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Path Planning in an Unknown Environment on the basis of Observations of Occluded Areas

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I. INTRODUCTION

What does a person do when they open their eyes and find themselves in a labyrinth that they have never seen before? Since there may be spaces that are not visible from their initial location, the observer will almost certainly move from his initial location so as to get a better look at their surrounding. It is also important to consider how such an observer would realize when there is space that is hidden. In reality, we instinctively know that such spaces can be negotiated based on discontinuities in the observed environment.

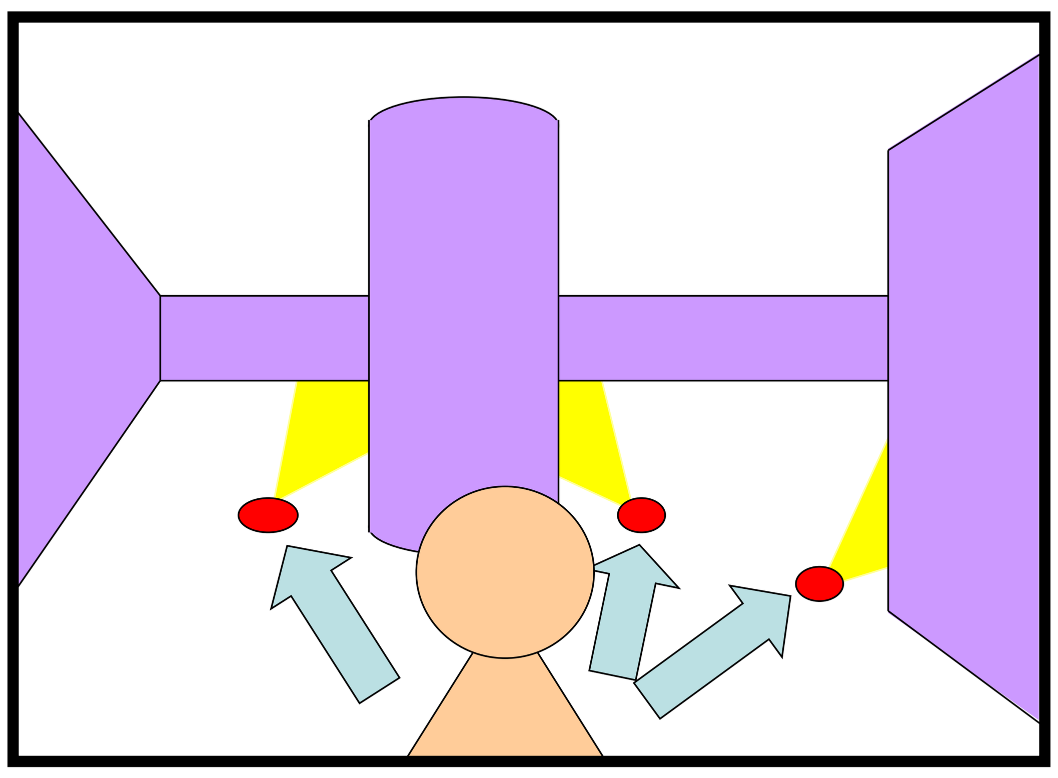


Fig.1 Observing and approaching the occluded areas.

This study focused on how an artificial agent identifies hidden regions from discontinuities in their observations and how the agent then searches those areas from which it can exit that environment, and in so doing, acquire knowledge about its surroundings.

II. DETECTING OCCLUSIONS

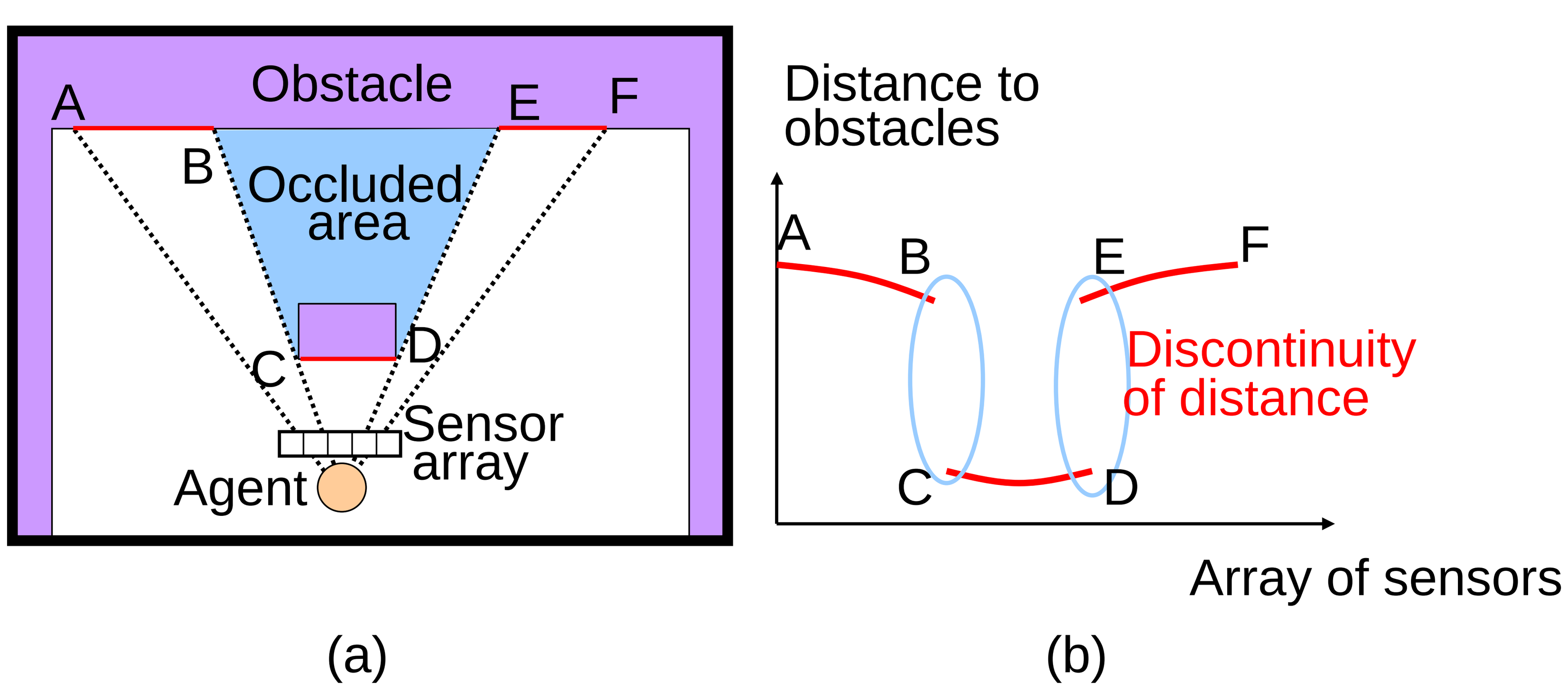


Fig.2 Occlusion and discontinuities of distance.

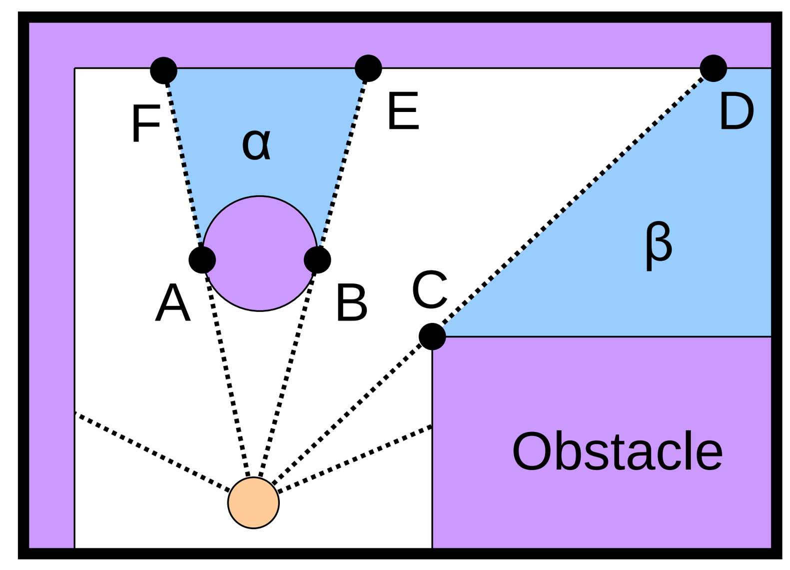
How do we detect occluded areas? Occluded areas are not directly detected because they are "occluded". Existence of occluded areas are deduced from discontinuity of measurement results. Fig.2(a) shows an arrangement of an agent and obstacles. Fig.2(b) shows measurement results of distances between the agent and obstacles. Measured distance varies continuously from the point A to B, C to D and E to F. Meanwhile, the distance varies discontinuously from B to C and D to E. And the line BC and DE border the occluded area. Discontinuity of measured distance is a sign of existence of occlusions. The agent is able to observe the occluded area by approaching to the border point C or D.

III. ALGORITHM

The search proceeds as following.

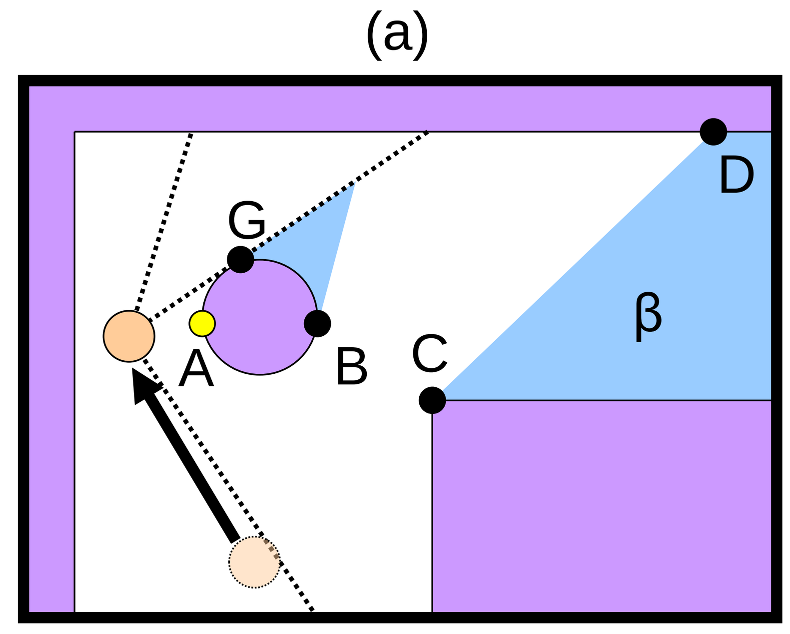
- Step1: Identify occluded areas in the process of observing the shapes of the surroundings with sensors, while simultaneously creating a map.
  - Step1-1: If the goal is identified during the search, stop searching and move straight toward the goal.
  - Step1-2: When a new occluded area is identified during the observation, record it.
- Step2: When the search is complete, select the next occluded area to observe.
- Step3: Go on to the next observation point and return to Step 1.

Fig.3 is an example of search process.



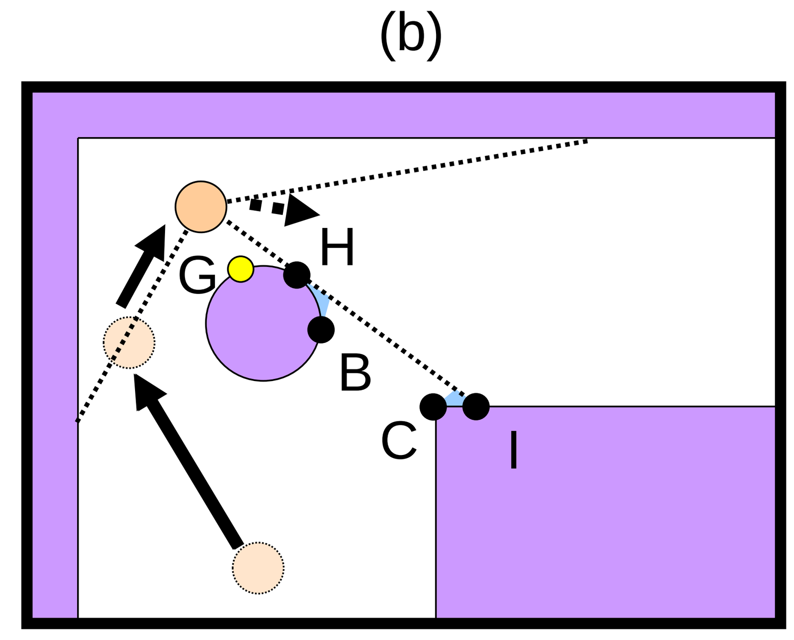
(a)

(a) The area α and β are occluded from the agent. The points A, …, D are border points of occluded areas. The agent will move to a point neighboring the border point A so as to observe the occluded area α.



(b)

(b) After arriving at the new observation point, the agent observes the occluded area α. The area α is decreased, and border points A, E and F are observed, while the new border point G is detected.



(c)

Fig.3 An example of a search process.

(c) The agent moves to the next new observation point near point G, and observes occluded areas. Then, almost all of the area α and β are observed. Next, the agent will move to a certain point neighboring H and observe remaining area of α. The agent repeats the observation and movement until all border points are observed.

IV. SIMULATION

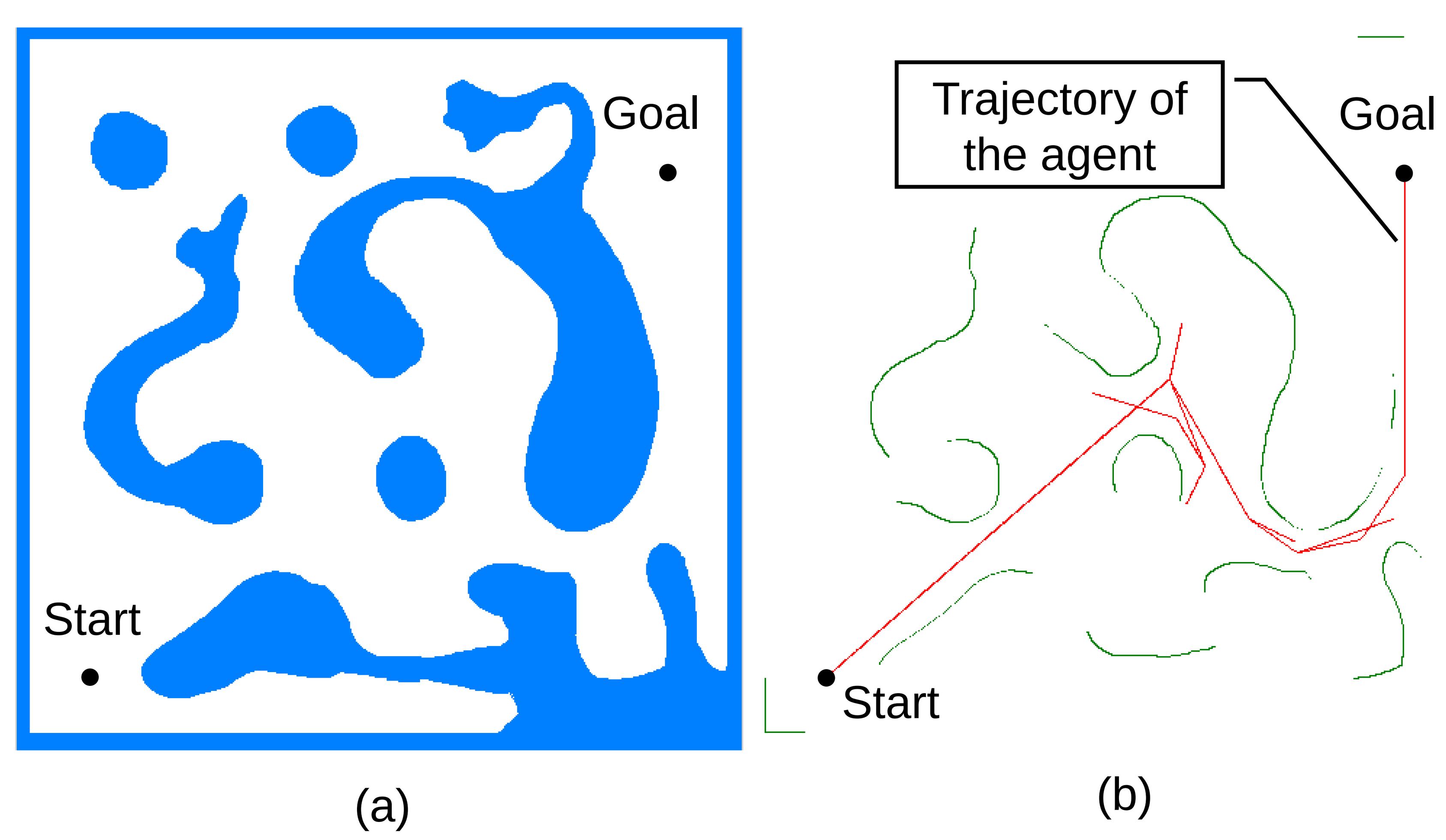


Fig.4 A result of simulation.

Fig.4(a) is a map of virtual environment where the agent searches. Fig.4(b) is a map which the agent had made up until it reached to the goal. Green lines in Fig.4(b) are the detected obstacles and red lines are trajectory of the agent. The agent could reach to the goal in the environment containing curved surfaces.

V. CONCLUSION

This study proposes a search method in an unknown environment. It uses a simple model to express general objects and actions, the observations taken by the agent and the actions it performed in order to take them. Therefore, as long as the environment meets certain conditions, the agent is capable of coping with obstacles even when they have curved surfaces. Path planning is not limited to 2-dimensional motion, but can be easily extended to 3 dimensions. Its capabilities to "see" objects and to reproduce the actions taken by the agent seem to promise construction potential for this algorithm in the future.