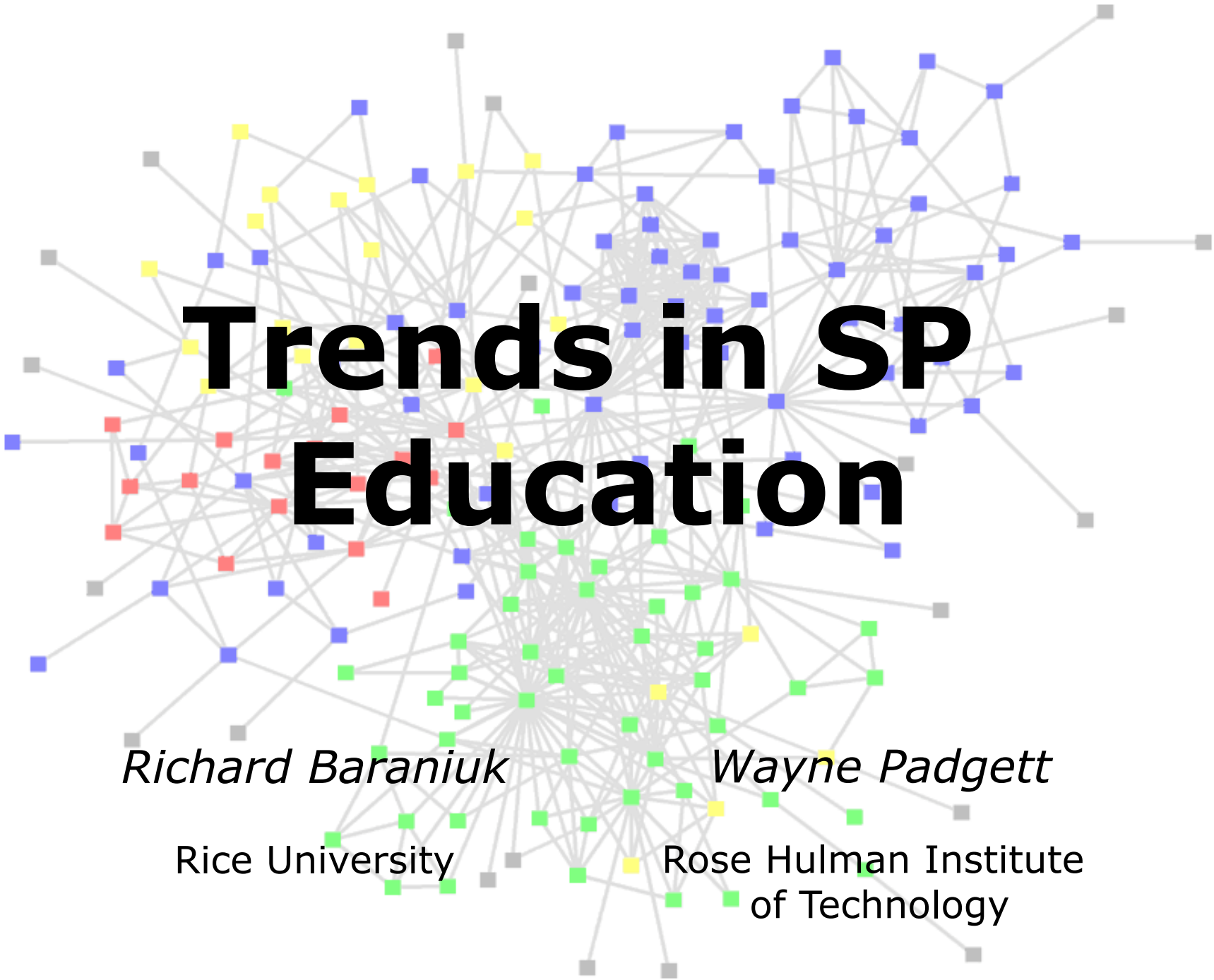


# Trends in SP Education

*Richard Baraniuk*

Rice University

*Wayne Padgett*

Rose Hulman Institute of Technology

# important caveats

- Wayne and Rich's opinions
- We will miss important trends, so please speak up!
- Thanks to Jim McClellan and others for slides

# issues in (SP) education

**not learner-centric**

- need to adapt to individual learner's "level" and context
- need to transfer responsibility to the learner

**passive student experience**

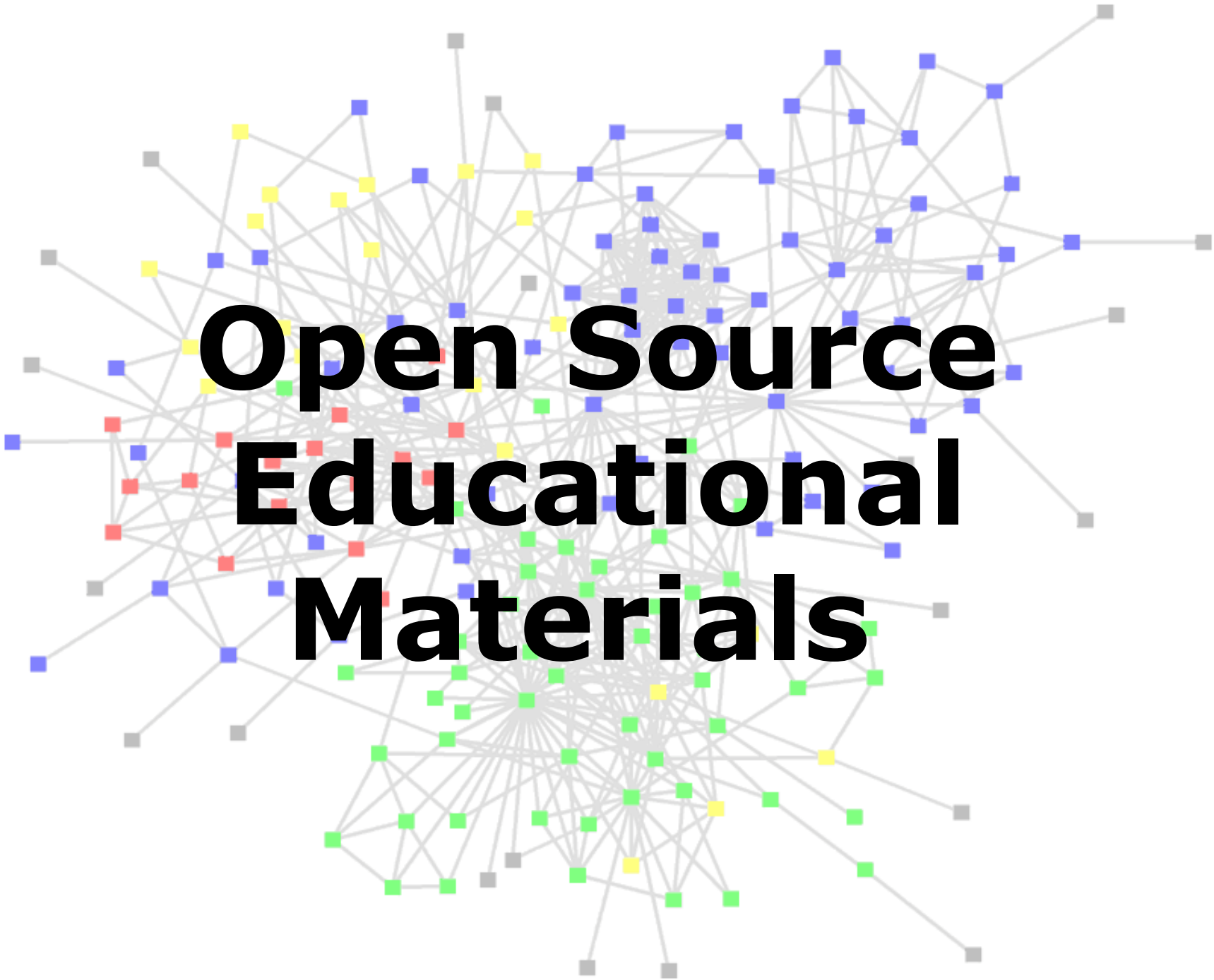
- studies show most undergraduates passively listen, transcribe, absorb, and repeat in course after course

**sequential and inflexible textbooks**

- sequential presentation, usually not customizable
- years to develop; costs rising quickly

**other components?**

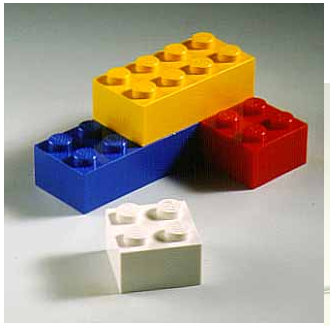
- labs, interactive demos, tutorials
- publishing/sustaining/quality control mechanisms for these components?

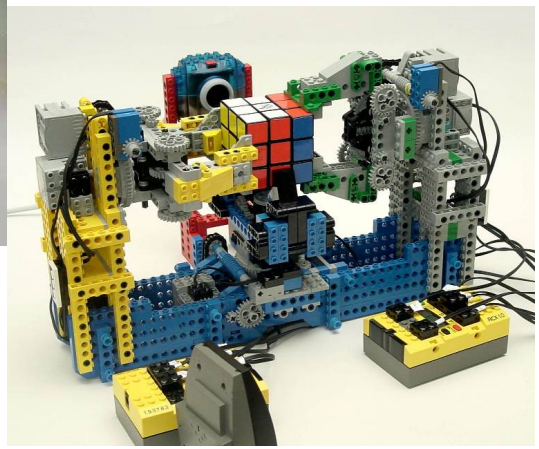

Open Source
Educational
Materials

# open education enablers

## technology

web, internet,
databases, ...





## intellectual property

open-source licenses for content

make content easy and safe to share

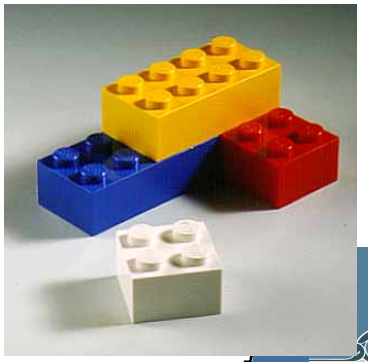
creative commons

# Connexions (cnx.org)

non-profit open education platform
founded at Rice Univ. 12 years ago

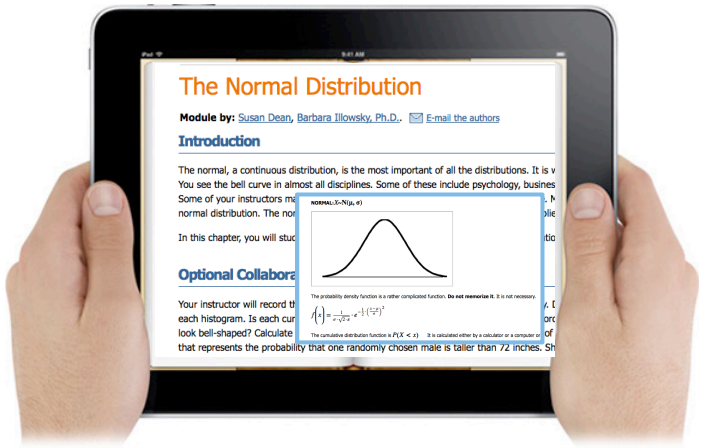
**1100** open textbooks/collections
**18000** Lego modules

from contributors *worldwide*
in 40+ languages

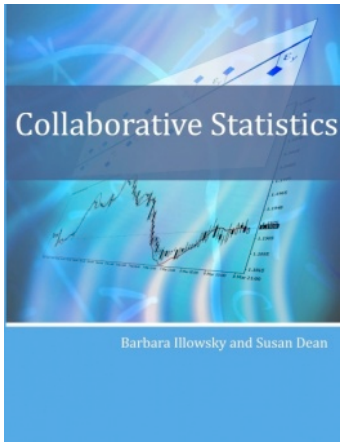


**usage per month:**
**>2 million unique users**
**100 million hits**
**from 190 countries**

**free online:** 4 million uses to date




**iPad/iPhone/Android**
via ePub




**$26 in print**
(627 pages)

# SP content in Connexions

- John Treichler
- Louis Scharf
- Sidney Burrus
- Don Johnson
- Albert Cohen
- Julius Smith
- Sam Shearman
- Rob Nowak
- Stephane Mallat

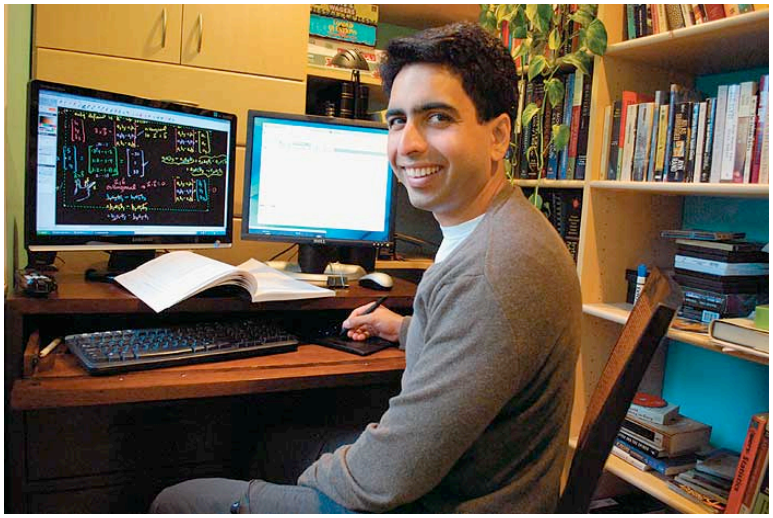
and many others

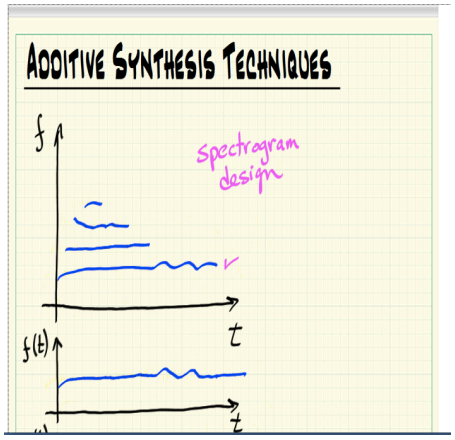
**cnx.org**

Video Tutorials

# video tutorials

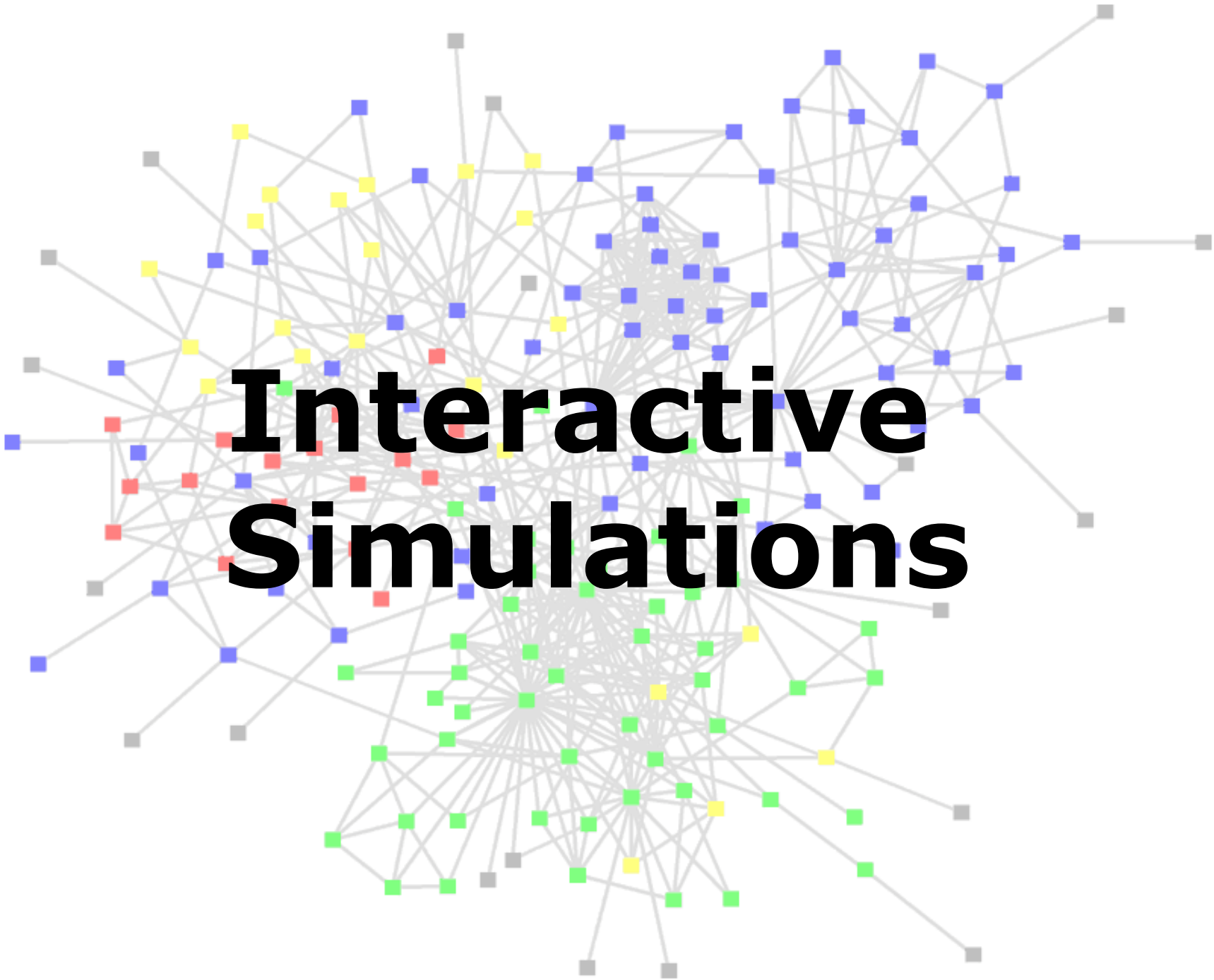
KHANACADEMY



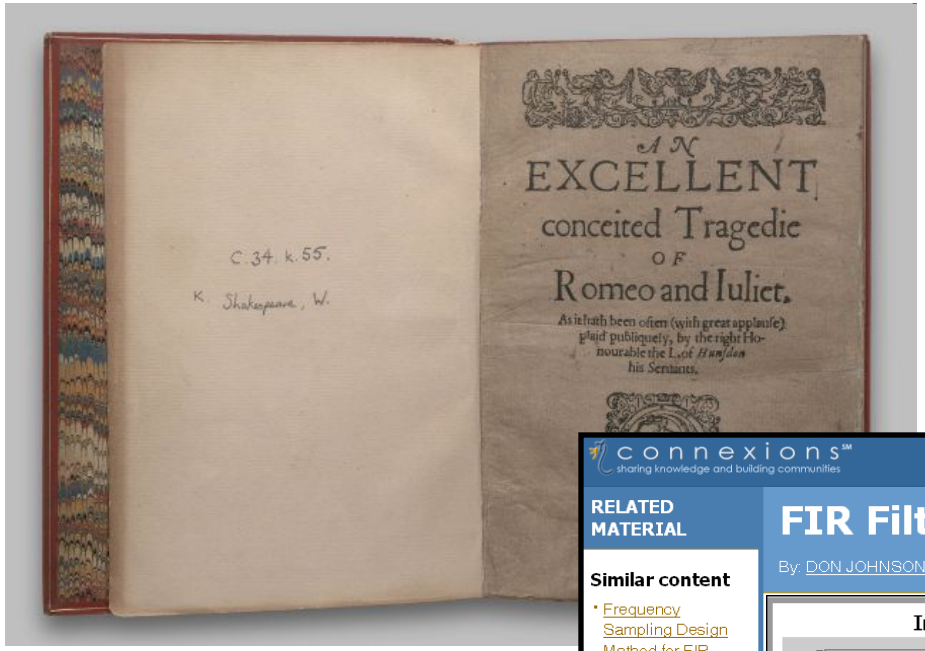



Camtasia Studio
TechSmith

- Out-of-class videos put to good use by increasing number of SP instructors
  - Yoder/Padgett/Doering at Rose Hulman
  - Geoffrey Hermann at UIUC
- Distance learning, time savings for training, "reversed instruction" …

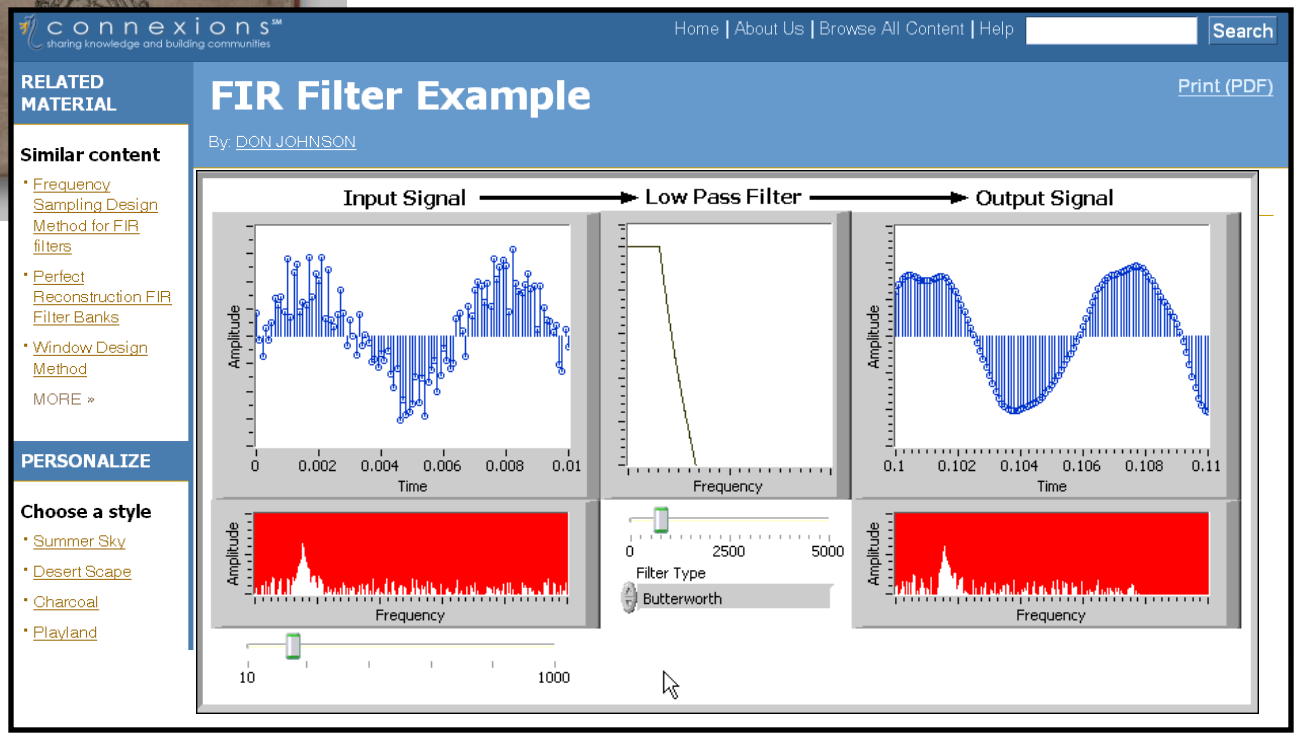

Interactive
Simulations

# interactivity

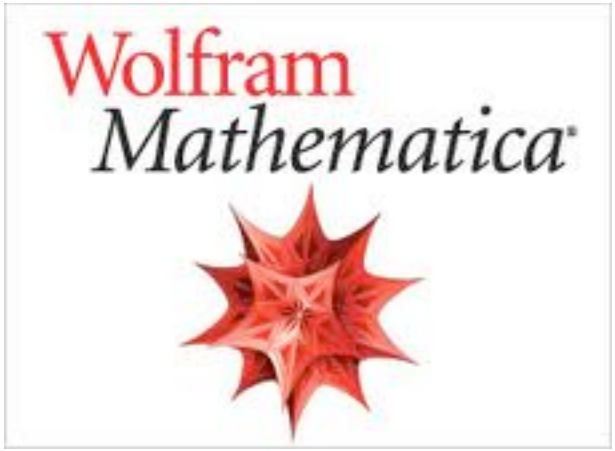


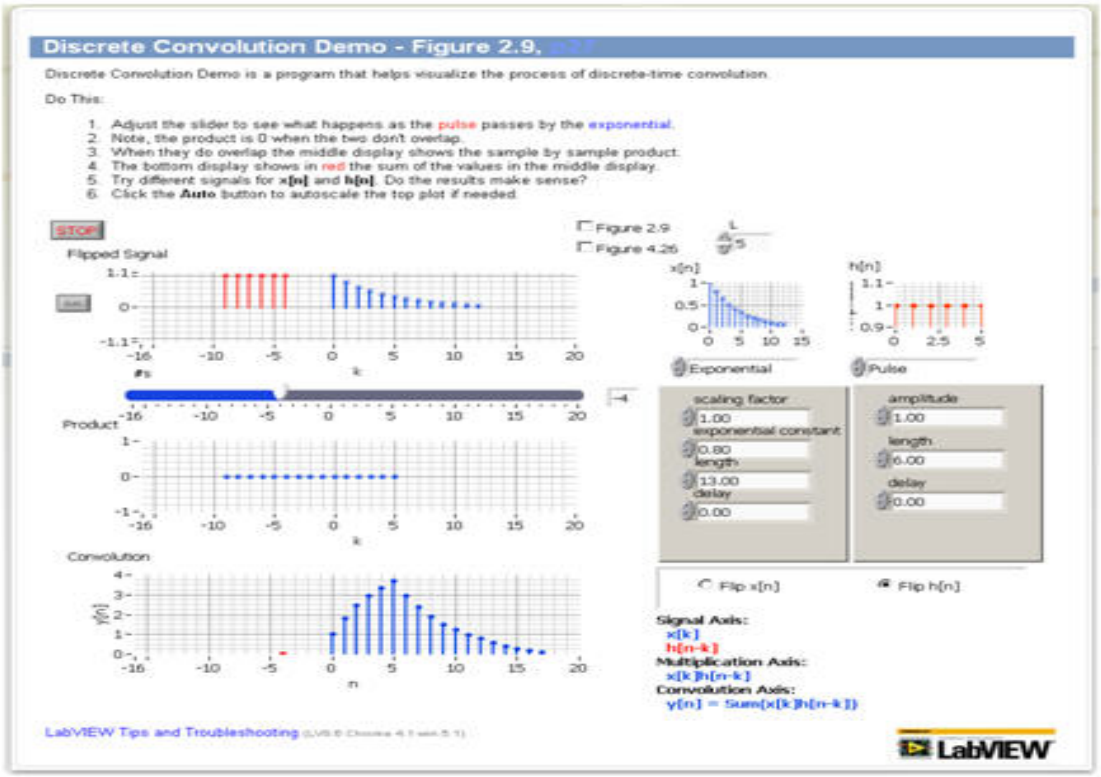

see

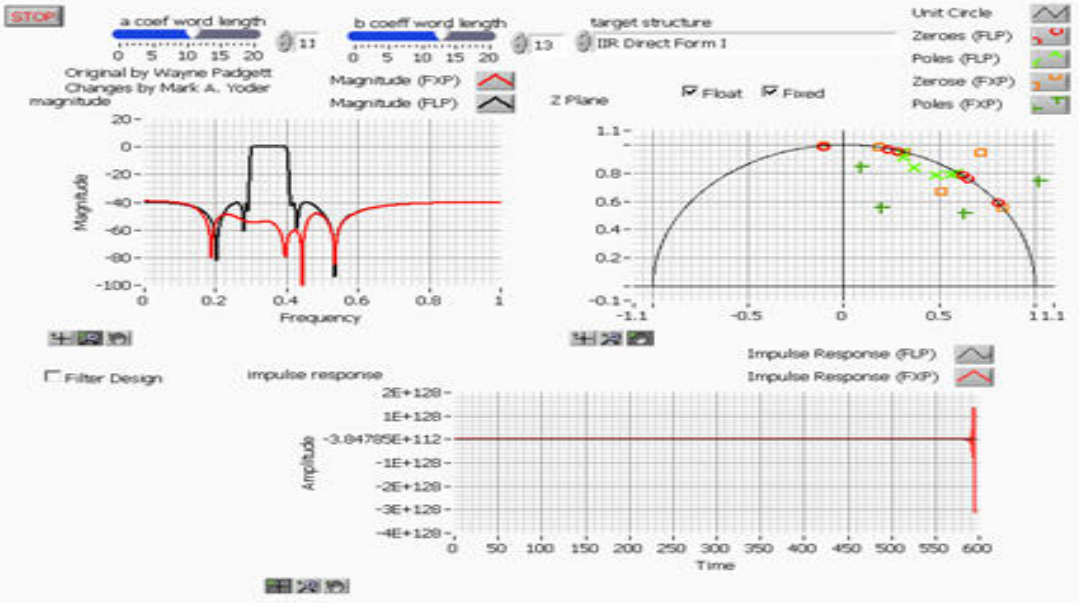
do



# a few simulation platforms




Discrete Convolution Demo - Figure 2.9,
Discrete Convolution Demo is a program that helps visualize the process of discrete-time convolution.
Do This:
1. Adjust the slider to see what happens as the pulse passes by the exponential.
2. Note, the product is 0 when the two don't overlap.
3. When they do overlap the middle display shows the sample by sample product.
4. The bottom display shows in red the sum of the values in the middle display.
5. Try different signals for x[n] and h[n]. Do the results make sense?
6. Click the Auto button to autoscale the top plot if needed.
STOP
Figure 2.9
Figure 4.26
Flipped Signal
Product
Convolution
x[n]
h[n]
Exponential
Pulse
scaling factor
1.00
exponential constant
0.80
length
13.00
delay
0.00
amplitude
1.00
length
6.00
delay
0.00
Flip x[n]
Flip h[n]
Signal Axis:
x[k]
h[n-k]
Multiplication Axis:
x[k]h[n-k]
Convolution Axis:
y[n] = Sum(x[k]h[n-k])
LabVIEW Tips and Troubleshooting
LabVIEW


STOP
a coef word length
b coeff word length
target structure
IIR Direct Form I
Original by Wayne Padgett
Changes by Mark A. Yoder
Magnitude (FXP)
Magnitude (FLP)
magnitude
Frequency
Z Plane
Float
Fixed
Unit Circle
Zeroes (FLP)
Poles (FLP)
Zeroes (FXP)
Poles (FXP)
Filter Design
impulse response
Impulse Response (FLP)
Impulse Response (FXP)
Amplitude
Time

Question
and
Answer
Databases

# Q/A databases

- For self-assessment, automated homework, …
- Signal Processing Question and Response (SPQR) system at Georgia Tech: **>999 solved problems**
- Question/Answer data base (QuADbase) at Rice
- QTI markup compatible with learning management systems and Connexions: import/export questions
- Track student performance through courses and across curricula versus concepts
- Under development: SP intelligent tutoring systems

# SPQR: its.vip.gatech.edu

| | Ch. 1 | Ch. 2 | Ch. 3 | Ch. 4 | Ch. 5 | Ch. 6 | Ch. 7 | Ch. 8 | Ch. 9 | Ch. 10 | Ch. 11 | Ch. 12 | Ch. 13 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Score | 0 pts | 0 pts | 0 pts | 0 pts | 215 pts | 893.33 pts | 100 pts | 1166.67 pts | 0 pts | 0 pts | 0 pts | 0 pts | 0 pts | 2375 pts |
| Percentage | 0 % | 0 % | 0 % | 0 % | 35.83 % | 89.33 % | 50 % | 89.74 % | 0 % | 0 % | 0 % | 0 % | 0 % | 76.61 % |
| Attempted/Available Questions | 0 / 15 | 0 / 39 | 0 / 33 | 0 / 23 | 6 / 31 | 10 / 28 | 2 / 40 | 13 / 19 | 0 / 13 | 0 / 2 | 0 / 0 | 0 / 0 | 0 / 0 | 31 / 243 |

CHAPTER 1 2 3 4 5 6 7 8 9 10 11 12 13

**Questions:** Chapter 7

**Review:** Chapter 8

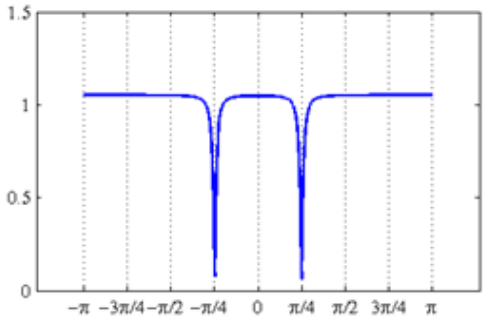
<

| qid | type |
|---|---|
| 1222 | mc |

>

5. An ECG device (in Europe) must remove 50-Hz interference. Suppose that this is done with a digital IIR notch filter whose frequency response is shown in the figure.

Determine the sampling frequency used when the ECG was recorded.




A. $f_s$ = 100 Hz
B. $f_s$ = 400 Hz
C. $f_s$ = 800 Hz
D. $f_s$ = 1200 Hz
E. $f_s$ = 8000 Hz

| ANSWER | B Correct |
|---|---|
| SCORE | 100 |

ITS v.128a • admin

Revisions • eDSPFirst • Spring 2010 Survey • Questions • Profiles • DATA

# QuADbase

QUAD BASE

Welcome, Richard Sign out

Write a question! | Find questions | Workspaces | Messages | Account | Help

*q. 7, unpublished*

Show Source

Edit Question

Edit Roles

Publish...

Delete Question

Consider the continuous-time signal $x(t) = \cos(8t) + 5\sin(16t) + 2e^{j4t} + 5$.

What is the period $T$ of $x(t)$? (i.e., find the smallest $T$ such that $x(t + kT) = x(t)$, where $k$ is any integer)

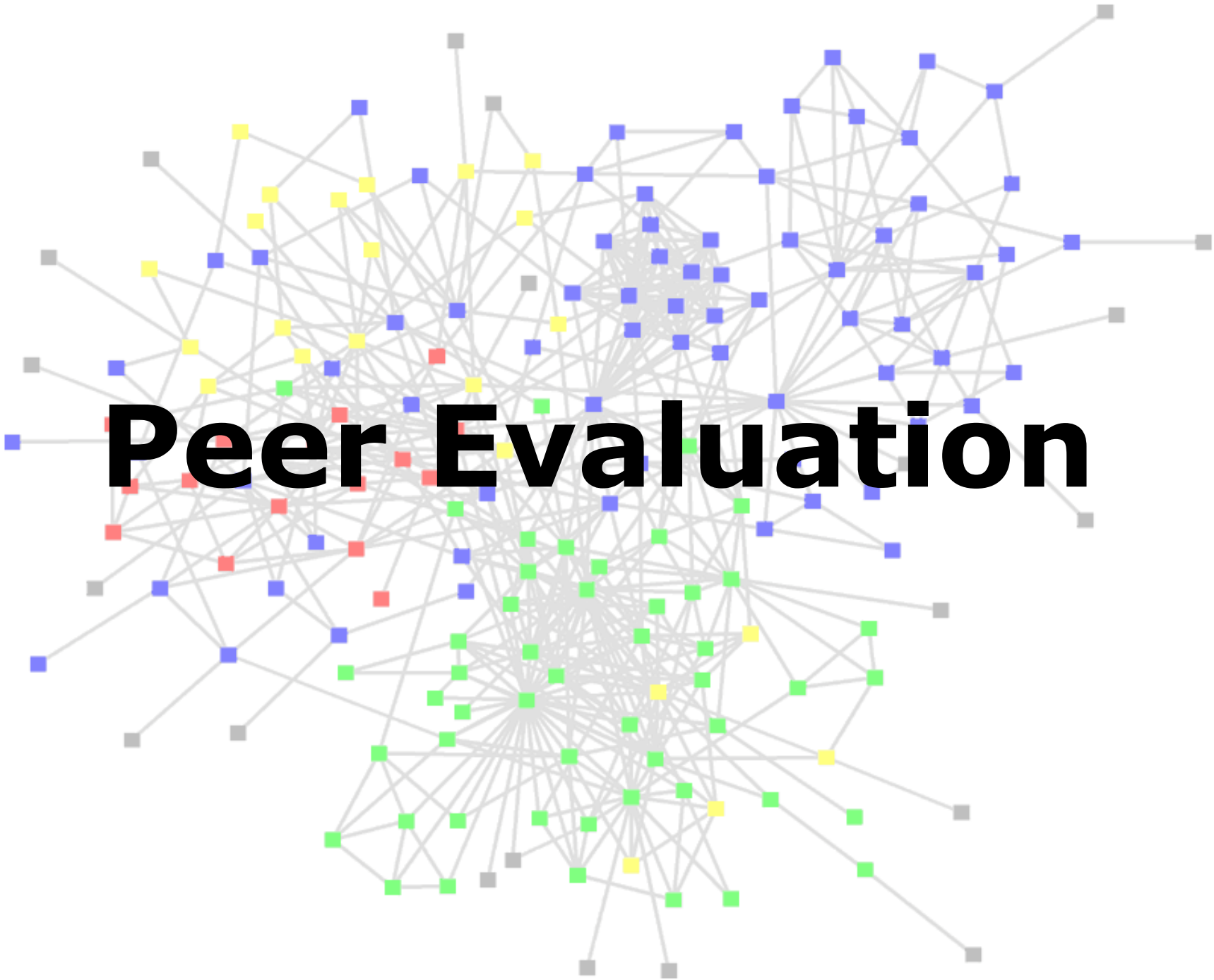
**a)** $\frac{2\pi}{4}$

**b)** $\frac{2\pi}{8}$

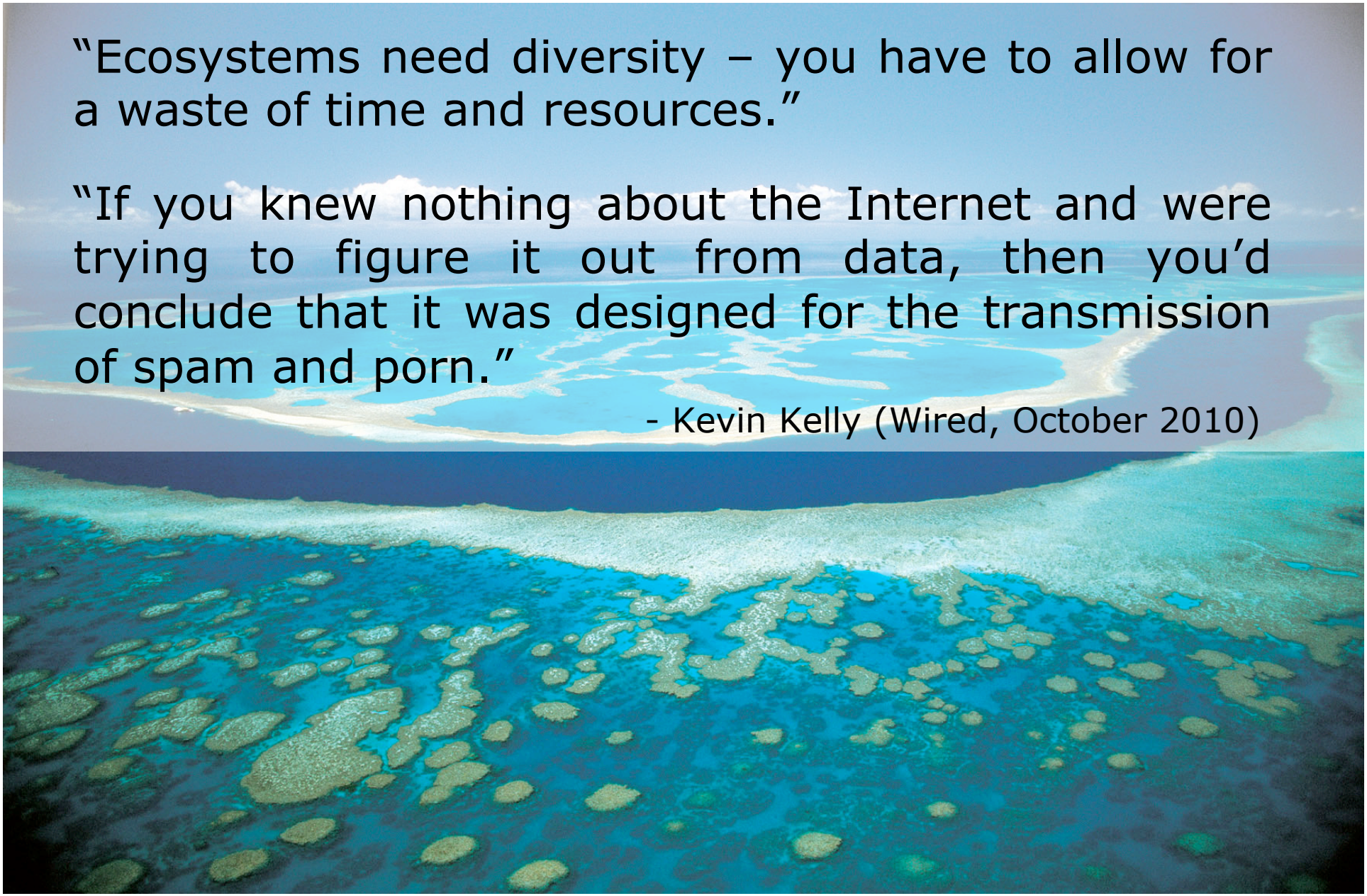
**c)** 4

**d)** none of the above

© Richard Baraniuk. Licensed under CC-BY 3.0.


Peer Evaluation

# diversity



"Ecosystems need diversity – you have to allow for a waste of time and resources."

"If you knew nothing about the Internet and were trying to figure it out from data, then you'd conclude that it was designed for the transmission of spam and porn."

- Kevin Kelly (Wired, October 2010)

# quality control

**must be *scalable***

# lenses

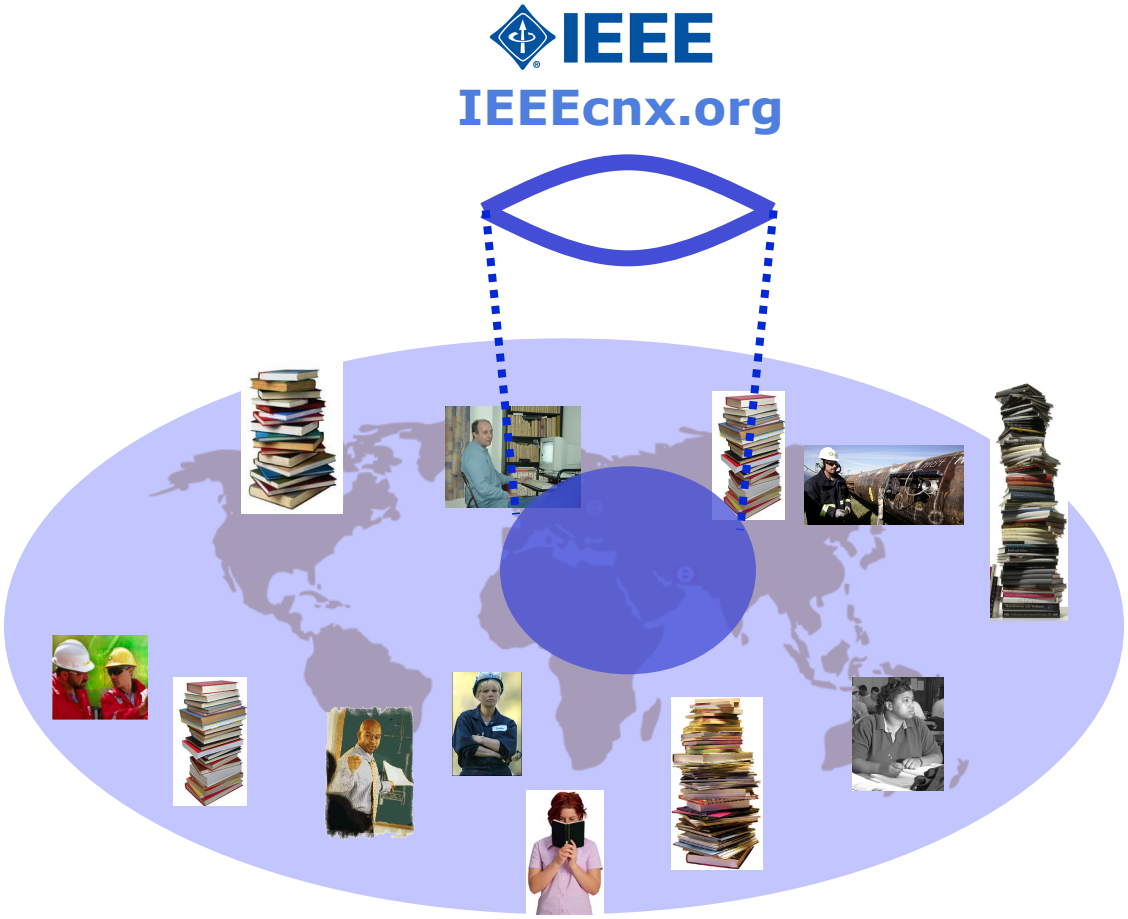
## social software for quality control

inspiration: del.icio.us social bookmarking

# lenses

## social software for quality control

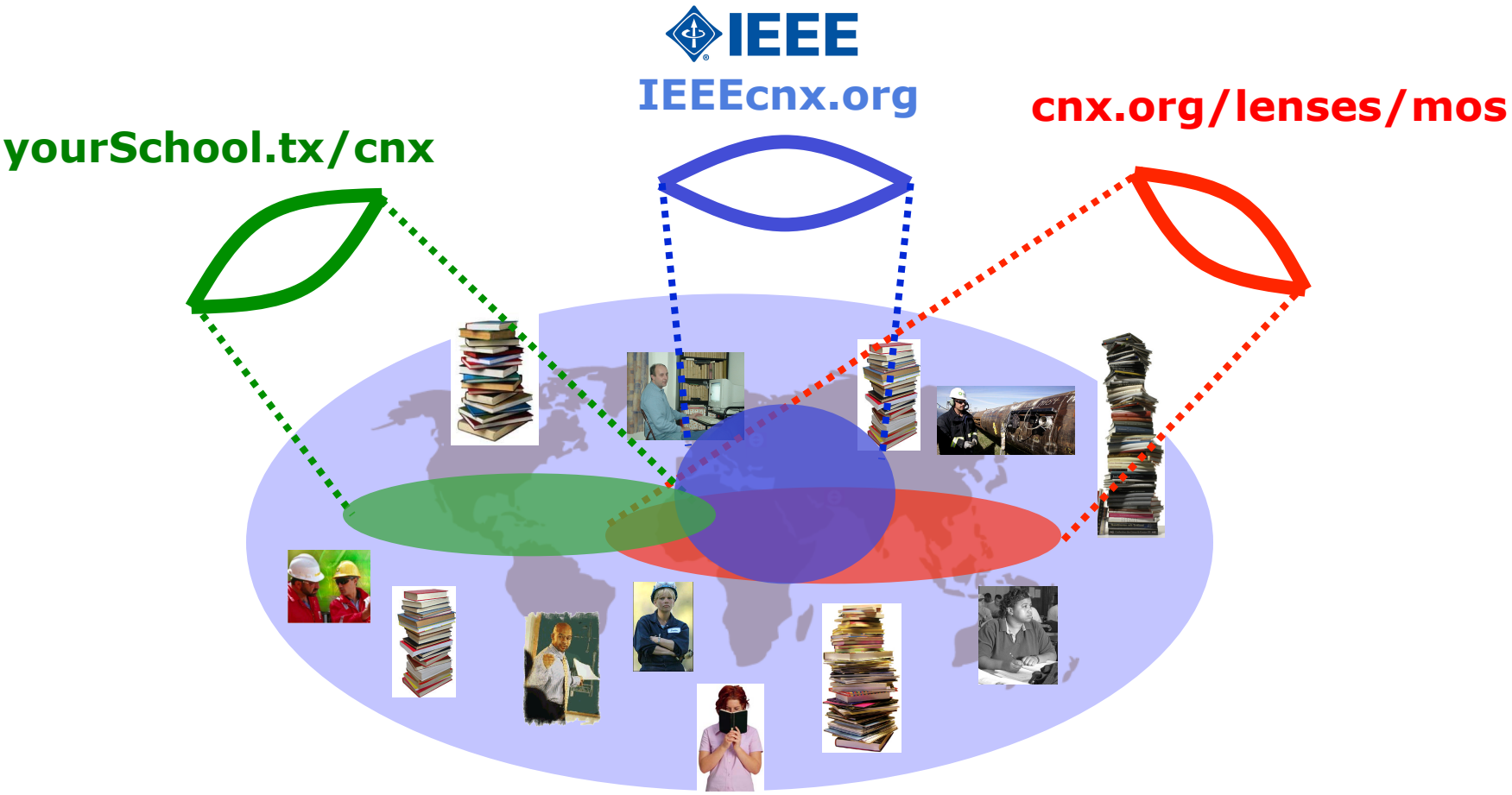
inspiration: del.icio.us social bookmarking



# lenses

## social software for quality control

inspiration: del.icio.us social bookmarking



RICE

TABLE OF CONTENTS

Detection Theory Basics
Detection Performance Criteria
Detection of Signals in Noise
Beyond the Basics

LENSES

What is a lens?

This content is ...

Endorsed by (?)
- IEEE-SPS

Affiliated with (?)
- Rice Digital Scholarship

Also in these lenses
- Evowl
- Lens for Engineering

RELATED MATERIAL

Similar content
- Analog Signal Processing Problems
- Signals and Systems
- Collaborative Statistics (with edits: Teegarden)

More »

RECENTLY VIEWED

Add to Favorites | Add to a lens | Reuse / Edit | Download | Print this page

INSIDE COLLECTION:
Elements of Detection Theory
Collection by: Don Johnson. E-mail the author

Order printed collection

« Previous | Next »

# Detection of Signals in Noise

**Module by:** Don Johnson. E-mail the author

**Based on:** White Gaussian Noise by Don Johnson

**User rating** (?): ☆☆☆☆☆ (0 ratings)

**Summary:** Detection theory is specialized to the most common decision problem that occurs in signal processing: determining which signal was received in the presence of additive noise.

Far and away the most common decision problem in signal processing is determining which of several signals occurs in data contaminated by additive noise. Specializing to the case when one of two possible of signals is present, the data models are

- $\mathcal{M}_0 : R(l) = s_0(l) + N(l), 0 \leq l < L$
- $\mathcal{M}_1 : R(l) = s_1(l) + N(l), 0 \leq l < L$

where $\{s_i(l)\}$ denotes the known signals and $N(l)$ denotes additive noise modeled as a stationary stochastic process. This situation is known as the **binary detection problem**: distinguish between two possible signals present in a noisy waveform.

We form the discrete-time observations into a vector: $\boldsymbol{R} = (R(0), \ldots, R(L-1))^T$. Now the models become

- $\mathcal{M}_0 : \boldsymbol{R} = \boldsymbol{s}_0 + \boldsymbol{N}$
- $\mathcal{M}_1 : \boldsymbol{R} = \boldsymbol{s}_1 + \boldsymbol{N}$

To apply our detection theory results, we need the probability density of $\boldsymbol{R}$ under each model. As the only probabilistic component of the observations is the noise, the required density for the detection problem is given by

$$\mathrm{p}_{\boldsymbol{R}|\mathcal{M}_i}(\boldsymbol{r}) = \mathrm{p}_{\boldsymbol{N}}(\boldsymbol{r} - \boldsymbol{s}_i)$$

and the corresponding likelihood ratio by

$$\Lambda(\boldsymbol{r}) = \frac{\mathrm{p}_{\boldsymbol{N}}(\boldsymbol{r} - \boldsymbol{s}_1)}{\mathrm{p}_{\boldsymbol{N}}(\boldsymbol{r} - \boldsymbol{s}_0)}$$

TABLE OF CONTENTS

Detection Theory Basics
Detection Performance Criteria
Detection of Signals in Noise
Beyond the Basics

LENSES

What is a lens?

This content is ...

Endorsed by (?)

- IEEE-SPS

Affiliated with (?)

- Rice Digital Scholarship

Also in these lenses

- Evowl
- Lens for Engineering

RELATED MATERIAL

Similar content

- Analog Signal Processing Problems
- Signals and Systems
- Collaborative Statistics (with edits: Teegarden)

More »

RECENTLY VIEWED

# Detection of Signals in Noise

**Module by:** Don Johnson. E-mail the author

**Based on:** White Gaussian Noise by Don Johnson

**User rating** (?): ☆☆☆☆☆ (0 ratings)

**Summary:** Detection theory is specialized to the most common decision problem that occurs in signal processing: determining which signal was received in the presence of additive noise.

Far and away the most common decision problem in signal processing is determining which of several signals occurs in data contaminated by additive noise. Specializing to the case when one of two possible of signals is present, the data models are

- $\mathcal{M}_0 : R(l) = s_0(l) + N(l), 0 \leq l < L$
- $\mathcal{M}_1 : R(l) = s_1(l) + N(l), 0 \leq l < L$

where $\{s_i(l)\}$ denotes the known signals and $N(l)$ denotes additive noise modeled as a stationary stochastic process. This situation is known as the **binary detection problem**: distinguish between two possible signals present in a noisy waveform.

We form the discrete-time observations into a vector: $\boldsymbol{R} = (R(0), \ldots, R(L-1))^T$. Now the models become

- $\mathcal{M}_0 : \boldsymbol{R} = \boldsymbol{s}_0 + \boldsymbol{N}$
- $\mathcal{M}_1 : \boldsymbol{R} = \boldsymbol{s}_1 + \boldsymbol{N}$

To apply our detection theory results, we need the probability density of $\boldsymbol{R}$ under each model. As the only probabilistic component of the observations is the noise, the required density for the detection problem is given by

$$\mathrm{p}_{\boldsymbol{R}|\mathcal{M}_i}(\boldsymbol{r}) = \mathrm{p}_{\boldsymbol{N}}(\boldsymbol{r} - \boldsymbol{s}_i)$$

and the corresponding likelihood ratio by

$$\Lambda(\boldsymbol{r}) = \frac{\mathrm{p}_{\boldsymbol{N}}(\boldsymbol{r} - \boldsymbol{s}_1)}{\mathrm{p}_{\boldsymbol{N}}(\boldsymbol{r} - \boldsymbol{s}_0)}$$

**PUBLIC LENSES**

All lenses

- Endorsements (13)
- Affiliations (23)
- Member lists (93)

What's a Lens?

**TAGS**

Select a tag to narrow the contents of this lens.

SISO code manifold classification Golay bound wavelets detection approximation learning regression echo delay regularization statistics compression space response besov reduction music speech decsion synthesis noise theory Vapnik-Chervonenkis comb processing LabVIEW dimensionality compressed impulse line sieve likelihood smoothness Fourier dcwill chirp hoeffding signal maximum filter sparsity complexity inequality chernoff embedding time spectrogram reverb sensing

**RECENTLY VIEWED**

**Collections**

Signals and Systems

**Modules**

Collaborative Statistics: Adoption

# IEEE Signal Processing Society Lens

**Lens by:** IEEE Signal Processing Society

The IEEE Signal Processing Society (SPS) is an international organization that aims to advance and disseminate state-of-the-art scientific information and resources; educate the signal processing community; and provide a venue for people to interact and exchange ideas. The materials in this lens have been carefully evaluated by the IEEE-SPS and found to be of high quality and relevant for anyone interested in signal processing. All of these materials are available for free access by anyone, anywhere, at any time. Contributions are welcome from all; visit www.IEEEcnx.org for more details on how to submit your materials for evaluation.

Visit Web page for IEEE-SPS

## Endorsed content (what's this?)

13 collections and 1 module

(What are modules and collections?)

Sort by: Type Results per page: 10

View: **Lens** | Detail | Compact | Statistics [1] 2 Next 4 »

### Analog-to-Digital Conversion (col10578)

**Author:** Don Johnson
**Lens Tags:** dcwill
**Lens Comments:** Language: en

### Concise Signal Models (col10635)

**Author:** Michael Wakin
**Lens Tags:** sparsity compression manifold approximation dimensionality reduction compressed sensing
**Lens Comments:** A resource on sparse, compressible, and manifold signal models for signals processing and compressed sensing.

### Elements of Detection Theory (col10531)

**Author:** Don Johnson
**Lens Tags:** signal processing detection signal noise
**Lens Comments:** An introduction to detection theory and performance characterization.

### Factoring Polynomials of High Degree (col10494)

**Author:** C. Sidney Burrus
**Lens Tags:** dcwill
**Lens Comments:** Language: en Supporting Agencies: The Polynomial Club, Rice University

### A First Course in Electrical and Computer Engineering (col10685)

**Author:** Louis Scharf

**PUBLIC LENSES**

All lenses

- Endorsements (13)
- Affiliations (23)
- Member lists (93)

What's a Lens?

**TAGS**

Select a tag to narrow the contents of this lens.

SISO code manifold classification Golay bound wavelets detection approximation learning regression echo delay regularization statistics compression space response besov reduction music speech decsion synthesis noise theory Vapnik-Chervonenkis comb processing LabVIEW dimensionality compressed impulse line sieve likelihood smoothness Fourier dcwill chirp hoeffding signal maximum filter sparsity complexity inequality chernoff embedding time spectrogram reverb sensing

**RECENTLY VIEWED**

**Collections**

Signals and Systems

**Modules**

Collaborative Statistics: Adoption

# IEEE Signal Processing Society Lens

**Lens by:** IEEE Signal Processing Society

The IEEE Signal Processing Society (SPS) is an international organization that aims to advance and disseminate state-of-the-art scientific information and resources; educate the signal processing community; and provide a venue for people to interact and exchange ideas. The materials in this lens have been carefully evaluated by the IEEE-SPS and found to be of high quality and relevant for anyone interested in signal processing. All of these materials are available for free access by anyone, anywhere, at any time. Contributions are welcome from all; visit www.IEEEcnx.org for more details on how to submit your materials for evaluation.

Visit Web page for IEEE-SPS

## Endorsed content (what's this?)

13 collections and 1 module

(What are modules and collections?)

Sort by: Type Results per page: 10

View: **Lens** | Detail | Compact | Statistics [1] 2 Next 4 »

### Analog-to-Digital Conversion (col10578)

**Author:** Don Johnson
**Lens Tags:** dcwill
**Lens Comments:** Language: en

### Concise Signal Models (col10635)

**Author:** Michael Wakin
**Lens Tags:** sparsity compression manifold approximation dimensionality reduction compressed sensing
**Lens Comments:** A resource on sparse, compressible, and manifold signal models for signals processing and compressed sensing.

### Elements of Detection Theory (col10531)

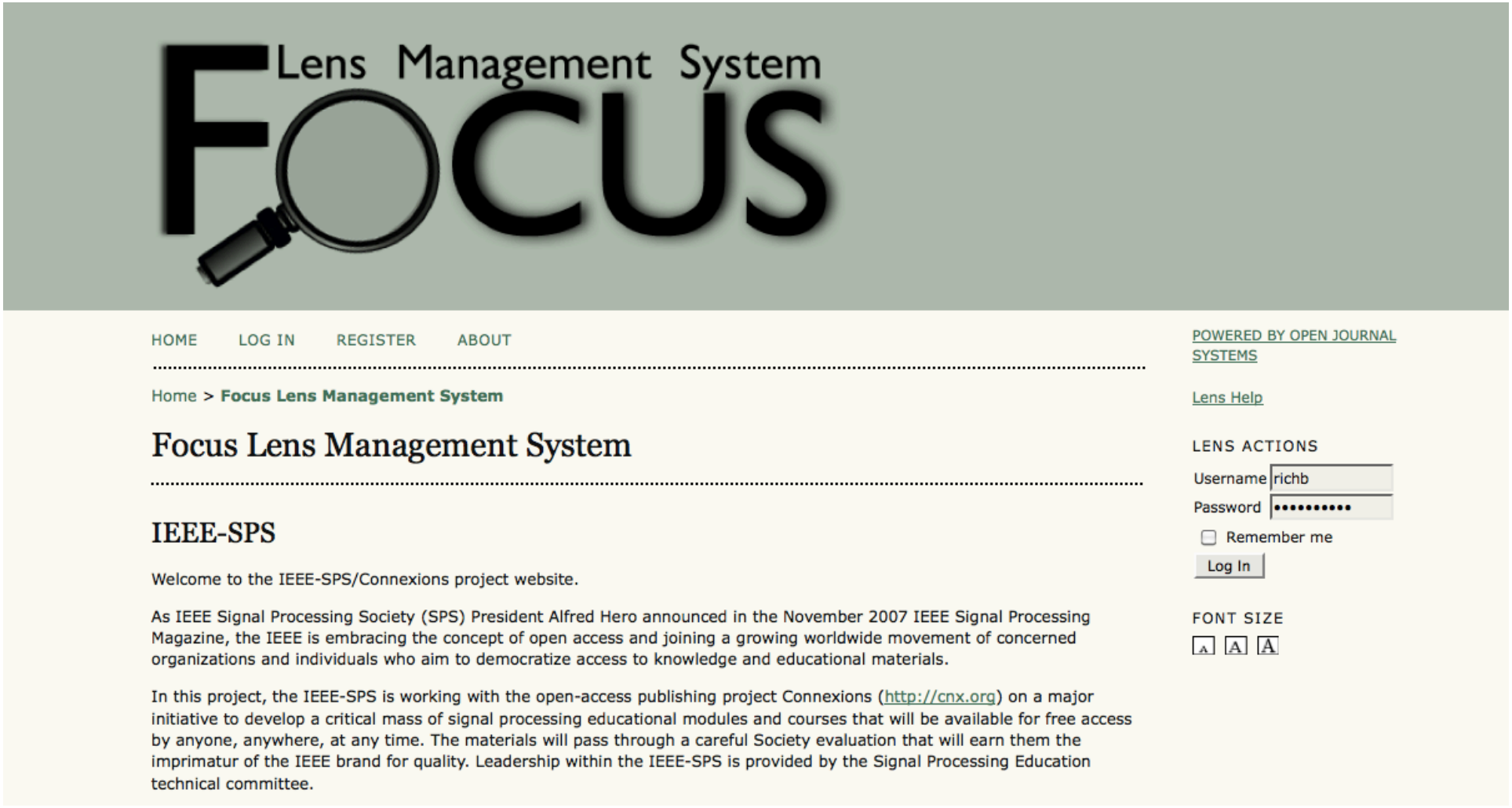
**Author:** Don Johnson
**Lens Tags:** signal processing detection signal noise
**Lens Comments:** An introduction to detection theory and performance characterization.

### Factoring Polynomials of High Degree (col10494)

**Author:** C. Sidney Burrus
**Lens Tags:** dcwill
**Lens Comments:** Language: en Supporting Agencies: The Polynomial Club, Rice University

### A First Course in Electrical and Computer Engineering (col10685)

**Author:** Louis Scharf

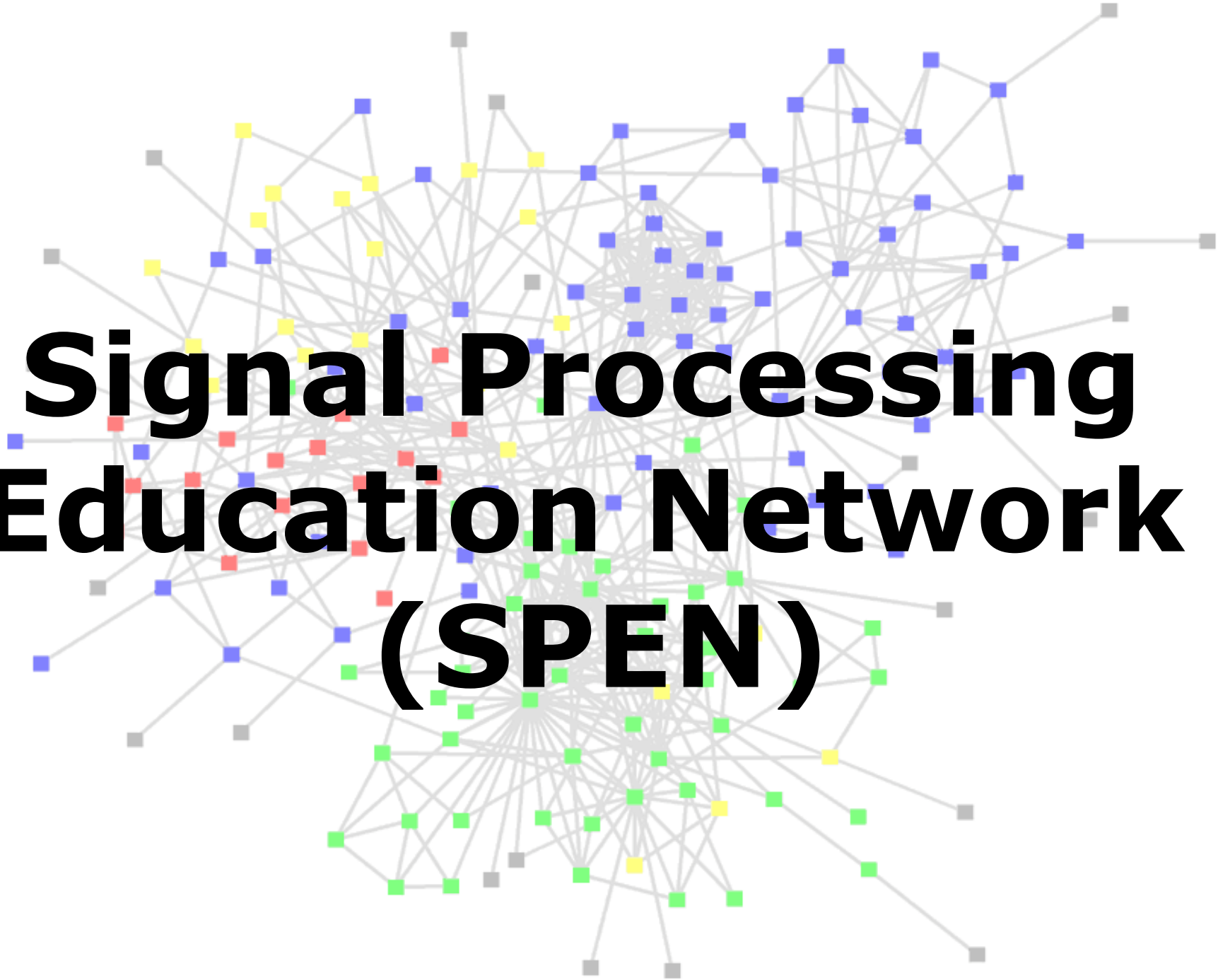



- administrative management system for the IEEE-SPS lens
- akin to Manuscript Central, etc.

# IEEE-SPS/CNX organization

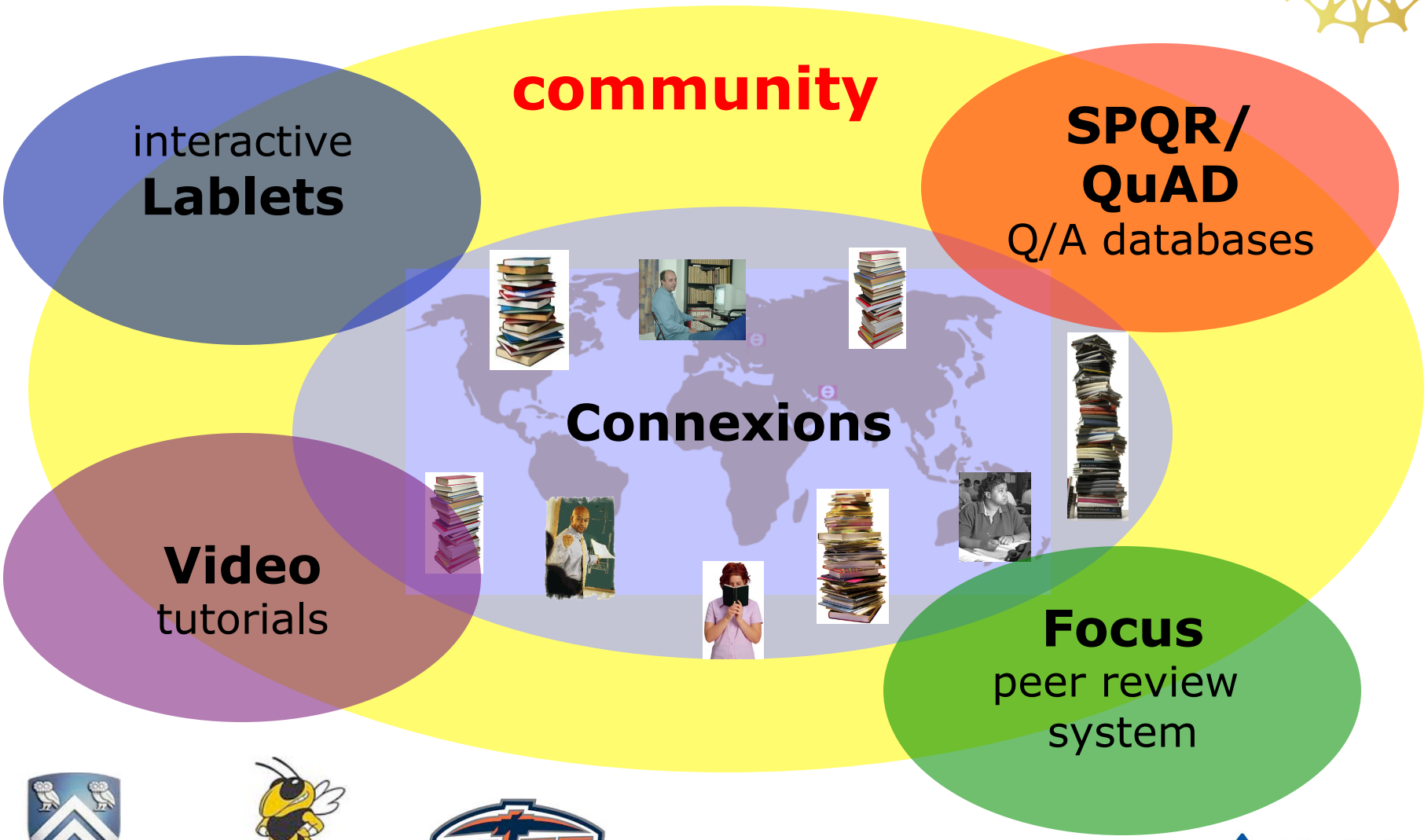
- Subcommittee of the SPED technical committee (akin to an "editorial board")

Roxana Saint-Nom (chair)
Richard Baraniuk
Sidney Burrus
Woon Seng Gan
Roger Green
Wayne Padgett
Bryan Usevitch
Douglas Williams
Mark Yoder



# Signal Processing Education Network (SPEN)

# sp education network




RICE GEORGIA TECH UTEP ROSE-HULMAN INSTITUTE OF TECHNOLOGY IEEE

# SPEN and beyond

- Get involved! **spenproject.org**
  - 2nd SPEN Workshop 20 September 2011 at Georgia Tech
  - contact richb@rice.edu for more info

- Contribute:
  - textbook/course/notes/lecture materials to Connexions
  - video tutorials
  - interactive simulations
  - questions/answers/feedback

- Volunteer as a peer evaluator for the IEEE-SPS lens **IEEEcnx.org**