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Based on:

Facial expression recognition based on Local Binary Patterns: A comprehensive study

*Caifeng Shan,
Shaogang Gong,
Peter W. McOwan*

Image and Vision Computing 27 (2009) 803–816

Facial expression

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- Facial expression is one of the most immediate and powerful way for a human being to communicate emotions.
- Automatic facial expression analysis can impact applications in areas such as human-machine interaction and data-driven animation.
- High accuracy recognition of facial expression is difficult due to their complexity and variability.

Automatic facial expression recognition

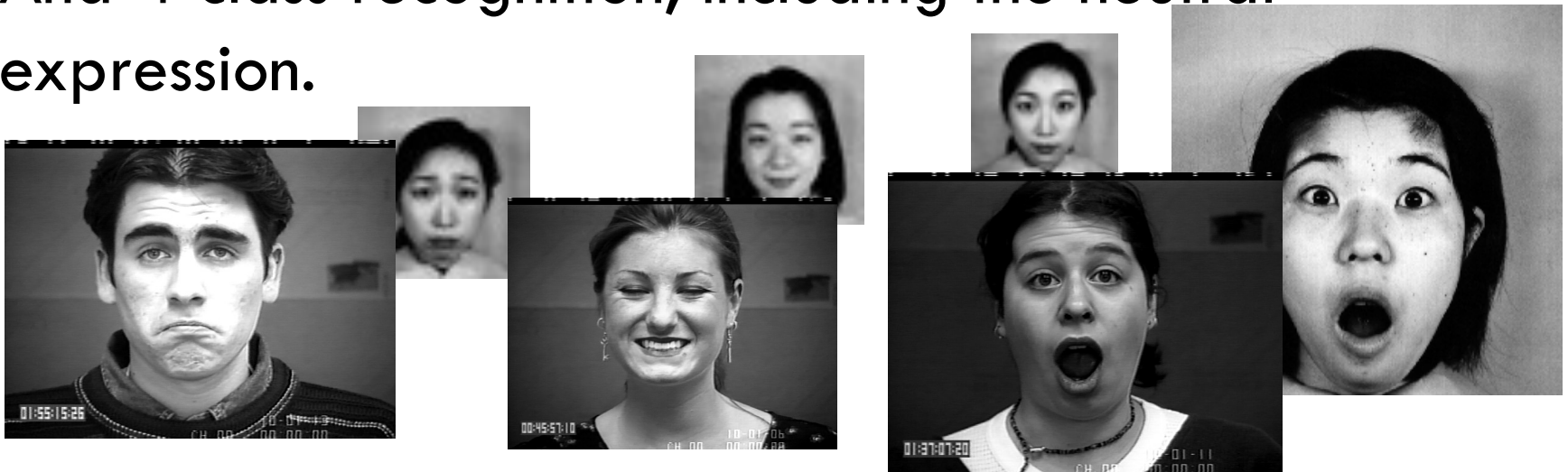
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- It involves two aspects:
 - ▣ Facial representation is to derive a set of feature from original face images, to represent faces.
Local Binary Patterns are used as appearance features for facial image analysis.
 - ▣ Classifier design.
Support Vector Machine is used to classify facial expressions.

Facial expression data

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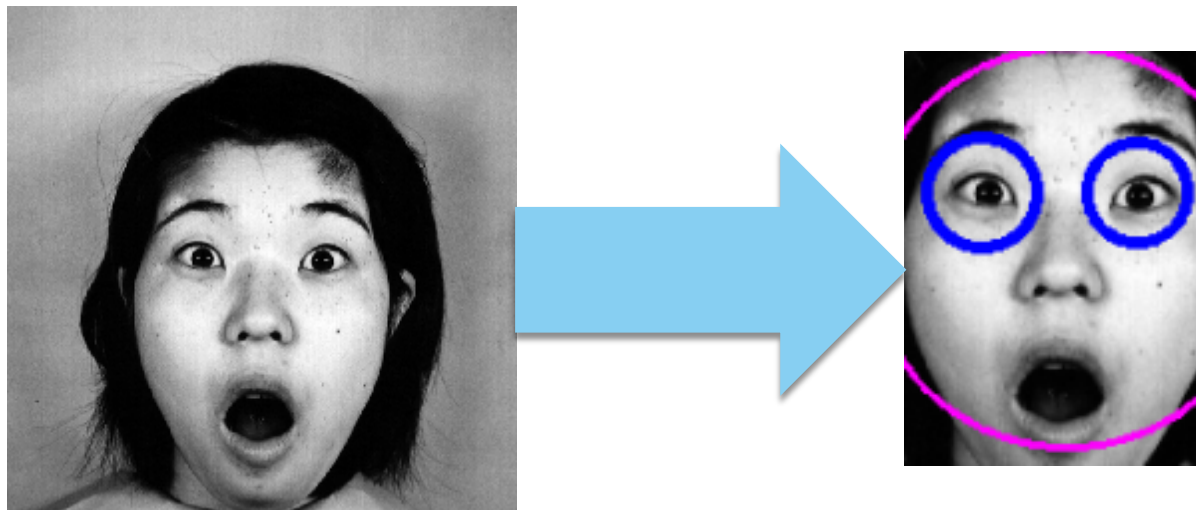
- Focus is on prototypic expression recognition.
- I considered 3-class recognition:
 - ▣ Happiness
 - ▣ Sadness
 - ▣ Surprise
- And 4-class recognition, including the neutral expression.



Data preprocessing

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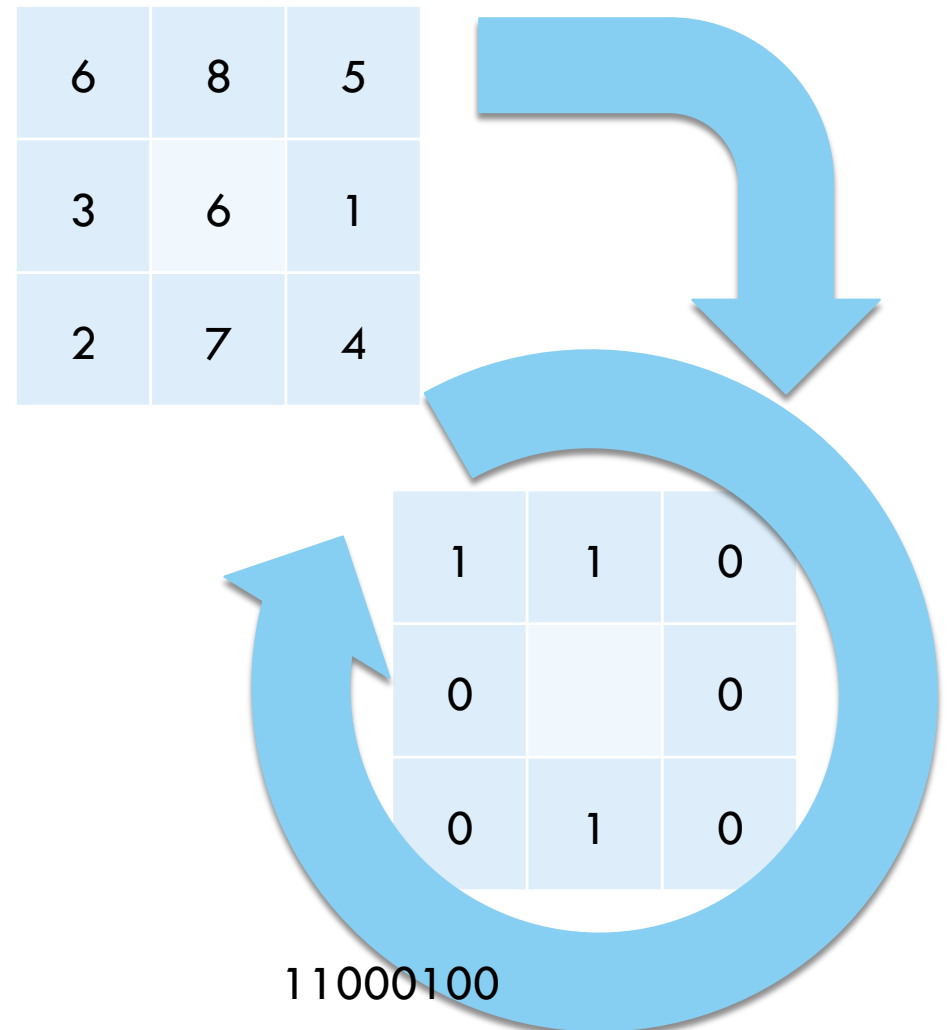
- The faces were normalized to a fixed distance between the eyes.
 - ▣ Opencv Haar Classifier Cascade was used to identify the face and then the eyes in the image.
 - ▣ The image was then resized and cropped to a 110x150 pixels image.



LBP operator

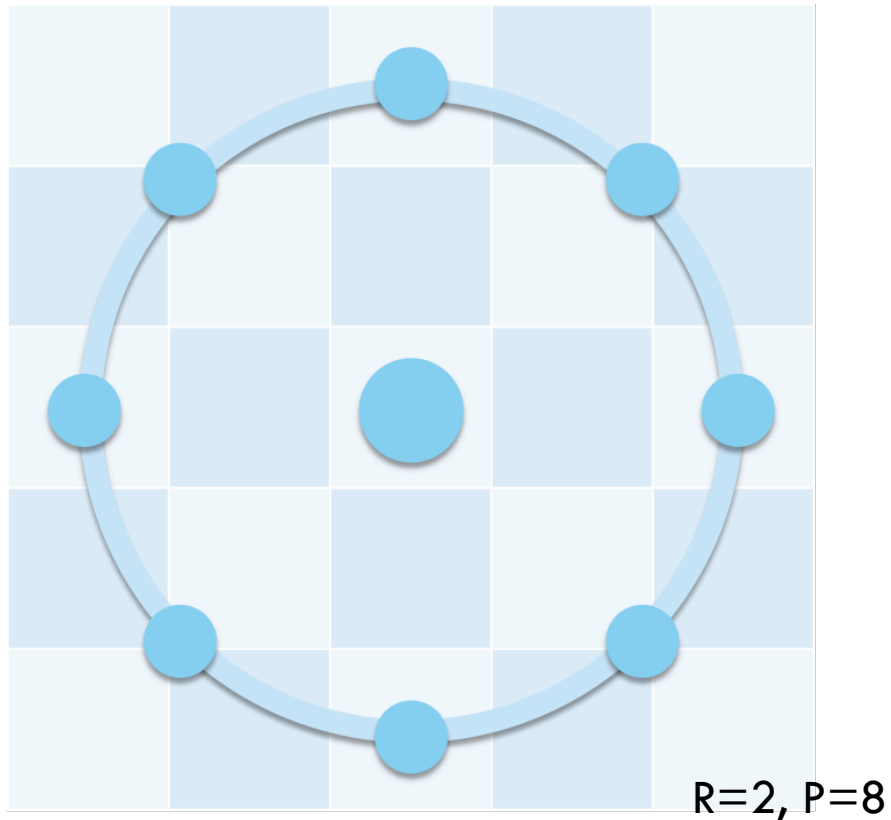
6

- Original LBP operator labels the pixels of an image by thresholding a 3x3 neighborhood of each pixel with the center value and considering the results as a binary number.
- The 256-bin histogram of the LBP labels computed over a region is used as a texture descriptor.



Extended LBP operator

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- LBP operator is extended to use neighborhoods of different sizes.
- Using a circular neighborhood and bilinearly interpolating values at non-integer pixel coordinates allow any radius and number of pixels in the neighborhood.

Uniform patterns

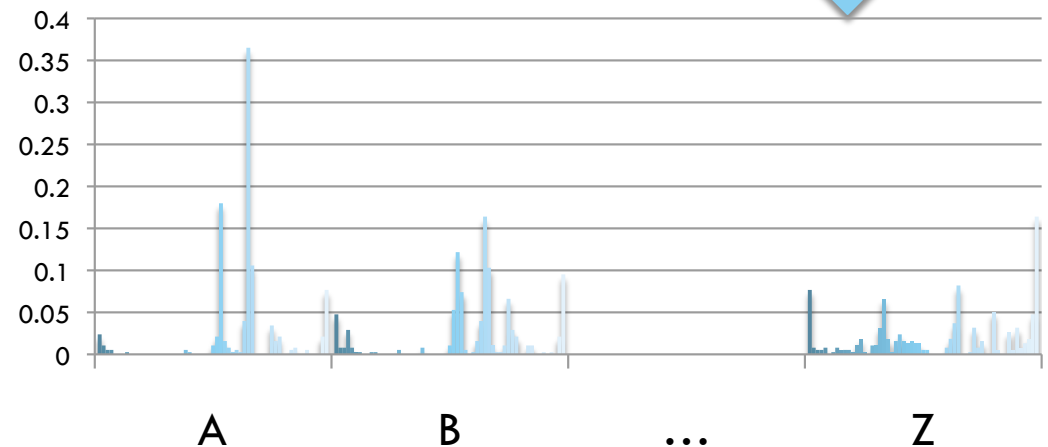
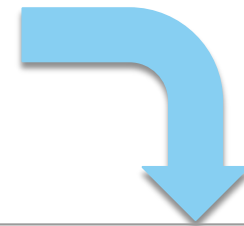
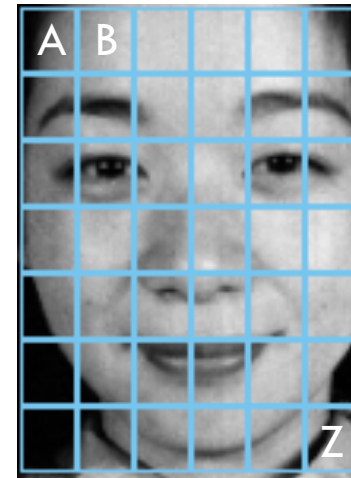
8

- $LBP_{P,R}$ operator produces 2^P different output values.
- Since certain bins contains more information, it's possible to use a subset of the 2^P patterns:
 - ▣ A uniform pattern is a LBP pattern that contains at most 2 bitwise transitions when the binary string is considered circular, i.e. 00000000, 00001100, 10000011.
- Accumulating the non-uniform patterns in a single bin, produces an operator with only $P(P-1)+3$ bins.

The histogram

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- A histogram of the labeled image is used to capture the information about the distribution of the local micro-patterns.
- To take into account the shape information of faces, these are equally divided into small regions to extract LBP histogram, the resulting histograms are then concatenated to form a single histogram.



Possible optimization

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- Some parameter can be optimized for better feature extraction:
 - ▣ The LBP operator (P and R)
 - ▣ The number of regions
- Following the setting of the article, I selected the $LBP_{8,2}$ operator (59-bin) and I divided the 110x150 pixels face image into 18x21 pixel regions.
- Therefore the images were divided into 6x7 regions and represented by the LBP histograms with the length of 2478.

Support Vector Machine

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- The basic SVM is a non-probabilistic binary linear classifier that predicts for each input, which of two possible classes the input belongs to.
- Given a set of training examples, each marked as belonging to one of two classes, an SVM training algorithm builds a model that assigns new examples into one class or the other.
- SVMs can perform a non-linear classification, mapping their inputs into high-dimensional feature spaces, using a kernel.

Kernels

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- **CvSVM::LINEAR** Linear kernel. No mapping is done, linear discrimination (or regression) is done in the original feature space. It is the fastest option.

$$K(x_i, x_j) = x_i^T x_j$$

- **CvSVM::POLY** Polynomial kernel:

$$K(x_i, x_j) = (\gamma x_i^T x_j + \text{coef}_0)^{\text{degree}}$$

- **CvSVM::RBF** Radial basis function (RBF), a good choice in most cases.

$$K(x_i, x_j) = e^{-\gamma \|x_i - x_j\|^2}$$

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Results

Ran on a MacBook Pro

2.8GHz dual-core Intel Core i7

16GB RAM and SSD

Image database

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□ Cohn Kanade DB

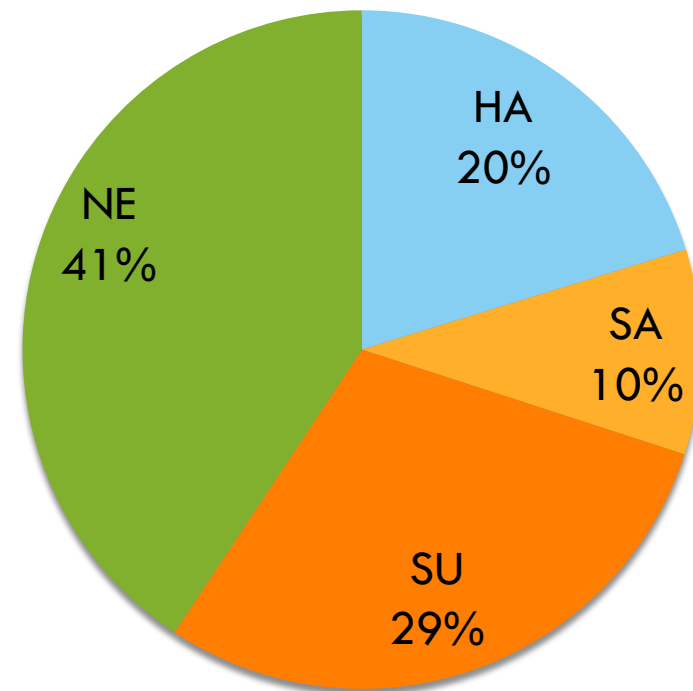
□ Happiness: 176

□ Sadness: 85

□ Surprise: 255

□ Neutral: 354

□ TOT: 870



<http://www.pitt.edu/~emotion/ck-spread.htm>

<http://www.consortium.ri.cmu.edu/ckagree/>

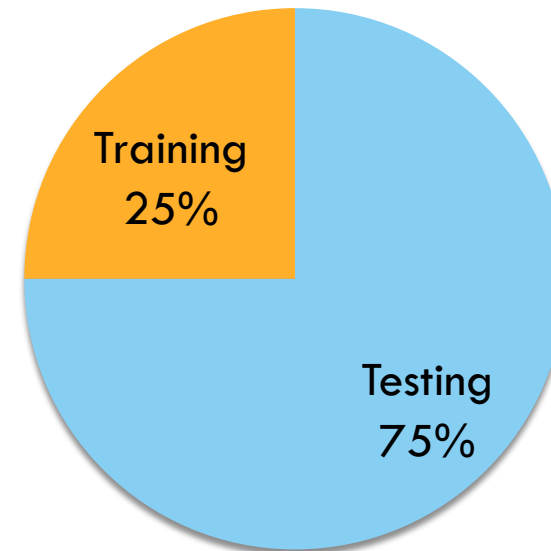
Some tests were done on: <http://www.kasrl.org/jaffe.html>

Training the SVM

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- **CvSVM::train_auto**
Trains an SVM with optimal parameters.
- Training images are chosen randomly.
- Results are the average on r repetitions.

Images subdivision



3-class results - default

16

Region subdivision	R	P	Kernel
6x7	2	8	RBF

%	HA	SA	SU
HA	89.280	0.076	10.644
SA	3.656	63.437	32.906
SU	0.635	0.000	99.364

Average run time
13.61s

Total %
90.008

4-class results - default

17

Region subdivision	R	P	Kernel
6x7	2	8	RBF

%	NE	HA	SA	SU
NE	95.902	0.586	1.823	1.688
HA	22.439	77.091	0.000	0.470
SA	44.953	0.000	52.859	2.188
SU	16.104	0.005	0.000	83.891

Average run time

41.92s

Total %

84.367

3-class results - linear

18

Region subdivision	R	P	Kernel
6x7	2	8	linear

%	HA	SA	SU
HA	99.151	0.023	0.826
SA	0.359	94.969	4.672
SU	0.359	0.307	99.333

Average run time
3.80s

Total %
98.552

4-class results - linear

19

Region subdivision	R	P	Kernel
6x7	2	8	linear

%	NE	HA	SA	SU
NE	97.797	0.064	1.538	0.602
HA	2.098	97.576	0.000	0.326
SA	19.688	0.000	80.000	0.313
SU	1.839	0.271	0.078	97.813

Average run time
7.56s

Total %
96.015

3-class results - polynomial

20

Region subdivision	R	P	Kernel
6x7	2	8	polynomial

%	HA	SA	SU
HA	99.159	0.045	0.795
SA	0.281	93.359	6.359
SU	0.265	0.276	99.458

Average run time
17.43s

Total %
98.351

4-class results - polynomial

21

Region subdivision	R	P	Kernel
6x7	2	8	polynomial

%	NE	HA	SA	SU
NE	97.932	0.0489	1.470	0.549
HA	2.765	96.947	0.000	0.288
SA	21.734	0.000	77.828	0.438
SU	1.922	0.266	0.141	97.672

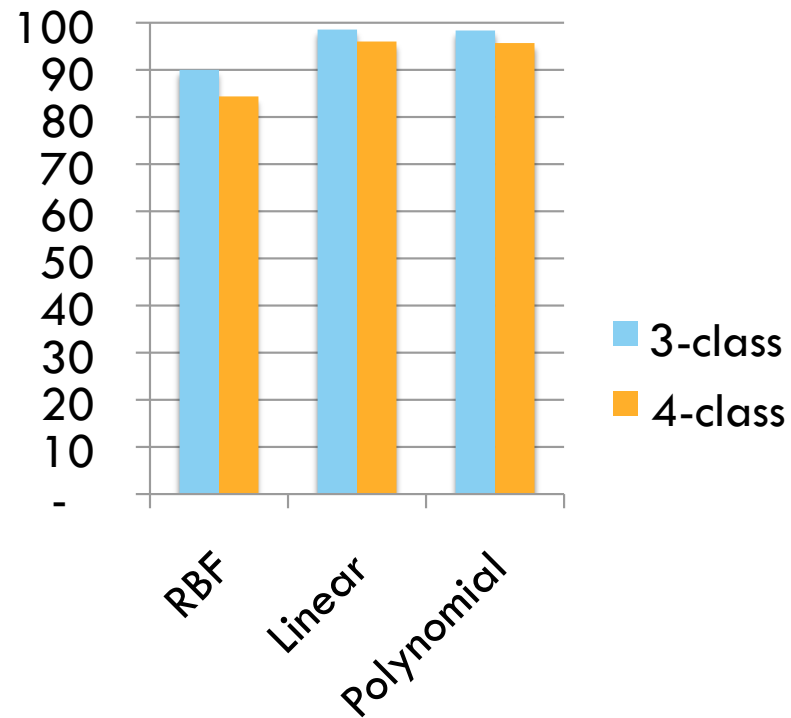
Average run time
52.66s

Total %
95.690

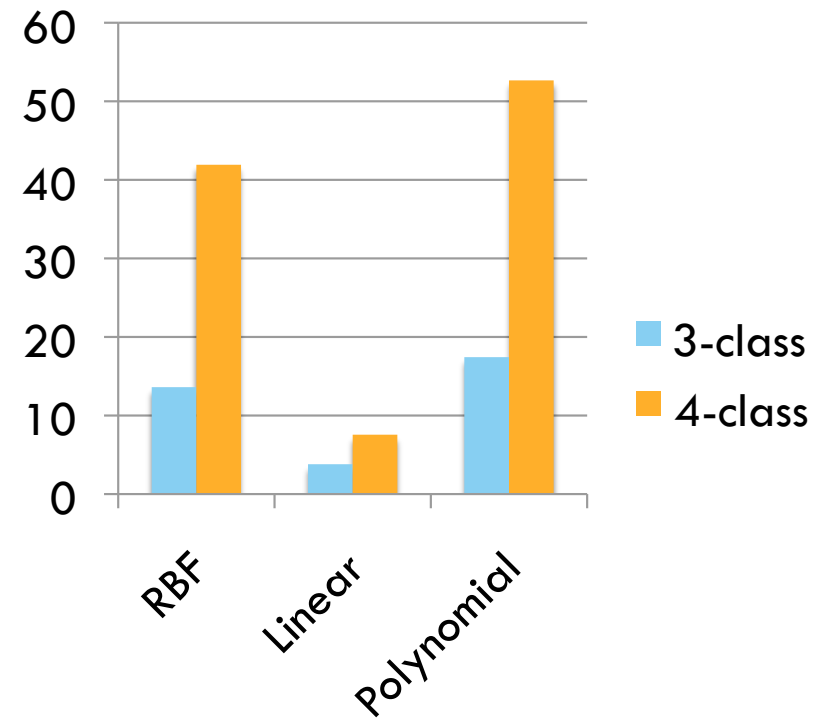
Kernels

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Success rate



Run time



3-class results - different regions

23

Region subdivision	R	P	Kernel
3x4	2	8	linear

%	HA	SA	SU
HA	98.886	0.515	0.598
SA	1.094	94.125	4.781
SU	0.328	1.120	98.552

Average run time
3.28s

Total %
97.936

4-class results - different regions

24

Region subdivision	R	P	Kernel
3x4	2	8	linear

%	NE	HA	SA	SU
NE	95.315	0.177	3.305	1.203
HA	2.432	97.189	0.106	0.273
SA	23.750	0.078	75.156	1.016
SU	4.057	0.016	0.120	95.807

Average run time
6.10s

Total %
93.865

3-class results - different regions

25

Region subdivision	R	P	Kernel
5x6	2	8	linear

%	HA	SA	SU
HA	99.144	0.008	0.849
SA	0.047	96.109	3.844
SU	0.370	0.292	99.339

Average run time
3.57s

Total %
98.740

4-class results - different regions

26

Region subdivision	R	P	Kernel
5x6	2	8	linear

%	NE	HA	SA	SU
NE	97.007	0.038	1.906	1.049
HA	1.174	98.333	0.000	0.492
SA	22.032	0.000	77.797	0.172
SU	2.495	0.208	0.245	97.052

Average run time
6.85s

Total %
95.408

3-class results - different regions

27

Region subdivision	R	P	Kernel
7x8	2	8	linear

%	HA	SA	SU
HA	99.182	0.083	0.735
SA	0.047	96.000	3.953
SU	0.250	0.281	99.469

Average run time
4.15s

Total %
98.799

4-class results - different regions

28

Region subdivision	R	P	Kernel
7x8	2	8	linear

%	NE	HA	SA	SU
NE	97.391	0.008	1.594	1.008
HA	1.205	98.333	0.008	0.455
SA	21.172	0.000	78.641	0.188
SU	1.661	0.214	0.078	98.047

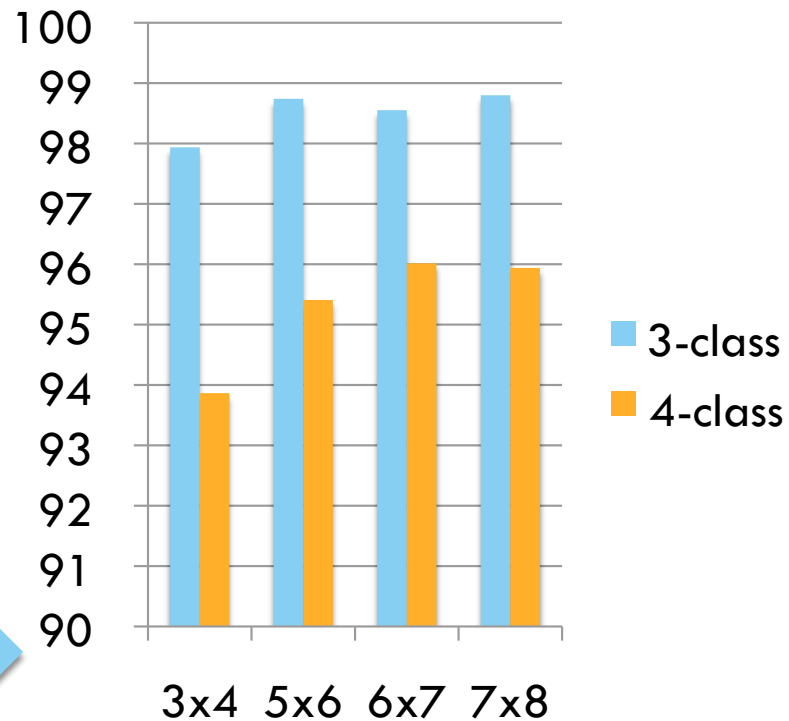
Average run time
8.57s

Total %
95.939

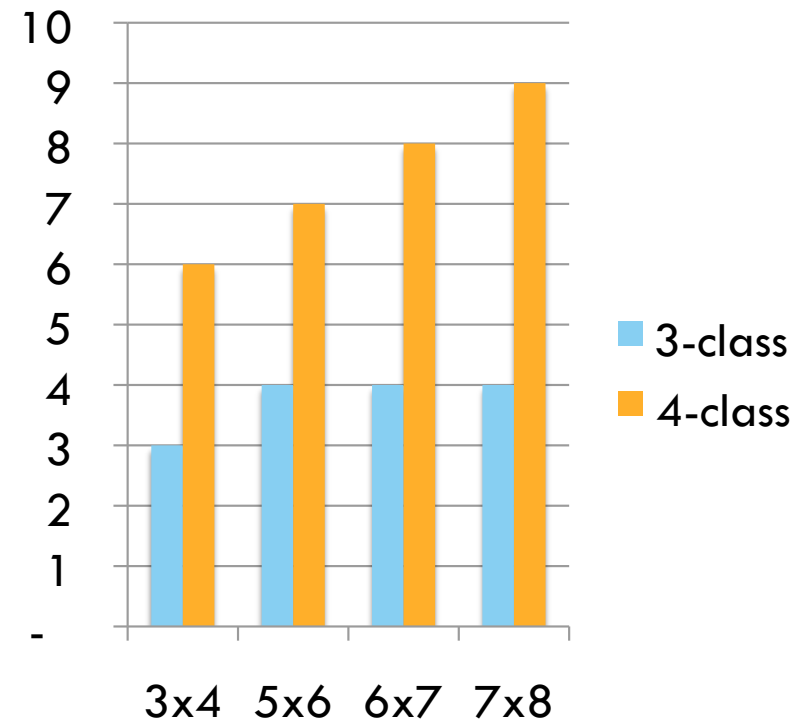
Regions

29

Success rate



Run time



3-class results - radius

30

Region subdivision	R	P	Kernel
6x7	1	8	linear

%	HA	SA	SU
HA	99.212	0.000	0.788
SA	0.172	95.547	4.281
SU	0.385	0.208	99.406

Average run time
3.86s

Total %
98.704

4-class results - radius

31

Region subdivision	R	P	Kernel
6x7	1	8	linear

%	NE	HA	SA	SU
NE	97.759	0.019	1.797	0.425
HA	1.689	97.977	0.000	0.333
SA	21.188	0.000	78.188	0.625
SU	1.672	0.318	0.042	97.969

Average run time

7.82s

Total %

95.950

3-class results - radius

32

Region subdivision	R	P	Kernel
6x7	3	8	linear

%	HA	SA	SU
HA	99.129	0.068	0.803
SA	0.109	94.406	5.484
SU	0.094	0.443	99.464

Average run time
3.83s

Total %
98.516

4-class results - radius

33

Region subdivision	R	P	Kernel
6x7	3	8	linear

%	NE	HA	SA	SU
NE	97.635	0.105	1.248	1.011
HA	2.833	96.659	0.000	0.508
SA	20.375	0.000	78.719	0.906
SU	1.719	0.016	0.151	98.115

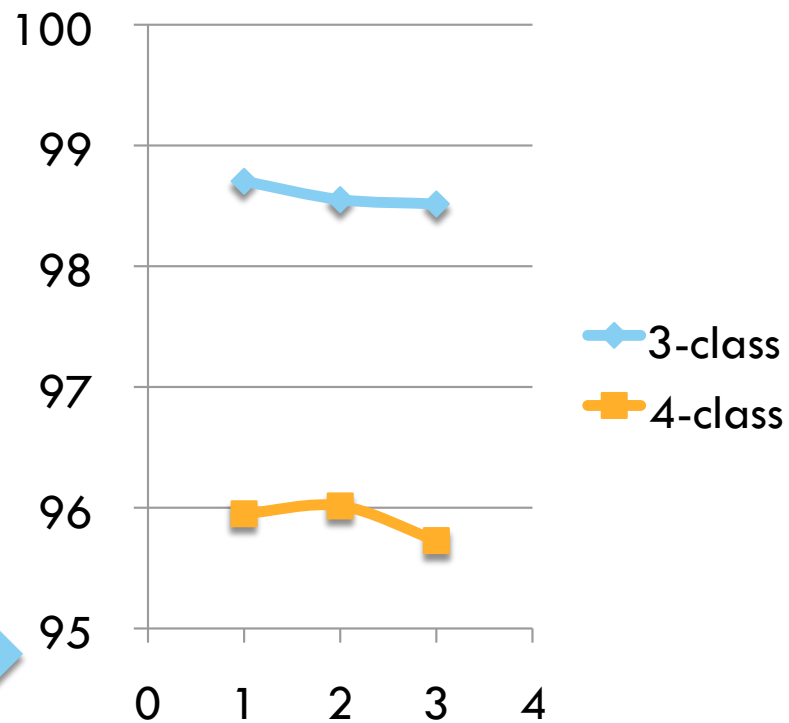
Average run time
7.43s

Total %
95.728

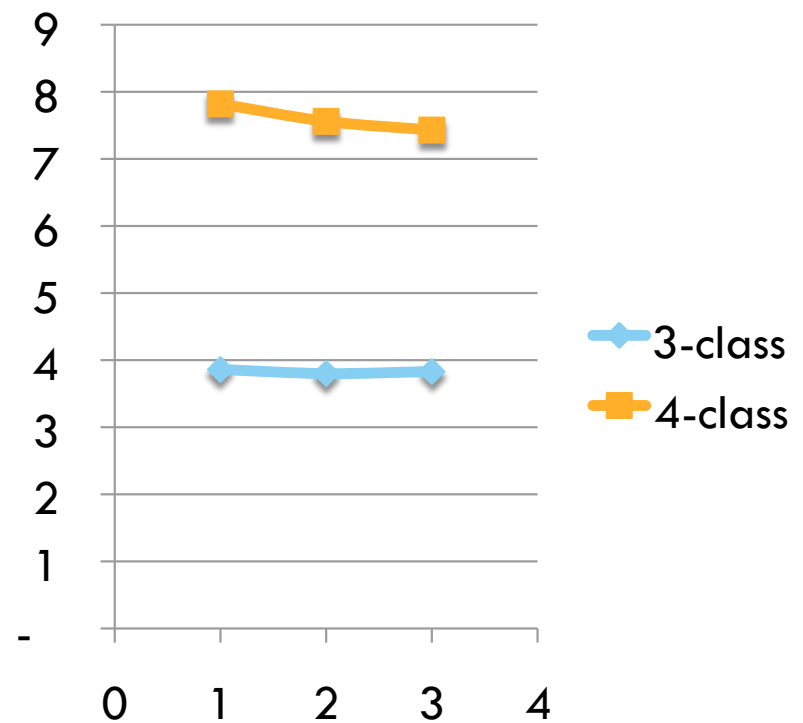
Radius

34

Success rate



Run time



3-class results - points

35

Region subdivision	R	P	Kernel
6x7	2	6	linear

%	HA	SA	SU
HA	99.492	0.000	0.508
SA	0.234	95.328	4.438
SU	0.432	0.620	98.948

Average run time
2.81 s

Total %
98.536

4-class results - points

36

Region subdivision	R	P	Kernel
6x7	2	6	linear

%	NE	HA	SA	SU
NE	97.872	0.041	1.421	0.665
HA	1.288	98.530	0.000	0.182
SA	16.719	0.000	82.844	0.438
SU	1.844	0.172	0.349	97.635

Average run time

5.44s

Total %

96.465

3-class results - points

37

Region subdivision	R	P	Kernel
6x7	2	12	linear

%	HA	SA	SU
HA	99.121	0.159	0.720
SA	0.609	95.344	4.047
SU	0.599	0.385	99.016

Average run time
8.96s

Total %
98.446

4-class results - points

38

Region subdivision	R	P	Kernel
6x7	2	12	linear

%	NE	HA	SA	SU
NE	97.955	0.053	1.305	0.688
HA	2.152	97.545	0.000	0.303
SA	20.089	0.000	78.891	0.625
SU	2.089	0.188	0.083	97.641

Average run time
7.87s

Total %
95.914

3-class results - points

39

Region subdivision	R	P	Kernel
6x7	2	16	linear

%	HA	SA	SU
HA	98.811	0.189	1.000
SA	0.719	93.578	5.703
SU	0.583	0.563	98.854

Average run time
54.61s

Total %
97.969

4-class results - points

40

Region subdivision	R	P	Kernel
6x7	2	16	linear

%	NE	HA	SA	SU
NE	97.594	0.079	1.635	0.692
HA	1.939	97.348	0.030	0.682
SA	22.094	0.015	77.141	0.750
SU	2.167	0.104	0.240	97.490

Average run time

94.14s

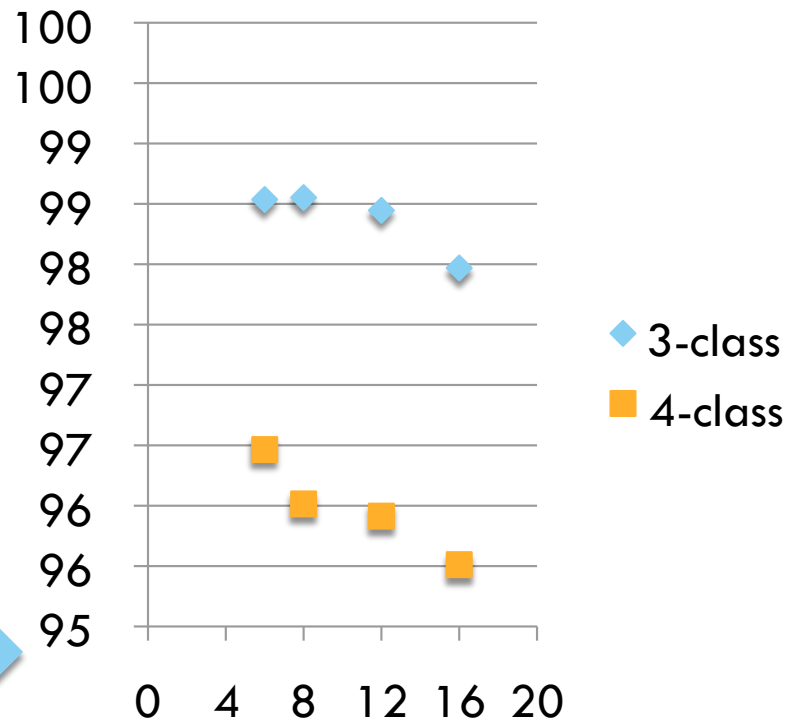
Total %

95.512

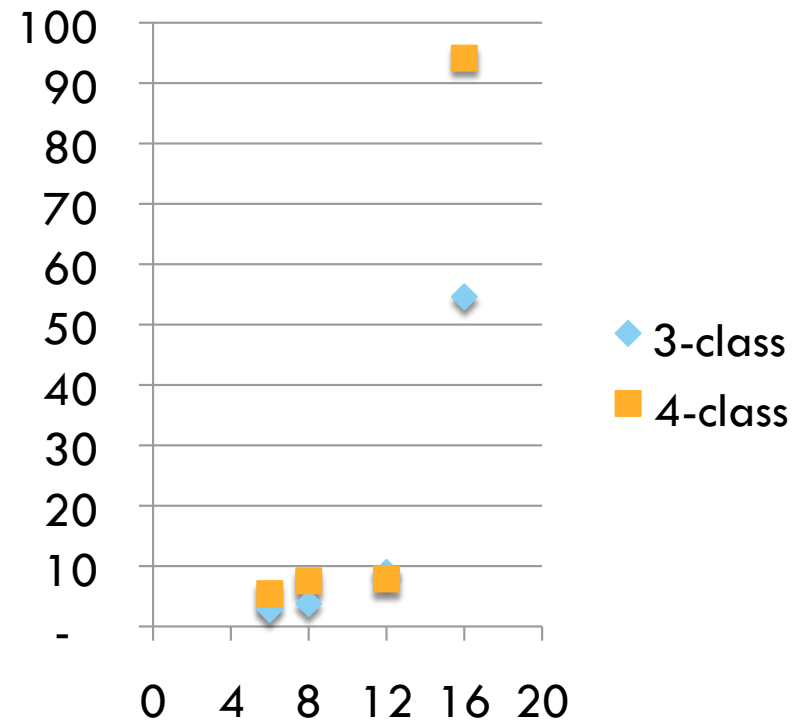
Points

41

Success rate



Run time



42

The End

Thank you