Cognitive Modeling Homework 1

Solomon Starkes and Drew Schiller

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1 Problem 1: True-False Questions (4 points)

1. Stochastic models will always produce the same output x given the same input parameters .
   FALSE

2. In psychology, replicability refers to obtaining consistent results using the same data and analysis methods, while reproducibility refers to obtaining consistent results by conducting a new study with different data under similar conditions.
   TRUE

3. In Python, the expression 5 + ”5” will result in a TypeError.
   TRUE

4. The git rebase command is used to squash commits in the history, but it cannot be used to reapply commits on top of a different base branch.
   FALSE

5. A detached HEAD state in Git means you are no longer on any branch and cannot commit changes until you switch back to a branch.
   FALSE

6. Function arguments in Python are passed by reference, meaning that modifying a mutable object within a function will also modify it outside the function scope.
   TRUE

7. Using the is operator in Python checks for value equality, similar to the == operator.
   FALSE

8. The .gitignore file in a Git repository is used to specify files that should not be tracked by Git and cannot be overridden by a user.
   FALSE

2 Problem 2: Inverse vs. Forward Problems (6 points)

Provide three examples of inverse and forward problems, and discuss their relative computational difficulty.

- **Seismology**
  The forward problem in seismology involves predicting seismic wave travel times and amplitudes given a known model of Earth's interior, including parameters like density and elasticity. This problem is computationally straightforward because it involves solving well-established equations of motion or wave propagation using numerical techniques like finite-difference or finite-element methods. These approaches are efficient and stable, provided the model parameters are accurate.

  The inverse problem in seismology is far more challenging. Here, the goal is to infer Earth's interior structure from seismic wave data recorded at multiple locations. This is an ill-posed problem because there is often insufficient data to uniquely determine the model, and the measurements are typically noisy.

  The computational cost is high since iterative algorithms must repeatedly solve the forward problem to refine the model. Regularization techniques and prior knowledge are often required to stabilize the solution, adding further complexity.

- **Medical Imaging**
  The forward problem in medical imaging involves simulating the signals or radiation emitted by the body based on a known distribution of tissues or physical properties. This problem can be solved efficiently using models of electromagnetic or acoustic wave propagation. Numerical methods, such as ray tracing or finite difference, are well-suited for this purpose and are computationally manageable given modern computing resources.

  The inverse problem requires reconstructing internal body structures from the collected measurements, such as reconstructing a 3D image from X-ray data in a CT scan.

  The computational cost is computationally intensive and ill-posed because the data is often incomplete, noisy, or undersampled. Solving the inverse problem typically involves solving large-scale optimization problems that account for noise and measurement errors, which significantly increases computational difficulty. Iterative reconstruction techniques like filtered back projection or Bayesian inference methods are often used, further compounding the computational cost.

- **Heat Conduction**

  The forward problem in heat conduction involves predicting the temperature evolution in a material over time, given initial temperature distribution and material properties. The heat equation, a partial differential equation, governs this process and can be solved efficiently using numerical techniques like finite difference, finite element, or spectral methods. These methods are stable and computationally efficient, making the forward problem relatively easy to solve.

  The inverse problemaims to determine the initial temperature distribution or material properties from observed temperature data at a later time. This is significantly harder because it is an ill-posed problem; small errors or noise in the observed data can lead to large inaccuracies in the inferred solution.

  The computational cost requires regularization techniques, such as Tikhonov regularization or Bayesian approaches, are needed to make the problem tractable, and iterative optimization methods are often required. Since these methods repeatedly solve the forward problem as part of their process, the computational cost is significantly higher.

3 Problem 3: Git and GitHub (12 points)

1. Explain the differences between the following git commands in terms of undoing changes to a repository by providing a minimal (actual or a synthetic) example:

   (a) git restore
   Restores specific files in the working directory to a previous state, either from the index (staging area) or a specific commit, without affecting commit history.

   (b) git checkout
   Can switch between branches, commits, or files. It has been largely replaced by git switch and git restore for better clarity in modern Git versions.

   (c) git reset
   Unstages changes or moves the current branch pointer to a different commit. It can also modify the working directory depending on the reset mode (–soft, –mixed, or –hard).

   (d) git revert
   Creates a new commit that undoes the changes introduced by a specific commit, preserving the history.

2. Fill in the following table:

Command	**Affects Commit History?**	**Affects Staging Area?**	**Affects Working Directory?**	**Typical Use Case**
git reset	Yes but only locally	Yes	No unless in –hard mode	To undo commits or unstage changes, moving branch pointer.
git restore	No	No unless using the –staged	Yes	To discard changes in the working directory or staging area.
git rm	No	Yes	Yes	To remove files from the repository and the working directory.