YOPO – You Pick Only Once

Digital Image Processing 2025

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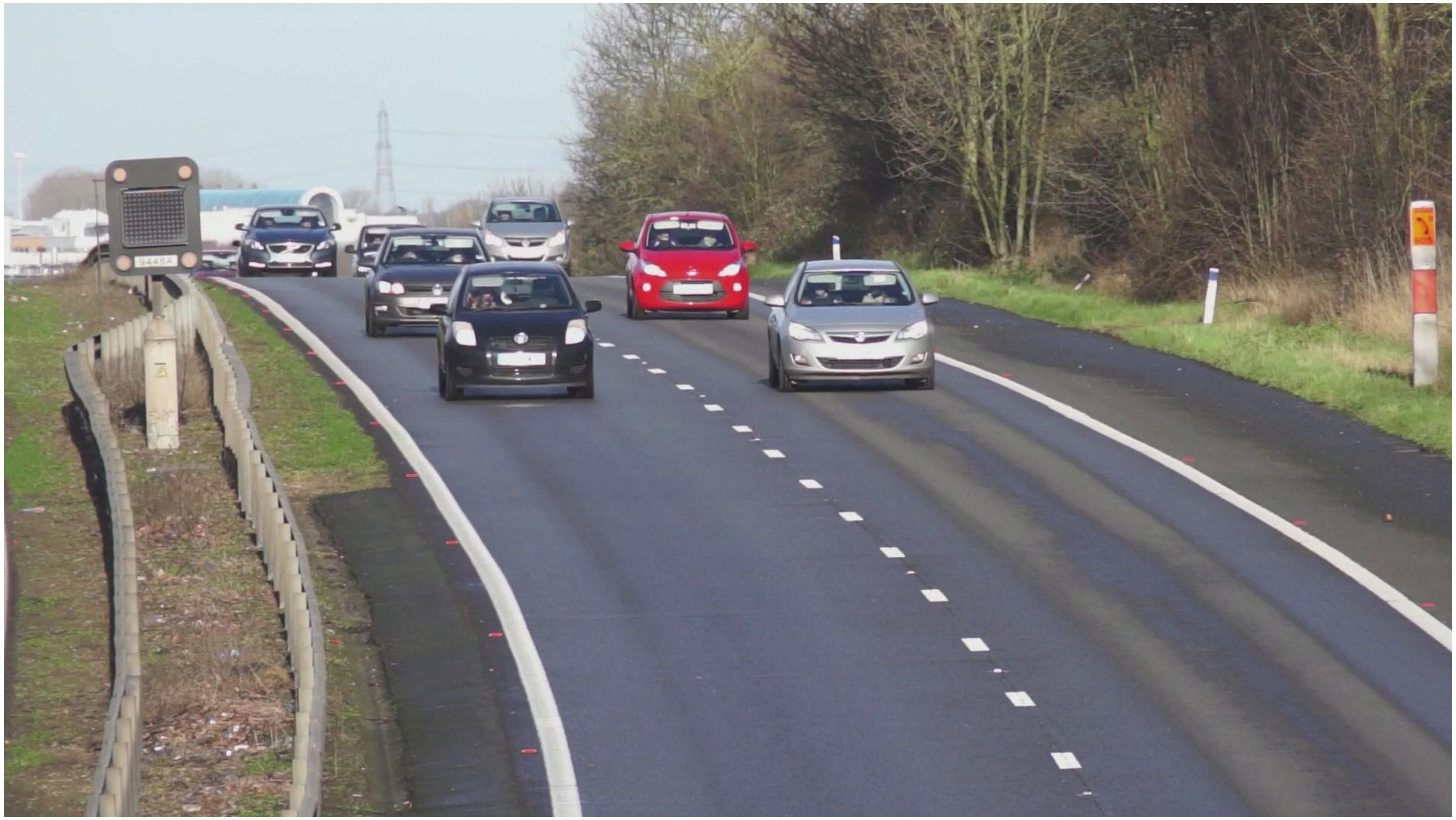
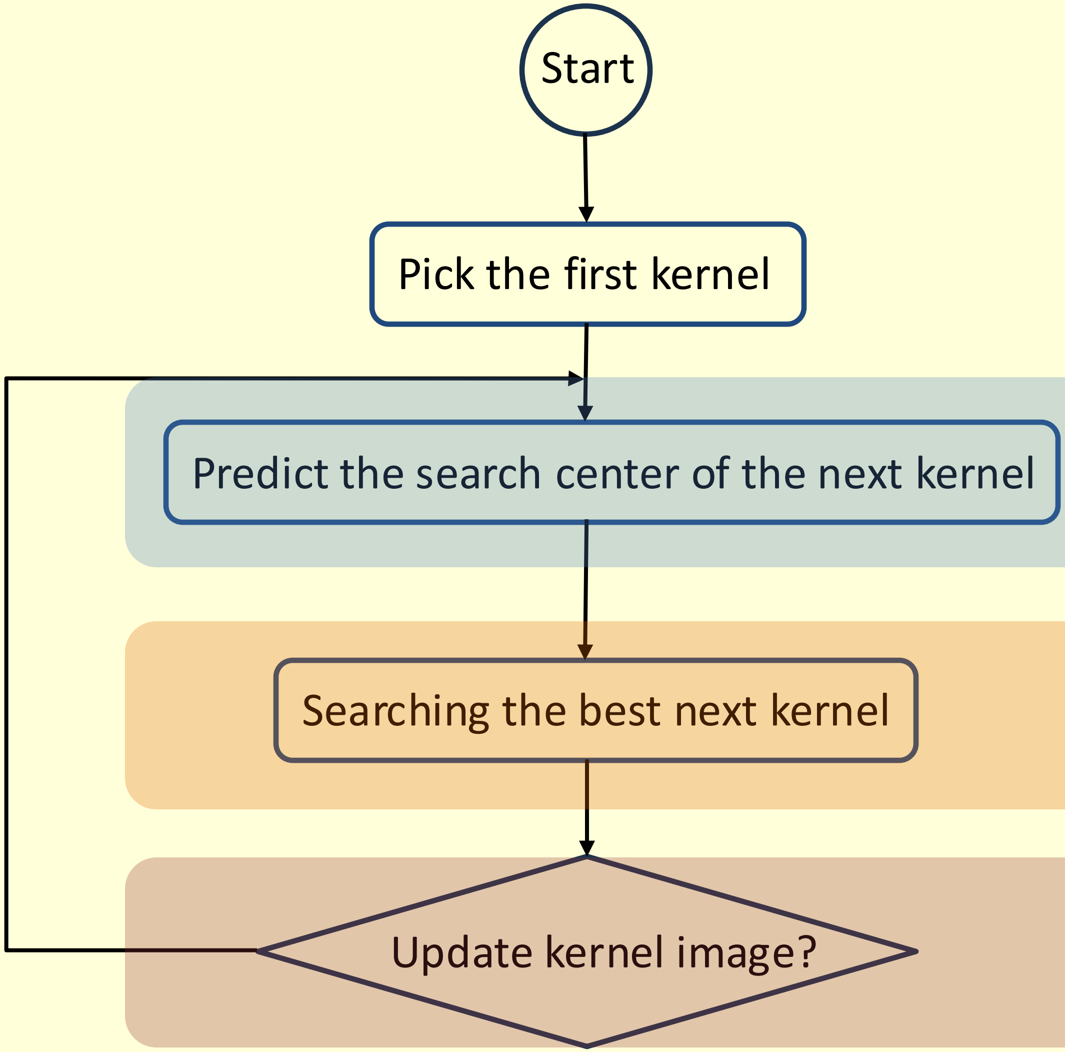
Problem Background

Requirement: Design a mathematical algorithm to track the red car and blue car in two sequences as much as possible.



Methodology: Overview



Start

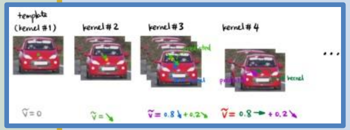
Pick the first kernel

Predict the search center of the next kernel

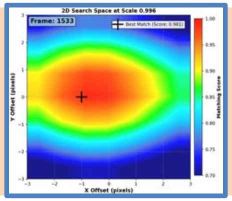
Searching the best next kernel

Update kernel image?

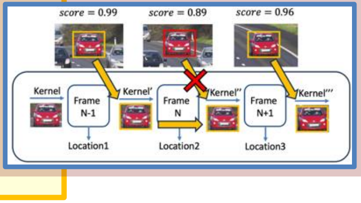
Together



Jinming Ren



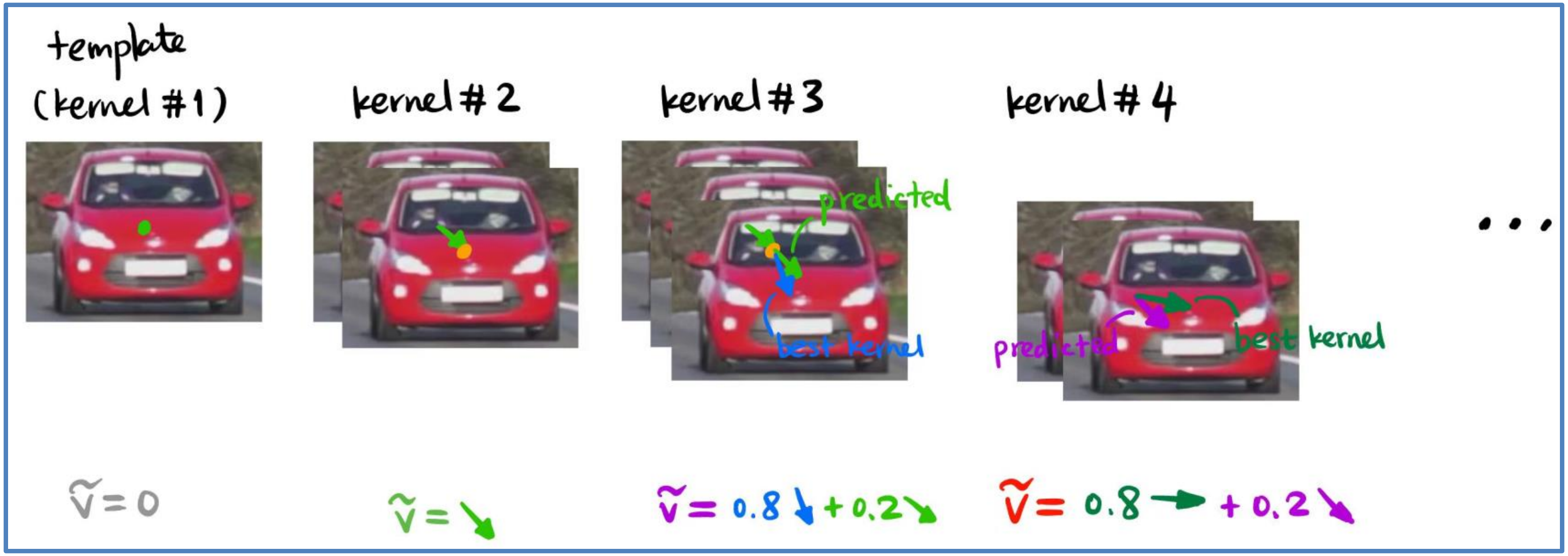
Yuhao Liu



Jiyi Yang

Methodology: Details

Step 1. Motion Prediction: Identify the center of the next most likely kernel



- **Moving Average Method**
  - First frame: no history knowledge, just use the center of the picked kernel
  - Remaining frames: set a weight (e.g., $\alpha = 0.8$) to the last velocity prediction:

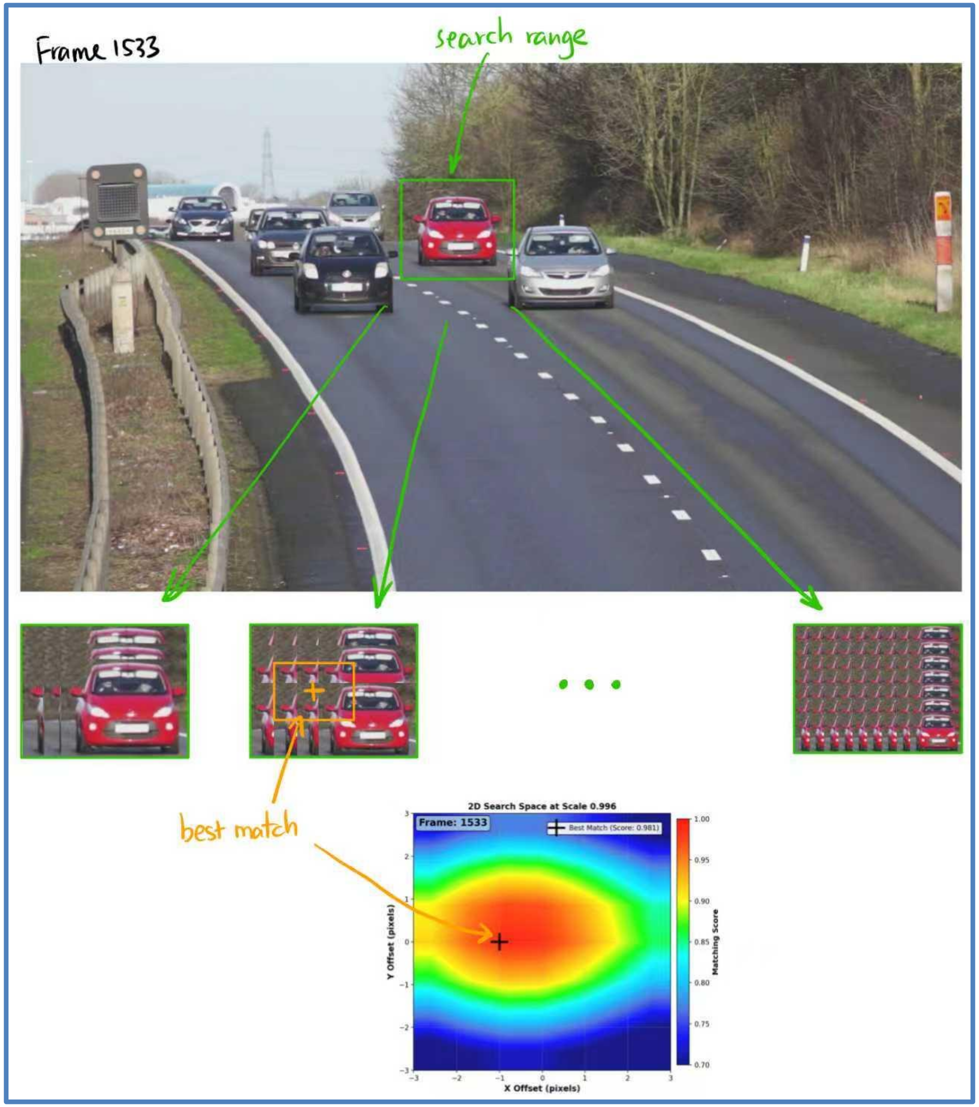
$$v_n = \alpha v_{n-1} + (1 - \alpha) v_{n-2}$$

Methodology: Details

Step 2. Searching: Search the car by the kernel in different size within a specific area around that center.

- We use the “best” kernel to scan the image within the area
- Also expand and shrink the size of the kernel to find the best size
- NCC value measures similarity:

$$-1 \leq NCC(kernel, image) \leq 1$$

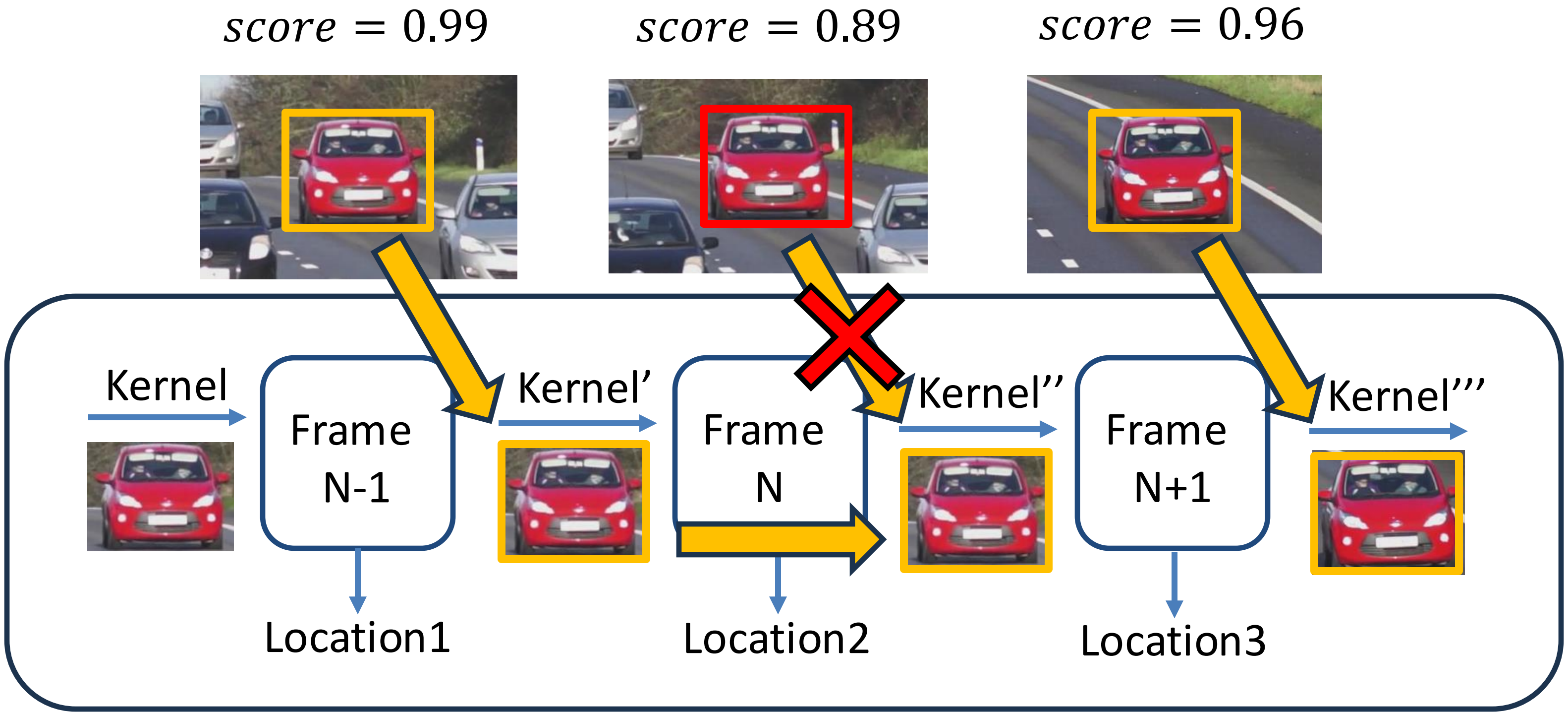


Methodology: Details

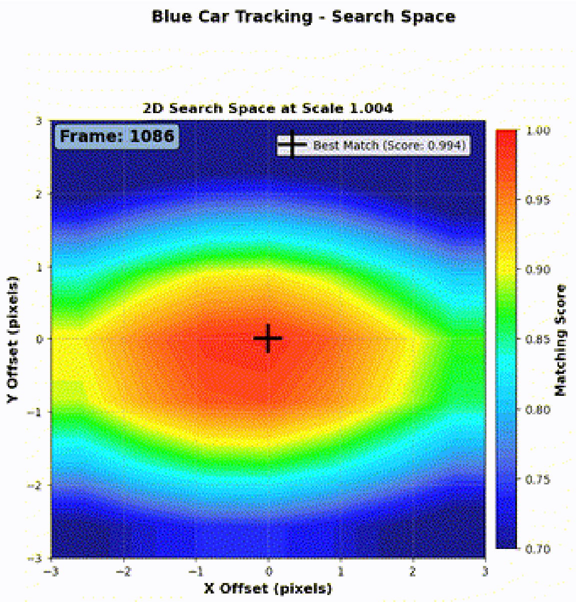
Step 3. Updating Rule:

- Position always updated
- Kernel content conditionally updated (based on an NCC threshold)

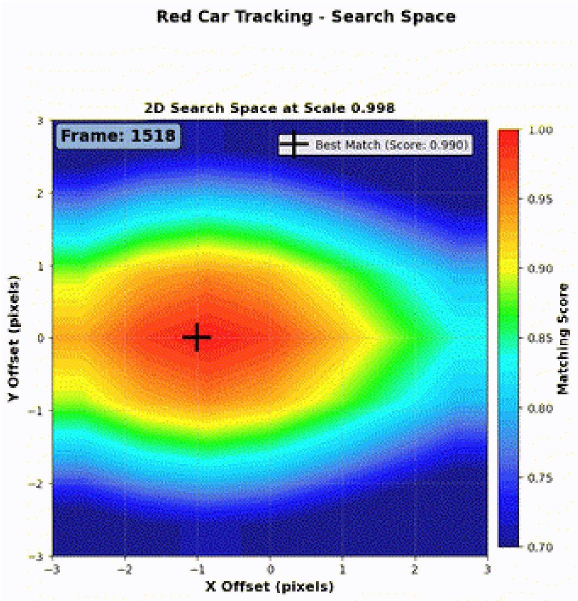
e.g., $NCC_{thres} = 0.94$



Results



The '+' refers to the greatest point. Where the deeper the color, the greater the value



Conclusion

Our solution successfully addressed the following problems:

- **Problem 1.** Object size and color changing
  - Sol. Updating the kernel!

- **Problem 2.** Computationally expensiveness in finding best matching
  - Sol. Predicting motion!
  - Actually, we also used color histogram to filter out some candidates inside the three for loops to further reduce computation costs!