Multi-template matching: A versatile tool for object-localization in microscopy images

Course: Computer Vision (CS 419)
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Introduction:

Generally, in a microscopic image, the main subject of interest is located in a very small field of view and is randomly positioned in the image. Our aim here is to develop a generalized way to localize the subject or subjects to zero down on that area in the image containing the subject/subjects. And for doing so, studying different template matching techniques and trying to mitigate the problems created by differences in size and noise in the image to get the best results most of the time.

There are several methods used for object localization and image segmentation in known knowledge space; however, in generalizing these methods, there could be specific problems as we discuss further; usually, intensity-based image segmentation would have worked for such a task, but the workflow around it is a bit complex and requires a lot of tuning to fit the particular subject resulting in high application-specific solutions; also it may fail to detect the entire body of the organism or tissue if it is not contrasted correctly,

Alternatively, we could go for edge and shape detection for low contrast images. Again, this limits the method to the shape and will be sensitive to noise, Deep-learning, or machine learning that might offer a wide range of algorithms. Still, they generally require a huge dataset to give satisfactory results on the test set and not overfitting the training set; also, the training times are high. The hyperparameters still need to be tuned mostly manually.

With the above discussion in mind, we propose the use of template matching for this problem; template matching would permit for most probable position of matching subject to the specified template with minor manual annotation and at a minimal computational cost.

Methodology:

We plan to let the user specify the templates for the subject and a set of input images over which they wish to localize the subject. Finally, save the processed images with a rectangle drawn about the identified subjects in the results folder.

As per the specified template, we use the sliding windows method and calculate either the difference/error or the correlation in the window and the template and all the points where the chosen metric satisfies a certain threshold; we mark this as an identified subject,

Now even the subject of the same class of images also tend to vary in appearance, so the use of only one template will limit the detection capacity of our program, so we use multiple templates and try to use different matching methods to increase confidence in the matches,

One problem that will arise due to this will be multiple matches overlapping with one another. To counter this, we need to eliminate the matchings that have an overlap beyond a specified

threshold. Template matching is a well-studied topic, and many methods of matching templates have already stated; for example,

Squared difference matching - match the squared differences in template and image segment,

Correlation matching - multiplicatively match the template against the image,

Correlation Coefficient methods - match the template relative to its mean against the image relative to its mean,

Cross-correlation matching etc.

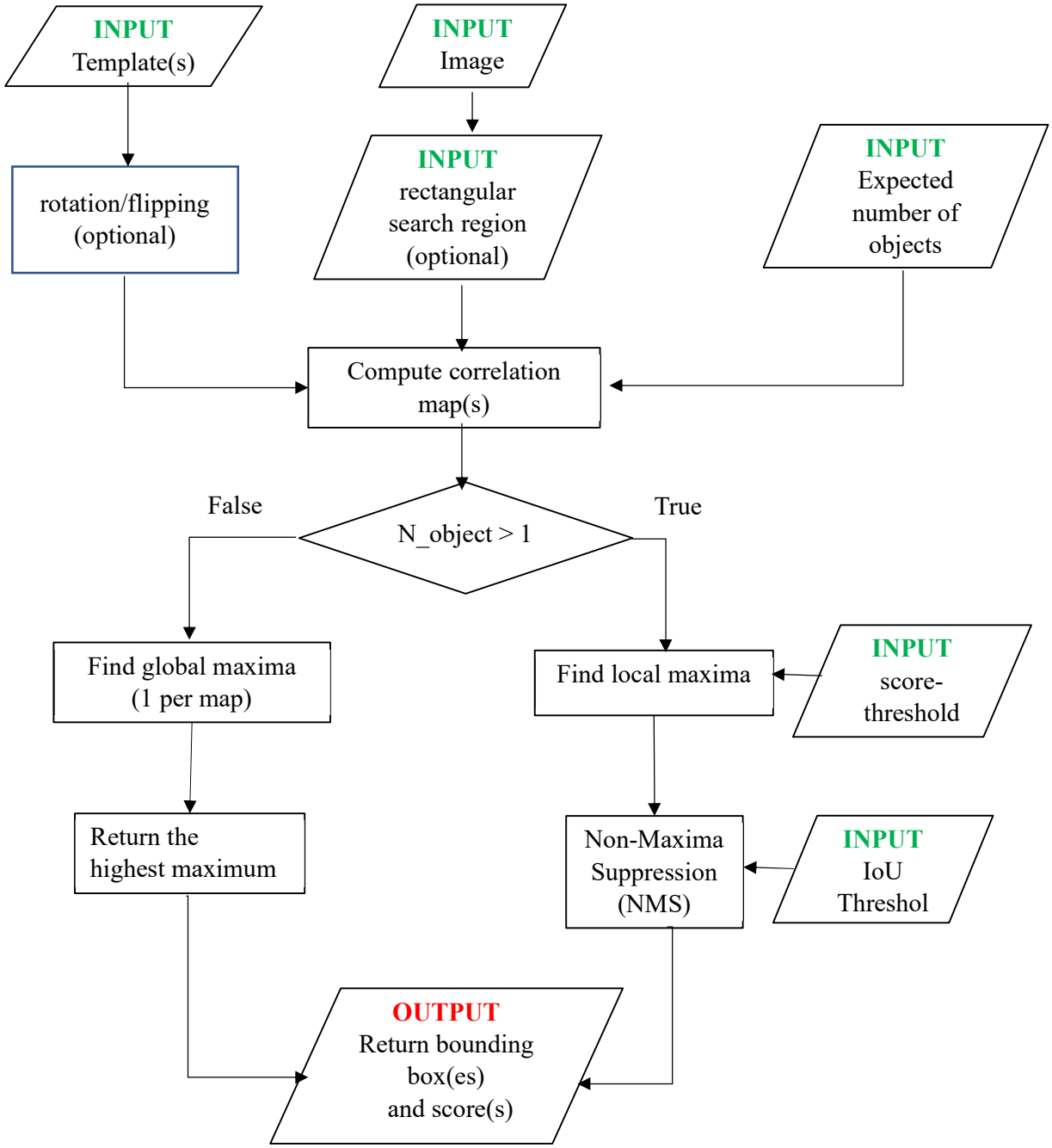

Fig: Flowchart of the implemented multi-template matching

Problems that we wish to overcome:

1. Size/scaling difference: As stated in the introduction with the methods from matching templates, if the sizes are too different, then the match will not be detected.
   Our Approach to solve this: to mitigate this, we plan on generating different size templates from the original template by scaling, rotating, and inverting the original template about the x and y-axis.
   We also plan on experimenting with varying measures of distance for template matching.
2. Noise reduction: The presence of noise will also affect the performance of the program
   Our Approach to solve this: before running the template matching algorithm, we plan to use some form of noise reduction method to pre-process the input images.
3. Rotated subjects: As mentioned earlier, the subject can be located in any part of the image and could be in any orientation; thus, only one template might miss the subject.
   Our Approach to solve this: As proposed in point 1, we plan on generating multiple templates from the original template by rotating and scaling; this should make the algorithm more robust towards alignment variations
4. Overlapping Subjects: In multiple subjects' presence, it is possible that two or more subjects are too close to one another or even overlapping one another; in such a case, neither of the subjects may give a fair match

Dataset:

Apart from the provided dataset, we plan on using datasets from different competitions,
We are trying to solve the scarce data availability problem, so we want to use a smaller dataset as our program is not learning any model, the scarcity of data should not pose an overfitting or underfitting problem.

Resources:

1. Multi-Template Matching for object-detection: - Link
2. Wiki: Template Matching:- Link
3. OpenCV:: Template Matching :- Link