Master of Technology in Knowledge Engineering

Unit 7:

Developing Intelligent Systems for Performing Business Analytics

Hybrid Systems: Case Study

-- Sample Solution

Dr. Zhu Fangming
Institute of Systems Science,
National University of Singapore.
E-mail: isszfm@nus.edu.sg

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Top Level Design

- Fuzzy System

  used to generate an initial population for the GA

  estimates which colorants to use and their ranges
- GA

  fine-tunes the colorant selection
- NN

  simulates the color of the paint resulting from the colorants (predicts the 3 spectral parameters)

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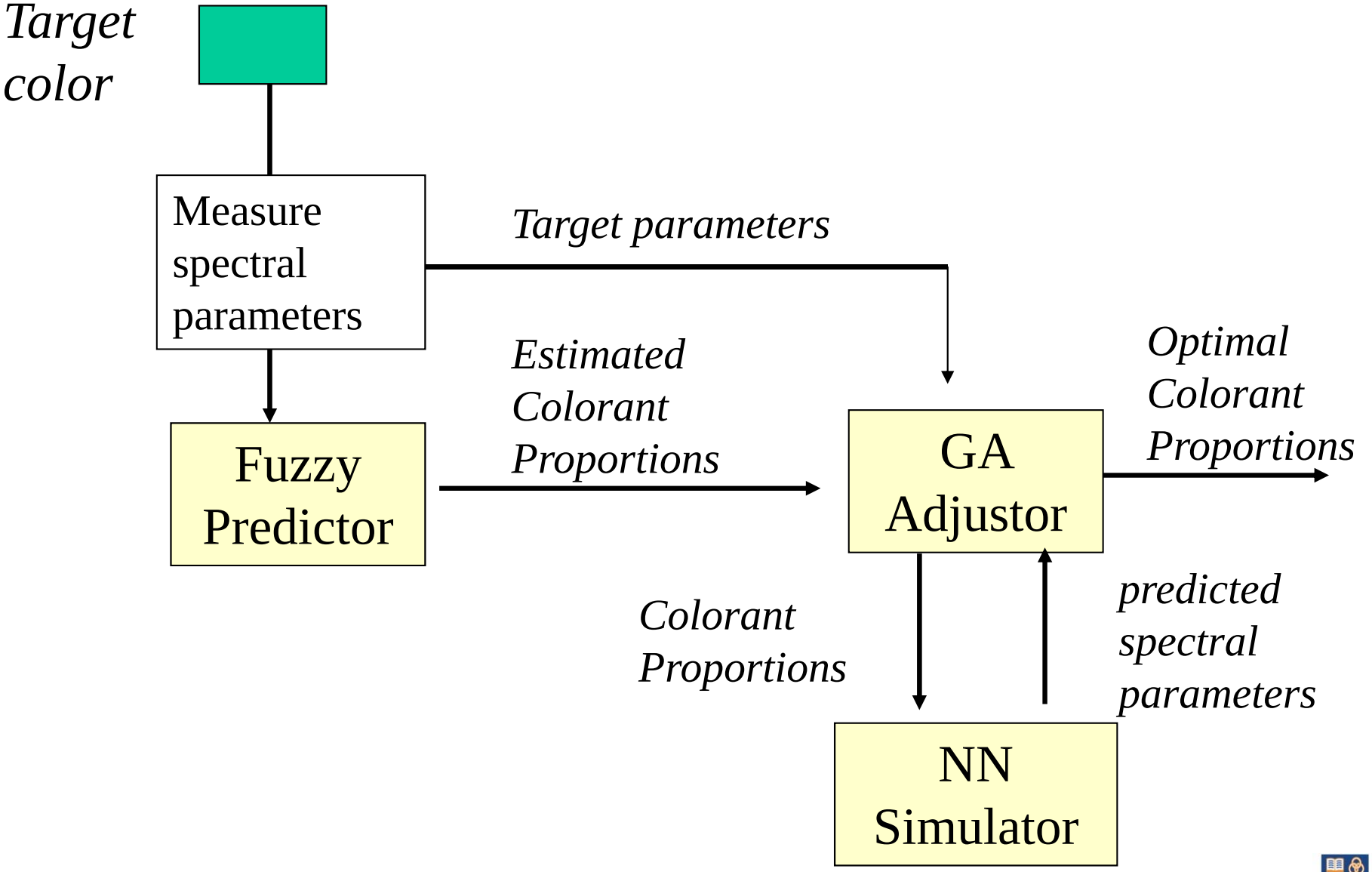
Top Level Design



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Example GA Chromosome

w	b	g1	g2	r1	r2	y1	y2	b	v
2	40	0	0	0	12	0	8	0	38

Genes must sum to 100%

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GA Fitness Function (v1)

- Difference between the predicted spectral parameters and the target parameters

  $= A * (L_t - L_p) + B * (a_t - a_p) + C*(b_t - b_p)$

  Where A, B ,C are scale factors – use domain knowledge to get their values

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GA Fitness Function (v2)

- How to get sufficient accuracy?
- Use a combination of 3 fitness functions
  - NN1 ~ predict spectral parameters
  - NN2 ~ inputs target spectral parameters and predicts good colorant mix, each output colorant value is either 1 or 0 (use or not)
  - Knowledge-Based fitness function

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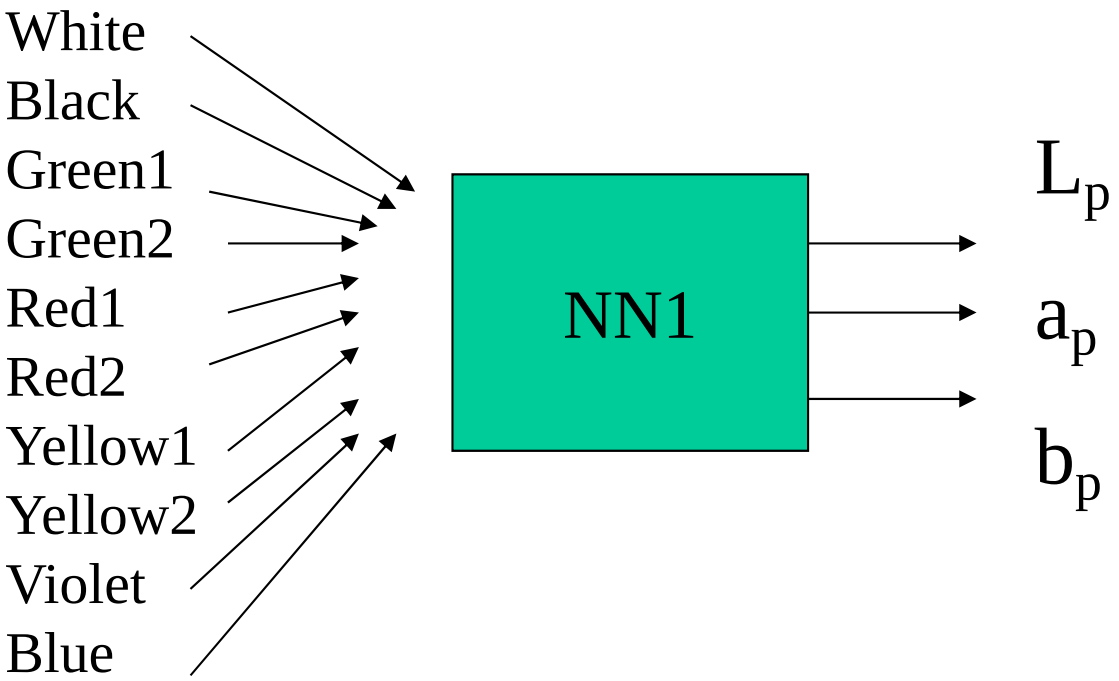
NN1: Predict Spectral Parameters



Training data need to be collected from the factory!

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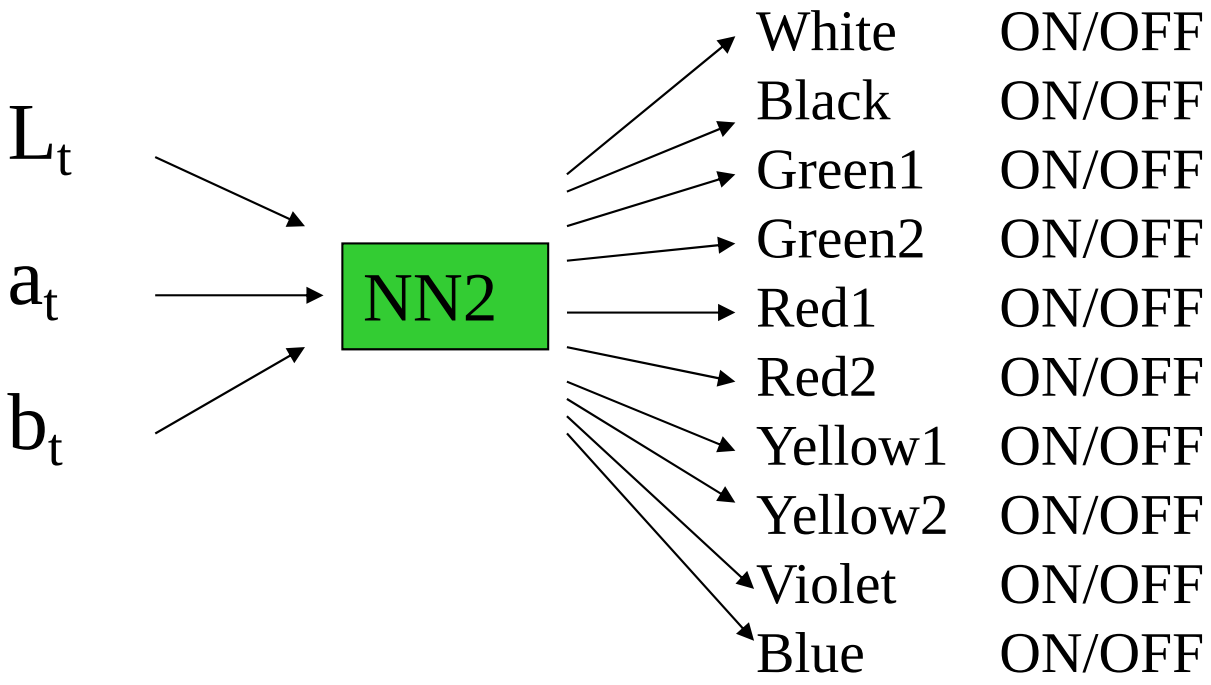
NN2: Predicting the Color Mix



One binary ON/OFF output for each colorant. Compare with the colorants selected by the GA to get fitness

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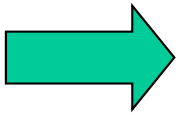
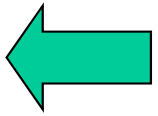
NN2: Fitness Calculation

NN2 

White	ON	1	ON
Black	ON	0	OFF
Green1	OFF	1	OFF
Green2	OFF	0	ON
Red1	ON	1	ON
Red2	ON	0	OFF
Yellow1	OFF	0	ON
Yellow2	ON	1	ON
Violet	OFF	1	OFF
Blue	OFF	0	ON

 GA

Fitness = 5

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Knowledge-Based Fitness

- Assess the fitness of a colorant mix by applying heuristics obtained from experience

- Example rules:

  Rule1: Keep total proportions around 100%

  Rule2: Avoid use of complementary colors (e.g. red & green)

  Rule3: Avoid use of same type of colorants at same time (e.g. red1 & red2)

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Fuzzy System Overview

- Goal = use the expert heuristics to suggest an initial "good guess" colorant mix
- Inputs?
  - For a fully automatic system then we have to use the 3 spectral parameters – or chroma, hue, lightness (obtained by a simple conversion)
  - Manual inputs – get an expert to judge the colour of the target as
    - Yellowish green
    - Redish brown etc

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Example Fuzzy Rule (1)

- The experts can give us rules such as:

If target color is greenish-yellow
Then
white = around 15% and
black = around 5-10% and
green1 = around 30-40% and
….
blue = zero

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Example Fuzzy Rule (1)

- In fuzzy notation

If target color is greenish-yellow
Then
white = small and
black = very small and
green1 = medium and
….
blue = zero

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Example Fuzzy Rule(2)

- For a fully automatic system - how do we know if a color is “yellowish green” without asking the human expert?

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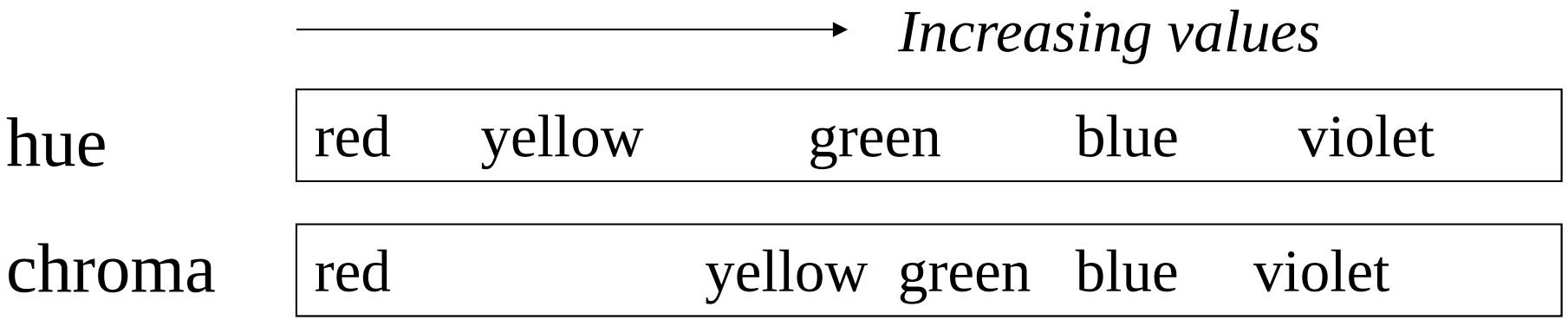
Measuring Color - Assumptions

- Assume the mapping between hue & chroma (obtained directly from spectral reflectance) and color is as shown below (based only loosely on reality!)



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Example Fuzzy Rule(2)

- ***Assuming*** the previous page was true then possible fuzzy rules could be

  If Hue is small then color is mostly Red
  If Chroma is large then color is very Blue
  If Chroma is very large then color is Violet
  etc….

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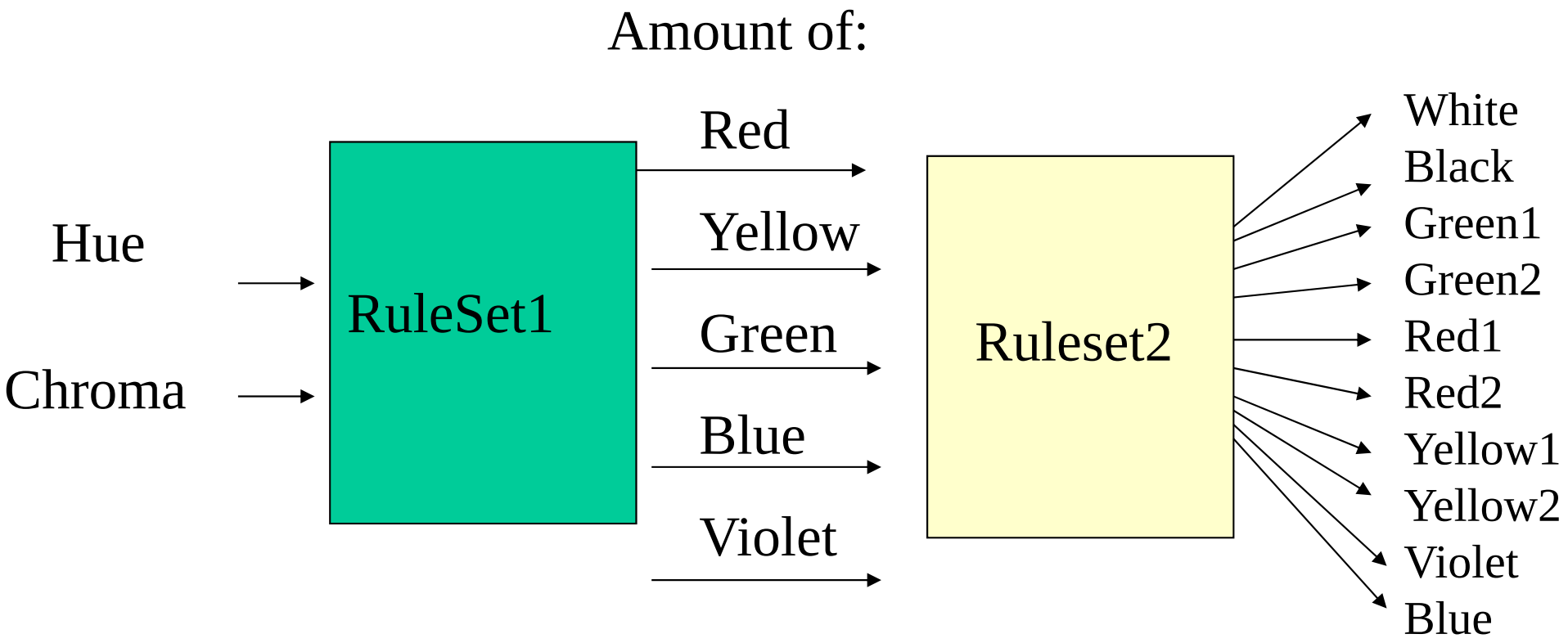
Fuzzy System



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Reference

- This case study is loosely modeled on the case study described in chapter 22 of the book “Neuro-Fuzzy and Soft Computing”, Jang, Sun, Mizutani (Prentice Hall, 1997, ISBN 0-13-261066-3)

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