UNIT - 8

MORPHOLOGICAL IMAGE PROCESSING

The word morphology commonly denotes a branch of biology which deals with the structure of animals and plants. we use the same word for extracting image components.

~~Preliminaries~~

Some Basic concepts from set theory:-

Let A be a set in Z^2. if $a = (a_1, a_2)$ is an element of A then we write

$$a \in A.$$

if a is not an element of A we write

$$a \notin A.$$

The set with no elements is called the null or empty set denoted by symbol ϕ.

→ A set is specified by the contents of two braces $\{\cdot\}$.

→ If every element of a set A is also an element of another set B, then A is said to be a subset of B. denoted as,

$$A \subseteq B$$

The union of two sets A and B denoted by.

$$C = A \cup B$$

The intersection of two sets A and B denoted by

$$D = A \cap B$$

Two sets A and B are said to be disjoint or mutually exclusive if they have no common elements

$$A \cap B = \phi.$$

The complement of a set A is the set of elements not contained in A

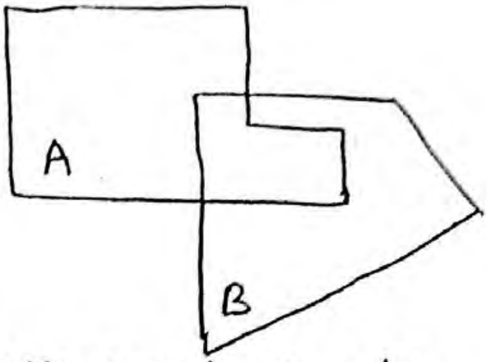
$$A^c = \{ w \mid w \notin A \}$$

(~~w is formed by multiplyi~~

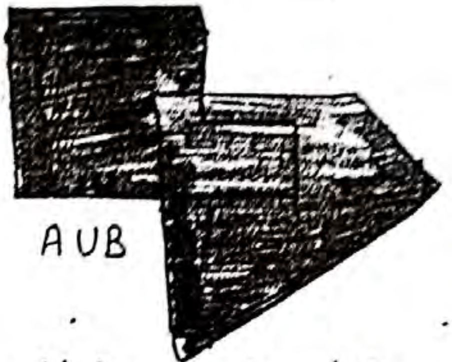
The difference of two sets A and B denoted A − B is

defined as

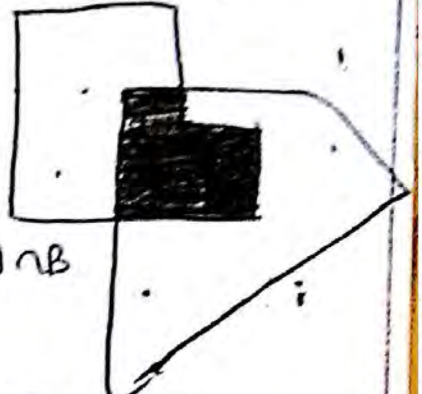
$$A - B = \{ w \mid w \in A, w \notin B \} = A \cap B^c$$



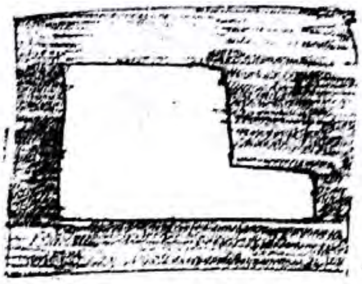
(a) Two sets A and B



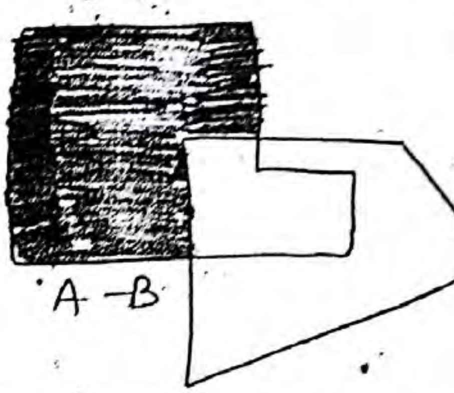
(b) Union of A and B



(c) intersection of A and B


$(A)^c$

d) Complement of A



e) difference of between A and B

Two additional definitions used extensively in morphology but not found in set theory.

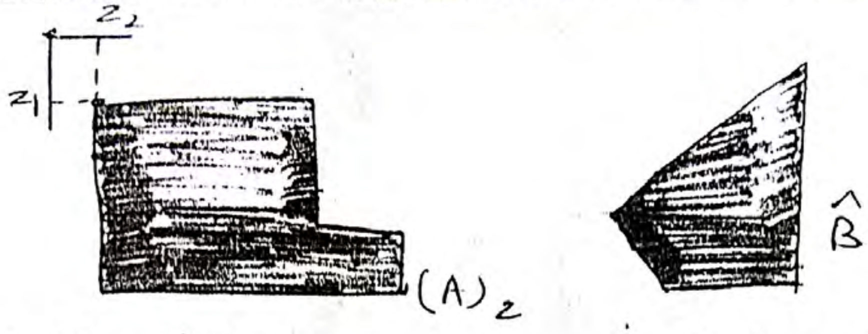
The reflection of set B denoted $\hat{B}$ is defined as

$$\hat{B} = \{ w \mid w = -b, \text{ for } b \in B \}$$

(means that set $\hat{B}$ is the set of elements w such w is formed by multiplying each of two coordinates by −1)

The translation of set A by point $z = (z_1, z_2)$ denoted $(A)_z$ is defined as

$$(A)_z = \{ c \mid c = a + z \quad \text{for } a \in A \}$$



(a) Translation of A by z (b) ~~Reflection~~ Reflection of B.

Logical operations Involving Binary Images:-

The principal logic operations used in image processing are AND, OR and NOT (COMPLEMENT).

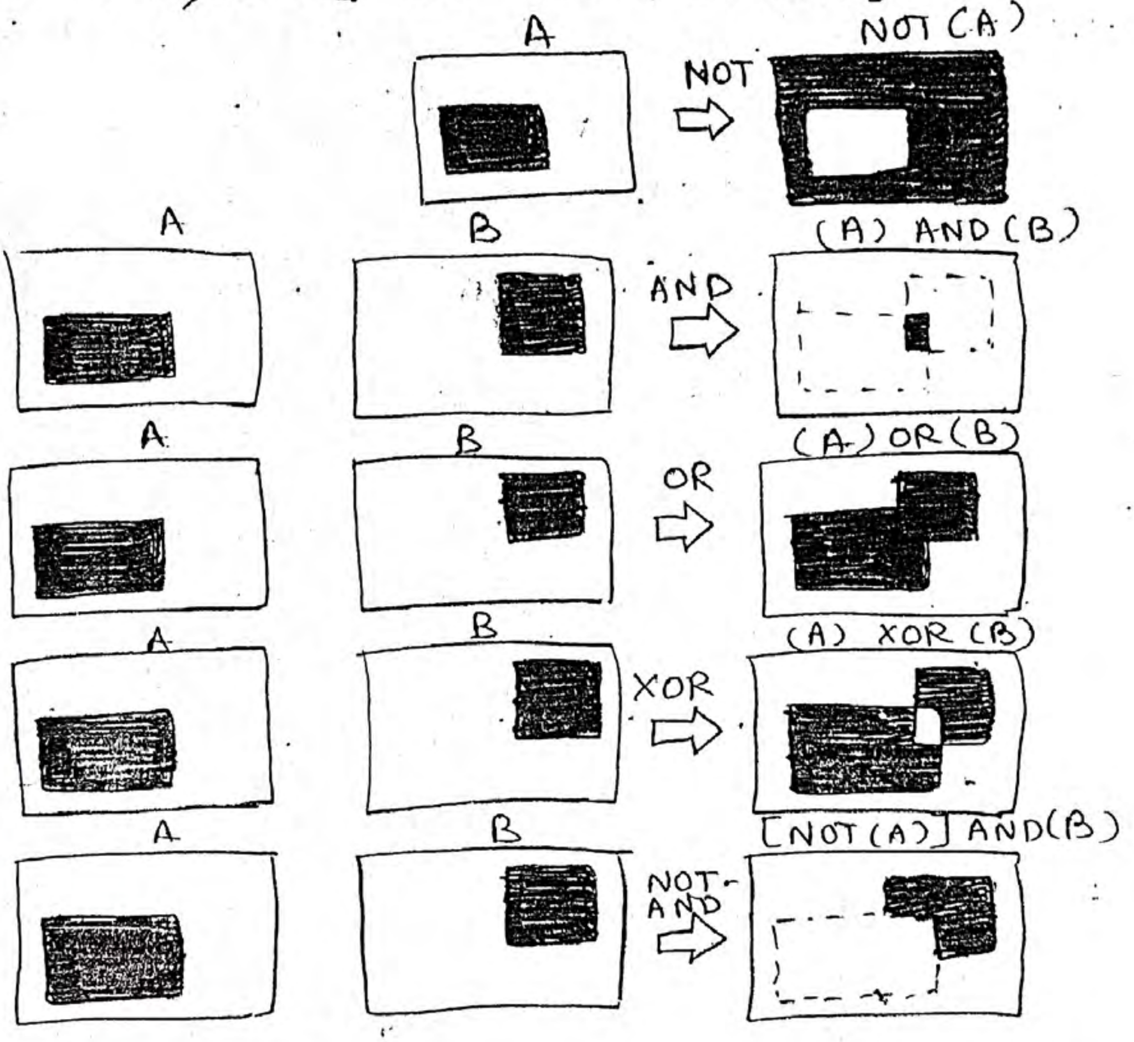


Fig:- Logic operations between Binary Images (Black represents binary 1s and white binary 0s in this example.

Dilation and Erosion:-

Dilation :-

With A and B as sets in Z^2 the dilation of A by B denoted $A \oplus B$ is defined as.

$$A \oplus B = \{ z \mid (\hat{B})_z \cap A \neq \phi \} \quad -(1)$$

This equation is based on obtaining reflection of B about its origin and shifting this reflection by z.

The dilation of A by B then is the set of all displacement z such that $\hat{B}$ and A overlap by at least an element

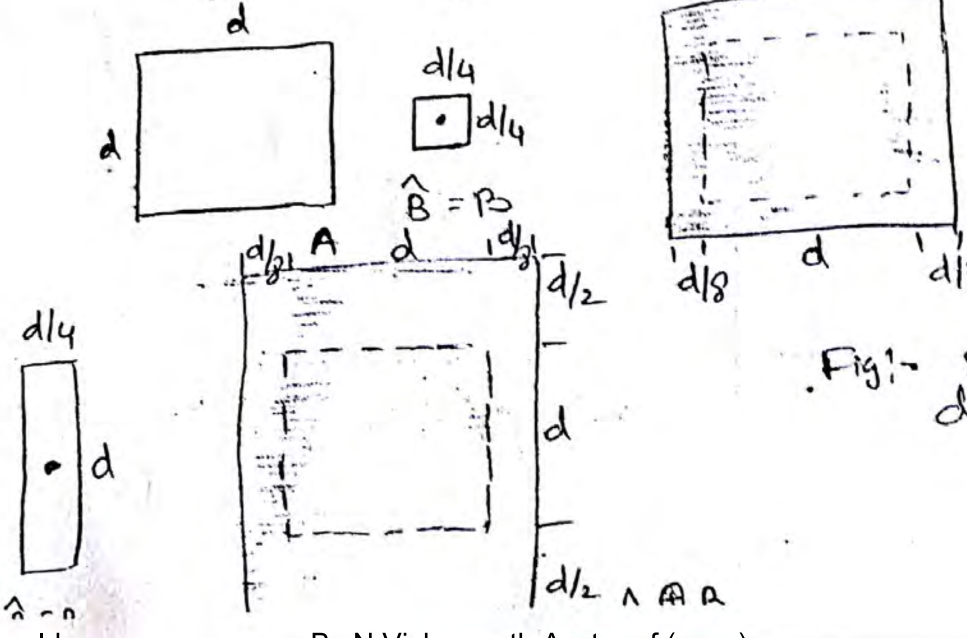
Eqn (1) can be rewritten as

$$A \oplus B = \{ z \mid [(\hat{B})_z \cap A] \subseteq A \}.$$

Set B is referred to as the structuring element in dilation

→ dilation is based on set operations, where as convolution is based on arithmetic operations.

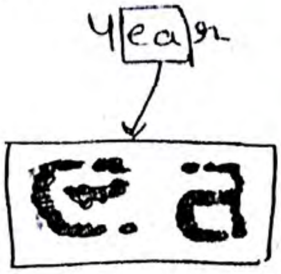
→ The basic process of flipping B about its origin and then successively displacing it so that it slides over set (image)

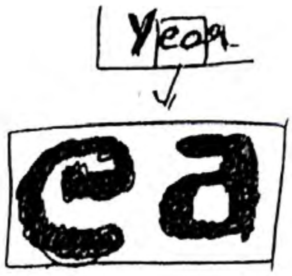


$A \oplus B$

Fig:- Set A
dilation of A by B

One of the simplest application of dilation is for bridging Gaps.





0	1	0
1	1	1
0	1	0

Structuring element

Erosion :—

For sets A and B in Z^2 the erosion of A by B, denoted $A \ominus B$ is defined as

$$A \ominus B = \{ z \mid (B)_z \subseteq A \}$$

In words this equation indicates that the erosion of A by B is the set of all points z such that B, translated by z is contained in A.

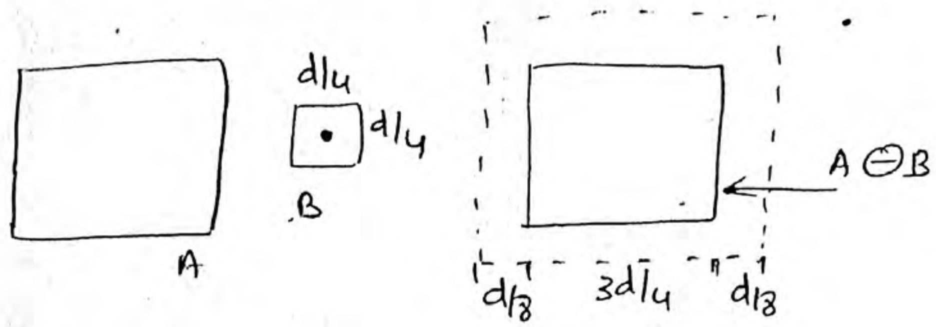
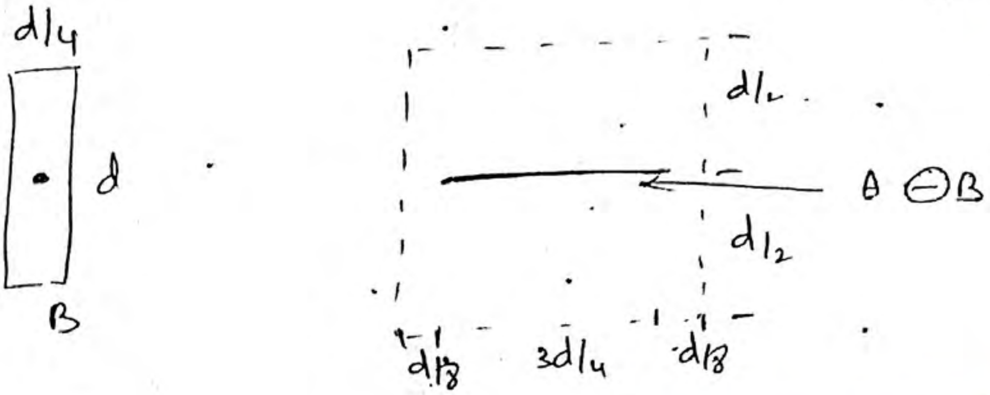


Fig: Erosion of A by B.



Note:- Dilation and erosion are duals of each other with respect to set complementation and reflection.
That is

$$(A \ominus B)^c = A^c \oplus \hat{B}.$$

Opening and closing:-

dilation expands an image and erosion shrinks it

→ The two other important morphological operations are opening and closing.

→ opening generally smoothes the contour of an object breaks narrow ~~isthmus~~ isthmuses and eliminates thin protrusions.

→ closing also tends to smooth sections of contours but as opposed to opening.

→ closing generally fuses narrow breaks and long thin gulfs, eliminates small holes and fills gaps in the contour.

The opening of set A by structuring element B denoted as $A \circ B$ is defined as

$$A \circ B = (A \ominus B) \oplus B.$$

The opening A by B is the erosion of A by B followed by a dilation of the result by B.

→ closing of set A by structuring element B denoted as $A \bullet B$ is defined as

$$A \bullet B = (A \oplus B) \ominus B.$$

The closing of A by B is simply the dilation of A by B followed

The opening operation has a simple geometric interpretation shown in below figure

Suppose that we view the structuring element B as a flat rolling ball.

The boundary of $A \circ B$ is then established by the points in B that reach the farthest into the boundary of A as B is rolled around the inside of this boundary.

$A \circ B = \cup \{ (B)_z \mid (B)_z \subseteq A \}$

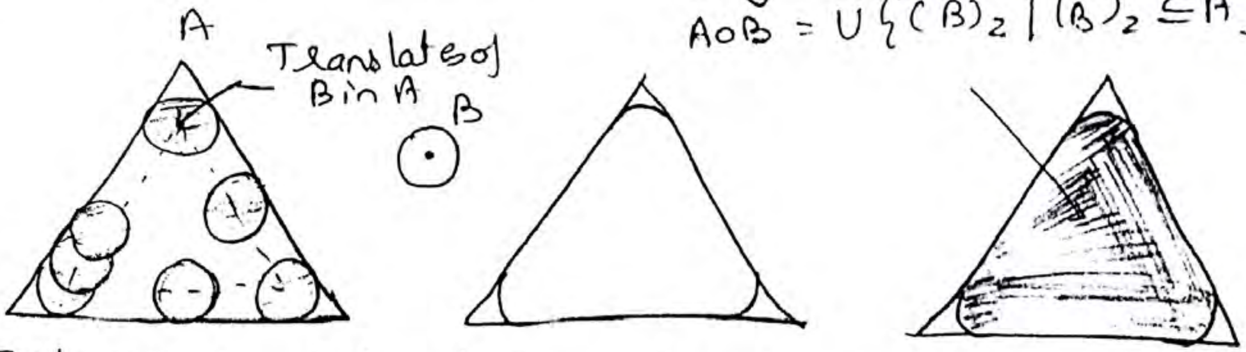


Fig:- opening (Structuring element B rolling along inner boundary of A)

Closing has a similar geometric interpretation except that now we roll B on the outside of the boundary.

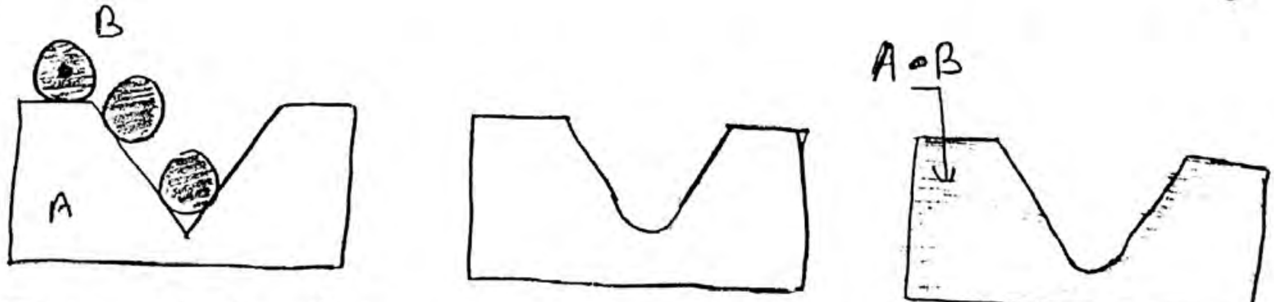


Fig:- Closing (Structuring element B rolling on the outer boundary of set A.

Another example of opening and closing operations is shown in next page.

Note:- The opening and closing are duals of each other with respect to set complementation and reflection

$$(A \bullet B)^c = (A^c \circ \hat{B}).$$

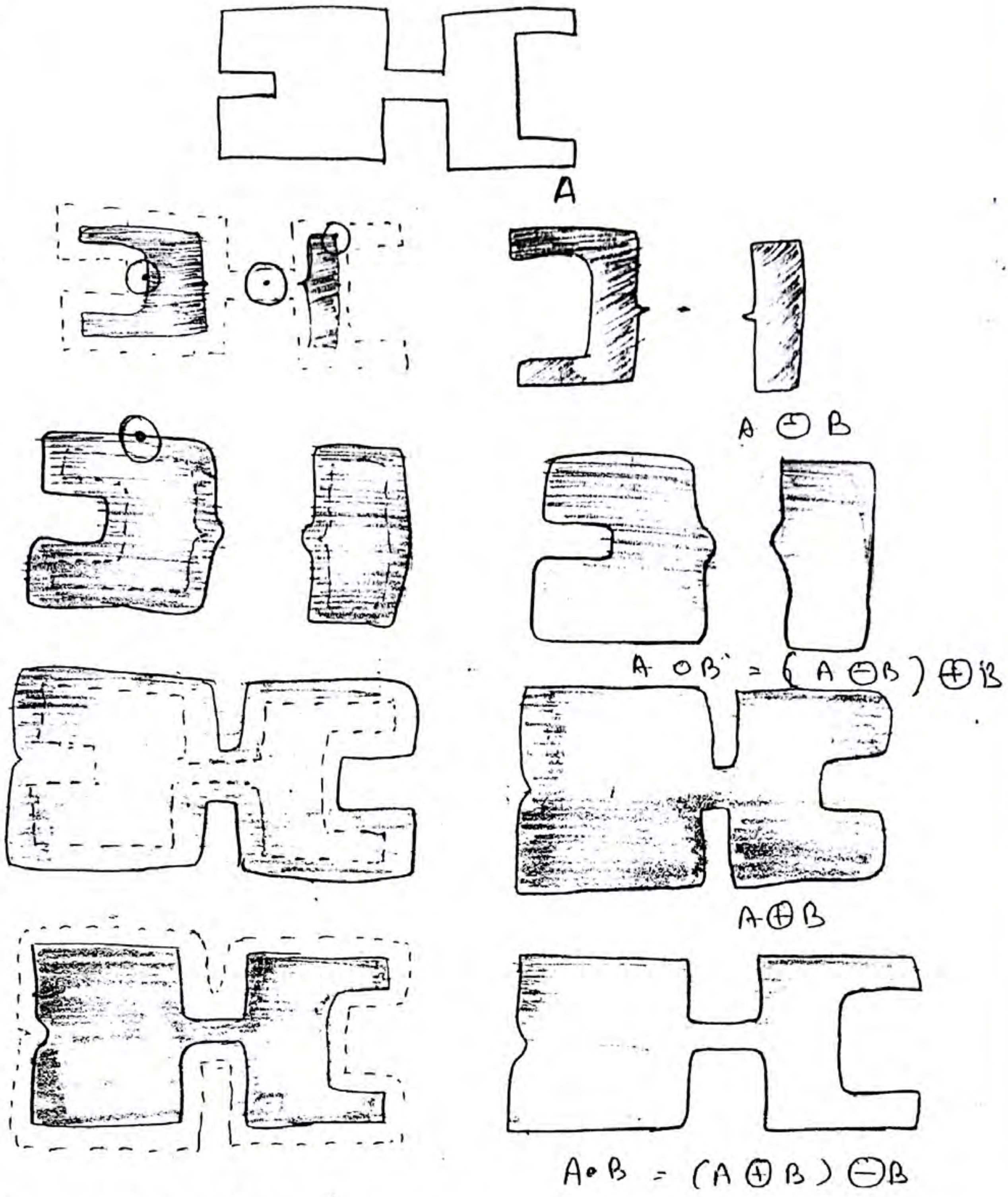


Fig:- Morphological opening and closing

→ The opening operation satisfies the following properties

(i) $A \circ B$ is a subset (subimage) of A

(ii) If C is a subset of D then $C \circ B$ is a subset of $D \circ B$

(iii) $(A \circ B) \circ B = A \circ B$

The closing operation satisfies the following properties

(i) A is a subset (subimage) of $A \bullet B$

(ii) If C is a subset of D then $C \bullet B$ is a subset of $D \bullet B$

(iii) $(A \bullet B) \bullet B = A \bullet B$

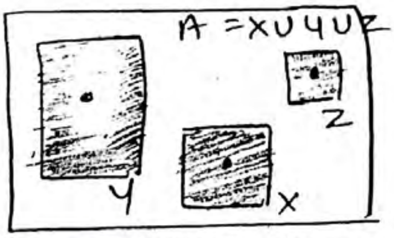
From the third condition in Both cases says that multiple openings or closings of a set have no effect after the operator has been applied onces.

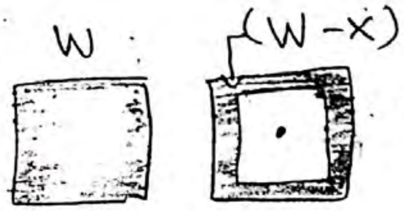
The Hit-or-Miss Transformation:-

The Morphological hit or miss transform is a basic tool for shape detection.:-

consider a set A consisting of three shapes (subsets) denoted X, Y and Z.

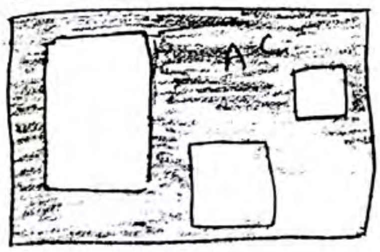
a) set A

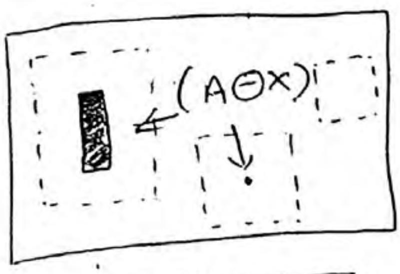




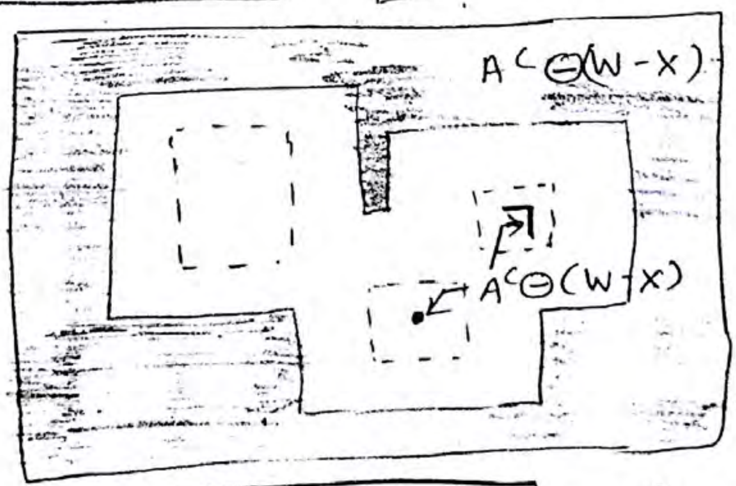
b) window W and (W-X)

complement of A

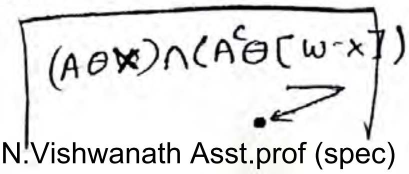




Erosion of A by X



e) Erosion of A^C by $(W - X)$



f) intersection of d & e showing location of ...

The objective is to find the Location of one of the shapes say X.

→ Let the origin of each shape be Located at its center of gravity.

→ Let X be enclosed by a Small window W.

The Local background of X with respect to W is defined as the set difference (W−X) as shown in (b) fig.

→ The erosion of A by X is the set of Locations of the origin of X. Shown in (d) fig

→ The erosion of the complement of A by the Local background set (W−X) is shown in (e) fig.

→ We ~~see~~ note from fig (d) & (e) that the set of Locations for which X exactly fits inside A is the intersection of the erosion of A by X and the erosion of A^c by (W−X).

→ The intersection is precisely the location sought

→ In other words if B denotes the set composed of X and its Background the match of B in A is denoted as $A \circledast B$ is

$$\boxed{A \circledast B = (A \ominus X) \cap [A^c \ominus (W-X)]} \quad -(1)$$

Let B_1 is an object and B_2 is the Local background.

i.e $B_1 = X$ $\quad B_2 = (W-X)$

then Eqn (1) can be written as

$$\boxed{A \circledast B = (A \ominus B_1) \cap (A^c \ominus B_2)}$$

The above equations are called as the morphological hit-or-miss transform.

Overview of Digital Image Watermarking Methods:-

Rapid growth in the field of digitised multimedia like image, video and audio has urged the need of copyright protection which can be used to produce evidence against any illegal attempt to reproduce or manipulate them.

→ Digital watermarking is a technique providing embedded copyright information in images.

Watermarking and Cryptography:-

Watermarking and cryptography are closely related but watermarking is distinct from encryption.

→ Cryptography scrambles the image so that it cannot be understood.

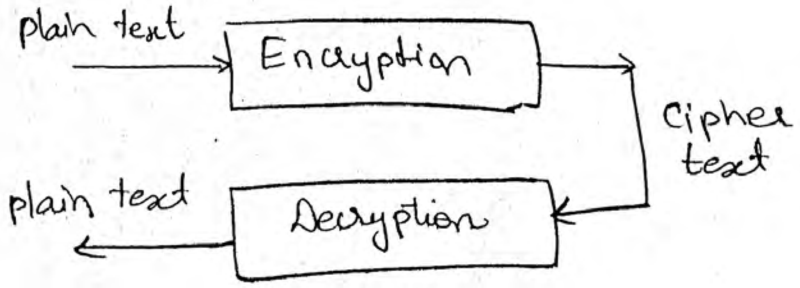


Fig:- Principle of Cryptography

In digital watermarking system information carrying the watermark is embedded in an original image.

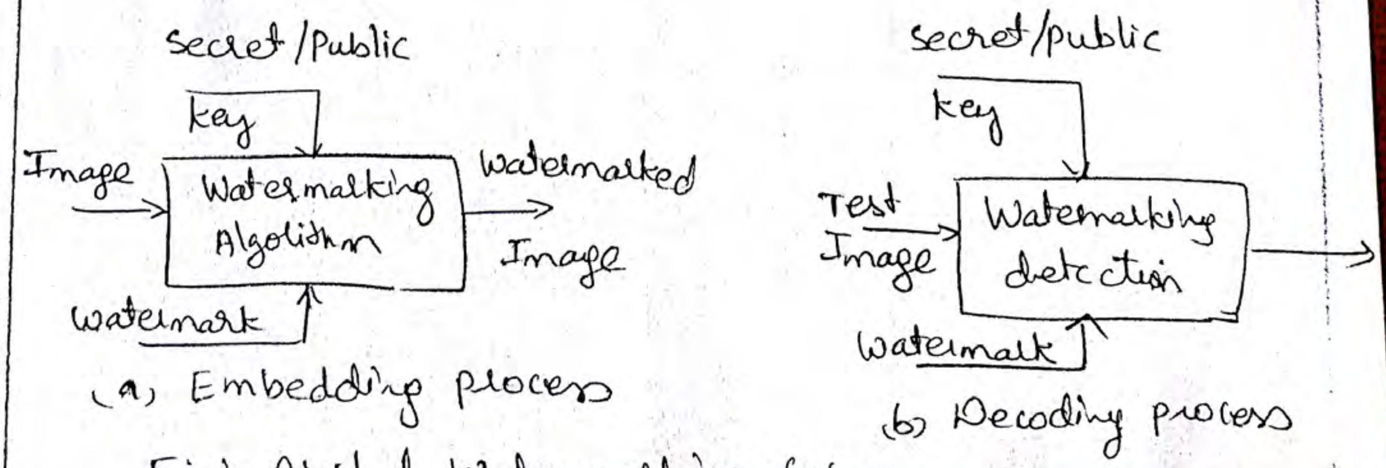


Fig:- Digital Watermarking Scheme

→ The goal of watermarking is not to restrict access to the original image, but to ensure that embedded data remain recoverable.

Classification of watermarking Methods:-

Watermarking techniques can be divided into four categories according to the type of document to be watermarked.

1. text watermarking
2. Image watermarking
3. Audio watermarking
4. Video watermarking

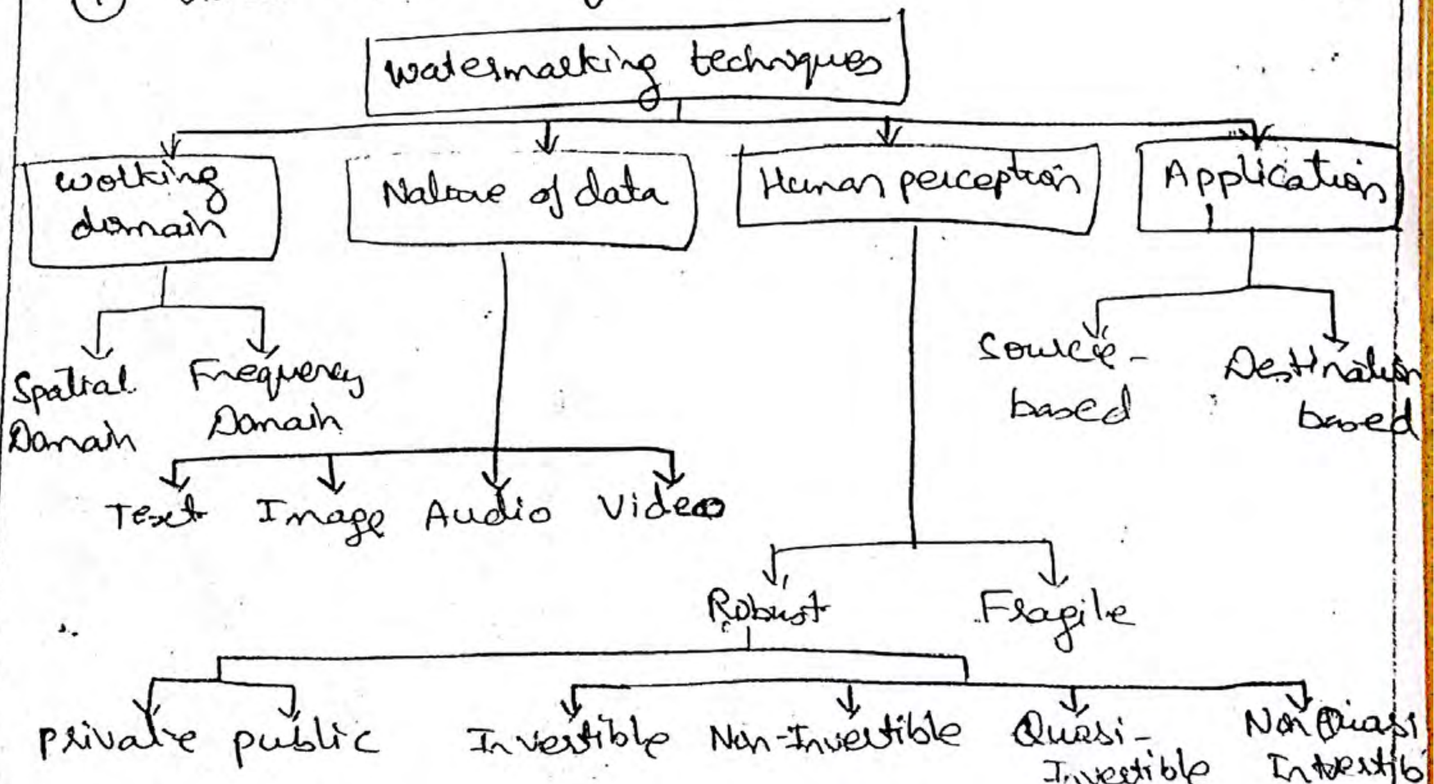


Fig:- classification of watermarking techniques

Applications of Digital Watermarking:

(i) Copyright protection
(ii) Tamper assessment
(iii) Hidden Annotations
(iv) Communication

(i) Copyright Protection :-

Digital watermarking is used to embed the copyright and authentication codes within media content.
→ The large-scale distribution of multimedia data has created the need to protect digital information against illegal duplication and manipulation.

(ii) Authentication :-

Digital watermarks are useful in the field of electronic commerce and distribution of multimedia content to end users for the proof of authenticity of documents.

~~Digita~~
(iii) Hidden Annotations :-

Digital watermarks can create hidden labels and annotations in medical applications. In medical applications watermarks can be used for identifying patient records.

(iv) Secure Communications :-

Digital watermarks find applications in the defense sector where it is a must to ~~transmit~~ transmit the data secretly.