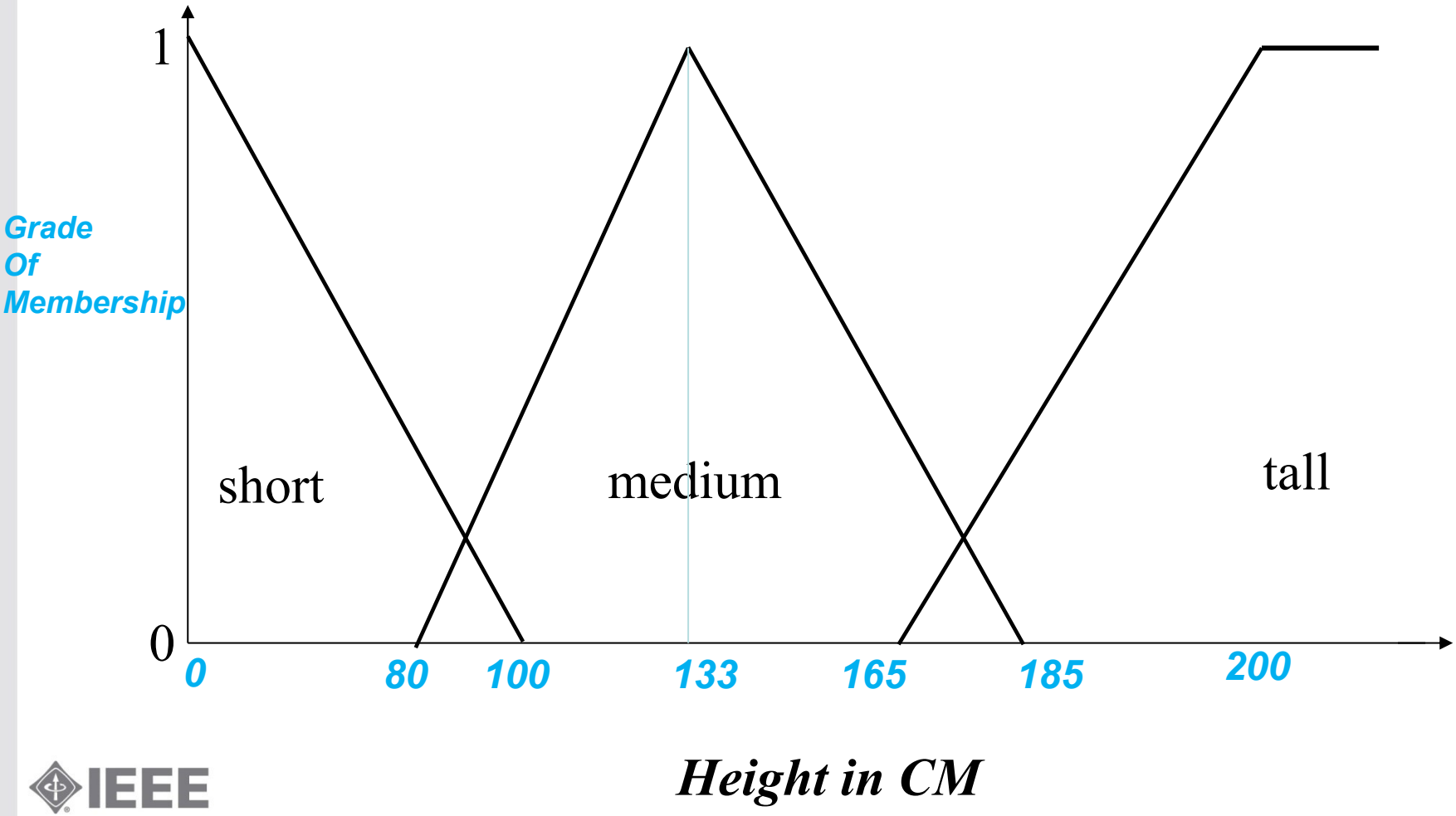
Note: 133cm is the midpoint of the triangular fuzzy set !

Pupils Membership

Name	Height (cm)	SHORT	MEDIUM	TALL
Jane	180	0	0	0.43
Alex	177	0	0	0.34
Haider	175	0	0	0.29
Surni	165	0	0.39	0
Max	142	0	0.83	0
Jo-ellen	142	0	0.83	0
Kaprisa	140	0	0.87	0
Stephen	139	0	0.89	0
Jo	100	0	0.38	0
Pei	98	0.02	0	0

Drawing Fuzzy Sets

- Now draw your fuzzy sets



Everyday Fuzzy Words

Can you identify other **fuzzy** keywords that you use everyday ?

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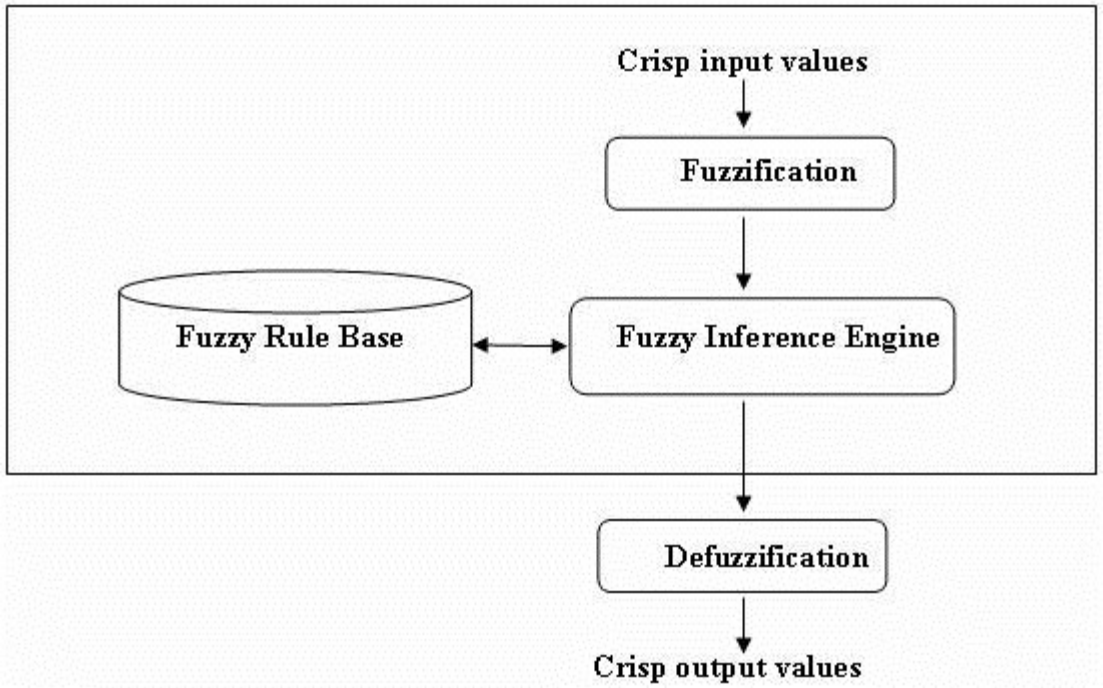
FUZZY SYSTEMS



Crisp Set

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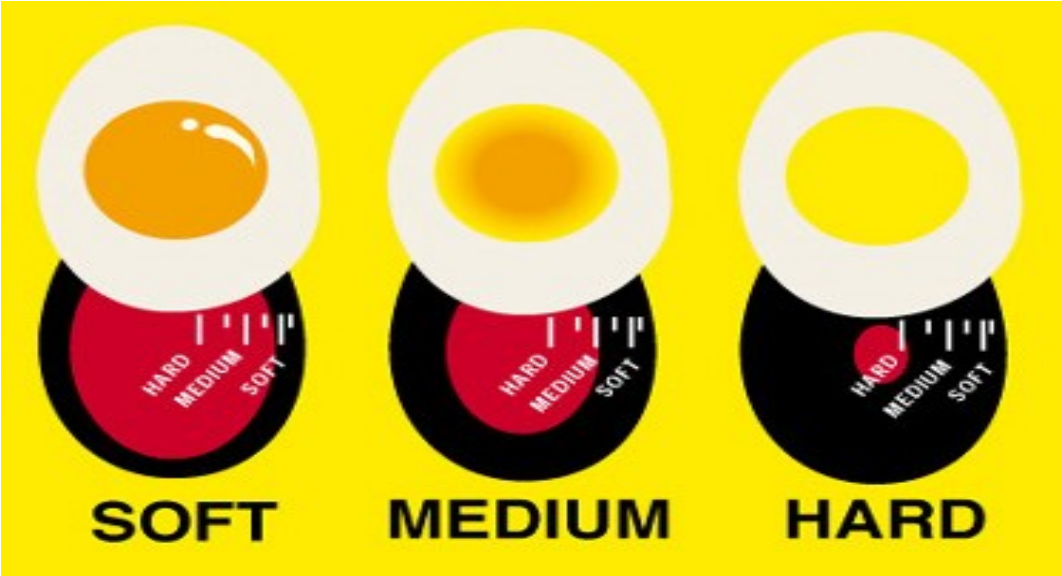
So you think you can boil a perfect egg ?

The Perfect Egg = Soft Boiled.



Activity: Boiling an Egg

- Discussion
  - How to come up with membership functions, based on our experience.
    - How small is a small egg? How large is a large egg?
    - What is soft ? What is hard ?
  - The process of fuzzification will define our fuzzy sets
  - The process of fuzzification
    - how long do we actually need to boil the egg ?

Egg-Boiling Fuzzy Logic Robot

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Experiment: Boiling an Egg

- Boil some eggs
- Make sure you weigh them first !!
- Fill in the table (or similar on Activity Sheet 2)

Soft-Boiled Eggs	44 grams	50 grams	63 grams
4 minutes			
5 minutes			
6 minutes			
7 minutes			

Multiple IF/THEN rules

- A common misconception is that Fuzzy Logic is an IF/THEN/ELSE statement.
- e.g. if small volume of water in kettle, heat it for 1 minute to boil; if large volume of water in kettle, heat for 3 minutes to boil.
- So how long should you boil a kettle if it is half full ?
- Discuss !

So you want to know more ?

- Watch an Introduction to Fuzzy Logic..

- How is your life fuzzy ?