CMSC 421 – Exam 2 Study Guide

1. Probability & Bayes' Rule

Bayes' Rule: P(A|B) = [P(B|A) * P(A)] / P(B)

- Prior: belief before evidence
- Likelihood: how expected evidence is if the hypothesis is true
- Posterior: updated belief

Example: Disease detection problem with prior, true positive, and false positive rates.

2. Markov Chains

- A state system where transitions depend only on the current state.
- Use a transition matrix to calculate next-state probabilities.

Example: Weather states (Sunny/Rainy) with given transitions.

3. Hidden Markov Models

- States are hidden; we only see emissions.
- Use both transition and emission matrices.
- Filtering helps estimate the current hidden state given observations.

4. Filtering & Particle Filtering

- Filtering updates belief about current state given past evidence.
- Particle filtering simulates many guesses (particles) and removes the least likely ones.

5. Game Theory

- Dominant Strategy: always best, regardless of opponent.
- Nash Equilibrium: no player can benefit by changing alone.
- Pareto Optimal: cannot improve one player without hurting another.
- Mixed Strategy: randomizing actions.
- Mixed Strategy Equilibrium: involves at least one player mixing.

6. Incomplete Information Games

- Players have unknown types or payoffs.
- Bayesian Nash Equilibrium: best response based on beliefs.
- Know basic auction types: English, Dutch, Sealed-bid, Vickrey.

7. Voting Theory

- May’s Theorem: Majority rule is fair for 2 choices (anonymity, neutrality, monotonicity, decisiveness).
- Arrow’s Theorem: No voting system is perfectly fair for 3+ choices.
- Condorcet Paradox: Group preferences can cycle.
- Condorcet Winner: wins all pairwise matchups.

Practice Questions

1. Use Bayes' Rule to update beliefs from test results.
2. Predict future states using Markov chains.
3. Filter states from emissions using HMM.
4. Identify dominant strategies and Nash equilibria.
5. Construct a Condorcet cycle.
6. Solve an incomplete info game using Bayesian reasoning.