Aerial Robotics Kharagpur

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***Abstract*— This project combines two computational approaches: pathfinding using the RRT-Connect (Rapidly-exploring Random Tree) algorithm and image-based analysis for pattern extraction and reconstruction. The RRT-Connect algorithm is implemented to find paths in maze-like environments efficiently. Simultaneously, an image-based analysis pipeline processes visual data to identify missing patterns and reconstruct images using logical operations. Applications include robotics navigation, computer vision, and cryptographic analysis.**

I. INTRODUCTION

This project addresses two distinct challenges: 1. **Pathfinding in Complex Environments**: Using the RRT-Connect algorithm to find paths between start and goal points in a maze. The algorithm grows two trees (from start and goal) and connects them when possible. 2. **Image-Based Pattern Analysis**: Extracting patterns from images (e.g., detecting missing numbers in a digitized representation of π) and reconstructing artwork using logical operations.

II. PROBLEM STATEMENT

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1. **Pathfinding Using RRT-Connect**: - Given a maze-like environment, find a collision-free path between specified start and goal points. - Challenges include avoiding obstacles and ensuring computational efficiency.

Nodes are extended towards random points until the trees connect.

2. **Image-Based Analysis**: - Identify missing patterns in a digitized image of π and reconstruct an artwork using logical operations. - Challenges include handling noise, scaling issues, and ensuring accurate pattern extraction.

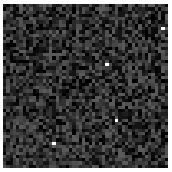

Fig. 1. Digitize π image

III. FINAL APPROACH

The process commenced with the conversion of the given image to grayscale, followed by a systematic analysis of pixel color values. By observing the distribution of these values, it was identified that each pixel encoded digits of , scaled by a factor of 10 and arranged sequentially. Extracting the pixel values and dividing them by 10 enabled the reconstruction of the sequence from the image. To refine the extracted values, a comparison was made against the actual digits of , yielding four distinct numerical values. These values were subsequently scaled by (10 π), arranged in descending order, and structured into a (2 x 2) filter matrix. The constructed filter was then applied to restore the provided distorted image.

Following image restoration, a matching process was performed using a whole-image pixel comparison technique based on the sum of squared differences (SSD). The image with the lowest SSD value was selected, and its coordinates within a pre-defined collage were extracted. These coordinates corresponded to a password granting access to a compressed archive, within which the maze was located.

For solving the maze, the Rapidly-Exploring Random Tree (RRT) algorithm was implemented. The approach involved selecting an initial random point on the screen and incrementally expanding trees from both the start and end positions. Tree expansion was carried out in discrete step distances, ensuring obstacle-free growth. If the trees remained unconnected, the process was iteratively repeated. Upon successful connection, a backtracking procedure was employed to extract the optimal path from the start to the end position, facilitating efficient maze traversal

IV. RESULTS AND OBSERVATION

- RRT-Connect efficiently finds paths in complex mazes but struggles with narrow passages. - Logical operations effectively reconstruct images but are sensitive to noise.

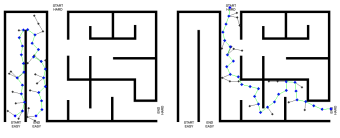

Fig. 2. RRT-connect results