Defence and Security Doctoral Symposium 2023

Infrared thermography as a non-invasive scanner for concealed weapon detection

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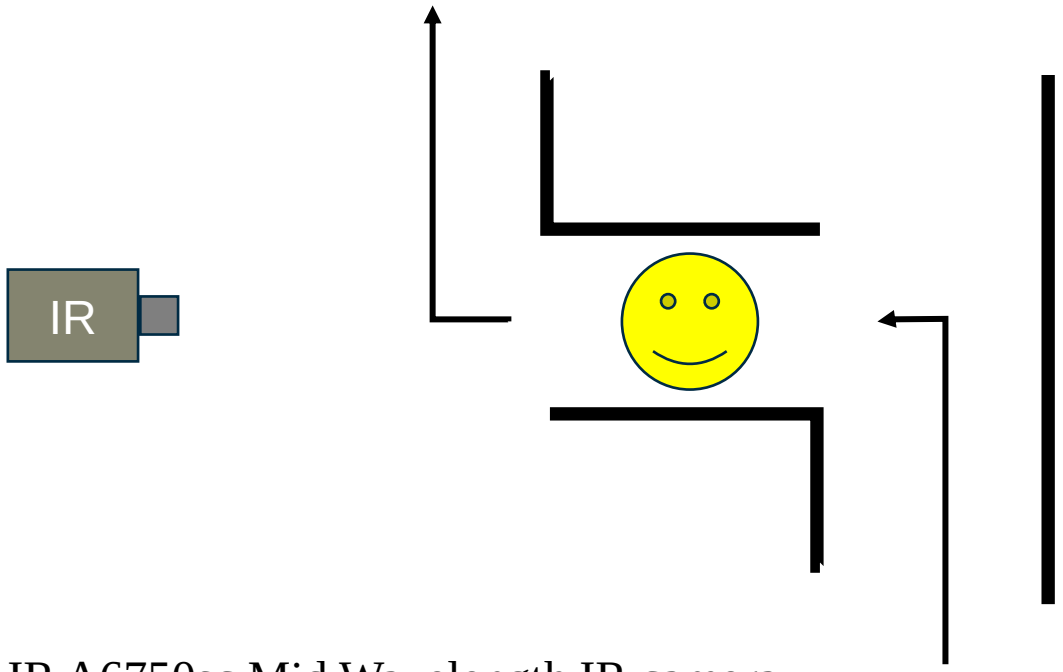
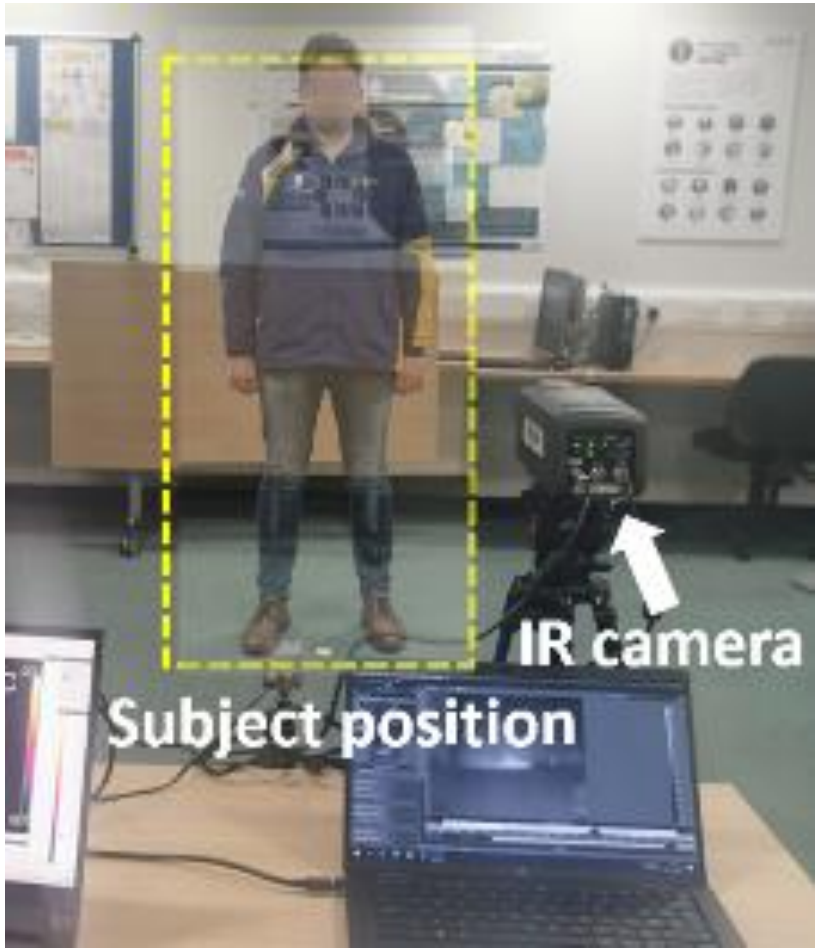
Contents

- Detection scenario
- IR visualisation
  - Background removal
  - Object area visualisation
- Classification using CNN
  - Transfer learning
  - Performance comparison
- Conclusion

Scenario

Scenario





- FLIR A6750sc Mid Wavelength IR camera
- 3 to 5 µm waveband
- thermal sensitivity of < 20 mK
- 640 × 512 pixels

Visualisation
-Background removal

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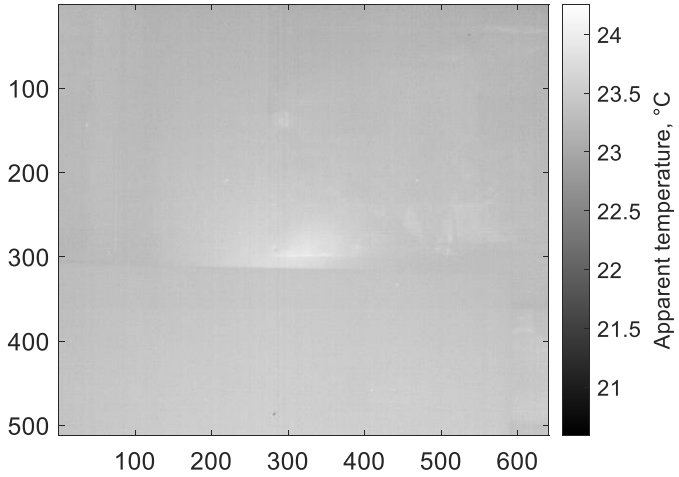
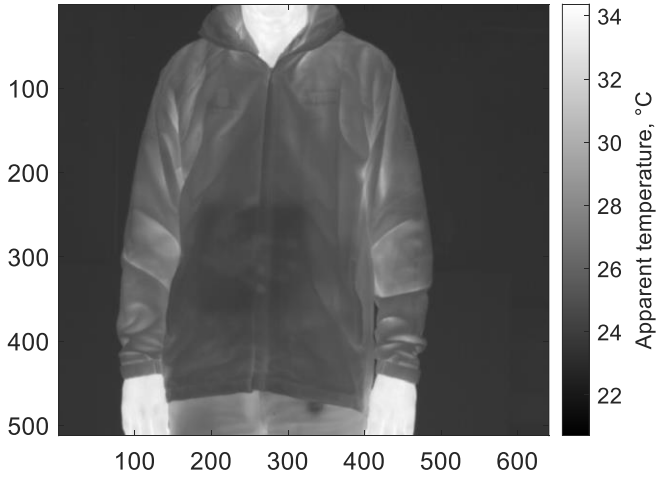
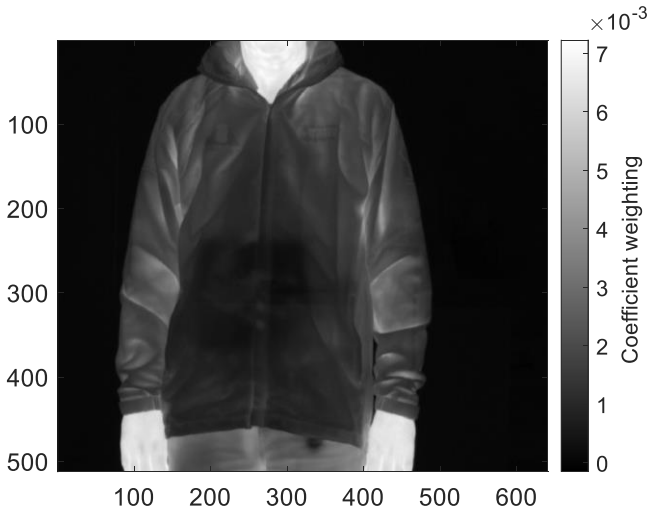
Background



Subject



Principal component



Visualisation
-Background removal

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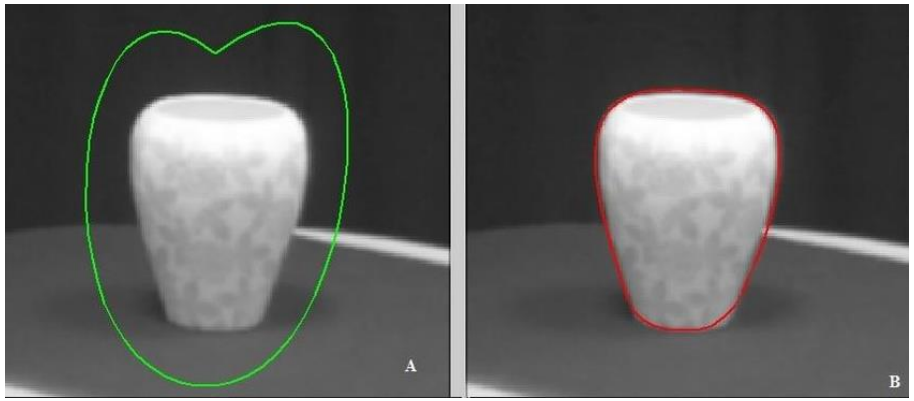
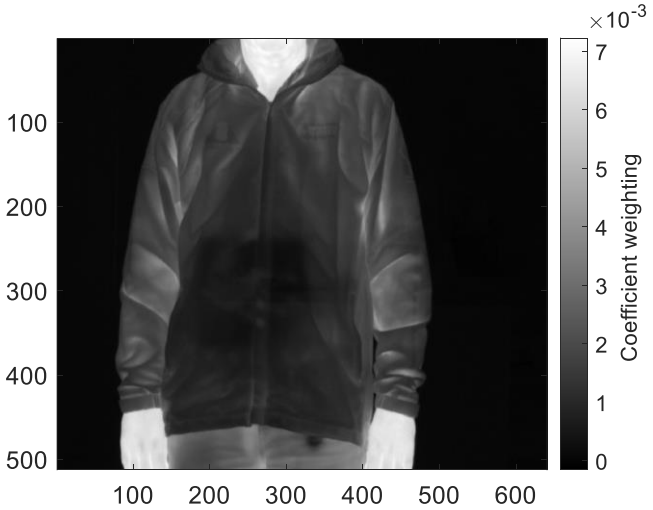
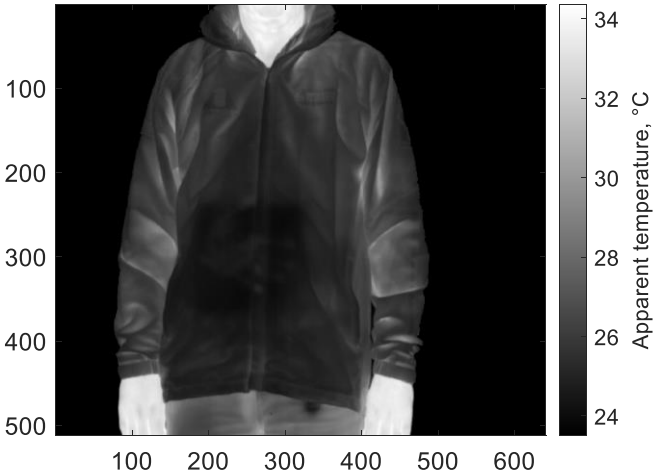
Active contour



Principal component



Reformed image



Visualisation -Object area

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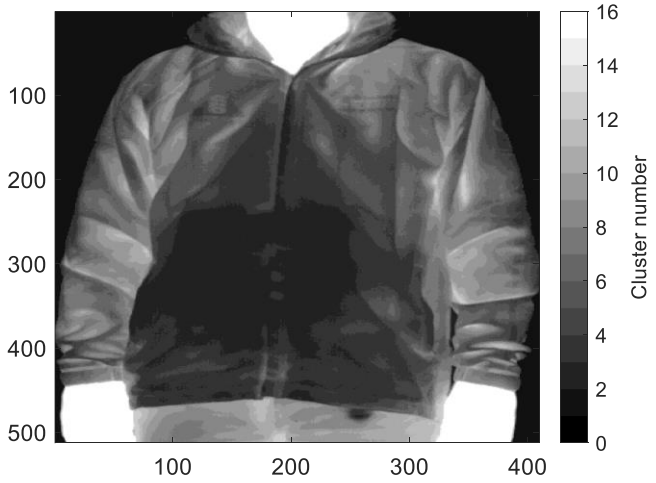
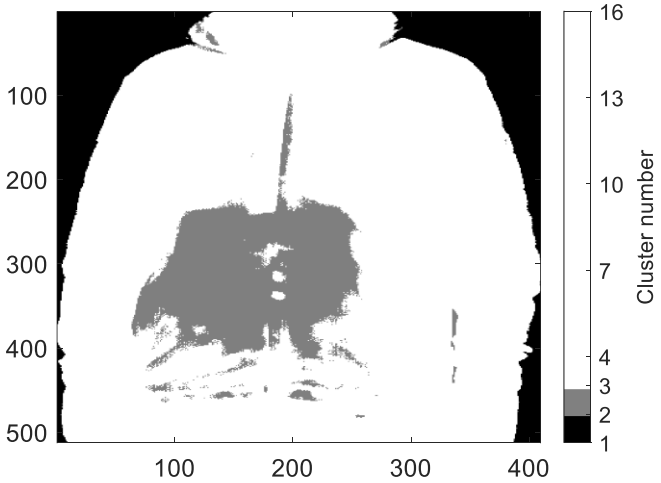
Fuzzy-c

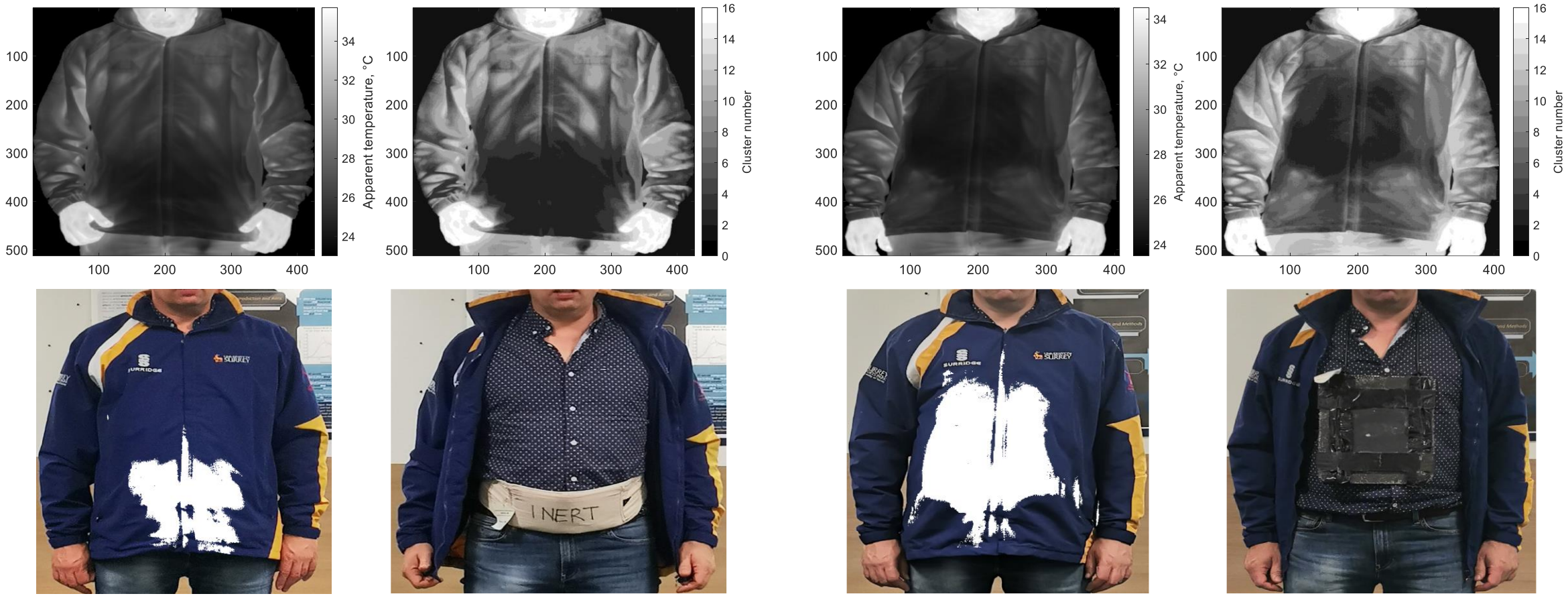


Object area



Visual illustration

Visualisation -Examples

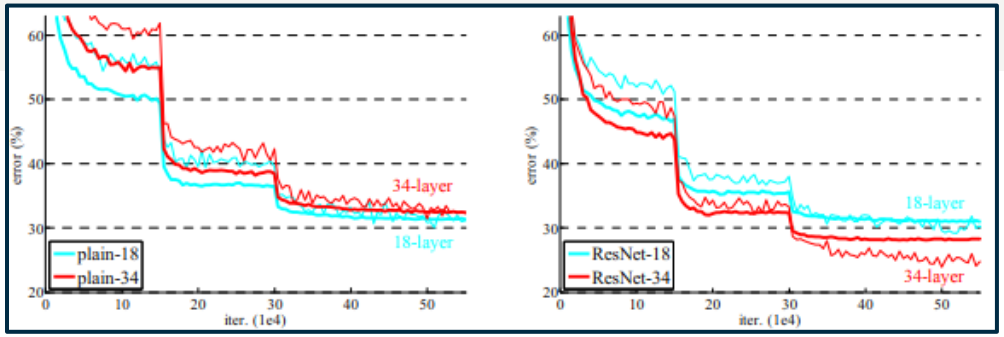


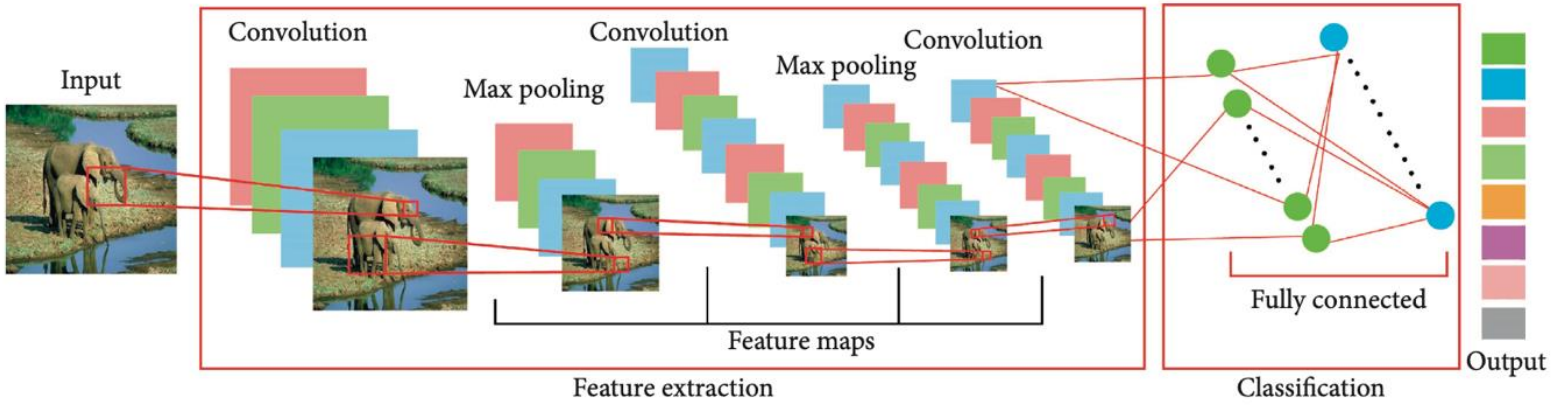
Classification using ResNet-50

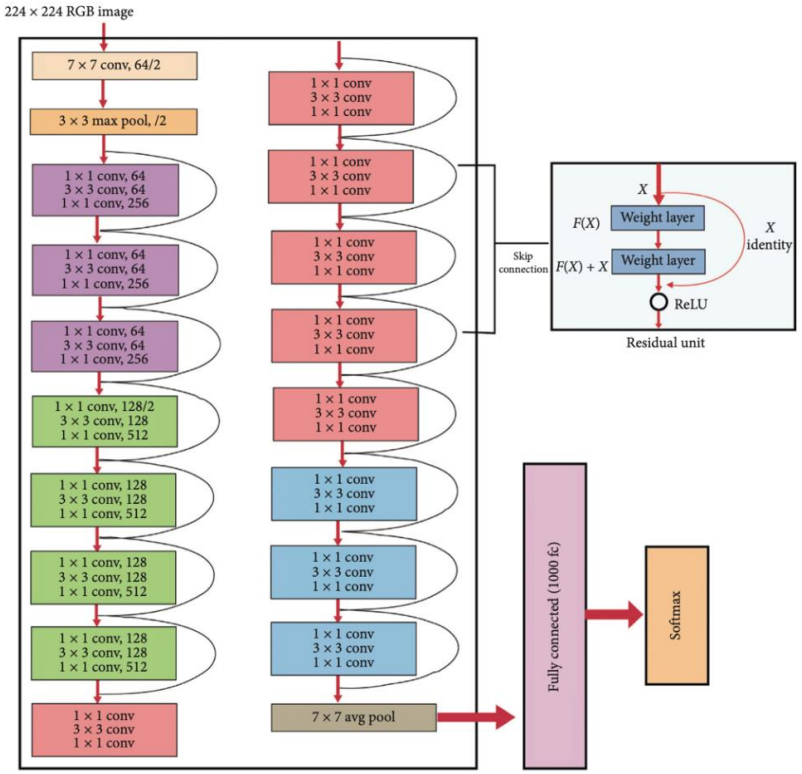
Objectives:

» Automate classification process

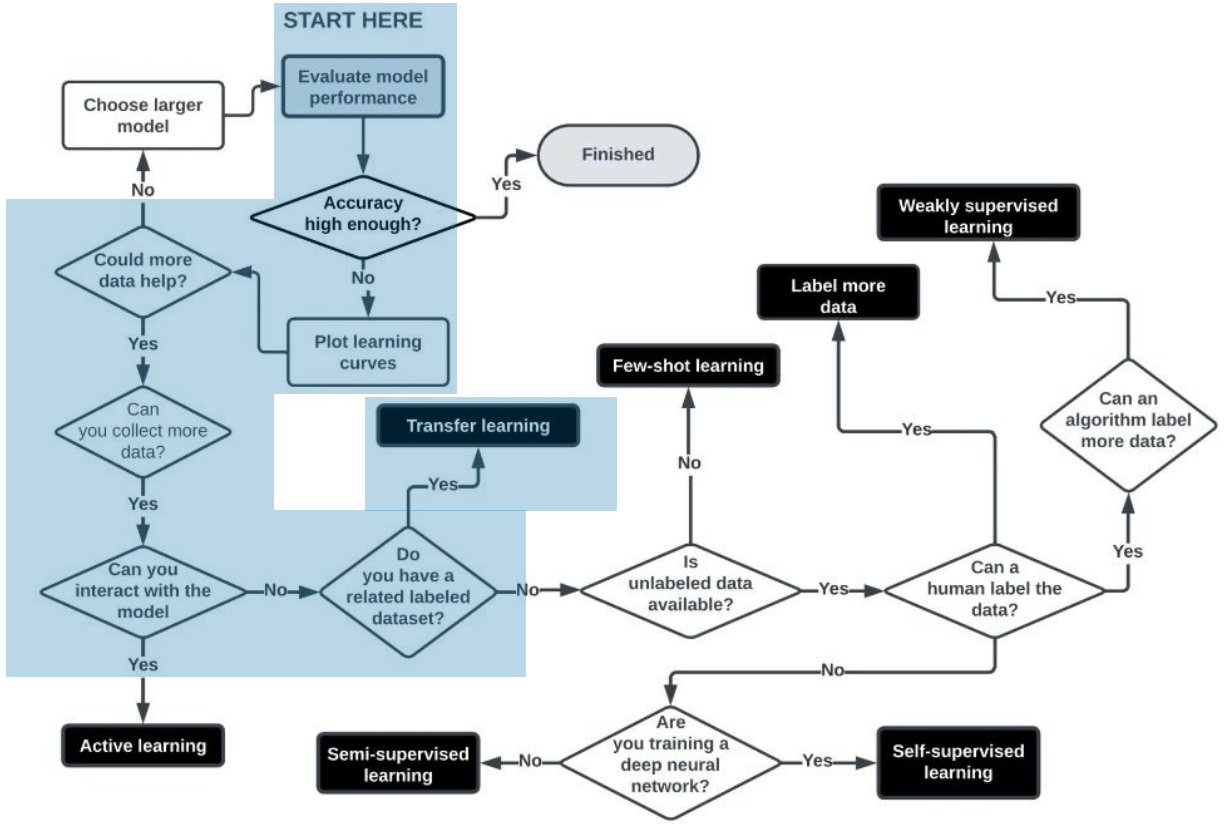
» Potentially outperform operator



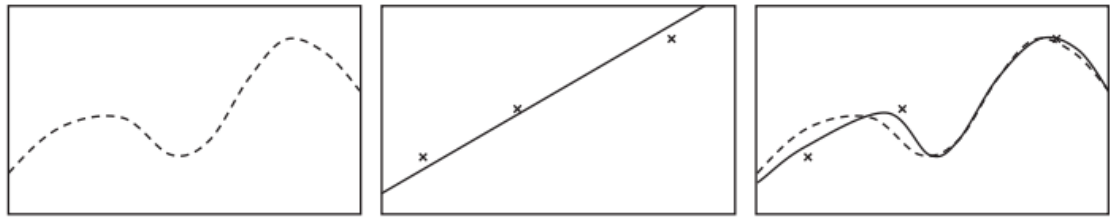




Classification using ResNet-50 -Transfer learning



Sebastian Raschka, 2023
Machine Learning Q and AI
https://leanpub.com/machine-learning-q-and-ai/



A simplified illustration of transfer learning, where:

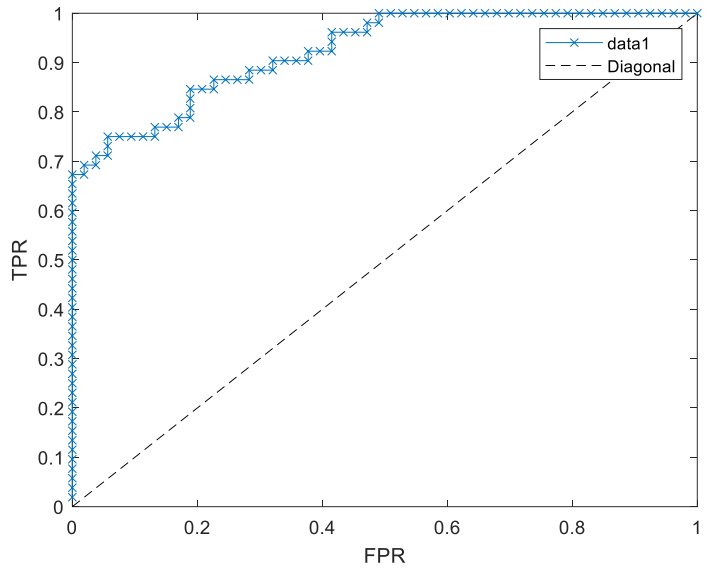
(a) is the model from the pre-trained domain,

(b) is the data from the target domain, and

(c) is the 'fine-tuned' pre-trained model to predict the target data, from [48].

Classification using ResNet-50 -Evaluation methodology

		Actual class	
		Positive	Negative
Predicted class	Positive	*TP*	*FP*
	Negative	*FN*	*TN*



- Receiver-operator characteristics curve, ROC
- Area-Under curve, AUC represents model performance
- General consensus on AUC
  - 0.5 no discrimination
  - 0.7 – 0.8 acceptable
  - 0.8 – 0.9 excellent
  - >0.9 outstanding

True Positive Rate (Sensitivity, Recall)

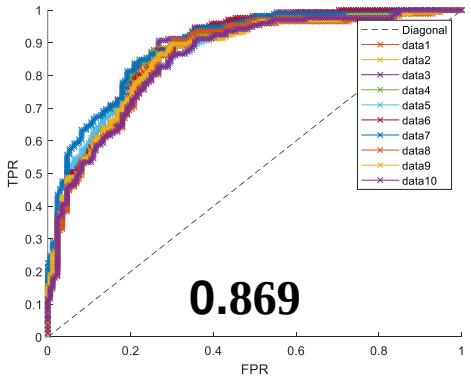
- $TPR = \frac{\Sigma TP}{\Sigma(TP+FN)}$

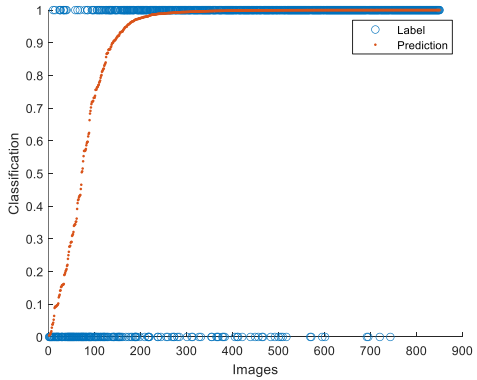
False Positive Rate (False alarm rate)

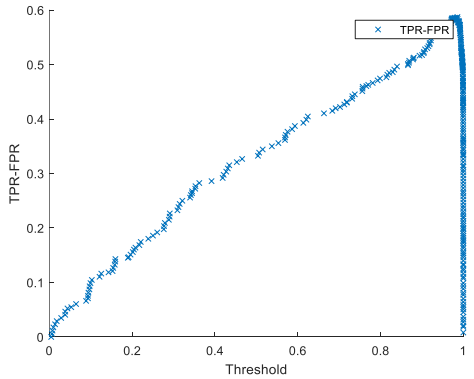
- $FPR = \frac{\Sigma FP}{\Sigma(FP+TN)}$

Classification using ResNet-50 -Training dataset size

Total training image	Training set		Validation set		ROC-AUC
	w/ object	w/o object	w/ object	w/o object	
900	462	438	678	172	0.869
3082	1918	1164			0.922



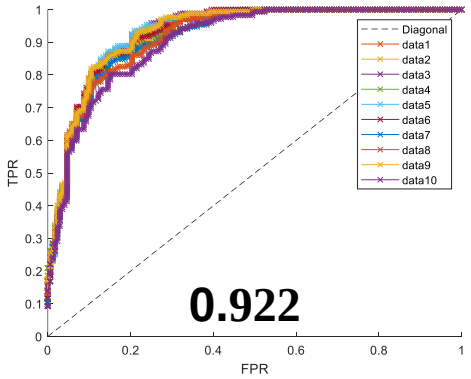


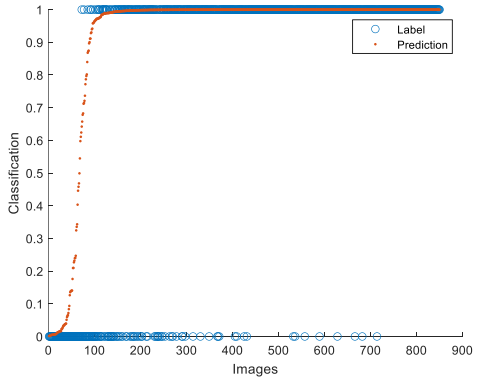


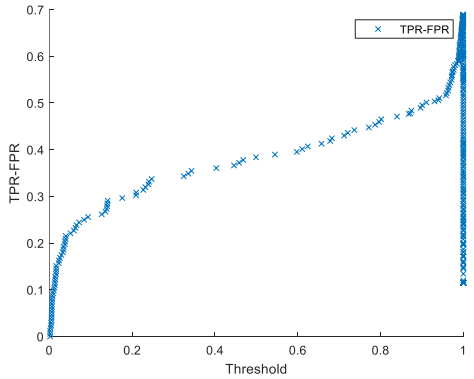
	Label True	Label False
Pred True	0.4358	0.1343
Pred False	0.0642	0.3657

19.9%
FP 13.4%
FN 6.4%

Larger dataset model







	Label True	Label False
Pred True	0.4256	0.0747
Pred False	0.0744	0.4253

14.9%
FP 7.5%
FN 7.4%

Conclusion

- ML techniques (i.e. PCA, active contour, and Fuzzy-c) improved IR visualisation.
- CNN (ResNet-50) performed adequately for classification of concealed objects.
  - Bigger training dataset improves model performance.
  - Transfer learning is effective for small dataset problems.

Future work

1. A study on the effect of body-worn concealed objects over time and whether this affects the results.
2. Performance evaluation under a broader range of environmental conditions, including temperature, direct sunlight, and rain.
3. A study that considers the presence of common clutter objects, such as phones and wallets.
4. Larger datasets, encompassing a more extensive sample of individuals, a wider variety of clothing, and individuals wearing clothing not previously encountered by the model.
5. A study comparing the performance of LWIR and MWIR bands.
6. An investigation using frames of data captured as people approach the sensor, as this may provide different views of concealed objects that could enhance results.
7. Exploration of techniques to reduce classification errors.

Sponsor and collaborators

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