Low-Latency Privacy-Aware Robot Behavior guided by Automatically Generated Text Datasets

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Abstract

Objective : **Realize humanoid robot exhibiting privacy-aware behavior.**

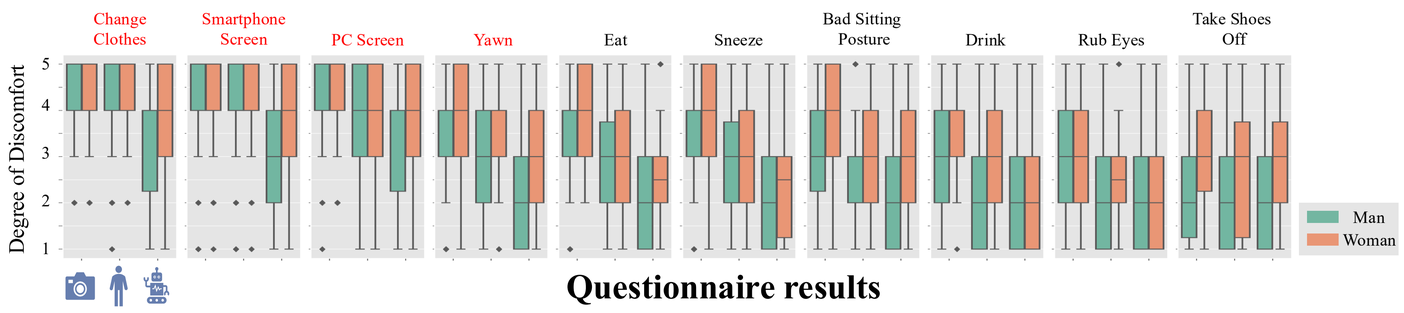
Summary : **Without collecting ethically sensitive images, distill knowledge from an LLM and achieve text-based image privacy recognition.**

Background

Humanoid robots with human-like appearance should behave naturally and consider privacy
⇒ User study with 200 participants

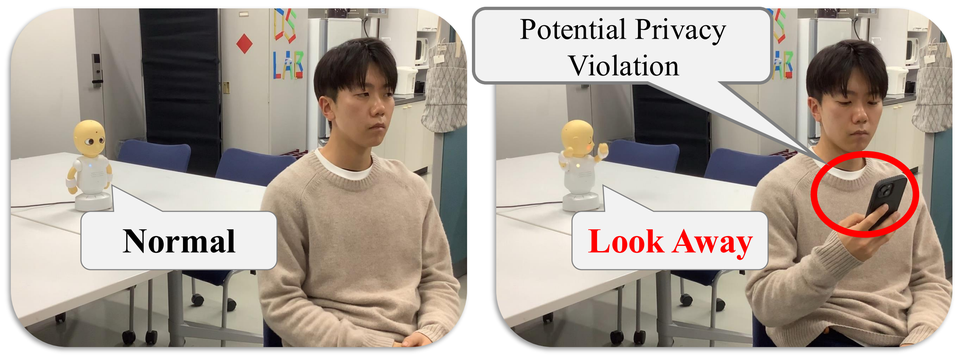
◆ Discomfort arises when a robot observes private scenes (e.g., changing clothes, smartphone/PC screen).

◆ Robot observation causes less discomfort than cameras or humans. However, discomfort remains in private contexts.



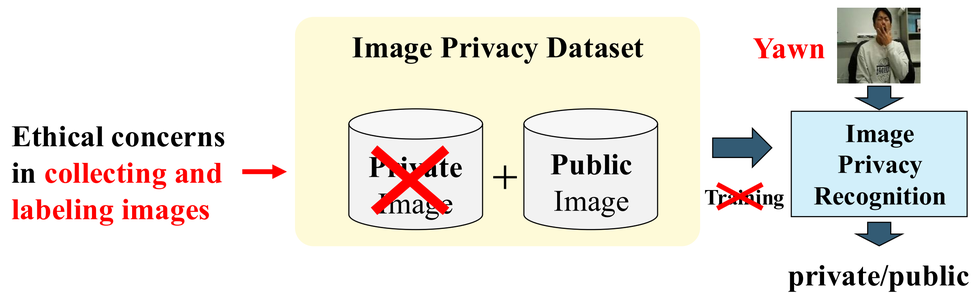
Questionnaire results

※ Discomfort rating for 10 types of actions and information were collected on a 5-point scale across 3 conditions



Problems of existing methods

■ Specialized model (Image Privacy Recognition Model) : usually requires an image privacy dataset



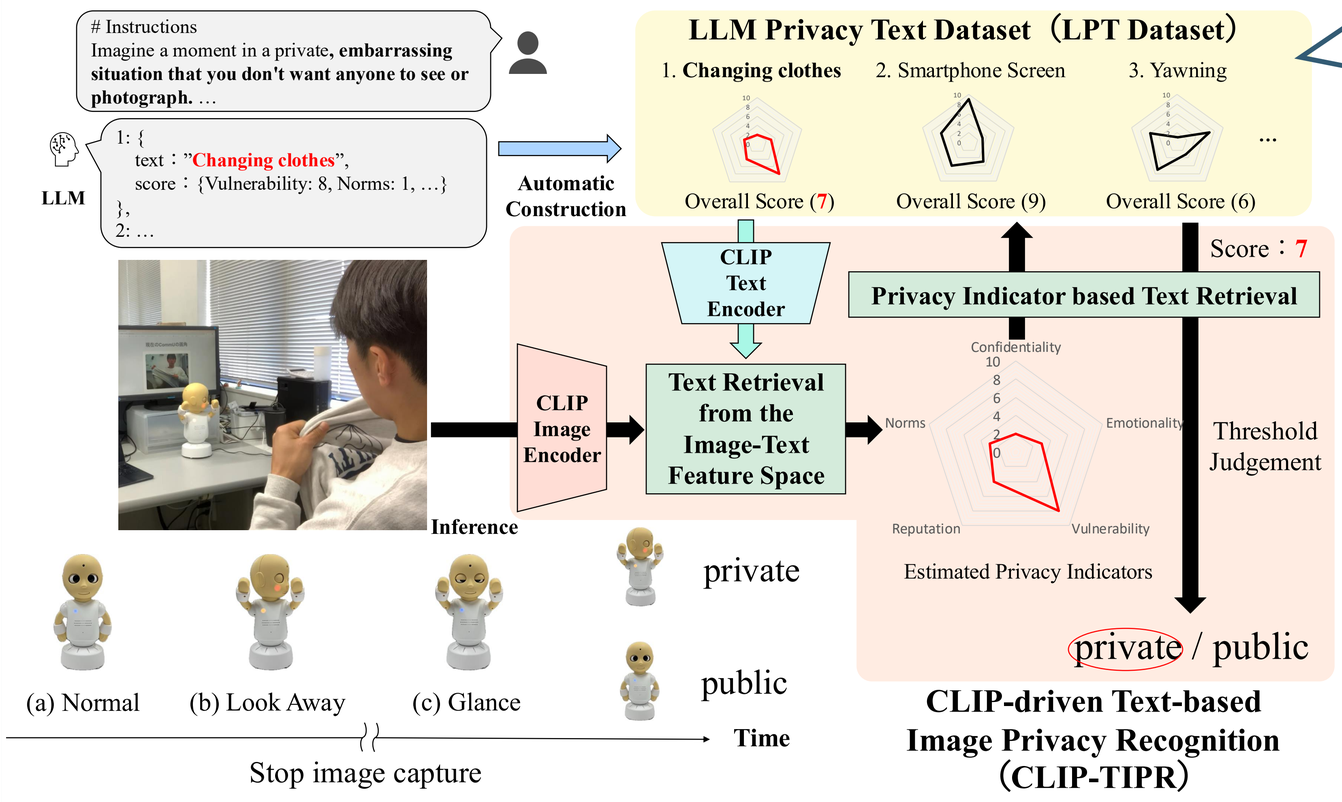
■ General-purpose model (LVLM): requires about 3 seconds for high-accuracy recognition, causing large delay

Proposed Framework

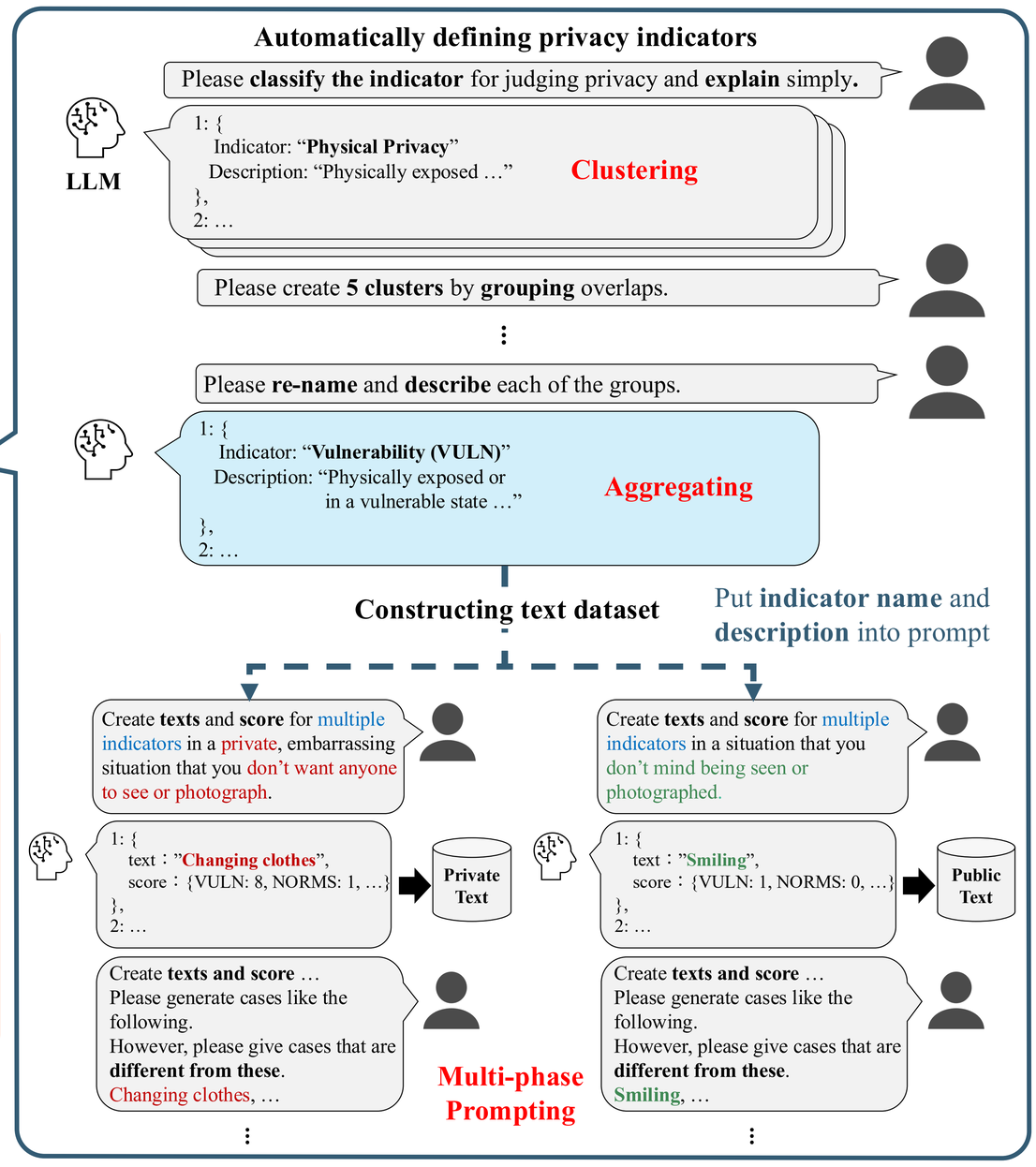
Contributions

i. Enable humanoid robots to **recognize privacy-sensitive situations** and **respond appropriately**.

ii. Propose a **low-latency and robust** recognition method with **fewer ethical concerns** by utilizing a **text dataset automatically constructed by an LLM**.



CLIP-driven Text-based Image Privacy Recognition (CLIP-TIPR)



Experiments

Details of LPT Dataset

- Model: GPT-4o
- Number of Indicators: 5
- Generated Texts: 1,000 × 2 (private/public)

Evaluation Metrics

macro F1-score

Comparison Methods

#	Methods	Text Dataset
I	ZSVCIP	LPT Dataset (binary)
II	CLIP-TIPR (Text-based)	Single Abstract Indicator ※ Construct with only overall score
III	CLIP-TIPR (Indicator-based)	LPT Dataset
IV	LVLM-simple	-
V	LVLM-cot	-

Examples of LPT Dataset text and scores

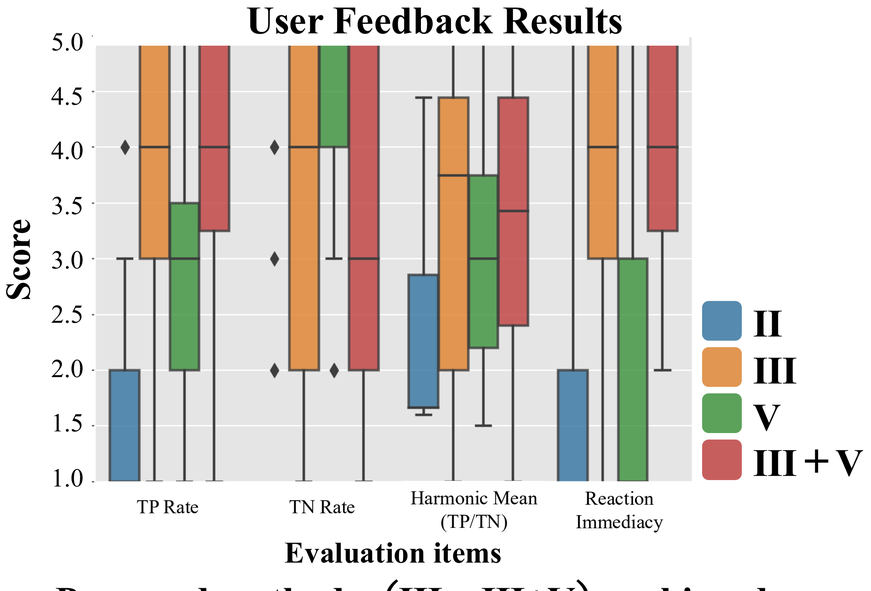
Text	CONF	EMO	VULN	REP	NORMS	OA
Having your pants accidentally torn in a very public place.	0	**6**	**8**	**7**	**9**	**10**
Having your phone sent a personal message to a group chat by mistake.	5	**7**	0	**6**	**8**	**9**
Photographed yawning widely in a serious meeting.	0	2	1	3	**6**	**6**

Quantitative Evaluation Results

#	macro F1-score ↑			Processing Time (s)↓
	CPI Dataset	PrivacyAlert	VISPR	
I	0.500	0.543	**0.525**	0.059
II	0.440	0.577	0.306	**0.058**
III	**0.680**	0.582	0.461	0.074
IV	0.417	0.249	0.437	2.040
V	0.644	**0.706**	0.415	3.198

CLIP-TIPR (III) achieved accurate and robust performance

User Feedback Results



Proposed methods (III・III+V) achieved accurate and low-latency recognition

Future Work

- Improve recognition for **fine-grained actions and objects.**
- Address differences in **privacy perceptions across cultures and individuals.**