

# Visualizing and Designing Multi Agent Search Algorithms

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## Introduction

The purpose of our research is to study distributed search-and-escape algorithms. These algorithms involve mobile agents (or bots) searching in geometric domains, such as a closed disk or a convex polygon. By working together and communicating with one another, the mobile agents search for an exit hidden on the perimeter. The goal of our research is to create and study exit strategies that terminate as quickly as possible.

## Definitions

- An **exit** is a point unknown to the agents, that is located on an perimeter on the domain. The agents must find the exit for the algorithm to finish.
- A **priority** agent is one that must reach the exit for the algorithm to terminate.
- A **helper** agent is one that simply assists the priority agent(s) in finding the exit.
- **Algorithm termination** occurs if a specified subset of agents shares a position with the exit.

## Main Result

The purpose of our research is to propose an algorithm for two distinguished agents and a helper agent to find an unknown exit on a disk. We show that this can be achieved in no more than 3.55 time units. This result does not represent all algorithms using 3 agents, nor does it represent all algorithms using distinguished agents.

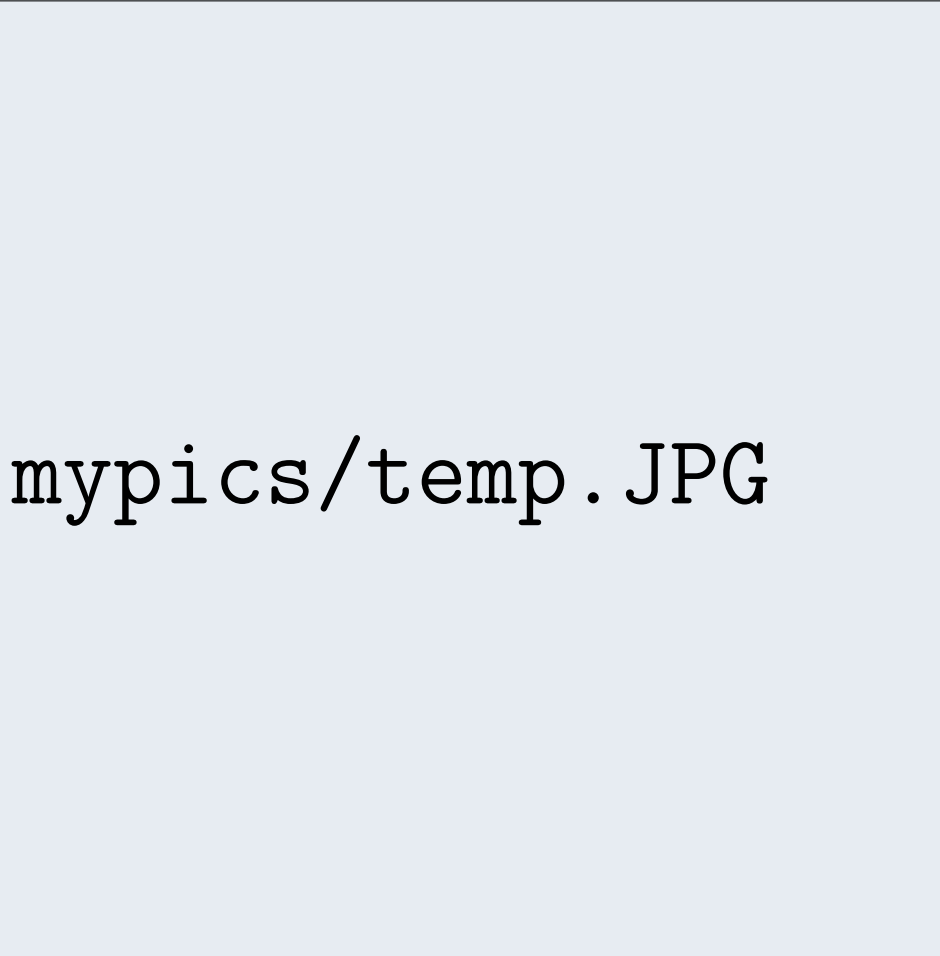


Figure 1. Temp 1

## Main Topic

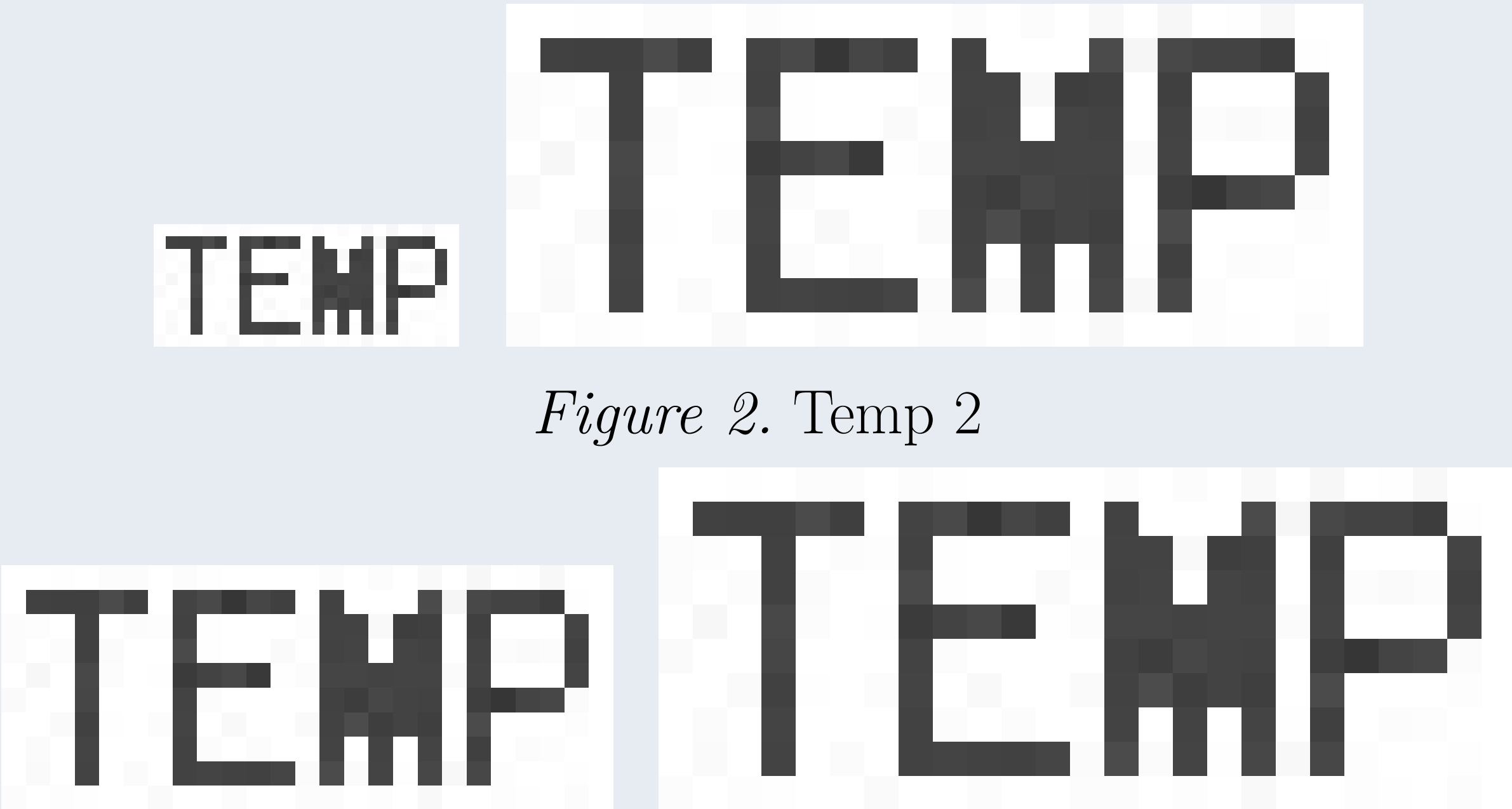


Figure 2. Temp 2

Figure 3. Temp 3

## Algorithm Description

In our algorithm, we use two **priority** agents and one **helper** agent. The termination condition in our algorithm is reached when either one of the two priority agents reaches the exit. We send one priority and one helper to some angle  $\alpha$  on the perimeter of the shape, in the third quadrant. The priority agent travels counter-clockwise, and the helper travels clockwise. The other priority agent travels to 0 radians and travels counter-clockwise.

## Future Work

Later on we will study further distributed algorithms of search and escape, such as lines or triangles.

## Our Conjectures and Analysis

In this algorithm, we observe two worst case situations. In one, the priority robot assigned to the third and fourth quadrant travels the entire distance of its arc, until it reaches the exit a small distance before 0 radians (Fig. 3 above). In the other, the helper agent finds the exit at a point such that the closest priority agent would have to travel along a chord to reach it (Fig. 4 above). We analyze the case in which the helper agent finds the exit in the second quadrant. Say that there is an angle of  $\theta$  between the closest priority and the helper agent, so that the shortest distance between the two agents is  $2\sin(\theta/2)$ . The angle  $\theta$  that would produce the longest distance between the priority agent along the top and the helper, is  $\theta = 2\pi/3$ . Therefore, the termination time for the algorithm in this case is  $1 + \alpha + 2\sin(\theta/2)$ , where  $\alpha$  is the circumferential distance already traveled by each robot. We can set this result equal to the termination time of the agent that explores the bottom part of the circle, which is  $1 + \gamma$ , where  $\gamma$  is a distance traveled by the priority agent such that it finds the exit a small distance before angle 0.

## Conclusions

This algorithm has an upper bound of 3.55 time units, being faster than an algorithm of one distinguished and two helpers with an upper bound of 3.83 time units.



Figure 4. Temp 4

## Acknowledgements

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## References

- [1] Jurek Czyzowicz, et. al., Evacuating Robots via Unknown Exit in a Disk, Springer-Verlag Berlin Heidelberg; 2014.
- [2] Jurek Czyzowicz, et. al., Fun with Algorithms, arXiv:1804.06011v1 [cs.MA] 17 Apr 2018.



Figure 5. Temp 5

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