15 min + 5 min question

POSTER 4ft (122cm) wide x 6ft (183 cm) tall

Masataro Asai

2nd year in Ph.D course

University of Tokyo

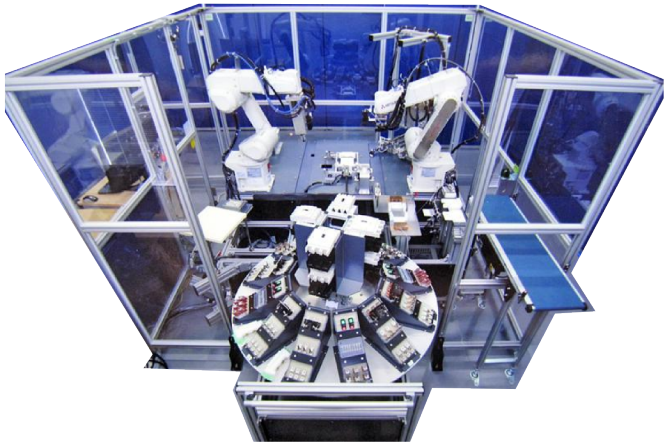
Short talk (15min)

1 Overview

- What I've been doing (5 min)
  - primarily in classical planning
  - **1st paper** : application-oriented macro-related paper
  - **2nd paper** : macro-related paper
  - **3rd paper** : A* tiebreaking paper
- What I'm insterested in (10 min)
  - *4th paper* : aiming to be a non ad-hoc macro paper
  - *Theory unifying all satisficing heuristic search*
  - → Hopefully a clean thesis with a consistent story?

2 Cell-Assembly system

Process scheduling w/
organized robotic arms



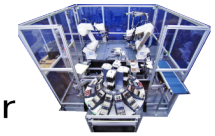
Next I'd like to provide a bit more details of my recent work, only briefly.

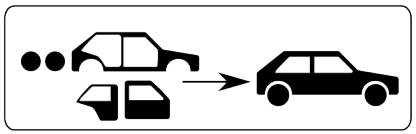
In this work, we proposed an automated method for solving large repetitive problems which are easy for human but difficult for programs. It detects a certain kinds of loops based only from the logical relationships between facts and actions.

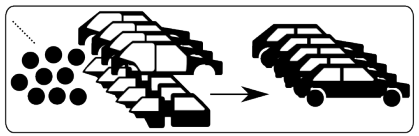
Asai, M.; Fukunaga, A: 2014. Fully Automated Cyclic Planning for Large-Scale Manufacturing Domains. In ICAPS2014.

2.1 Issues addressed

Production scale problems
PDDLs containing 1000 object instances
Repetition should not confuse the planner

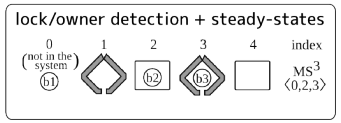






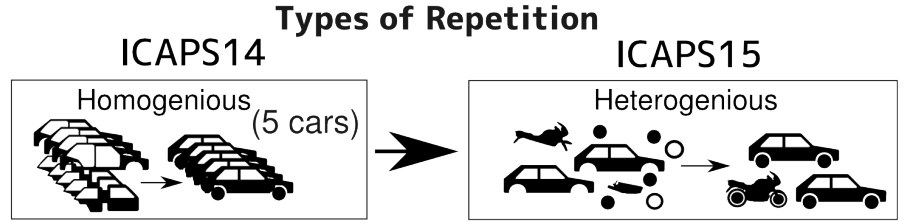
Proposed Method:

Detecting one cycle of a loop (*steady states* of the enviroment) and perform Loop-Unrolling

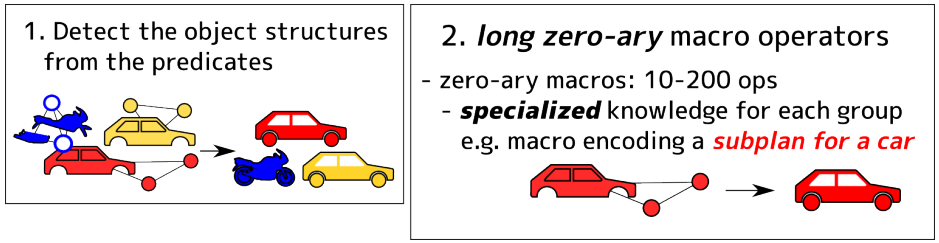


3 ICAPS15 paper

heterogeneous



Methods:



In this work, we generalized the proposed method by detecting and categorizing the logical structure which forms each loop. For example, programs do not know that cars consists of several parts such as doors, engines and tires.

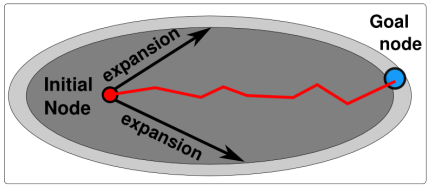
Asai, M.; Fukunaga, A: 2015. Solving Large-Scale Planning Problems by Decomposition and Macro Generation. In ICAPS2015.

4 AAAI16 paper (visit my 2nd poster session)

*Understanding the search space of A**

f > f* (entire search space)
f = f* (some nodes are expanded by A*)
f < f* (all nodes are expanded by A*)
Optimal solution

2D pathfinding etc.



*Few nodes have f=f**
Tiebreaking not important

4.1 AAAI16 paper (visit my 2nd poster session)

*Understanding the search space of A**

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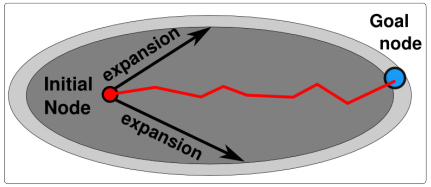
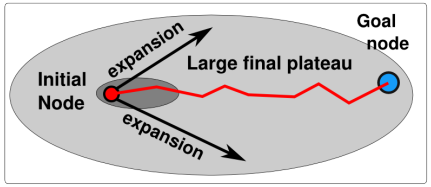


*Few nodes have f=f**
Tiebreaking not important

Classical Planning

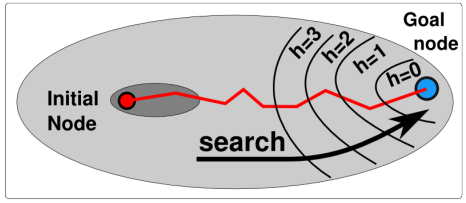


*Almost all nodes are f=f**
→Tiebreaking has a huge impact

Asai, M.; Fukunaga, A: 2016. Tiebreaking Strategies for A* Search: How to Explore the Final Frontier. In AAAI-2016.

4.2 Investigating *h*-tiebreaking in A*

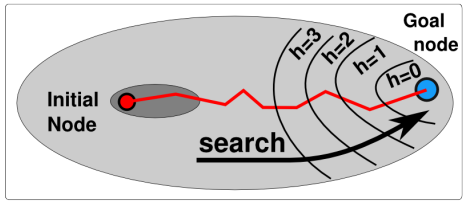
Domains with strictly Positive Action Costs only



h-based tiebreaking gives heuristic guidance

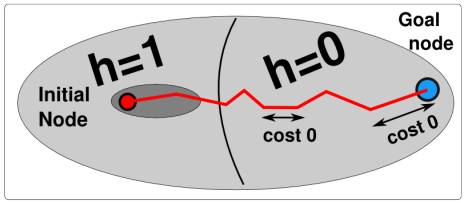
4.3 Investigating *h*-tiebreaking in A*

Domains with strictly Positive Action Costs only



h-based tiebreaking gives heuristic guidance

Domains with 0-cost Actions

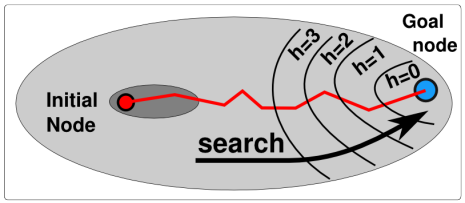


Has larger h-plateaus
h-tiebreaking does not work

Asai, M.; Fukunaga, A: 2016. Tiebreaking Strategies for A* Search: How to Explore the Final Frontier. In AAAI-2016.

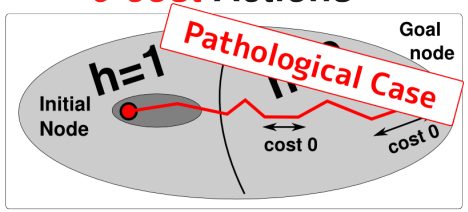
4.4 Investigating *h*-tiebreaking in A*

Domains with strictly Positive Action Costs only



h-based tiebreaking gives heuristic guidance

Domains with 0-cost Actions

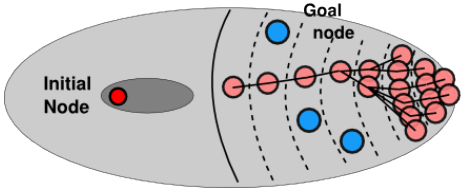


Enlarge h-plateaus
h-tiebreaking does not work

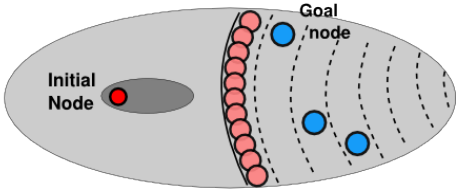
4.5 Investigating *h* + LIFO/FIFO tiebreaking in A*

4.4 goal node, init

LIFO=Depth-first could miss the shallow solutions

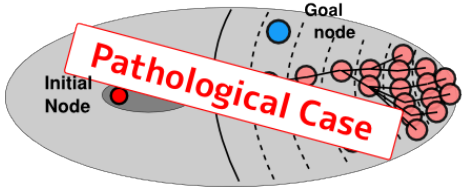


FIFO=Breadth-first doesn't reach solutions

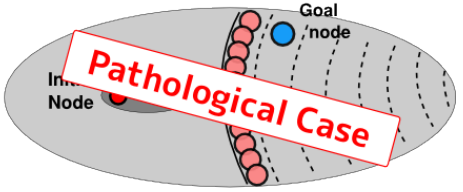


4.6 Investigating *h* + LIFO/FIFO tiebreaking in A*

LIFO=Depth-first could miss the shallow solutions

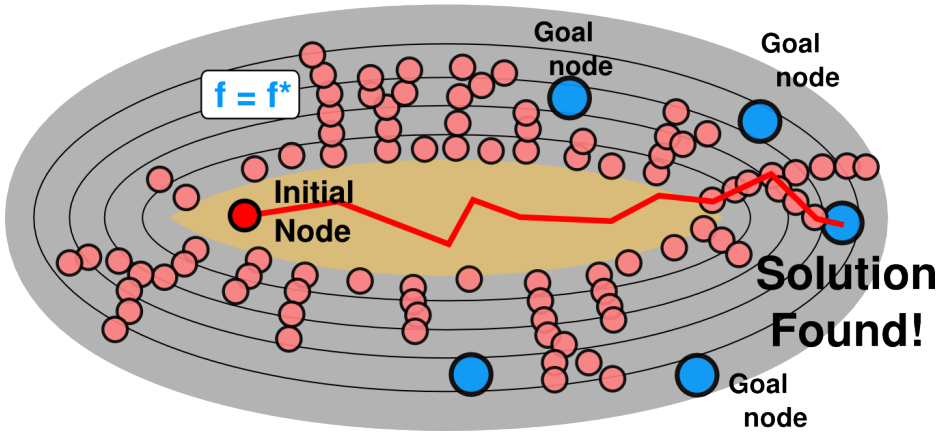


FIFO=Breadth-first doesn't reach solutions



4.7 A* with *h* + Depth Diversification

Select a depth randomly (Random Depth)
Select a node randomly (Random Order)



annd ”plateau search = satisficing planning”

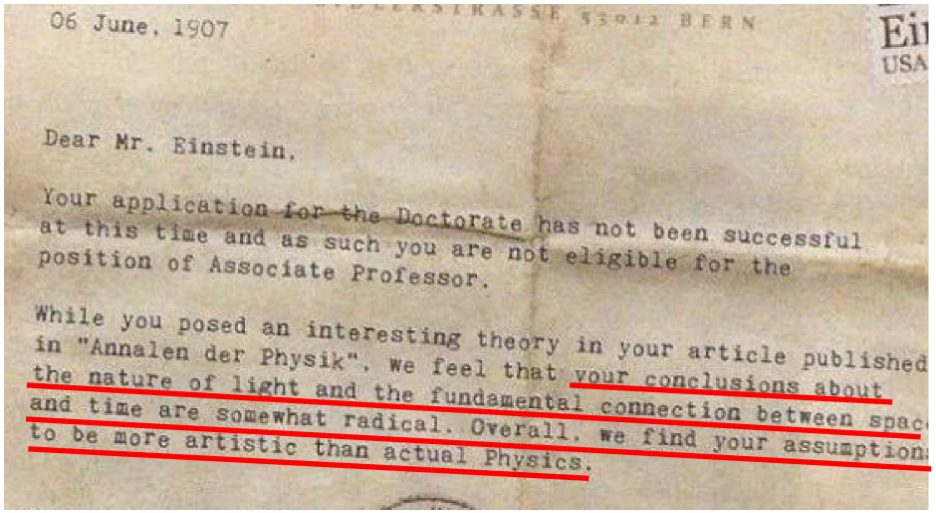
5 Toward Thesis Proposals

- **How to make a consistent thesis?**
  - Macro papers → satisficing search
  - Tiebreaking papers → optimal search (A*)
  - I have to **unify them**

6 Inherent Danger of Showing Research Ideas at DC

I am inclined to continuing research after graduation as a PostDoc / maybe in industry, but showing too much unreliable ideas here may cause this:

(just be sure, I'm **not** claiming I am Einstein, no!)



06 June, 1907

Dear Mr. Einstein,

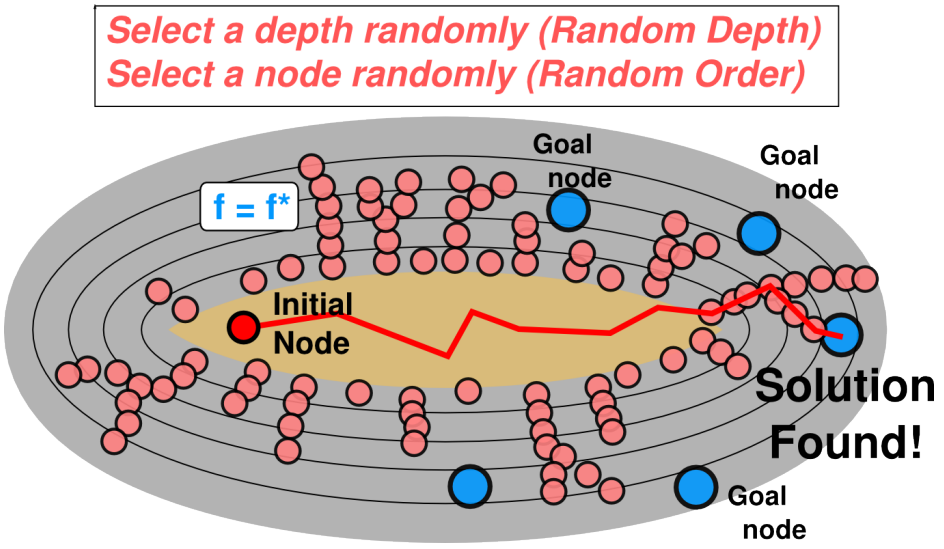
Your application for the Doctorate has not been successful at this time and as such you are not eligible for the position of Associate Professor.

While you posed an interesting theory in your article published in "Annalen der Physik", we feel that your conclusions about the nature of light and the fundamental connection between spac and time are somewhat radical. Overall, we find your assumption to be more artistic than actual Physics.

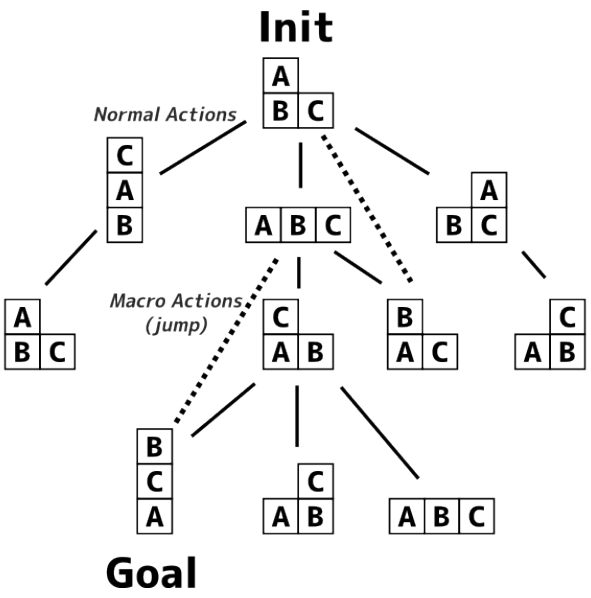
7 Danger Zone!

Research IDEAs : not yet fully developped

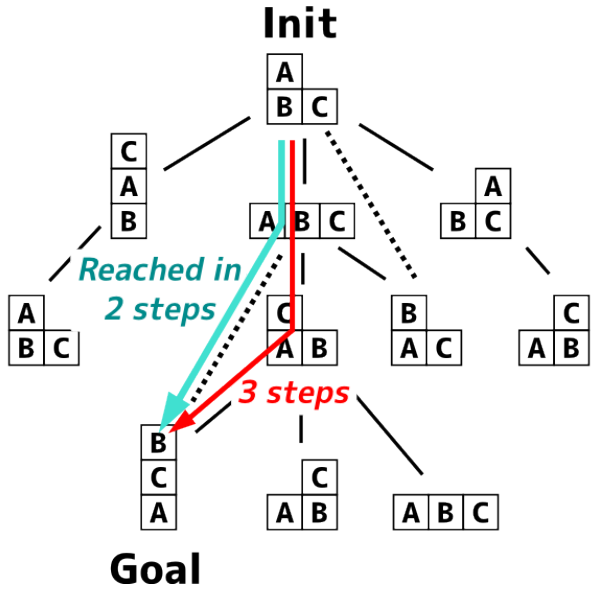
8 Background 1: A* [RD RO] paper was about search space



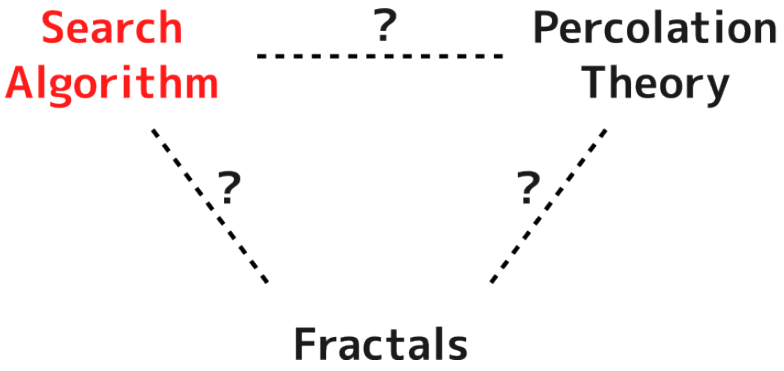
9 Background 2: Macro operators changes the search space structure



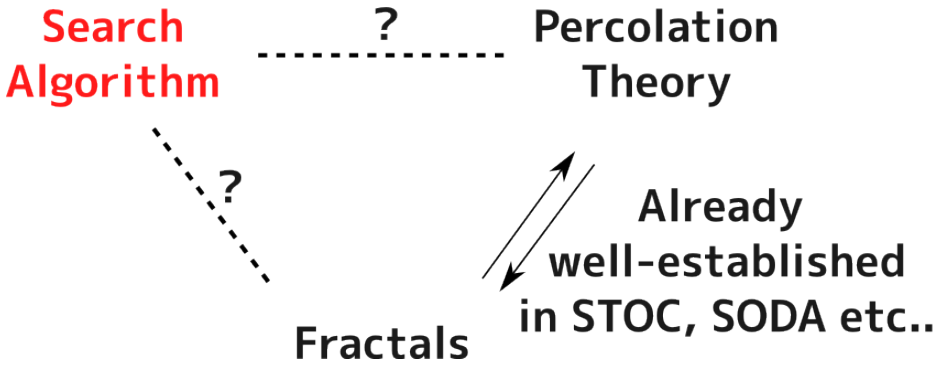
10 Background 2: Macro operators changes the search space structure



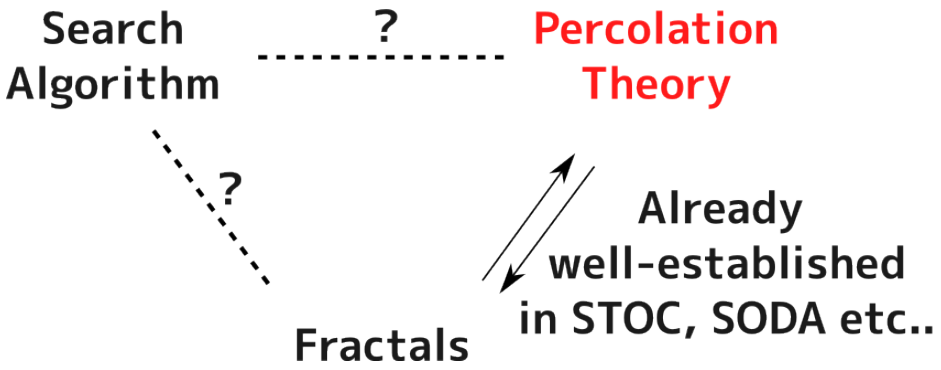
11 Unifying Framework : Discuss Search Space Theoretically



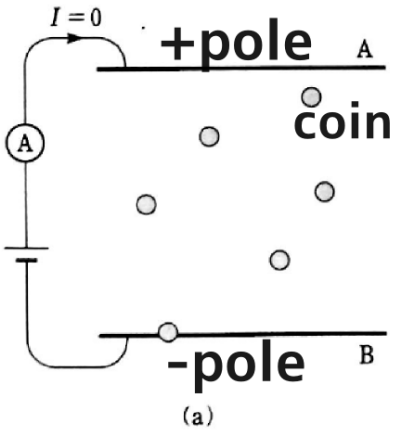
12 Unifying Framework : Discuss Search Space Theoretically

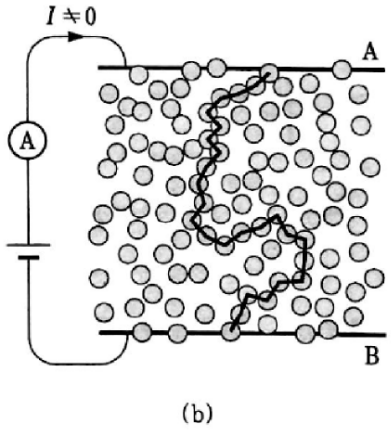


13 Unifying Framework : Discuss Search Space Theoretically



14 Percolation Theory – Toward Planning Complexity

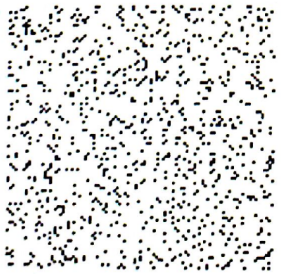




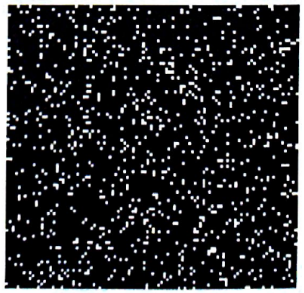
At what density does a circuit emerge?

14.1 Occupation Ratio *r*

occupied node = black
unoccupied node = white

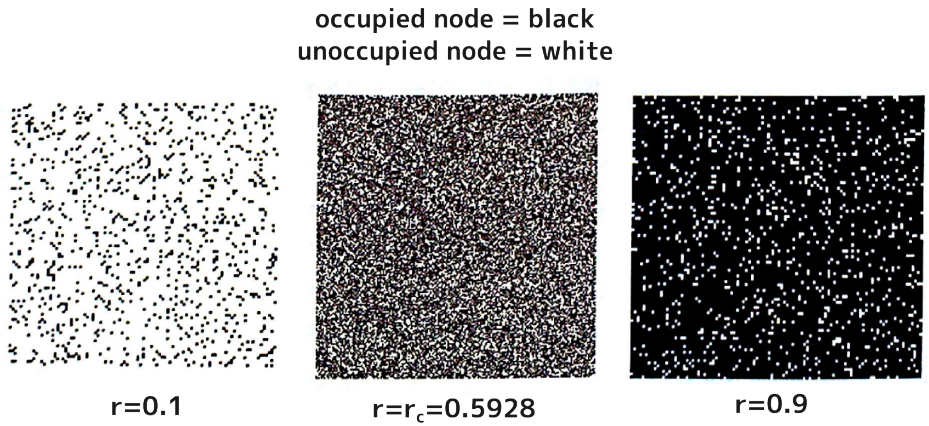


r=0.1

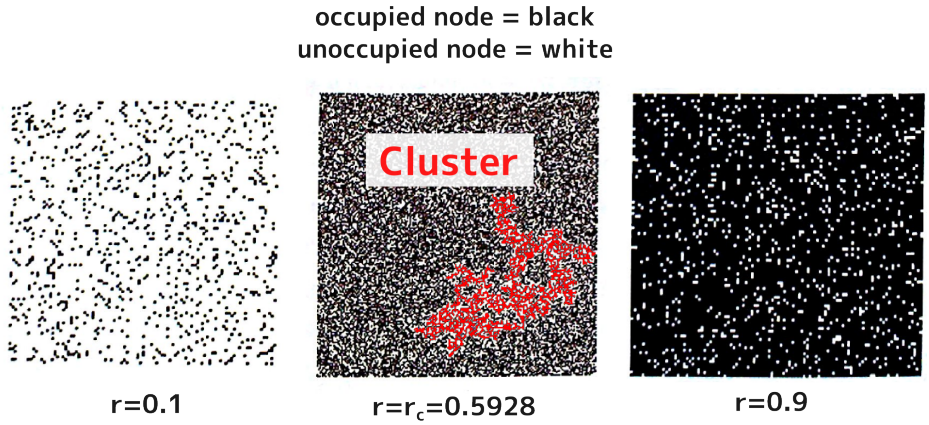


r=0.9

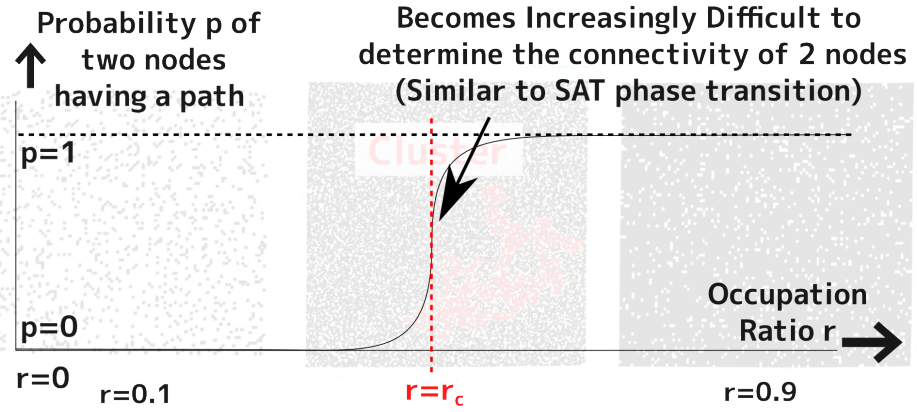
14.2 Occupation Ratio *r*



14.3 Occupation Ratio *r*



14.4 Phase Transition



14.5 Open Question

- What is the occupation ratio of the search space of particular search algorithm?
- Does the same theory holds for heuristic search?
  - c.f. (Rintanen 2004) on phase transition in STRIPS
- Does **Junk Macros** changes the occupation ratio ?
  - Purely randomly generated, un-opinionated macros

14.6 Preliminary results on Junk Macros

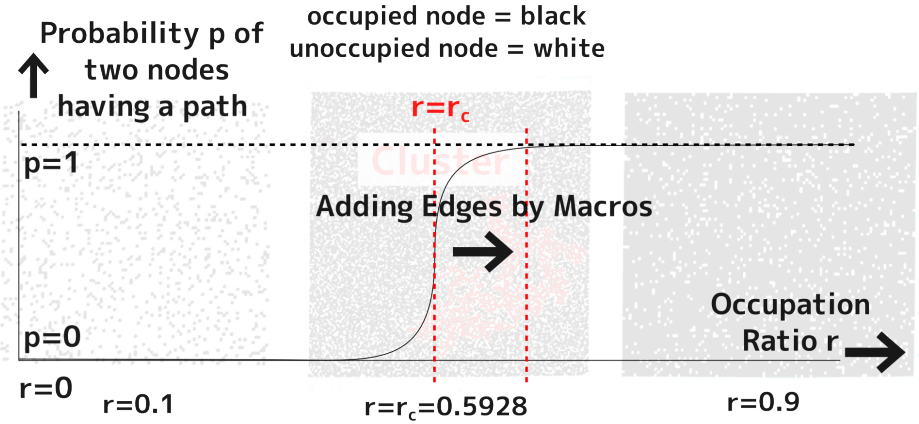
junk macros reduces number of evaluations

(LAMA) Domain	L	Eval [node]
airport	8	**280721 (.74)**
cybersec	8	3309
depot	8	**190577 (.47)**
driverlog	5	**179752 (.88)**
hanoi	2	2070986 (.97)
mystery	5	**2643 (.08)**
pipesworld-t	8	**355576 (.89)**
rovers	2	**87475 (.90)**
transport-sat11	2	**47244 (.47)**

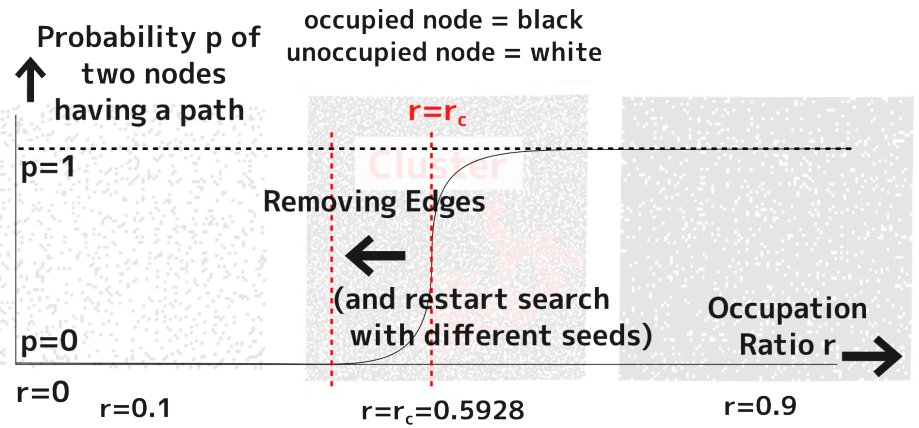
Random junk macros reduce the number of evaluations compared to w/o macros

Table 2: Selective results showing the improvements by junk macros of length L, using LAMA planner. Each cell shows the sum over all instances in the domain solved by all configurations, averaged by the 10 runs. Ratios relative to LAMA are shown, e.g., "(.86)" means the ratio compared to LAMA is 0.86. **Improvement**/*degradation* are tested with statistical significance ($p < 0.001$).

14.7 Macros may be shifting to the right

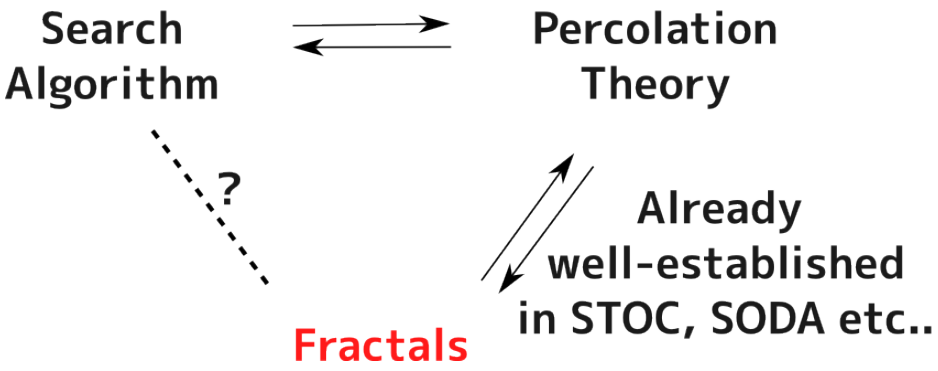


14.8 Opposite : Randomly removing edges — shifting to the left

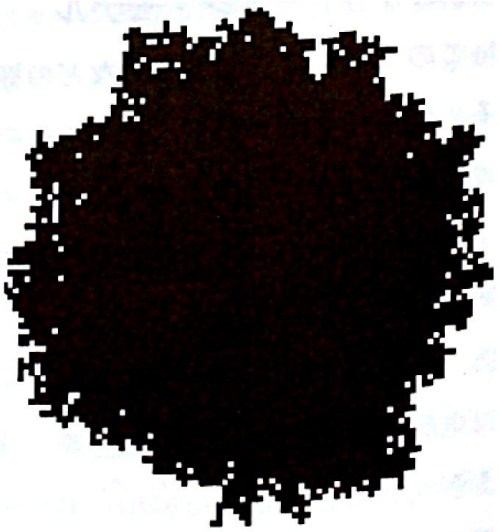


Quickly finding UNSAT, **iterate with different random seeds**?

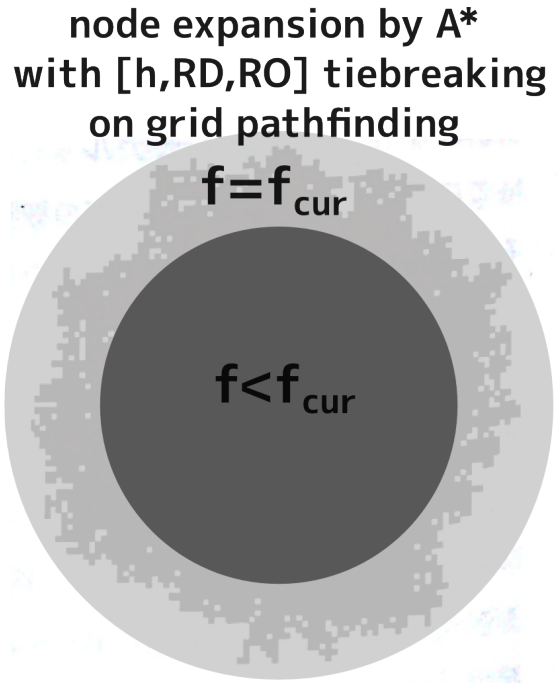
15 Unifying Framework : Discuss Search Space Theoretically



16 Fractals

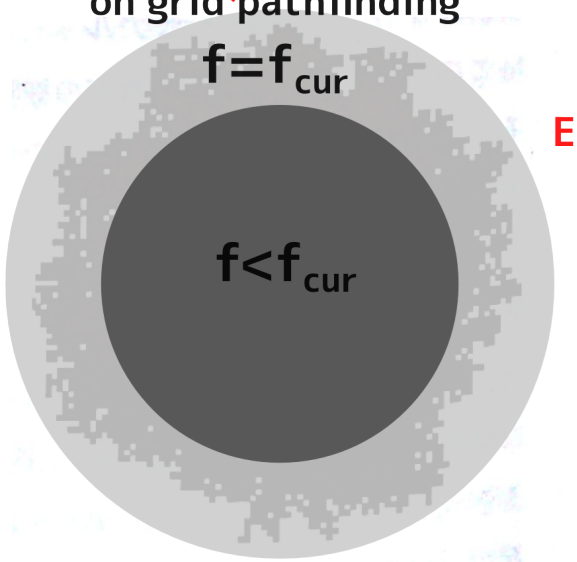


16.1 Fractals



16.2 Fractals

node expansion by A*
with [h,RD,RO] tiebreaking
on grid pathfinding

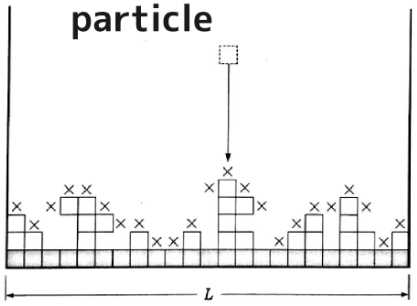


Eden growth model
(citation)

Famous example
of surface fractal

16.3 Famous Fractals (BA)

Ballistic Aggregation model



aggregation model of dusts

16.4 Connections between Fractals and Search Algorithms

Different growth model		*Different expansion model*
??? model	↔	A* + LIFO
??? model	↔	A* + FIFO
Eden model (surface fractal)	↔	A* + [RD,RO]
BA model (surface fractal)	↔	New algorithm?
DLA model (fractal)	↔	New algorithm?

Problem: Allegy toward Nature-inspired algorithms

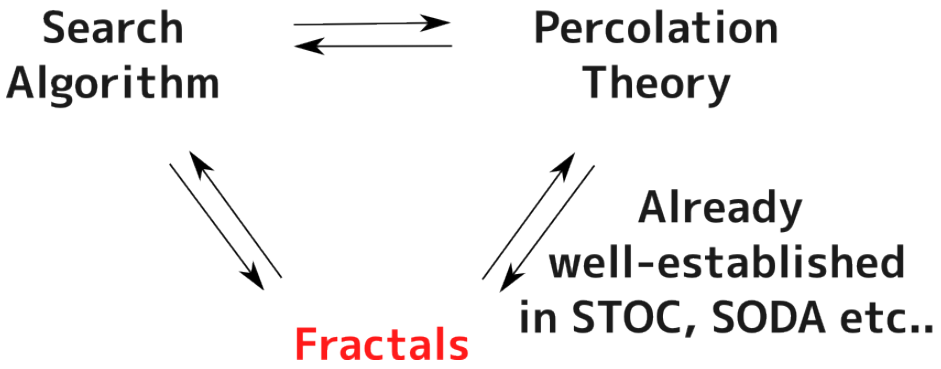
Let's make it look more sensible

16.5 Connections between Fractals and Percolation

Fractal dimension
of the red cluster

$$D \cong \begin{cases} 1.89 & (d=2) \text{ 2D grid} \\ 2.53 & (d=3) \text{ 3D grid} \end{cases}$$

17 Unifying Framework : Discuss Search Space Theoretically



18 Possible Benefits:

- More thoeries about macro operators. Only thing we know:
  - "**Increases branching factor**"
  - **!= effective** branching factor by heuristic search
- Understand Search Algorithms by the **shape of the explored space**
  - What is the fundamental difference between 2 algorithms?

19 Conclusion

Apply Percolation Theory / Fractals to macros / search algorithms

- Analyze macros analyze ICAPS15 macros????
- Analyze search algorithm behavior

→ Unified, consistent thesis!