Correlation

<u>Problem #1:</u> Suppose a matched filter is designed to recognize character A, as shown in Fig. 1A (Optical Character Recognition, OCR). The input image contains characters A, B, C, and D (Fig. 1B). (**40 points**) (Our grade will email these files to students).

(a) Computer the normalized correlation function between <A, A>, <A, B>, <A, C>, <A, D>.
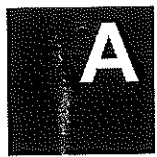
(b) Prove that <A, A> is the largest one.

Fig. 1A
128x128 pixel, raw format
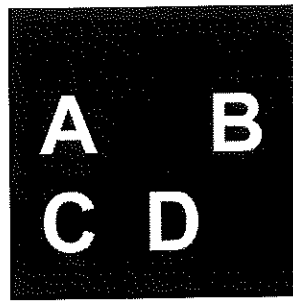
Fig. 1B
256x256 pixel, raw format
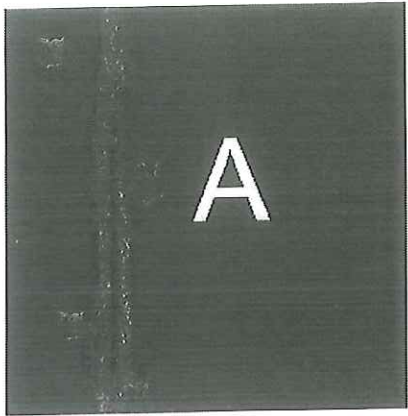
The character "A" is the object that needs to be recognized
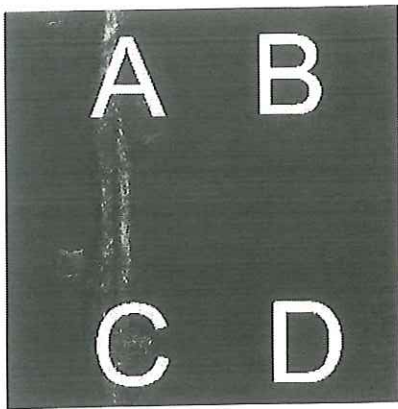
The input object contains four characters "A, B, C, D".

Then, we do the correlation operation

The correlation process follows the flow chart, as shown in Figure 1.

Flow chart of your program

$o(x,y)$

$f(x,y)$

⑦

```
┌───────┐          ┌───────┐
│ A  D  │          │   A   │
│ C  B  │          │       │
└───┬───┘          └───┬───┘
    │                  │
    ▼                  ▼
┌───────┐          ┌───────┐
│  FFT  │          │  FFT  │
└───┬───┘          └───┬───┘
    │                  │ $F(p,q)$
    │ $O(p,q)$         ▼
    │              ┌───────┐
    │              │   *   │  C. C.
    │              └───┬───┘
    │   multiplication │  $F^*(p,q)$
    │        ╱─╲       │
    └───────( X )──────┘
             ╲─╱
              │ ← $O(p,q) \cdot F^*(p,q)$
              ▼
         ┌───────┐
         │  FFT  │
         └───┬───┘
             │
             ▼
      $O(x,y) ⊛ f(x,y)$
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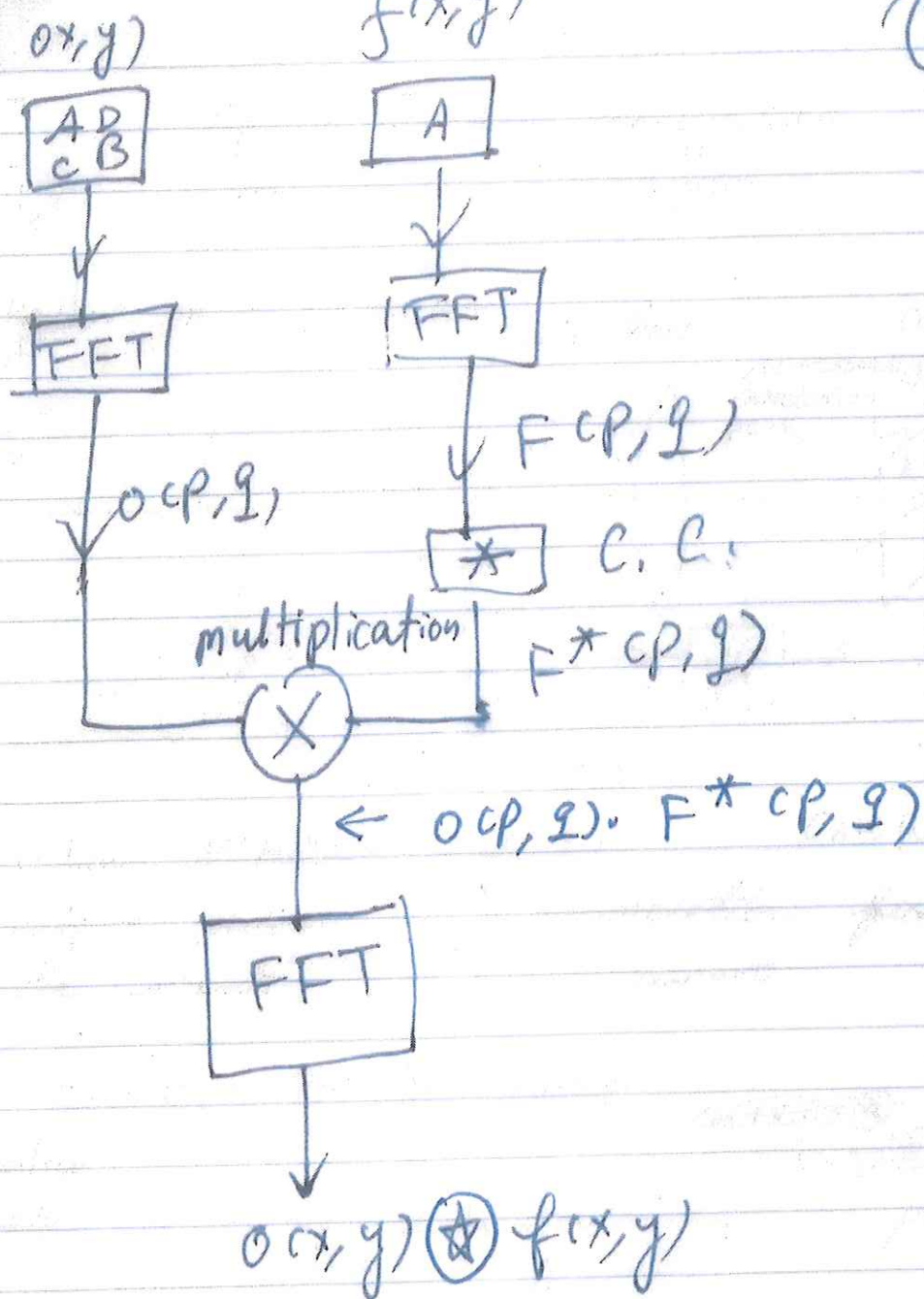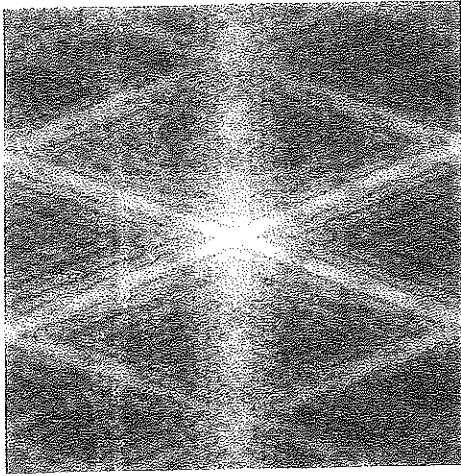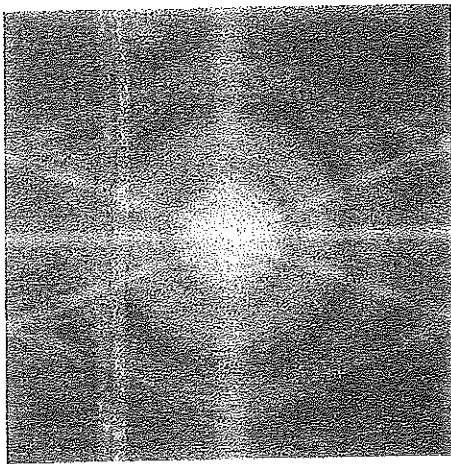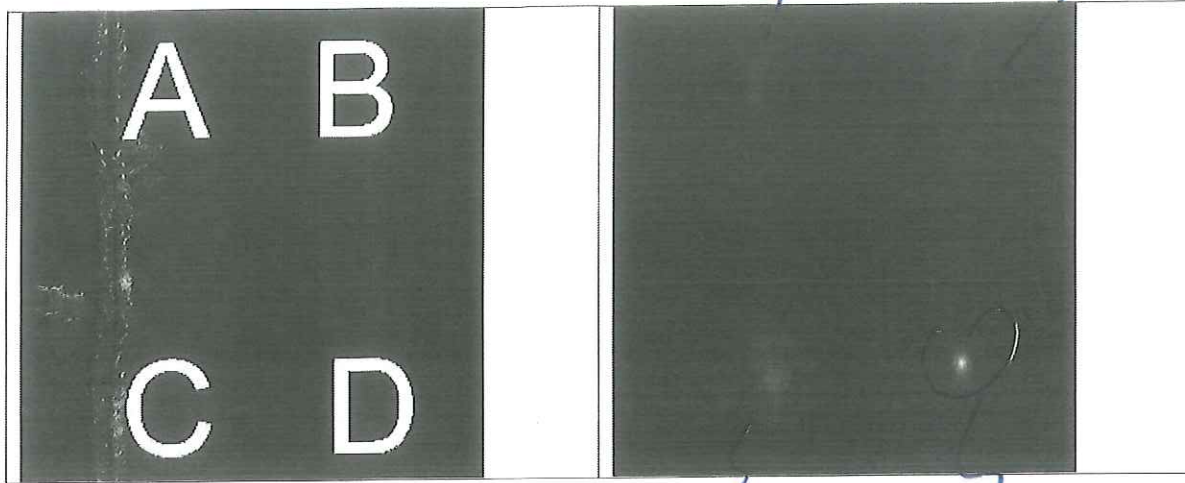
Figure 1

This is the Fourier transform of Object "A", to be recognized.

This is the Fourier transform of input object "ABCD".

$(A) \circledast (B)$ $(A) \circledast (C)$

$(A) \circledast (B)$ $(A) \star (A)$

{ This is the correlation output between character "A" and input object "ABCD". This is the inverted correlation output. "x axis" becomes "-x axis" and "y axis" becomes "-y axis".

(To avoid this flip, do inverse FFT in the last part (mentioned above)