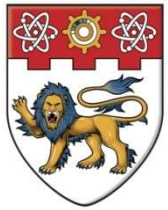

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Tattoo Detection Based on CNN and Remarks on the NIST Database

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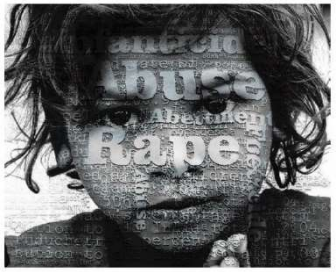
Presented by

Soham Ghosh, (Undergraduate Student)
June 15, 2016

Current practices

Face detectors

Porn detectors



Child
porn detectors

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Why are tattoos important?

- Tattoos are an important soft biometric trait
- Many people have tattoos: estimated 45 million Americans
- Tattoos have a lot of information for investigation.

Target Application

TARGET APPLICATION

Detecting tattoo images stored in IT devices of suspects

120 TB

- There is a need to build **robust** automated algorithms for tattoo detection.

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Why do we need to detect tattoos?

- To search other criminals related to the case.
- In child sexual offense cases **120 TB images and videos data** should show **a lot of offenders**. If they have tattoos, they can be identified easily.
- Tattoo searching algorithms have been developed.

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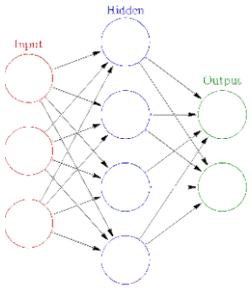
Why do we need to detect tattoos?
(Case 1: For further investigation, our target)

Seized computers



Tattoo detection

Tattoo matching

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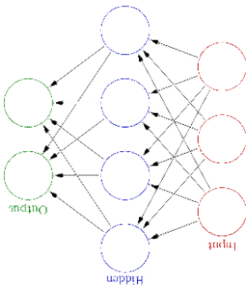
Why do we need to detect tattoos?

(Case 2: Tattoo database construction, mentioned in the NIST challenge)



Tattoo detection

Yes

Tattoo database

Note: Non-tattoos are likely faces because currently law enforcement agencies collect face and tattoos in the process.

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Past work

	NIST Tatt-C	Heflin et al.	Wilber et al.	Our study
Training Samples	• **Positive**: 1349, • **Negative**: 1000	• **Total**: 150	• **Positive**: 50 • **Negative**: 800	• **Positive**: 5,740 • **Negative**: 4,260
Testing Samples	• **Positive**: 1349, • **Negative**: 1000	• **Positive**: 50 • **Negative**: 500	**Total**: 100	• **Positive**: 5,740 • **Negative**: 4,260
Remarks	• 5-fold cross-validation • Images from inner environments • Negative images are faces	Negative images were collected from dermatology forums and face databases	All positive images are butterfly.	• 5-fold cross-validation • No limit on positive and negative samples • Images collected from Flickr
Techniques	-	One class SVM	Exemplar Codes	CNN

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NIST Tattoo Recognition Challenge

- To advance research and development into automated image-based tattoo recognition technology
  - identifying tattoos,
  - detecting region of interest,
  - matching visually similar or related tattoos using different types of non-tattoo imagery (e.g., scanned print and sketch),
  - matching similar tattoos from different subjects and
  - detecting tattoos from images

- The NIST challenge is **open-book.**

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Results of NIST Tattoo Detection Challenge

Algorithm	Non-tattoo detection accuracy	Tattoo detection accuracy	Overall accuracy
French Alternative Energies and Atomic Energy Commission (CEA_1)	**98.8%**	93.2%	95.6%
Compass Technical Consulting (Compass)	38.6%	79.8%	62.2%
MITRE Corporation (MITRE 1)	75.0%	73.4%	74.1%
MITRE Corporation (MITRE 2)	94.8%	92.4%	93.4%
Morpho/MorphoTrak (MorphoTrak)	95.0%	**97.2%**	**96.3%**

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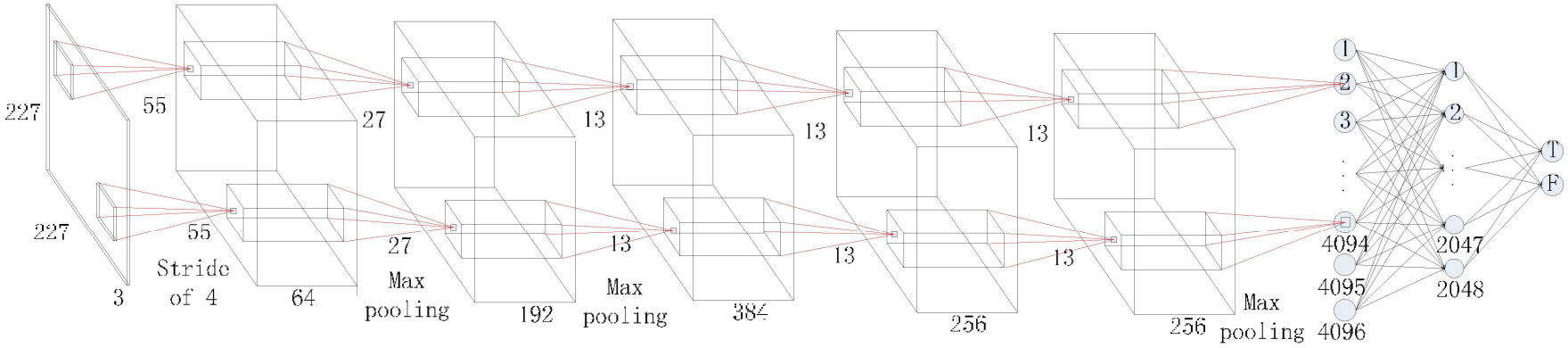
Questions to be answered

1. Can CNN outperform the past winner of Tatt-C challenge?

2. How does the training database affect detection performance?

3. Is the NIST database suitable for our target application?

Convolutional Neural Network



T N

Binary Classification

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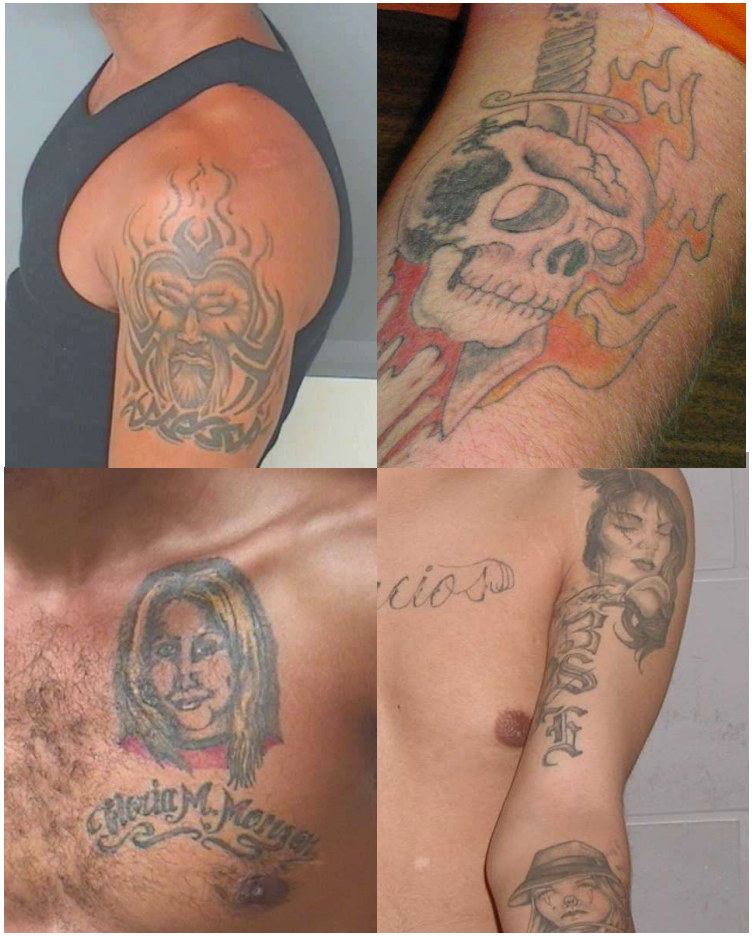
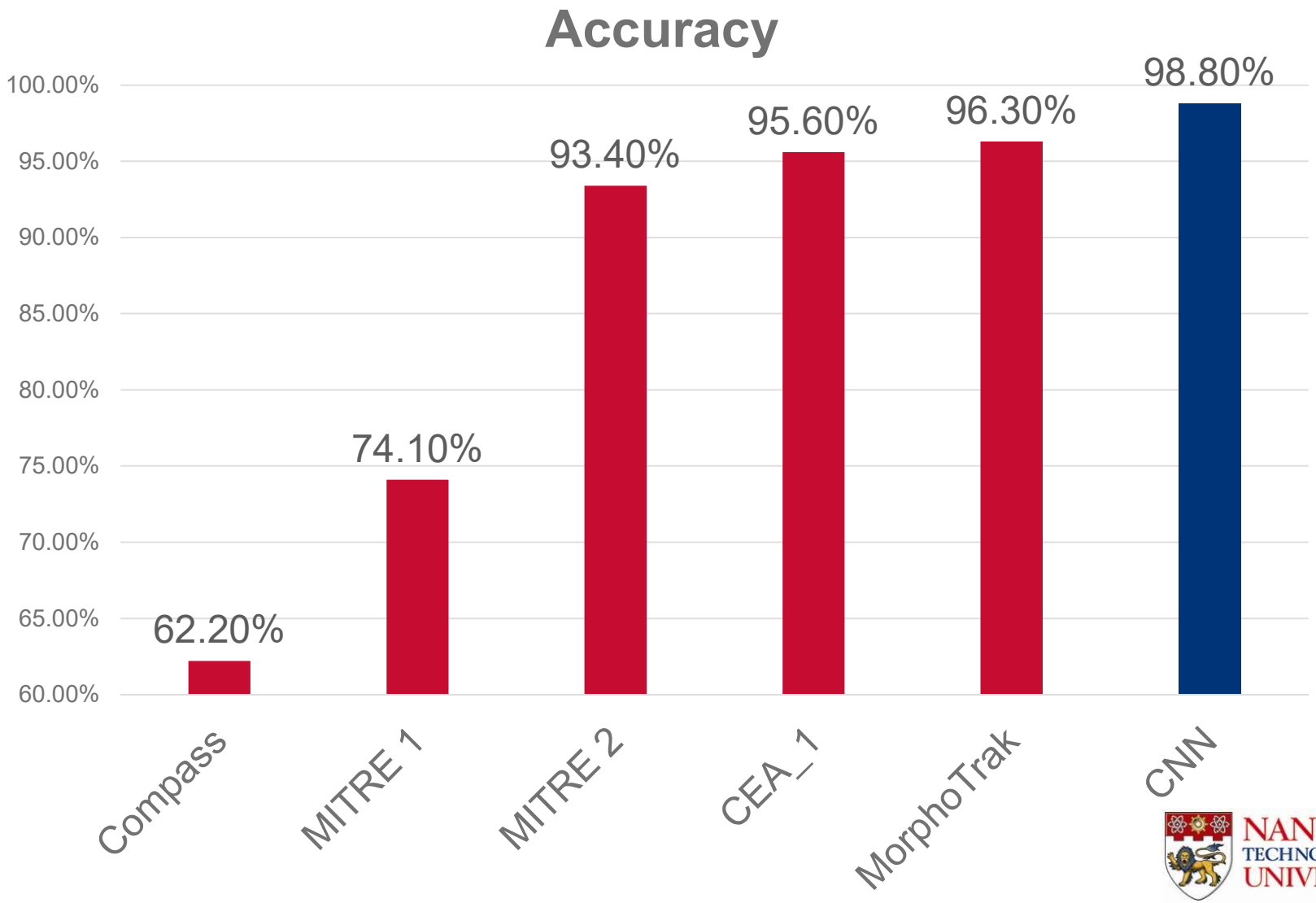
NIST Tattoo Recognition Challenge Dataset

Positive (1349)



Negative (1000)

Results: NIST dataset



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Results: NIST dataset

Algorithm	Non-tattoo detection accuracy	Tattoo detection accuracy	Overall accuracy
CEA_1	98.8%	93.2%	95.6%
Compass	38.6%	79.8%	62.2%
MITRE 1	75.0%	73.4%	74.1%
MITRE 2	94.8%	92.4%	93.4%
MorphoTrak	95.0%	97.2%	96.3%
CNN	**98.9%**	**98.7%**	**98.8%**

Remark 1: CNN is better than all the four participants in the NIST challenge.

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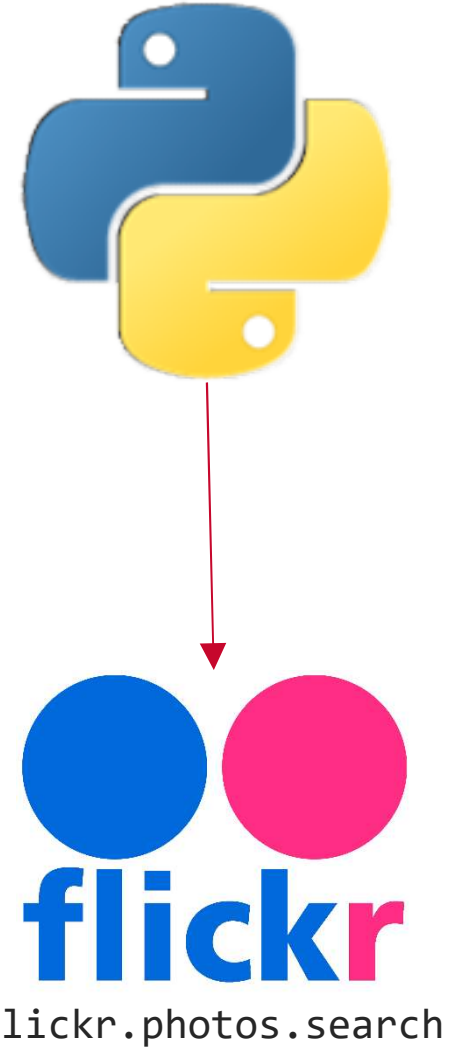
Flickr Datasets



- Downloaded using Flickr API
- Four dataset sizes
  - Flickr2349
  - Flickr3.5K
  - Flickr5K
  - Flickr10K
- Same ratio of *positive*:*negative* (1.349:1)
- Datasets available at http://forensics.sce.ntu.edu.sg/
- These datasets are more similar to images in IT devices of suspects.

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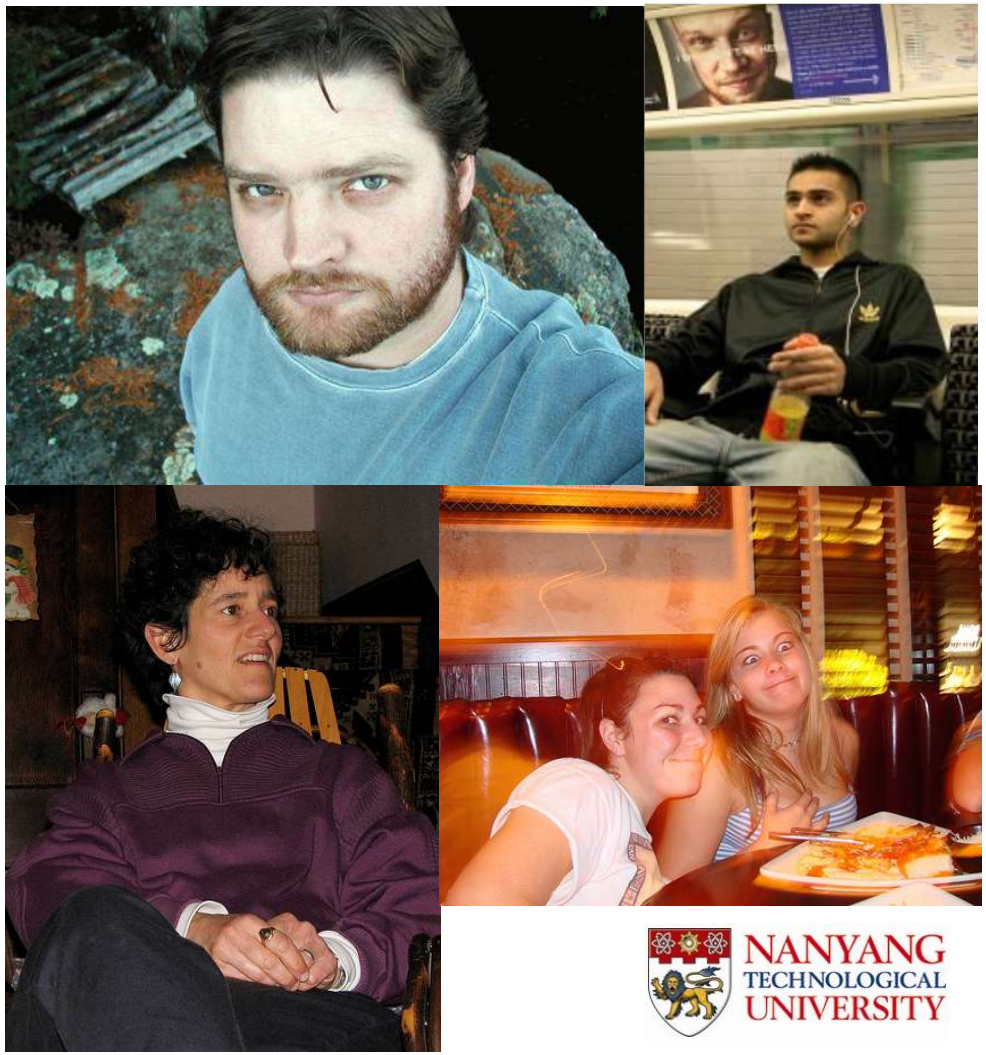
Flickr Datasets

Positive (keyword: *tattoo*)

Negative (keyword: *human, face)*



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Results: Cross-dataset experiments

TRAIN \ TEST	NIST	Flickr
NIST	98.81%	65.77%
Flickr	83.31%	78.29%

- Key observations
  - Accuracy drops significantly when the Flickr2349 dataset is used for testing.
  - Train NIST - Test Flickr performs the ***worst***.
  - Train Flickr – Test NIST is better than Train Flickr – Test Flickr

Remark 2: NIST dataset is not suitable to train classifiers for our target application, detecting tattoos in IT devices of suspects.
Remark 3: Flickr dataset is much more challenging.

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What causes the drop in accuracy?

Experiments	Non-tattoo detection accuracy	Tattoo detection accuracy	Accuracy difference
1) Train NIST – Test NIST	98.70%	98.89%	-0.19%
2) Train NIST – Test Flickr	43.40%	82.36%	-38.96%
3) Train Flickr – Test NIST	74.40%	81.02%	-6.62%
4) Train Flickr – Test Flickr	70.10%	93.18%	-23.08%

Observations

- Detection accuracy for non-tattoos is much lower
- Discrepancy is largest for experiment 2 and 4.

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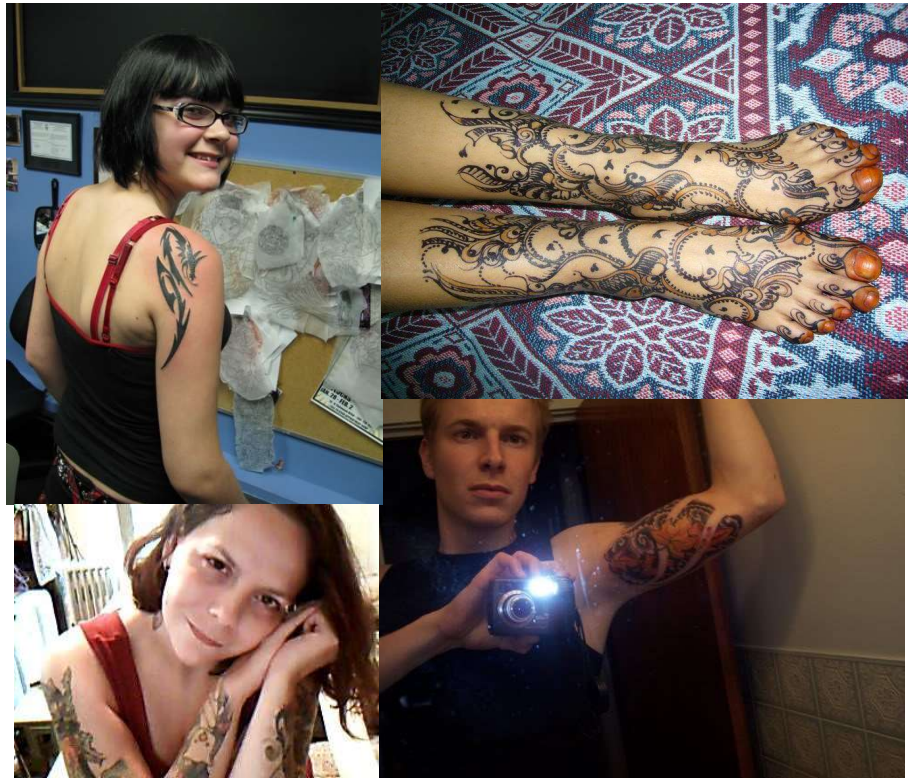
What causes the drop in accuracy? (negative class)

- Negative (Flickr)

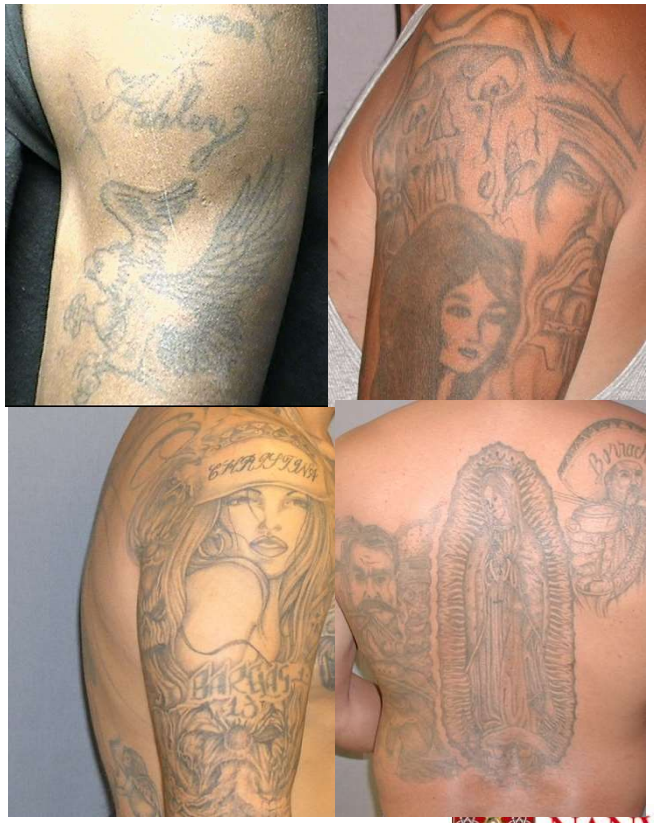
- Negative (NIST)

What causes the drop in accuracy? (positive class)

- Positive (Flickr)



- Positive (NIST)



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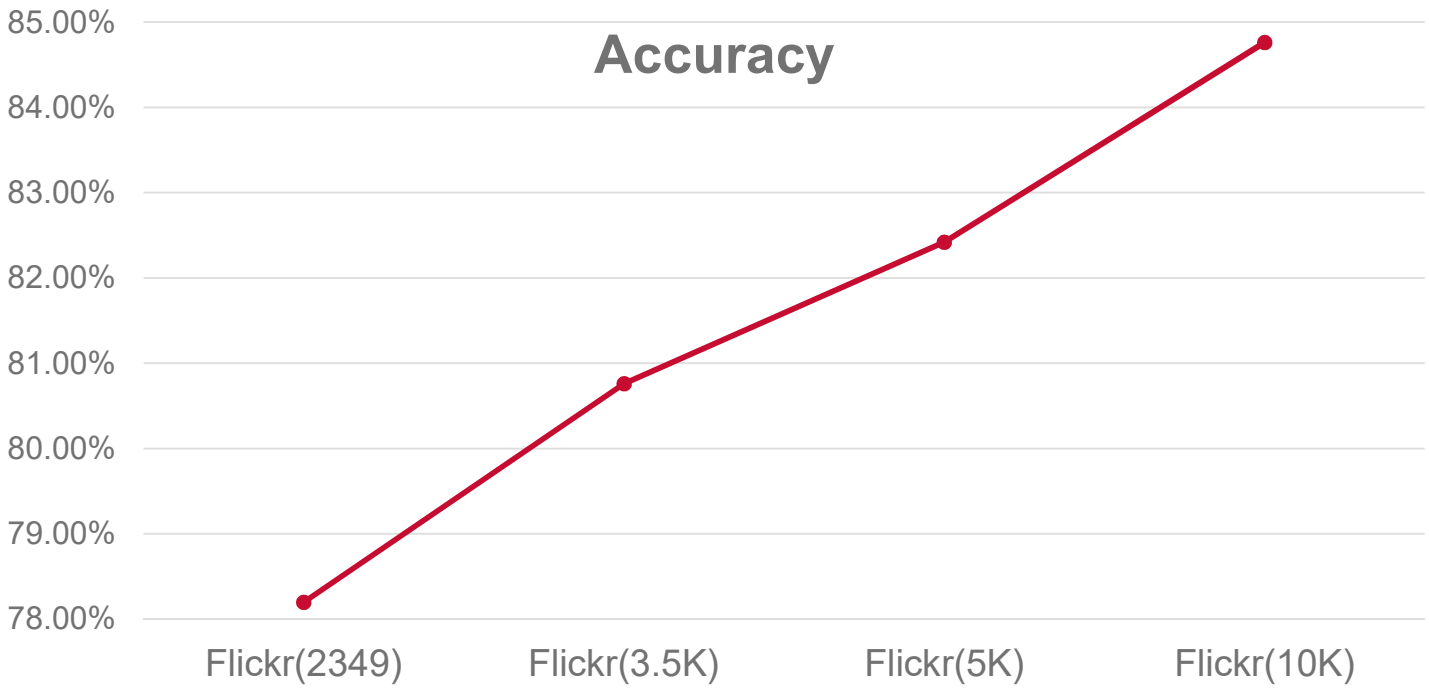
Results: Flickr



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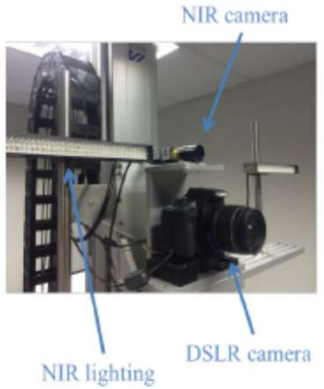
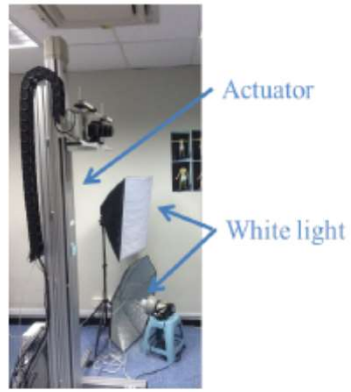
Conclusions and suggestions

- Flickr images are more **challenging**
  - More diverse, hence closer to target application setting
- NIST database is **suitable for tattoo database construction.**
- NIST database is **not suitable** for the **target application.**
- **Large**, unconstrained dataset is needed

Suggestions

- For tattoo database construction, our **prisoner data collection system** may be a better solution. Tattoos and their accurate locations are collected at the same time.





"A preliminary report on a full-body imaging system for effectively collecting and processing biometric traits of prisoners", *IEEE Symposium Series on Computational Intelligence*, 2014.

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Future Work

- Collecting a larger database
- Improving network architecture

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Acknowledgments

- Thanks:
  - NIST for sharing the data.
  - Ngan, Mei Lee, NIST pointed out the error of the database link in the revised version.
  - Grant agents, Ministry of Education, Singapore Singapore and China Scholarship Council.
  - Renaissance Engineering Programme, for financially supporting my conference trip.

Flickr database http://forensics.sce.ntu.edu.sg/.

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THANK YOU

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