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TARP Benchmarks for Detection Problems

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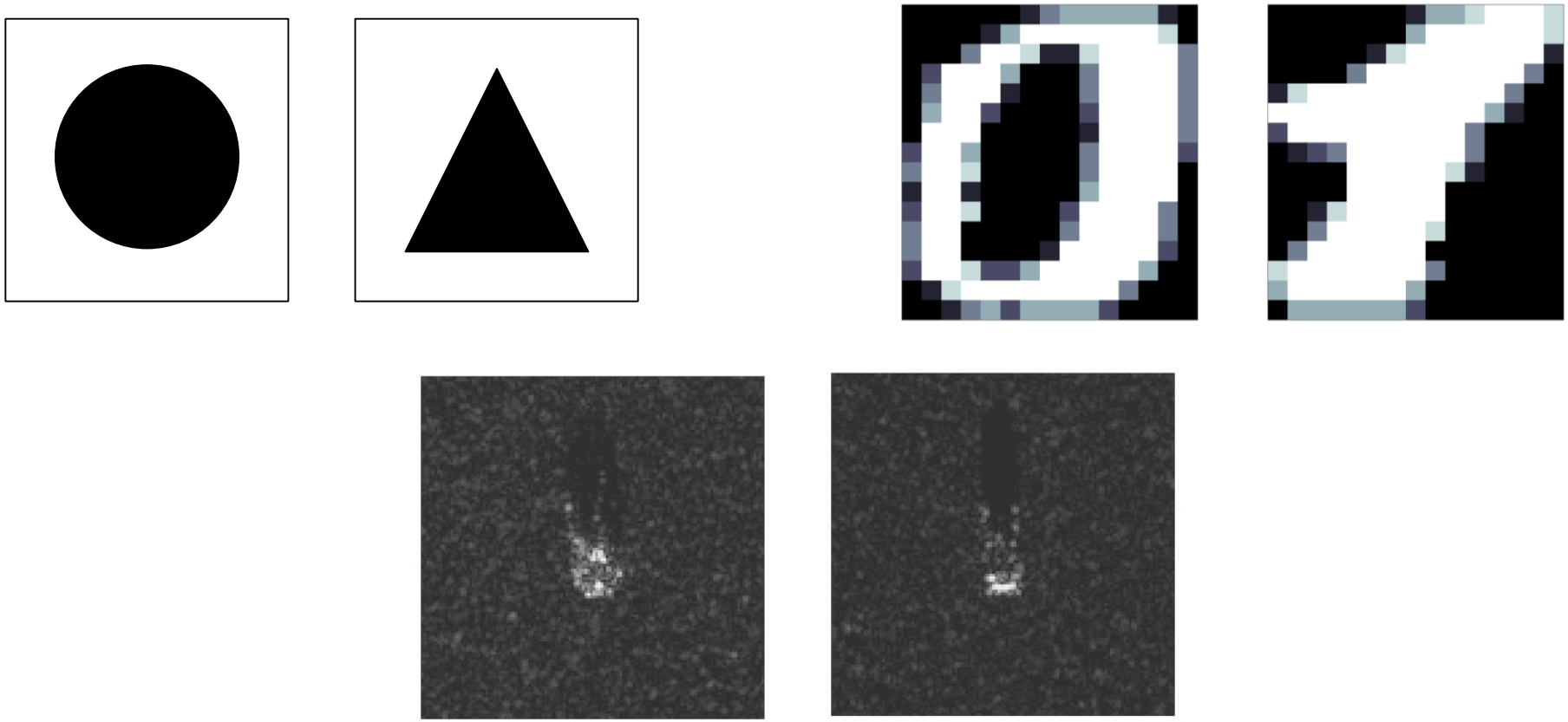
Introduction

- Let's say you develop an object detection or classification algorithm. How do you determine success?
  - Download a data set
  - Train and test your algorithm
  - Compare your results to others'
  - OR build your own data set, define acceptable results, and test your algorithm
- Is your solution significant?

Problem

- Intuitive feel for difficulty of classification task



- Can we tell if a data set is “inherently separable?”

Previous Work

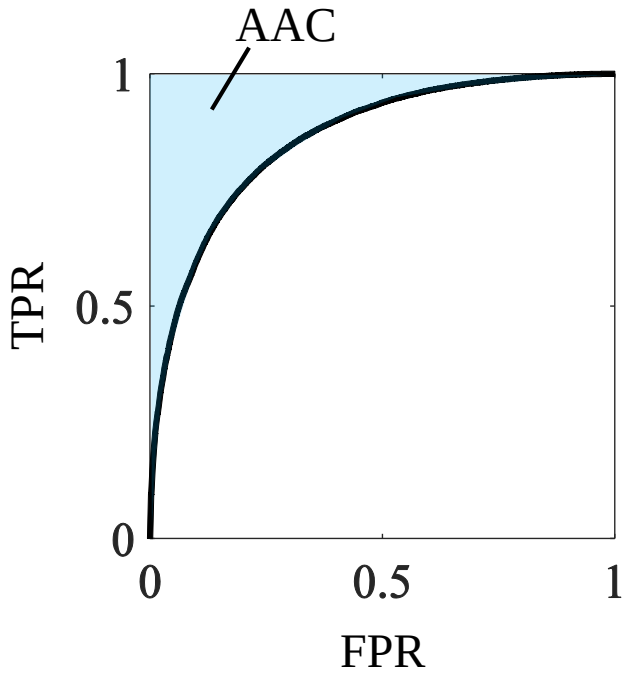
- Previous work suggests:
  - Real data has structure *(Han & Boutin, 2015)*
  - Random projections can reveal structure *(Kaski, 1998; Bingham & Mannila, 2001)*
- TARP (Thresholding After Random Projections) *(Yellamraju et. al, 2015)*
  - Use series of random projections to develop benchmarks

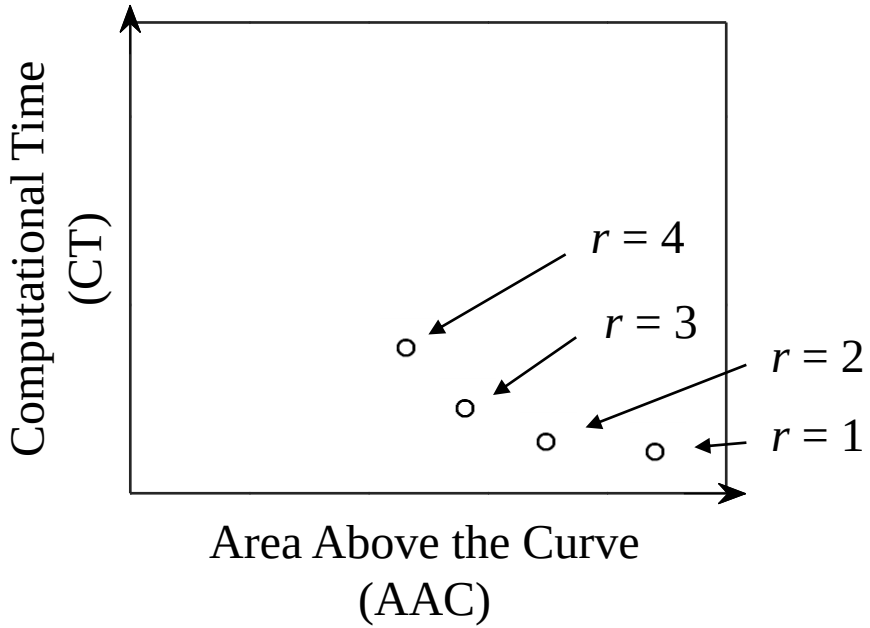
Proposed Solution

- TARP (Thresholding After Random Projections)
  - Randomly project data to 1-D *r* times
  - Classify with sliding threshold
  - Build ROC curve
  - Find the “best” projection – the one with the lowest AAC (area above the ROC curve)
  - Measure elapsed time (complexity)
  - Repeat for $r = 1, 2, 3, \ldots$

Proposed Solution

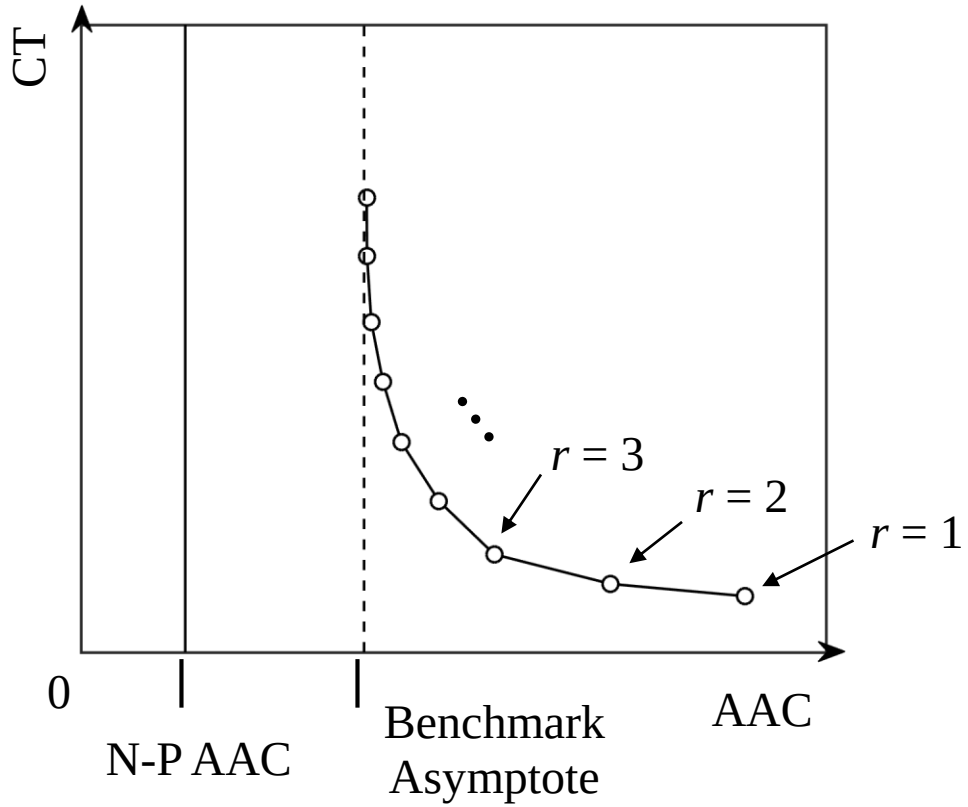
- Use expected results as series of benchmarks
  - Threshold average approximates expected best ROC curve
  - The AAC of the expected best ROC vs. the expected elapsed computational time (CT) for each *r* is considered a benchmark





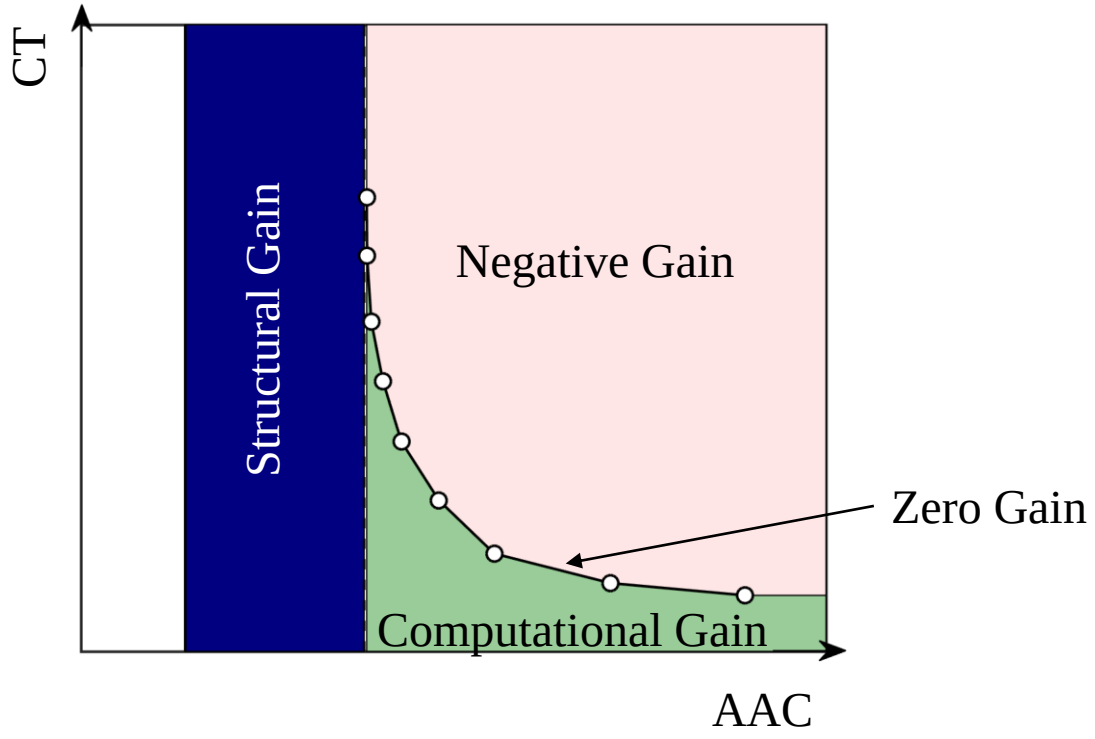
Proposed Solution

- Plotting the benchmarks yields a curve on AAC-CT plane:
  - Neyman-Pearson (N-P) test for theoretical maximum separability



Proposed Solution

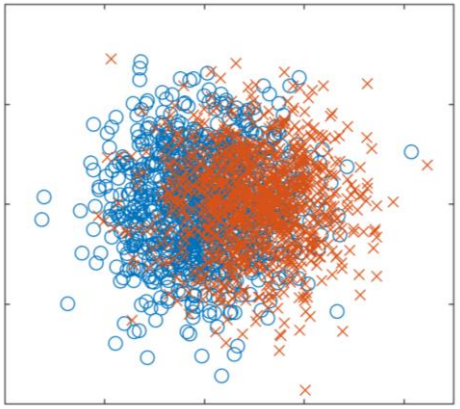
- The AAC-CT space is divided into regions
  - The regions characterize other detection methods



Experimental Results

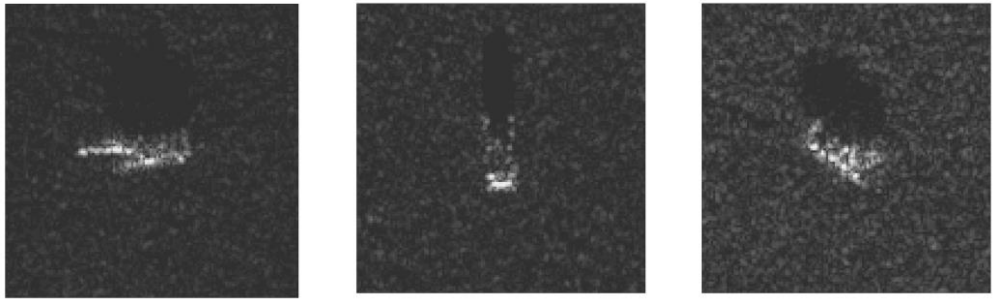
- Selected results from different data sets:

Synthetic 2-D normal



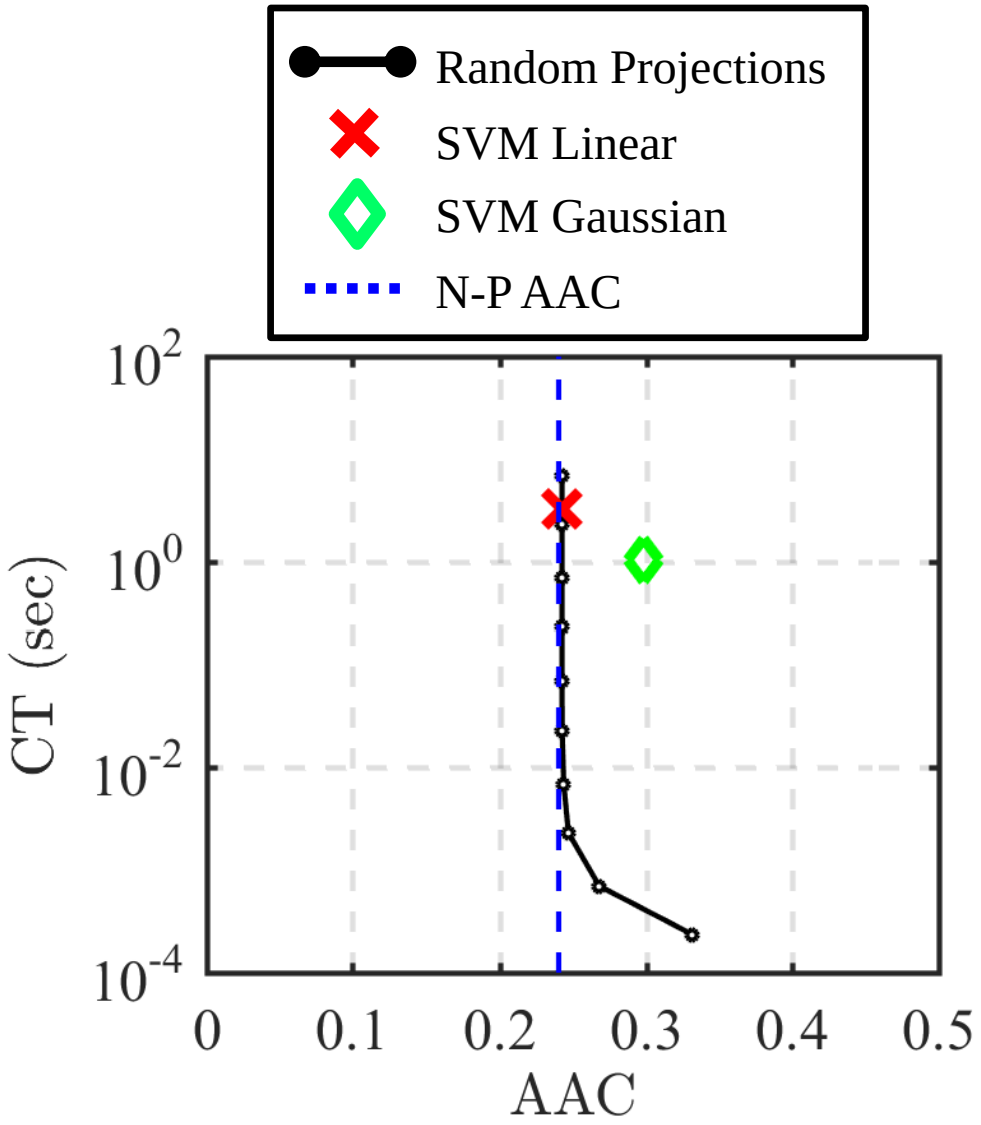
MFEAT handwritten digits *(Duin, 1998)*

MSTAR SAR (radar) targets *(SDMS, 1995)*



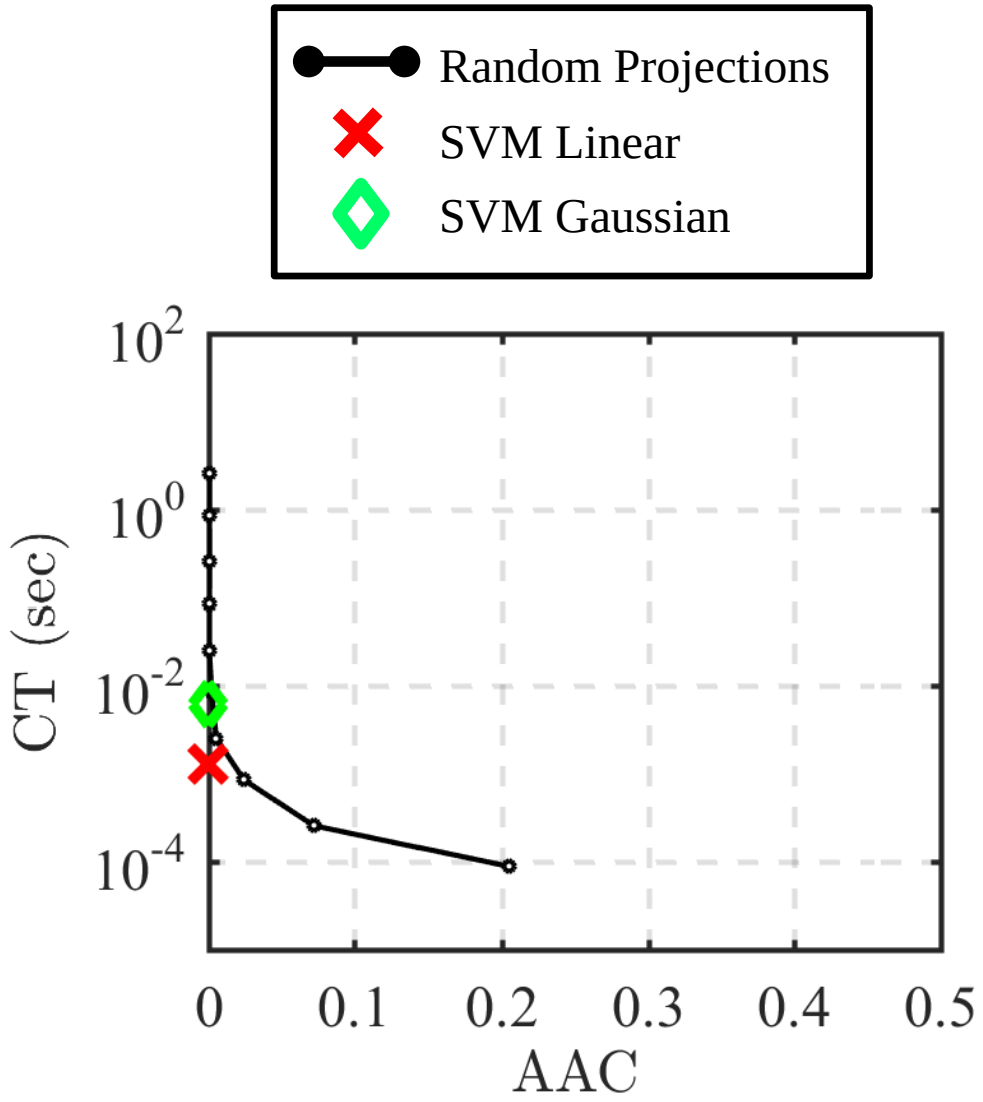
Experimental Results

- Synthetic 2-D normal
  - Covariance I
  - Class means (0, 0) and (0, 1)
  - 4,000 samples



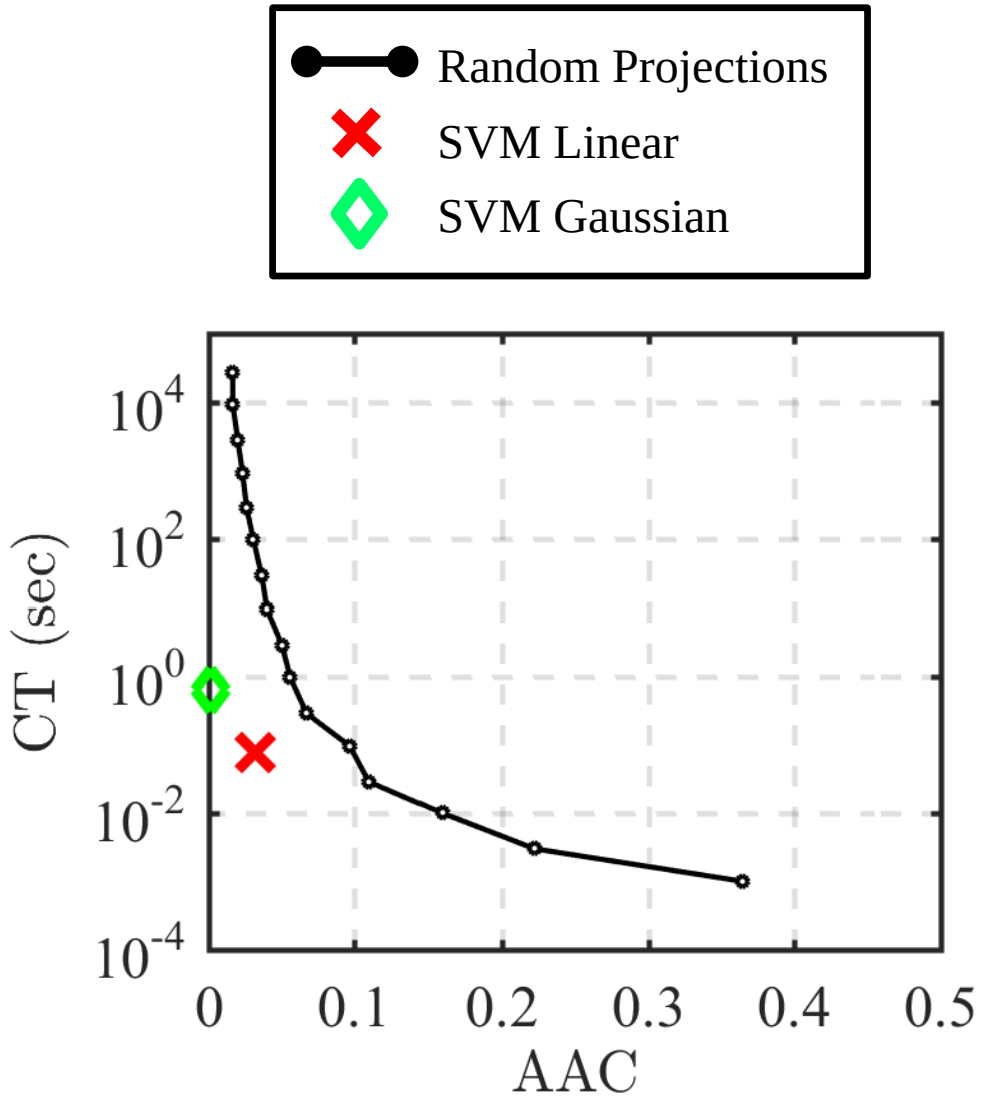
Experimental Results

- MFEAT 0 vs. 1
  - Fourier coefficients
  - 76-D
  - 400 samples



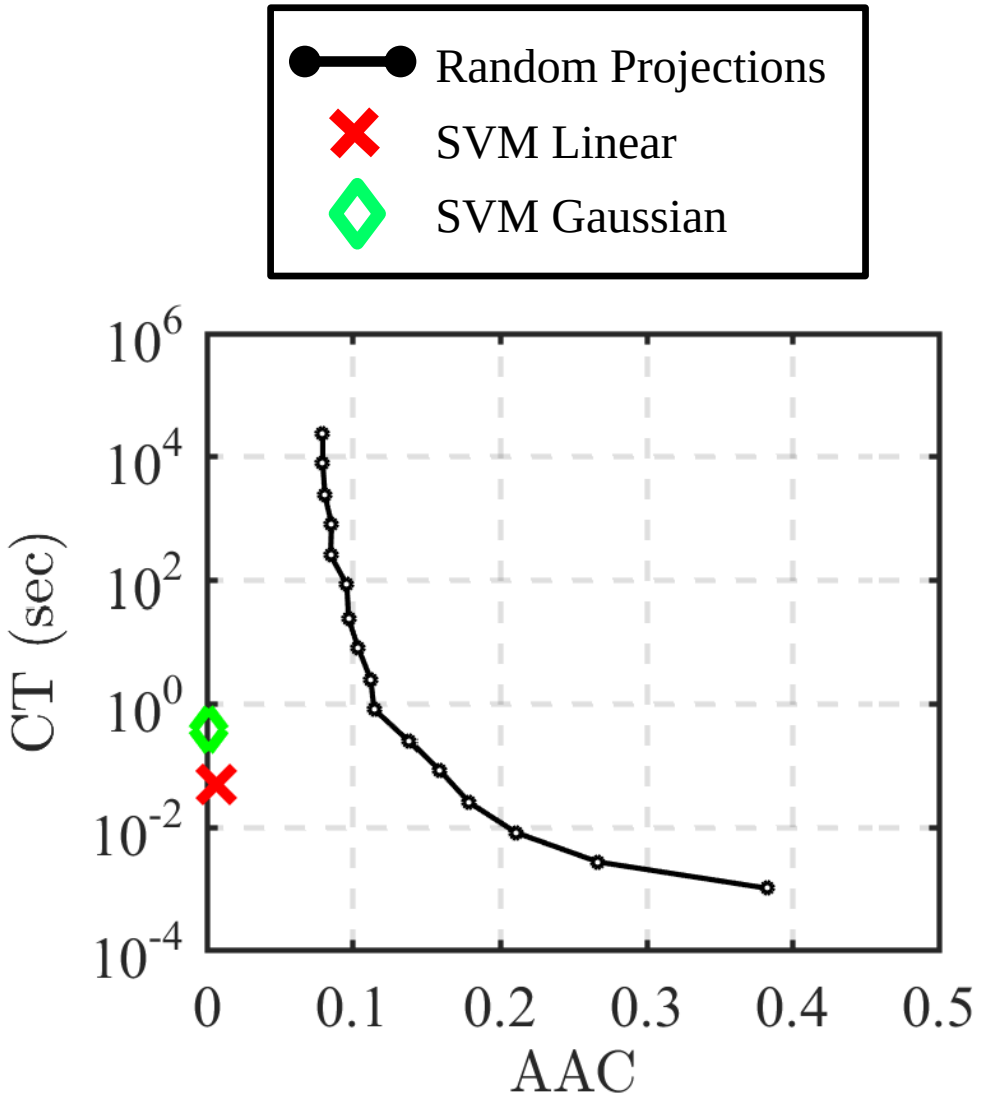
Experimental Results

- MFEAT even vs. odd
  - Profile correlations
  - 216-D
  - 2,000 samples



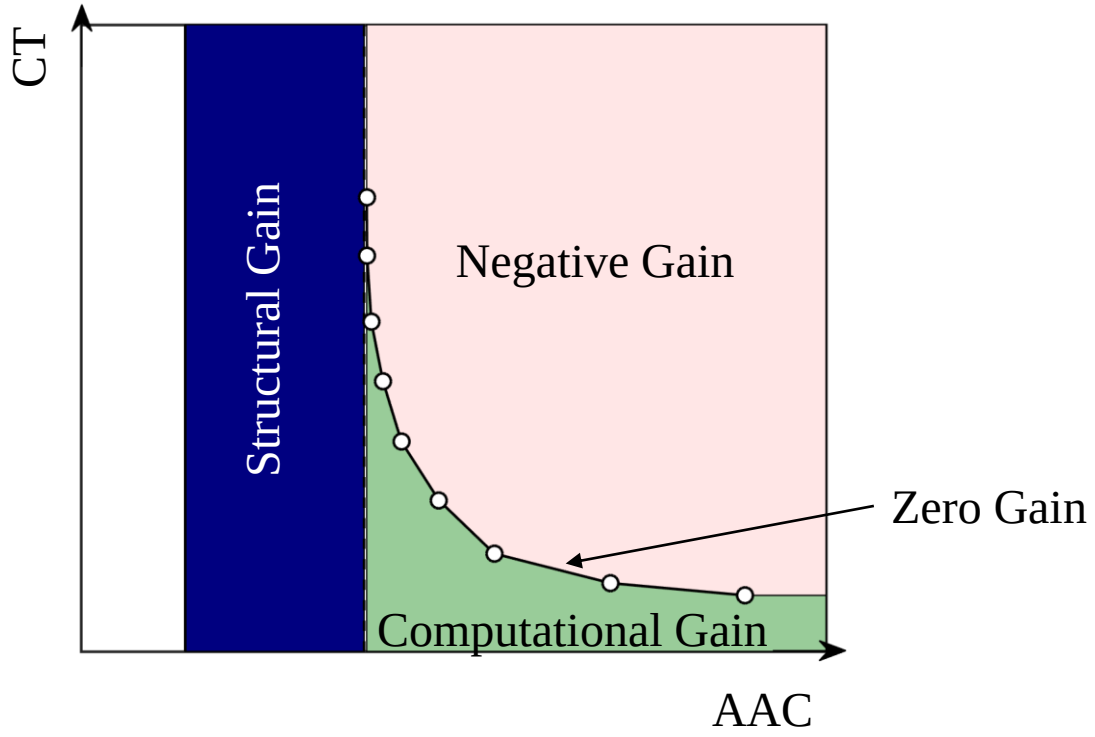
Experimental Results

- MSTAR BTR70 vs. T72
  - PCA coefficients
  - 358-D
  - 1,556 samples
    (392 BTR70/1,164 T72)



Conclusion

- Detection problems have different difficulties
- Investigated benchmark curve



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“MSTAR Public Targets,” SDMS, 1995. [Online]. Available: www.sdms.afrl.af.mil/index.php?collection=mstar&page=targets

T. Yellamraju, J. Hepp, and M. Boutin, “Benchmarks for Image Classification and Other High-Dimensional Pattern Recognition Problems,” Submitted, 2017.

Acknowledgements

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For more information:

K. Larson and M. Boutin, "TARP Benchmarks for Detection Problems," in *Proceedings of the 2016 IEEE Global Conference on Signal and Information Processing*, November 2017.

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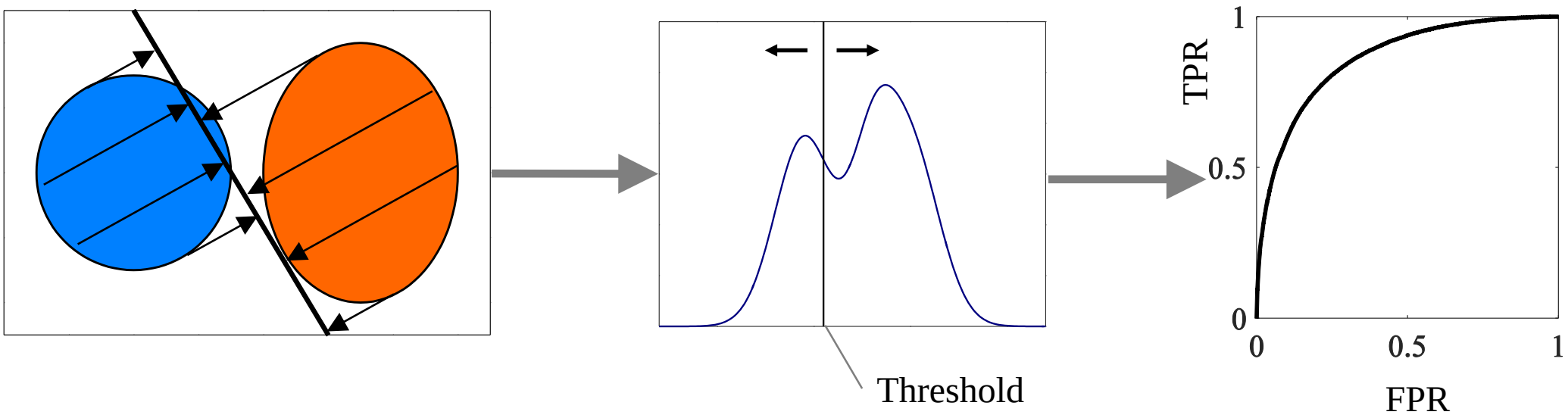
Extra Slides

Demonstration for $r = 2$

Extra Slides

$r = 2$ demo

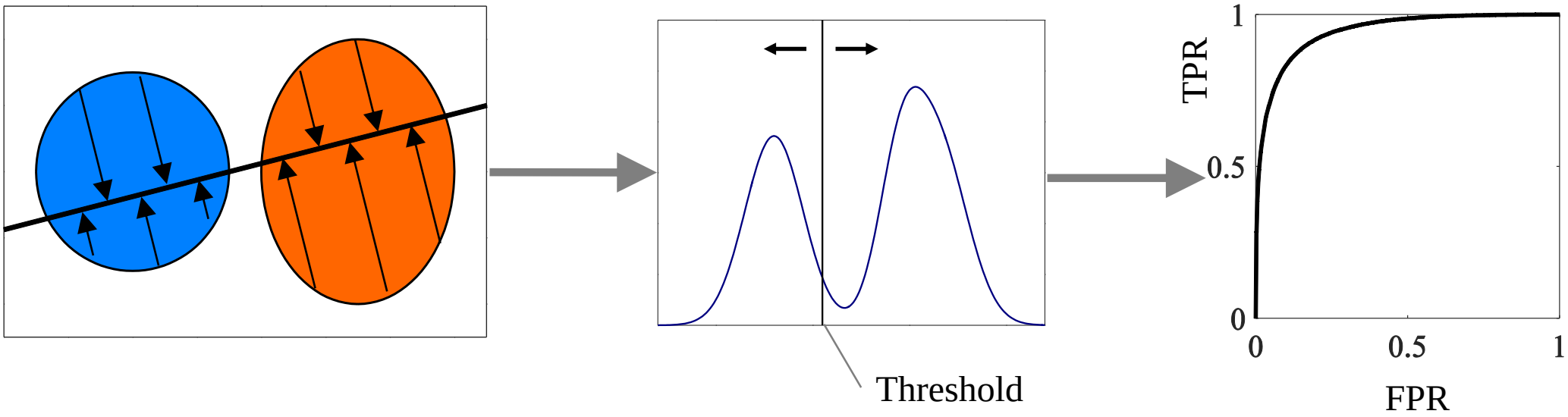
First random vector projection



Extra Slides

$r = 2$ demo

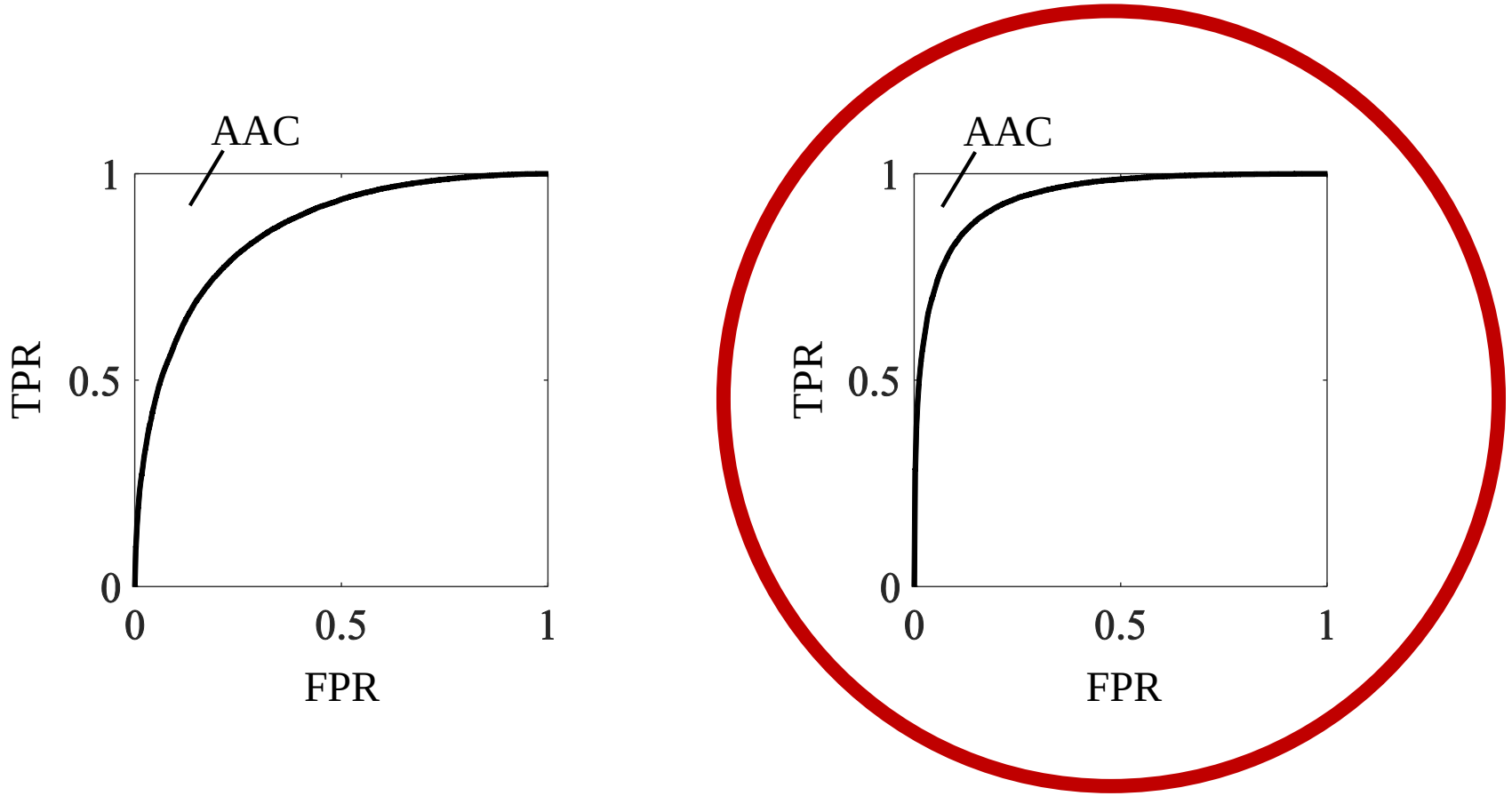
Second random vector projection



Extra Slides

$r = 2$ demo

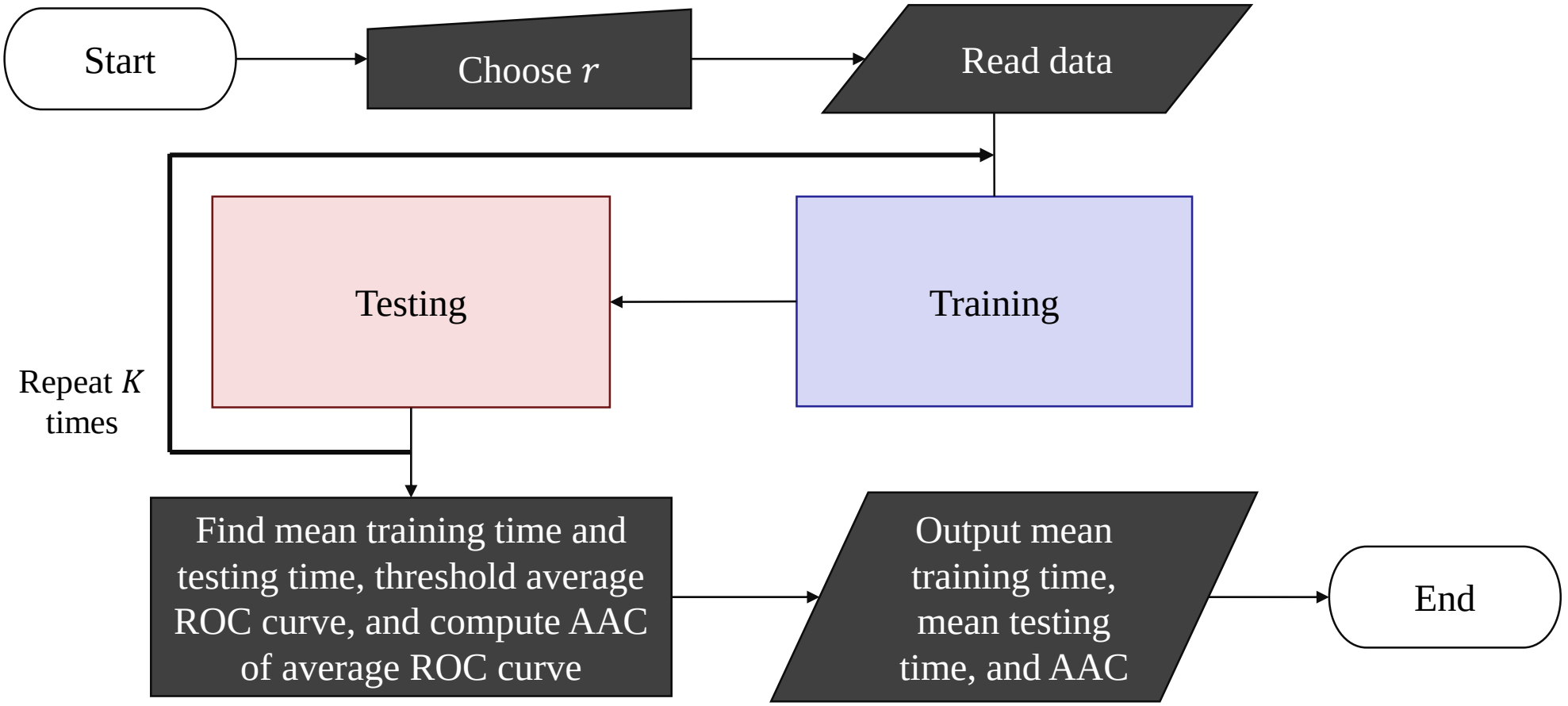
Choose the best ROC curve out of 2



Extra Slides

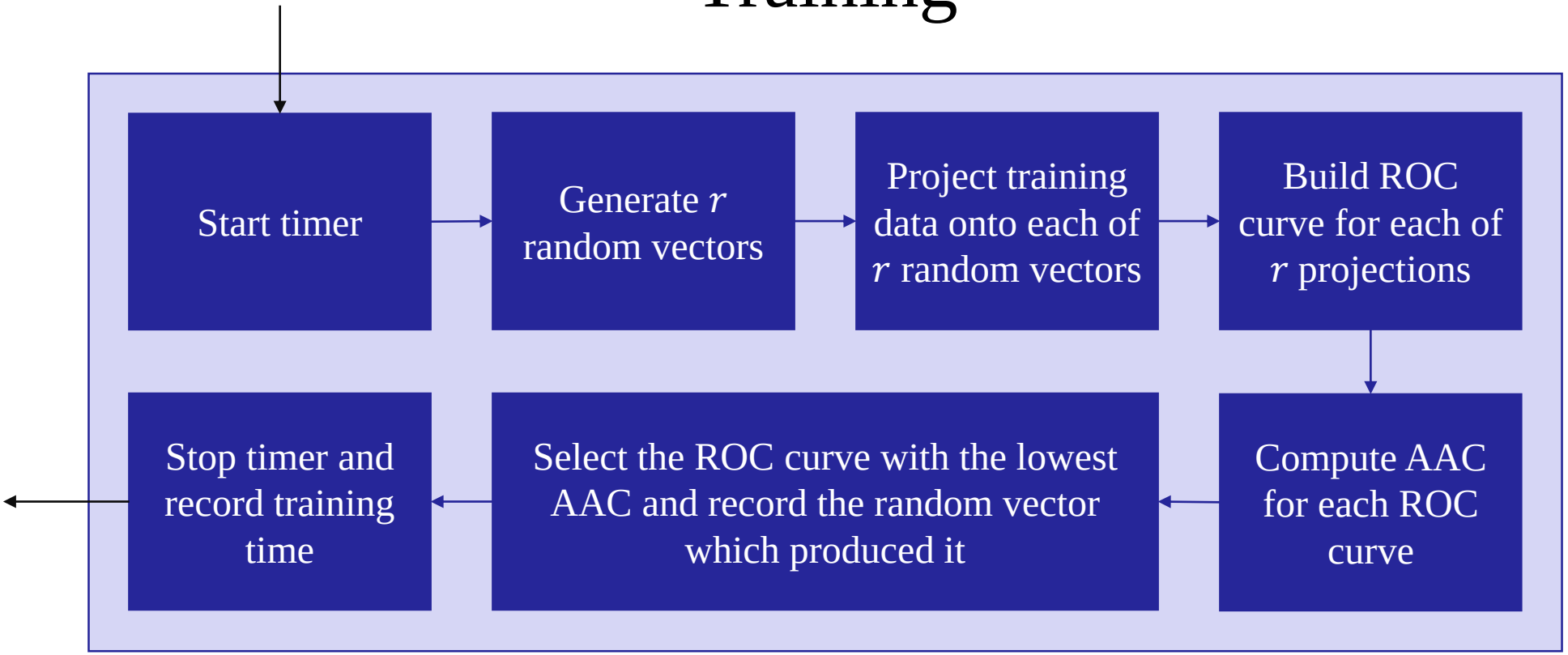
Algorithm Flowchart

Extra Slides



Extra Slides

Training



Extra Slides

Testing