

Bayesian Data Analysis
A PHY 451/551 and I CSI 451/551
Problem Suggestions

1. Baseball Pitches

Given the initial velocity (speed and direction) of the baseball, and where it hits in the strike zone (± 5 cm) what is the initial spin orientation and rate of the baseball? You will need to simulate the trajectory of the baseball using differential equations.

2. Model of the Human Eye

The human eye has four light receptors. The rods detect light and dark (broadband spectrum) and the cones detect color (red, green and blue). Given a light source with a specific frequency, the forward model consists of computing the relative responses of each of the four sensors. You will need to simulate this. The inverse problem consists of inferring the most probable wavelength given the four light sensor outputs.

What wavelength does your eye model estimate with a red light source?

What wavelength does your eye model estimate with a blue light source?

What wavelength does your eye model estimate with a green light source?

What wavelength does your eye model estimate with both a red and green light source?

How does this compare to your perception?

3. Hiking Accident

A person who was hiking in the woods was found dead. The person was curled up into a ball obviously trying to keep warm. Given a constant temperature during the night, and the temperature of the body in the morning, and a rate of cooling, estimate the time of death. You will need to come up with some model describing how bodies cool. Anything remotely reasonable will be acceptable here. You may treat the body as a sphere of water, or you may find a model in a forensics text.

4. Planetary Flyby

A foreign space probe has just performed a flyby of one of Jupiter's moons. Your job is to figure out which one. Given the course of the probe at time t long after the flyby, and the current position of Jupiter and its four Galilean moons (Io, Europa, Ganymede, and Callisto) estimate the probable trajectories of the craft, and decide which moon was the target.

5. Alien Signal Detection

You are working for SETI (Search for Extraterrestrial Intelligence). Given a sine wave buried in noise, can you estimate the amplitude, phase and frequency of the underlying sine wave? How noisy can it get before the problem becomes impossible.

6. Acceleration of Gravity

Repeat the experiment we did in class for multiple heights and estimate the acceleration of gravity taking into account the fact that there is a time delay for the release mechanism. Marginalize over the probability for this delay to get a probability distribution for g alone.

List of Selected Past Projects

- Ryan Kristensen *On the Determination of Random Field Ising Model Parameters for a Ferromagnetic Chain Exhibiting Zero-Temperature Hysteresis*
- David Liguori *Analysis of Coupled Harmonic Oscillators*
- Perveen Akhter and Hassan Abbas
Estimating the Point Spread Function of a Light Sensor
- Roger Pink *Amplitude of Sound Wave Emissions from a Speaker*
- Shahid Nawaz *Model Selection for the Distribution of Prime Numbers*
- Laxman Mainali *The Two Lighthouse Problem*
- Lance Latham *Subcellular Localization of Gram Positive Bacterial Proteins*
- Indra Sahu *Multifrequency Fit of EPR Spectra of a Metal Complex*
- Victoria Rojo *Alignment of the ATLAS Muon Spectrometer*
- Patrick Zongo and Mitchell Troise
Crater Imaging using Nested Sampling
- Tim Curley *Lighthouse Problem on a Sphere with a Satellite*
- Jordan Ponzio *Evaluating the NXT Ultrasonic Sensor*