ECE 407: Pattern Recognition

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ERF 3007

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Teaching Assistant:??

Grading (tentative) & Office Hours

- Midterm Exam 1: 25%,
- Midterm Exam 2: 25%
- HW: 10%
- Project: 10%
- Final Exam: 30%
- Android or Iphone project: %5

- A. Enis Cetin: Monday 11:00 am to 13:00pm
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Textbooks and Course Material

- Recommended: S. Theodoridis, A. Pikrakis, K. Koutroumbas **Introduction to Pattern Recognition, A MATLAB® Approach, 2010**
- I. Goodfellow, Y. Bengio, A. Courville, *Deep Learning*, MIT Press, 2016.
- K. P. Murphy, *Machine Learning: A Probabilistic Perspective*, MIT Press, 2012.
- C. M. Bishop, *Pattern Recognition and Machine Learning*, Springer, 2006.
- R. O. Duda, P. E. Hart, D. G. Stork, *Pattern Classification*, 2nd edition, John Wiley & Sons, Inc., 2000.
- S. Theodoridis, K. Koutroumbas, *Pattern Recognition*, 4th edition, Academic Press, 2009.
- D. Koller, N. Friedman, *Probabilistic Graphical Models: Principals and Techniques*, MIT Press, 2009.
- A. Webb, *Statistical Pattern Recognition*, 2nd edition, John Wiley & Sons, Inc., 2002.
- T. Hastie, R. Tibshirani, J. Friedman, *The Elements of Statistical Learning*, Springer, 2003.
- K. Fukunaga, *Introduction to Statistical Pattern Recognition*, Academic Press, 1990.
- R. Schalkoff, *Pattern Recognition: Statistical, Structural and Neural Approaches*, John Wiley & Sons, Inc., 1992.
- A. K. Jain, R. C. Dubes, *Algorithms for Clustering Data*, Prentice Hall, 1988.
- http://www.cs.bilkent.edu.tr/~saksoy/courses/cs551-Fall2017/index.html

Some Benefits of This Course

- The course objectives are to familiarize students with
  – Fundamental concepts of pattern recognition and machine learning
  – Computational methods for signal, sound, speech, image and video recognition.
- Pattern recognition and finds applications in a variety of problems in engineering, such as speech recognition, computer vision, object recognition, data science, big-data analysis,
- Prerequisites: Linear Algebra, Probability Theory, Signals and Systems, DSP

Course objectives

- Students will be able to
  -learn feature extraction from data, signals, images and video
  -classify and recognize feature vectors using a classification ``engine``
  -to identify, formulate, and data science problems by applying
  principles of probability, statistics and linear algebra.

Students will be able to
- build a complete system using MATLAB, and Apps in an Android or IOS device

Basic Stages Involved in the Design of a Pattern Classification System

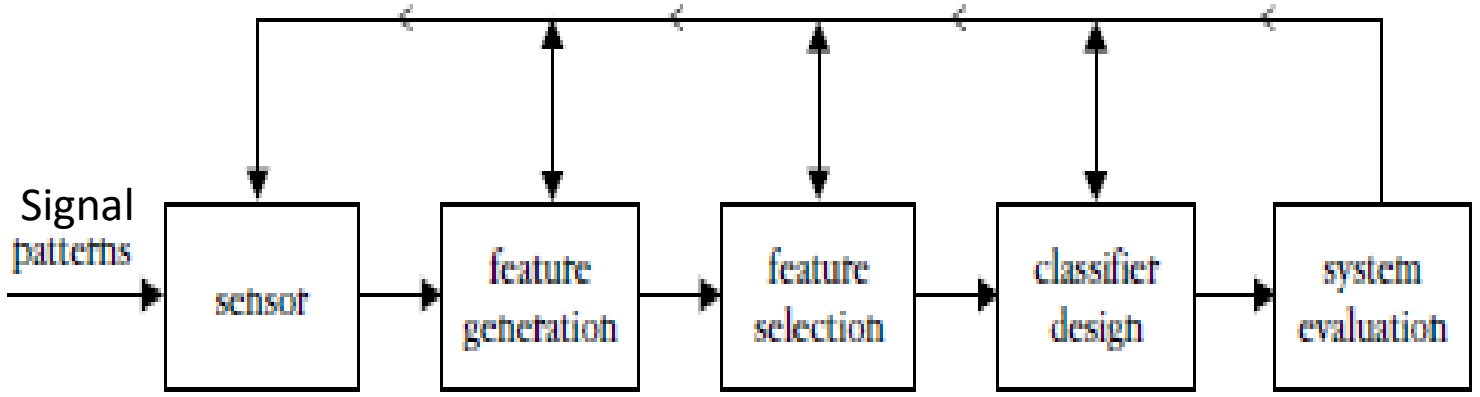


FIGURE 1.3

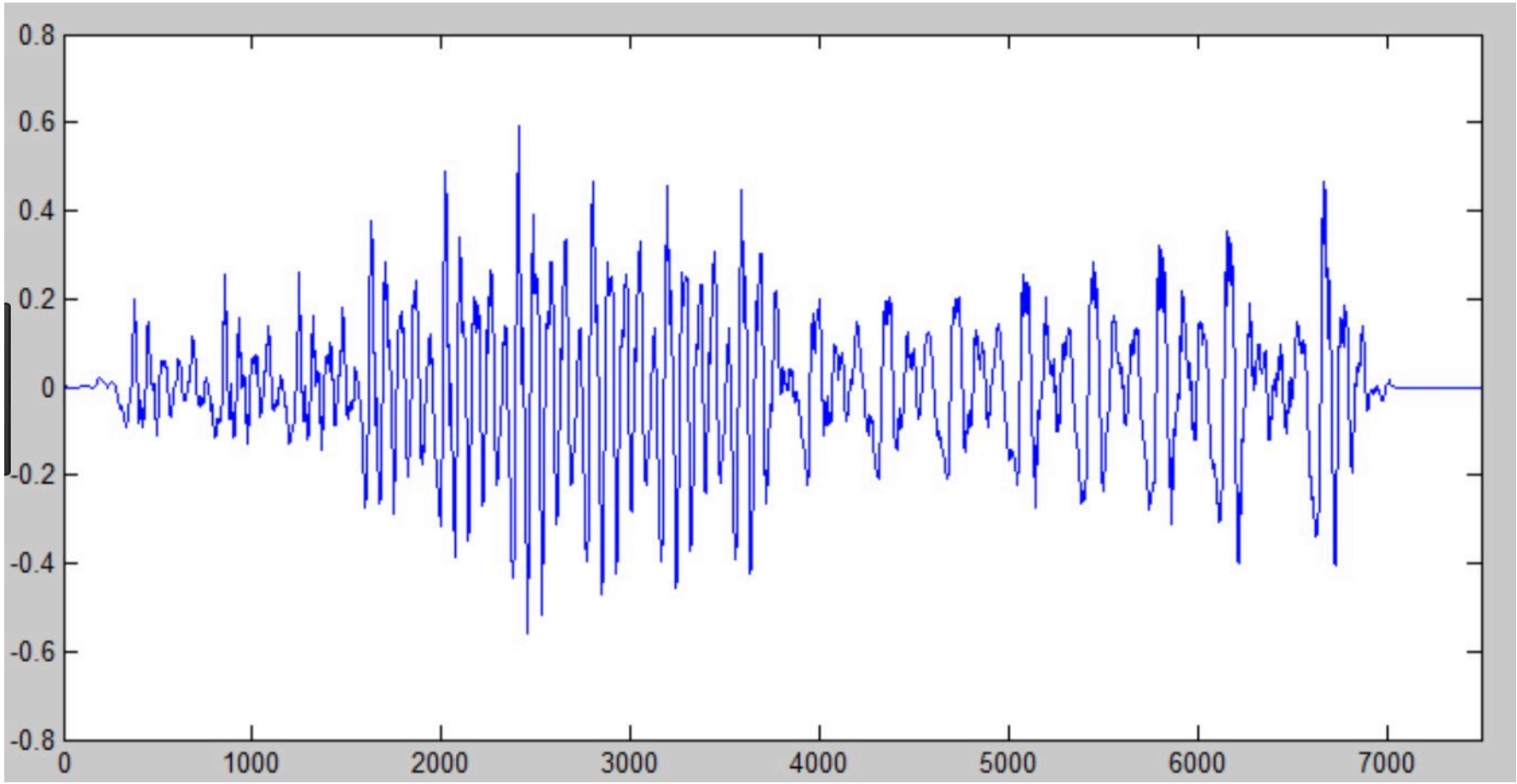
The basic stages involved in the design of a classification system.

Feature Extraction

- Classical Approach:
  - Extract features from the image or the signal
  - A typical feature is usually a vector representing the data.
  - The size of the vector is shorter than the length of the signal (or size of the image)
- Deep Learning (after 2012)
  - Feed the data to a Deep Neural Network without feature extraction
  - Machine ``learns`` from data.
  - But deep learning requires a huge set of training data

A typical speech signal: x(t)

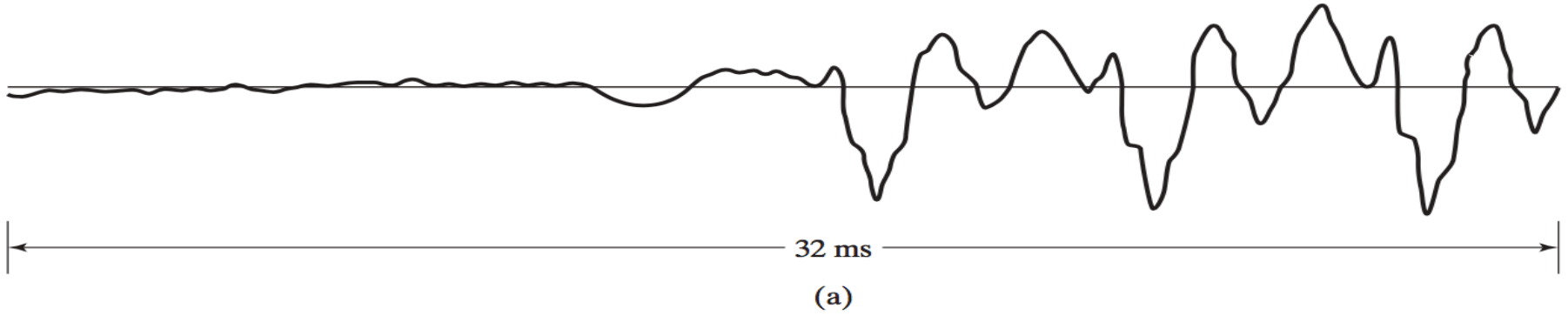
X(t)



Time (t) →

Speech Recognition example: Sampling converts continuous-time speech signals to discrete-time signals:

$x_a(t)$ =



Discrete-time signal x[n] is our data and we extract feature vectors from the data to recognize speech :

x[n] =

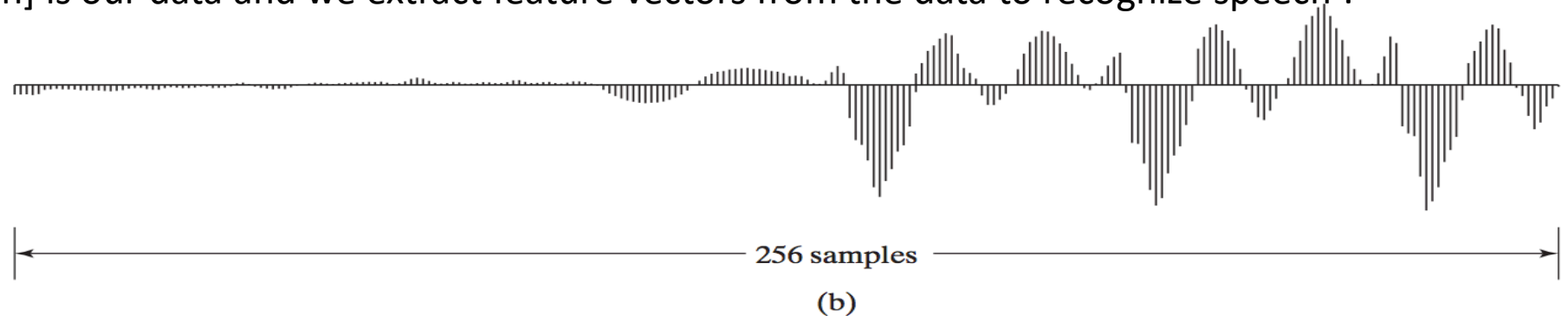


Figure 2.2 (a) Segment of a continuous-time speech signal $x_a(t)$. (b) Sequence of samples $x[n] = x_a(nT)$ obtained from the signal in part (a) with $T = 125\ \mu s$.

Figure is downloaded from Oppenheim and Schafer, DSP, Prentice Hall.

Feature Extraction from Speech Signals

- The discrete-time speech signal is divided into frames of length 10 to 30 ms: There are about 250 samples in each frame with 8kHz sampling rate
- Mel-cepstrum feature vector:

  - Compute the Discrete-Fourier Transform of each block

  - Apply the Mel-scale filterbank to DFT coefficients

  - Compute the log-energy of each filter output

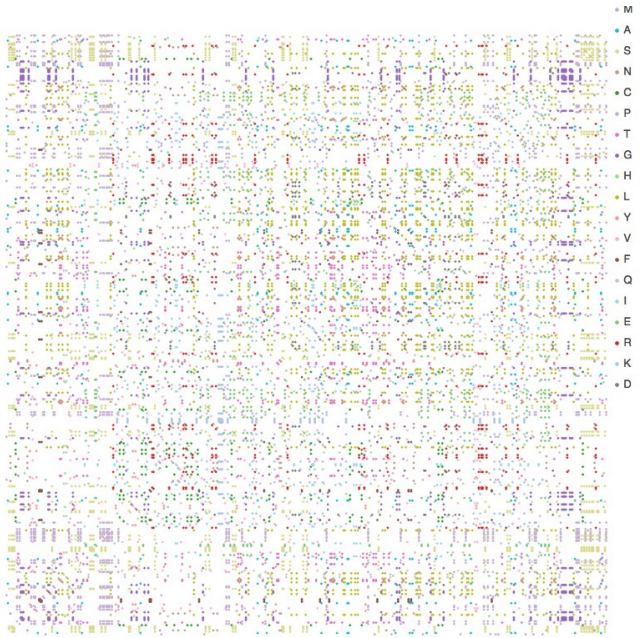
  - Compute the inverse DCT and keep the first 10-20 coefficients

  - Also compute a difference vector from two consecutive frames to form the final feature vector

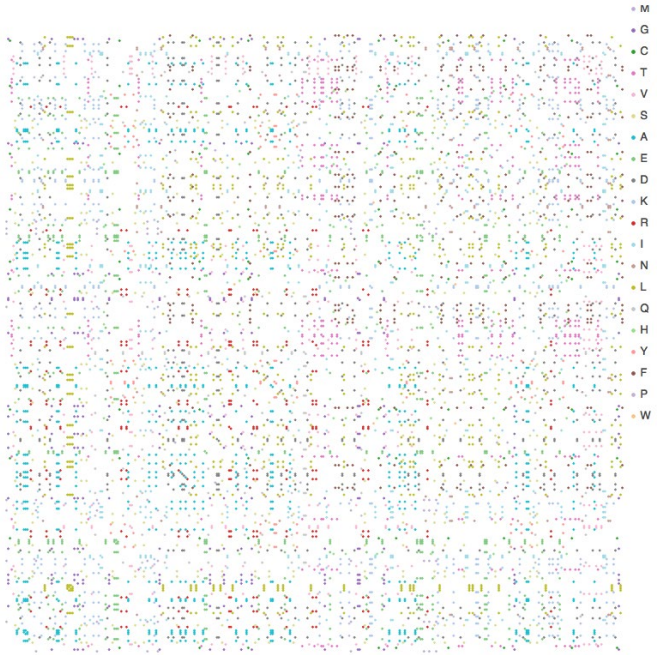
- Classification engine is a mixture of Hidden Markov Models (HMM) and Deep Neural Networks

Biomedical Image Processing Example:

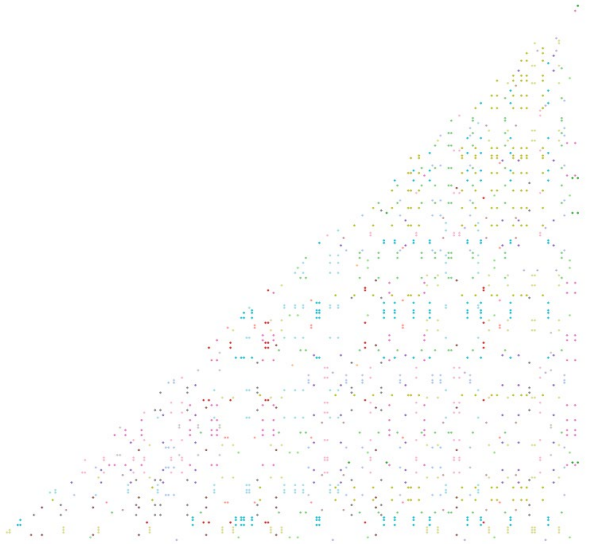
- Nres class:



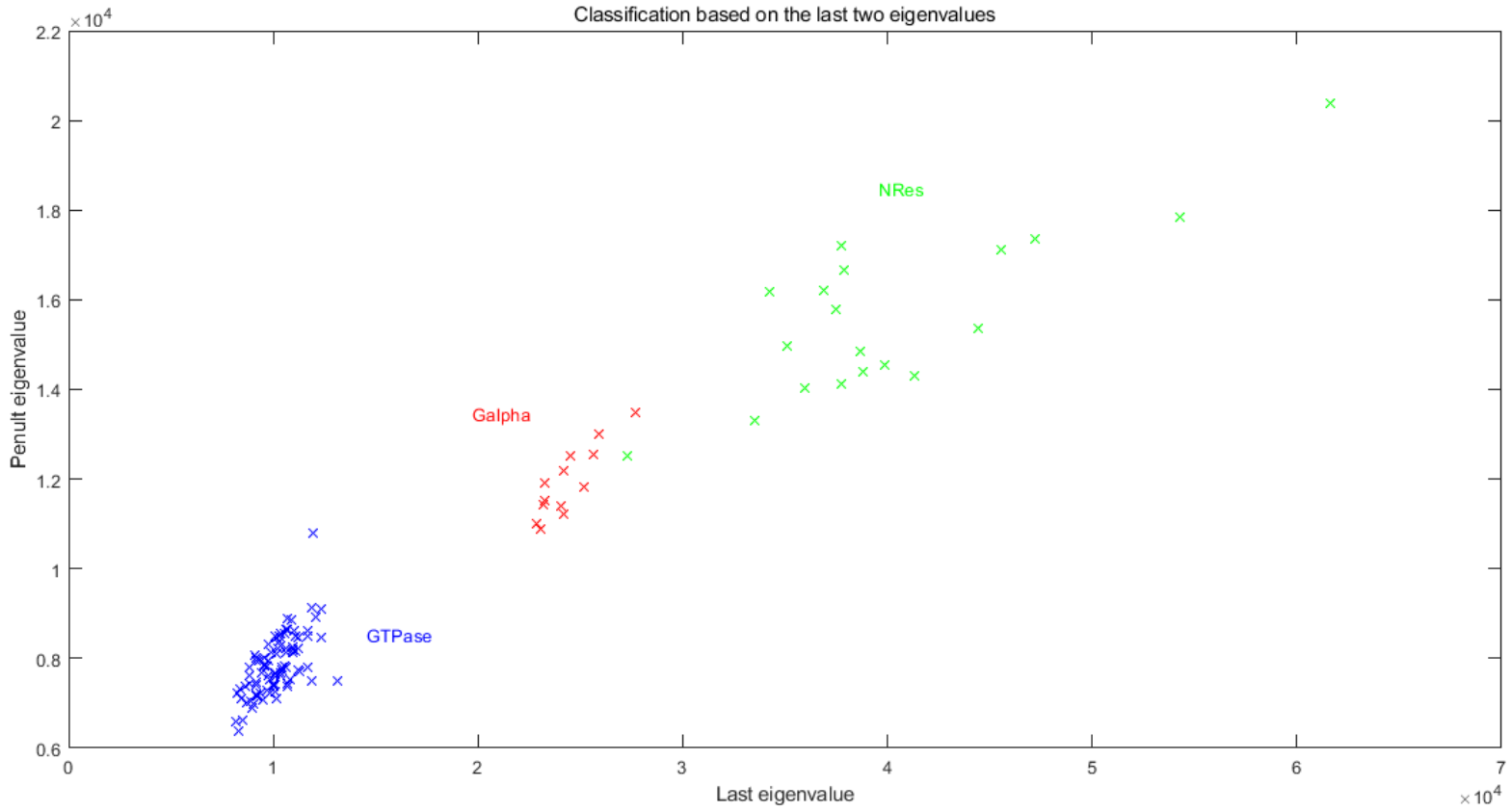
Galpha class:



Gtphase:

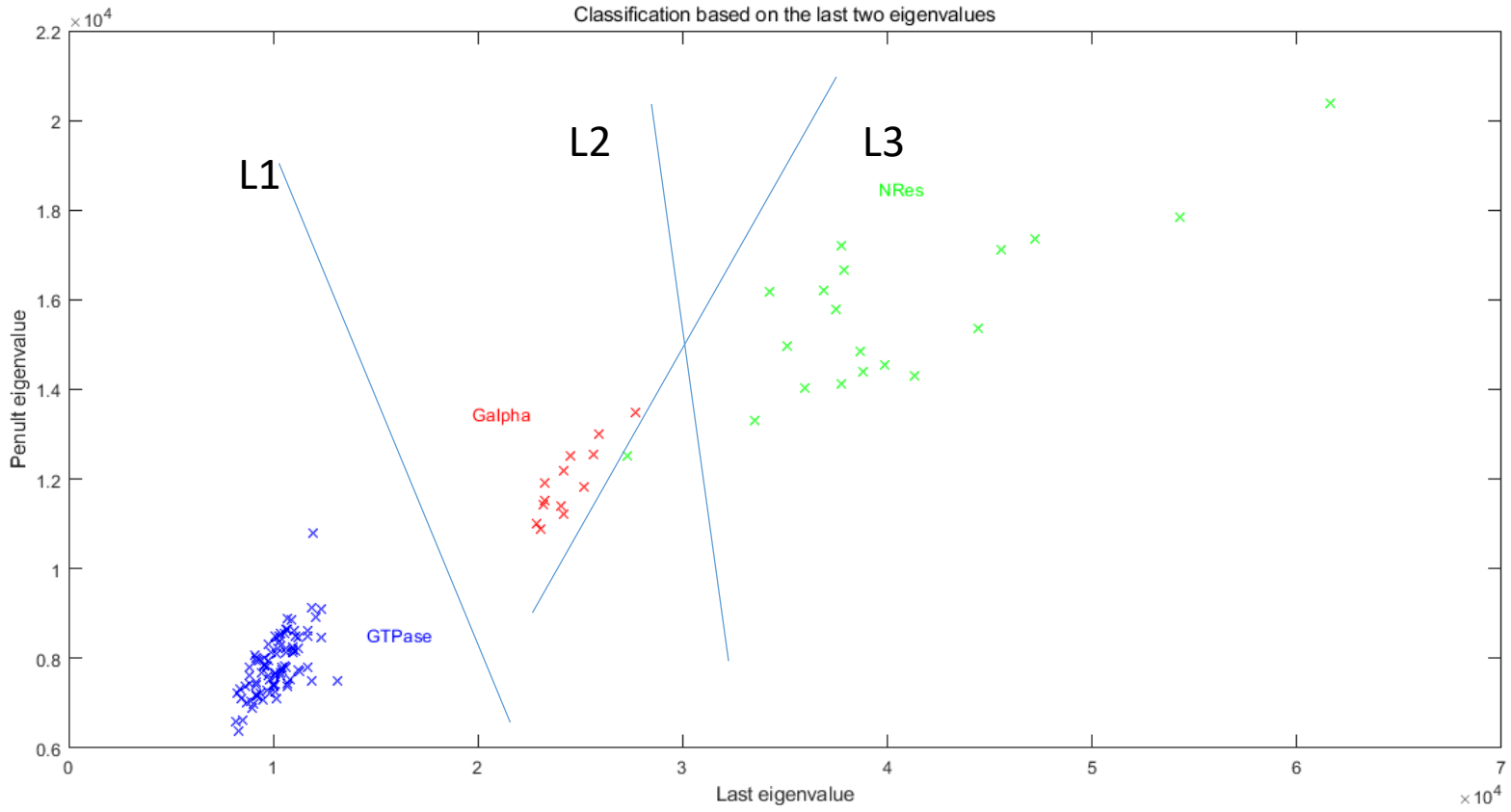


Classification based on Features



Feature vector is the top two eigenvalues.
There are three classes and we can easily classify these three classes of objects with very high accuracy.

Classification Engine Design Using the Training Data

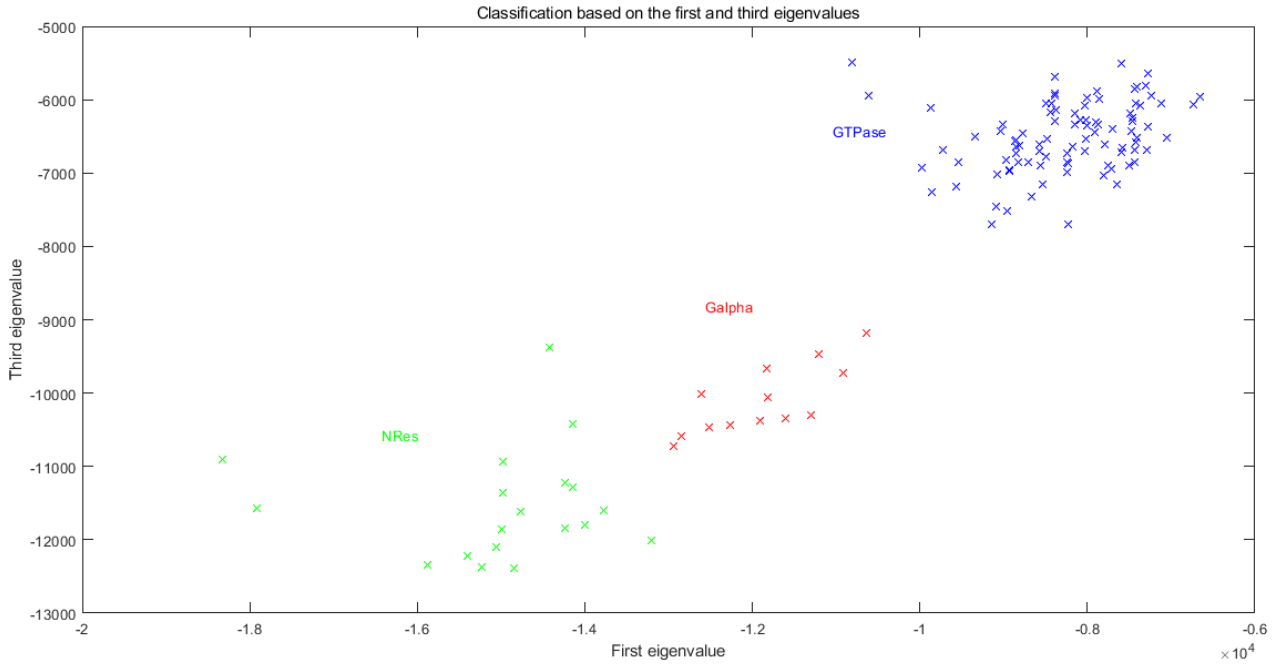


What is the best set of lines separating these classes?

L1 and L2 pair may be better than L1 and L3 pair during testing (recognition). L3 “overfits” data

Another Feature Vector

- Use the 1st and 3rd eigenvalue as the feature vector:

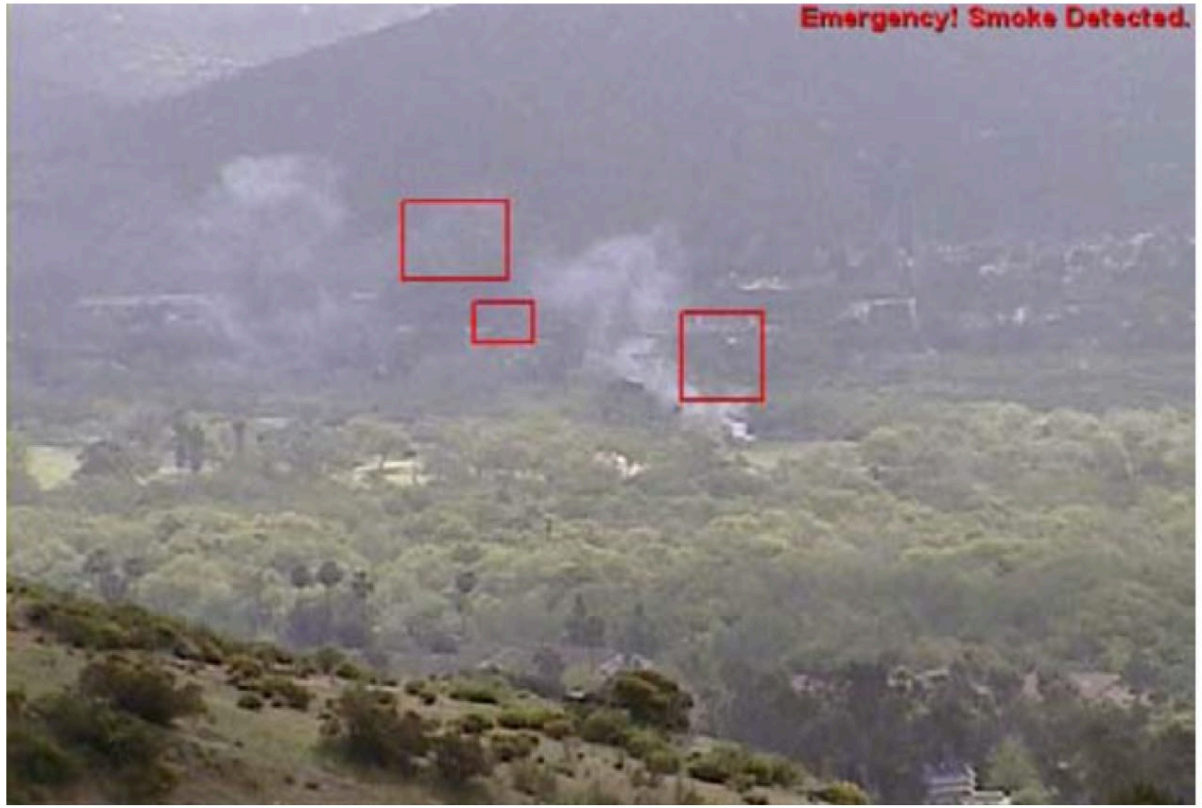


- It looks like this vector is better than the previous one!

Image Pattern Recognition Example:

- License plate recognition

Computer Vision Application



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Wildfire detection using computer vision ¶

Religious Holidays

https://oae.uic.edu/religious/: The faculty of the University of Illinois at Chicago shall make every effort to avoid scheduling examinations or requiring that student projects be turned in or completed on religious holidays. Students who wish to observe their religious holidays shall notify the faculty member by the tenth day of the semester of the date when they will be absent unless the religious holiday is observed on or before the tenth day of the semester. In such cases, the students shall notify the faculty member at least five days in advance of the date when he/she will be absent.
The faculty member shall make every reasonable effort to honor the request, not penalize the student for missing the class, and if an examination or project is due during the absence, give the student an exam or assignment equivalent to the one completed by those students in attendance.
If the student feels aggrieved, he/she may request remedy through the campus grievance procedure

ACADEMIC INTEGRITY

Policy on cheating/plagiarism.
Some useful information is available at https://dos.uic.edu/community-standards/

You could you use something like this in your syllabus:

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HARRASMENT

- https://can.uic.edu: If you have experienced sexual assault, domestic/dating violence, stalking, or harassment, there is help available on campus. The Campus Advocacy Network (CA) provides free and confidential services to UIC students, faculty, and staff who have experienced or are experiencing interpersonal violence. If you would like to speak with an advocate, please contact CAN at can-appointment@uic.edu, call (312) 413-8206, or stop by the CAN office at 1101 W. Taylor St. To learn more, visit CAN's website at https://can.uic.edu/.

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DRC: Disability Resource Center

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