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MOTIVATION

The WHY: Narrow down the search space to assist law enforcement in combating crimes such as human trafficking and child exploitation.

The WHAT: Victims are often photographed in hotel rooms, and traffickers share these images within criminal networks and online advertisements. Identifying the hotel from such images can help determine where a victim was photographed and reveal potential trafficking hot spots [1].

The HOW: When a large and representative reference dataset is available, the task is formulated as a Content-based image retrieval (CBIR) problem. In the absence of such a dataset, geolocation relies on universal visual cues to infer location directly from the image.

REAL WORLD INSPIRATION



“Trace an Object” is a crowdsourcing campaign by Europol that enlists the public to identify everyday items such as furniture, logos, or locations appearing in the background of child sexual abuse material, helping law enforcement generate new investigative leads [2].

PLUG TO PLACE

Electrical plug sockets are consistent and recognizable indoor markers, as each country or region uses specific socket types defined by distinct pin configurations. A computer vision based three-stage pipeline is applied to automatically detect plug sockets, classify them into one of 12 types, and map them to a set of possible countries, thereby constraining the geographical search space and supporting subsequent investigative analysis.

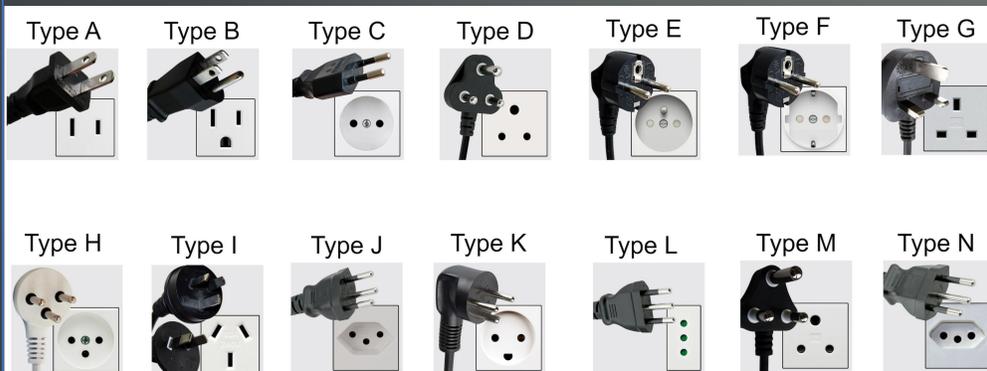


Figure 1: Plug and Socket Types from Type A to Type N.

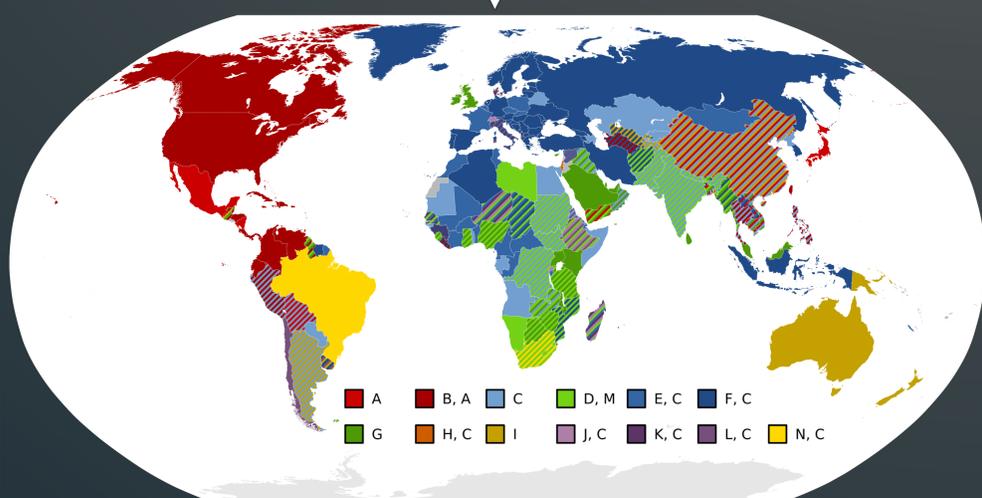


Figure 2: Worldwide plug type distribution map.

EVALUATION AND RESULTS

Stage	Task/Model	Dataset	Metrics	Results
Stage 1	Socket Detection (YOLOv11-Small, K-Fold Cross-Validation)	Socket Detection Dataset – 2,328 annotated images + 4,074 augmented	Precision	0.8675
			Recall	0.7990
			mAP@0.5	0.843
			mAP@0.5:0.95	0.5771
Stage 2	Socket Type Classification (Best Model: Xception)	Socket Type Classification Dataset – 12 socket type, 3,187 images	Accuracy	0.877
			Precision	0.894
			Recall	0.884
			F1-Score	0.881
Stage 3	Geolocation	Evaluation Dataset: Hotels-50K (TraffickCam) 44,630	Accuracy @ Confidence Thresholds (%)	
			≥ 70%	91.61
			≥ 80%	93.73
			≥ 90%	96.29

Three-stage pipeline: (1) Socket detection, (2) Socket type classification, and (3) Geolocation

For more information refer to “Plug to Place: Indoor Multimedia Geolocation from Electrical Sockets for Digital Investigation,” accepted for publication in *Forensic Science International: Digital Investigation* [3].

FUTURE DIRECTIONS

1. INDOOR GEOLOCATION CUES



2. SAME ROOM DETECTION



3. PATTERN BASED CBIR



REFERENCES

- Bhavanasi, Sai Shreyas, and Abby Stylianou. "Hotel recognition using object ensembles." *2023 IEEE Applied Imagery Pattern Recognition Workshop (AIPR)*. IEEE, 2023.
- <https://www.europol.europa.eu/stopchildabuse>
- Aftab, Kanwal, Graham Adams, and Mark Scanlon. "Plug to Place: Indoor Multimedia Geolocation from Electrical Sockets for Digital Investigation." *arXiv preprint arXiv:2512.16620* (2025).