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中国科学院自动化研究所
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DTLLM-VLT: Diverse Text Generation for Visual Language Tracking Based on LLM

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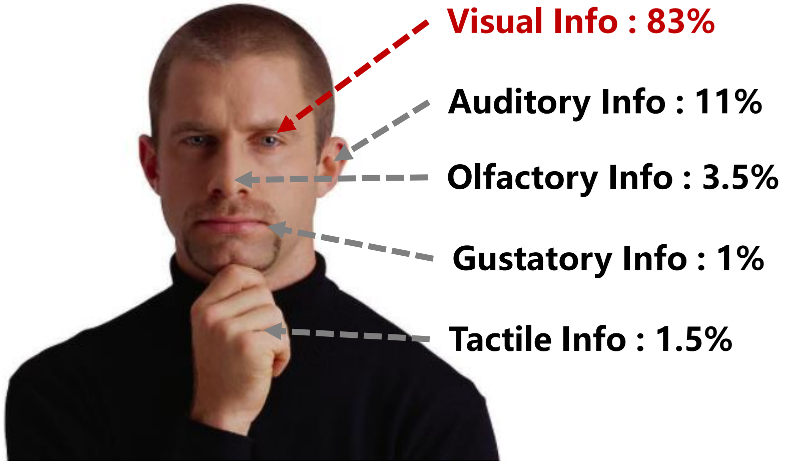
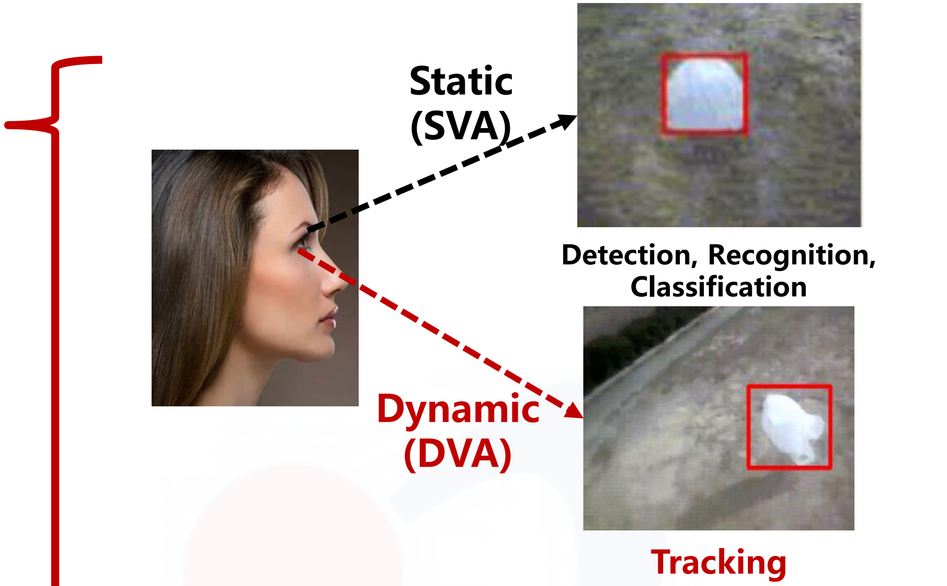
Task Definition



Humans are “visual creatures”

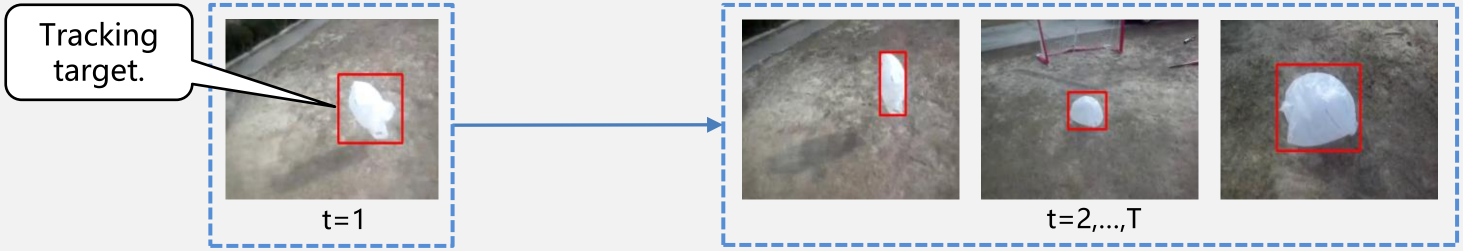


Object tracking is a fundamental function of **the human dynamic visual system**

modeling

VLT (Visual Language Tracking)

- **Definition :** Only providing the initial position and natural language descriptions of a moving object and continuously locating it in a video sequence.

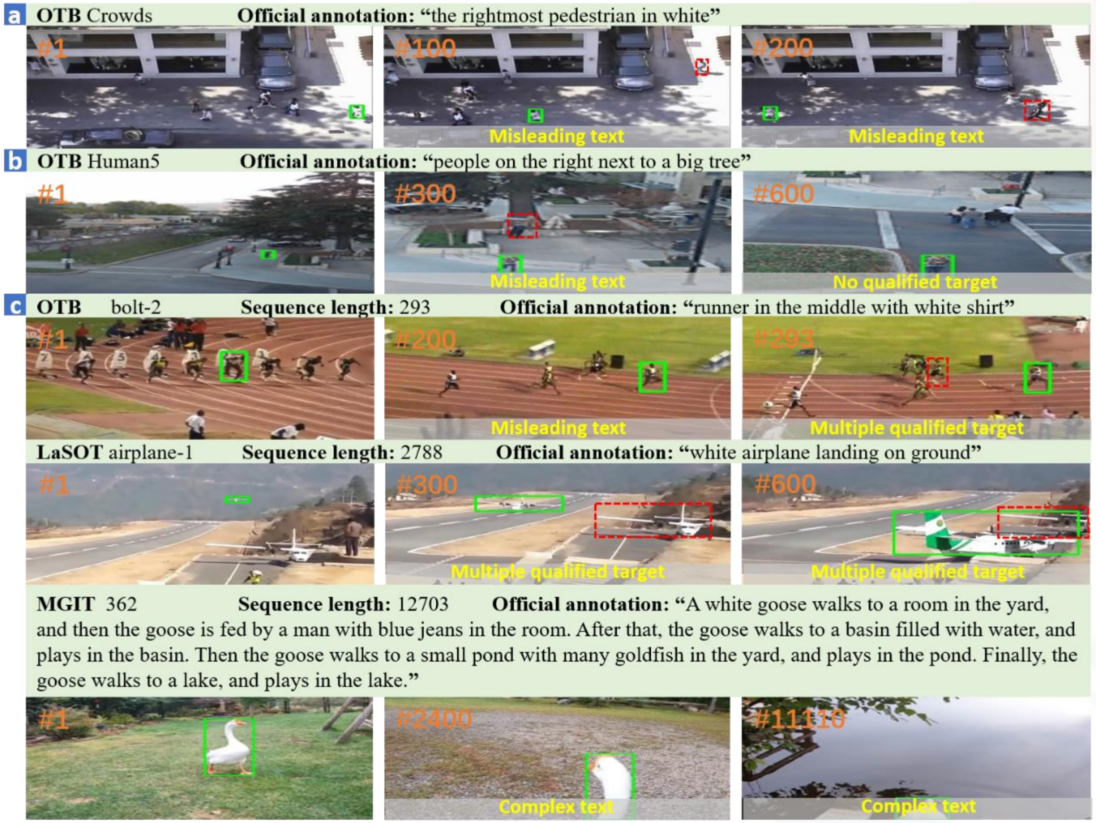


First frame : Initialize by NL & BBox

Video sequence : Locate continuously in video sequence

Motivation

- Most VLT benchmarks are annotated in a **single granularity** and **lack a coherent semantic framework** to provide scientific guidance.
- Current VLT benchmarks considers studying from different perspective :
  - **Limitations1.** Semantic annotations in OTB99_Lang mainly describe **the first frame**, which may **misguide the algorithm**.
  - **Limitations2.** Sequence in MGIT has such **complex text** that they are **not conducive to algorithmic learning**.



a OTB Crowds Official annotation: "the rightmost pedestrian in white"

b OTB Human5 Official annotation: "people on the right next to a big tree"

c OTB bolt-2 Sequence length: 293 Official annotation: "runner in the middle with white shirt"

LaSOT airplane-1 Sequence length: 2788 Official annotation: "white airplane landing on ground"

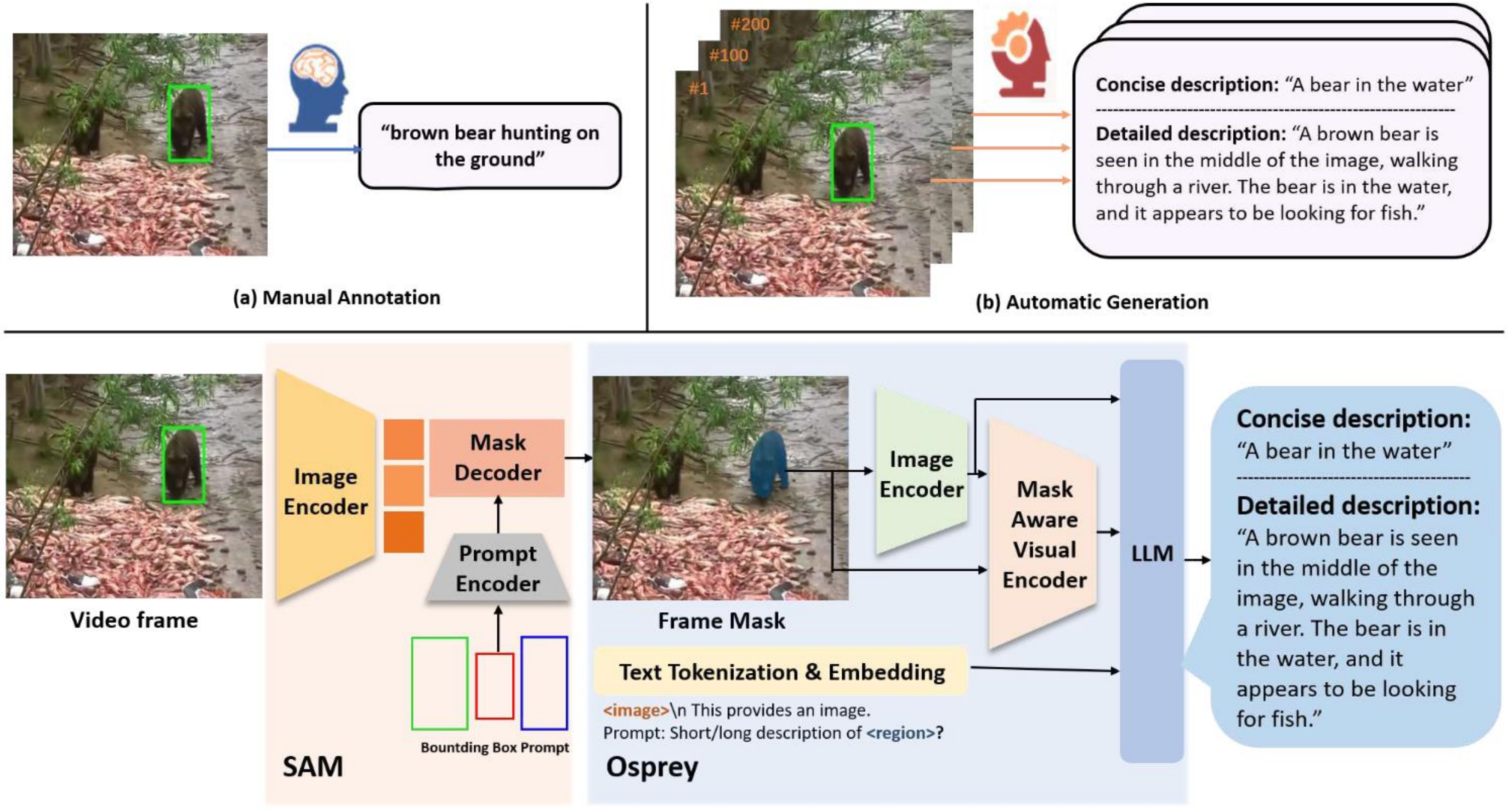
MGIT 362 Sequence length: 12703 Official annotation: "A white goose walks to a room in the yard, and then the goose is fed by a man with blue jeans in the room. After that, the goose walks to a basin filled with water, and plays in the basin. Then the goose walks to a small pond with many goldfish in the yard, and plays in the pond. Finally, the goose walks to a lake, and plays in the lake."

- **Research objective :** Using LLM to provide multi-granularity semantic information for VLT from efficient and diverse perspectives, enabling fine-grained evaluation. This work can be extended to more datasets to support vision datasets understanding.

DTLLM-VLT: Diverse Text Generation for Visual Language Tracking Based on LLM

Contribution 1: Diverse text generation method based on LLM (DTLLM-VLT)

- **Diverse texts** matter → Integrating the **LLM** into the text generation process, offer a **diverse environment** conducive to VLT research.



"brown bear hunting on the ground"

(a) Manual Annotation

Concise description: "A bear in the water"

Detailed description: "A brown bear is seen in the middle of the image, walking through a river. The bear is in the water, and it appears to be looking for fish."

(b) Automatic Generation

<image>\n This provides an image.
Prompt: Short/long description of <region>?

Concise description: "A bear in the water"

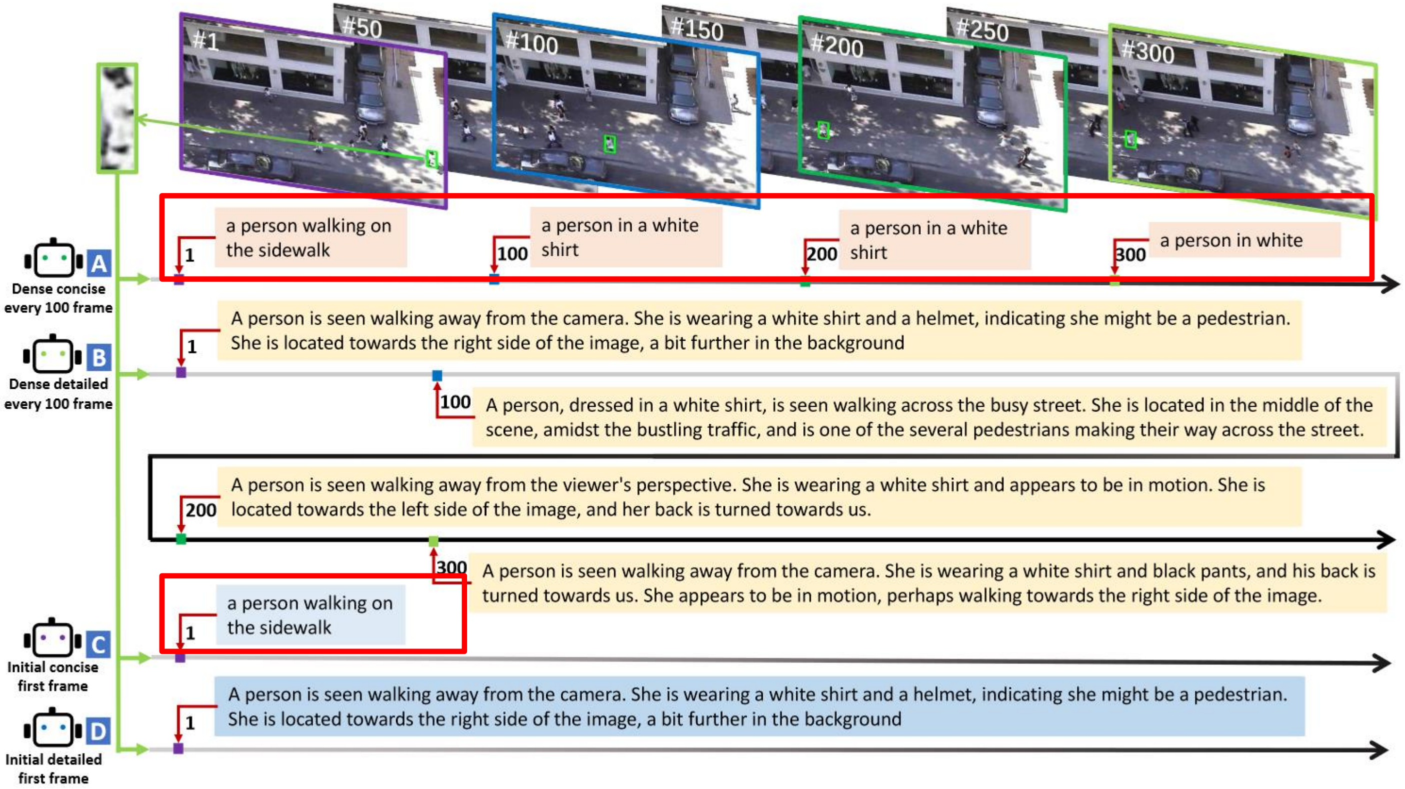
Detailed description: "A brown bear is seen in the middle of the image, walking through a river. The bear is in the water, and it appears to be looking for fish."

(c) Framework of DTLLM-VLT

DTLLM-VLT: Diverse Text Generation for Visual Language Tracking Based on LLM

Contribution 2: Multi-Granularity Diverse Semantic Generation Strategy

- Applying **multi-granularity generation**
  - **Initial texts:** Following the text annotations method in OTB99_Lang and TNL2K, we generate text for the **initial frame** of each video.
  - **Dense texts**: Considering the worst situation and infer that the algorithm lacks an efficient memory system. Consequently, at 25 FPS, equating to **every 100 frames** in 4 seconds, we supply the algorithm with relevant generated text.


#1
#50
#100
#150
#200
#250
#300
A
Dense concise every 100 frame
B
Dense detailed every 100 frame
C
Initial concise first frame
D
Initial detailed first frame

1 a person walking on the sidewalk

100 a person in a white shirt

200 a person in a white shirt

300 a person in white

1 A person is seen walking away from the camera. She is wearing a white shirt and a helmet, indicating she might be a pedestrian. She is located towards the right side of the image, a bit further in the background

100 A person, dressed in a white shirt, is seen walking across the busy street. She is located in the middle of the scene, amidst the bustling traffic, and is one of the several pedestrians making their way across the street.

200 A person is seen walking away from the viewer's perspective. She is wearing a white shirt and appears to be in motion. She is located towards the left side of the image, and her back is turned towards us.

300 A person is seen walking away from the camera. She is wearing a white shirt and black pants, and his back is turned towards us. She appears to be in motion, perhaps walking towards the right side of the image.

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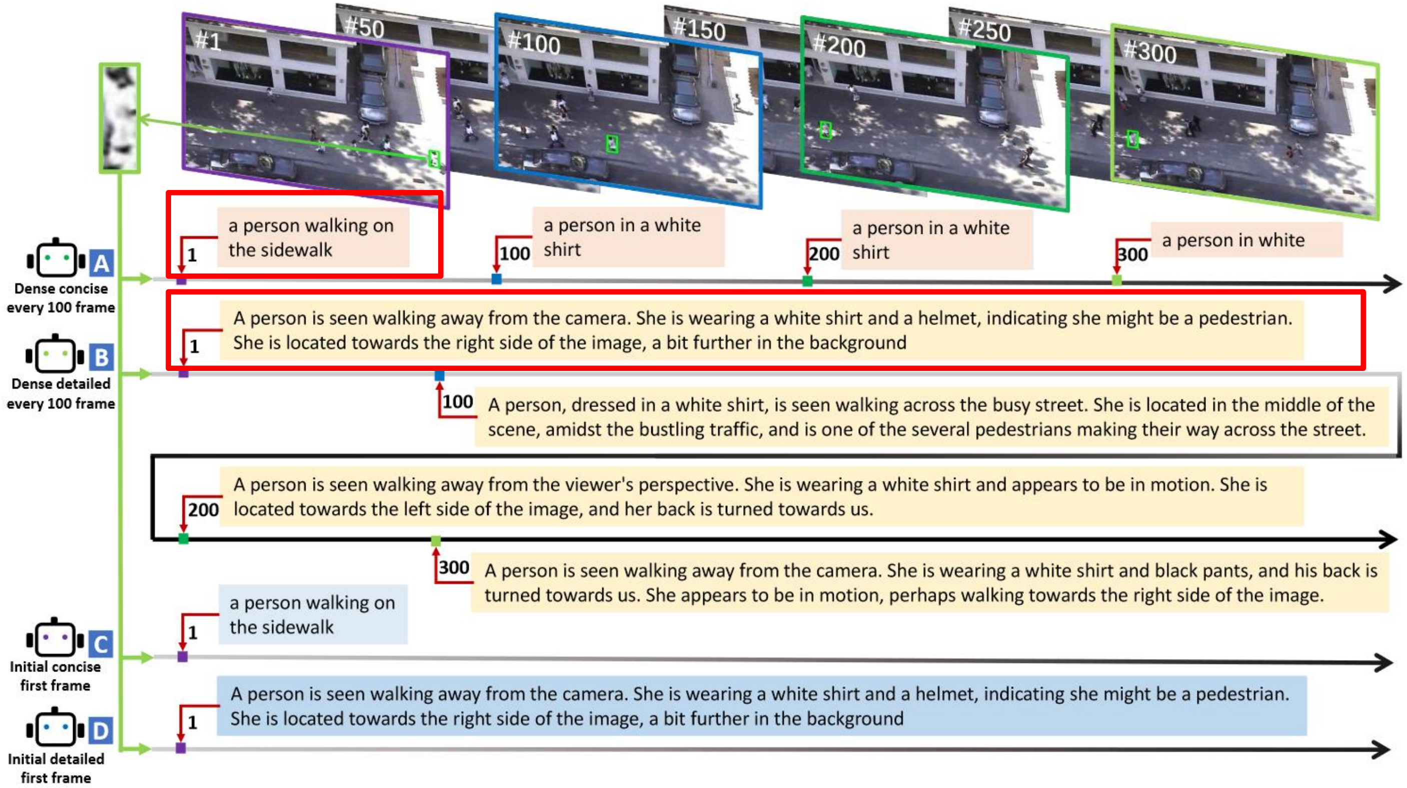
DTLLM-VLT: Diverse Text Generation for Visual Language Tracking Based on LLM

Contribution 2: Multi-Granularity Diverse Semantic Generation Strategy

- Applying **multi-granularity generation**
  - **Concise texts:** if the BBox already sufficiently describes the temporal and spatial changes of the object, the text descriptions should focus on providing **essential semantic details** like the category and positions of the object.
  - **Detailed texts**: In cases where the BBox lacks sufficient information for effective learning by the tracker, more **elaborate texts are necessary** to compensate for the missing temporal and spatial relationships.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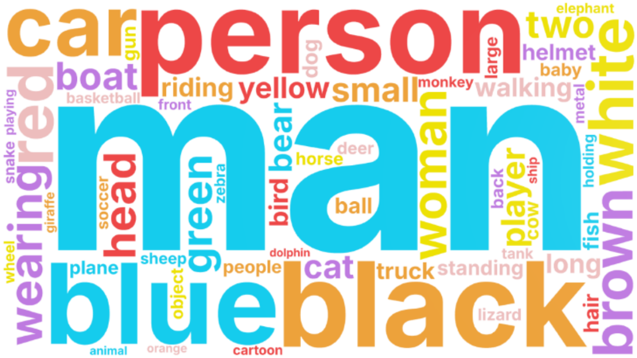
DTLLM-VLT: Diverse Text Generation for Visual Language Tracking Based on LLM

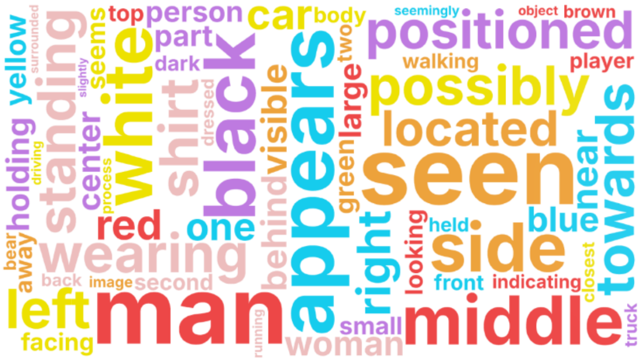
Contribution 2: Multi-Granularity Diverse Semantic Generation Strategy

- **Diverse Generation**
  - **1.9M** words
  - **14.8K** non-repetitive words.
  - 7,238 initial descriptions
  - 128.4K dense descriptions

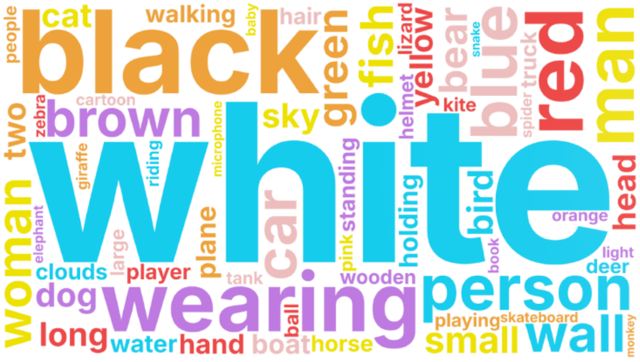
Dataset	Number of Language Description				
	Official	*Dense Concise*	*Dense Detailed*	*Initial Concise*	*Initial Detailed*
OTB99_Lang	99	*596*	*596*	*99*	*99*
LaSOT	1,400	*35.2K*	*35.2K*	*1,400*	*1,400*
TNL2K	2,000	*12.4K*	*12.4K*	*2,000*	*2,000*
MGIT	1,753	*16.1K*	*16.1K*	*120*	*120*



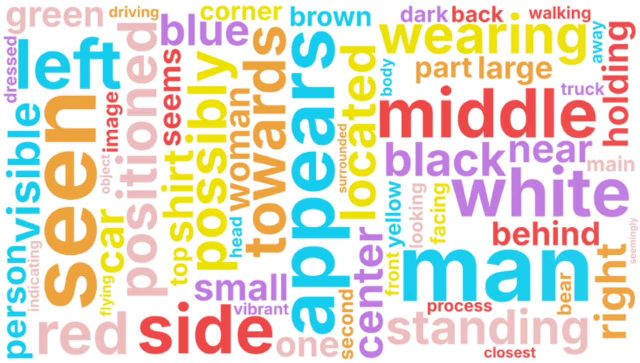
(a) The word cloud of initial concise texts



(b) The word cloud of initial detailed texts



(c) The word cloud of dense concise texts



(d) The word cloud of dense detailed texts

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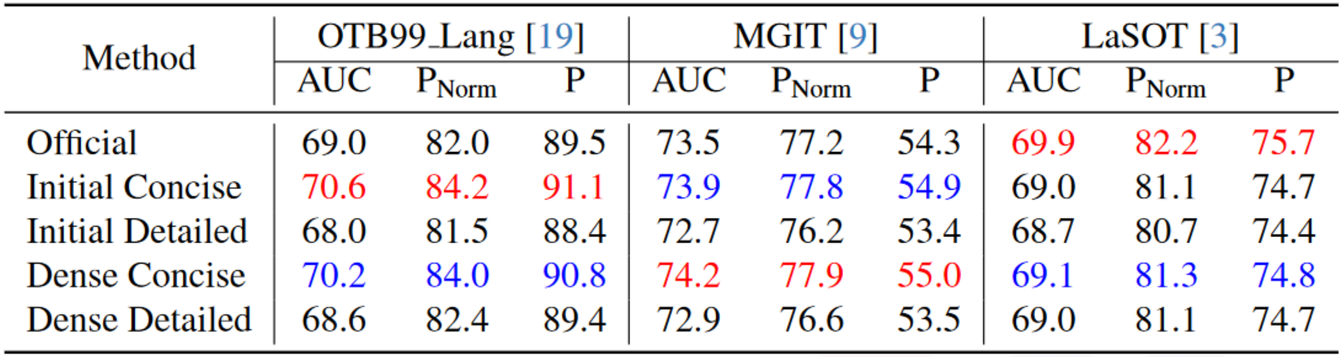
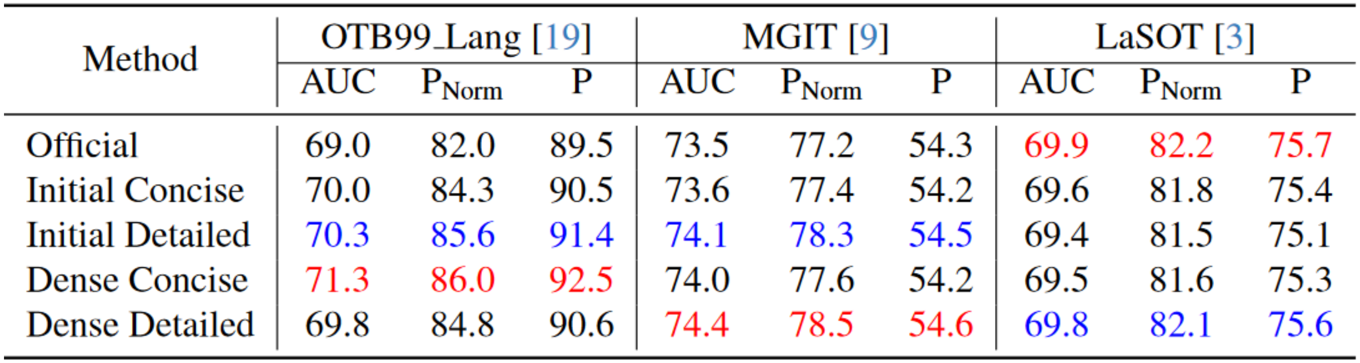
Contribution 3: Evaluation mechanism and analysis for VLT task

- Mechanism A: Utilizing the official weight files provided, we keep all parameters unchanged and **directly test** the tracking performance.



Method	OTB99_Lang [19]			MGIT [9]			LaSOT [3]		
	AUC	P_{Norm}	P	AUC	P_{Norm}	P	AUC	P_{Norm}	P
Official	69.0	82.0	89.5	73.5	77.2	54.3	69.9	82.2	75.7
Initial Concise	70.6	84.2	91.1	73.9	77.8	54.9	69.0	81.1	74.7
Initial Detailed	68.0	81.5	88.4	72.7	76.2	53.4	68.7	80.7	74.4
Dense Concise	70.2	84.0	90.8	74.2	77.9	55.0	69.1	81.3	74.8
Dense Detailed	68.6	82.4	89.4	72.9	76.6	53.5	69.0	81.1	74.7

- Mechanism B: We **continue training** for an additional 50 epochs based on the official weights, using datasets such as OTB99_Lang, LaSOT, TNL2K, and RefCOCOg. During the training process, we replace the official texts with different texts.



Method	OTB99_Lang [19]			MGIT [9]			LaSOT [3]		
	AUC	P_{Norm}	P	AUC	P_{Norm}	P	AUC	P_{Norm}	P
Official	69.0	82.0	89.5	73.5	77.2	54.3	69.9	82.2	75.7
Initial Concise	70.0	84.3	90.5	73.6	77.4	54.2	69.6	81.8	75.4
Initial Detailed	70.3	85.6	91.4	74.1	78.3	54.5	69.4	81.5	75.1
Dense Concise	71.3	86.0	92.5	74.0	77.6	54.2	69.5	81.6	75.3
Dense Detailed	69.8	84.8	90.6	74.4	78.5	54.6	69.8	82.1	75.6

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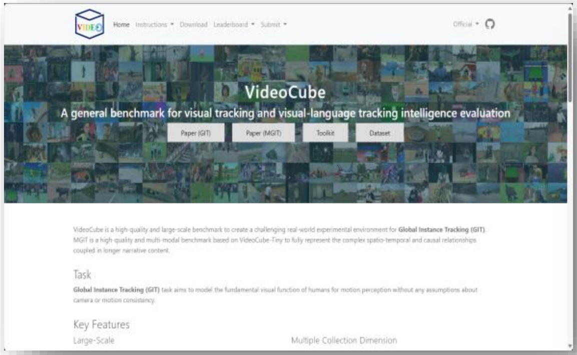
Experimental analysis: Diverse texts are suitable for different tasks

- The existing algorithm tends to learn and understand **short text**.

- For short-term tracking task, **dense concise text** will bring greater gains. While **dense detailed text** is more suitable for the other two tasks.

- The text processing method and multi-modal alignment ability need to be adjusted and improved.

Series Work on SOT and VLT



VideoCube

A general benchmark for visual tracking and visual-language tracking intelligence evaluation

VideoCube is a high-quality and large-scale benchmark to create a challenging real-world experimental environment for **Global Instance Tracking (GIT)**. MGIT is a high-quality and multi-modal benchmark based on VideoCube-Tiny to fully represent the complex spatio-temporal and causal relationships coupled in longer narrative content.

Task

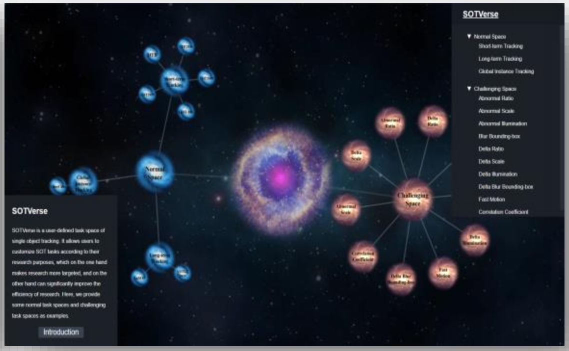
Global Instance Tracking (GIT) task aims to model the fundamental visual function of humans for motion perception without any assumptions about camera or motion consistency.

Key Features

Large-Scale

Multiple Collection Dimension

VideoCube Platform



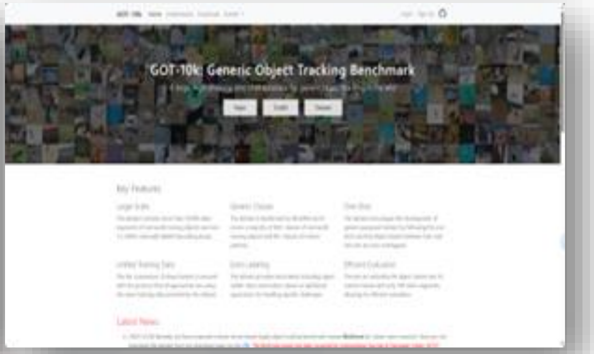
SOTVerse

- ▼ Normal Space
  - Short-term Tracking
  - Long-term Tracking
  - Global Instance Tracking
- ▼ Challenging Space
  - Abnormal Ratio
  - Abnormal Scale
  - Abnormal Illumination
  - Blur Bounding-box
  - Delta Ratio
  - Delta Scale
  - Delta Illumination
  - Delta Blur Bounding-box
  - Fast Motion
  - Correlation Coefficient

SOTVerse

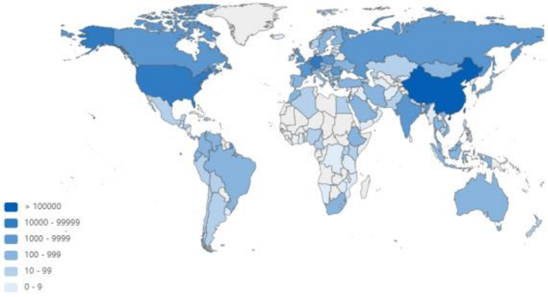
SOTVerse is a user-defined task space of single object tracking. It allows users to customize SOT tasks according to their research purposes, which on the one hand makes research more targeted, and on the other hand can significantly improve the efficiency of research. Here, we provide some normal task spaces and challenging task spaces as examples.

SOTVerse Platform



GOT-10k: Generic Object Tracking Benchmark

GOT-10k Platform



3.9M IP Views from 160+ Countries

7,000+ Downloads and Evaluation for 215k+ Trackers

VideoCube Platform (TPAMI'23 & NIPS'23): http://videocube.aitestunion.com/

SOTVerse Platform (IJCV'23): http://metaverse.aitestunion.com/

GOT-10k Platform (TPAMI'21): http://got-10k.aitestunion.com/

Thanks!

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