





Composed Image Retrieval for Remote Sensing

Bill Psomas, Ioannis Kakogeorgiou, Nikos Efthymiadis, Giorgos Tolias, Ondrej Chum, Yannis Avrithis, Konstantinos Karantzalos

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Explosive Growth of Remote Sensing Data



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Explosive Growth of Remote Sensing Data

 Challenge in managing and extracting relevant information



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Explosive Growth of Remote Sensing Data

- Challenge in managing and extracting relevant information
- Organize image archives and retrieve images is crucial!



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- Search and retrieve images from RS archives
- Key solution!

 $Agour is\ et\ al.,\ An\ environment\ for\ content-based\ image\ retrieval\ from\ large\ spatial\ databases,\ ISPRS\ Journal,\ 1999$

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query image



Dongyang et al., Exploiting low dimensional features from the mobilenets for remote sensing image retrieval, Earth Science Informatics, 2020

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Dongyang et al., Exploiting low dimensional features from the mobilenets for remote sensing image retrieval, Earth Science Informatics, 2020

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query image





Dongyang et al., Exploiting low dimensional features from the mobilenets for remote sensing image retrieval, Earth Science Informatics, 2020

query image







Dongyang et al., Exploiting low dimensional features from the mobilenets for remote sensing image retrieval, Earth Science Informatics, 2020

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query image



top-k retrieved images







descending order of similarity to the query image

Dongyang et al., Exploiting low dimensional features from the mobilenets for remote sensing image retrieval, Earth Science Informatics, 2020



Dongyang et al., Exploiting low dimensional features from the mobilenets for remote sensing image retrieval, Earth Science Informatics, 2020

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Dongyang et al., Exploiting low dimensional features from the mobilenets for remote sensing image retrieval, Earth Science Informatics, 2020

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unisource

Zhou et al., Remote sensing image retrieval in the past decade: Achievements, challenges, and future directions, IEEE J-STARS, 2023

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unisource

cross-source

Zhou et al., Remote sensing image retrieval in the past decade: Achievements, challenges, and future directions, IEEE J-STARS, 2023

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cross-source

Zhou et al., Remote sensing image retrieval in the past decade: Achievements, challenges, and future directions, IEEE J-STARS, 2023



cross-source

Zhou et al., Remote sensing image retrieval in the past decade: Achievements, challenges, and future directions, IEEE J-STARS, 2023

top-k retrieved images query image single-label unisource residential residential residential basketball parking court space multi-label cars, grass, cars, grass, cars, grass, cars, pavement pavement pavement pavement pavement view cross-source drone street street street street BW building BW building BW building BW building MSS building

Limitation of Remote Sensing Image Retrieval

query image single-label unisource query image multi-label

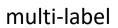
query of single modality!

view cross-source



Limitation of Remote Sensing Image Retrieval

query image single-label unisource query image



view





query of single modality!

restricts users from expressing specific requirements...

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cross-source

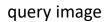
Remote Sensing Composed Image Retrieval 🥬

Remote Sensing Composed Image Retrieval 🥬

query image



Remote Sensing Composed Image Retrieval 🥕





query text

"dense"

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Remote Sensing Composed Image Retrieval 🥕

query image





"dense"



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Remote Sensing Composed Image Retrieval 🥕



query image





"dense"





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Remote Sensing Composed Image Retrieval 🤌



query image





"dense"







Remote Sensing Composed Image Retrieval 🤌

query image



query text

"dense"



top-k retrieved images

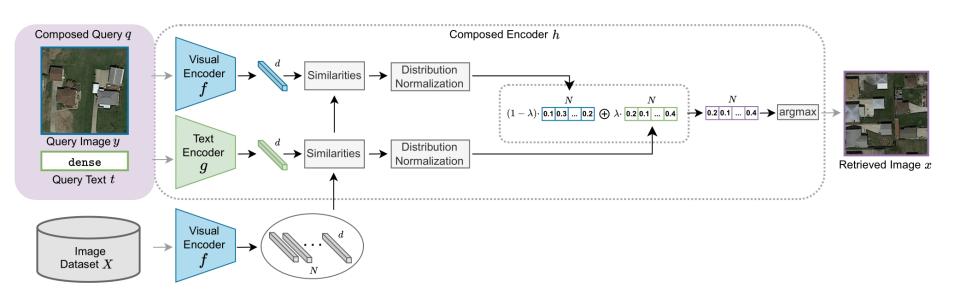






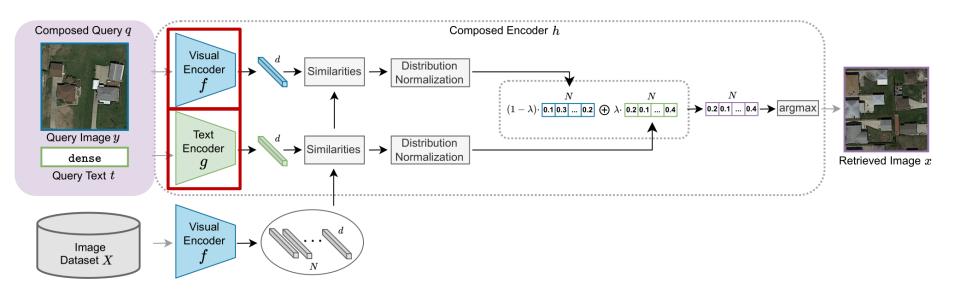


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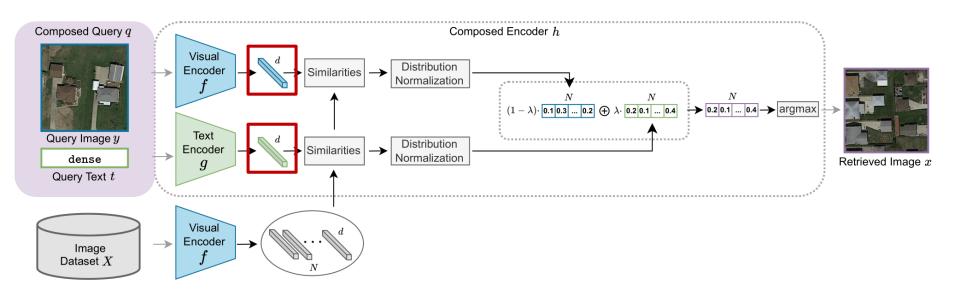


Radford et al., Learning transferable visual models from natural language supervision, ICML, 2021 Liu et al., Remoteclip: A vision language foundation model for remote sensing, IEEE TGRS, 2024

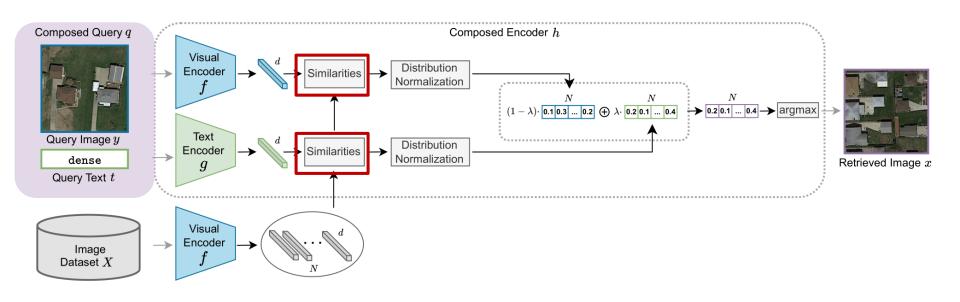
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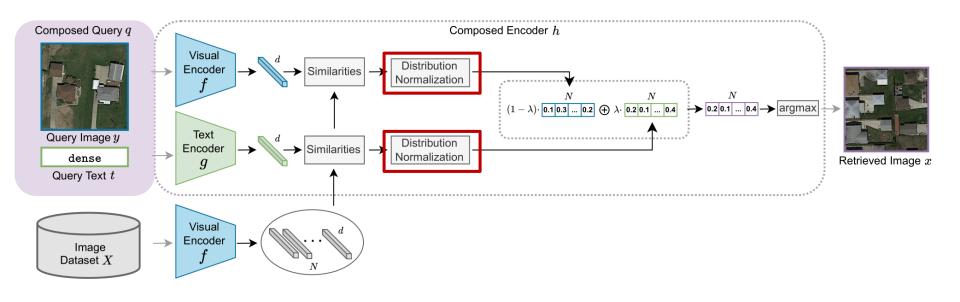
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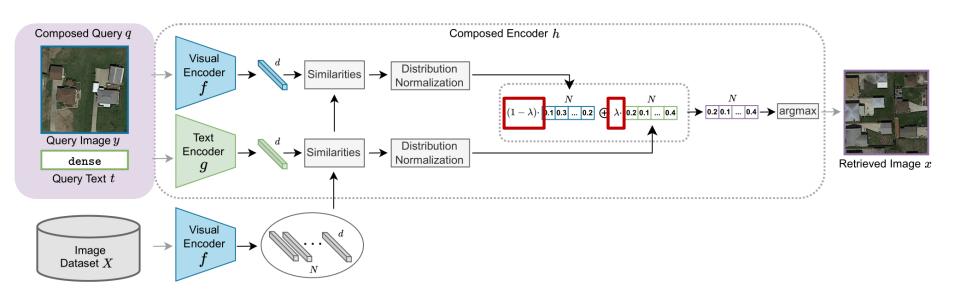
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WeiCom's control parameter λ

query image

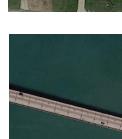




WeiCom's control parameter λ

query image



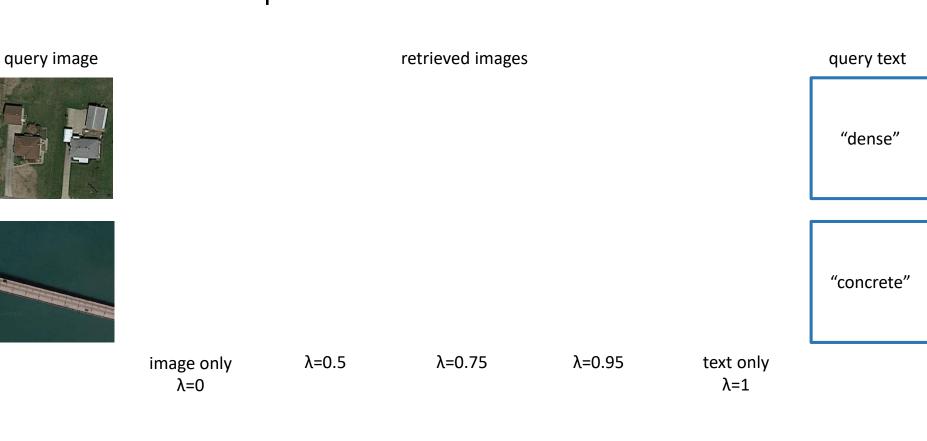


query text

"dense"

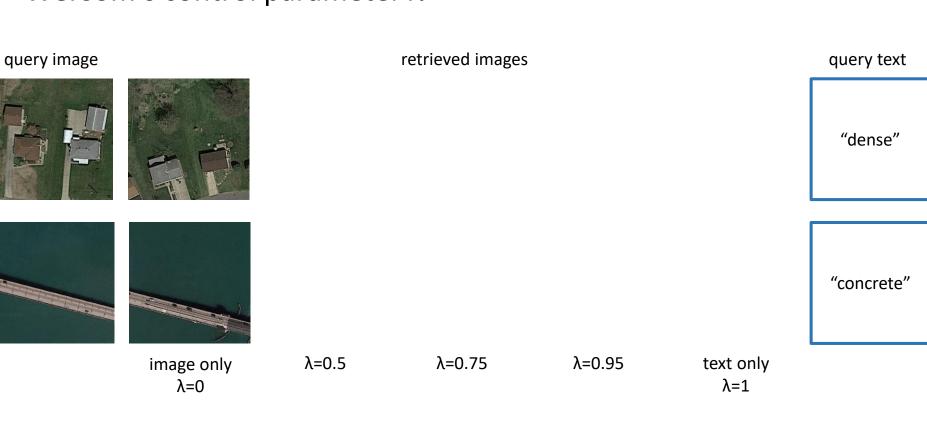
"concrete"

WeiCom's control parameter λ



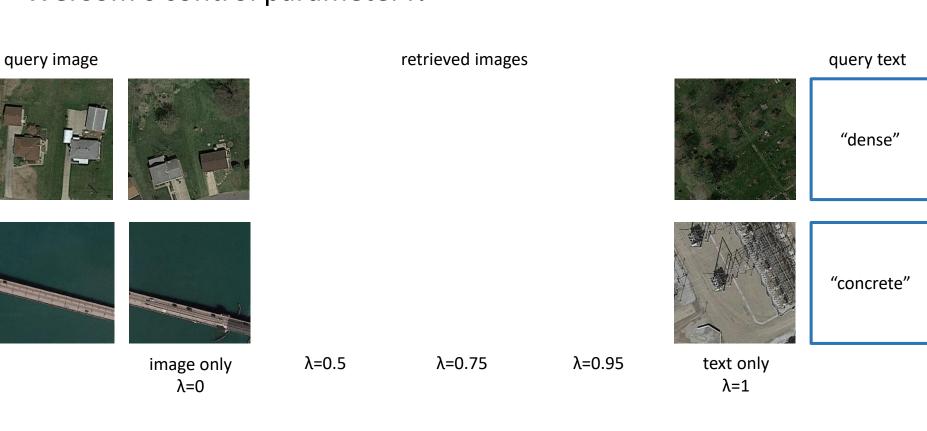
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WeiCom's control parameter λ



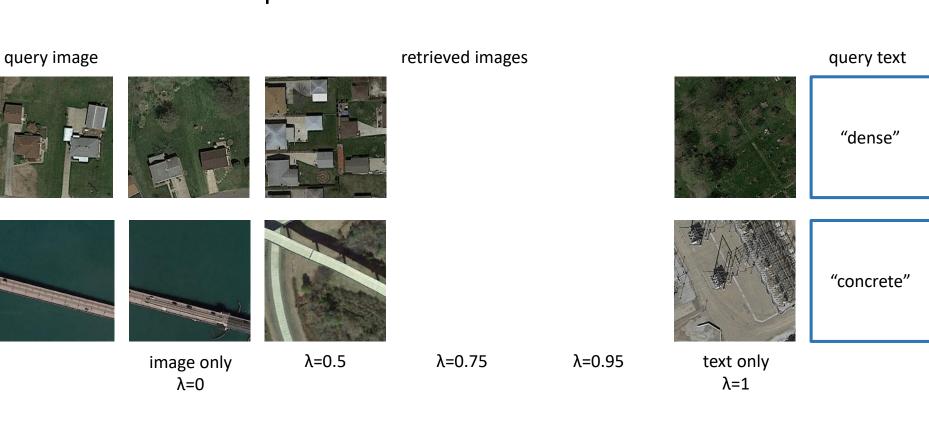
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WeiCom's control parameter λ



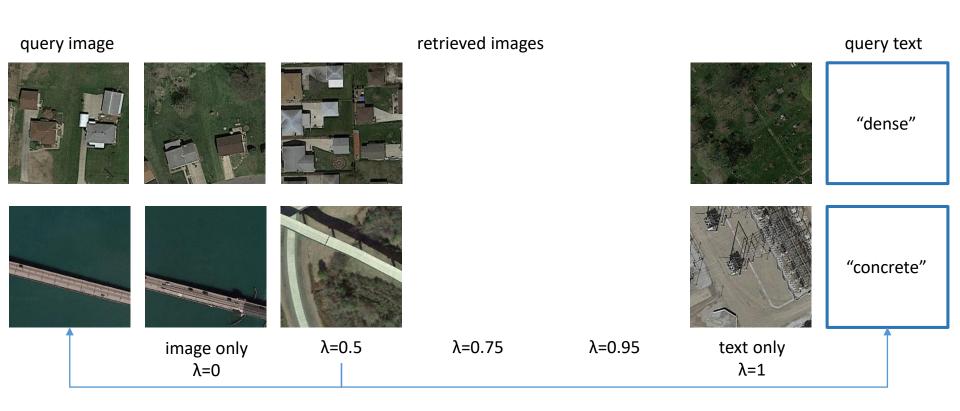
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WeiCom's control parameter λ



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WeiCom's control parameter λ



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WeiCom's control parameter λ

retrieved images query image query text "dense" "concrete" λ=0.5 $\lambda = 0.75$ $\lambda = 0.95$ text only image only λ=0 λ=1

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ATTRIBUTE	CLASS	VALUE	#Positives	#Queries
	oimplana	white	672	53
	airplane	purple	53	672
	nursing home	white	85	383
	nursing home	gray	383	85
	crosswalk	white	412	388
color	CIOSSWAIK	yellow	388	412
		blue	339	287
		brown	2	624
	tennis court	gray	50	576
		green	211	415
		red	24	602
		rectangular	261	299
	swimming pool	oval	52	508
		kidney-shaped	247	313
shape	river	curved	177	623
	nver	straight	623	177
	road	cross	800	800
	Toau	round	800	800

Statistics for color and shape attributes of PatternCom

Zhou et al., Patternnet: A benchmark dataset for performance evaluation of remote sensing image retrieval, ISPRS Journal, 2018

ATTRIBUTE	CLASS	VALUE	#Positives	#Queries
	airplane	white purple	672 53	53 672
	nursing home	white	85 383	383 85
	crosswalk	gray white	412	388
color		yellow blue	388 339	412 287
	tennis court	brown gray	2 50	624 576
		green	211	415
		red	24	602
		rectangular	261	299
	swimming pool	oval	52	508
		kidney-shaped	247	313
shape	river	curved	177	623
	11101	straight	623	177
	road	cross	800	800
	Toda	round	800	800

Statistics for color and shape attributes of PatternCom

ATTRIBUTE	CLASS	VALUE	#Positives	#Queries
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	crosswalk	white	412	388
color	CIOSSWAIK	yellow	388	412
		blue	339	287
		brown	2	624
	tennis court	gray	50	576
		green	211	415
		red	24	602
		rectangular	261	299
	swimming pool	oval	52	508
		kidney-shaped	247	313
shape	#ix or	curved	177	623
	river	straight	623	177
	road	cross	800	800
	road	round	800	800

Statistics for color and shape attributes of PatternCom

ATTRIBUTE	CLASS	VALUE	#Positives	#Queries
	airnlana	white	672	53
	airplane	purple	53	672
	nursing home	white	85	383
	nursing home	gray	383	85
	crosswalk	white	412	388
color	CIOSSWAIK	yellow	388	412
		blue	339	287
		brown	2	624
	tennis court	gray	50	576
		green	211	415
		red	24	602
		rectangular	261	299
	swimming pool	oval	52	508
		kidney-shaped	247	313
shape	eix oe	curved	177	623
	river	straight	623	177
	road	cross	800	800
	road	round	800	800

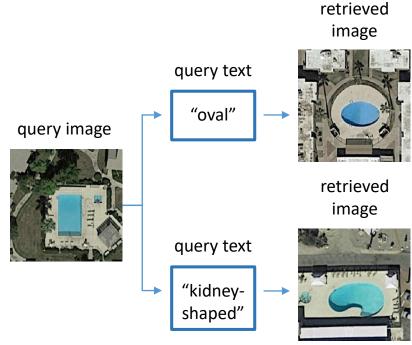
image query text "oval" query image

retrieved

Statistics for color and shape attributes of PatternCom

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ATTRIBUTE	CLASS	VALUE	#Positives	#Queries
	oimalon o	white	672	53
	airplane	purple	53	672
	nursing home	white	85	383
	nursing home	gray	383	85
	crosswalk	white	412	388
color	CIOSSWAIK	yellow	388	412
		blue	339	287
	tennis court	brown	2	624
		gray	50	576
		green	211	415
		red	24	602
		rectangular	261	299
	swimming pool	oval	52	508
		kidney-shaped	247	313
shape	wix row	curved	177	623
	river	straight	623	177
	road	cross	800	800
	Toau	round	800	800



Statistics for color and shape attributes of PatternCom

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ATTRIBUTE	CLASS	VALUE	#POSITIVES	#Queries
	-:1	white	672	53
	airplane	purple	53	672
	nursing home	white	85	383
	nursing home	gray	383	85
	crosswalk	white	412	388
color	CIOSSWAIK	yellow	388	412
		blue	339	287
		brown	2	624
	tennis court	gray	50	576
		green	211	415
		red	24	602
		rectangular	261	299
	swimming pool	oval	52	508
		kidney-shaped	247	313
shape	river	curved	177	623
	TIVET	straight	623	177
	road	cross	800	800
	Toau	round	800	800

retrieved image query text "oval" query image retrieved image query text "kidneyshaped"

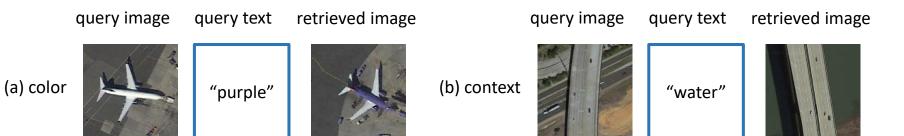
Statistics for color and shape attributes of PatternCom

>21k queries in total!

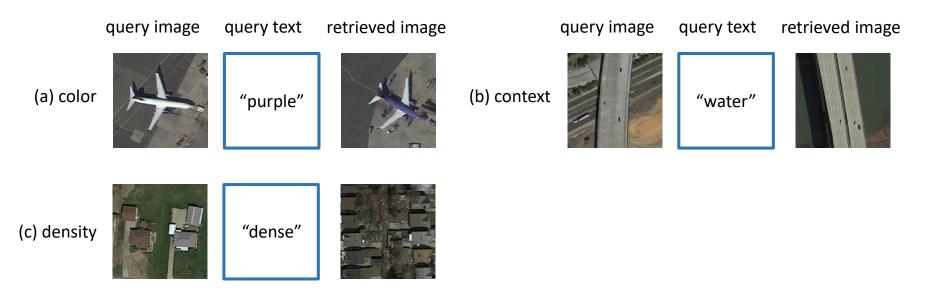
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query image query text retrieved image query image query text retrieved image

(a) color "purple" (b) context "water"

(c) density "dense" (d) existence (full)"

Patto	ernCom:	attribut	es					
	query image	query text	retrieved image		query image	query text	retrieved image	
(a) color		"purple"		(b) context		"water"	r.	
(c) density		"dense"		(d) existence		"full"	FERRER ECENT CONTROL OF THE SECOND CONTROL O	
(e) quantity		"four"						

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Datta wa Cara, attuib...taa

Patte	ernCom:	attribute	es				
	query image	query text	retrieved image		query image	query text	retrieved image
(a) color		"purple"		(b) context		"water"	6 00
(c) density		"dense"		(d) existence		"full"	COPPE STATE OF STATE
(e) quantity		"four"		(f) shape		"oval"	

CLIP

Метнор	Color	Context	DENSITY	Existence	QUANTITY	Sнаре	AVG
Text Image Text & Image	14.14 11.80 19.59	4.83 8.32 11.02	3.58 13.49 15.87	4.38 13.50 13.77	6.30 6.30 7.82	6.22 15.76 21.38	
$WEICOM_{\lambda=0.5}$ $WEICOM_{\lambda=0.3}$		17.45 20.97	16.49 22.07	9.24 12.07	18.00 18.40	23.97 26.22	

Radford et al., Learning transferable visual models from natural language supervision, ICML, 2021

CLIP

Метнор	Color	Context	DENSITY	EXISTENCE	QUANTITY	Sнаре	Avg
Text Image Text & Image	14.14 11.80 19.59	4.83 8.32 11.02	3.58 13.49 15.87	4.38 13.50 13.77	6.30 6.30 7.82	6.22 15.76 21.38	6.58 11.53 14.91
$WeiCom_{\lambda=0.5}$ $WeiCom_{\lambda=0.3}$		17.45 20.97	16.49 22.07	9.24 12.07	18.00 18.40	23.97 26.22	

RemoteCLIP

Метнор	Color	CONTEXT	DENSITY	EXISTENCE	QUANTITY	Sнаре	Avg
Text Image Text & Image	11.89 11.72 19.84	8.87 6.62 10.01	22.16 15.11 18.45	12.49 9.29 10.56	12.56 5.41 6.23	24.12 15.18 19.63	11.19
$\begin{array}{c} \textbf{WEICOM}_{\lambda=0.5} \\ \textbf{WEICOM}_{\lambda=0.6} \end{array}$		31.45 31.59	39.94 41.56	14.27 14.79	14.14 14.53	29.78 31.24	

Attribute modification mAP (%); comparison of WeiCom with baselines.

For each attribute value, average mAP over all the rest attribute values.

Liu et al., Remoteclip: A vision language foundation model for remote sensing, IEEE TGRS, 2024

C	LI	Р
C	LI	

Метнор	Color	Context	DENSITY	Existence	QUANTITY	SHAPE	AVG
Text Image Text & Image	14.14 11.80 19.59	4.83 8.32 11.02	3.58 13.49 15.87	4.38 13.50 13.77	6.30 6.30 7.82	6.22 15.76 21.38	6.58 11.53 14.91
$\begin{array}{c} \mathbf{WEICOM}_{\lambda=0.5} \\ \mathbf{WEICOM}_{\lambda=0.3} \end{array}$		17.45 20.97	16.49 22.07	9.24 12.07	18.00 18.40	23.97 26.22	21.05 23.41

8.5%

RemoteCLIP

Метнор	Color	Context	DENSITY	Existence	QUANTITY	SHAPE	AVG
Text Image Text & Image	11.89 11.72 19.84	8.87 6.62 10.01	22.16 15.11 18.45	12.49 9.29 10.56	12.56 5.41 6.23	24.12 15.18 19.63	11.19
$\begin{array}{c} \textbf{WEICOM}_{\lambda=0.5} \\ \textbf{WEICOM}_{\lambda=0.6} \end{array}$		31.45 31.59	39.94 41.56	14.27 14.79	14.14 14.53	29.78 31.24	

Attribute modification mAP (%); comparison of WeiCom with baselines. For each attribute value, average mAP over all the rest attribute values.

		П
C	LI	Υ

Метнор	Color	Context	DENSITY	EXISTENCE	QUANTITY	SHAPE .	Avg
Text	14.14	4.83	3.58	4.38	6.30	6.22	6.58
Image	11.80	8.32	13.49	13.50	6.30	15.76	11.53
Text & Image	19.59	11.02	15.87	13.77	7.82	21.38 1	14.91
$\overline{\text{WeiCom}_{\lambda=0.5}}$	41.15	17.45	16.49	9.24	18.00	23.97 2	21.05
$\text{WEICOM}_{\lambda=0.3}$	40.71	20.97	22.07	12.07	18.40	26.22	23.41

RemoteCLIP

Метнор	Color	Context	DENSITY	EXISTENCE	QUANTITY	SHAPE	AVG
Text Image Text & Image	11.89 11.72 19.84	8.87 6.62 10.01	22.16 15.11 18.45	12.49 9.29 10.56	12.56 5.41 6.23	24.12 15.18 19.63	11.19
$\begin{array}{c} \text{WEICOM}_{\lambda=0.5} \\ \text{WEICOM}_{\lambda=0.6} \end{array}$		31.45 31.59	39.94 41.56	14.27 14.79	14.14 14.53	29.78 31.24	28.28 28.65

11.7%

Attribute modification mAP (%); comparison of WeiCom with baselines. For each attribute value, average mAP over all the rest attribute values.

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Метнор	Color	Context	DENSITY	EXISTENCE	QUANTITY	SHAPE	AVG
Text Image Text & Image	14.14 11.80 19.59	4.83 8.32 11.02	3.58 13.49 15.87	4.38 13.50 13.77	6.30 6.30 7.82	6.22 15.76 21.38	6.58 11.53
$\frac{\text{WEICOM}_{\lambda=0.5}}{\text{WEICOM}_{\lambda=0.3}}$	41.15	17.45 20.97	16.49 22.07	9.24 12.07	18.00 18.40	23.97 26.22	21.05

5.2%

RemoteCLIP

Метнор	Color	Context	DENSITY	Existence	QUANTITY	SHAPE	AVG
Text Image Text & Image	11.89 11.72 19.84	8.87 6.62 10.01	22.16 15.11 18.45	12.49 9.29 10.56	12.56 5.41 6.23		16.99 11.19 14.85
$WEICOM_{\lambda=0.5}$ $WEICOM_{\lambda=0.6}$		31.45 31.59	39.94 41.56	14.27 14.79	14.14 14.53	29.78 31.24	28.28 28.65

Attribute modification mAP (%); comparison of WeiCom with baselines. For each attribute value, average mAP over all the rest attribute values.

Conclusion

- ✓ Introduce Remote Sensing Composed Image Retrieval, accompanied with PatternCom, a benchmark dataset
- Demonstrate its versatility through use cases modifying attributes like color and shape
- Introduce WeiCom, a training-free method utilizing a modality control parameter λ

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Collaborators



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Ondrej Chum



Yannis Avrithis



Konstantinos Karantzalos

Thanks for your attention!



paper



code and dataset

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