AI for Software Engineering

Assignment: Understanding the AI Development Workflow

Total Points: 100

Part 1: Short Answer Questions (30 Points)

1. Problem Definition (6 Points)

Hypothetical Problem: Predicting Student Dropout Rates in Online Universities

Objectives:

1. Identify students at risk of dropping out based on behavioral and academic data.
2. Recommend timely interventions to reduce dropout likelihood.
3. Improve overall student retention and graduation rates by at least 15% over 12 months.

Stakeholders:

- University Administration
- Students

Key Performance Indicator (KPI):

- Model accuracy in predicting student dropout, with a target of ≥85%.

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2. Data Collection & Preprocessing (8 Points)

Data Sources:

1. Student Enrollment Records (demographics, grades, attendance)
2. Learning Management System (LMS) Logs (logins, submission timestamps, interaction levels)

Potential Bias:

- Students with poor internet access may be underrepresented or misclassified due to inconsistent activity data.

Preprocessing Steps:

1. Handle missing values in attendance and engagement logs using imputation.
2. Normalize grade and score data to a common scale.
3. Encode categorical features such as course type and study mode (full-time/part-time).

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3. Model Development (8 Points)

Chosen Model: Random Forest
Justification:

- Handles both numerical and categorical data.
- Resilient to missing values and less prone to overfitting.
- Offers feature importance insights.

Data Split Strategy:

- 70% training
- 15% validation
- 15% testing

Hyperparameters to Tune:

1. `n_estimators` - number of trees; affects model accuracy and computation time.
2. `max_depth` - limits tree depth to prevent overfitting.

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4. Evaluation & Deployment (8 Points)

Evaluation Metrics:

1. Accuracy - measures overall prediction correctness.
2. Recall - critical for identifying most actual dropouts.

Concept Drift:

- Definition: A change in data patterns over time affecting model performance.
- Monitoring Strategy: Schedule model re-evaluation every academic term with drift detection tools like River or Alibi Detect.

Deployment Challenge:

- Scalability: System must serve multiple departments and process large volumes of student records in real time.

Part 2: Case Study Application (40 Points)

Scenario: Hospital Readmission Prediction System

Problem Scope (5 Points)

Problem Statement:
Predict the risk of patient readmission within 30 days of discharge to enable timely interventions.

Objectives:

1. Reduce readmission rates and improve patient outcomes.
2. Assist healthcare staff in proactive care planning.

Stakeholders:

- Hospital Management
- Physicians and Nurses
- Patients

Data Strategy (10 Points)

Data Sources:

1. Electronic Health Records (EHRs)
2. Patient Demographics and Historical Admissions

Ethical Concerns:

1. Patient data privacy and risk of data leaks.
2. Bias in treatment recommendations due to underrepresentation of minority groups.

Preprocessing Pipeline:

- Remove duplicates from patient records.
- Impute missing lab test results.
- Feature engineering: Number of prior admissions, comorbidities, age brackets, length of stay.
- Normalize vital signs and numerical attributes.
- Encode diagnosis codes using ICD-10 mapping.

Model Development (10 Points)

Selected Model: Logistic Regression
Justification:

- High interpretability.
- Well-suited for binary classification.
- Ideal for healthcare scenarios where model decisions must be transparent.

Confusion Matrix (Hypothetical):

	Predicted: Yes	**Predicted: No**
Actual: Yes	80	20
Actual: No	30	170

Precision: 80 / (80 + 30) = 0.73
Recall: 80 / (80 + 20) = 0.80

Deployment (10 Points)

Integration Steps:

1. Wrap model in a RESTful API using Flask or FastAPI.
2. Connect API to the hospital's EHR dashboard.
3. Display risk scores in doctor workflows.
4. Integrate alert system for high-risk patients.

Compliance Measures:

- Encrypt all patient data using SSL/TLS.
- Implement role-based access control (RBAC).
- Align with HIPAA guidelines for data storage, sharing, and retention.

Optimization (5 Points)

Overfitting Mitigation:

- Use regularization (L2 penalty) to control model complexity and improve generalization.

Part 3: Critical Thinking (20 Points)

Ethics & Bias (10 Points)

Impact of Bias:
Biased training data may lead to poorer predictions for minority or underserved patient groups, resulting in unequal care or overlooked interventions.

Bias Mitigation Strategy:

- Ensure balanced training datasets across age, race, gender.
- Conduct fairness testing using tools like AI Fairness 360.
- Involve clinicians in evaluating model fairness and utility.

Trade-offs (10 Points)

Interpretability vs Accuracy:

- More accurate models (e.g., deep neural networks) may be black boxes, making them harder to trust in clinical decisions.
- Simpler models (e.g., logistic regression) are interpretable but may have lower performance.
- In healthcare, interpretability is often prioritized.

Limited Computational Resources:

- Prefer lightweight models like logistic regression or gradient boosting.
- Use batch prediction over real-time processing to conserve resources.

Part 4: Reflection & Workflow Diagram (10 Points)

Reflection (5 Points)

Most Challenging Part:

- Designing a robust data preprocessing pipeline due to varied data types and missing values in healthcare.

Improvements with More Time/Resources:

- Collect more diverse data.
- Involve domain experts for better feature selection.
- Deploy a retraining pipeline with CI/CD support.

Workflow Diagram (5 Points)

AI Development Workflow:

1. Problem Definition
2. Data Collection
3. Data Preprocessing

4. Model Development
5. Model Evaluation
6. Deployment
7. Monitoring & Maintenance

[Insert labeled flowchart showing connections and feedback loops between each step. Use tools like draw.io, Canva, or Lucidchart.]

References

- Udacity AI for Software Engineering Course Material
- TensorFlow Documentation: https://www.tensorflow.org/
- HIPAA Guidelines: https://www.hhs.gov/hipaa/index.html
- AI Fairness 360 Toolkit by IBM: https://aif360.mybluemix.net/
- scikit-learn Documentation: https://scikit-learn.org/

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