Interactive Educational Puzzle Platform Utilizing Computer Vision

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PROJECT OVERVIEW

This project develops an interactive educational game that simulates the classic children's puzzle completion activity, where traditional early-learning puzzles, such as matching two-piece puzzles are validated by parents. However, instead of parental supervision, our system employs computer vision technology to automatically verify whether the child has selected the correct puzzle piece to complete the image. The game transforms a simple physical toy into an intelligent digital learning experience that provides immediate feedback and progressive difficulty levels.

The core concept centers on presenting children with an incomplete image, dynamically sourced via external APIs to ensure an endlessly fresh experience, where one or more sections have been replaced with black rectangles. The child must then select the correct missing piece from multiple options displayed on screen. Unlike static puzzle games that simply check if a piece was dropped in the correct coordinate box, our system employs Computer Vision (CV) algorithms as the primary validation mechanism. This allows the application to verify image coherence, texture, and color continuity just as a human eye would. The result is a system that provides immediate, encouraging feedback, fostering independent skill development and cognitive growth without the need for constant adult intervention.

DATA ACQUISITION

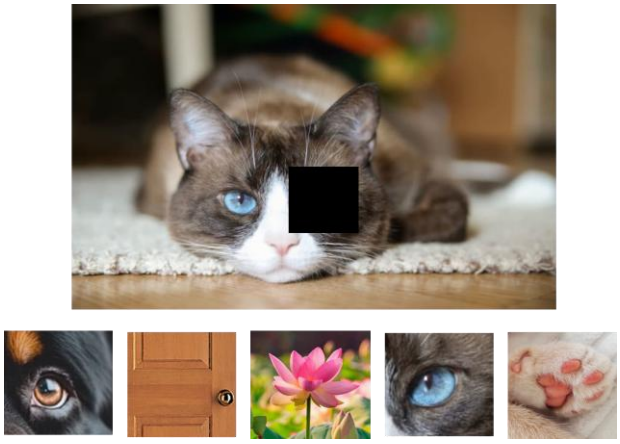
The application ensures an infinite variety of content by integrating with the Unsplash API. The image retrieval system operates in two distinct modes:

- User-Driven Search: The user inputs a specific keyword (For example: “Flowers”, “Cars”, “Animals”) into a search bar, triggering an API call to fetch relevant high-resolution imagery.
- Randomized Discovery: To facilitate varied gameplay, the system utilizes a backend database populated with diverse search terms. The application randomly selects a term from this repository to fetch an image, creating a surprise factor for the user.

GAME MECHANICS AND DIFFICULTY PROGRESSION

Once an image is retrieved, behind the scenes, an algorithm processes the retrieved image by converting specific pixels to black, effectively creating the missing section. The system stores the original pixel data of this hidden section in memory and generates a small square image from it, which becomes one of the 3-6 answer choices presented to the user. The other options are decoy pieces generated to provide appropriate difficulty based on the current level.

The game features multiple difficulty levels that challenge the user's visual recognition and problem-solving abilities. At the beginner level, the image is divided into just 2 pieces, with one piece hidden and replaced by a black square. The system presents 3-6 different piece options, and the user must identify which piece belongs in the missing location.



The higher the level, the smaller the missing pieces get. In the more advanced stages, multiple pieces (2-4) can be hidden simultaneously, requiring the user to understand not just individual elements but also how multiple components work together to form a coherent image. At these advanced levels, users must not only identify which pieces belong to the puzzle but also place each piece in its correct location, adding spatial reasoning to the challenge.

COMPUTER VISION VALIDATION ENGINE

In this project we will use Computer Vision for answer validation by analyzing edge continuity at boundaries, color distribution matching between the piece and surrounding context, and texture pattern consistency. Upon successful verification, the system triggers a positive reinforcement event to the user. Otherwise, the system prompts the user to "Try Again," fostering a resilient learning environment.

PROJECT SIGNIFICANCE

This project demonstrates practical application of computer vision technology in educational contexts, showing how artificial intelligence can support child development and learning. The system provides an autonomous learning environment that reduces the need for constant adult supervision while maintaining educational quality. The completed system will serve as both a functional educational tool and a demonstration of how computer vision can solve real-world challenges in early childhood education.