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Helwan University Image Annotation System (HIAS) Project Timeline

Introduction

The **Helwan University Image Annotation System (HIAS)** project is designed to create a web-based platform that enables efficient manual and AI-assisted image annotation. This system facilitates: - **Manual Annotation**: Allowing users to draw polygons or bounding boxes to annotate objects. - **AI-Assisted Annotation**: Leveraging YOLOv5 for object detection and auto-labeling. - **Image Categorization**: Organizing images into user-defined categories. - **Progress Persistence**: Ensuring annotations and user data are saved and retrievable upon logging in.

This timeline provides a step-by-step guide for the development process, divided into six months, with detailed tasks and deliverables for each phase. By following this structured plan, the team can build, test, deploy, and present a robust annotation tool tailored for research and practical use.

Month 1: Planning and Environment Setup

Week 1: Requirement Gathering and Planning

Tasks

1. **Finalize Project Requirements**
    - Define the core features:
        - **Manual Annotation Editor**: Tools for polygon drawing, label assignment, and undo/redo.
        - **Image Categorization**: Organize uploaded images into user-defined categories.
        - **Progress Persistence**: Ensure annotations and categories are saved and accessible upon login.
        - **AI-Assisted Labeling**: Integrate YOLOv5 for object detection and auto-labeling.
    - Prioritize into:
        - **MVP**: Manual annotation and image categorization.
        - **Stretch Goals**: AI-assisted labeling and performance optimizations.
2. **Team Role Allocation**
    - **Frontend Team**:
        - Build UI components using React.
        - Develop the annotation editor and categorization dashboard.
    - **Backend Team**:
        - Design and implement RESTful APIs.
        - Set up the PostgreSQL database.
    - **AI Service Team**:
        - Research YOLOv5 for object detection.
        - Set up a Flask service for predictions.
3. **Define the System Architecture**
    - Document interactions between **frontend**, **backend**, and **AI service**:
        - **Frontend** sends requests to the backend for user data, images, and annotations.
        - **Backend** stores data in PostgreSQL and communicates with the AI service.
        - **AI Service** processes images and returns predictions.

4. **Write the PRD (Product Requirements Document)**
    - Include:
        - Project overview and objectives.
        - Feature list and technical requirements.
        - Risks, milestones, and deliverables.

Deliverables

- Finalized PRD.
- Feature list with priorities.
- Role assignments and system architecture diagram.

Week 2: Wireframes and Mockups

Tasks

1. **Design Wireframes and Mockups**
    - Use tools like **Figma** or **Adobe XD** to create:
        - **Annotation Editor**:
            - Canvas for drawing polygons.
            - Label assignment dropdown or input field.
            - Undo/Redo buttons.
        - **Dashboard**:
            - Image upload form with category selection.
            - Categorized image grid or list view.
            - Progress tracker (e.g., images annotated vs. total images).
        - **Authentication**:
            - Login/Signup pages.
            - Profile management page.
2. **Define API Specifications**
    - Use tools like **Swagger/OpenAPI** or **Postman** to design backend APIs:
        - **User Management**:
            - `POST /auth/signup`: Register new users.
            - `POST /auth/login`: Authenticate users and return JWT.
        - **Image Handling**:
            - `POST /images/upload`: Upload and categorize images.
            - `GET /images?category=<name>`: Retrieve images by category.
        - **Annotations**:
            - `POST /annotations`: Save annotations.
            - `GET /annotations/:imageId`: Retrieve annotations for an image.
        - **AI Integration**:
            - `POST /predict`: Accept image input and return bounding boxes and labels.

3. **Database Schema Design**
    - Define tables for:
        - **Users**: Store user credentials and preferences.
        - **Images**: Store metadata (filename, category, and user ID).
        - **Annotations**: Save bounding boxes and labels linked to images.
        - **Categories**: Allow users to organize their images.

Deliverables

- Wireframes and mockups for frontend UI.
- API specifications documented with Swagger/Postman.
- Initial database schema design.

Week 3: Development Environment Setup

Tasks

1. **Set Up Project Repositories**
    - Create GitHub repositories for:
        - **Frontend**: React.js with TypeScript.
        - **Backend**: Express.js with TypeScript.
        - **AI Service**: Flask with YOLOv5 integration.
    - Configure branch protection rules for **main** and **develop** branches.
2. **Initialize the Frontend**
    - Create a React project:

      ```
      npx create-react-app app --template typescript
      ```

    - Install libraries:

        - **React Router** for navigation.
        - **Tailwind CSS** for styling.
    - Set up basic folder structure:

      ```
      app/
      ├── src/
      │   ├── components/   # Reusable UI components
      │   ├── pages/        # Main pages (Dashboard, Editor, Auth)
      │   ├── services/     # API service calls
      │   └── App.tsx       # Main entry point
      ```

3. **Initialize the Backend**
    - Set up an Express.js project with TypeScript:

      ```
      mkdir api && cd api
      npm init -y
      npm install express typescript ts-node @types/node @types/express
      ```

    - Install PostgreSQL and Prisma/Sequelize for database management.
    - Write a basic server setup:

      ```
      import express from 'express';

      const app = express();
      app.use(express.json());

      app.listen(5000, () => console.log('API running on port 5000'));
      ```

4. **Initialize the AI Service**
    - Clone the YOLOv5 repository and set up a Flask project:

      ```
      git clone https://github.com/ultralytics/yolov5
      mkdir auto-labeler && cd auto-labeler
      python -m venv venv
      source venv/bin/activate
      pip install flask torch torchvision
      ```

    - Write a basic Flask server with a placeholder `/predict` endpoint.
5. **Set Up Docker Compose**
    - Create a `docker-compose.yml` file to manage:
        - **Frontend**.
        - **Backend**.
        - **AI Service**.
        - **PostgreSQL** database.

Deliverables

- Initialized repositories for all components.
- Functional development environment for local testing.

Week 4: Initial Implementation

Tasks

1. **Frontend**
    - Build placeholders for:
        - Login/Signup pages.
        - Dashboard with mock image grid.
    - Set up basic routing using **React Router**.
2. **Backend**
    - Implement:
        - Authentication endpoints (`/auth/signup`, `/auth/login`).
        - Image upload API with dummy storage.
    - Connect to PostgreSQL and write migrations for initial schemas.
3. **AI Service**
    - Test YOLOv5 locally with sample images.
    - Create a Flask `/predict` endpoint that returns dummy bounding boxes and labels.
4. **CI/CD Integration**
    - Use **GitHub Actions** to:
        - Run unit tests for frontend and backend.
        - Lint codebases for consistency.

Deliverables

- Frontend with basic routing and mock components.
- Backend with authentication and image upload APIs.
- Flask AI service with placeholder `/predict` endpoint.
- CI/CD pipelines integrated for all repositories.

Month 2: User Management, Image Upload, and Categorization

Week 5: User Authentication

Tasks

1. **Frontend**
    - Build **Login and Signup pages**:
        - Create forms for username, email, and password input.
        - Add client-side validation:
            - Ensure password complexity (e.g., minimum 8 characters).
            - Validate email format.
        - Display error messages for invalid inputs or failed attempts.
    - Manage user sessions:
        - Use **localStorage** or **cookies** to store JWT tokens securely.
        - Redirect users to the dashboard upon successful login.
2. **Backend**
    - Implement authentication endpoints:
        - `POST /auth/signup`:
            - Validate input (e.g., unique email).
            - Hash passwords with **bcrypt**.
            - Save user data in the `users` table.
        - `POST /auth/login`:
            - Verify email and password.
            - Return a JWT token upon successful authentication.
        - `POST /auth/logout` (optional for session tracking).
    - Write unit tests for all endpoints.
3. **AI Service**
    - No specific tasks this week. The placeholder `/predict` endpoint remains available for integration testing.

4. **Integration**
    - Connect frontend login and signup forms to backend APIs.
    - Test the full **login/signup flow**:
        - Validate that users can register and log in.
        - Ensure JWT tokens are correctly stored and included in future requests.

Deliverables

- Fully functional login and signup pages.
- Backend authentication APIs with JWT-based session management.
- End-to-end user authentication workflow.

Week 6: Image Upload

Tasks

1. **Frontend**
    - Build the **image upload interface**:
        - Add a file input for image selection.
        - Include a dropdown or text field for assigning categories.
        - Display an image preview before upload.
        - Implement an upload button to send the image and metadata to the backend.
2. **Backend**
    - Implement the `POST /images/upload` endpoint:
        - Accept multipart form-data (image file and category).
        - Store uploaded image files in:
            - A local directory (for development).
            - A cloud storage service (e.g., AWS S3) for production.
        - Save metadata (e.g., filename, category, user ID) in the `images` table.
    - Create a `GET /images` endpoint:
        - Fetch all images for a user, optionally filtered by category.
3. **AI Service**
    - Begin integrating YOLOv5 into the Flask project:
        - Load the pre-trained YOLOv5 model.
        - Test local inference on sample images.
        - Prepare a `/predict` endpoint that processes uploaded images and returns:
            - Bounding box coordinates.
            - Class labels.
            - Confidence scores.
4. **Integration**
    - Connect the frontend upload form to the backend:
        - Enable file uploads and display success/error messages.
        - Save image metadata in the database and display it on the frontend.

Deliverables

- Functional image upload interface.
- Backend endpoints for saving images and metadata.
- Initial `/predict` endpoint in the AI service for inference testing.

Week 7: Image Categorization

Tasks

1. **Frontend**
    - Extend the dashboard to support **image categorization**:
        - Group images by category using tabs or dropdown filters.
        - Display categorized images in a responsive grid or list view.
    - Add a progress tracker:
        - Show the number of images categorized or annotated.
2. **Backend**
    - Enhance the `GET /images` endpoint:
        - Add support for filtering images by category (e.g., `GET /images?category=<name>`).
        - Implement pagination for large datasets.
    - Create a `GET /categories` endpoint:
        - Fetch all unique categories for a user.
3. **AI Service**
    - Test YOLOv5 inference on sample images:
        - Validate accuracy of bounding boxes and labels.
        - Measure response times for image processing.
4. **Integration**
    - Connect the frontend dashboard to the backend:
        - Fetch and display categorized images.
        - Enable users to create new categories and update image metadata.

Deliverables

- Categorization feature in the dashboard.
- Backend support for filtering and organizing images by category.
- Initial AI inference results verified with sample images.

Week 8: Testing and Refinement

Tasks

1. **Frontend**
    - Conduct usability testing for:
        - Login/signup forms.
        - Image upload and categorization workflows.
    - Refine UI/UX based on feedback:
        - Improve error messages and feedback during uploads.
        - Ensure responsive design across devices.
2. **Backend**
    - Write integration tests for:
        - Authentication endpoints.
        - Image upload and retrieval.
        - Category filtering.
    - Optimize database queries for:
        - Image retrieval by category.
        - Pagination support.
3. **AI Service**
    - Add logging and error handling to the Flask app for debugging.
    - Write unit tests for the `/predict` endpoint to validate output consistency.
4. **Integration**
    - Test the end-to-end workflow:
        - User logs in, uploads images, assigns categories, and views categorized images.
        - Verify API communication between frontend, backend, and AI service.

Deliverables

- Fully tested and refined authentication, image upload, and categorization features.
- Optimized backend API and database.
- Functional AI service ready for further integration.

Month 2 Deliverables Summary

1. **Authentication**:
    - Login and signup pages with backend integration.
    - JWT-based session management.
    - Unit and integration tests for all authentication endpoints.
2. **Image Upload**:
    - Frontend image upload form with category assignment.
    - Backend endpoints for saving images and metadata.
3. **Categorization**:
    - Dashboard displaying categorized images.
    - APIs for managing and retrieving categories.
4. **AI Service**:
    - Functional `/predict` endpoint with bounding box and label output.
    - YOLOv5 integration tested with sample images.
5. **Integration**:
    - End-to-end workflows for authentication, image upload, and categorization tested and validated.

Month 3: Annotation Editor Development

Week 9: Building the Annotation Editor (Part 1)

Tasks

1. **Frontend**
    - **Set up the annotation canvas**:
        - Use **HTML5 `<canvas>`** or an **SVG-based library** to create an interactive drawing area.
        - Implement tools for:
            - **Polygon drawing**: Allow users to click points to form a polygon outlining an object.
            - **Bounding boxes**: Add support for rectangular object annotations.
        - Add basic controls:
            - **Undo/Redo** for actions.
            - **Reset** to clear the canvas.
    - Develop a UI for label assignment:
        - A dropdown menu or text input field to assign object labels to the drawn shapes.
        - Include a "Save" button to finalize annotations.
2. **Backend**
    - Implement endpoints for annotation management:
        - `POST /annotations`:
            - Save new annotations (bounding box coordinates and labels) to the `annotations` table.
            - Validate data and ensure it is linked to the correct image.
        - `GET /annotations/:imageId`:
            - Retrieve annotations for a specific image.
    - Write unit tests for the new endpoints.
3. **AI Service**
    - Add functionality to validate and preprocess images before prediction:
        - Ensure input images are resized to the correct dimensions for YOLOv5.
        - Return placeholder predictions (bounding boxes and labels) for testing with the frontend.

4. **Integration**
    - Connect the frontend canvas to the backend:
        - Save user-drawn annotations to the database via the `POST /annotations` endpoint.
        - Fetch existing annotations for an image from the `GET /annotations/:imageId` endpoint.

Deliverables

- Initial version of the annotation editor with drawing tools and label assignment.
- Backend APIs for saving and retrieving annotations.
- Basic integration of frontend annotation tools with the backend.

Week 10: Building the Annotation Editor (Part 2)

Tasks

1. **Frontend**
    - **Enhance the canvas tools**:
        - Add visual feedback:
            - Highlight selected shapes.
            - Display labels on or near annotated objects.
        - Enable users to edit and delete existing annotations.
    - Implement a **navigation workflow**:
        - Add “Next” and “Previous” buttons to navigate between images in a project.
        - Indicate the current image’s progress (e.g., “3/10 images annotated”).
2. **Backend**
    - Refine annotation endpoints:
        - Add support for updating and deleting annotations:
            - `PUT /annotations/:id`: Update an existing annotation.
            - `DELETE /annotations/:id`: Delete an annotation by ID.
    - Write tests for update and delete functionality.
    - Optimize data retrieval:
        - Use indexed queries to speed up fetching annotations for large datasets.
3. **AI Service**
    - Finalize the `/predict` endpoint:
        - Process uploaded images using YOLOv5 and return:
            - Bounding box coordinates.
            - Class labels.
            - Confidence scores.
    - Write unit tests to validate the endpoint’s outputs.

4. **Integration**
    - Integrate AI predictions into the frontend:
        - Call the `/predict` endpoint when an image is uploaded or selected.
        - Display the predicted bounding boxes and labels on the canvas.
        - Allow users to accept, edit, or delete AI-generated annotations.

Deliverables

- Enhanced annotation editor with editing, deletion, and navigation tools.
- Backend support for updating and deleting annotations.
- Fully functional `/predict` endpoint in the AI service.

Week 11: Editor-Backend Integration and Refinement

Tasks

1. **Frontend**
    - **Refine the annotation editor UI**:
        - Improve user experience based on team feedback.
        - Add tooltips or instructions for first-time users.
        - Style labels and bounding boxes for better visibility.
    - Enable real-time updates:
        - Automatically refresh the canvas when annotations are added, updated, or deleted.
2. **Backend**
    - Add validation to annotation APIs:
        - Ensure bounding box coordinates are within the image dimensions.
        - Prevent duplicate labels for the same object in an image.
    - Write integration tests for the full annotation workflow:
        - Image upload → Annotation creation → Annotation retrieval.
3. **AI Service**
    - Optimize the YOLOv5 model:
        - Test different confidence thresholds to reduce false positives.
        - Apply quantization to improve inference speed without sacrificing accuracy.
    - Add logging and error handling for the `/predict` endpoint.
4. **Integration**
    - Test the end-to-end workflow:
        - User selects an image, annotates manually, and saves annotations.
        - AI suggestions are generated, reviewed, and saved or discarded.
        - Verify that all data flows correctly between the frontend, backend, and AI service.

Deliverables

- Fully integrated annotation editor with real-time updates.
- Optimized annotation APIs with validation.
- Improved AI predictions integrated into the editor.

Week 12: Testing and Finalization

Tasks

1. **Frontend**
    - Perform usability testing for:
        - Annotation editor tools (drawing, editing, deletion).
        - Label assignment and navigation.
        - Integration of AI suggestions into the user workflow.
    - Address feedback from testing:
        - Fix bugs or inconsistencies in the annotation editor.
        - Improve responsiveness for different screen sizes.
2. **Backend**
    - Conduct load testing for annotation-related APIs:
        - Simulate multiple users uploading and annotating images simultaneously.
    - Optimize database queries for large datasets.
3. **AI Service**
    - Perform stress testing:
        - Simulate high-frequency requests to the `/predict` endpoint.
        - Monitor performance and adjust model parameters if needed.
    - Ensure the Flask app can handle concurrent requests.
4. **Integration**
    - Test complete workflows:
        - Login → Image upload → Annotation → Save progress.
        - Ensure progress persistence when users log out and log back in.
    - Debug and resolve any integration issues.

Deliverables

- Tested and refined annotation editor.
- Backend and AI service optimized for performance.
- Fully integrated system ready for deployment in Month 4.

Month 3 Deliverables Summary

1. **Annotation Editor**:
    - Functional editor with tools for drawing, editing, and deleting annotations.
    - Integrated AI suggestions displayed alongside user annotations.
    - Navigation tools for switching between images.
2. **Backend**:
    - APIs for creating, updating, retrieving, and deleting annotations.
    - Optimized queries for large datasets.
    - Integration tests for annotation workflows.
3. **AI Service**:
    - Finalized `/predict` endpoint using YOLOv5.
    - Optimized for inference speed and accuracy.
    - Stress-tested for concurrent requests.
4. **Integration**:
    - End-to-end workflow validated across all components.
    - Usability tested and refined for deployment readiness.

Month 4: AI Integration and Refinement

Week 13: AI-Assisted Labeling (Part 1)

Tasks

1. **Frontend**
    - **Display AI-generated annotations**:
        - Integrate predictions from the AI service into the annotation editor.
        - Highlight AI-generated bounding boxes with a distinct color or style.
        - Add options to:
            - **Accept** AI suggestions as-is.
            - **Modify** bounding boxes or labels.
            - **Delete** AI-generated annotations.
    - Update the **editor UI**:
        - Include toggles to switch between manual and AI-assisted annotation modes.
        - Display confidence scores for AI-predicted annotations.
2. **Backend**
    - Implement the AI integration endpoint:
        - `POST /ai/annotate`:
            - Accept an image ID.
            - Send the image to the Flask AI service.
            - Return the predictions to the frontend.
        - Add caching for AI predictions to avoid redundant calls.
    - Write unit tests for the AI integration endpoint.
3. **AI Service**
    - Finalize the `/predict` endpoint:
        - Ensure consistent output format:
            - Bounding boxes (x_min, y_min, x_max, y_max).
            - Labels and confidence scores.
        - Test model inference with images of varying resolutions and sizes.
    - Optimize inference:
        - Reduce processing time per image by adjusting batch sizes or model settings.

4. **Integration**
    - Test the complete AI-assisted annotation workflow:
        - User uploads an image → AI predictions are generated → Predictions are displayed in the editor.

Deliverables

- Functional AI-assisted labeling integrated into the annotation editor.
- Backend API for sending images to the AI service and retrieving predictions.
- Optimized and tested `/predict` endpoint in the AI service.

Week 14: AI-Assisted Labeling (Part 2)

Tasks

1. **Frontend**
    - **Enhance user interactions with AI suggestions**:
        - Add visual indicators (e.g., a confidence bar) for AI-generated labels.
        - Allow users to refine the position and size of bounding boxes.
    - Add bulk actions:
        - Accept or reject multiple AI suggestions at once.
    - Refine navigation between images:
        - Skip images that have already been fully annotated.
2. **Backend**
    - Store AI suggestions in the database:
        - Update the `annotations` table schema to track AI-generated annotations separately.
        - Save AI-generated annotations when the user accepts them.
    - Add API support for:
        - Fetching pending AI suggestions.
        - Overwriting AI suggestions with user edits.
3. **AI Service**
    - Implement preprocessing for large images:
        - Resize images dynamically to fit YOLOv5's input dimensions.
        - Normalize pixel values for better model performance.
    - Add logging:
        - Record inference times and input/output statistics for debugging and optimization.
4. **Integration**
    - Test the workflow for bulk actions:
        - Ensure that multiple annotations can be saved, modified, or deleted in a single operation.
    - Debug issues with AI predictions or database integration.

Deliverables

- Enhanced annotation editor with refined AI interaction tools.
- Backend APIs for saving and managing AI suggestions.
- Optimized AI service for handling large images and concurrent requests.

Week 15: System Refinement

Tasks

1. **Frontend**
    - Conduct usability testing for the annotation editor:
        - Focus on the integration of AI suggestions.
        - Gather feedback on the ease of use for bulk actions and manual edits.
    - Refine UI/UX based on feedback:
        - Adjust the layout and styles for better visibility.
        - Add tooltips or inline help for new features (e.g., AI suggestions).
2. **Backend**
    - Optimize database performance:
        - Add indexing to speed up annotation retrieval and updates.
        - Review caching strategies to minimize redundant queries.
    - Conduct API load testing:
        - Simulate multiple users uploading images and generating AI predictions simultaneously.
3. **AI Service**
    - Tune YOLOv5 for production:
        - Experiment with model quantization or pruning to reduce size and improve speed.
    - Conduct stress testing:
        - Simulate high-frequency prediction requests.
        - Measure and optimize response times.
4. **Integration**
    - Perform end-to-end testing:
        - Login → Image upload → AI prediction → Annotation saving → Logout → Data persistence.
    - Validate workflows for edge cases:
        - Large images.
        - Images with overlapping objects or complex scenes.

Deliverables

- Fully refined annotation editor with improved UI/UX.
- Optimized backend APIs and database performance.
- Production-ready AI service tuned for accuracy and speed.

Week 16: Final Testing and Preparation for Deployment

Tasks

1. **Frontend**
    - Conduct cross-browser testing:
        - Ensure compatibility with Chrome, Firefox, Edge, and Safari.
    - Optimize performance:
        - Minify JavaScript and CSS.
        - Lazy-load components where applicable.
2. **Backend**
    - Finalize API security:
        - Implement rate limiting for APIs to prevent abuse.
        - Secure endpoints with proper validation and error handling.
    - Write comprehensive API documentation using **Swagger** or **Postman**.
3. **AI Service**
    - Set up monitoring:
        - Use tools like **Prometheus** or **Flask Monitoring Dashboard** to track request metrics.
    - Finalize Docker container for the AI service:
        - Ensure all dependencies are included and test the container in isolation.
4. **Integration**
    - Conduct system-wide testing:
        - Simulate real-world usage scenarios with multiple concurrent users.
        - Validate all features, including:
            - AI-assisted labeling.
            - Progress persistence.
            - Annotation saving and editing.

Deliverables

- Fully tested and optimized frontend, backend, and AI service.
- Comprehensive API documentation.
- Deployment-ready system with production configurations.

Month 4 Deliverables Summary

1. **Annotation Editor**:
    - Fully functional AI-assisted annotation tools.
    - Enhanced user interaction with AI-generated predictions.
    - Bulk actions for managing annotations.
2. **Backend**:
    - APIs for managing AI suggestions and annotations.
    - Optimized database performance with indexing and caching.
    - Load-tested endpoints for high concurrency.
3. **AI Service**:
    - Finalized and optimized YOLOv5-based `/predict` endpoint.
    - Stress-tested for production workloads.
    - Dockerized and ready for deployment.
4. **Integration**:
    - End-to-end workflows validated for all use cases.
    - Fully refined system ready for deployment in Month 5.

Month 5: Testing and Optimization

Week 17: Comprehensive Testing (Part 1)

Tasks

1. **Frontend**
    - **Unit Testing**:
        - Test individual components using **React Testing Library** and **Jest**.
        - Focus on:
            - Annotation editor tools (polygon drawing, undo/redo, label assignment).
            - Image upload and categorization workflows.
    - **Integration Testing**:
        - Test the interaction between:
            - The dashboard and categorization APIs.
            - The annotation editor and backend endpoints.
        - Ensure smooth transitions between screens (e.g., login → dashboard → annotation editor).
2. **Backend**
    - **API Unit Testing**:
        - Write unit tests for all major endpoints:
            - Authentication (`/auth/signup`, `/auth/login`).
            - Image management (`/images/upload`, `/images`).
            - Annotation management (`/annotations`, `/annotations/:id`).
        - Validate input and error handling.
    - **Integration Testing**:
        - Simulate workflows:
            - User uploads images and retrieves metadata.
            - User saves and retrieves annotations.

3. **AI Service**
    - **Unit Testing**:
        - Validate the `/predict` endpoint's output format and accuracy with sample inputs.
    - **Integration Testing**:
        - Test the integration between the Flask service and backend APIs.
        - Verify that images sent by the backend are correctly processed by YOLOv5.
4. **System Testing**
    - Test end-to-end workflows:
        - Login → Upload image → Generate AI predictions → Annotate → Save progress → Logout → Log back in to verify data persistence.

Deliverables

- Unit and integration tests for all components (frontend, backend, AI service).
- Validated end-to-end workflows ensuring system stability.

Week 18: Comprehensive Testing (Part 2)

Tasks

1. **Frontend**
    - **Cross-Browser Testing**:
        - Ensure compatibility with Chrome, Firefox, Edge, and Safari.
    - **Responsive Design Testing**:
        - Validate UI performance on various screen sizes (e.g., desktop, tablet, mobile).
    - Fix any issues identified during testing.
2. **Backend**
    - **Load Testing**:
        - Use tools like **Apache JMeter** or **k6** to simulate concurrent users:
            - Simulate multiple users uploading images simultaneously.
            - Stress-test annotation APIs with high-frequency read/write operations.
    - Optimize performance:
        - Add indexing to frequently queried database columns.
        - Optimize SQL queries for pagination and filtering.
3. **AI Service**
    - **Stress Testing**:
        - Simulate high-frequency prediction requests using tools like **Locust**.
        - Measure response times and optimize model inference settings.
    - Refine YOLOv5:
        - Experiment with lower-confidence thresholds to reduce false positives.
        - Adjust input image resizing to maintain accuracy without increasing latency.
4. **Integration**
    - Conduct performance tests across the entire system:
        - Measure latency for combined frontend-backend-AI workflows.
        - Identify bottlenecks and optimize accordingly.

Deliverables

- Cross-browser and responsive frontend validated.
- Backend APIs tested and optimized for high concurrency.
- Stress-tested AI service capable of handling production loads.

Week 19: Optimization and Refinement

Tasks

1. **Frontend**
    - **Performance Optimization**:
        - Minify JavaScript and CSS for faster loading times.
        - Implement lazy loading for images and other assets.
        - Optimize state management for smoother UI interactions.
2. **Backend**
    - **Caching**:
        - Use **Redis** to cache:
            - Frequently accessed data (e.g., image metadata, annotations).
            - AI predictions for recently processed images.
    - **API Rate Limiting**:
        - Protect APIs from abuse by implementing rate limits using libraries like **express-rate-limit**.
3. **AI Service**
    - Optimize the YOLOv5 model:
        - Apply model quantization or pruning to reduce size and inference time.
    - Implement asynchronous request handling:
        - Use **Celery** or a similar tool for processing large image batches in the background.
4. **Integration**
    - Test real-world scenarios:
        - Simulate a complete workflow with multiple concurrent users.
        - Ensure smooth transitions and minimal downtime during interactions.

Deliverables

- Optimized frontend with faster load times and smoother UI performance.
- Backend caching and rate limiting implemented for stability.
- AI service optimized for high-speed predictions.
- Fully tested and refined system for deployment.

Week 20: Final Preparations for Deployment

Tasks

1. **Frontend**
    - Build the React app for production using:

      ```
      npm run build
      ```

    - Test the production build locally to ensure no issues.
    - Prepare deployment scripts for cloud platforms (e.g., AWS, Vercel).
2. **Backend**
    - Finalize production configurations:
        - Set environment variables for database connections, AI service URL, and JWT secrets.
        - Prepare Docker Compose for production with `docker-compose.prod.yml`.
3. **AI Service**
    - Finalize the Docker container:
        - Ensure all dependencies are included.
        - Test the container in isolation to verify functionality.
    - Add monitoring tools like **Prometheus** or **Flask Monitoring Dashboard** for runtime metrics.
4. **System-Wide Testing**
    - Conduct final end-to-end tests with the production build:
        - Test workflows for all major features (login, image upload, annotation, AI suggestions).
        - Verify data persistence and performance under load.

Deliverables

- Production-ready frontend, backend, and AI service builds.
- Deployment scripts and production configurations finalized.
- Fully validated system ready for deployment in Month 6.

Month 5 Deliverables Summary

1. **Frontend**:
    - Unit, integration, and cross-browser tests completed.
    - Optimized performance with minified assets and lazy loading.
    - Production build ready for deployment.
2. **Backend**:
    - Load-tested APIs optimized for high concurrency.
    - Implemented caching and rate limiting for stability.
    - Production configurations finalized.
3. **AI Service**:
    - Stress-tested `/predict` endpoint for concurrent requests.
    - Optimized YOLOv5 for inference speed and accuracy.
    - Docker container finalized with monitoring tools.
4. **Integration**:
    - Fully validated end-to-end workflows.
    - Real-world scenarios simulated with multiple concurrent users.

Month 6: Deployment and Finalization

Week 21: Deployment Preparation

Tasks

1. **Frontend**
    - Prepare the production build:
        - Generate the optimized build using:

          ```
          npm run build
          ```

        - Test the build locally to ensure no issues with routing, assets, or functionality.
    - Set up deployment scripts:
        - Use **AWS S3** or **Vercel** for hosting static files.
        - Configure environment variables for backend API URLs.
2. **Backend**
    - Finalize production settings:
        - Set up environment variables for:
            - **Database connection strings**.
            - **AI service URL**.
            - **JWT secrets**.
        - Configure `docker-compose.prod.yml` for deploying the backend with PostgreSQL.
    - Harden security:
        - Use HTTPS for all API calls.
        - Implement input validation and error handling.

3. **AI Service**
    - Finalize the Docker container for deployment:
        - Include all dependencies in the `requirements.txt` file.
        - Optimize the Flask app for production using **Gunicorn**:

          ```
          gunicorn -w 4 -b 0.0.0.0:5000 app:app
          ```
    - Add monitoring endpoints:
        - Expose metrics for request count, latency, and errors.
4. **Deployment Environment**
    - Set up a cloud environment (e.g., AWS, GCP, or DigitalOcean):
        - Create a virtual machine for hosting the backend and AI service.
        - Configure a load balancer for traffic management.
    - Set up **NGINX** as a reverse proxy:
        - Route traffic to the appropriate services (frontend, backend, AI service).
        - Enable SSL using **Let's Encrypt** for secure connections.

Deliverables

- Production-ready builds for frontend, backend, and AI service.
- Deployment scripts and configurations prepared for the cloud environment.
- Secure and scalable deployment setup.

Week 22: System Deployment

Tasks

1. **Deploy Frontend**
    - Upload the React production build to:
        - **AWS S3** or **CloudFront** for static hosting.
        - **Vercel** or similar platforms for serverless hosting.
    - Test deployment:
        - Ensure the frontend communicates correctly with backend APIs.
2. **Deploy Backend**
    - Use Docker Compose to deploy the backend and PostgreSQL:

      ```
      docker-compose -f docker-compose.prod.yml up -d
      ```

    - Verify:
        - API endpoints are reachable.
        - Database migrations are applied successfully.
3. **Deploy AI Service**
    - Deploy the Flask service container:

      ```
      docker run -d -p 5000:5000 your-ai-service-image
      ```

    - Verify:
        - The `/predict` endpoint processes requests correctly.
        - Performance metrics are available via monitoring tools.
4. **System Testing**
    - Conduct final end-to-end tests:
        - Test all workflows (e.g., login, image upload, annotation, AI suggestions).
        - Verify data persistence and performance under production load.
    - Fix any deployment-related issues.

Deliverables

- Fully deployed system accessible via a public URL.
- Validated workflows in the production environment.

Week 23: Documentation

Tasks

1. **User Documentation**
    - Write a comprehensive **user guide**:
        - Instructions for:
            - Logging in and signing up.
            - Uploading images and assigning categories.
            - Annotating images manually and using AI suggestions.
        - Include screenshots and step-by-step tutorials.
2. **Developer Documentation**
    - Prepare a **developer guide**:
        - Setup instructions for:
            - Local development environments.
            - Running tests.
            - Deploying the system.
        - API documentation:
            - Use **Swagger** or **Postman** for interactive documentation.
3. **Technical Overview**
    - Document the system architecture:
        - Describe the interaction between frontend, backend, and AI service.
        - Include diagrams for data flow and deployment architecture.
4. **Monitoring and Maintenance**
    - Write a guide for:
        - Monitoring the deployed system (e.g., logs, metrics).
        - Scaling the system (e.g., adding more instances for AI service).

Deliverables

- Complete user guide for application usage.
- Developer documentation for system setup and deployment.
- Technical documentation with system architecture and monitoring instructions.

Week 24: Demo and Final Presentation

Tasks

1. **Prepare the Demo**
    - Record a video walkthrough:
        - Highlight key features:
            - Manual and AI-assisted annotation.
            - Image upload and categorization.
            - Progress tracking and persistence.
        - Showcase workflows from start to finish.
    - Test the live system for the demo:
        - Ensure all major features work seamlessly.
        - Prepare fallback solutions for potential issues.
2. **Create the Presentation**
    - Structure the presentation:
        - **Introduction**:
            - Overview of the problem and project objectives.
        - **Features**:
            - Highlight the annotation tools, AI integration, and categorization system.
        - **Technical Details**:
            - System architecture and key technologies used.
            - Challenges faced and how they were resolved.
        - **Results**:
            - Metrics on system performance, accuracy of AI predictions, and user feedback.
        - **Future Work**:
            - Potential enhancements and scalability improvements.
3. **Rehearse**
    - Practice delivering the presentation as a team.
    - Prepare to answer technical questions about the project.

Deliverables

- Recorded demo video showcasing the system.
- Final presentation slides highlighting project features, architecture, and results.
- Team rehearsed and ready for the final delivery.

Month 6 Deliverables Summary

1. **Deployment**:
    - Fully deployed system accessible via a public URL.
    - Secure and scalable deployment environment set up on the cloud.
2. **Documentation**:
    - Comprehensive user and developer guides.
    - Technical overview with architecture diagrams.
3. **Demo and Presentation**:
    - Recorded demo video showcasing workflows and features.
    - Final presentation slides prepared and rehearsed.
4. **Final System**:
    - Tested, optimized, and production-ready application.