RiFeGAN: Rich Feature Generation for Text-to-Image Synthesis from Prior Knowledge

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A. Training Details in Caption Matching

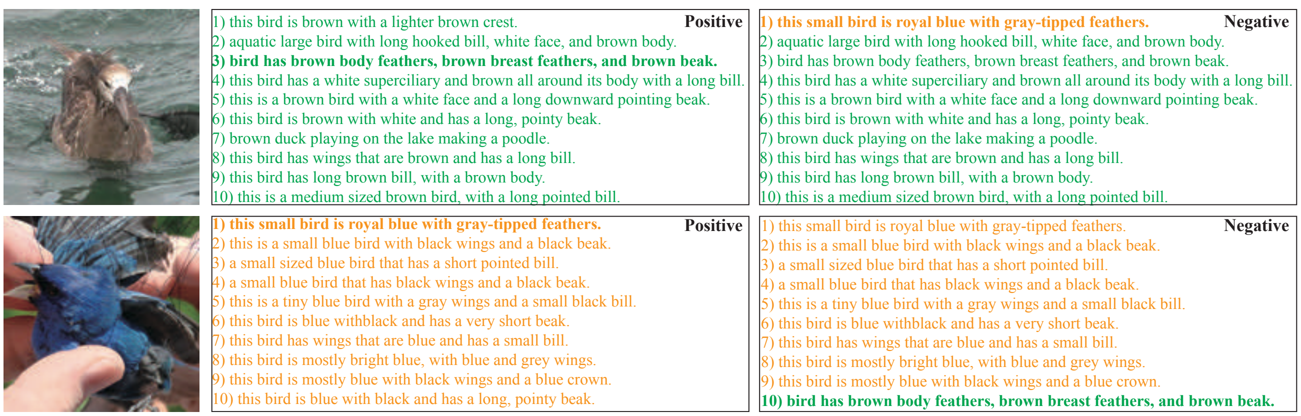


Figure 1. Examples of positive and negative samples for training: captions in the middle are positive samples, and the right ones are negative samples, where the querying captions $\{t\}$ are masked as bold.

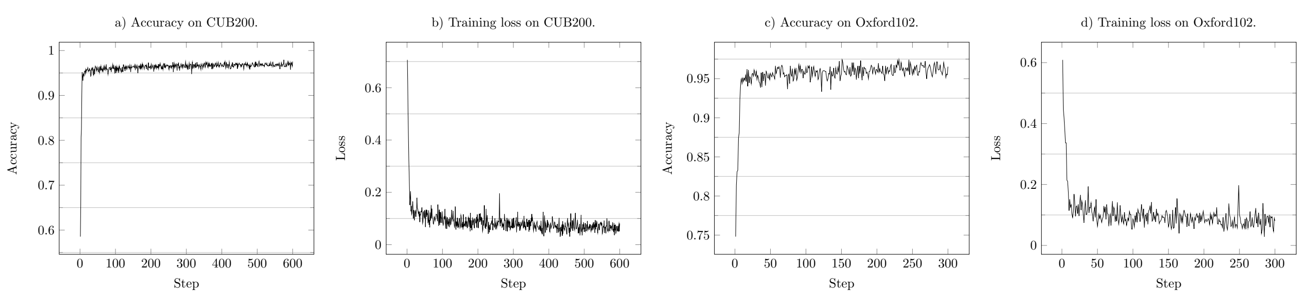


Figure 2. Accuracy and the training loss: we dynamically construct the samples for each training epoch and evaluation, as described in Section 3.1 of the main paper.

As described in Section 3.1 of the main paper, we treat captions of an image as a positive sample by selecting a caption as the query t. For its negative sample, another query is randomly selected from captions of an image belonging to a different class. For example, in Fig. 1, the captions in a middle black box are a positive sample, where the query t is marked as bold, and the rest are its positive context. The captions in the right box are its negative sample by selecting a different querying caption, masked as a different color, as the negative caption. In training, we dynamically construct the positive and negative samples and evaluate the models every 2.5K samples, denoted as a step, as shown in Fig. 2. For training loss, we exploit the log sigmoid for numerical stability. The results show the models can distinguish the compatible context of a query from others effectively.

B. Additional Experiment Results

We present more semantically consistent experiments in Fig. 3 and more results about combining two captions in Fig. 4. In Fig. 5, we demonstrate the influence of N_{sel} in Our$_F$ and Our$_F^{SA}$. Finally, we show the more enriching examples with the given captions in Fig. 6.

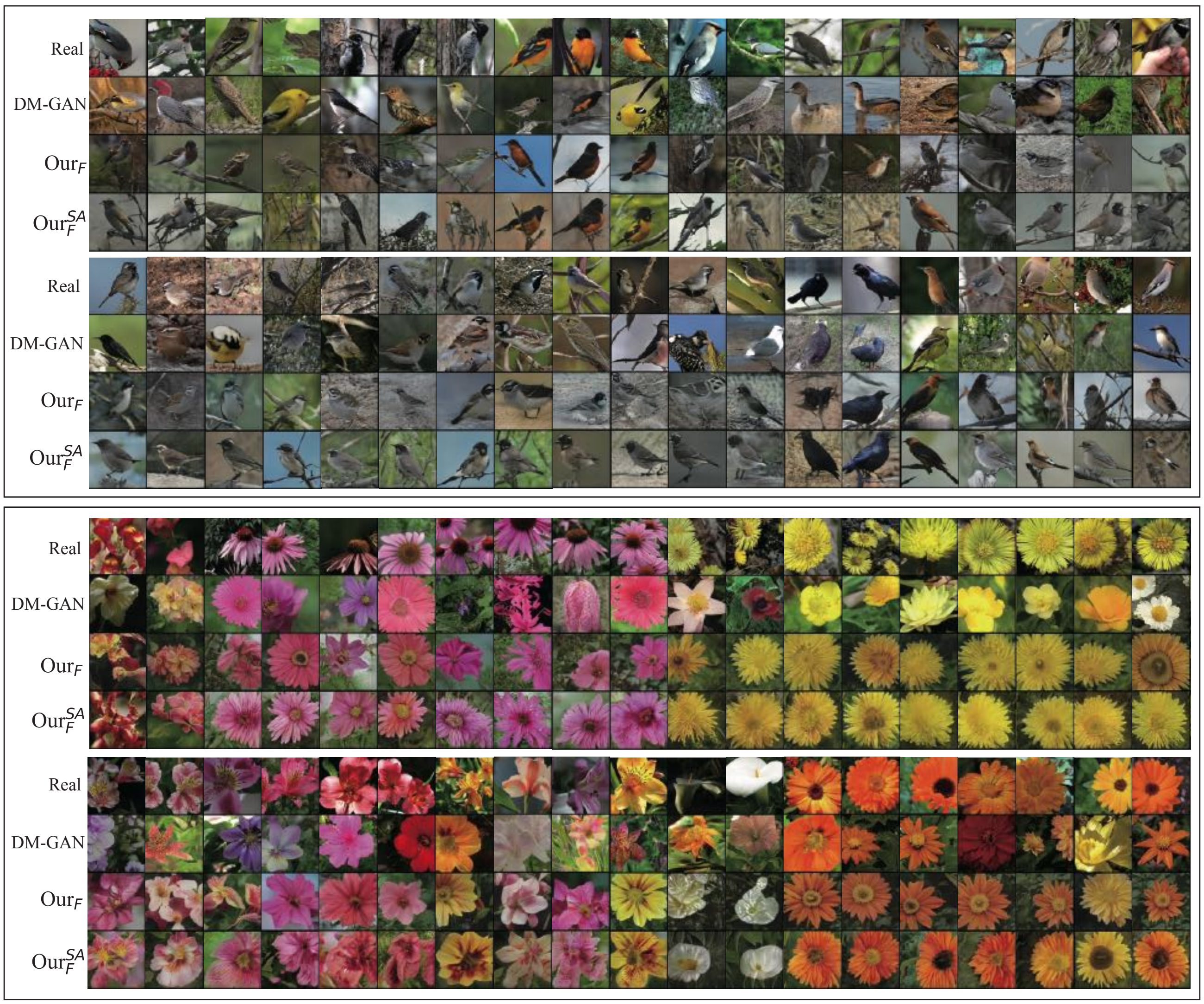
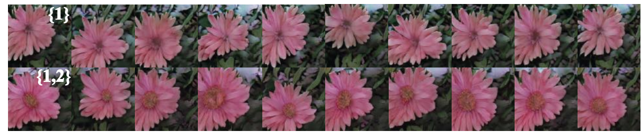


Figure 3. The images synthesized with the captions: Our$_F$ and Our$_F^{SA}$ synthesize more semantically consistent images with the real images than DM-GAN by using the original captions, while Our$_F^{SA}$ is better than Our$_F$.

(a) 1. this bird is **red with white** and has a very **short beak**.
2. this bird has wings that are **black** and has a **white belly**.

The k-best prominent words of two captions in F_1^{attn}:
1. bird:1.000, **beak:0.233**, this:0.193, **short:0.121**, is:0.115, **white:0.050**, with:0.032, **red:0.028**, very:0.020
2. has:1.000, **white:0.444**, bird:0.335, this:0.218, belly:0.053, **black:0.036**, a:0.022, are:0.022, that:0.014

The k-best prominent words of two captions in F_2^{attn}:
1. this:1.000, bird:0.864, is:0.431, **beak:0.222, red:0.210**, **short:0.138**, white:0.128, a:0.109, very:0.106
2. belly:1.000, a:0.688, **white:0.627**, **black:0.584**, this:0.564, bird:0.540, has:0.423, wings:0.318, has:0.306



(b) 1. petals are **oval** in shape they are **light pink** in color.
2. the petals on this flower are **pink** with **orange** stamen.

The k-best prominent words of two captions in F_1^{attn}:
1. are:1.000, petals:0.907, **oval:0.874, pink:0.684**, shape:0.617, in:0.593, **light:0.399**, are:0.370, they:0.293
2. petals:1.000, **pink:0.787**, the:0.541, are:0.439, this:0.419, on:0.413, flower:0.381, stamen:0.276, **orange:0.140**

The k-best prominent words of two captions in F_2^{attn}:
1. **pink:1.000**, color:0.273, in:0.245, **light:0.239**, are:0.228, are:0.205, shape:0.190, **oval:0.184**, they:0.183
2. **pink:1.000**, this:0.332, **orange:0.318**, are:0.307, flower:0.264, the:0.259, stamen:0.223, on:0.185, petals:0.174

(c) 1. this is a **white** bird with a **brown** crown and a **black** bill.
2. a small bird with **brown white and black** feathers for its wings.

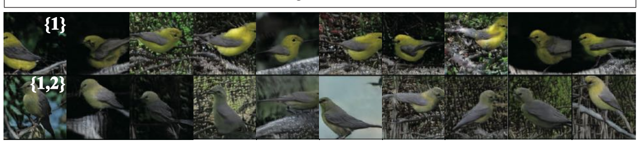
The k-best prominent words of two captions in F_1^{attn}:
1. with:1.000, a:0.566, bill:0.501, is:0.450, bird:0.265, this:0.223, **black:0.188**, **white:0.136**, **brown:0.034**
2. with:1.000, bird:0.352, small:0.282, a:0.204, its:0.155, wings:0.122, **white:0.047**, for:0.039, **brown:0.039**

The k-best prominent words of two captions in F_2^{attn}:
1. is:1.000, this:0.870, bird:0.830, with:0.748, a:0.720, a:0.710, **white:0.616**, **black:0.489**, bill:0.414, a:0.347
2. a:1.000, black:0.740, bird:0.682, small:0.655, wings:0.599, its:0.520, for:0.502, with:0.423, **brown:0.228**

(d) 1. this is a **pink** flower with a large and thick **orange** pistil.
2. this flower has a **round brown** center and **long pink** petals.

The k-best prominent words of two captions in F_1^{attn}:
1. **pink:1.000**, a:0.781, is:0.579, this:0.463, pistil:0.279, flower:0.155, **orange:0.155**, with:0.133, a:0.117
2. flower:1.000, **pink:0.896**, has:0.795, this:0.767, **long:0.748**, a:0.565, **brown:0.406**, and:0.337, center:0.325

The k-best prominent words of two captions in F_2^{attn}:
1. **pink:1.000**, a:0.374, is:0.298, this:0.295, pistil:0.227, **orange:0.218**, thick:0.178, flower:0.161, with:0.097
2. this:1.000, flower:0.945, a:0.727, has:0.697, **pink:0.496**, petals:0.355, **brown:0.340**, **round:0.300**, center:0.294



(e) 1. a **small round yellow** bird with **gray** wings and black eyerings.
2. a **medium** sized bird with a **gray** body on most of its body.

The k-best prominent words of two captions in F_1^{attn}:
1. **small:1.000**, a:0.498, with:0.402, **round:0.293**, eyerings:0.266, and:0.249, black:0.203, **yellow:0.158**
2. **medium:1.000**, of:0.602, with:0.568, bird:0.517, sized:0.415, its:0.381, a:0.341, **gray:0.338**, body:0.107

The k-best prominent words of two captions in F_2^{attn}:
1. **gray:1.000**, eyerings:0.490, wings:0.463, **yellow:0.326**, with:0.295, and:0.227, a:0.199, **black:0.193**
2. **medium**:1.000, sized:0.781, **gray:0.746**, a:0.611, body:0.582, bird:0.519, with:0.434, a:0.334, its:0.304

(f) 1. the petals on this flower are **purple** with **no visible** stamen.
2. a **white** flower with a golden and **purple** center.

The k-best prominent words of two captions in F_1^{attn}:
1. petals:1.000, **no:0.781**, **visible:0.776**, the:0.583, on:0.549, **purple:0.520**, are:0.344, stamen:0.342, this:0.341
2. with:1.000, a:0.656, flower:0.586, a:0.492, **white:0.426**, golden:0.204, center:0.190, **purple:0.120**, and:0.063

The k-best prominent words of two captions in F_2^{attn}:
1. **purple:1.000**, are:0.827, flower:0.648, this:0.647, **no:0.638**, on:0.507, the:0.397, petals:0.390, with:0.366
2. **white:1.000**, **purple:0.466**, a:0.345, flower:0.322, a:0.245, with:0.196, and:0.171, center:0.154, golden:0.153

(g) 1. this **small** bird is mostly **tan** with **black** wings his head has a tuft that comes to a point.
2. a **medium** sized bird with a **gray** body on most of its body.

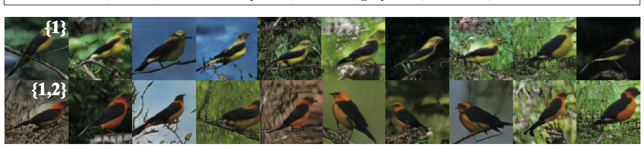
The k-best prominent words of two captions in F_1^{attn}:
1. bird:1.000, **small:0.171**, to:0.094, point:0.051, this:0.050, comes:0.044, a:0.029, is:0.026, that:0.017
2. **medium:1.000**, bird:0.680, with:0.523, sized:0.410, a:0.321, of:0.299, its:0.168, most:0.045, **gray:0.041**

The k-best prominent words of two captions in F_2^{attn}:
1. a:1.000, has:0.787, **tan:0.724**, is:0.708, bird:0.640, tuft:0.631, this:0.615, **black:0.542**, head:0.541
2. **medium:1.000**, a:0.815, sized:0.773, body:0.768, bird:0.637, **gray:0.568**, with:0.518, a:0.449, its:0.396

(h) 1. a flower with **thin long pink** petals central cluster of **orange** stamen.
2. petals are **oval** in shape they are **light purple** in color.

The k-best prominent words of two captions in F_1^{attn}:
1. flower:1.000, **thin:0.884**, with:0.859, **pink:0.817,** a:0.815, **long**:0.380, stamen:0.302, petals:0.166
2. petals:1.000, are:0.955, **oval:0.733**, in:0.483, shape:0.459, light:0.322, **purple:0.293**, are:0.285, they:0.249

The k-best prominent words of two captions in F_2^{attn}:
1. **pink:1.000**, flower:0.522, a:0.519, with:0.364, **orange:0.320**, **thin:0.272, long:0.246**, central:0.129
2. **purple:1.000**, light:0.906, color:0.849, in:0.631, shape:0.596, are:0.501, are:0.481, **oval:0.476**, in:0.439



(i) 1. this particular bird has a **yellow** belly and breast and **black** secondaries.
2. this bird is **black and red** in color with a very **sharp** beak.

The k-best prominent words of two captions in F_1^{attn}:
1. bird:1.000, has:0.893, secondaries:0.333, particular:0.286, **black:0.253**, this:0.064, and:0.035, **yellow:0.021**
2. bird:1.000, beak:0.234, is:0.107, **sharp:0.067**, this:0.058, beak:0.045, **black:0.045**, a:0.011, very:0.010

The k-best prominent words of two captions in F_2^{attn}:
1. **black:1.000**, secondaries:0.515, and:0.437, and:0.370, breast:0.324, **yellow:0.264**, belly:0.188, bird:0.178
2. **black:1.000**, beak:0.843, bird:0.726, and:0.678, this:0.654, **red:0.499**, is:0.445, sharp:0.382, with:0.236

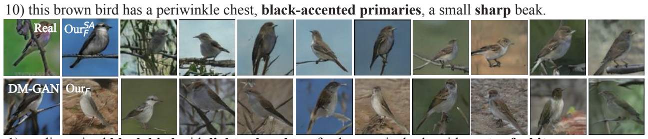
(j) 1. this flower has many long narrow petals that are **pink** around an **orange** center.
2. this flower has many long narrow petals that are **blue** around an **orange** center.

The k-best prominent words of two captions in F_1^{attn}:
1. flower:1.000, has:0.813, this:0.743, **pink:0.476**, many:0.376, center:0.371, narrow:0.369, **orange:0.220**
2. flower:1.000, has:0.906, this:0.661, petals:0.502, narrow:0.469, **blue:0.452**, many:0.411, that:0.245, long:0.218

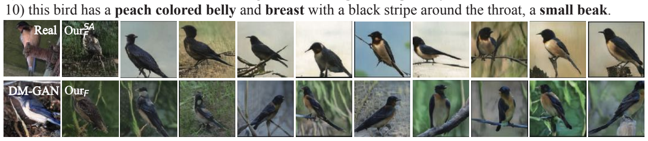
The k-best prominent words of two captions in F_2^{attn}:
1. **orange:1.000,** this:0.923, flower:0.896, has:0.824, **pink:0.726**, many:0.626, long:0.505, an:0.291, center:0.280
2. **orange:1.000**, long:0.588, has:0.442, flower:0.428, many:0.390, this:0.379, are:0.312, **blue:0.302**, center:0.294

Figure 4. Examples synthesized by two captions: the bold black words indicate prominent visual details, while the red words indicate conflicting visual details in captions. Words in black boxes are prominent features in generating steps, specifically, F_1^{attn} and F_2^{attn}.

1) the bird has **white throat**, **gray breast** and **white belly** and **abdomen**, it has **sharp** and **pointed beak**.
2) this bird is **small** with a **short beak** and has long tail feathers.
3) this is a **grey belly** with a **brown head** and a **small pointy beak**.
4) **golden brown colored** back and head, eith **dark colored** wings and tail, and a **white belly** and **breast**.
5) this bird is **brown** and **white** in color with a sharp **brown beak**, and **brown eye rings**.
6) this bird is **small** and compact, with a short **pointed bill**, **white belly**, and tan feathers ending.
7) a bird with a **brown beak**, **brown head**, **grey body** with **brown wings** with black wing tips.
8) this bird has wings that are **brown** and has a **white belly.**
9) a **small** bird with **purple feathers** on its breast and green feathers on its abdomen.
10) this brown bird has a periwinkle chest, **black-accented primaries**, a small **sharp** beak.

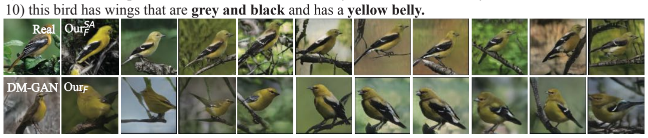


1) medium sized **black bird** with **light colored tan** feathers on its body with **spots of white**.
2) this bird has a split tail with **blue undertails** coverts - the crown is **dark black**.
3) light **brown** bird, wth a light belly and **dark black head, tail, and nape**.
4) lemon breasted and bellied bird with **orange throat** and **black head**.
5) this bird has a **fluffy tan underside**, a **reddish-orange band** on the nape of it's neck, a split **black tail**.
6) this bird has a **dark black face and head**, **white and light orange breast** belly and vent, and a **red** face.
7) a small bird with **brown** and **black coloring**, and blue on the underside of its wings.
8) this bird has wings that are **blue** and has a **white belly.**
9) this bird has a **black crown** with a orange throat and **light orange belly**.
10) this bird has a **peach colored belly** and **breast** with a black stripe around the throat, a **small beak**.

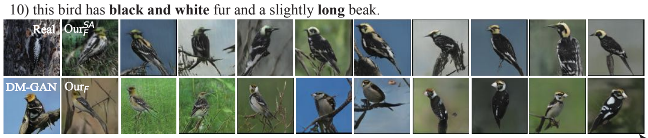


1) this bird has a **white throat** that extends to the breast, **black body**, a long, pointed **black bill**.
2) this is a white bird with a **black head** and a **yellow crown**.
3) a small bird with **yellow crown**, **white throat** and **breast** and **grey belly**.
4) this bird has a **yellow crown**, a long flat **black bill**, a **white breast**, and a black belly.
5) a small bird with a **white belly**, and a **yellow top** on crown.
6) this bird has wings that are **black** and has a **white chest.**
7) this bird is **white with black** and has a long, **pointy beak**.
8) smallish bird with a **bright yellow crown**, it has a **black head** and **black bill**.
9) this bird has wings that are **black** and has a **yellow crown.**
10) the bird has a **bright yellow brown**, a **cream belly** and throat, and a **black nape**.

1) a mostly **yellow** bird with **black and white wings** and **black eyes**.
2) small bird with **white nape and belly**, brown wings with **white wing bars**, brown outer rectrices.
3) bird has **brown body** feathers, **yellow breast** feather, and **pointed beak.**
4) this bird has a **yellow breast** and **head** and **a black and white wing**.
5) this bird has a **yellow head, chest, belly** and tail and **black and white wing feathers**.
6) the bird has a pink bill, **yellow crown and breast**, and **black and white striped wings**.
7) this bird has wings that are **black and white** and has a **yellow belly.**
8) this bird has wings that are **black** and has a **yellow belly.**
9) a bird with **black primaries**, white secondaries and a **yellow breast and belly**.
10) this bird has wings that are **grey and black** and has a **yellow belly.**

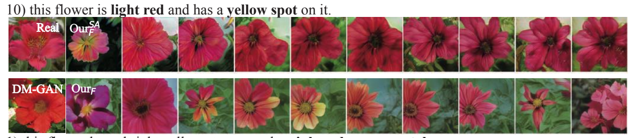


1) **black and white** feathered bird with **yellow head** feathers.
2) this is a **black and white** bird with a **yellow** nape on its head.
3) a small **black and white** bird with a **gray beak**.
4) a small bird with **black wings**, a white back and belly, and **white streaks** along its head.
5) this bird has a **black body**, a white belly, a **white malar stripe**, white eyebrows and a **yellow crown**.
6) although **primarily black and white** this bird has a **yellow orange patch** on his crown.
7) an interesting bird with **black and white** covering most of the body, the wing tips being **black**.
8) the bird has a **patch of white feathers** on it's back and it has **black and white wing**s. it has a **white stripe**.
9) this **black and white spotted** bird has a **bright yellow crown**.
10) this bird has **black and white** fur and a slightly **long** beak.



N/A 1-1 1-2 1-3 1-4 1-5 1-6 1-7 1-8 1-9 1-10

1) this flower is **pink and yellow** in color, with petals that are **striped** near the center.
2) this flower has large **wide red petals** with **vertical striations** surrounding thin **pink stamen**.
3) **dark pink petals** with **yellow and black stripes** in the middle green long leaves.
4) petals are **red** in color and are **rounded** in shape.
5) this flower has petals that are **red with black lines.**
6) this flower has smooth and large **red petals** which are **wide and slightly ruffled**.
7) this flower is **pink** in color, and has petals that are **oval shaped.**
8) this flower has petals that are **pink** with blotches of yellow and **purple lines.**
9) the flower has **maroon petals** and a **yellow and black** spotted stamen, with lavender colored filaments.
10) this flower is **light red** and has a **yellow spot** on it.



1) this flower has a bright yellow stamen and a **pink and orange petal.**
2) this flower has several wide **purple petals** with **yellow tinted** accents.
3) the **five petals** on this flower are very delicate, and uniquely it has three petals that are **yellow**.
4) two of the four petals look like they have come from a **leopard**.
5) this flower is **pink and yellow** in color, with petals that are **spotted**.
6) this flower has **orange petals** with **yellow patches** and **black lines.**
7) this flower has **yellow petals** as well as a **green** pistil.
8) this **multicolored flower** has **orange petals** along with **yellow petals** that have **darker lines** on them.
9) this flower has layers of **peach colored petals** with **yellow and dark red markings**.
10) this flower is **pink, orange, and yellow** in color, with **multi colored petals**.

1) this flower is **pink and red** in color, with petals that are **oval shaped**.
2) this flower has petals that are **pink with red steman.**
3) this flower has a **red**, **spikey center** with **orange dots**, and surrounded by **long, light purple petals**.
4) the flower has **thin purple petals** surround the **red stamen** in the middle.
5) the flower has **multiple purple petals** that are **long, thin** and oval shaped.
6) the petals of this flower are **pink** and the pistil is **red.**
7) this **light purple** flower has **numerous slim**, **sparse petals** that surround a round pistil of a **red color**.
8) this flower is **pink and red** in color, and has petals that are oval shaped.
9) this flower has petals that are **pink** and has **red stamen.**
10) this flower has **long, skinny purple petals** with a **red and black spherical pistil**.

1) the flower has several thin and oblong **pink petals**, with a large center of **dark orange pistils**.
2) the petals of the flower are **light pink** in color and have a **brown middle**.
3) this flower is **pink and brown** in color, with petals that are **oval shaped**.
4) the flower has **long pink petals** with a **wavy edge** and a **dark brown pistil**.
5) this flower has petals that are **pink** with **black stigma.**
6) this flower has a **large brownish pistil** with long **narrow pink petals** surrounding it.
7) this flower has a **round brown center** and **thin pink petals** which have tapered tips.
8) this flower has **pink petals** and has many **red stamen.**
9) this **light pink** flowers has **long and thin** petals and a large, **brown pistil**.
10) this flower has **thin pink petals** with a **full round scarlet stamen**.

1) this flower has petals that are **pointed** and **orange with white centers**.
2) this flower has a **long orange petal** with a **white center.**
3) the beautiful autumn burnt **orange color pales** in comparison to the sun kissed **gold colored petals**.
4) this flower is **yellow and white** in color, with petals that are **pointed at the tips**.
5) this flower has a lot of **colorful, pointed petals**.
6) this flower has petals that are **orange** and are very **thin.**
7) this flower has **large yellow petals** and light green pedicel.
8) the petals are sharply **pointed and orange**, and there is one large, pointed sepal.
9) this flower has a **sparse arrangement** of tall, spiky **orange petals**.
10) this flower has **yellow petals** as well as a white pedicel.

N/A 1-1 1-2 1-3 1-4 1-5 1-6 1-7 1-8 1-9 1-10

Figure 5. The synthesized images with increasing captions: the bold words in a caption indicate the prominent features, and *1-b* indicates the image is generated with the captions from the first one to the b^{th} one.

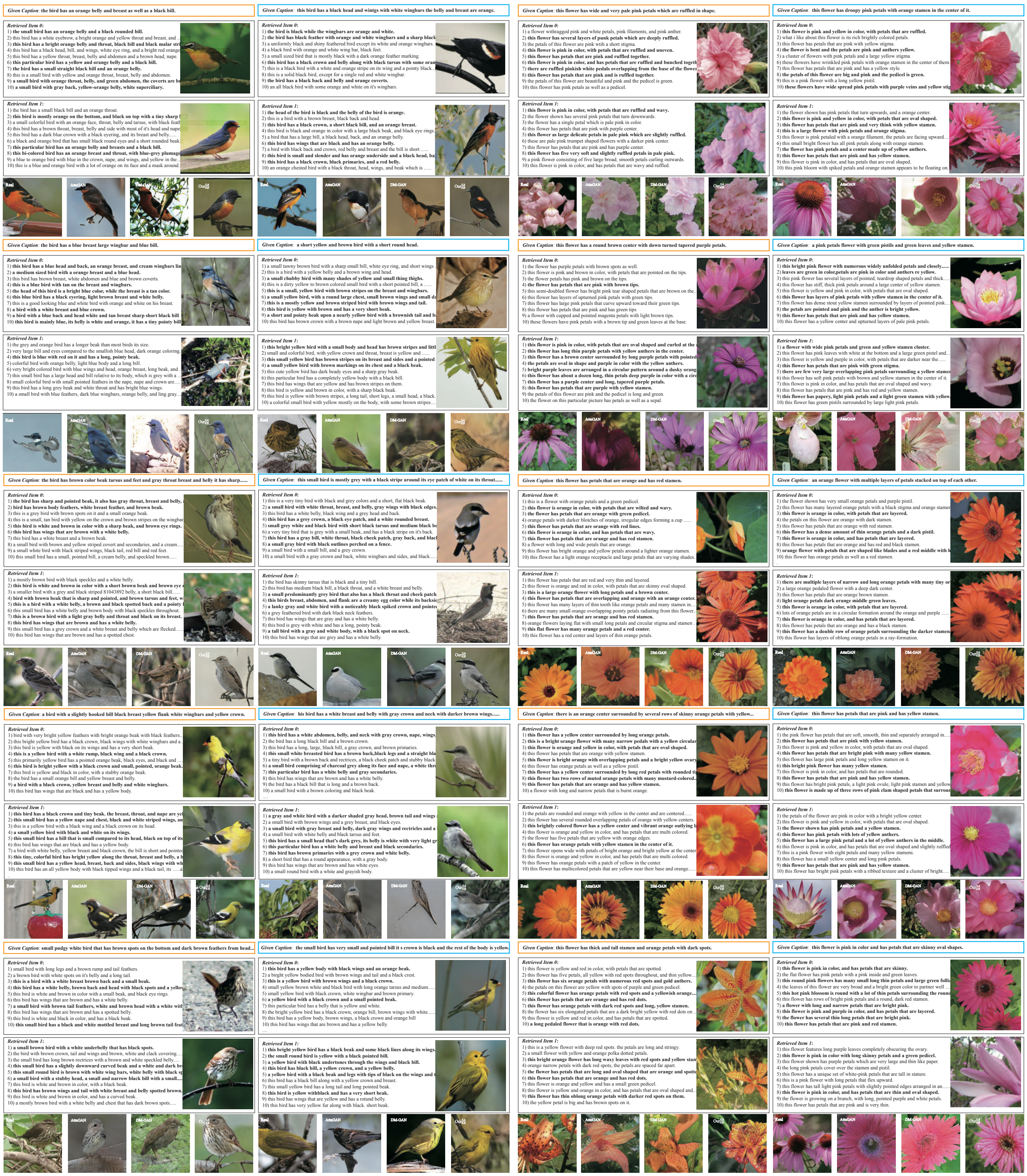


Figure 6. Synthesized examples by exploiting the recalling captions: given a caption, caption matching will retrieve the compacted items and select their captions, masked as bold, to synthesize images.