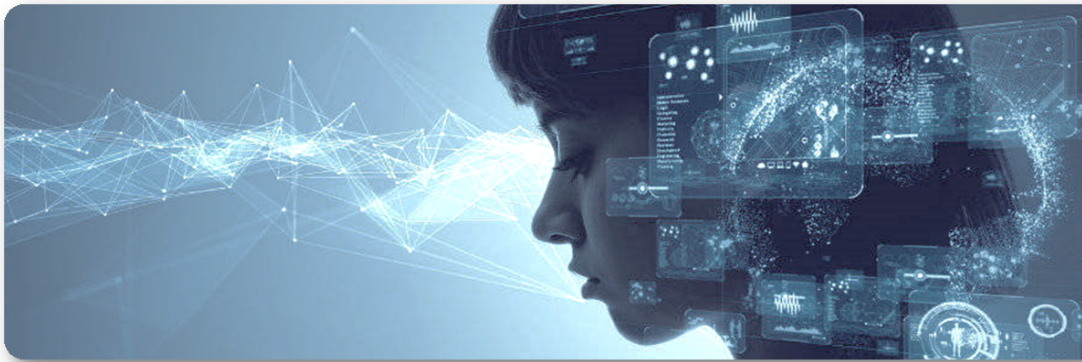

COMP 2211 Exploring Artificial Intelligence

Practice Problems: Digital Image Processing, CNN, Minimax and Alpha-beta Pruning and Ethics of AI

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Digital Image Processing

A 3-bit/pixel (i.e. pixel value is in range 0 and 2^3=8) of size 3×3 is given below.

3	7	6
2	4	6
4	7	2

(a) Find the output of a 3×3 averaging kernel at (1,1).

(b) Find the output of a 3×3 median kernel at (1,1).

(c) Find the edge magnitude at (1,1) using the Sobel masks shown below.

-1	-2	-1
0	0	0
1	2	1

Sobel kernel for extracting horizontal edges

-1	0	1
-2	0	2
-1	0	1

Sobel kernel for extracting vertical edges

Note: Edge magnitude $= \sqrt{horizontal\_edge\_value^2 + vertical\_edge\_value^2}$.

Convolutional Neural Network

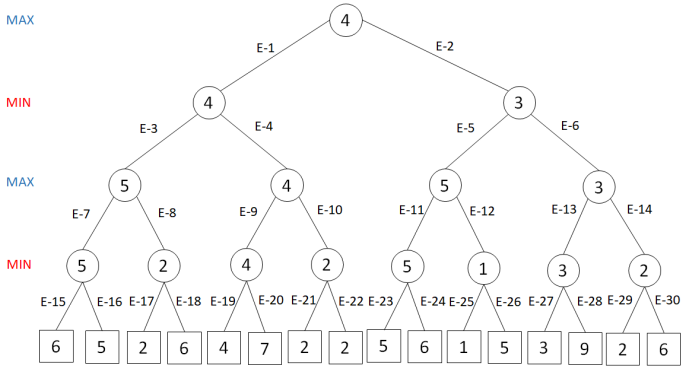
Consider a convolutional neural network that is used to classify images into two classes. The architecture of the network is as follows:

- Input: 100×100 grayscale images
- Layer 1: Convolutional layer with 100 5×5 kernels
- Layer 2: Convolutional layer with 100 5×5 kernels
- Layer 3: A max pooling layer that down-samples Layer 2 by a factor of 4 (from 100×100 to 50×50)
- Layer 4: Flatten layer
- Layer 5: Dense layer with 100 units
- Layer 6: Dense layer with 100 units
- Layer 7: Single output unit

How many parameters does this network have?

Minimax and Alpha-Beta Pruning

Consider the game tree below filled with the values returned by the standard minimax algorithm.



(a) State the best initial move for the first player (i.e. E-1 or E-2).

(b) Apply alpba-beta pruning on the given tree and state the branches that need not be examined or considered by putting down the edge label(s) (e.g. E-1, E-2, E-3, ..., E-30).

Ethics of Artificial Intelligence

Match the European Union Principles with the given Common Grounds by completing the following table with numbers.

Seven European Union Principles

(A) Human agency and oversight
(B) Technical robustness and safety
(C) Privacy and data governance
(D) Transparency
(E) Diversity, non-discrimination and fairness
(F) Societal and environmental well-being
(G) Accountability

Common Grounds

(1) Autonomy
(2) Beneficence
(3) Non-maleficence
(4) Justice
(5) Explicability

A	B	C	D	E	F	G

Digital Image Processing (Solution)

(a) The output value of a 3×3 averaging kernel at (1,1) is

$$\frac{3+7+6+2+4+6+4+7+2}{9} = \frac{41}{9}$$

(b) The output of a 3×3 median filter at (1,1) is

$$\texttt{Sorted pixel values}: 2, 2, 3, 4, 4, 6, 6, 7, 7$$
$$\texttt{Median value}: 4$$

(c) Horizontal edge value

$$= 1 \times 3 + 2 \times 7 + 1 \times 6 + 0 \times 2 + 0 \times 4 + 0 \times 6 + (-1) \times 4 + (-2) \times 7 + (-1) \times 2$$
$$= 3 + 14 + 6 - 4 - 14 - 2 = 3$$

Vertical edge value

$$= 1 \times 3 + 0 \times 7 + (-1) \times 6 + 2 \times 2 + 0 \times 4 + (-2) \times 6 + 1 \times 4 + 0 \times 7 + (-1) \times 2)$$
$$= 3 - 6 + 4 - 12 + 4 - 2 = -9$$

Edge magnitude $= \sqrt{(3)^2 + (-9)^2} = \sqrt{90} = 9.49$

Convolutional Neural Network (Solution)

- The number of parameters in each of the layers:
  - Layer 1: $100 \times 5 \times 5 + 100 = 2600$
  - Layer 2: $100 \times 100 \times 5 \times 5 + 100 = 250100$
  - Layer 3: 0
  - Layer 4: 0
  - Layer 5: $50 \times 50 \times 100 \times 100 + 100 = 25000100$
  - Layer 6: $100 \times 100 + 100 = 10100$
  - Layer 7: $100 \times 1 + 1 = 101$
- The parameters this network have
  $= 2600 + 250100 + 0 + 0 + 25000100 + 10100 + 101 = 25263001.$

Minimax and Alpha-Beta Pruning (Solution)

(a) E-1

(b) E-18, E-22, E-26, E-28, and E-30.

Ethics of Artificial Intelligence (Solution)

A	B	C	D	E	F	G
5	3	1	5	4	2	1