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Course: CAP5602
Project Name: Sliding puzzle game by AI

Project Overview

The Sliding Puzzle Game is a web-based implementation of the classic 3x3 sliding tile puzzle. Users can upload their own images, which are automatically divided into tiles to create an interactive puzzle. The game includes both manual solving capabilities and an AI-powered automatic solver.

Technical Implementation

- **Backend (Flask):**
  - Framework: Python Flask
  - Key Libraries:
  - PIL (Python Imaging Library) for image processing
  - NumPy for numerical operations
  - Werkzeug for file handling
  - Heapq for priority queue implementation in A* algorithm

- Frontend
  - Technologies:
  - HTML5
  - CSS3
  - JavaScript (ES6+)
  - Axios for HTTP requests
  - Responsive Design: Adaptable layout using CSS Grid and Flexbox.

Core Components:

- **Image Processing**
  - Image upload with format validation
  - Automatic tile generation (3×3 grid)
  - Dynamic tile management with unique identifiers
  - Support for multiple image formats (PNG, JPG, JPEG, GIF, BMP, WEBP)

- Puzzle Logic
  - Solvability validation using inversion counting
  - State management for puzzle configuration
  - Valid move detection system
  - Blank tile tracking

- AI Solver

- Implementation of A* pathfinding algorithm
- Manhattan distance heuristic
- State space exploration with priority queue
- Solution path reconstruction

Features

User Interface

- Clean, intuitive design
- Real-time move counter
- Visual feedback for tile movement
- Celebration animation on puzzle completion
- Error handling with user-friendly messages

Game Mechanics

- Image upload and automatic puzzle creation
- Manual puzzle solving through tile clicking
- AI-assisted solving with step-by-step animation
- Puzzle state validation
- Move tracking and statistics

Technical Features

- Secure file handling
- Automatic puzzle solvability checking
- Efficient state management
- Asynchronous operations for smooth user experience

Implementation Details

- **Puzzle Generation**

1. Image upload and validation
2. Division into 3×3 grid
3. Random but solvable state generation
4. Tile path management

- **AI Solver Algorithm**

1. A* search implementation
2. Manhattan distance calculation
3. State space exploration
4. Solution path generation
5. Step-by-step move execution

State Management

1. Puzzle state tracking
2. Move validation
3. Solution verification
4. Tile position updates

Security Measures

- File type validation
- Secure filename handling
- Size limitations (16MB max)
- Server-side validation
- Error handling and sanitization

Performance Considerations

- Efficient image processing
- Optimized A* implementation
- Asynchronous operations
- Resource cleanup
- Memory management

Future Improvements

- **Potential Enhancements**
  - Multiple difficulty levels
  - Different grid sizes
  - User accounts and scores
  - Puzzle sharing capabilities
  - Mobile optimization

- **Technical Optimizations**
  - Solution caching
  - Better heuristic functions
  - Performance optimization
  - Additional solver algorithms

Conclusion

The Sliding Puzzle Game successfully implements a classic puzzle with modern features and AI capabilities. The combination of Flask backend and interactive frontend provides a smooth user experience while maintaining good performance and security standards.

The implementation demonstrates proper software engineering practices including:

- Modular code structure
- Robust error handling
- Security considerations
- User experience focus
- Scalable architecture

The project serves as a solid foundation for future enhancements and features while maintaining core functionality and performance.

I encounter of difficulty that my AI method one time work but only the tile should moved but not moved the tile I try fix it and spend a lot of time but unfortunately cannot solve it I did not get any error and because of my other final I don't have time to spend on it but after final again work on it.