Tutorial 06 for Fundamentals of Artificial Intelligence

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Problem 1

1. Answer the following questions:
(a) What difference between PL (Propositional Logic) and FOL (First-Order Logic)? (L7: P4,7)
(b) Please explain some new concepts: 1) Object, 2) function, 3) property, 4) relation, and 5) predicate. (L7: P5-6)
(c) What about the model for FOL? Which component is required in FOL model? (L7: P-9)
(d) In FOL, what are: 1) variable symbols; 2) connectives; 3) quantifiers; 4) ground terms? (L7: P12-13)
(e) What is the difference between $\forall x\ \exists y\ P(x, y)$ and $\exists x\ \forall y\ P(x, y)$? Please give an example. (L7: P16)

Differences between PL and FOL

- Not expressive enough v.s. Expressiveness
- Easy Inference v.s. Complicated inference

- FOL fixes problems with PL:
  - PL doesn't have variables.
    FOL does.
  - Identifying individuals in PL is hard.
    FOL it's easy.
  - PL can't directly express properties of individuals or relations between individuals.
    FOL can.

New Concepts in FOL

- Object: Nouns
- Function: Mapping applied on object(s)
- Relation: Adjectives (unary or *n*-ary)
- Predicate: The links among objects
- Property: Unary Relation

The model for FOL and its Required Components

- Combination of the values for the variables in the Domain
- Domain of an FOL model
  - A set of possible objects (domain elements) in KB
- Required Components
  - A set of things in the world
  - A list of constants
  - A list of predicates, relations, or functions

Syntax of FOL

- FOL supplies these primitives:
  - **Variable symbols**. E.g., `x`, `y`
  - **Connectives**. Same as in PL: not (~), and (^), or (v), implies (=>), if and only if (<=>)
  - **Quantifiers**: Universal (`A`) and Existential (`E`)

- If a variable is a constant, it is ground term.

Nested Quantifiers

- $\forall x \ \exists y \ P(x, y)$ and $\exists x \ \forall y \ P(x, y)$?

$\forall x \exists y$ Loves $(x,y) \neq$
$\exists y \forall x$ Loves (y,x)

Examples:
- Everyone loves someone
- Someone loves everyone

$\forall x \exists y$ Loves $(y,x) \neq$
$\exists y \forall x$ Loves (x,y)

Examples:
- Everyone is loved by someone
- Someone is loved by everyone

Problem 1

1. Answer the following questions:
(f) Please do some explanation: AI (Artificial Intelligence) vs ML (Machine Learning) vs DL (Deep Learning). (L7: P30-31)
(g) What is image histogram? What are peaks and plains in image histogram? Compare the differences between two types of bimodal histograms. (L7: P39-40)
(h) Understand the point operation. Contrast enhancement is the main application of pixel operation. Two methods of contrast enhancement are introduces in this lecture. Please compare them. (L7: P41-45)
(i) Why neighbourhood operations? Give the applications of group operations. (L7: P46-47)

AI vs ML vs DL

- AI is a broader concept than ML, which addresses the use of computers to mimic the cognitive functions of humans.
    - Computer Vision
    - Natural Language Processing and Understanding
    - Cognition and Reasoning
    - Robotics
    - Game Theory and Ethics
    - Machine Learning
- ML is a subset of AI and focuses on the ability of machines to receive a set of data & learn for themselves.
- DL can be considered a subset of ML. The concept of DL is sometimes just referred to as "deep neural networks".

AI vs ML

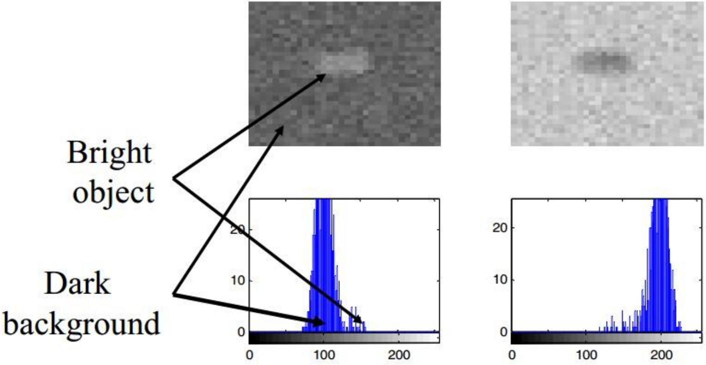
Mat Velloso
@matvelloso

Difference between machine learning and AI:

If it is written in Python, it's probably machine learning

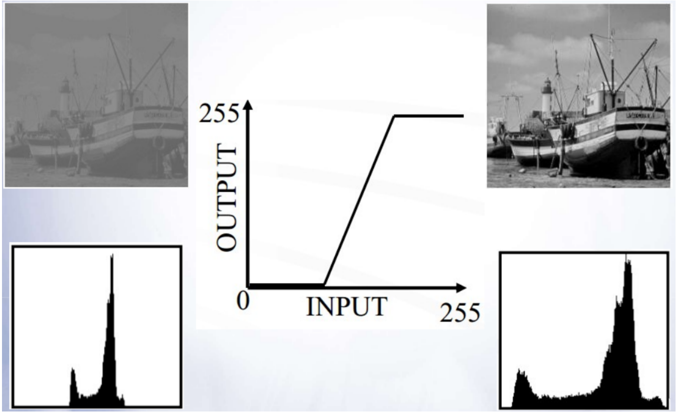
If it is written in PowerPoint, it's probably AI

Image Histogram



Point Operation: Contrast Enhancement

- Linear Stretching

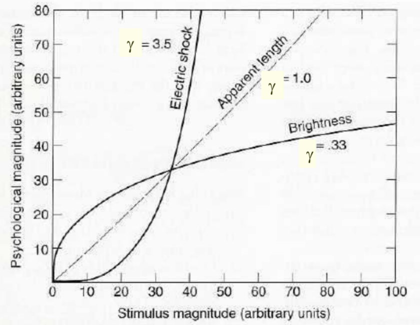


Point Operation: Contrast Enhancement

- Power Law Function

$$O = I^{\gamma}$$

- $\gamma < 1$ to enhance contrast in dark regions
- $\gamma > 1$ to enhance contrast in bright regions.



Neighbourhood Operations

- Provide context for individual pixels.
- Relationships between neighbours determine image features.
- Noise Reduction
- Edge Enhancement
- Zooming

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- Relationships between neighbours determine image features.
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Problem 2

2. $P(x, y)$ represents the statement $x + 2y = xy$, where x and y are integers. Determine the truth value of the following statements.

(a) $P(1, -1)$
(b) $P(0, 0)$
(c) $\exists y \ P(3, y)$
(d) $\forall x \exists y \ P(x, y)$
(e) $\exists x \forall y \ P(x, y)$
(f) $\forall y \exists x \ P(x, y)$
(g) $\exists y \forall x \ P(x, y)$
(h) $\neg \forall x \exists y \ \neg P(x, y)$

Problem 2

2. $P(x, y)$ represents the statement $x + 2y = xy$, where x and y are integers. Determine the truth value of the following statements.

(a) $P(1, -1)$

True

(b) $P(0, 0)$

True

Problem 2

2. $P(x, y)$ represents the statement $x + 2y = xy$, where x and y are integers. Determine the truth value of the following statements.

(c) $\exists y \ P(3, y)$

True: $(3 + 2y = 3y, y = 3)$

(d) $\forall x \exists y \ P(x, y)$

False: $(y = x/(x - 2))$. y is undefined when $x = 2)$

(e) $\exists x \forall y \ P(x, y)$

False: (from (d), given a certain value of x, there is only one y which satisfies the equation)

Problem 2

2. $P(x, y)$ represents the statement $x + 2y = xy$, where x and y are integers. Determine the truth value of the following statements.

(f) $\forall y \exists x \; P(x, y)$

False: $(x = 2y/(y-1)$. x is undefined when $y = 1)$

(g) $\exists y \forall x \; P(x, y)$

False: (from (f), given a certain value of y, there is only one x which satisfies the equation)

(h) $\neg \forall x \exists y \; \neg P(x, y)$

False: $(\forall x \exists y \neg P(x, y)$ is true: for every x, we can find y such that y such that the equation does not hold, e.g. given $x = 1, y = 1/2, (1, 5)$ is such a pair. So, $\neg \forall x \exists y \neg P(x, y)$ is false)

Problem 3

3. Write the statements.
(a) Let the predicate $F(x)$ to denote "x visited France" and $P(x)$ to denote "x stayed in Paris". Assume the universe of discourse for x consist of all people in the world, write in symbols using predicates and quantifiers: "Everyone who visited France stayed in Paris."
(b) Let x represents students, y represents courses, and $T(x, y)$ means "x is taking course y". Write "No course is being taken by all students." in symbol.
(c) Let the predicate $P(x)$ to denote "x stayed in Paris". Assume the universe of discourse consists of all students in the class. Write "There are at least two students in the class who have stayed in Paris." in symbol.

Problem 3

3. Write the statements.
(a) Let the predicate $F(x)$ to denote "x visited France" and $P(x)$ to denote "x stayed in Paris". Assume the universe of discourse for x consist of all people in the world, write in symbols using predicates and quantifiers: "Everyone who visited France stayed in Paris."

$$\forall x(F(x) \rightarrow P(x))$$

(b) Let x represents students, y represents courses, and $T(x, y)$ means "x is taking course y". Write "No course is being taken by all students." in symbol.

Ans1: $\neg\exists y\forall x T(x, y)$ Or Ans2: $\forall y\neg\forall x T(x, y)$

(c) Let the predicate $P(x)$ to denote "x stayed in Paris". Assume the universe of discourse consists of all students in the class. Write "There are at least two students in the class who have stayed in Paris." in symbol.

$$\exists x\exists y(x \neq y \wedge P(x) \wedge P(y))$$

Problem 4

4. Use quantifiers and predicates to express the following statements. You should assume that the domain of discourse consist of all students in the class and you should only make use of predicates with two variables.
(a) There is a student in the class who can speak Japanese.
(b) Every student in the class plays one kind of sports.
(c) Some student in the class has visited London but has not visited Tokyo.
(d) All students in the class written programs with at least one programming language.
(e) There is a student in this class who has passed all the courses offered by at least one of the department in the university.

Problem 4

4. Use quantifiers and predicates to express the following statements. You should assume that the domain of discourse consist of all students in the class and you should only make use of predicates with two variables.

(a) There is a student in the class who can speak Japanese.

Let $S(x, y)$ mean that student x can speak language y, our statement is $\exists x S(x, Japanese)$

(b) Every student in the class plays one kind of sports.

Let $P(x, y)$ mean that person x plays sport y, our statement is $\forall x \exists y P(x, y)$

(c) Some student in the class has visited London but has not visited Tokyo.

Let $V(x, y)$ means that person x has visited city y, our statement is $\exists x (V(x, London) \wedge \neg V(x, Tokyo))$

Problem 4

4. Use quantifiers and predicates to express the following statements. You should assume that the domain of discourse consist of all students in the class and you should only make use of predicates with two variables.

(d) All students in the class written programs with at least one programming language.

> Let $L(x, y)$ mean that person x has written programs in programming language y, our statement is $\forall x \exists y L(x, y)$

(e) There is a student in this class who has passed all the courses offered by at least one of the department in the university.

> Let $P(x, y)$ mean that person x has passed course y, and let $O(y, z)$ mean that course y is offered by department z, our statement is $\exists x \exists z \forall y (O(y, z) \rightarrow P(x, y))$

Problem 6

6. Please check the convolution result in P50. Now there is an input image and a mask as below. Could you give the convolved image?

Mask

-1	2	1
-1	2	1

Input image

4	4	7	1	9
4	3	8	2	9
3	5	9	8	9
3	6	9	8	9
3	6	10	9	9

Problem 7

7. There are two methods of noise reduction: low pass filter and median filter (P53-58). Please give the noise reduction results of the input image in Q6 by using a) the mask of mean filter: $\frac{1}{9}\begin{pmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{pmatrix}$, and b) the mask of median filter: $\begin{pmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{pmatrix}$

Input image

4	4	7	1	9
4	3	8	2	9
3	5	9	8	9
3	6	9	8	9
3	6	10	9	9

Problem 8

8. In P60-61 there are some examples of filter operations. Please point out the difference of Low-pass filters, High-pass filters and Edge enhancement filters. Notice that the "0"-Sum mask for Edge enhancement filters and "1"-Sum for others.

Filter Operations

1 Low-pass Filter

- Class: Image Enhancement/Restoration
- Implementation: Pixel group process & smooth(平滑) an image

$$\begin{matrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{matrix} \Big/ 9 \qquad \begin{matrix} 1 & 1 & 1 \\ 1 & 2 & 1 \\ 1 & 1 & 1 \end{matrix} \Big/ 10 \qquad \begin{matrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{matrix} \Big/ 16$$

Filter Operations

2 High-Pass Filter

- Implementation: Pixel group process & sharpen(锐化) an imag

$$\begin{matrix} -1 & -1 & -1 \\ -1 & 9 & -1 \\ -1 & -1 & -1 \end{matrix} \qquad \begin{matrix} 0 & -1 & 0 \\ -1 & 5 & -1 \\ 0 & -1 & 0 \end{matrix} \qquad \begin{matrix} 1 & -2 & 1 \\ -2 & 5 & -2 \\ 1 & -2 & 1 \end{matrix}$$

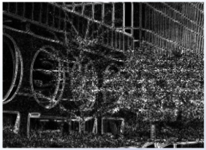
3 Laplacian Edge Enhancement

- Implementation: All edge extraction

$$\begin{matrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{matrix} \qquad \begin{matrix} 0 & -1 & 0 \\ -1 & 4 & -1 \\ 0 & -1 & 0 \end{matrix} \qquad \begin{matrix} 1 & -2 & 1 \\ -2 & 4 & -2 \\ 1 & -2 & 1 \end{matrix}$$


Original


High-Pass


Laplacian