Jigsaw Puzzle Solver Project Overview

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Solving a jigsaw puzzle entails arranging a fixed set of pieces such that they reconstruct an original source image. With a traditional jigsaw puzzle, there are two primary factors that significantly reduce the difficulty of the problem, namely:

1. Piece Shape – Due to different piece shapes, most pieces are mechanically unable to be placed adjacent to one another. What is more, through shape alone, the approximate location of some pieces can be known (e.g. corner pieces). This greatly reduces the number of possible permutations of each piece making what would potentially be an intractable problem quite simple.

2. Knowledge of the Source Image – By knowing the source image, the solver can determine with certainty whether a piece is in the right location.

This project will develop a tool that will attempt to reconstruct a jigsaw puzzle of uniform, square pieces for an unknown image.

CS297 Deliverables

1. **Jigsaw Puzzle Generator**
    a. *Predicted Duration:* 2 to 3 Weeks

    b. *Description:* Given a source image, the generator will:
        i. Import a bitmap image
        ii. Parse the image into a specified number of equal size tiles (Note: some of the picture may be cropped during this process)
        iii. Perform a Fisher-Yates shuffle of the pieces
        iv. Optionally rotate each tile randomly
        v. Display the shuffled image (with optional borders for clarity)

    c. *Goals:* I have never worked with image processing in the past. This will provide me experience working with image files and their formats. What is more, the quality of jigsaw solution may be subjective. The ability to visualize that image is expected to provide clear insight into the strengths and weaknesses of a solver's approach and how it may be improved.

    d. *Programming Language:* Python with most likely the Pillow Library

2. **Top-down versus Bottom Up Solution Comparison**
    a. *Predicted Duration:* 2 weeks

    b. *Description:* There are multiple approaches that have been and can be used to solve this problem including: genetic algorithm, neural networks, local beam search, constraint satisfaction, etc. I classify these solutions into two primary categories namely:

i. Bottom-Up: Start with a single piece and grow the solution one piece at a time. This is the approach used by humans when solving the problem.

ii. Top Down: Start with a fully placed board and optimize the solution by transposing pieces or sets of pieces.

3. **Jigsaw Puzzle Result Evaluation Metric Identification and Comparison**
    a. *Predicted Duration:* 1 to 2 weeks

    b. *Description:* The quality of the solution to the jigsaw puzzle problem is subjective. For example, given an image of a single, solid color, pieces could be rotated or transposed without affecting the solution. It is hypothesized that no single metric will be sufficient to determine whether one solution is superior to another. What is more, it is further theorized that different metrics may be needed depending on the characteristics intrinsic to the source image.

    For this deliverable, a set of quality and accuracy metrics for jigsaw puzzle solutions will be proposed and eventually implemented (see deliverable #4).

4. **Solution Implementation**
    a. *Predicted Duration:* 2 to 3 weeks

    b. *Description:* As an initial proof of concept, I will develop the infrastructure to implement one of the solver approaches proposed as part of deliverable #2. It is anticipated that the solver will be bottom up with the piece selection implemented using the Strategy Design Pattern so that new approaches can be easily incorporated into the general framework.

    In addition to implementing a solver, this step will include implementing the metrics enumerated by deliverable #3.

5. **CS298/CS299 Project Proposal**
    a. *Predicted Duration:* 2 to 3 weeks. However, it is anticipated that work on this task will be done throughout the semester.

    b. *Description:* This is the culminating document for this semester's activities. It will include:
        i. An overview of the project problem
        ii. Summary of previous work and solutions of the problem
        iii. Discuss the strategies I plan to use to solve the problem
        iv. Discuss the solution quality and metrics that will be used to compare solutions.
        v. Provide a description of the two tools implemented namely the image parser and the solver.