

REGULATIONS

Due date: 23:59, 26 December 2022, Monday (*Not subject to postpone*)

Submission: Electronically. You should save your program source code as a text file named `the3.py`, and submit this file via the ODTUCLASS page of the course.

Team: There is **no** teaming up. This is an EXAM.

Cheating: Source(s) and Receiver(s) will receive zero and be subject to disciplinary action.

INTRODUCTION

Your task in this assignment is to search for a 2-dimensional (2D) pattern \mathcal{P} in a 2D image \mathcal{I} . A 2D pattern¹ \mathcal{P} with size $N \times M$ is a matrix with N rows and M columns such that $\mathcal{P}[i, j]$ denotes the pixel value at i^{th} row and j^{th} column. Similarly, an image \mathcal{I} is a matrix with H rows and W columns such that $\mathcal{I}[i, j]$ denotes the pixel value at i^{th} row and j^{th} column. It is assumed that patterns are always smaller than images; i.e., $N < H$ and $M < W$.

In this task, we will consider a simplified notion of the presence of a pattern in an image. To be specific, we will say that an image \mathcal{I} with size (H, W) contains a pattern \mathcal{P} with size (N, M) if the following summation is equal to $N \times M$ for some pixel coordinate i, j such that $1 \leq i \leq H - N$ and $1 \leq j \leq W - M$:

$$\sum_{k=1}^N \sum_{l=1}^M \mathbb{1}(\mathcal{P}[k, l] \stackrel{?}{=} \mathcal{I}[i + k, j + l]), \quad (1)$$

where $\mathbb{1}(\cdot)$ is the indicator function defined as follows:

$$\mathbb{1}(x) = \begin{cases} 1, & \text{if } x \text{ is True} \\ 0, & \text{otherwise} \end{cases} \quad (2)$$

PROBLEM & SPECIFICATIONS

- You should write a function called `pattern_search(P, I)` which computes the similarity defined in Equation 1 and should return:
 - The `bool` value `False` if the pattern `P` is not in the image `I`.
 - The `tuple` value `(i, j, Theta)` if the pattern `P` is in the image `I` such that:
 - * `i, j` is the starting coordinate² of the pattern in the image,
 - * `Theta` is the (clockwise) orientation (in degrees) of the pattern at coordinate `i, j`. We will limit the task and consider `Theta` to be only 0, 90, 180 or 270 degrees. `i, j, Theta` are all integers.

¹As we will only consider 2D patterns and images, we will drop the explicit use of ‘2D’ in the rest of the document.

²Note that pattern/image coordinates start at 0 in Python.

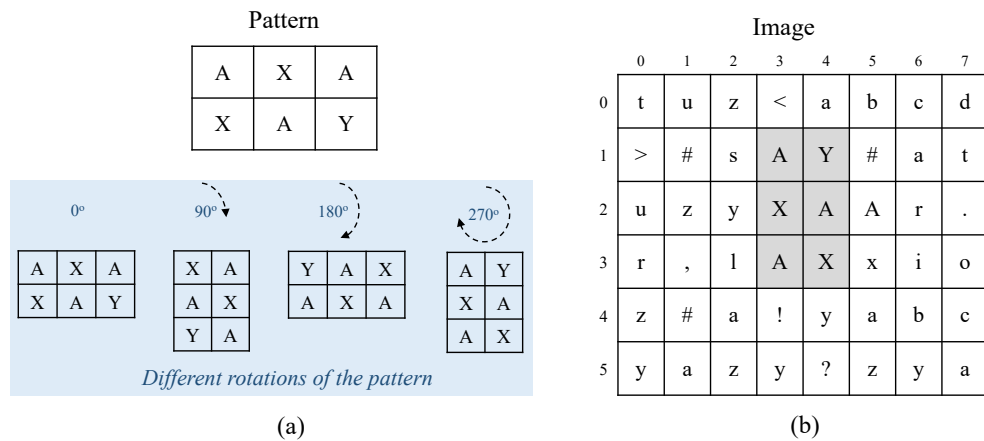


Figure 1: (a) A sample pattern and its clockwise rotations that you should consider. (b) A sample image which contains the sample pattern in (a) at coordinate (1,3) with a 270-degree orientation (**Theta**).

- To simplify the task, we will provide you a pattern P and an image I as “ASCII images”, as illustrated in Figure 1. In other words, P and I are lists of strings as follows:

```
[
    "....."      # <-- This is the first row
    "....."      # <-- This is the second row
    ...
    "....."      # <-- This is the last row
]
```

such that:

- Each string is a row of the pattern or the image.
 - Each string has the same number of characters.
 - The value at a pixel i, j can be accessed easily with $P[i][j]$ or $I[i][j]$.
 - The strings will contain only ASCII characters.
- The given pattern can be present in the given image at most once.

SAMPLE RUN

```
>>> P1 = ["AXA", "XAY"]
>>> P2 = ["AXA", "XAZ"]
>>> I = ["tuz<abcd", ">#sAY#at", "uzyXAAr.", "r,lAXxio", "z#a!yabc", "yazy?zya"]
>>> pattern_search(P1, I)
(1, 3, 270)
>>> pattern_search(P2, I)
False
```

RESTRICTIONS and GRADING

- **You are not allowed to import any libraries.**
- The similarity definition in Equation 1 is case sensitive; i.e., 'A' and 'a' are two different characters.
- Comply with the specifications outlined. Do not expect any input from the user or print anything on screen. Conform to the specifications and the expected return type. Your program will be graded through an automated process and any violation of the specifications will lead to errors (and reduction of points) in automated evaluation.
- Your program will be tested with multiple data (a distinct run for each data). Any program that performs only 30% and below will enter a glass-box test (eye inspection by the grader TA). The TA will judge an overall THE2 grade in the range of [0,30].
- A program based on randomness will be graded zero.
- The glass-box test grade is not open to discussion nor explanation.