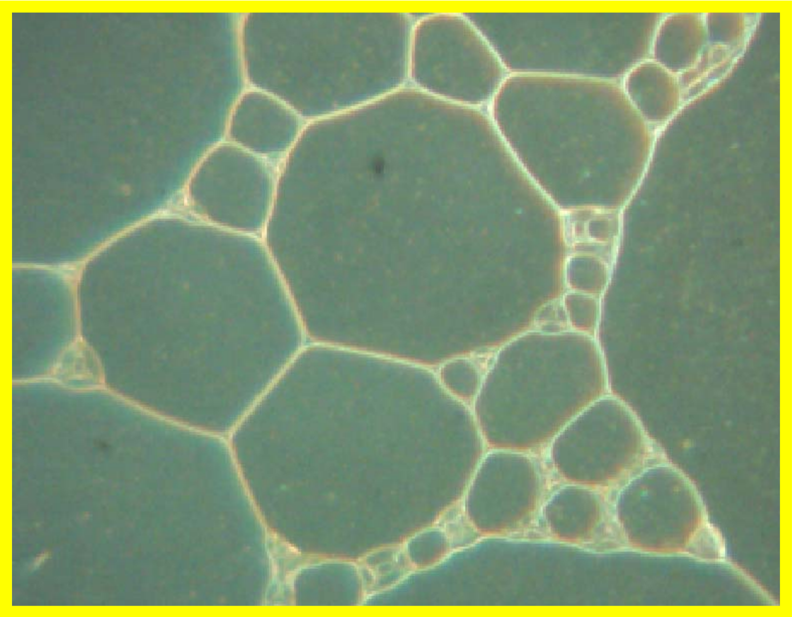
[A] Flow of viscoelastic materials

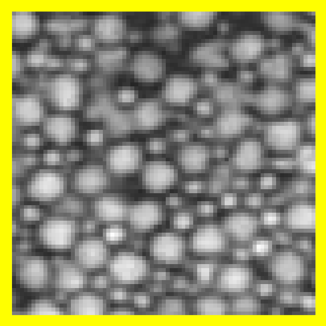
Xia Hong 洪霞, Xin Du 杜鑫, and Eric Weeks



Emulsions: liquid droplets in another immiscible liquid

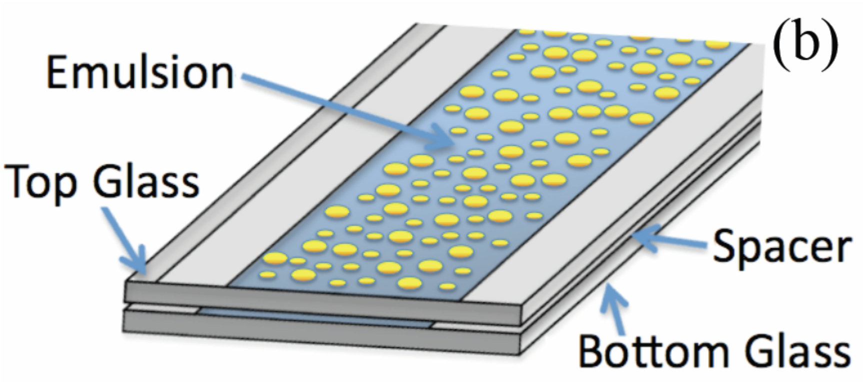
Foam: air bubbles in a liquid (with soap)

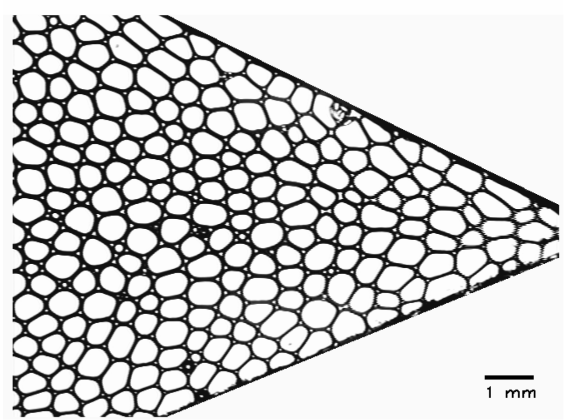
Colloids: solid particles in liquid



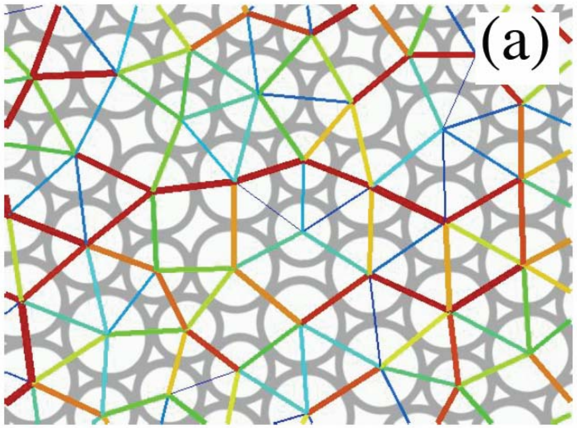
What you'll do in our module:

1. Make emulsion: oil droplets in water
2. Make sample chamber: many shapes possible





3. Image analysis to identify drops
4. Learn to measure flow profile
5. Study forces between droplets

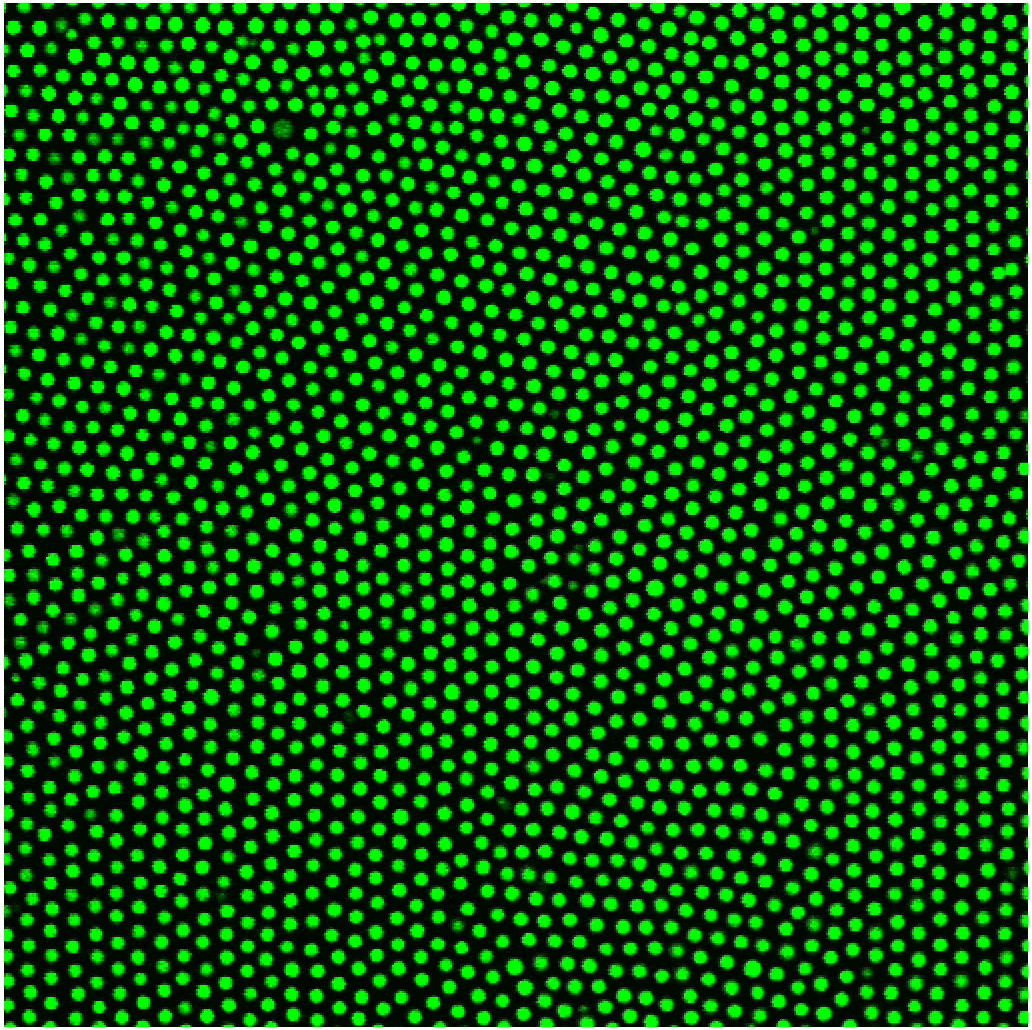


B (414)

Measuring normal modes in 2D colloidal systems

Lei Xu, Peng Tan
Physics Department
The Chinese University of Hong Kong

Motion of the colloids



Computing normal modes with covariance matrix method

- Constructing covariance matrix from particle tracking: $C_{i,j} = <[r_i(t) - <r_i(t)>][r_j(t) - <r_j(t)>]>$
  <>: time average, i,j : particle index

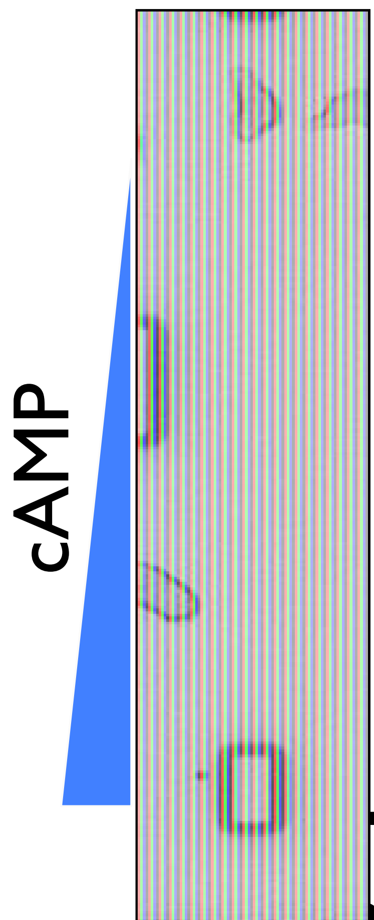
- Eigenvectors give normal modes, eigenvalues yield frequencies ω [1]: $\lambda = kT / m\omega^2$

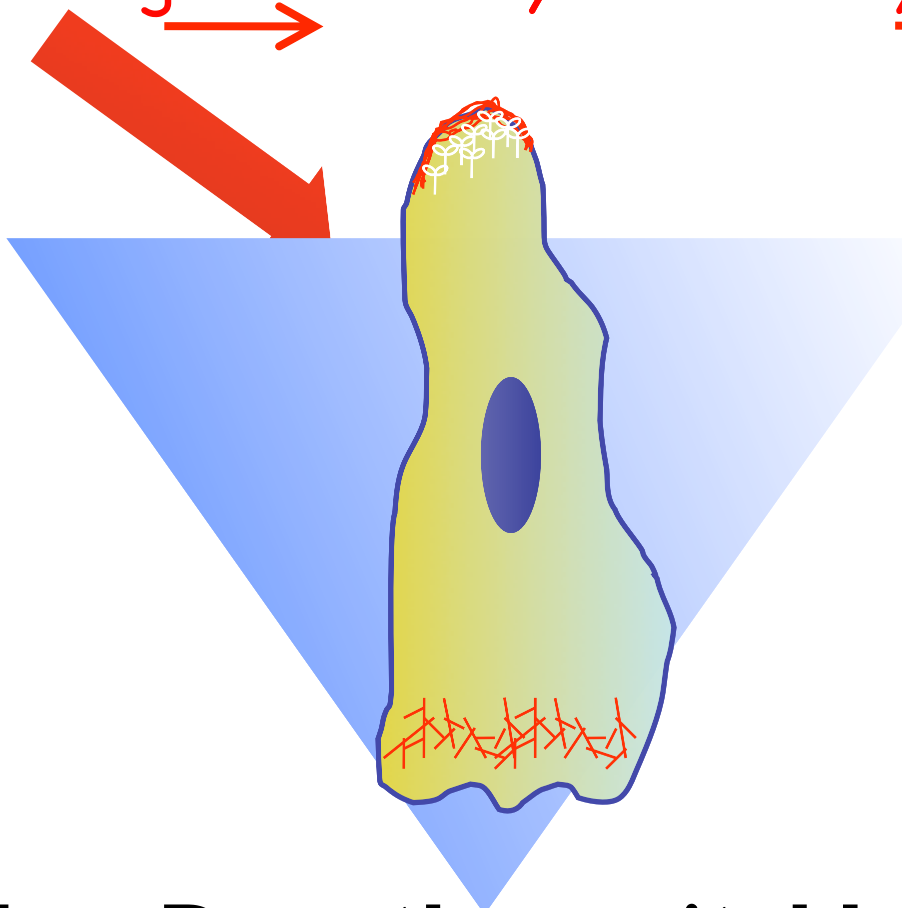
- Reveals normal modes at single-particle level.

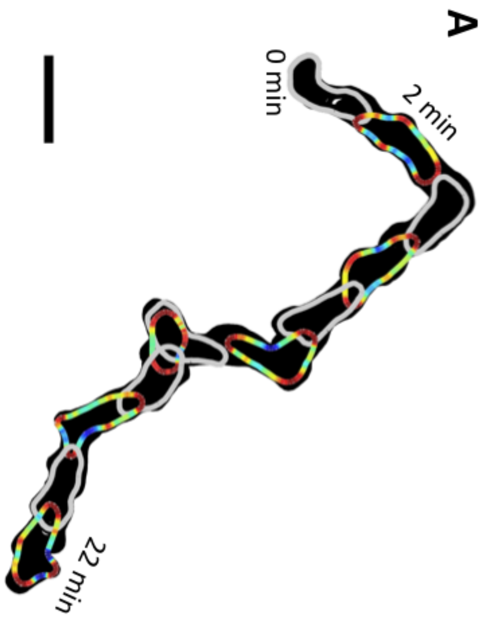
[1] Henkes, Brito, Dauchot, arXiv:1112.5412v1, 2011

Hands On Session C
Shape Analysis in Cell Migration

gradient sensing → Motility Machinery → chemotaxis

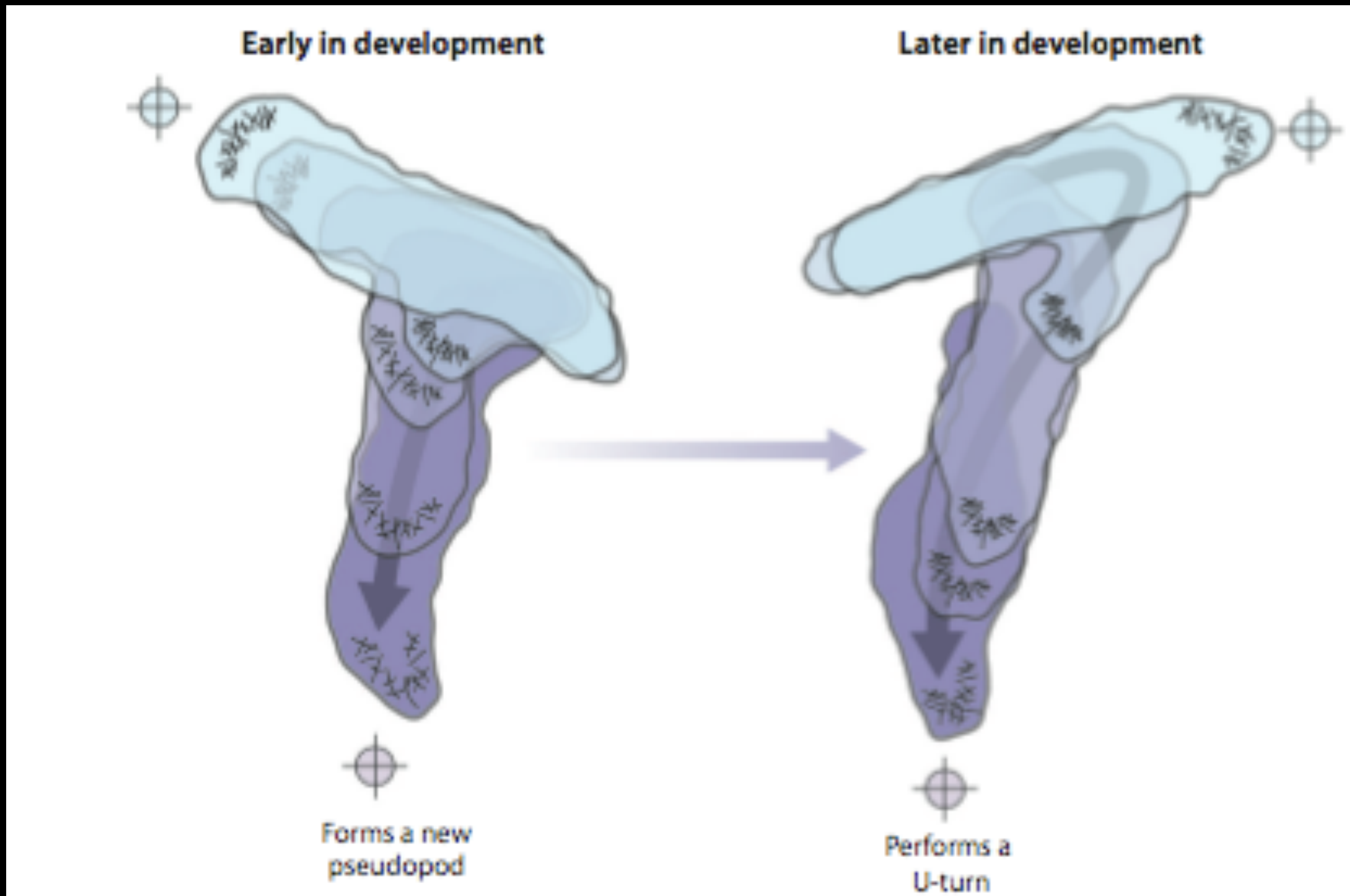






How Does the excitable cell “compass” connect with the cell “motor” ?

How does the cell turn around?



Over the course of the two weeks, we'll compare Wild Type to drug treated cells and hopefully gain understanding on how proteins influence the compass/motor connection

D

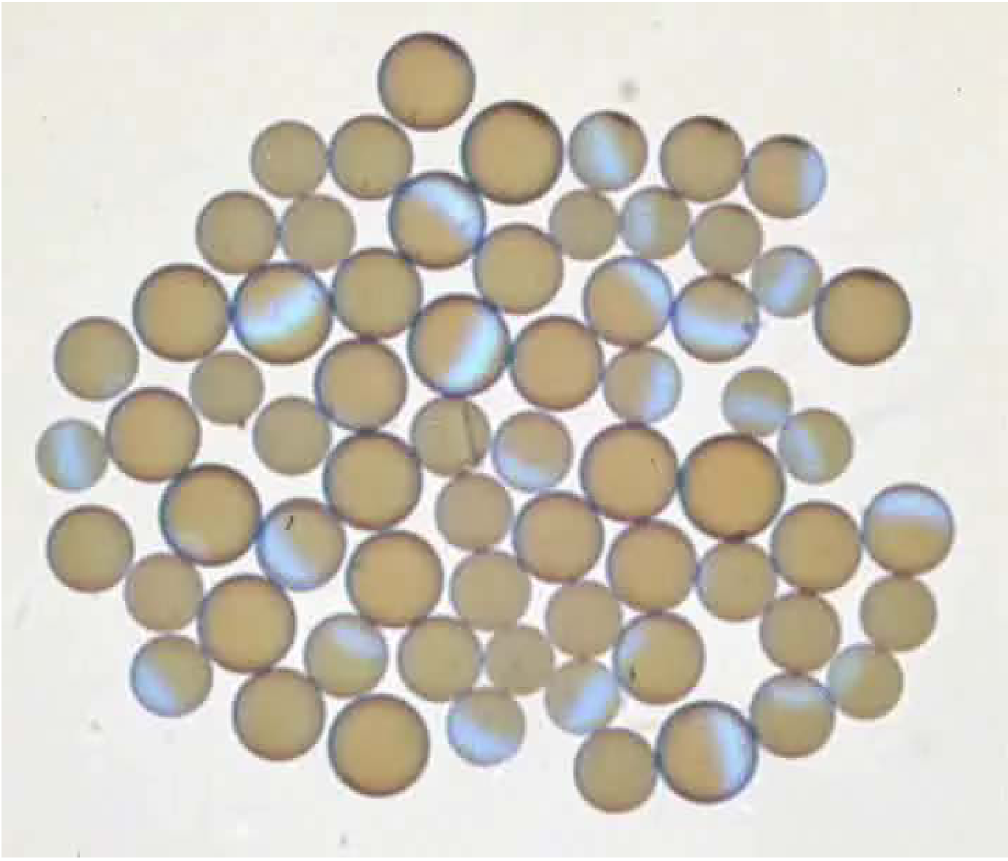
Synchronization of Coupled Chemical Oscillators

Mark Tinsley, Simba Nkomo, Ken Showalter

Experiment: Oscillatory catalyst-loaded micrometer particles in a catalyst-free Belousov-Zhabotinsky (BZ) reaction mixture.

Observable: Oscillations in the oxidation state of the catalyst on the particle surface; brown in the reduced state and blue in the oxidized state.

Coupling: Species produced during the oscillations ($HBrO_2$ and Br^-) diffuse into surrounding solution.



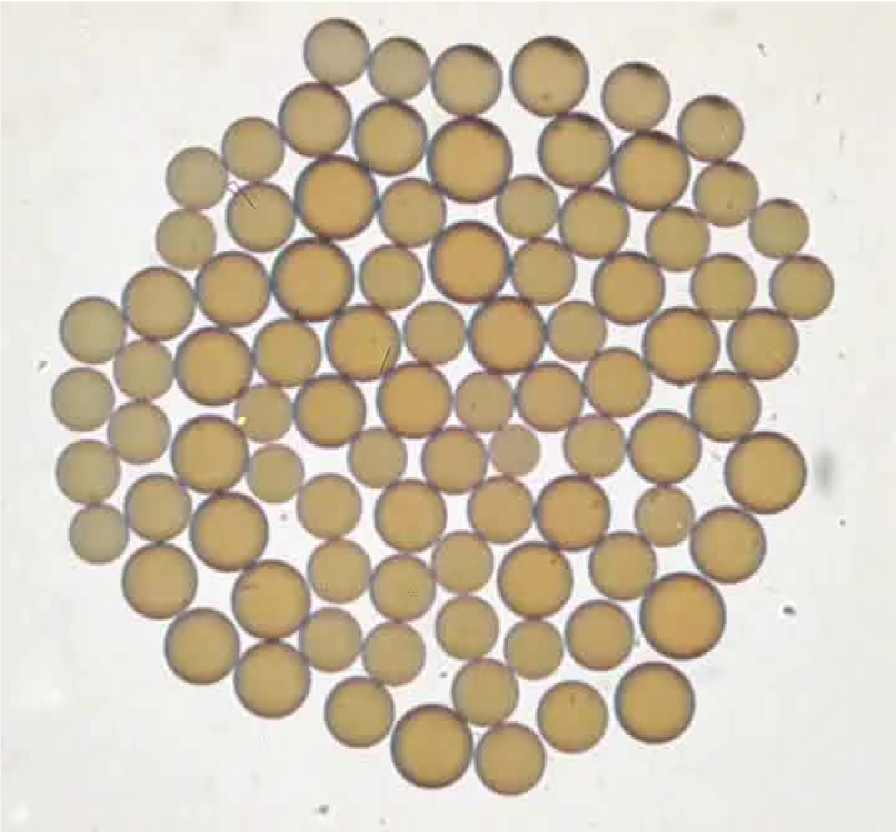
Synchronization:
Oscillations of one particle affect the oscillations of another particle through the $HBrO_2$ and Br^- coupling.

Synchronization of Coupled Excitable Particles

Below critical group size: Particles are in excitable steady state. Image analysis shows no activity.

Above critical group size: Entire collection of particles undergoes transition to spatiotemporal oscillations.

Control experiment: After determining critical group size, independent particles are checked for oscillatory behavior.

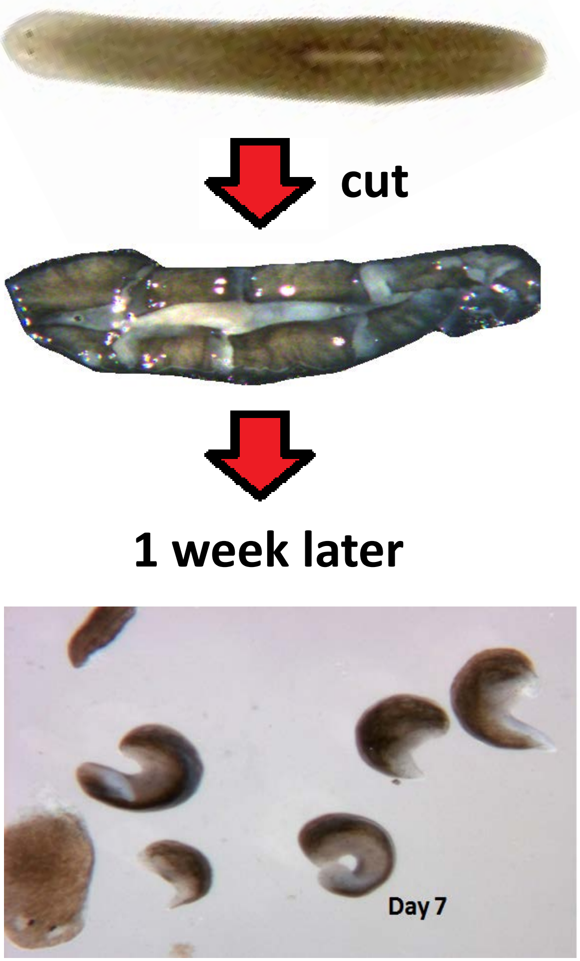


Prep system
Optimize video
Collect data
Data analysis
- I.D. Particle
- Frequency analysis
- Phase analysis
- Correlation analysis

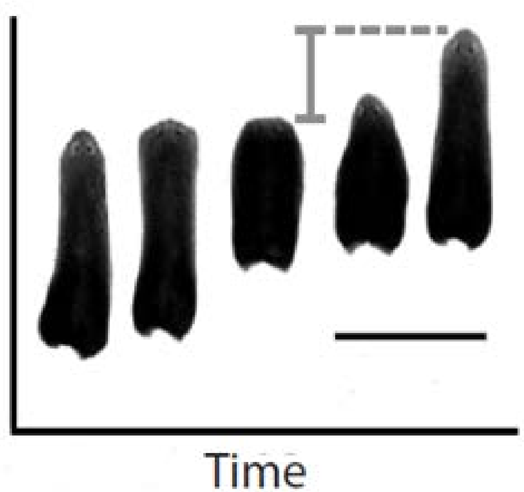
Mechanical oscillations in regeneration and locomotion

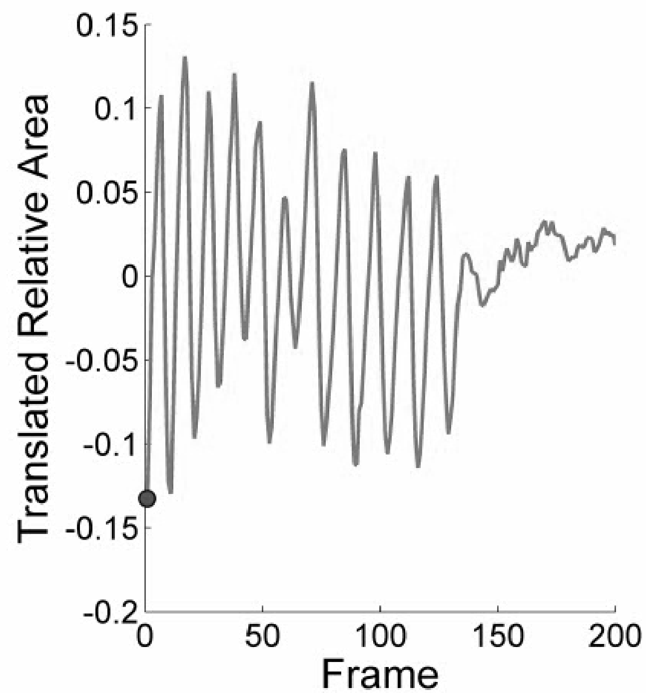
Session E

Planarians: masters of regeneration

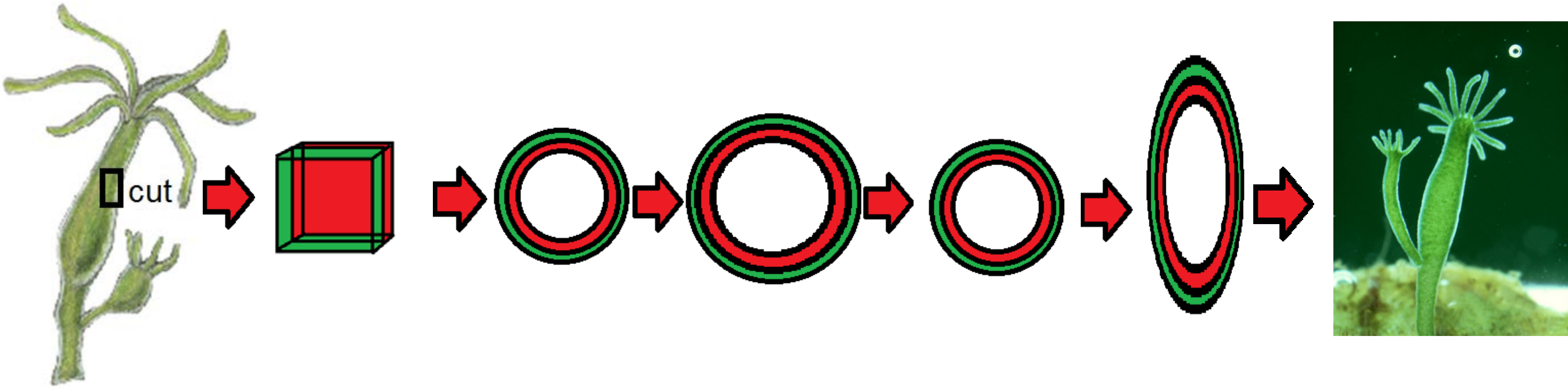


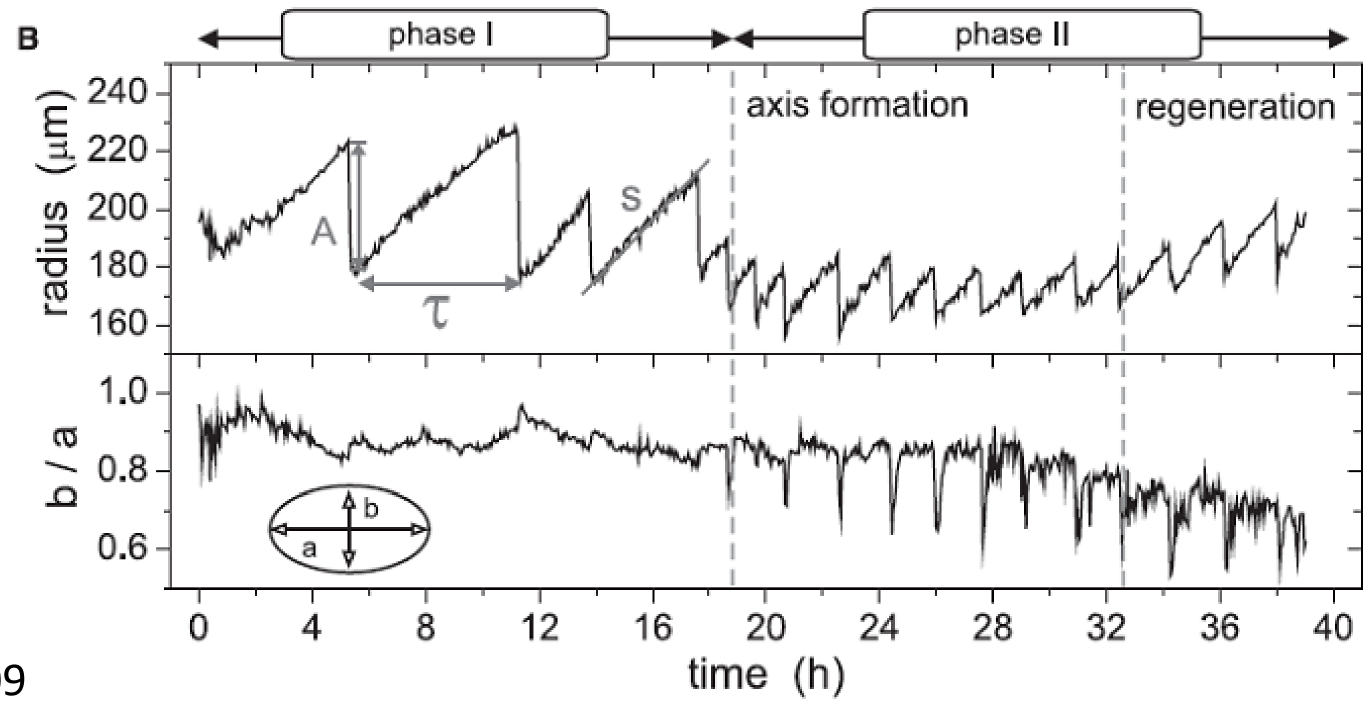
When stressed (cut), planarians start to inchworm





Oscillations in hydra regeneration



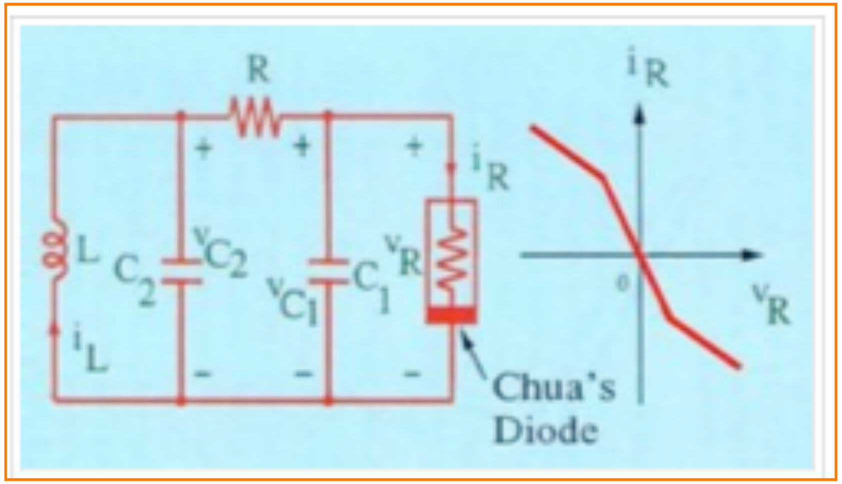


Soriano et al, 2009

Hands_on session-F (Room # 404)
on
Dynamics of Nonlinear Electronic Circuits

Gautam Sethia and Mitesh Patel

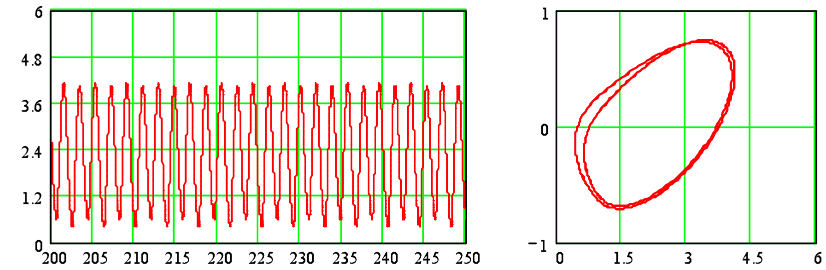
Chua circuit



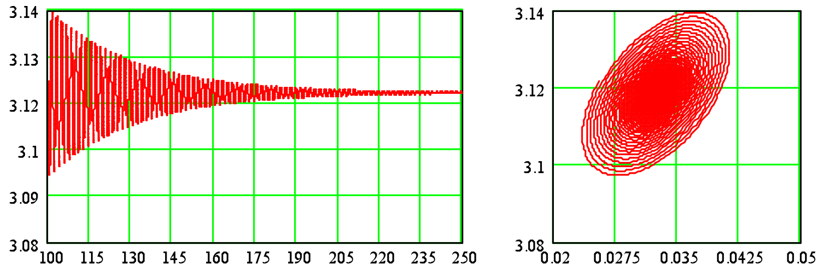
- RLC circuit
- Chua diode
- **PSPICE** simulation
- Build a circuit

One of the simplest nonlinear circuits that can demonstrate a host of nonlinear phenomena – such as limit cycle oscillations, period doubling sequence, chaos, scroll attractors etc.

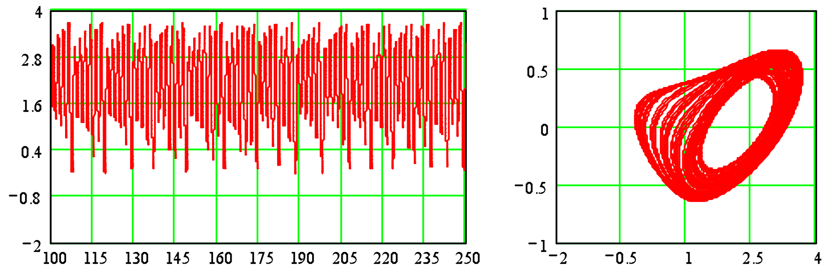
Chua circuit output



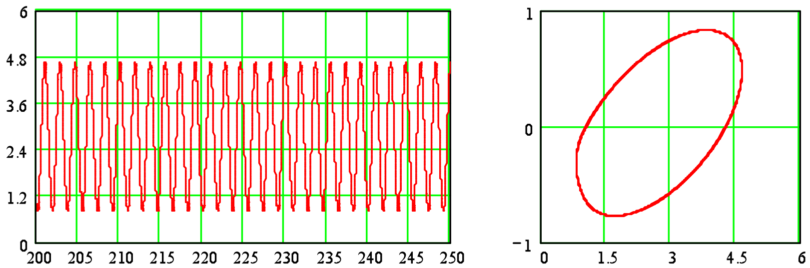
R_1=1740 Ω



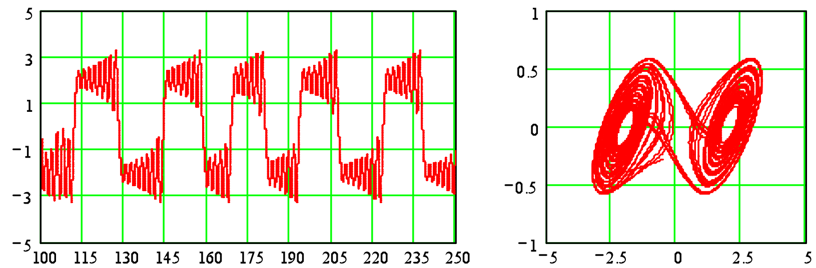
R_1=1900 Ω



R_1=1680 Ω

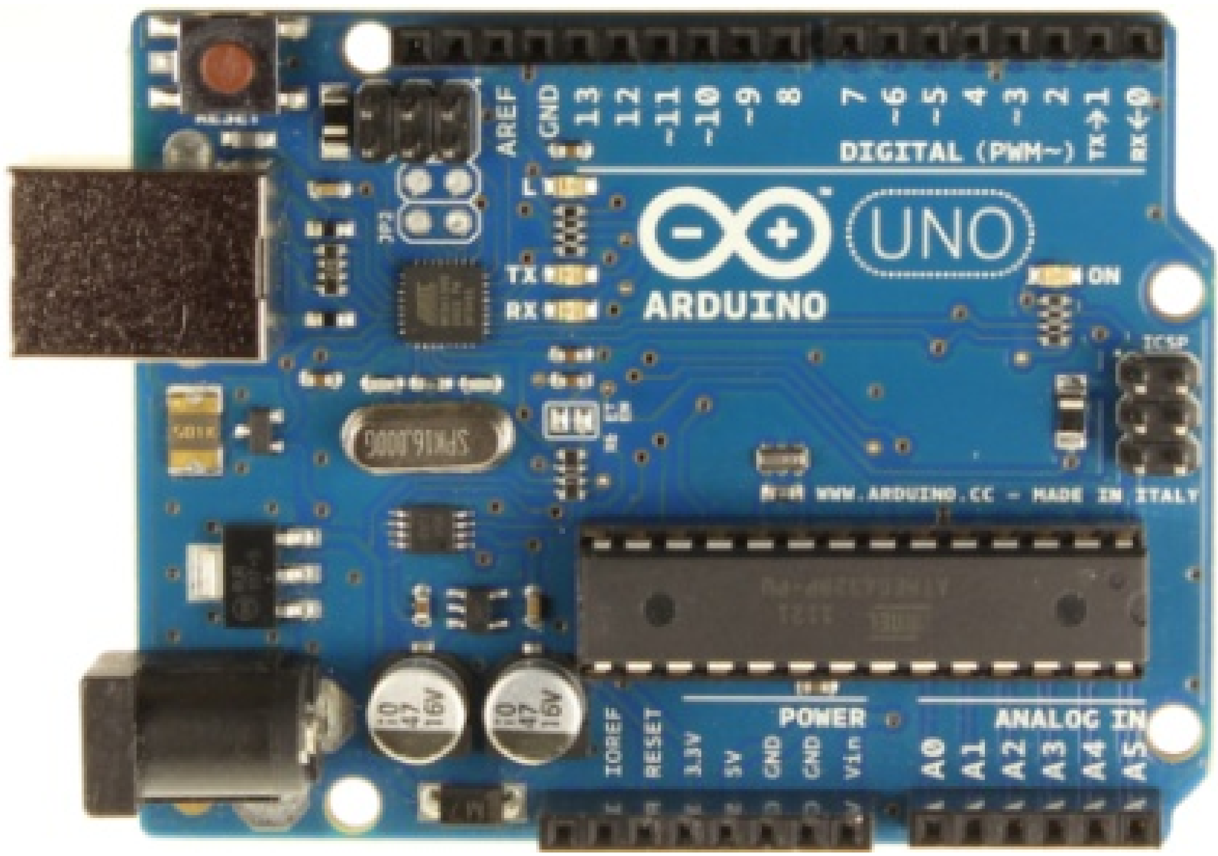


R_1=1820
Ω



R_1=1620 Ω

[G] USING PROGRAMMABLE MICROCONTROLLERS (ARDUINO) IN TABLETOP EXPERIMENTS



Hands-on Research in Complex Systems

Shanghai Jiao Tong University

June 17 – 29, 2012

ARDUINO

UNIVERSITY OF MARYLAND 1856

[G] OBJECTIVES

sketch_jun15a | Arduino 1.0.1

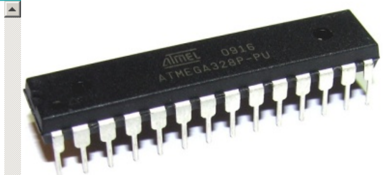
File Edit Sketch Tools Help

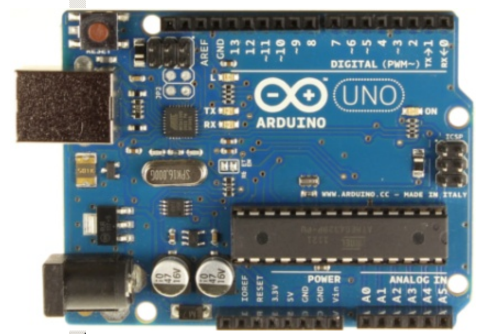
sketch_jun15a

In this Hands-On session, you will:

- Learn about microcontrollers: what they are and how they can be used
- Learn how to program the Arduino (a versatile, interactive, open-source, inexpensive “physical computing platform”)
- Design, build and test experiments using the Arduino

1 Arduino Uno on COM1



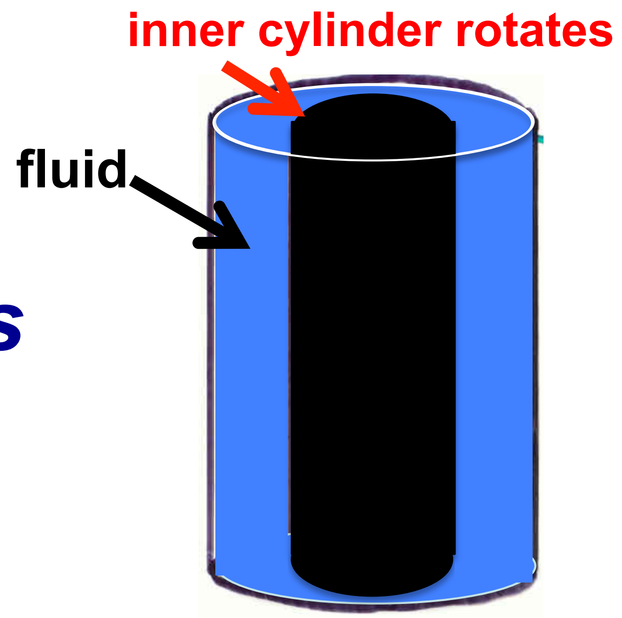


ALL PARTICIPANTS GET TO BRING HOME THEIR OWN ARDUINO BOARD!

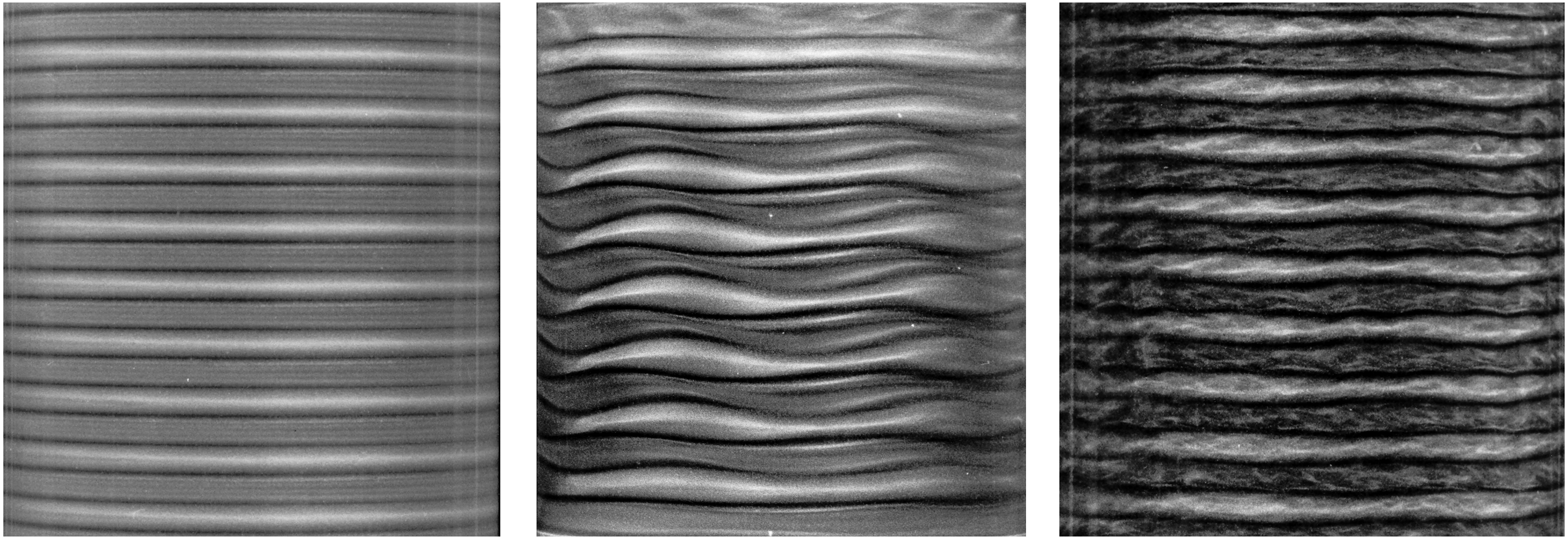
Session H

Instabilities in flow between concentric cylinders

Swinney, Rodenborn, Zhang, Wang

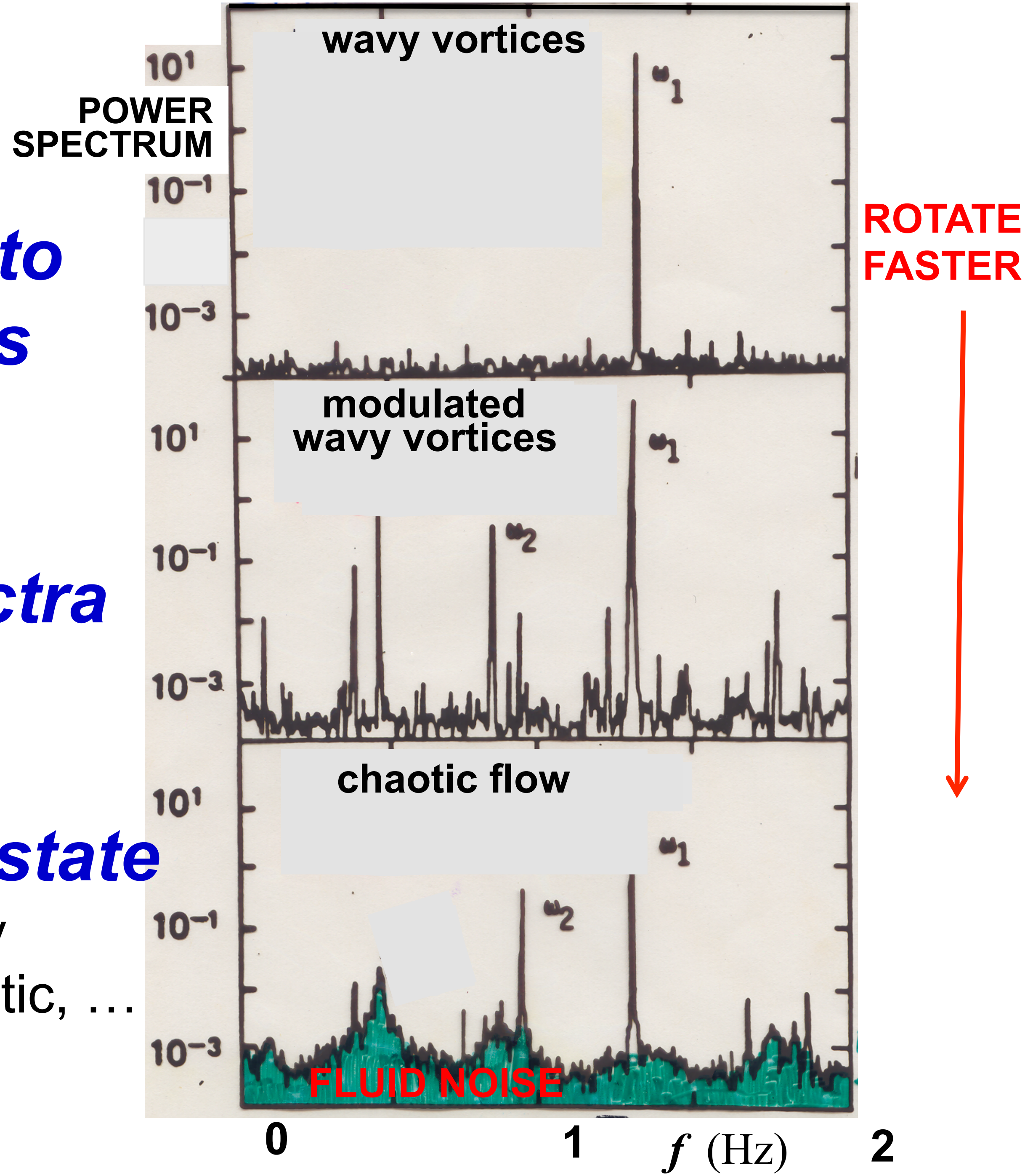


increasing cylinder rotation rate →



Session H

- ***Use webcam to make movies***
- ***Compute power spectra***
- ***Determine dynamical state***
  -- periodic, doubly periodic, chaotic, …

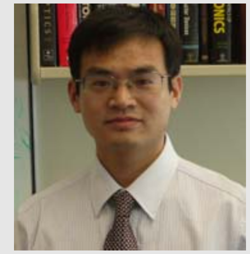


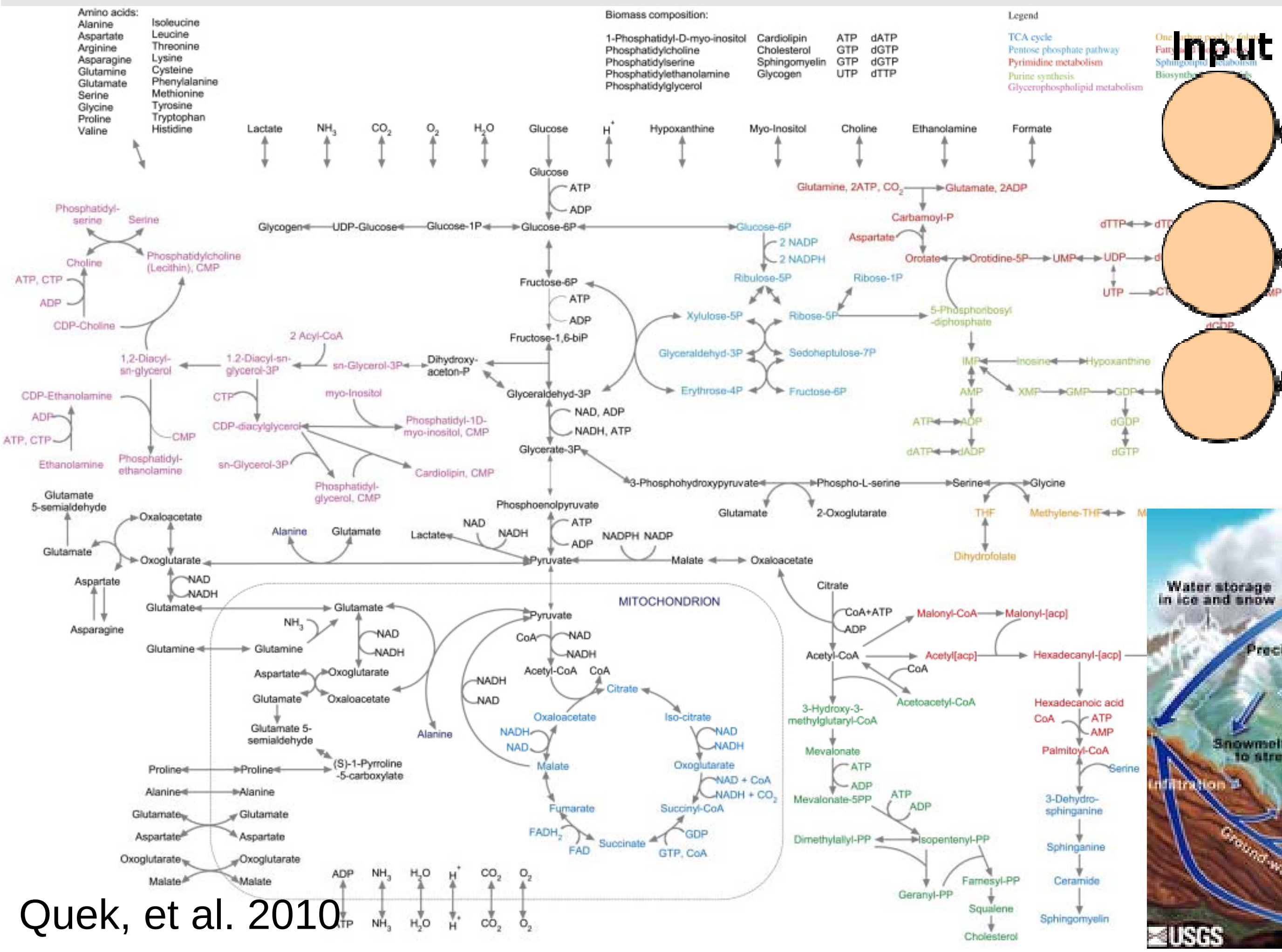
Boolean Network Dynamics – “I”

Daniel P. Lathrop – Univ. of Maryland

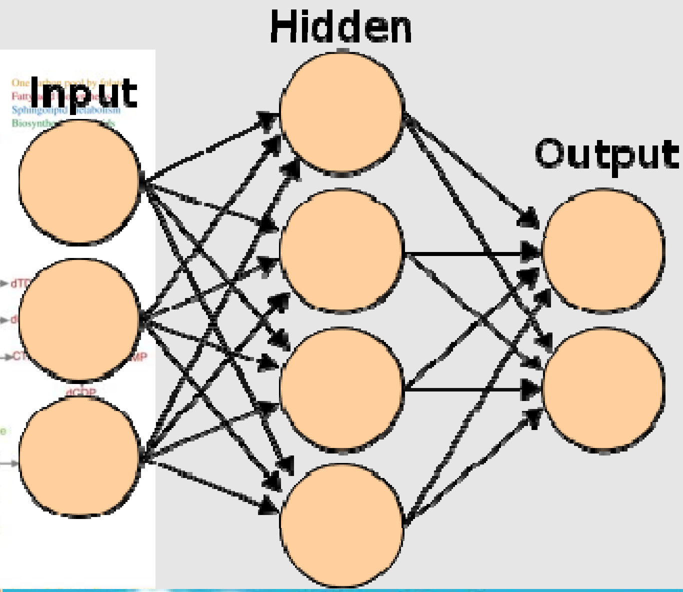
David Meichle – Univ. of Maryland

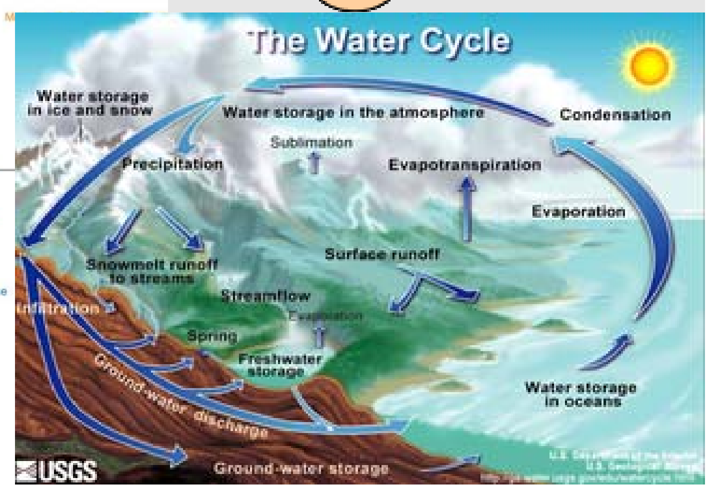
Haiwei Du – Shanghai Jiao Tong Univ.



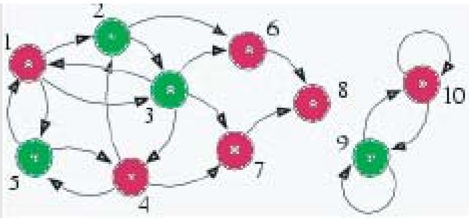


Quek, et al. 2010

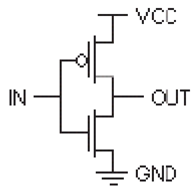




Scaling in ordered and critical random Boolean networks
J.E.S. Socolar and S.A. Kauffman, Phys. Rev. Lett 90, 068702 (2003).

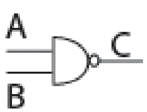


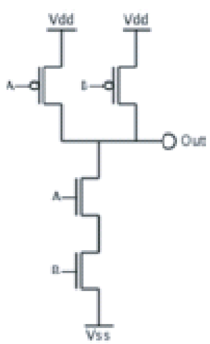
not



A	B
0	1
1	0

nand

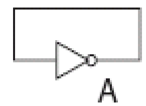




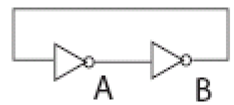
A	B	C
0	0	1
0	1	1
1	0	1
1	1	0

You will build:

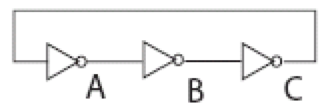
1-not loop



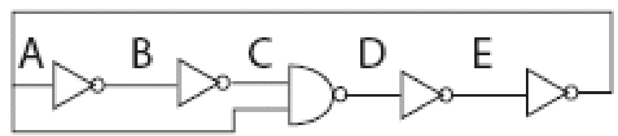
2-not loop

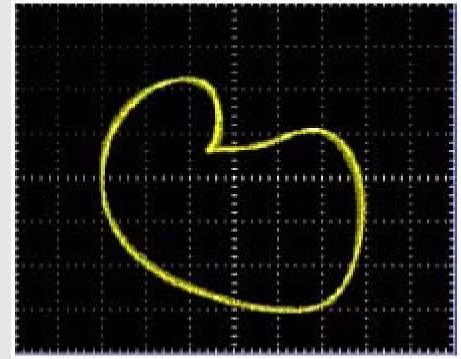


3-not loop

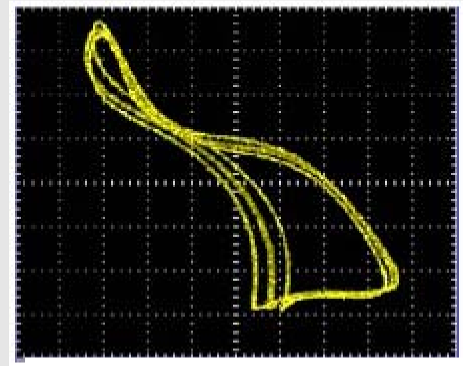


not a ring
2-not, nand, 2-not

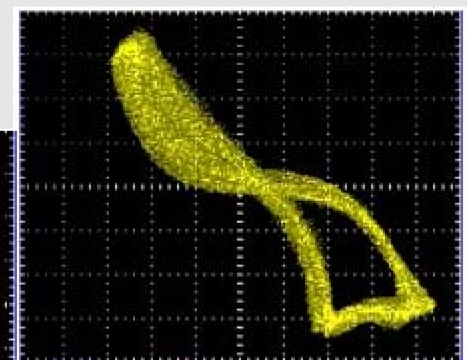




Peridodic

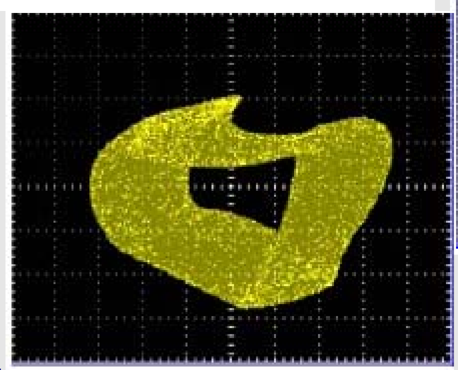


Multiply Peridodic



Chaotic

Ideas explored:
Feedback
Bifurcation
Spectra
Lyapunov exponent
Synchronization



2-tori

Boolean Network Dynamics – “I”

Session J

Nonlinear Dynamics of Human Locomotion

Dan Goldman

Nick Gravish

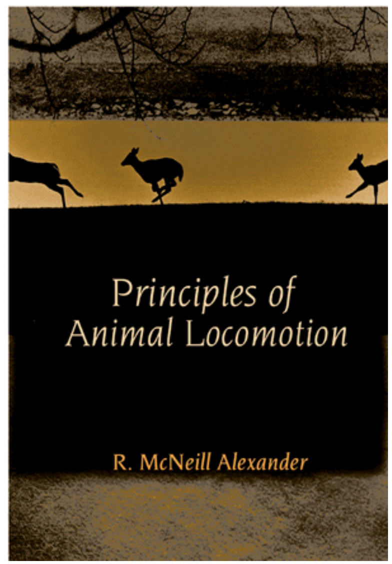
Sarah Sharpe

Georgia Institute of Technology, Atlanta, GA, USA

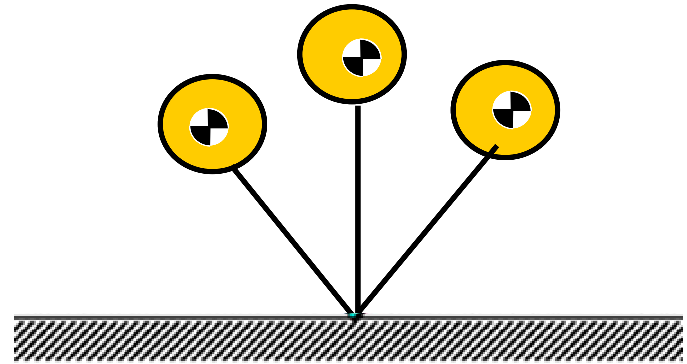
He Li

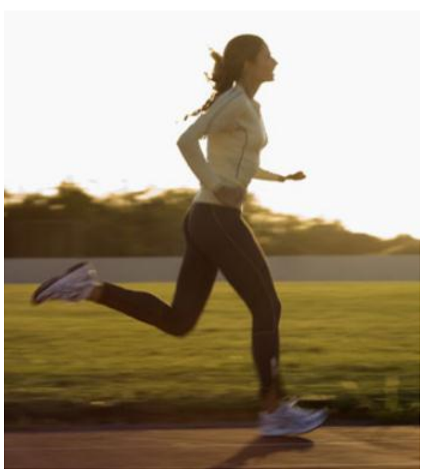
Shanghai Jiao Tong University, Shanghai, China

Classical models of terrestrial locomotion

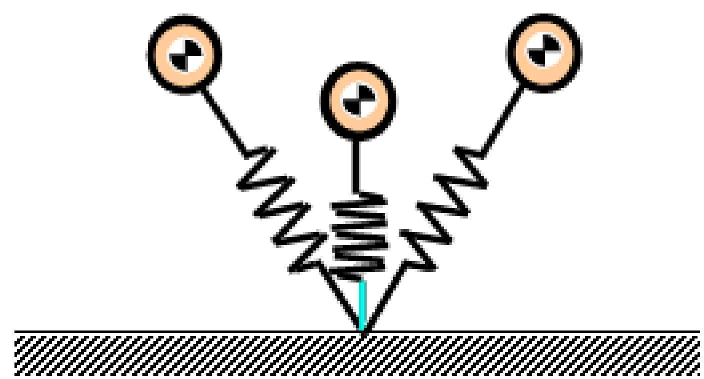


walking: inverted pendulum



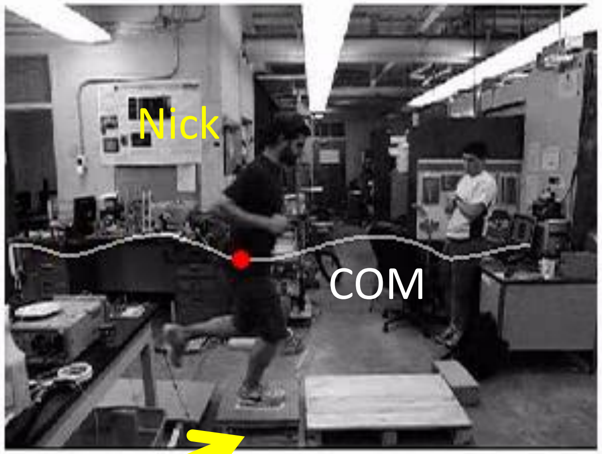


running: spring-loaded inverted pendulum

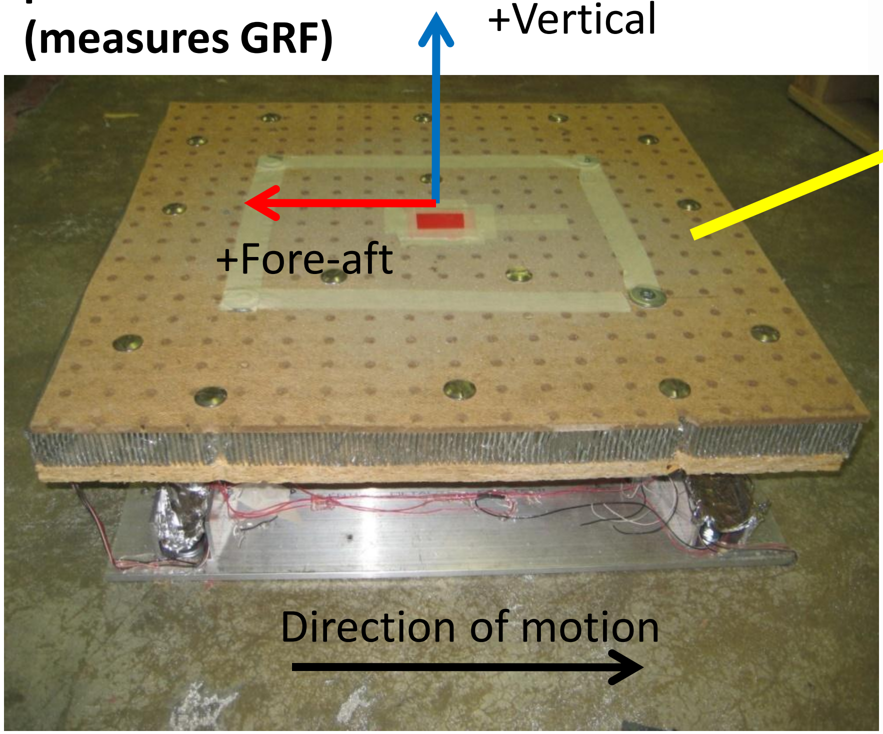


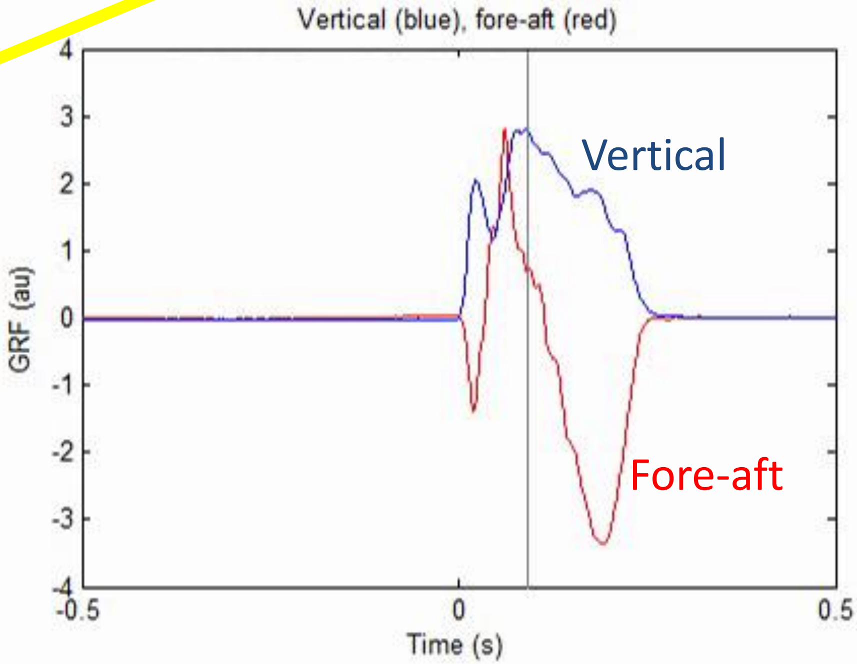
Hands-on session: Kinematics & Dynamics measurements

High speed camera (200 fps)



2 axis force platform (measures GRF)





Important

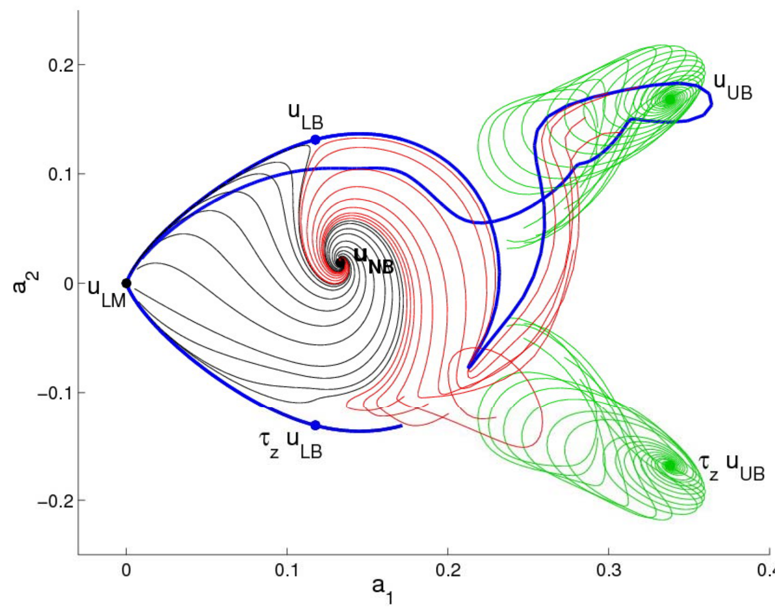
Please wear clothes & shoes in which you can walk and *jog*

Session K:
Turbulence: Particle Imaging Flow Analysis

Mike Schatz, Bala Suri, Jeff Tithof (Georgia Tech); Xiang Wu (SJTU)

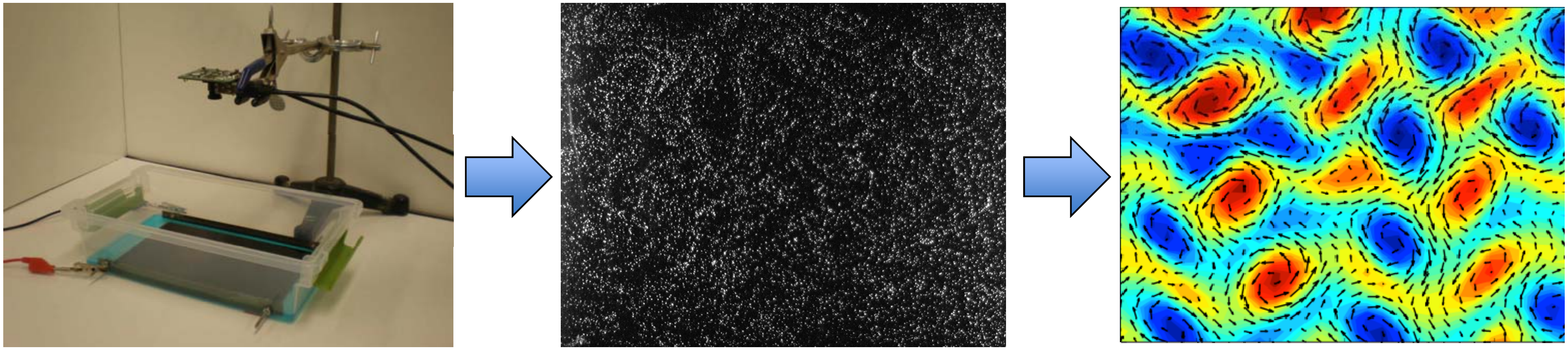
- Fundamental and Practical Importance

- New Ideas

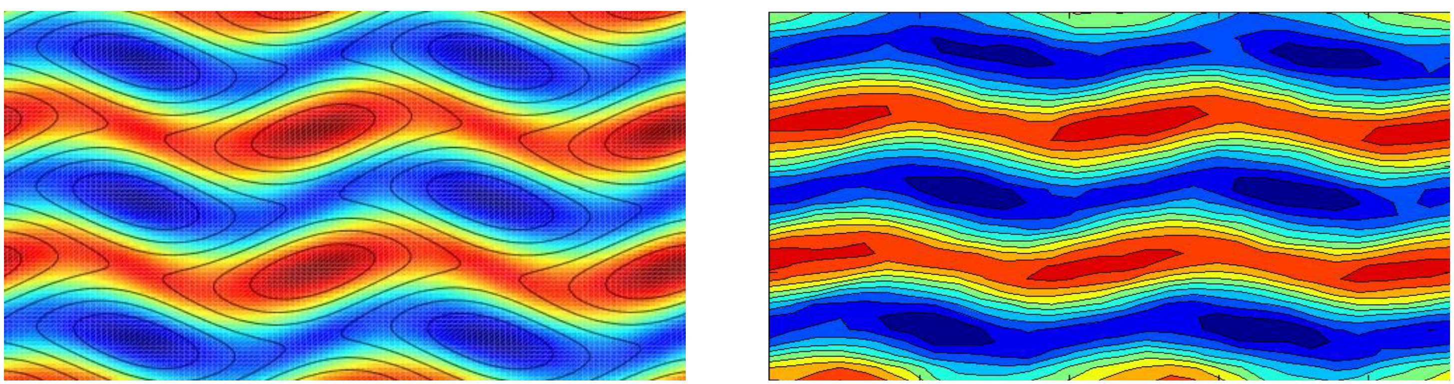


Session K: Turbulence…

- **Quantitative** table-top experiment

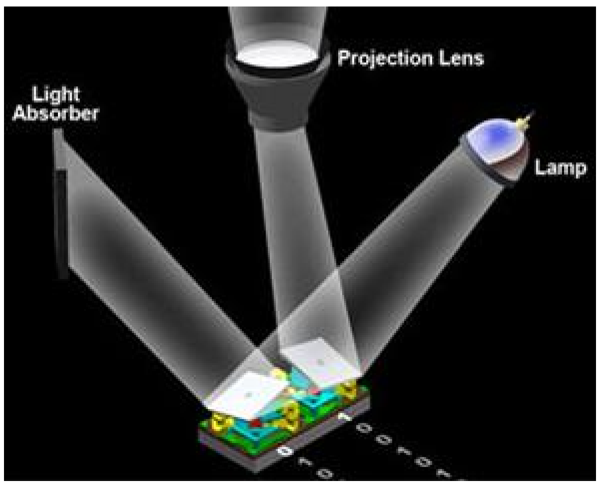


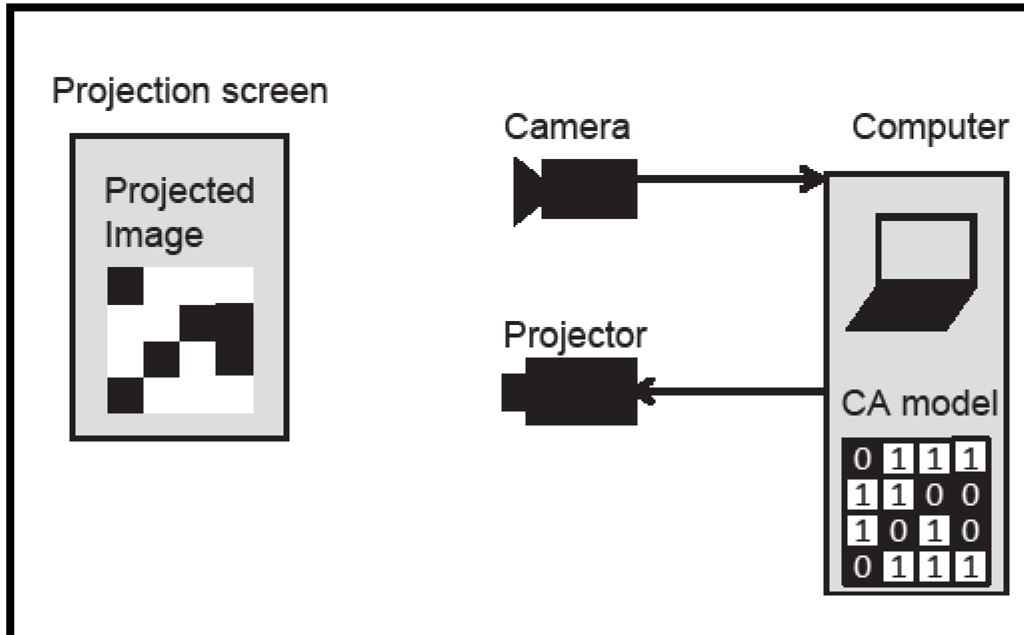
- **Quantitative** comparison with theory/numerics
(Math Modeling Session N: B. Storey/J. Baca)



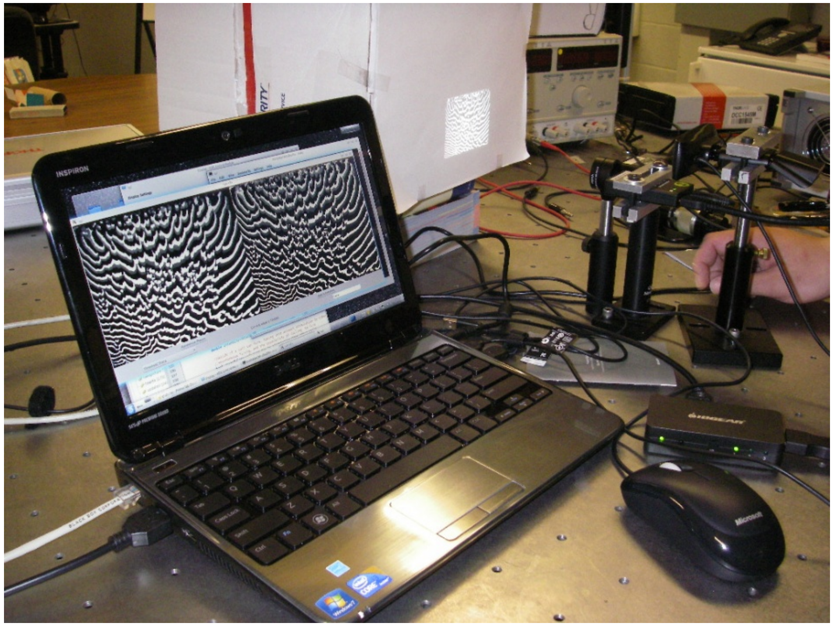
Micromirror SLMs and Feedback

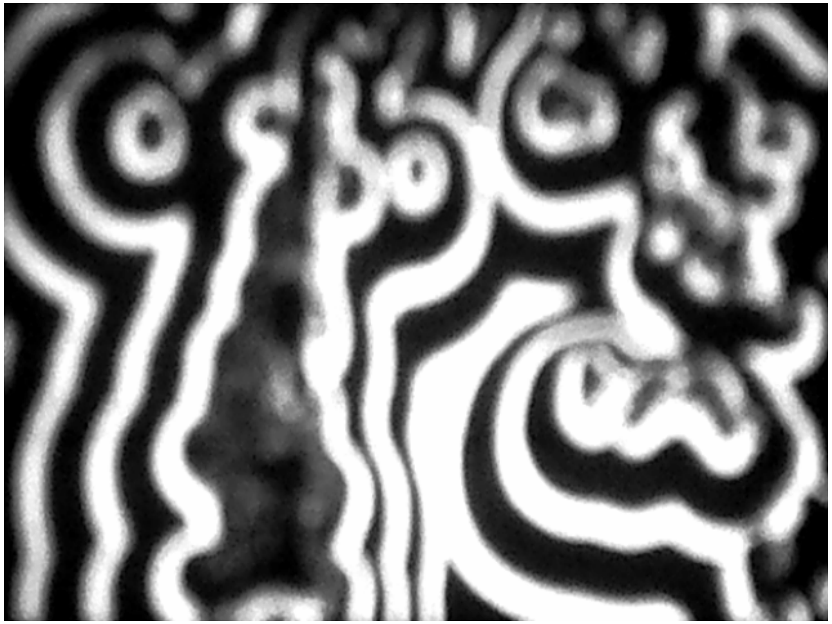
Session L





Pattern Generation with our System





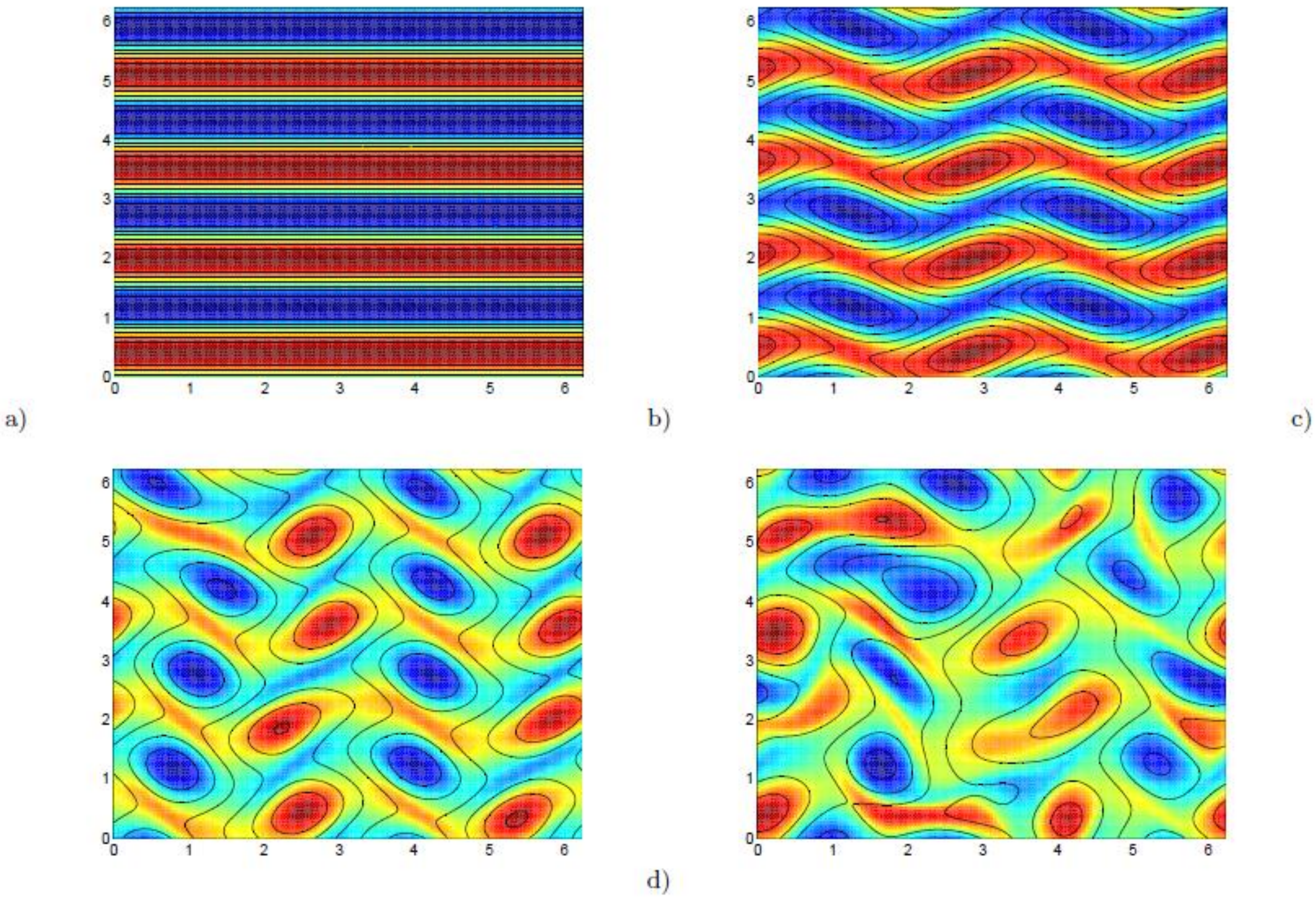
Hands-on Session M: Introduction to MATLAB

- Overview of basic MATLAB commands and programming useful for other modeling sessions
- Practice importing and analyzing data from a digital camera movie of a double pendulum
- Compare data with simulation from a model

Modeling 2D turbulence [N]

A brief introduction to computational fluid dynamics

Brian Storey & Jacqui Baca



- Who should attend?
  - **Interested in associated experimental session**
  - Interested in systems with dynamics in space and time or pattern forming systems.
  - Interested in fluid dynamics or turbulence.
  - Interested in learning some numerical methods.
  - Interested in practicing with MATLAB.
- Background needed?
  - A little MATLAB (introduction here is sufficient)
  - A little math (basic linear algebra, vector calculus, ODEs, Fourier series)

Session O

Mathematical Modeling

Brian Hunt
University of Maryland

2 Aug 2010

Hands-On Session O: Modeling Dynamical Systems

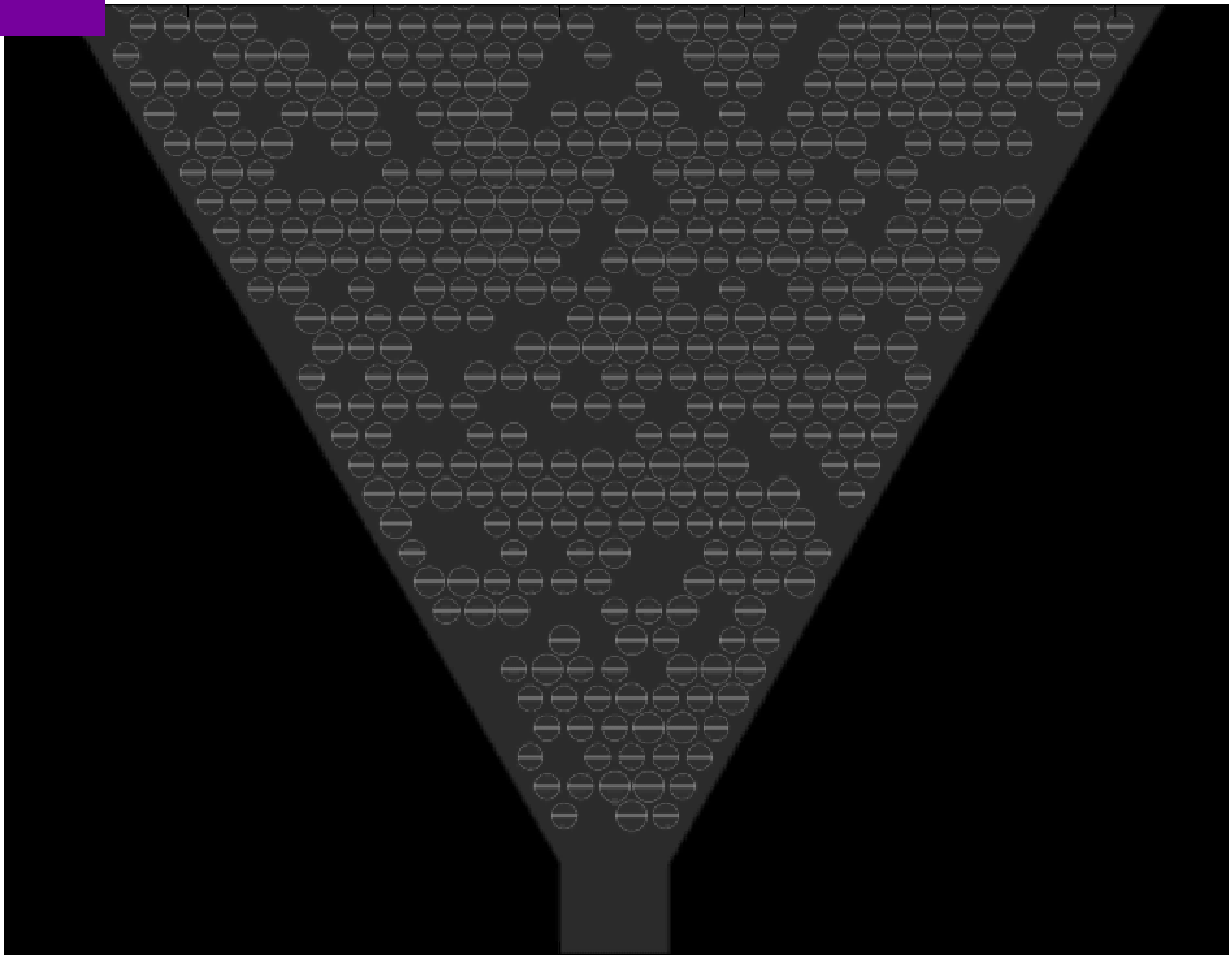
- Introduction to numerical methods and MATLAB comands for solving ODEs
- Practice with various nonlinear mathematical models
- Bifurcation diagrams and other visualizations of results

P

Modeling: Molecular Dynamics

- Determine the motion of a collection of objects by solving Newton's equations for the forces between the objects.
- Discuss the major components of a molecular dynamics simulator.
- Write your own simple molecular dynamics simulator in Matlab. (Less than 10 lines.)
- Add more advance features for large numbers of particles and other complications.

Hopper Flow



Section Q

Mathematical Modeling of Biological Neurons

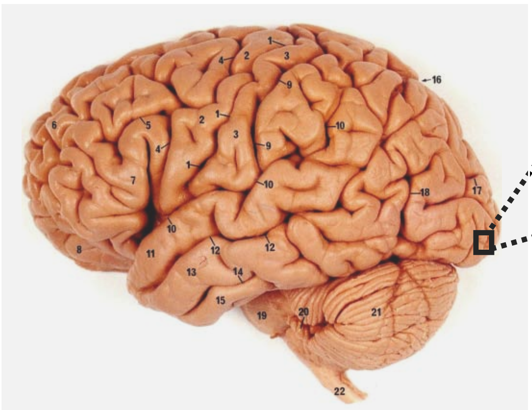
Douglas Zhou & David Cai

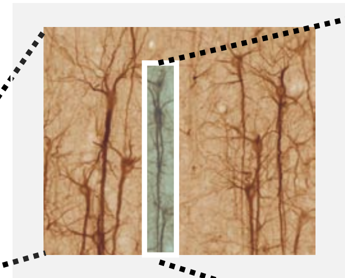
Math. Dept. and the Institute of Natural Sciences
Shanghai Jiao Tong University

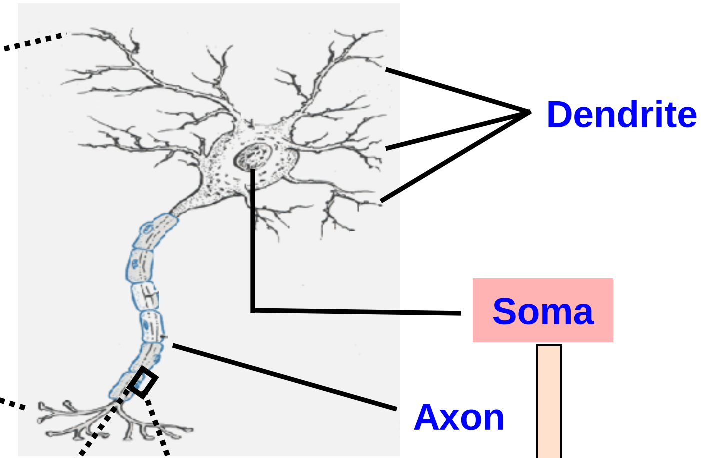
June. 17th, 2012

Cerebral Cortex and Neurons

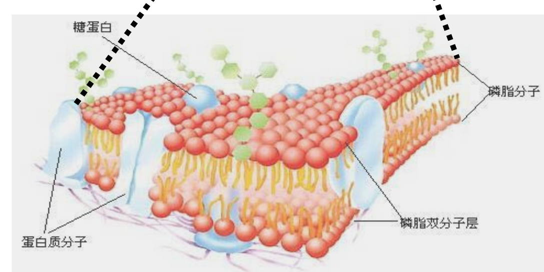
- 10^{11} neurons and 10^{15} connections, ~10^{4} neurons per mm^{2}, shape and functions



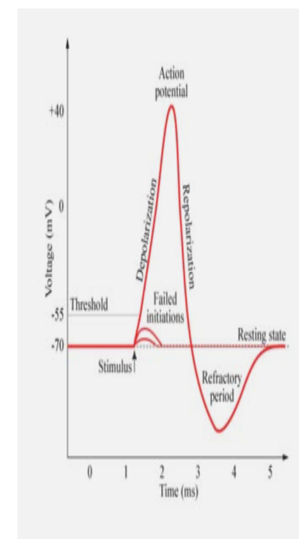




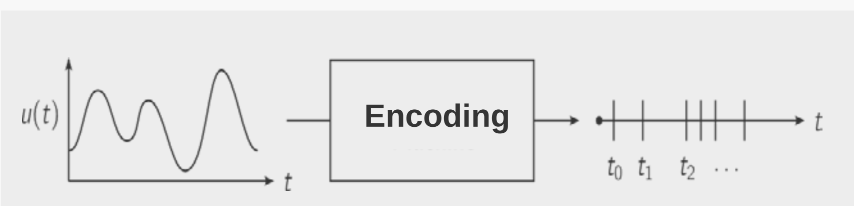
Action Potential (spike)

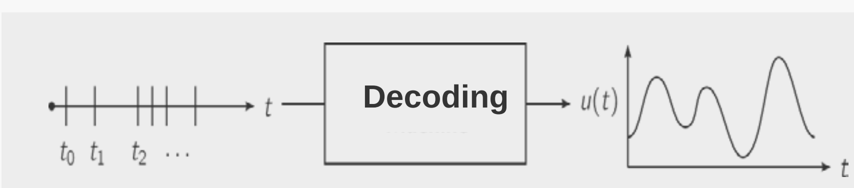


$$V_m(t) = V_{in}(t) - V_{out}(t)$$

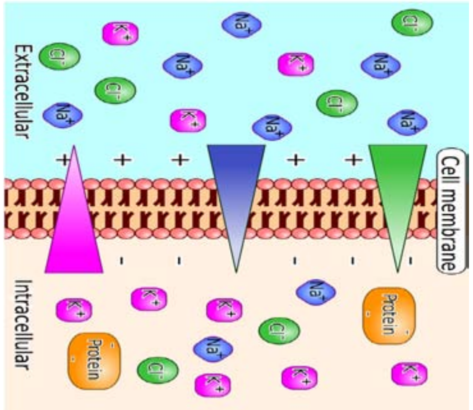


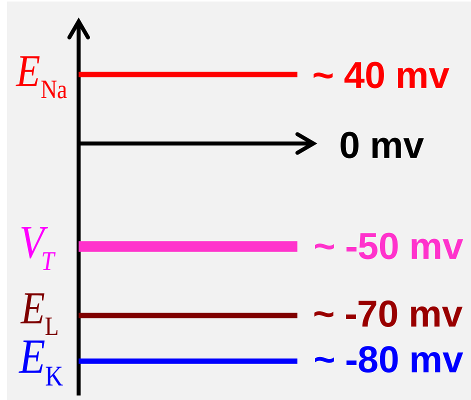
Information encoding and decoding



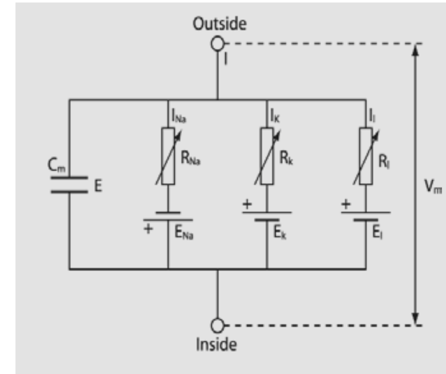


Hodgkin-Huxley (HH) model



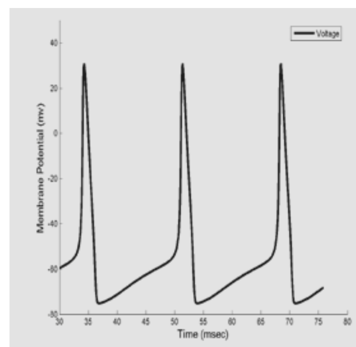


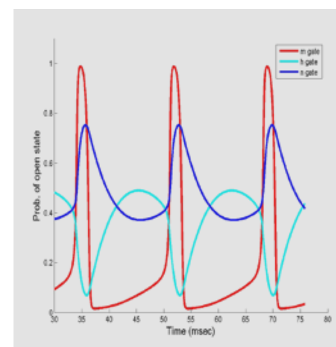
modeling

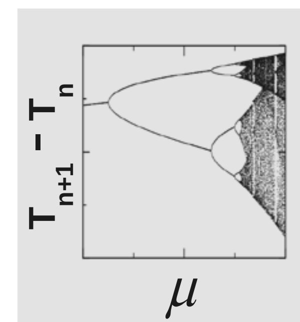


$$
\begin{cases}
C\dfrac{dV}{dt} = -G_L\left(V-E_L\right) - G_{Na}m^3h\left(V-E_{Na}\right) - G_K n^4\left(V-E_K\right) + I^{\text{external}}(t) \\
\dfrac{dm}{dt} = \alpha_m\left(1-m\right) - \beta_m m = \dfrac{1}{\tau_m(V)}\left(m_\infty(V)-m\right) \\
\dfrac{dh}{dt} = \alpha_h\left(1-h\right) - \beta_h h = \dfrac{1}{\tau_h(V)}\left(h_\infty(V)-h\right) \\
\dfrac{dn}{dt} = \alpha_n\left(1-n\right) - \beta_n n = \dfrac{1}{\tau_n(V)}\left(n_\infty(V)-n\right)
\end{cases}
$$

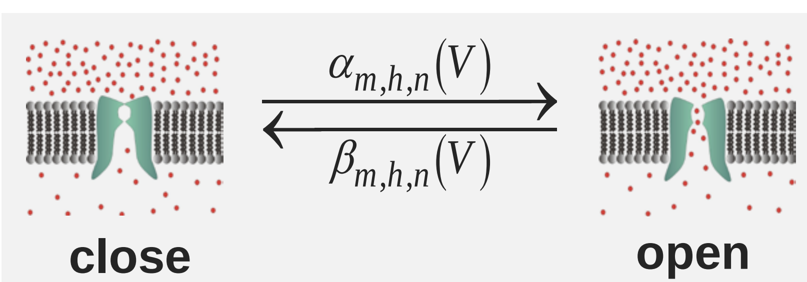
e.g. $I^{\text{external}}(t) = I_0 + I_1\sin(2\pi\mu t)$

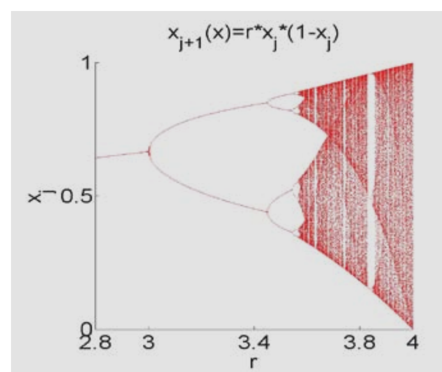






gating variables: $m,\ h,\ n$





Logistic map

$$x_{j+1} = rx_j\left(1-x_j\right)$$