

Harvesting Training Images for Fine-Grained Object Categories using Visual Descriptions

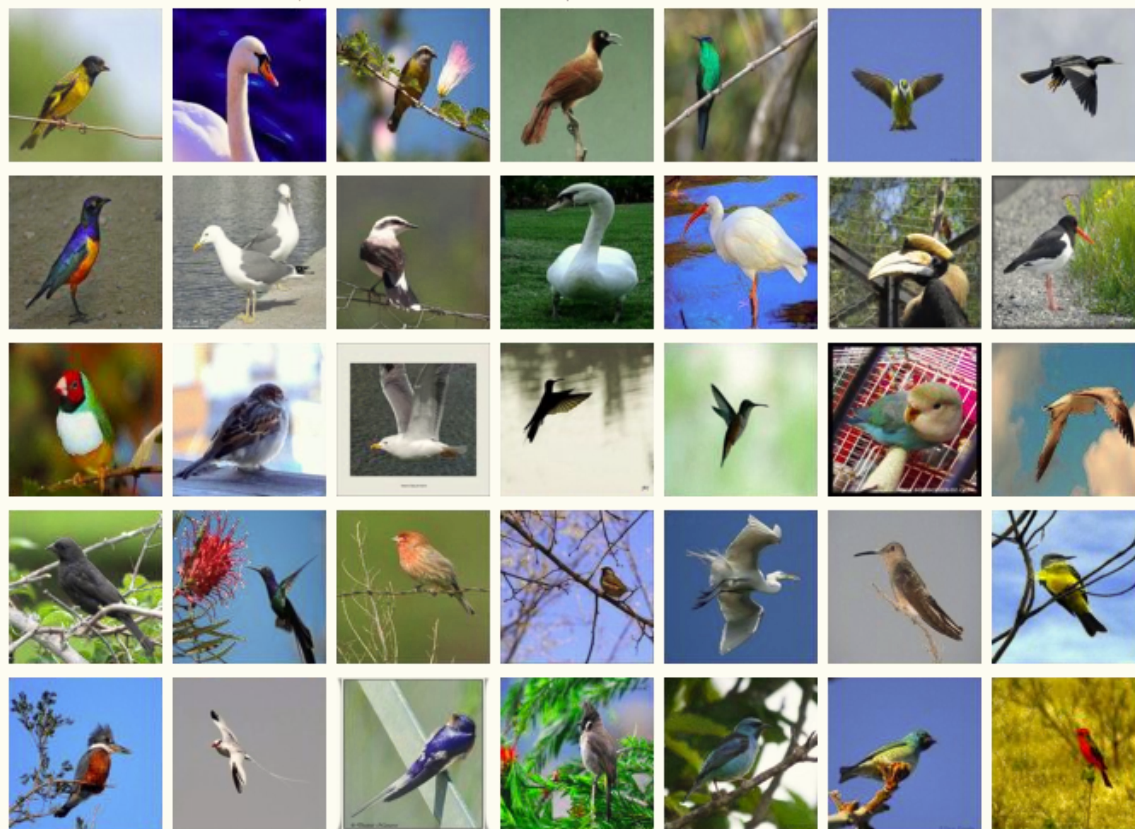
Josiah Wang, Katja Markert, Mark Everingham[†]



[†] Posthumous author

Background & Motivation

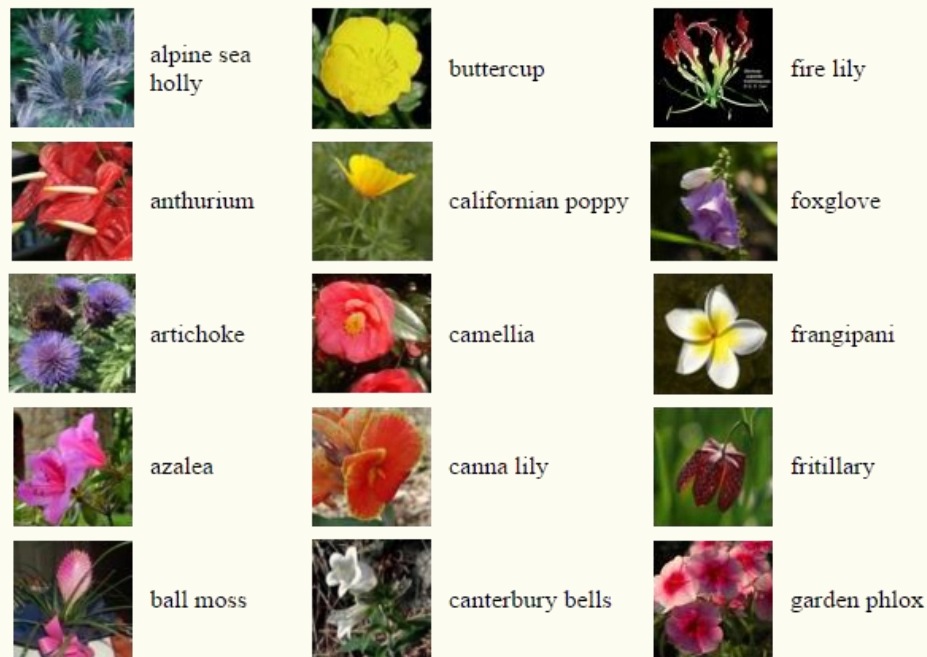
- Visual recognition: Large-scale image datasets available
 - State-of-the art: ~3% classification error for 1,000 categories



“birds” on
ImageNet

Background & Motivation

- Fine-grained categories (animal and plant species)
 - Large-scale dataset is still limited
 - Annotation is onerous & requires domain expertise



Oxford 102 Category
Flower Dataset

Background & Motivation

- One solution: gather training data automatically for training visual classifiers for fine-grained categories
- How?

Main Idea

- Start with only the **category name** and **visual description** for a **fine-grained** category...

Monarch *Danaus plexippus*

+ SAVE TO LIST  SEND ECARD

[enlarge +](#)



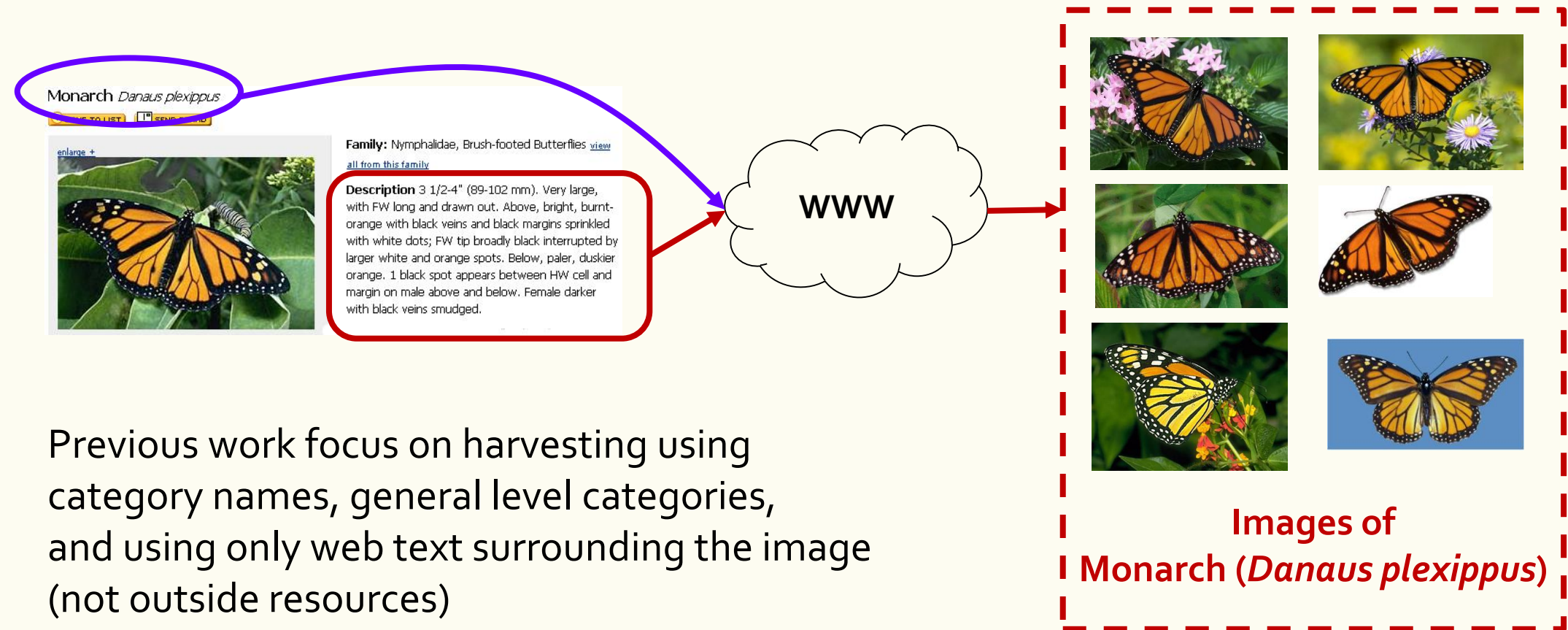
Family: Nymphalidae, Brush-footed Butterflies [view all from this family](#)

Description 3 1/2-4" (89-102 mm). Very large, with FW long and drawn out. Above, bright, burnt-orange with black veins and black margins sprinkled with white dots; FW tip broadly black interrupted by larger white and orange spots. Below, paler, duskier orange. 1 black spot appears between HW cell and margin on male above and below. Female darker with black veins smudged.

(eNature.com)

Main Idea

- Automatically harvest training images from the Web



Objectives

- Use visual descriptions for fine-grained categories to:
 - improve search engine querying
 - rerank images: compare web page text to visual descriptions
- Our claim:
 - visual descriptions can improve precision over name-based search

Visual Descriptions

- Define appearance properties of an object category
- Readily available for certain object categories (butterflies, flowers, sign language, judo moves, *etc.*)

Very large, with forewing long and drawn out. Above, bright, burnt-orange with black veins and black margins sprinkled with white dots; forewing tip broadly black interrupted by larger white and orange spots. Below, paler, duskier orange.

Wang et al., BMVC 2009

Also:

Elhoseiny et al. 2013

Ba et al. 2015

- Learn models using only visual descriptions
 - No training images used

Monarch *Danaus plexippus*

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Fine-grained Categories

- Harvest images for ten butterfly categories
 - Leeds Butterfly Dataset (Wang et al. 2009)



*Danaus
plexippus*



*Heliconius
charitonius*



*Heliconius
erato*



*Junonia
coenia*



*Lycaena
phlaeas*



*Nymphalis
antiopa*



*Papilio
cresphontes*



*Pieris
rapae*



*Vanessa
atalanta*

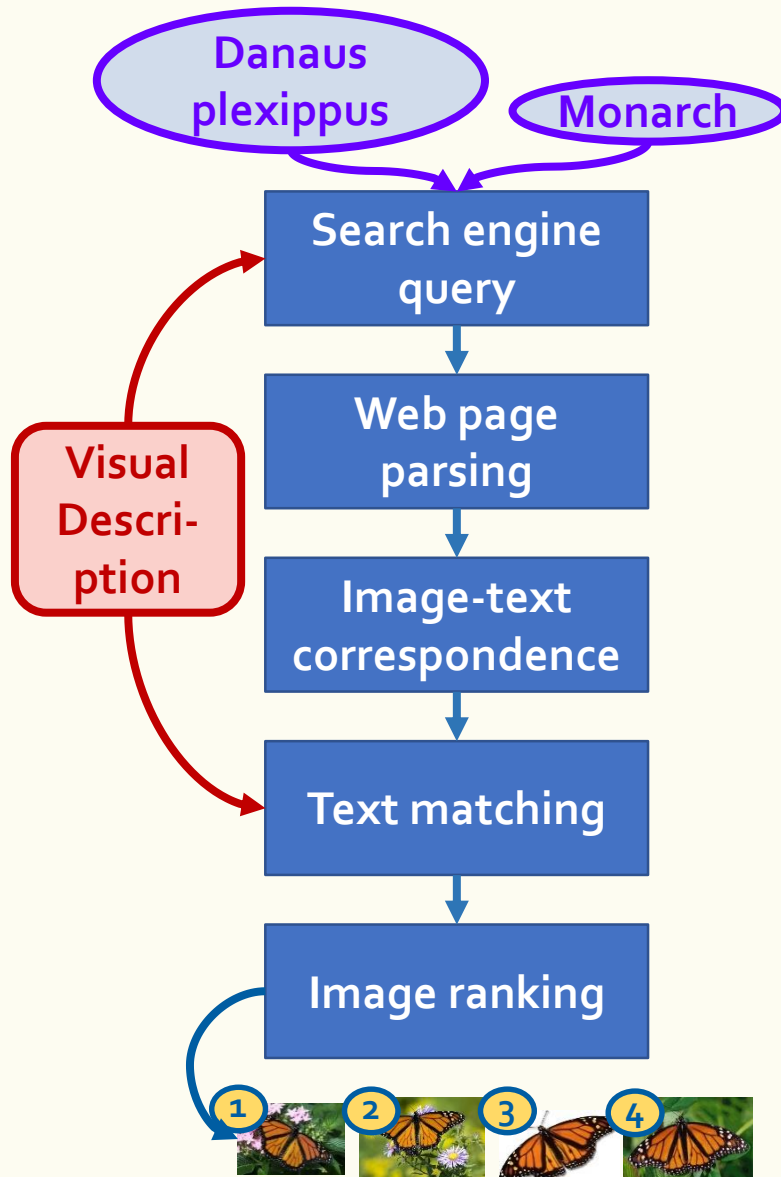


*Vanessa
cardui*

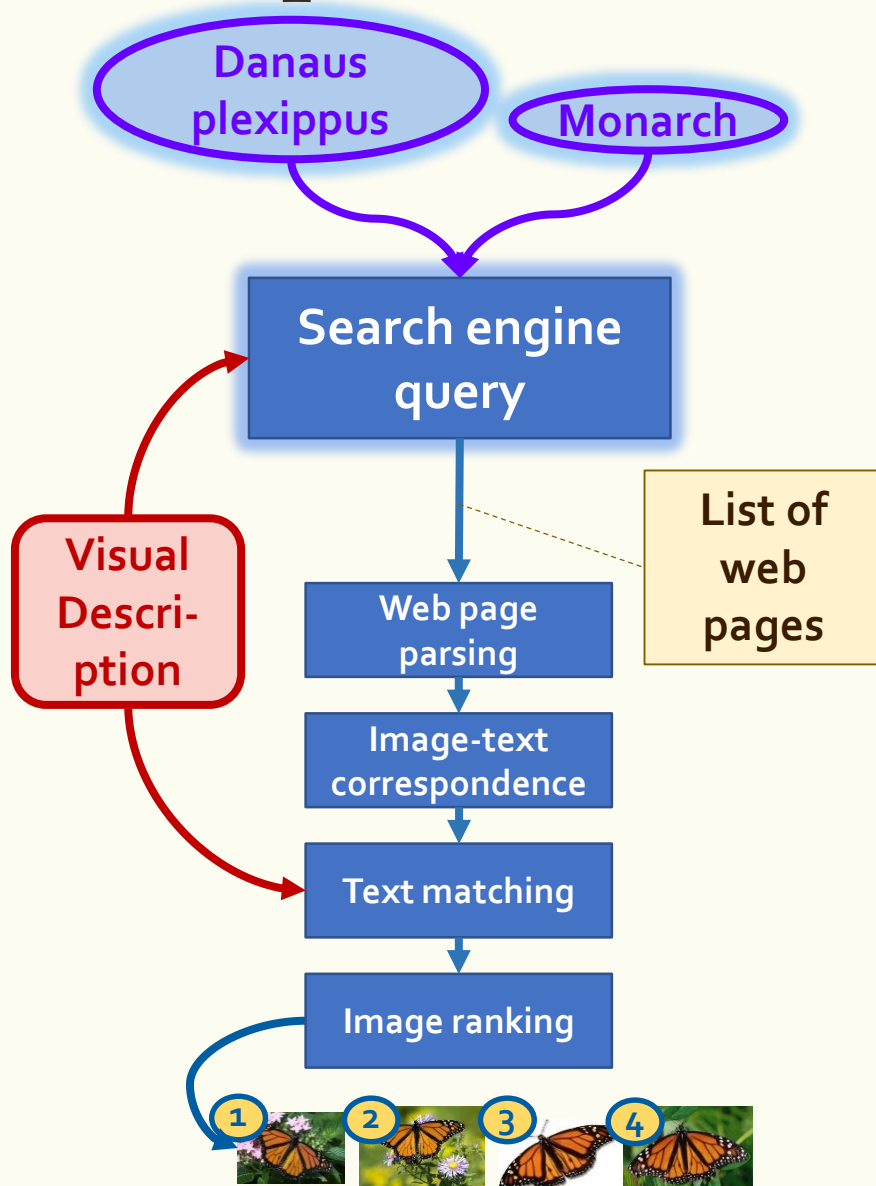
Framework Overview



Framework Overview



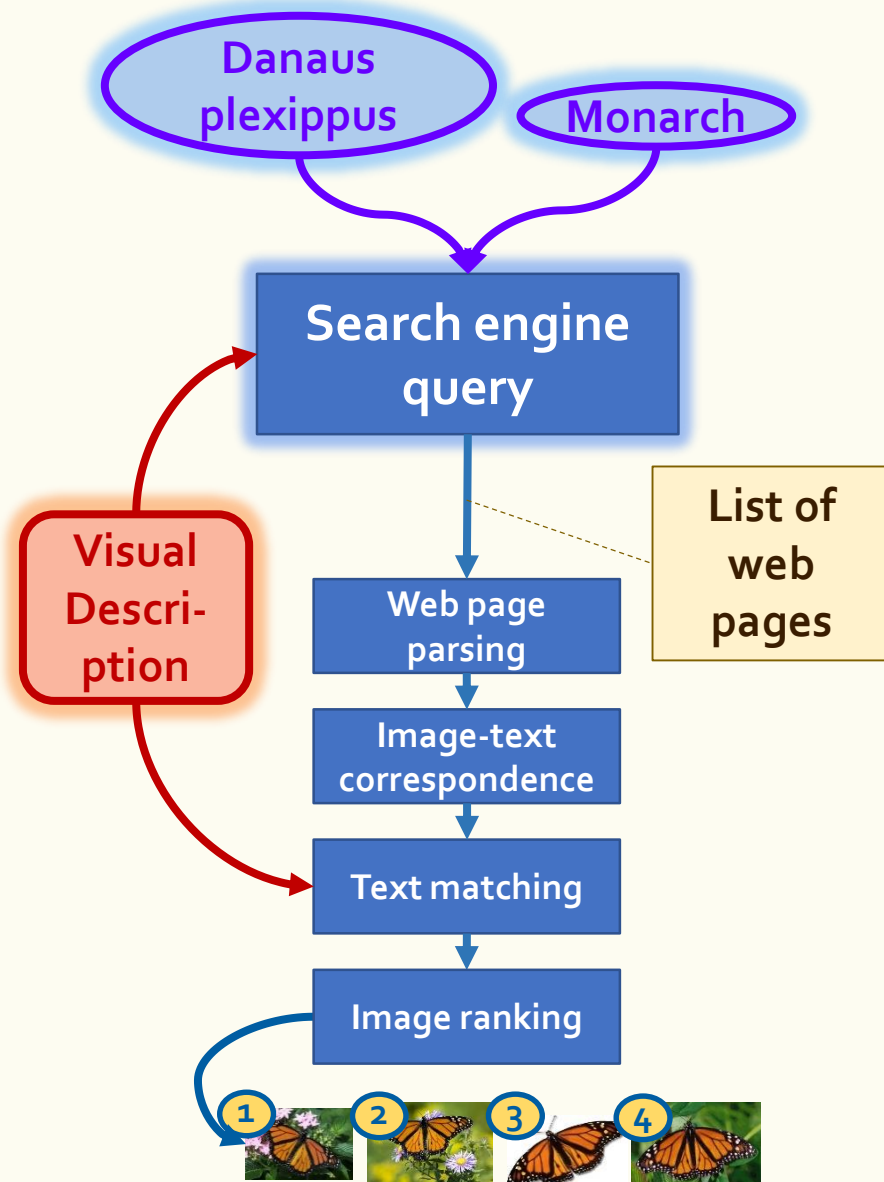
Step 1: Search Engine Query



- Base queries
 - "Danaus plexippus"
 - "Monarch" + butterfly **Polysemy!**
 - "Danaus plexippus" + (description OR identification)
 - "Monarch" + (description OR identification) **Improve recall**



Step 1: Search Engine Query



- Seeded queries
 - Improve precision
 - NP and AP from visual descriptions

FW tip extended, clipped. Above, black with orange-red to vermillion bars across FW and on HW border. Below, mottled black, brown, and blue with pink bar on FW. White spots at FW tip above and below, bright blue patch on lower HW angle above and below.

bright blue patch

black brown and blue

fw tip

hw border

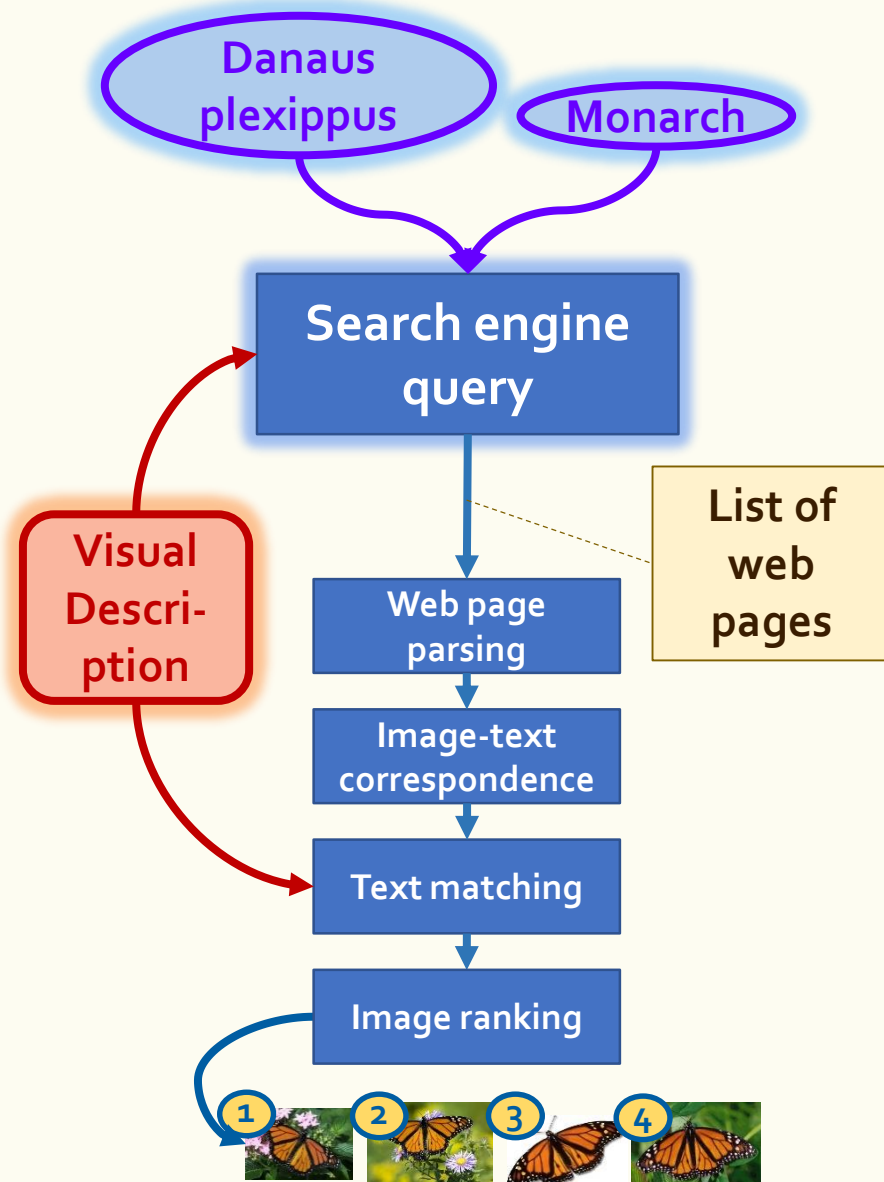
lower hw angle

white spots

orange red to vermillion bars

pink bar

Step 1: Search Engine Query



- Seeded queries

- Single

Danaus plexippus bright blue patch

- Pairs

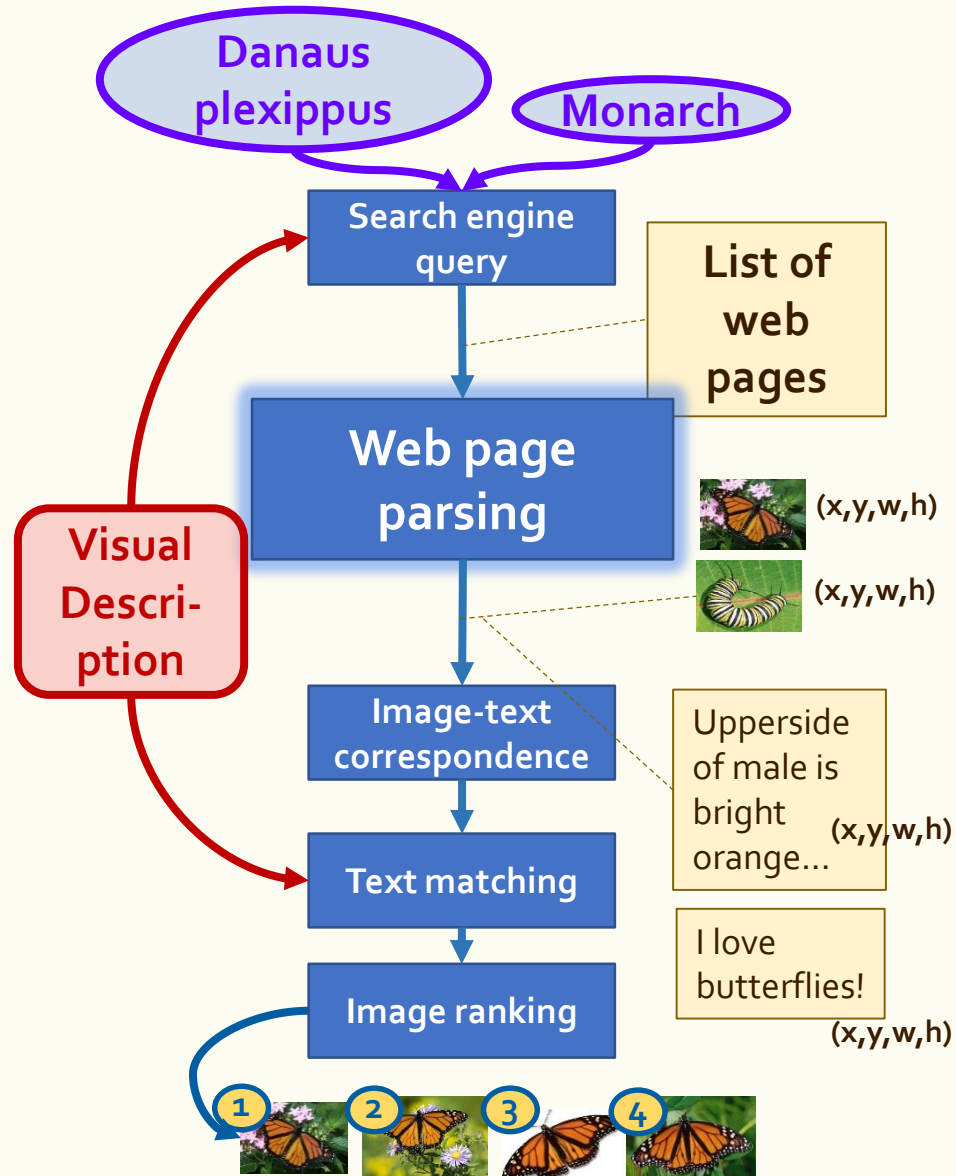
Danaus plexippus bright blue patch white spots

- Triplets

Danaus plexippus fw tip white spots pink bar

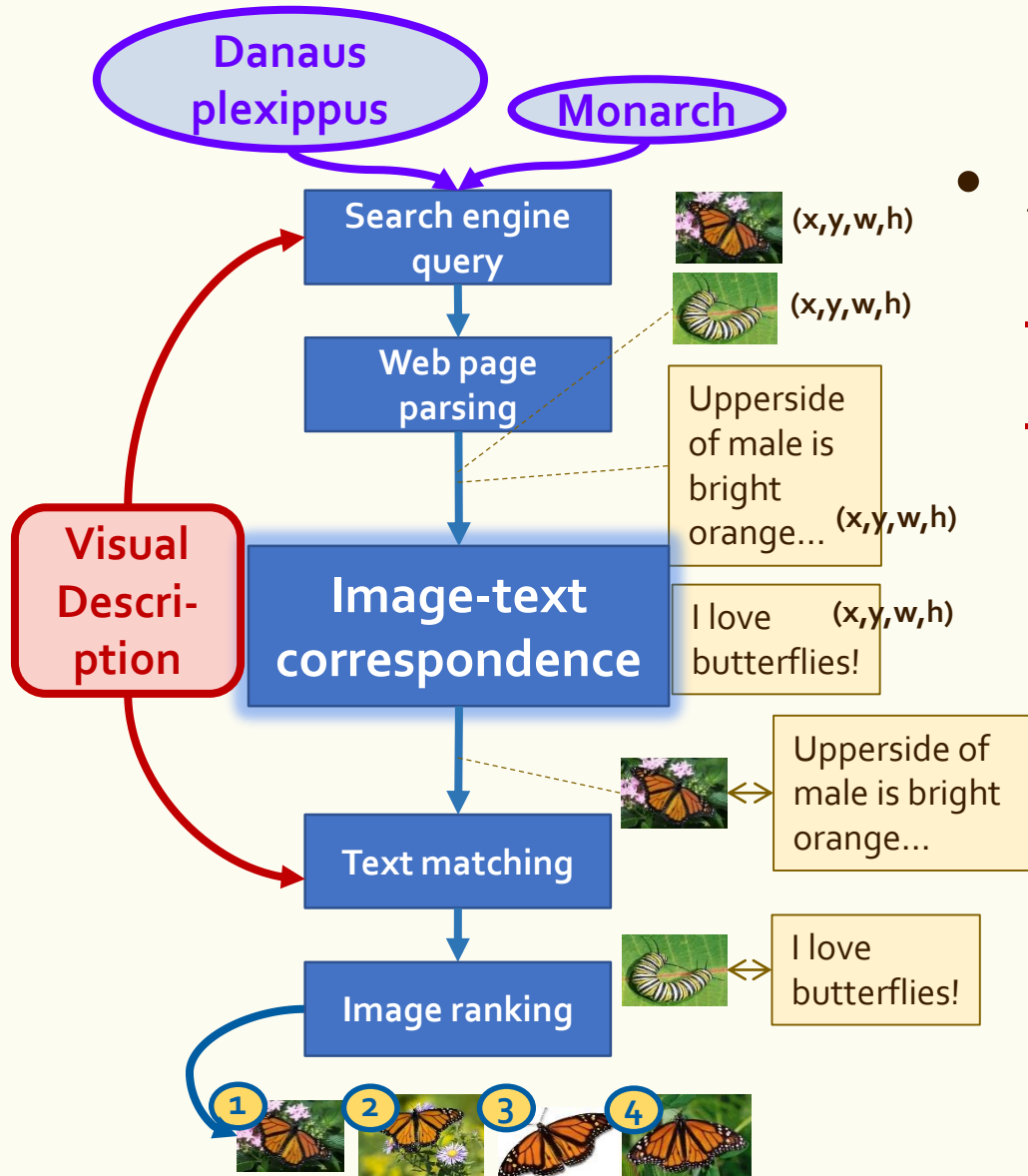
- Combine base queries, seeded queries (each for Latin and English name)

Step 2: Web Page Parsing



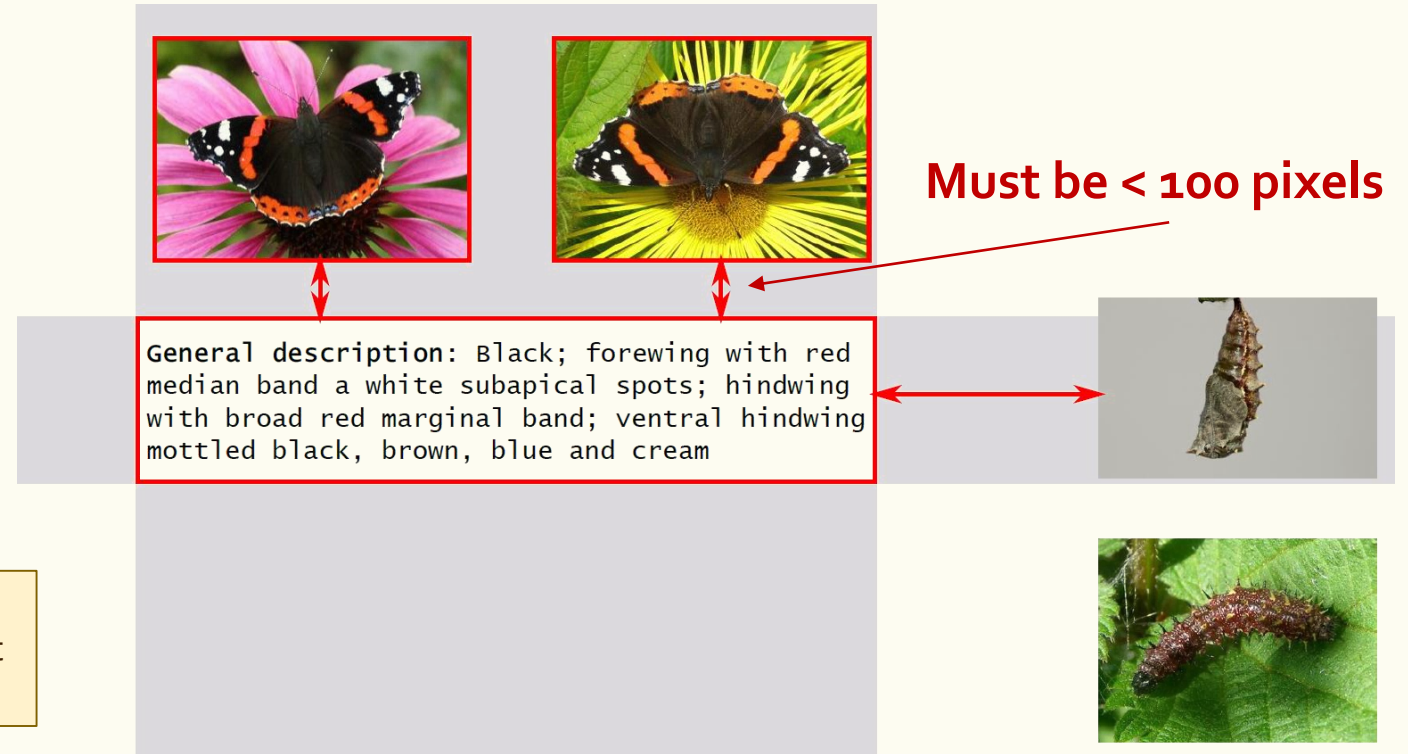
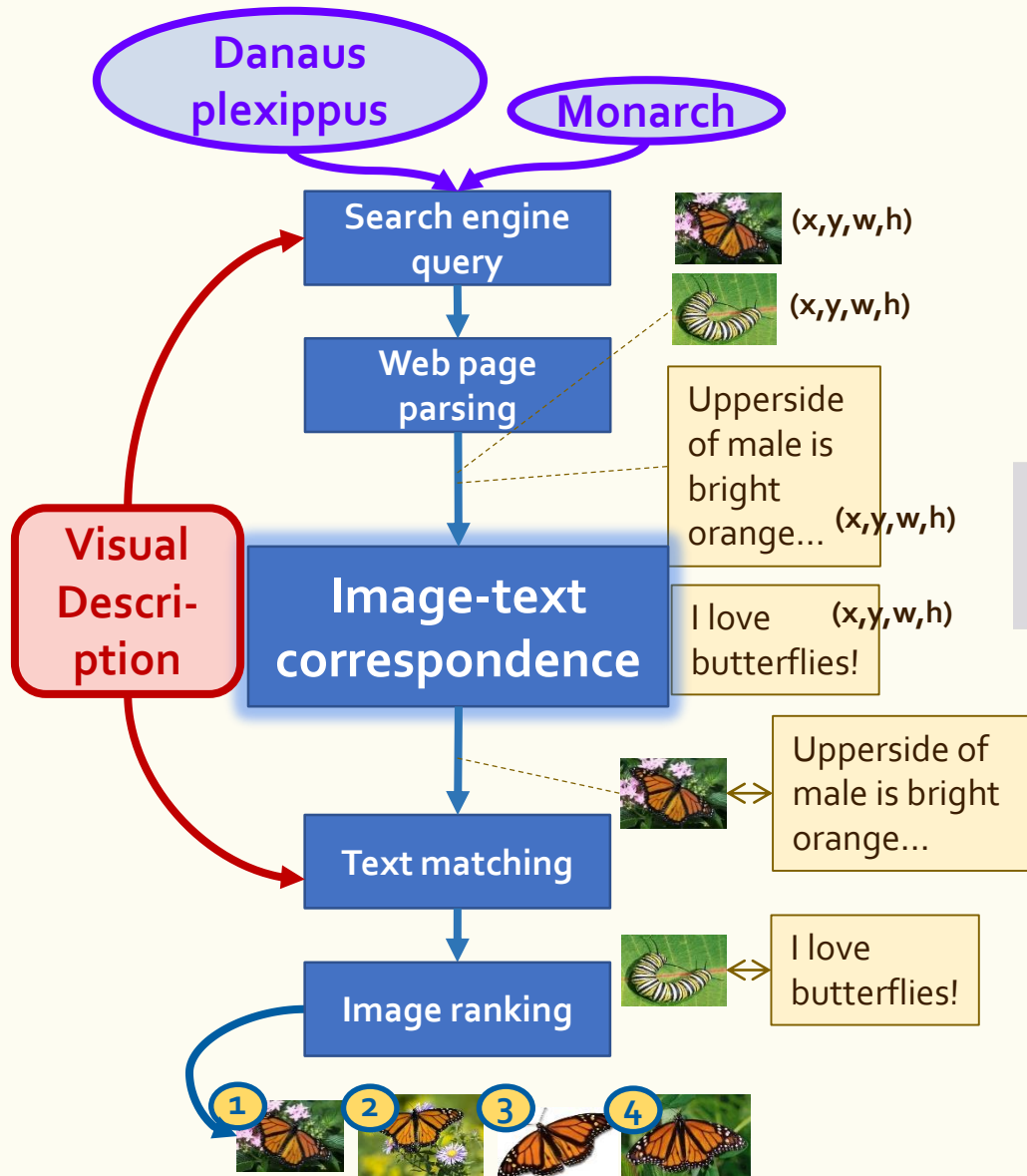
- Extract images and text blocks & their position on webpage
 - Use layouting engine of QtWebKit
- Filtering (adverts, headers, etc.)
 - Retain images with butterfly name in metadata (img src, alt, title)
 - Exclude negative terms (caterpillar, pupa)

Step 3: Image-text Correspondence



- Align image and text by their position as displayed on a web browser

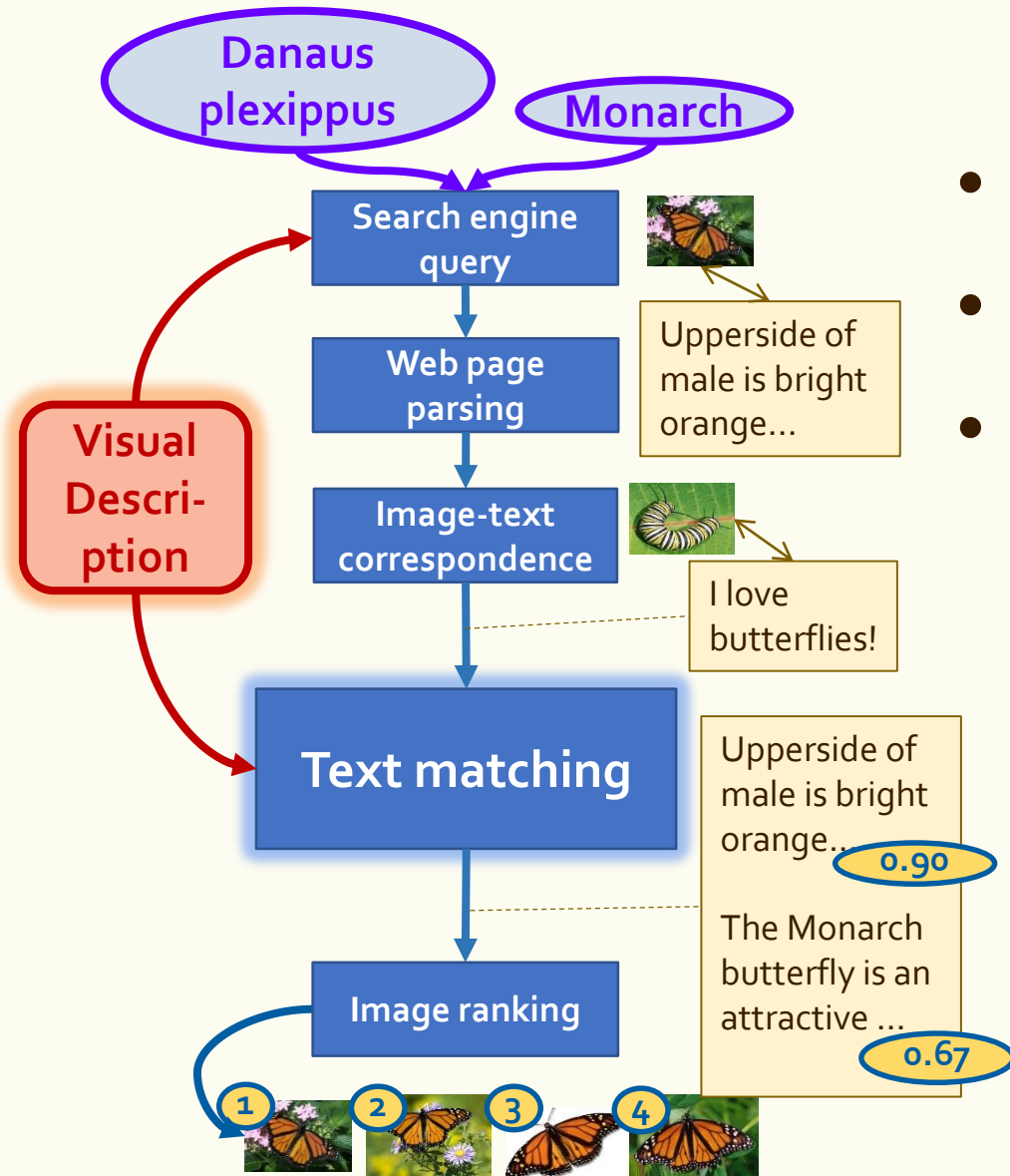
Step 3: Image-text Correspondence



1 image -> multiple text blocks
1 text block -> 1 image (unless same distance)

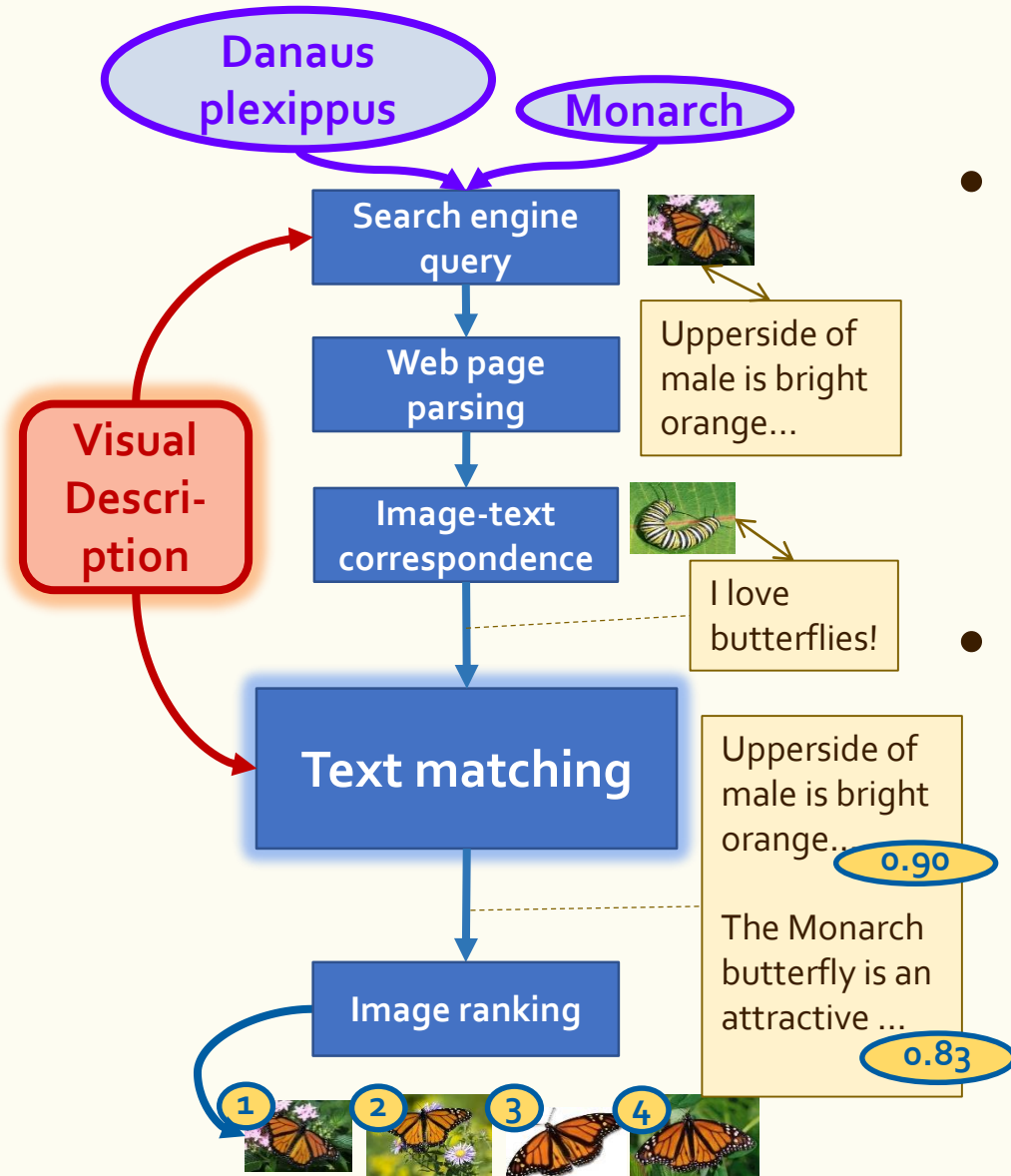
Must be within shaded region

Step 4: Text Matching



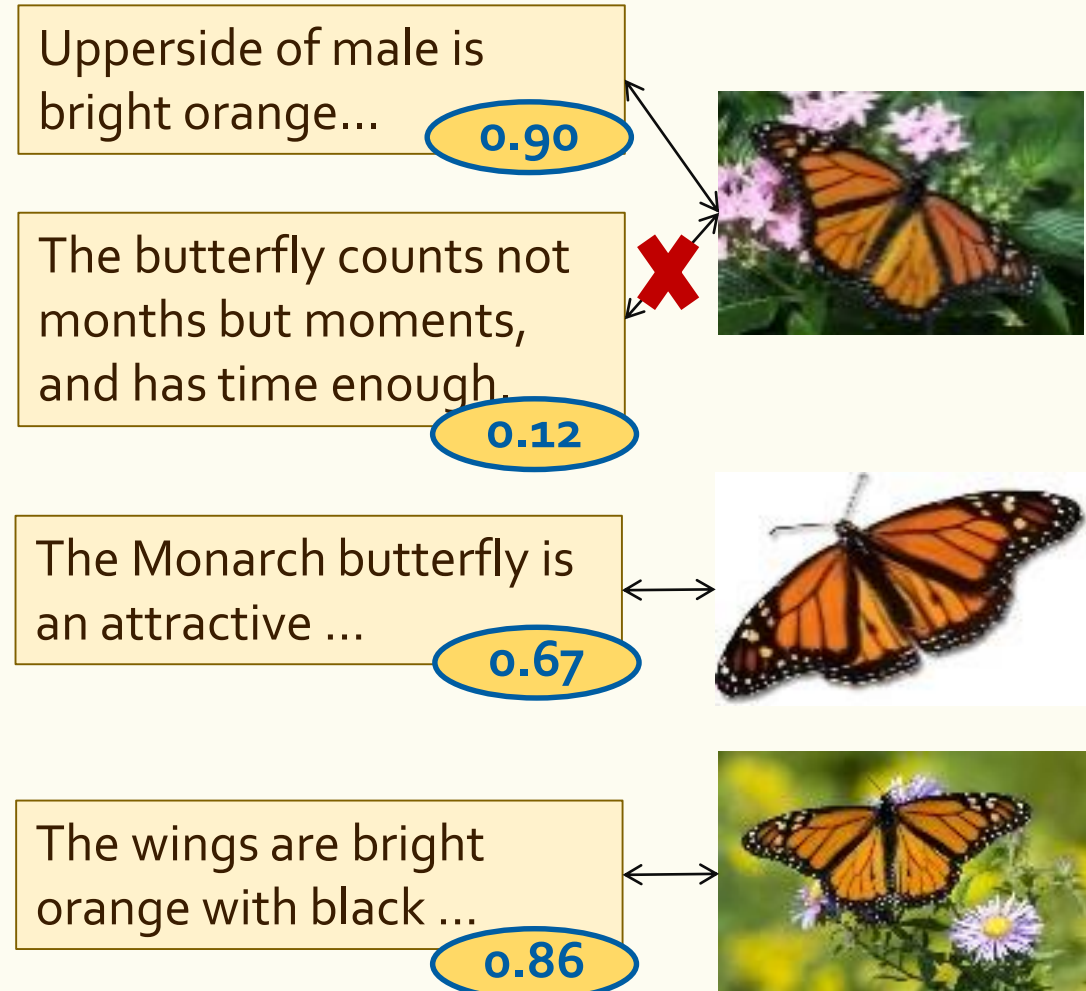
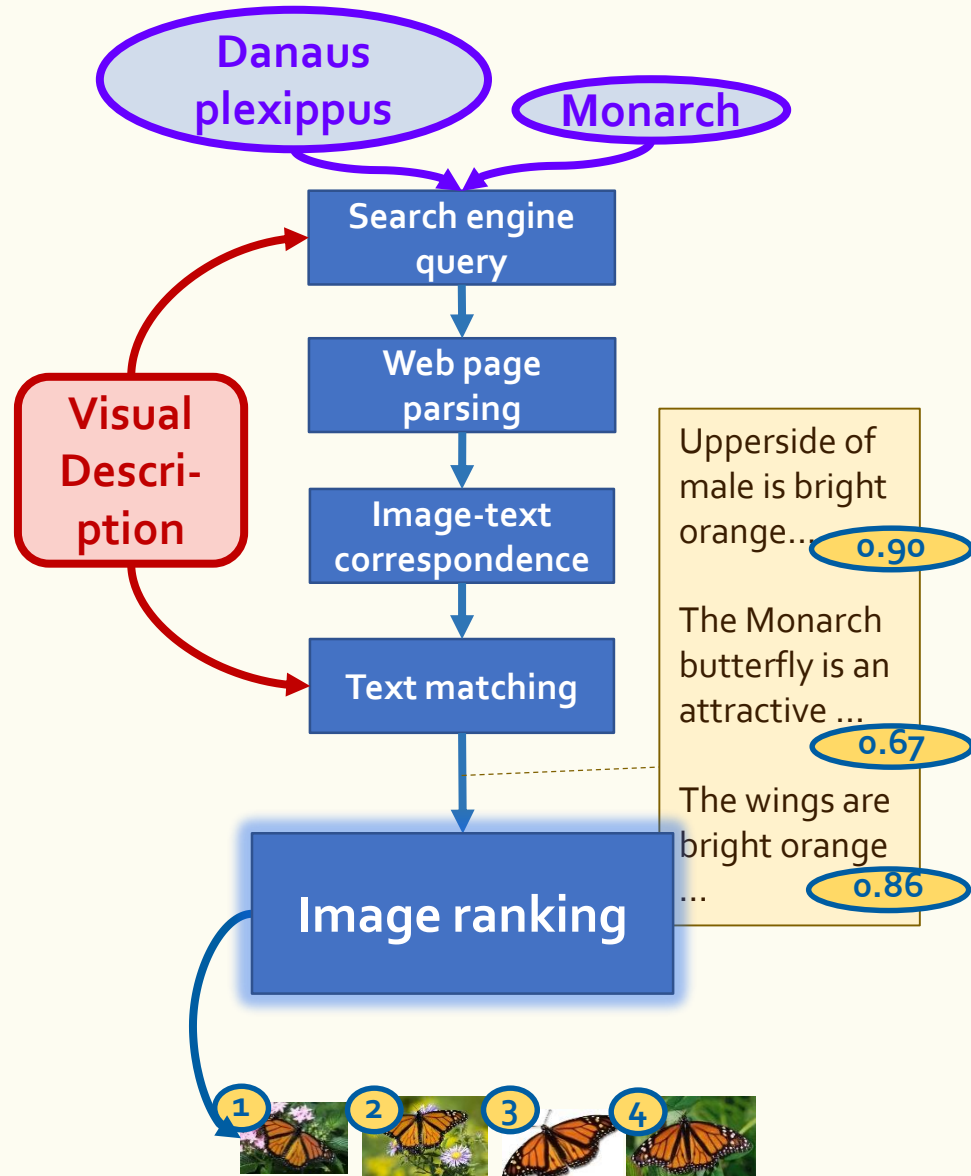
- Query: Visual description
- Documents: Extracted text blocks
- Objective:
 - Search for documents similar to query
 - Assign each document a similarity score

Step 4: Text Matching

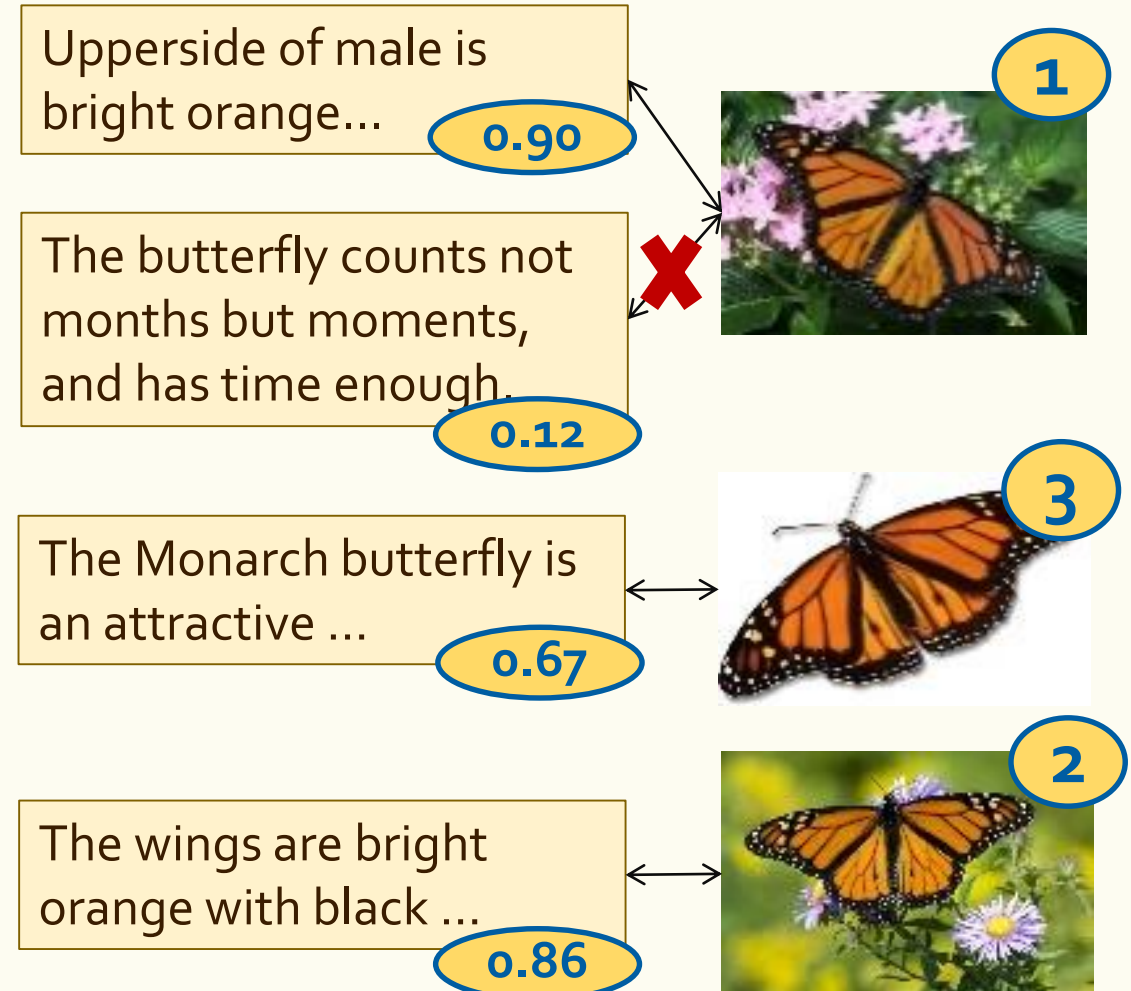
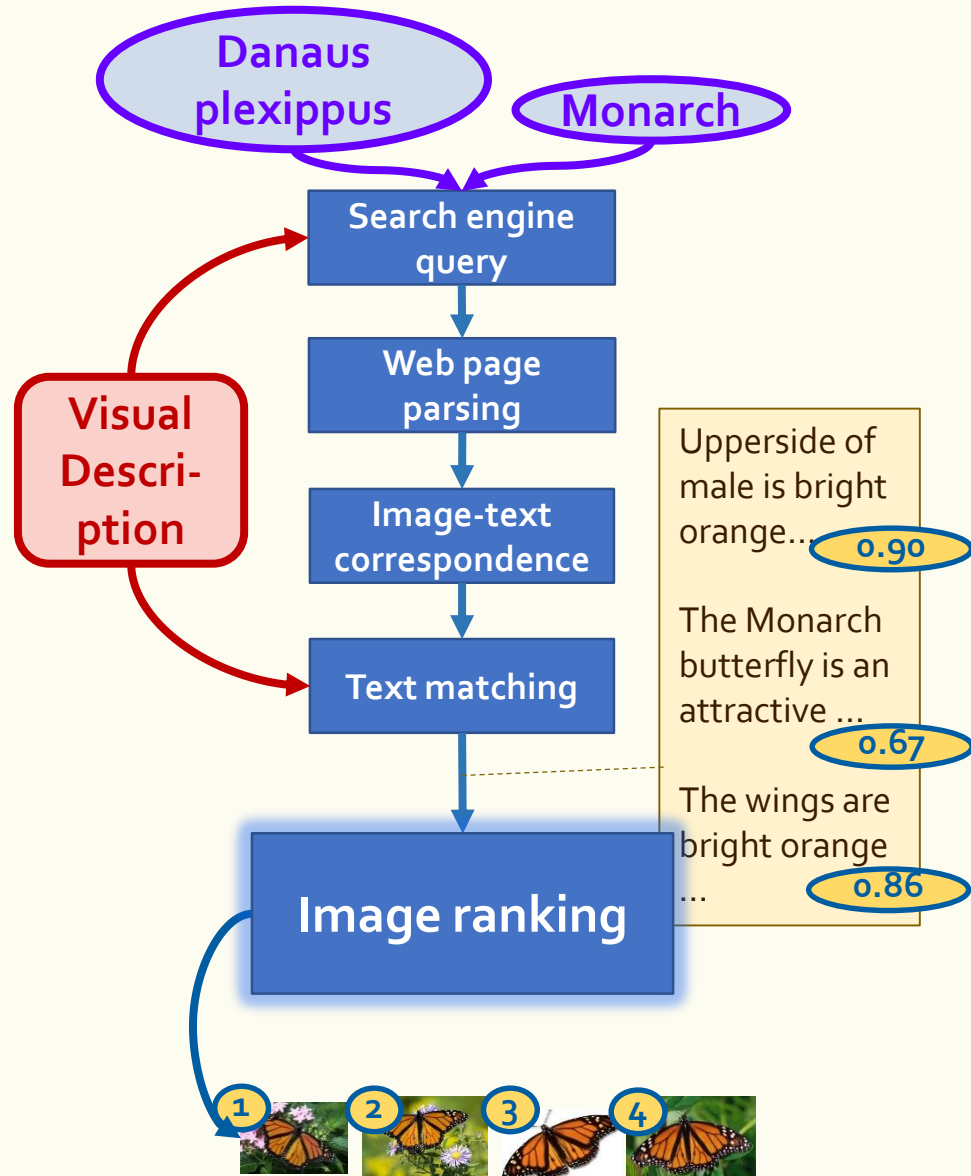


- Explore a simple model + matcher
 - Bag of words with TF-IDF weighting
 - Cosine similarity
- Advanced models (sequential/compositional) or matching functions (BM25) are left as future work

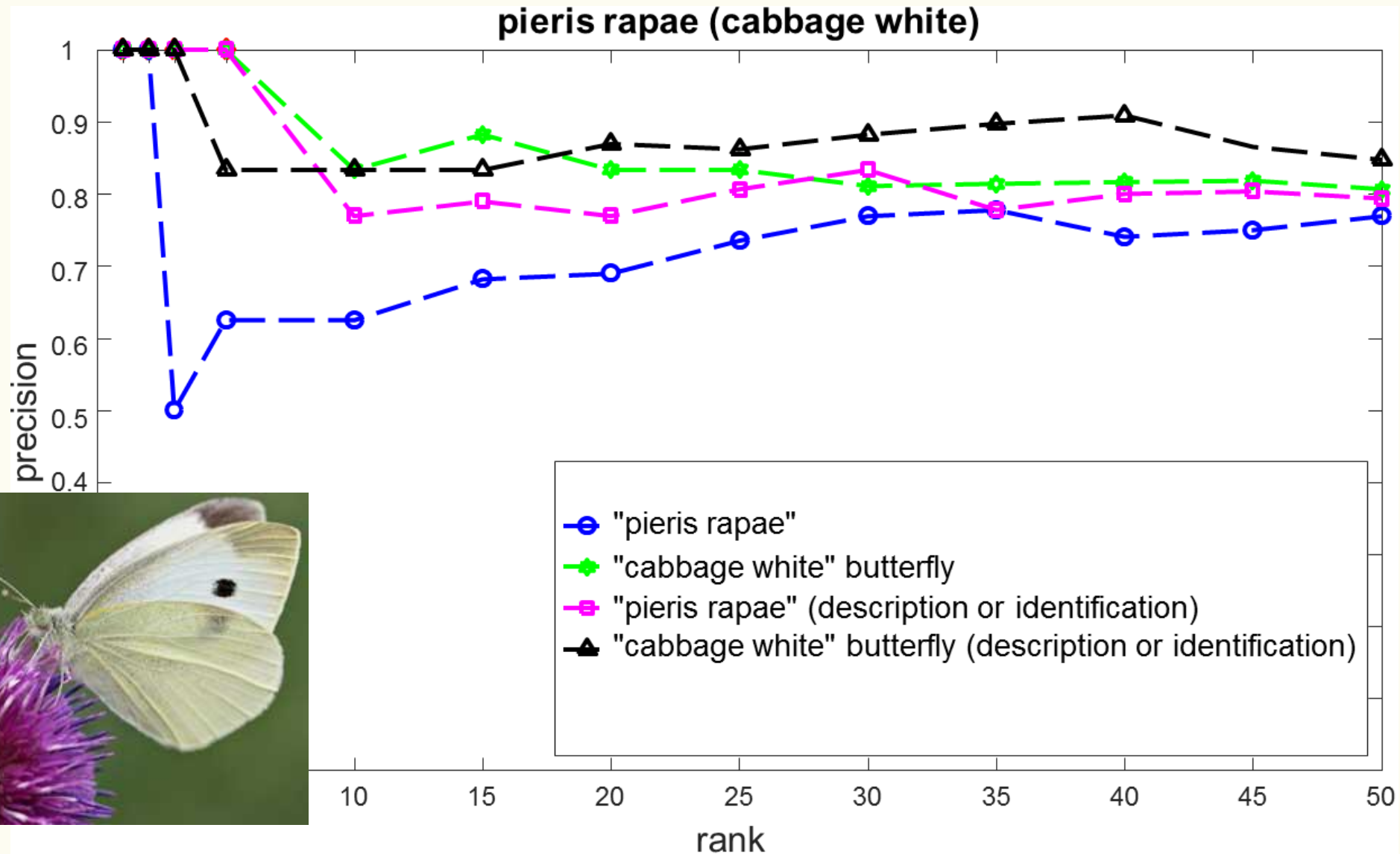
Step 5: Image ranking



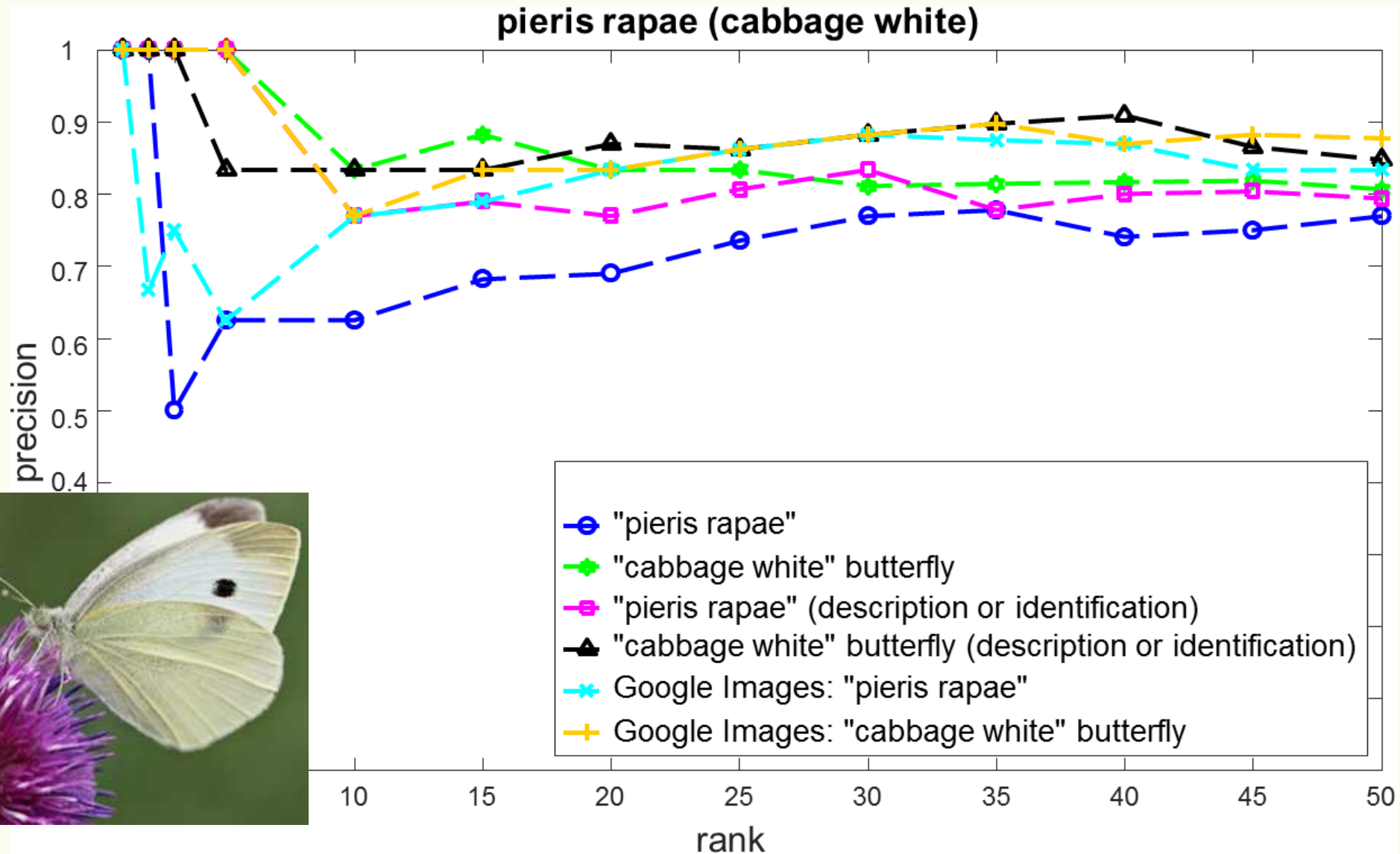
Step 5: Image ranking



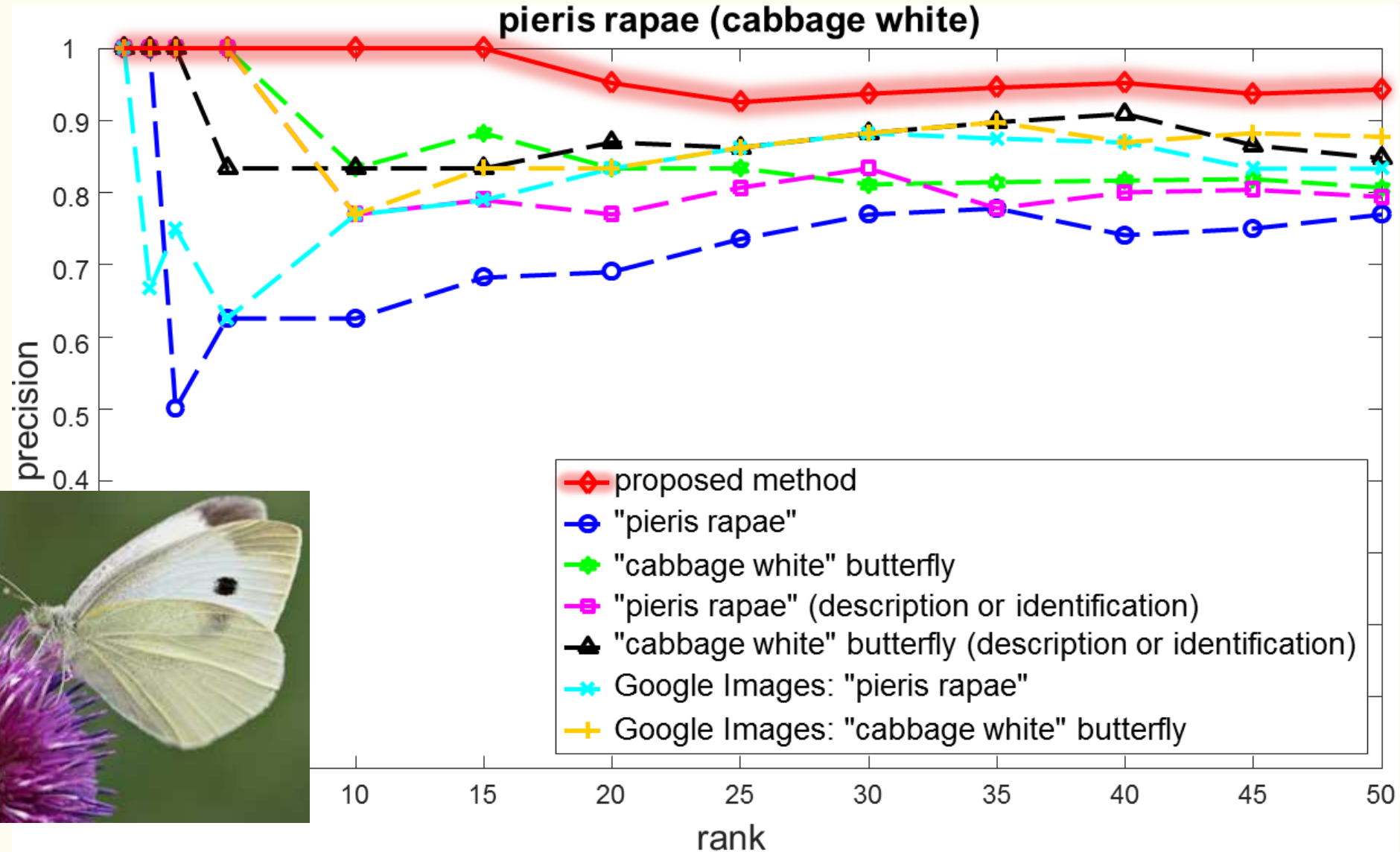
Experimental Results: Baseline



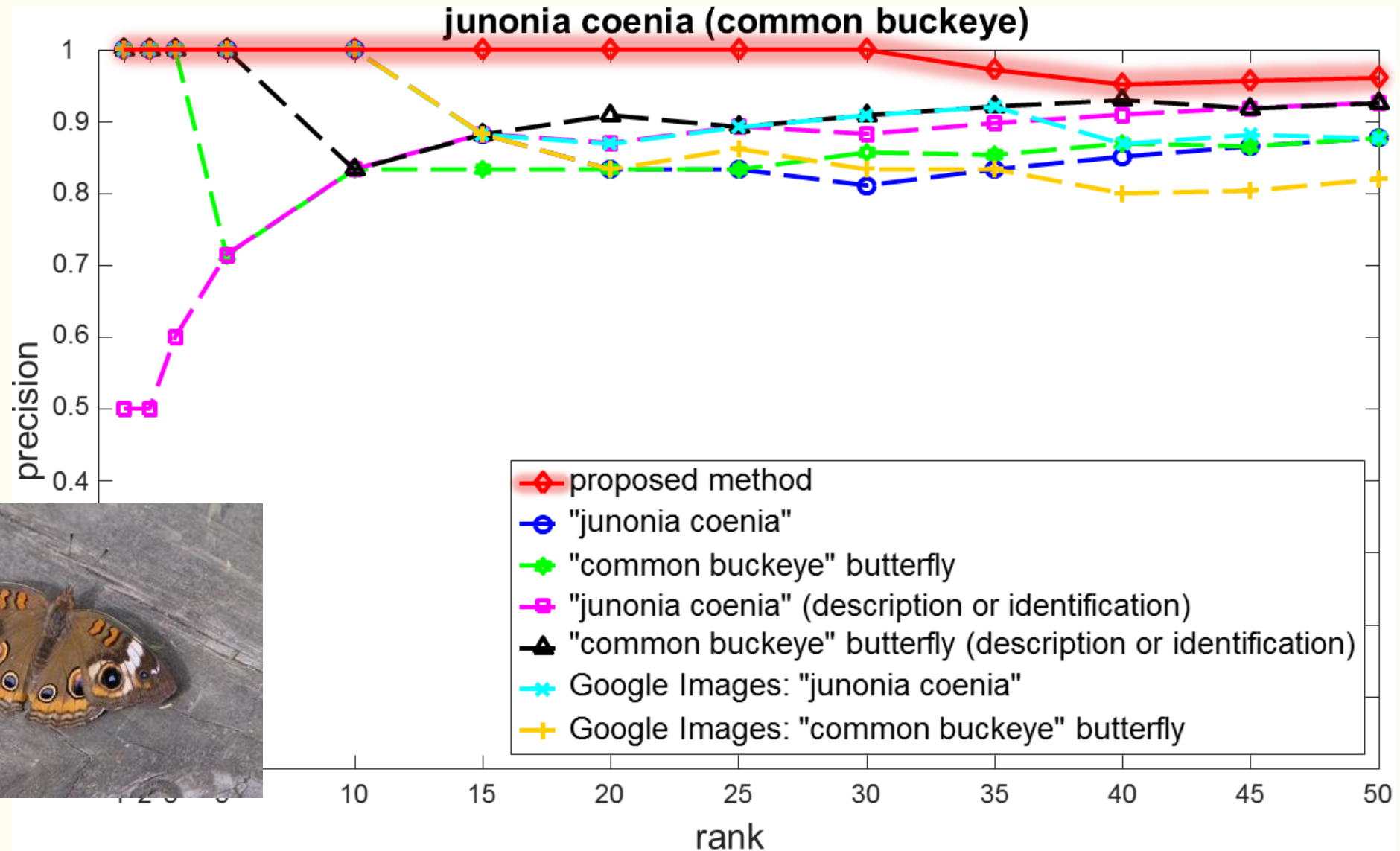
Experimental Results: Baseline



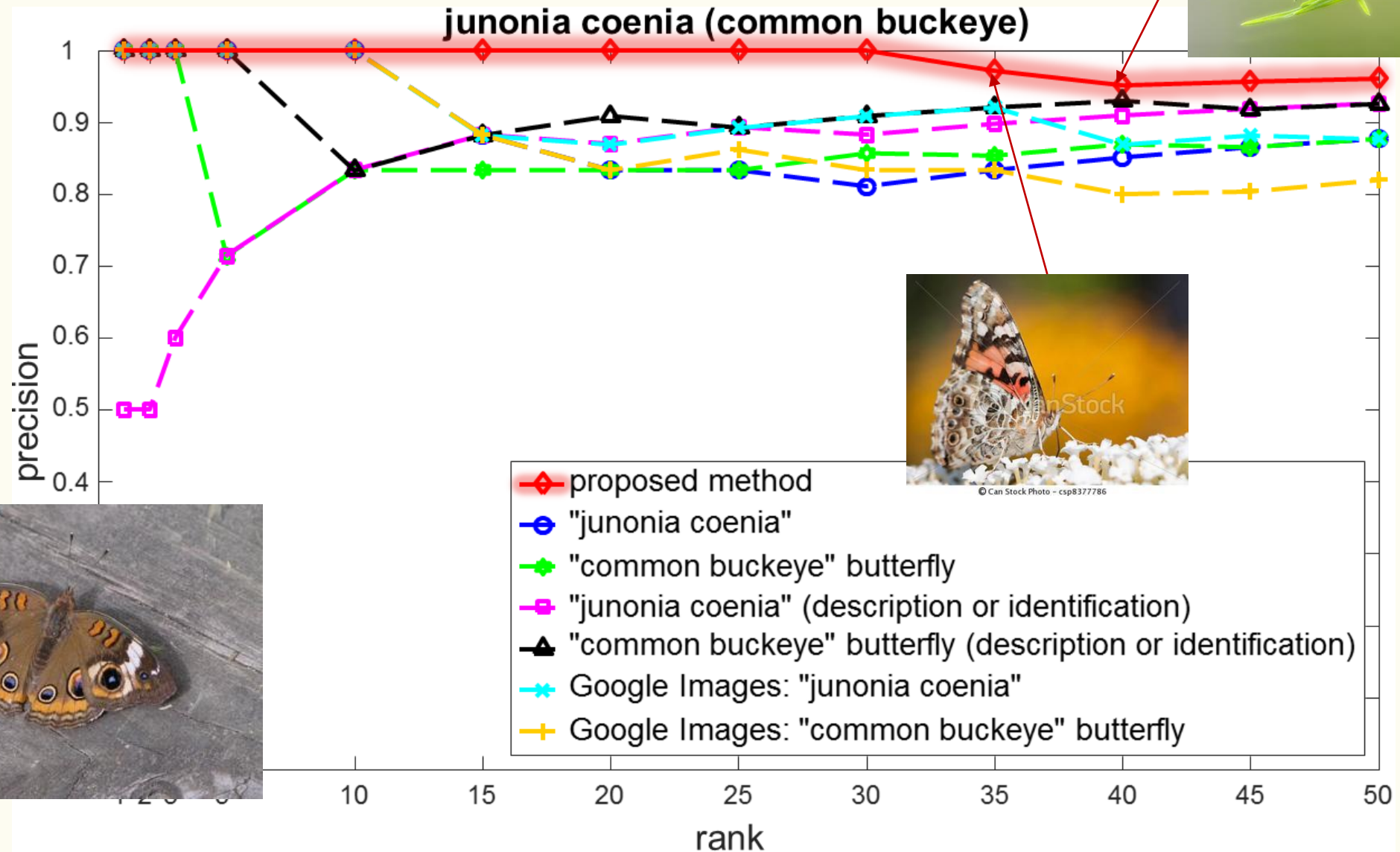
Experimental Results: Excellent Case



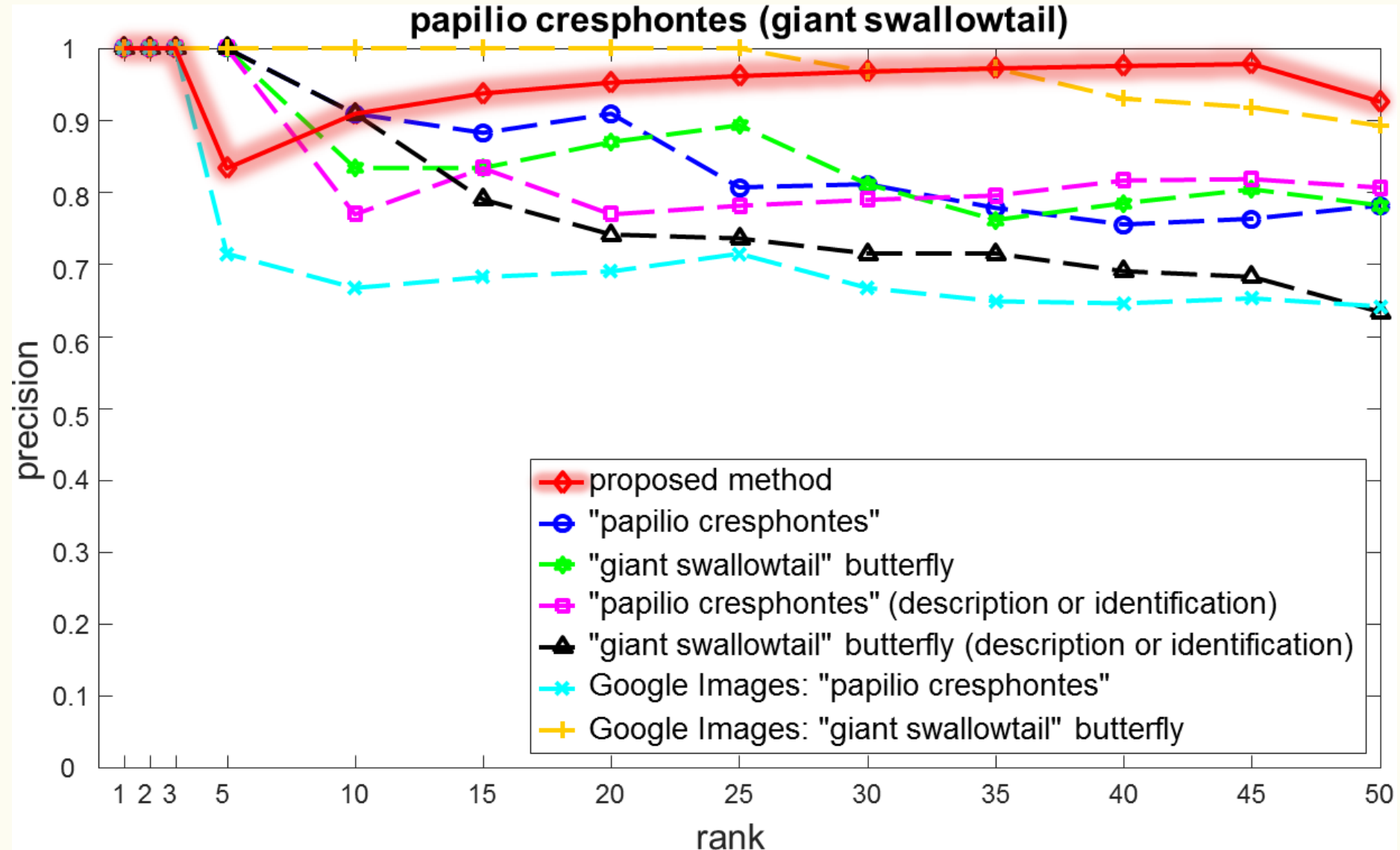
Experimental Results: Excellent Cases



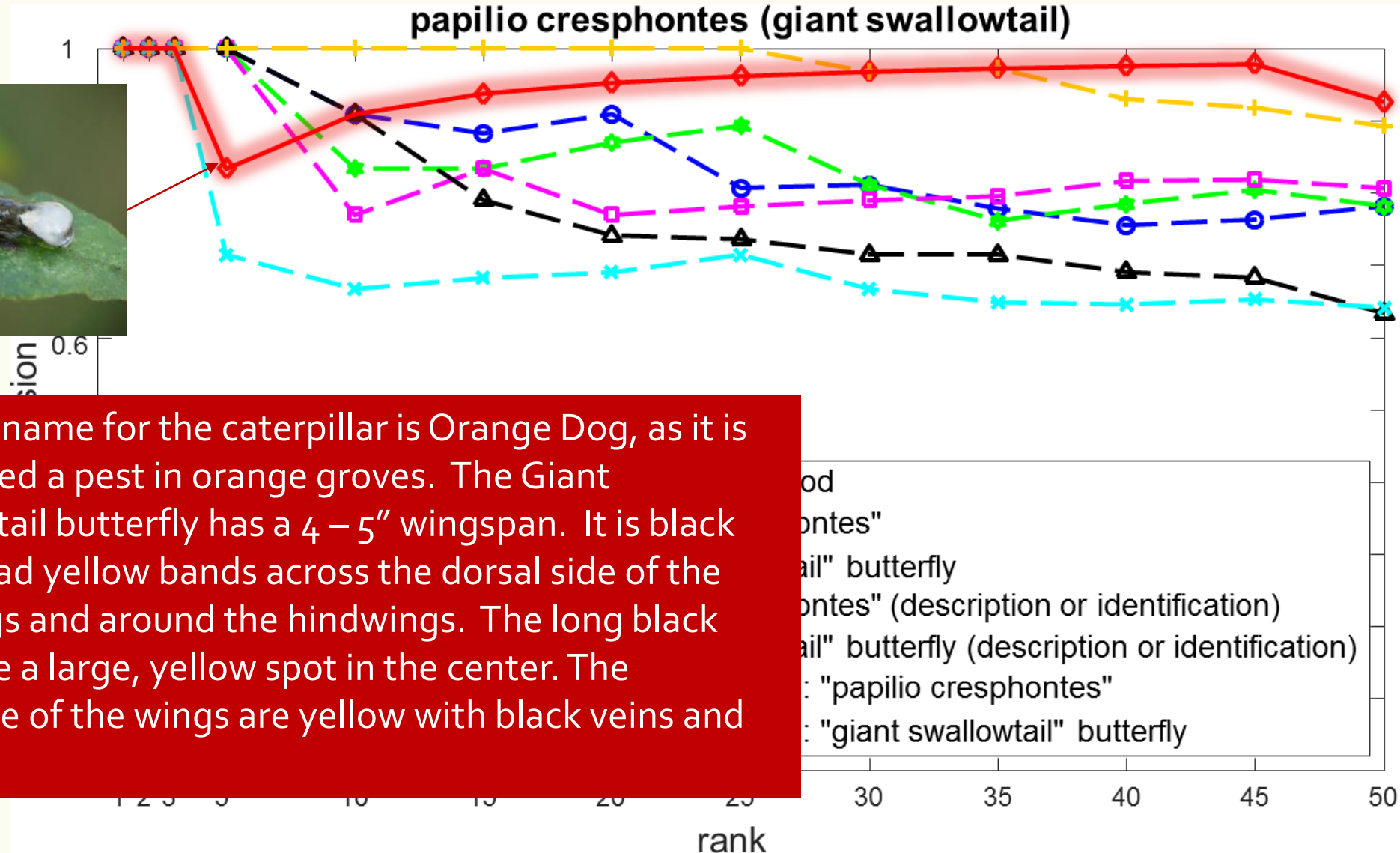
Experimental Results: Excellent C



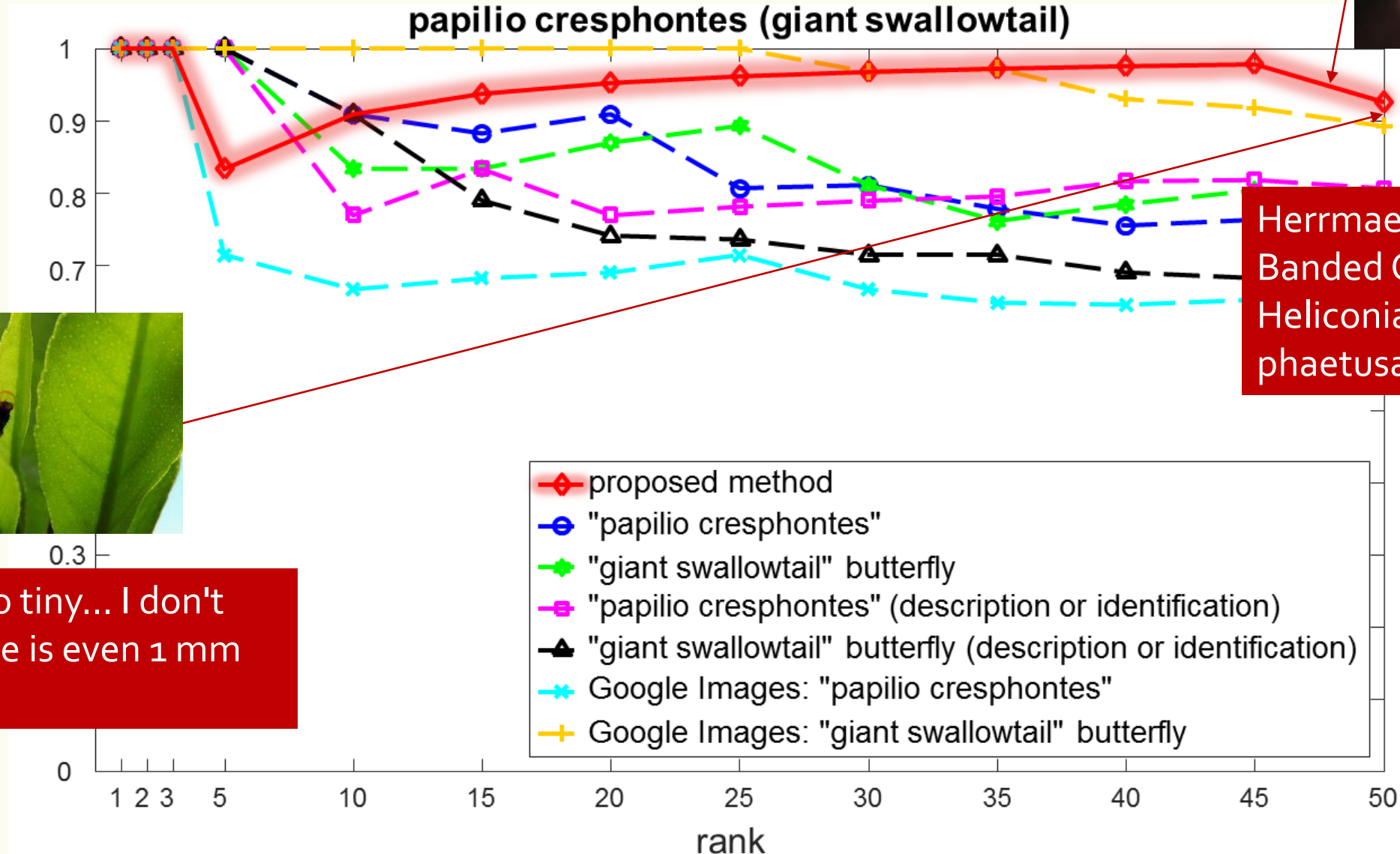
Experimental Results: Good Cases



Experimental Results: Good Cases



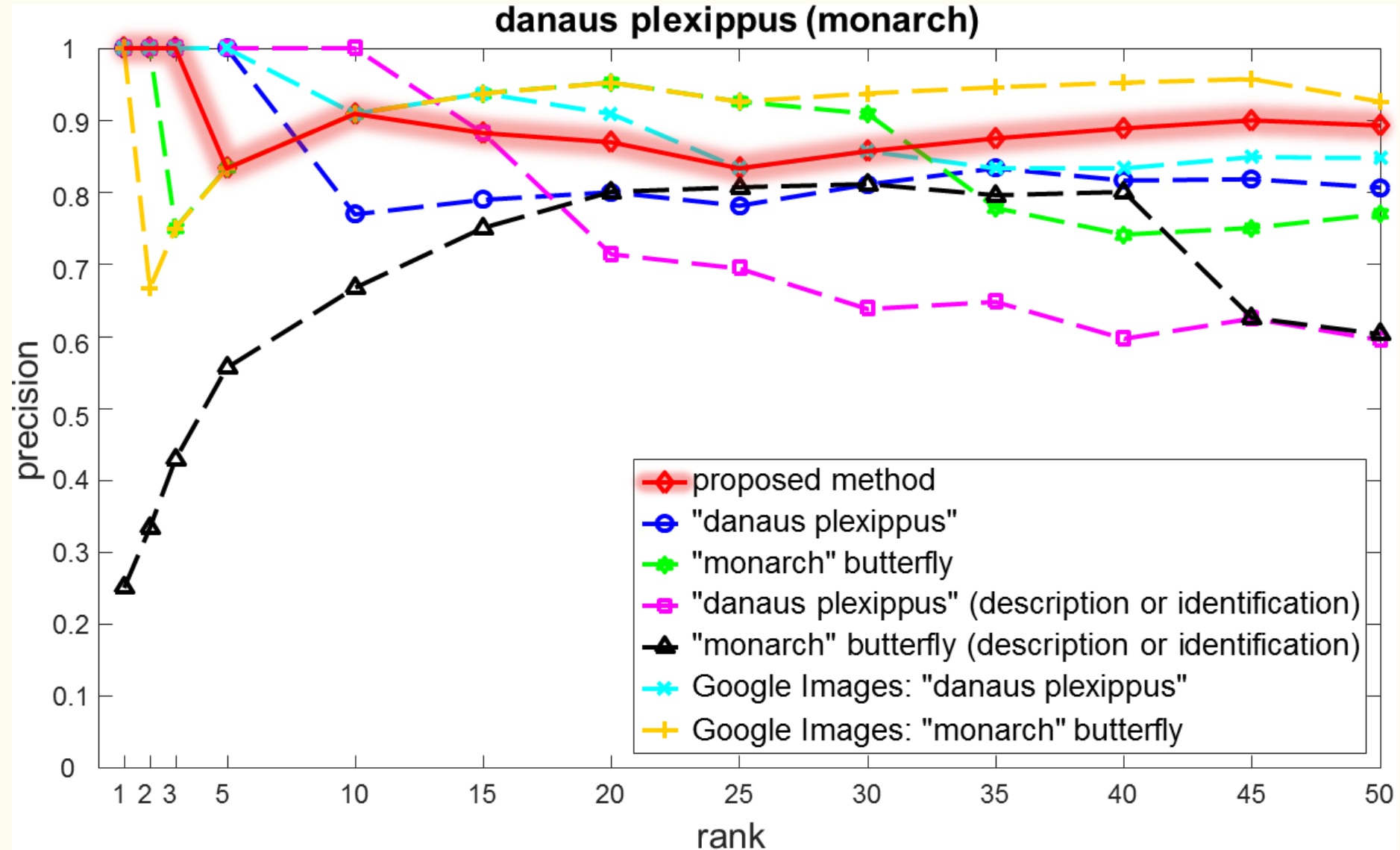
Experimental Results: Good Cases



He is so tiny... I don't think he is even 1 mm long.

Herrmaennchen :
Banded Orange
Heliconian (*Dryadula
phaetusa*)

Experimental Results: Good Cases



Original description for *Danaus plexippus* (Monarch)

3 1/2-4" (89-102 mm). Very large, with FW long and drawn out. Above, bright, burnt-orange with black veins and black margins sprinkled with white dots; FW tip broadly black interrupted by larger white and orange spots. Below, paler, duskier orange. 1 black spot appears between HW cell and margin on male above and below. Female darker with black veins smudged.

1



Monarch Butterfly (*Danaus plexippus*)
Description 3 1/2-4" (89-102 mm). Very large, with FW long and drawn out. Above, bright, burnt-orange with black veins and black ...

2



Description : Family: Nymphalidae, Brush-footed Butterflies view all from this family Description 3 1/2-4" (89-102 mm). Very large, with FW long and drawn out. Above, bright, burnt-orange with black veins and black veins and black margins sprinkled with white dots; FW tip broadly ...

3



The wings are bright orange with black veins and black margin decorated with white spots. Female's veins are thicker.

4



Diagnosis: The Monarch is one of the largest Canadian butterflies (wingspan: 93 to 105 mm). The upperside is bright orange with heavy black veins, and a wide black border containing a double row of white spots ...

5



male bright orange w/oval black scent patch (for courtship) on HW vein above, and abdominal "hair-pencil;" female dull orange, more thickly scaled black veins

(Reason: ambiguous layout)

6



Description: This is a very large butterfly with a wingspan between $3 \frac{3}{8}$ and $4 \frac{7}{8}$ inches. The upperside of the male is bright orange with wide black borders and black veins. The hindwing has a patch of scent scales. The female is orange ...

16



The Monarch's wingspan ranges from 3--4 inches. The upper side of the wings is tawny-orange, the veins and margins are black, and in the margins are two series of small white spots. The fore wings also have a few orange spots near the tip. The underside is similar but the tip of the fore wing and hind wing are yellow-brown instead of tawny-orange and the white spots ...

(Reason: Butterfly image discarded at pre-filtering step)

Other Types of Mistakes

- Web page author mixing up similar butterflies
- Text matching: “Pale yellow” can be used to describe non-butterflies (e.g. caterpillar)

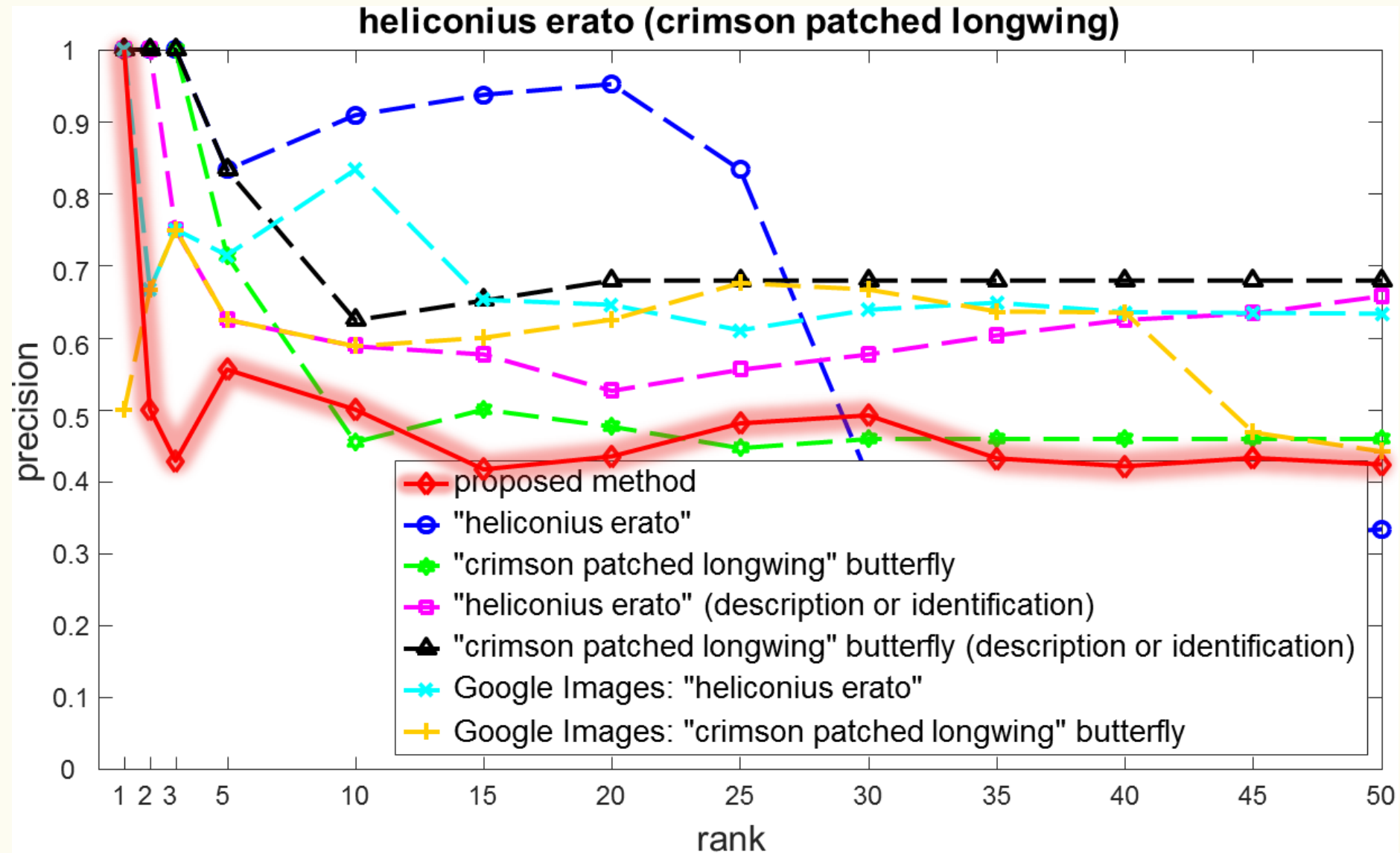


Monarch



Viceroy

Experimental Results: Poor Case





Discussion

- Used visual descriptions for harvesting training images for fine-grained object categories:
 - Querying candidate web pages
 - Reranking collected images
- Method mostly outperforms category name only
 - And retrieves further visual descriptions for category!
- Future work:
 - Better models/retrieval measures
 - Impact of harvested training data on visual classification

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