

EE/AA 449  
Control Systems Capstone  
Project Ideas

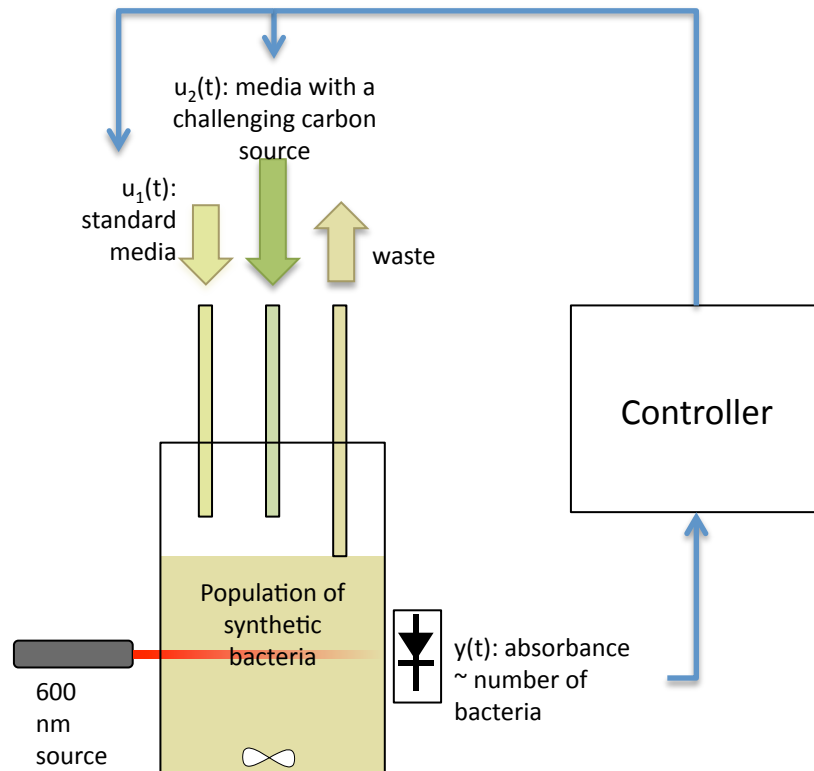
Instructor: Eric Klavins  
Teaching Assistant: Charlie Matlack

# Course Structure

- Groups of three
- Must have a “customer”
- Projects should include feedback control
- Can be hardware or software based
- Five milestone reports / five presentations
- Lab visit / demo
- Grades based on
  - Reports
  - Presentations
  - Lab demo
  - Evaluation of you by your partners
  - Evaluation by the customer
  - *General awesomeness of the project*

# High Throughput Chemostat

Klavins Lab

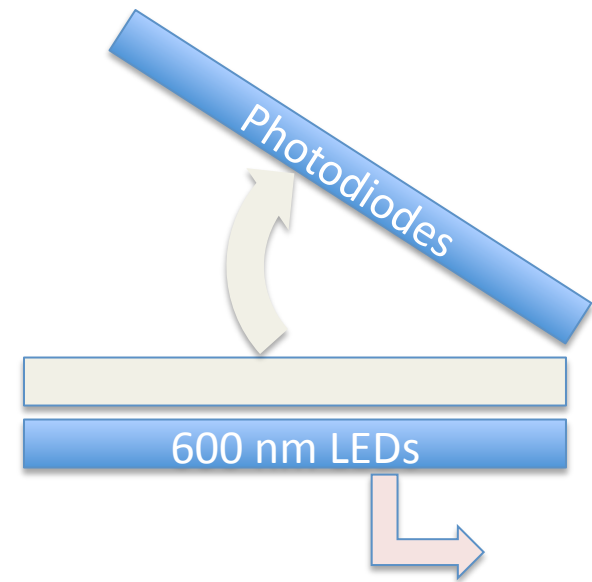
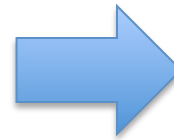
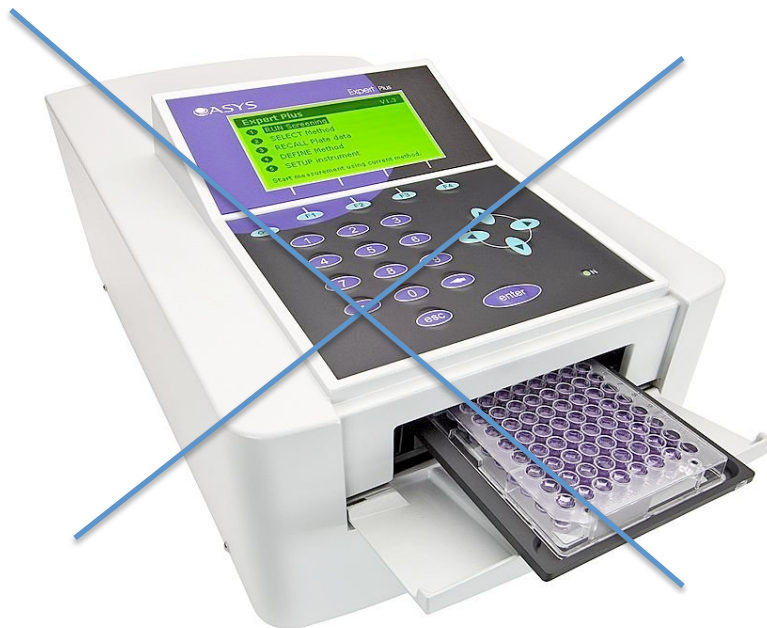


## Goals:

- Program / configure the liquid handler to act as a chemostat
- Interface with other pieces of equipment
- Create a “directed evolution experiment configuration tool
- Perform demonstration experiments in direct evolution

# Mini Plate Reader

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USB  
Interface to  
liquid  
handler

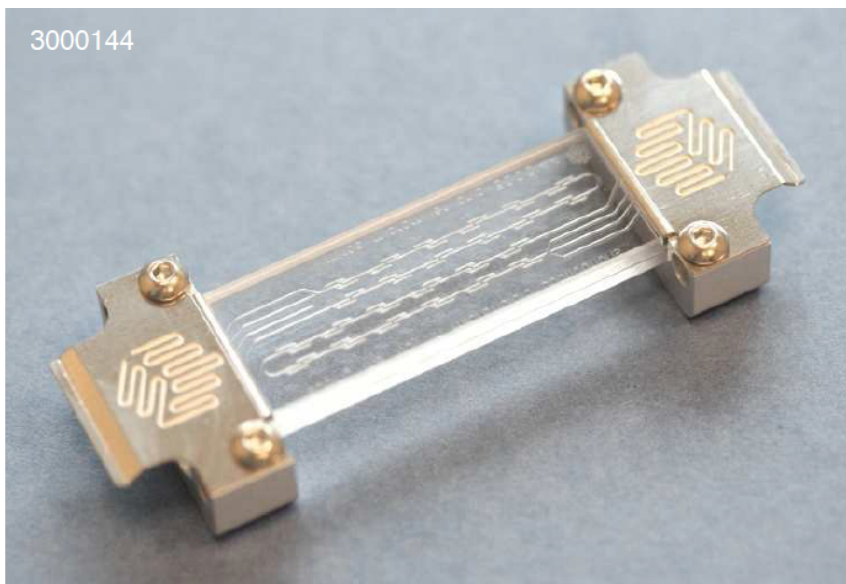
Goals:

- Interface with chemostat team to demonstrate “turbidostat” behavior!

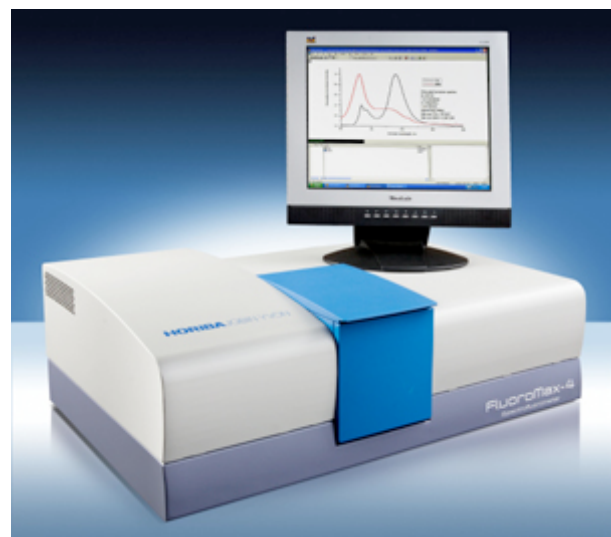


# Microfluidic Chemostat

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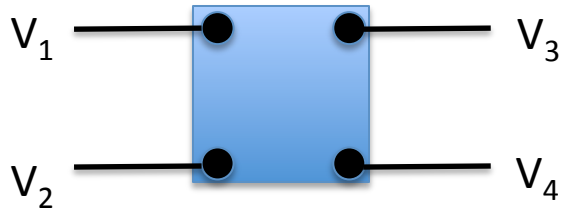


$E + S \rightleftharpoons ES \rightarrow E + P$   
Requires “fuel strands”  
P is fluorescent  
Goal: replenish reactants to keep the  
reaction going indefinitely.



# Electrokinetic Mixer

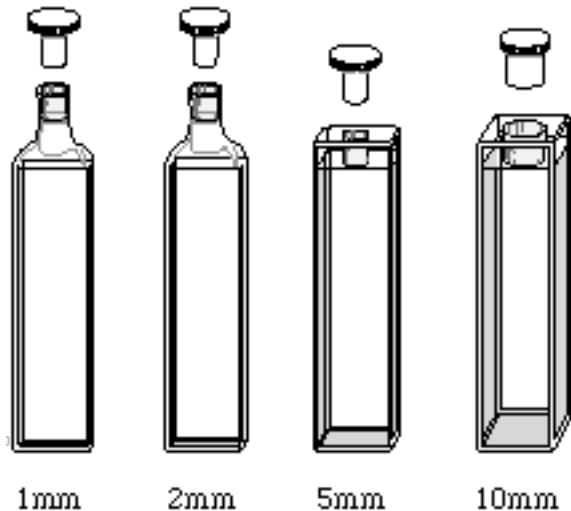
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Idea: Polar molecules move in response to electric field increasing interactions = increasing the effective rate of diffusion!

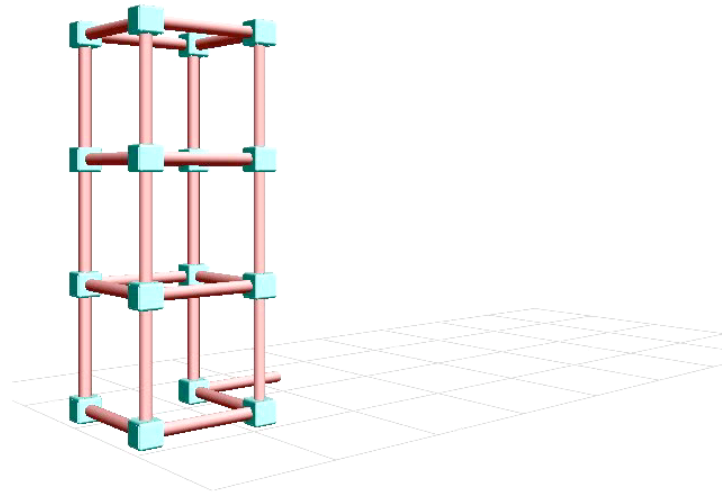
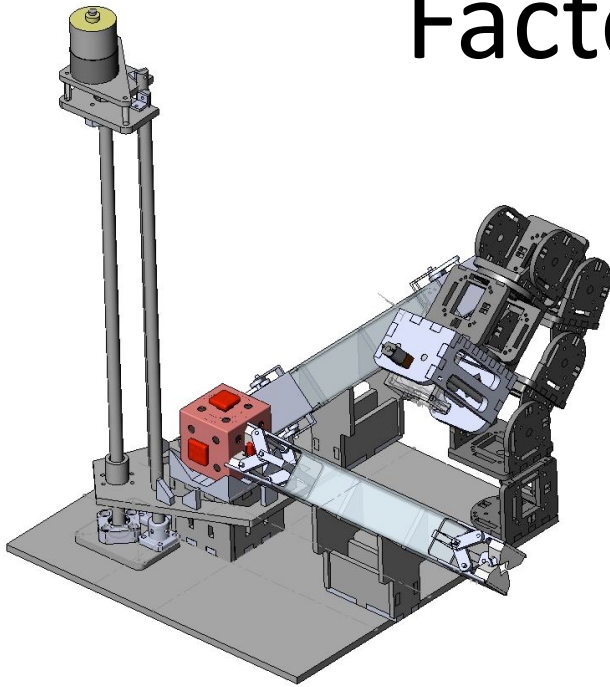
Goal:

- 1) Demonstrate electrokinetic mixing with simple DNA reactions.
- 2) Design a computer interface (USB or similar + GUI)
- 3) Scale up to 96 well plate attachment.



# Factory Floor Robots

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UW Just received first shipment of robots.

Goals: Program robot in CCL with distributed algorithms for assembly.

Software in the loop.

Travel opportunities.

# Energy-Based Feedback Control of Communication and Coordination of Underwater Vehicles

**Goal:** Construct an algorithm for multivehicle control that uses more or less communication (transmissions of bits per second) to perform a task with more or less accuracy (error between desired and actual states)

**Steps:**

- Determine accuracy relation for a given task based on received information (e.g. headings of other vehicles at a given update rate)
- Change transmission rate (feedback) based on desired accuracy relative to measured accuracy
- Implement algorithm on fish robots and potentially on Seaglidors

**Skills:** Programming in Matlab, interest in working with hardware

This work is in support of ongoing grants from NSF and ONR



Department of Aeronautics and Astronautics  
Nonlinear Dynamics and Control Lab  
Prof. Kristi Morgansen

<http://www.aero.washington.edu/research/ndcl>

# Quadrotor Control (DSSL- Mesbahi)

- Given the equations of motion governing the quadrotor, develop the control law based on the nonlinear or linearized dynamics of the vehicle.
- Primary Objective:** To get the quadrotor to a specific position in a well-defined grid (X,Y,Z) and hover at that point.
- The Quadrotor:** Draganflyer XP by Draganfly Innovations, Inc.
- Sensors:** Hi-Res motion capture IR camera system from Vicon. It is used to determine the position and orientation of the vehicle.
- Control System:** Candidate Control Laws have been developed that need to be refined and tested.
- The computer-on-module:** The Gumstix-Robostix-wifi assembly sits on the Quadrotor. The Gumstix receives commands and data from the base (Linux) machine through the 802.11g wireless interface and sends the signals to Robostix(AVR) which drives the motors.



# Feedback Controlled Spotter

- Goal: Add visual feedback to a spotter
- Customer: Prof. Michael Hochberg (EE)

# Hannaford Lab Proj. 1

Motion control for capstan during maintenance and assembly tasks

RAVEN is a complex surgical robotic mechanism. Cables must be wound precisely around motor capstans during construction and maintenance (recabling). Students would program a closed loop controller with trajectory generator to respond to keyboard commands with  $N$  turns of the capstan at a specified maximum velocity and with specified acceleration parameters.

# Hannaford Proj. 2

Controller design competition: may be best controller win! (requires two teams!)

A 1-axis model of our RAVEN surgical robot will be programmed with a variety of control approaches. Performance in terms of tracking error and stability robustness will be evaluated for various controllers. A model of the system with parameter ID is available in Matlab. Control implementation will be in C. Existing control software can be modified with new controllers.

Team 1: Start with a PD control design. Tune controller parameters for best performance.

Team 2: A previous research team has developed a sophisticated controller using a dynamic model and an Unscented Kalman Filter state estimator shows as yet unrealized potential for better position and velocity sensing of the robot.

Identical performance tests will be devised for the two teams and their controllers will run on the same hardware. May the best controller win!