15 min + 5 min question

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

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2nd year in Ph.D course

University of Tokyo

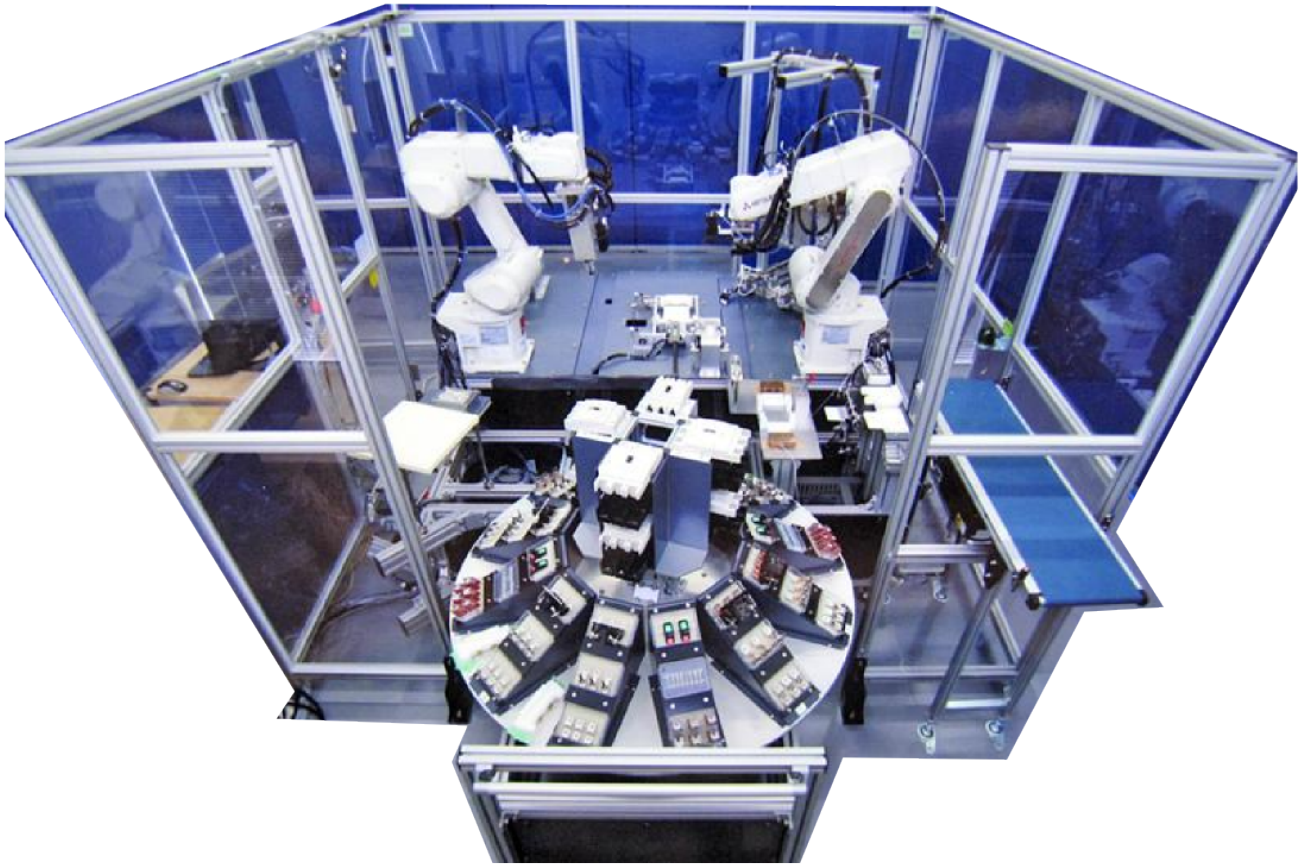
Short talk (15min)

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
- How to form a clean thesis & what I'm insterested in (10 min)
  - To construct a consistent story $\rightarrow$
  - *Theory unifying all satisficing heuristic search*
  - *4th paper* : aiming to be a non ad-hoc macro paper

2 Cell-Assembly system

Process scheduling w/
organized robotic arms

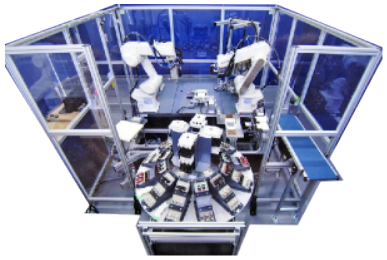


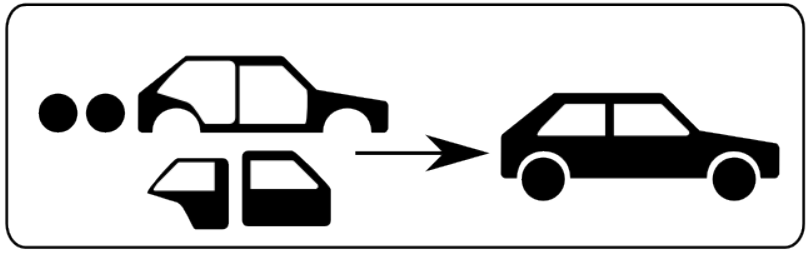
2.1 Issues addressed

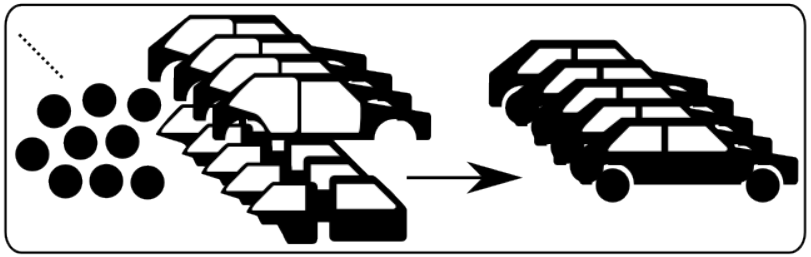
Production scale problems

PDDLs containing 1000 object instances

Repetition should not confuse the planner





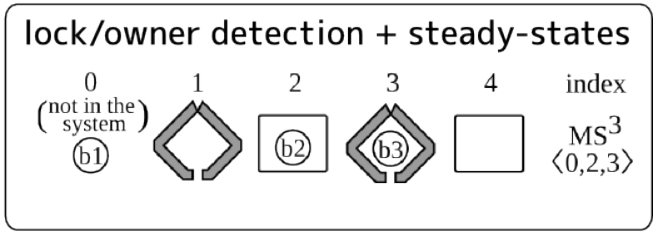


Proposed Method:

Detecting one cycle of a loop

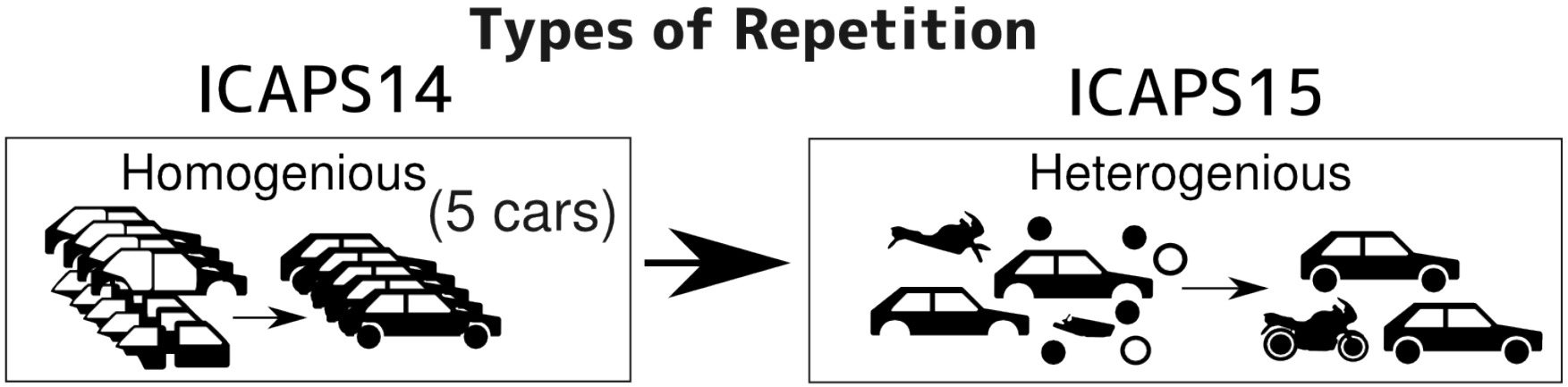
(*steady states* of the enviroment)

and perform Loop-Unrolling



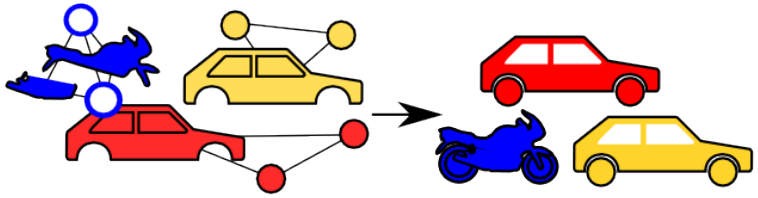
3 ICAPS15 paper

heterogeneous



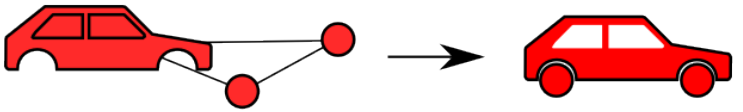
Methods:

1. Detect the object structures from the predicates



2. *long zero-ary* macro operators

- zero-ary macros: 10-200 ops
  - ***specialized*** knowledge for each group
    e.g. macro encoding a ***subplan for a car***



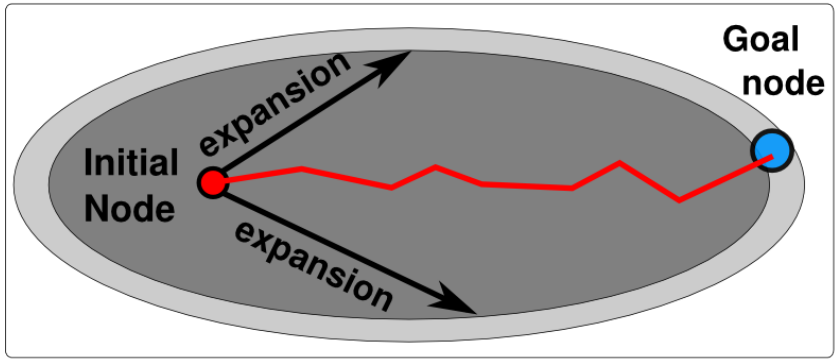
4 AAAI16 paper (visit my 2nd poster session)

*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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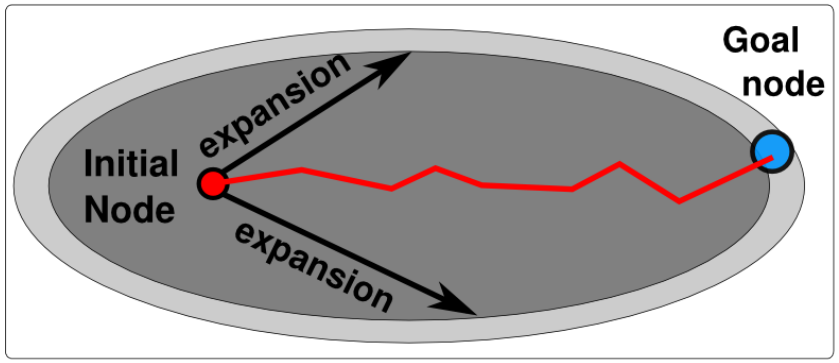
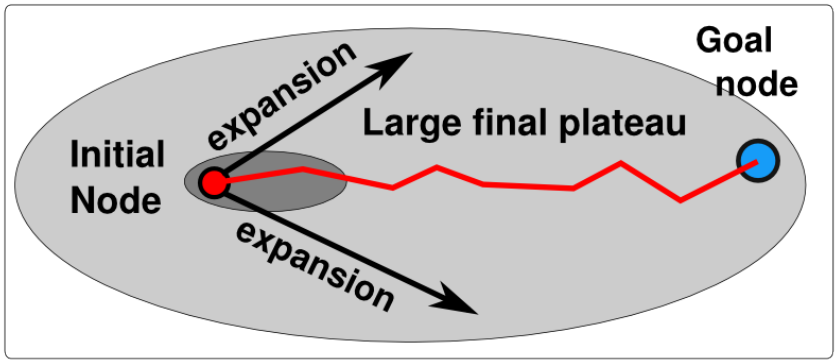


Few nodes have f=f*

Tiebreaking not important

Classical Planning

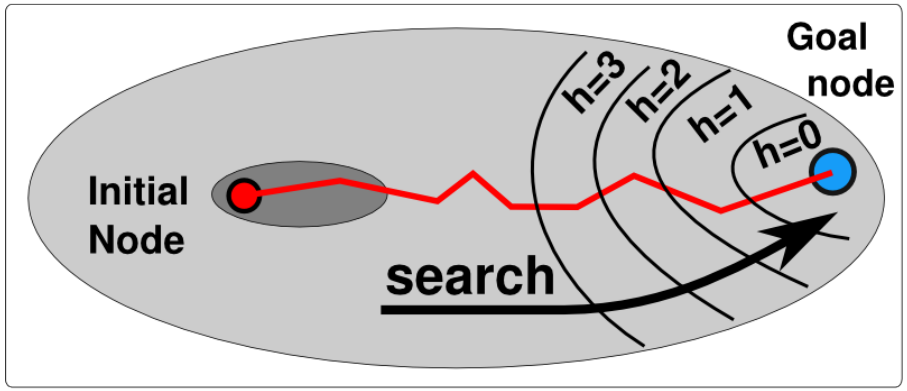


Almost all nodes are f=f*

→Tiebreaking has a huge impact

4.2 Investigating *h*-tiebreaking in A*

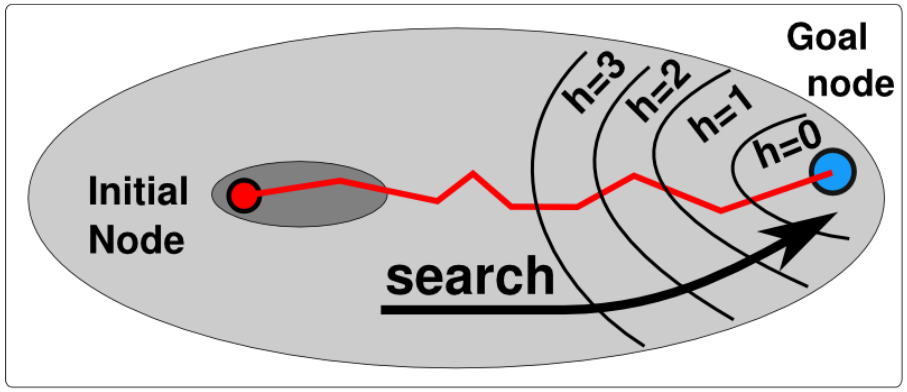
Domains with strictly Positive Action Costs only



h-based tiebreaking gives heuristic guidance

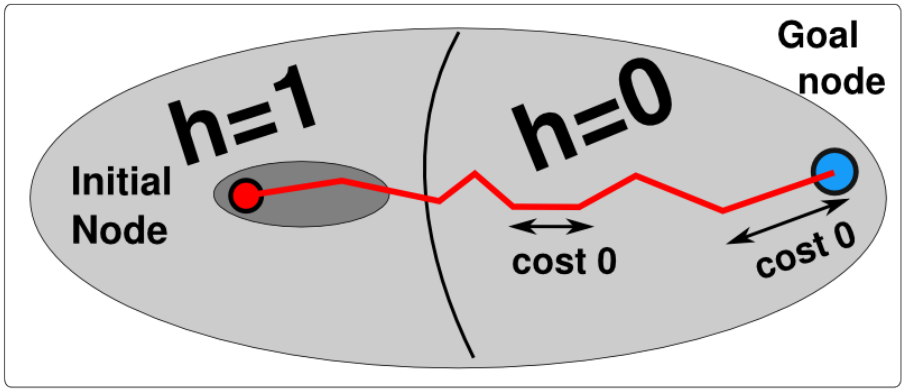
4.3 Investigating *h*-tiebreaking in A*

Domains with strictly Positive Action Costs only



h-based tiebreaking gives heuristic guidance

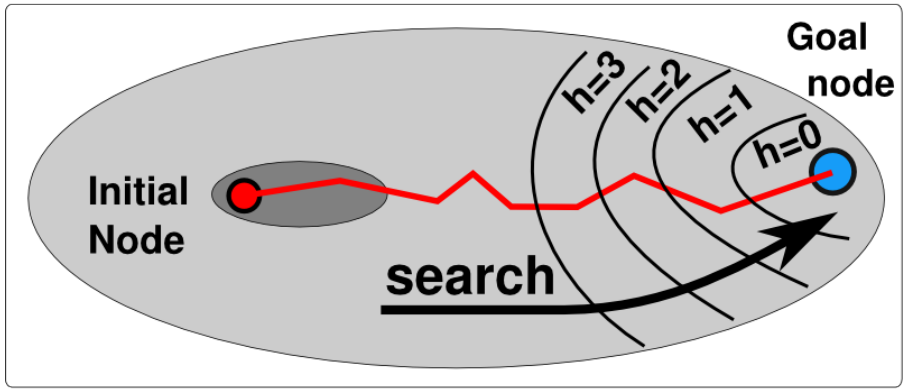
Domains with 0-cost Actions



Has larger h-plateaus
h-tiebreaking does not work

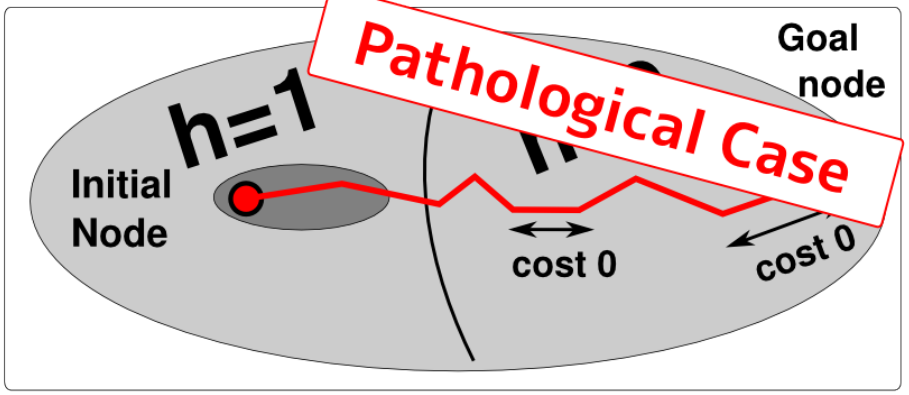
4.4 Investigating *h*-tiebreaking in A*

Domains with strictly Positive Action Costs only



***h*-based tiebreaking gives heuristic guidance**

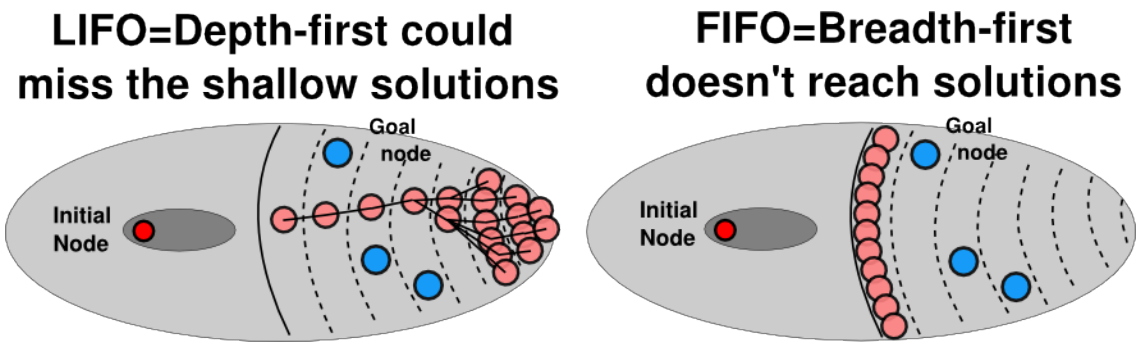
Domains with 0-cost Actions



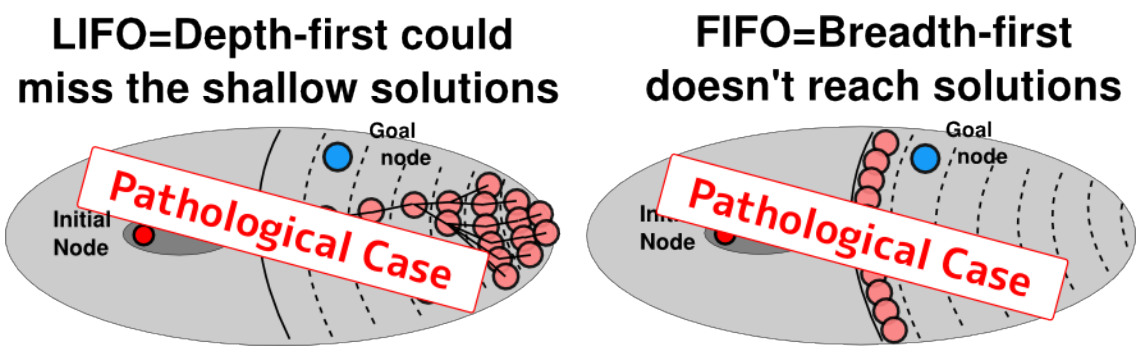
Enlarge h-plateaus
***h*-tiebreaking does not work**

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

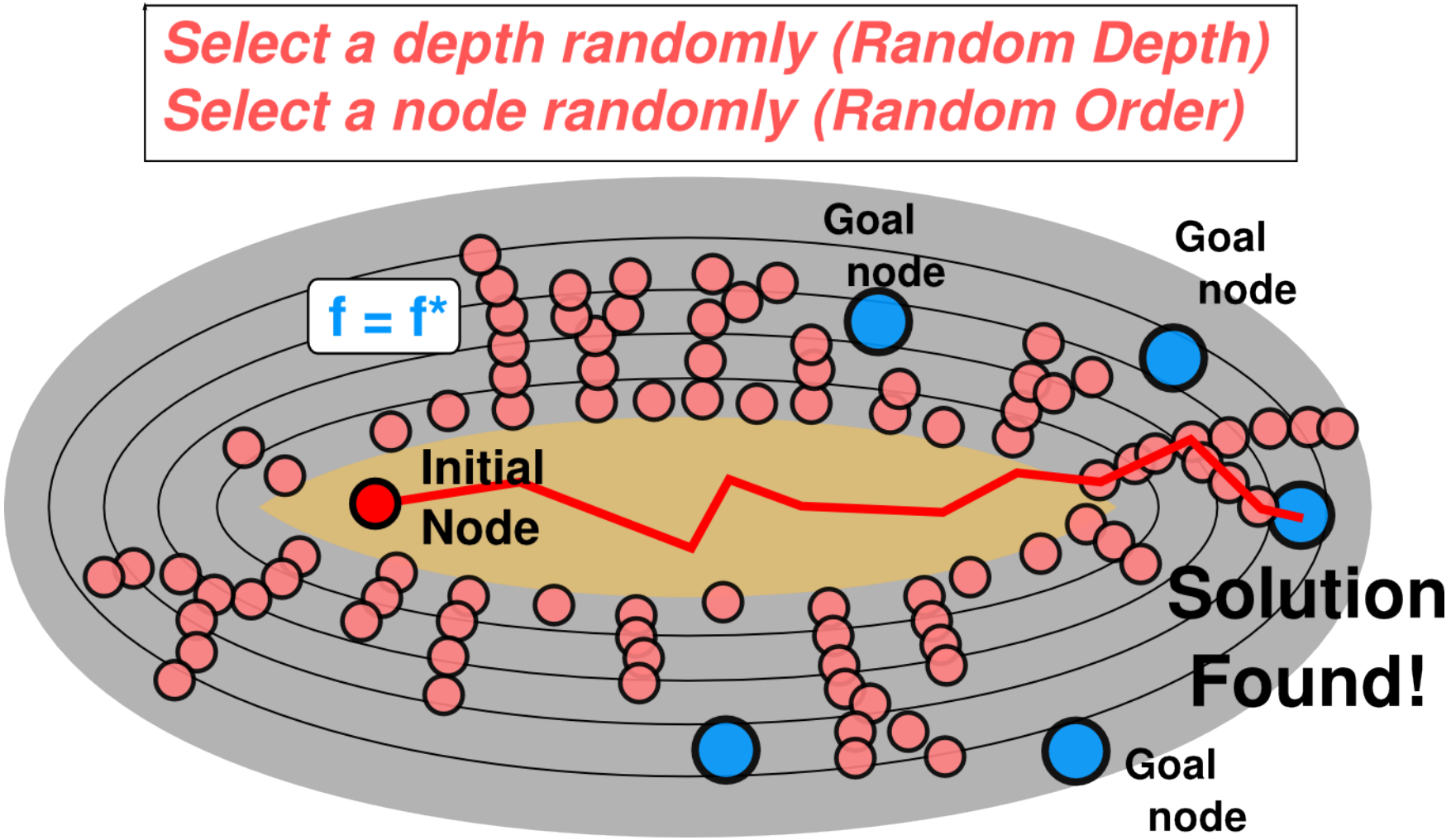
4.4 goal node, init



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



4.7 A* with *h* + Depth Diversification



annd ”plateau search = satisficing planning”

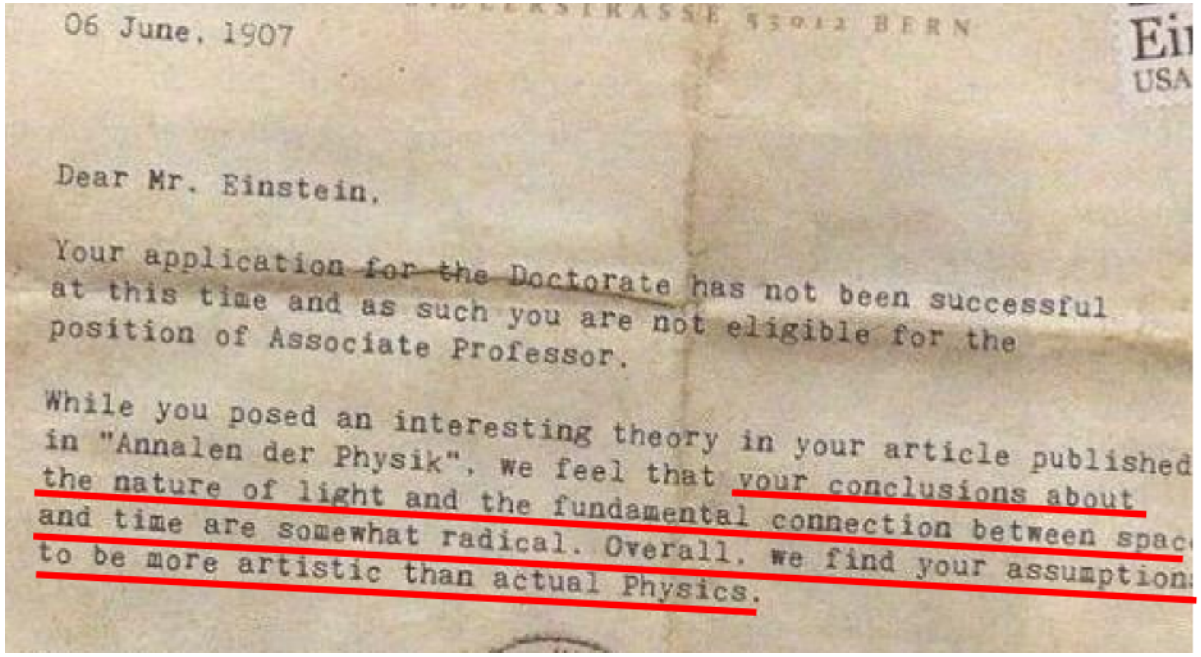
5 Toward Thesis Proposals

- **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.

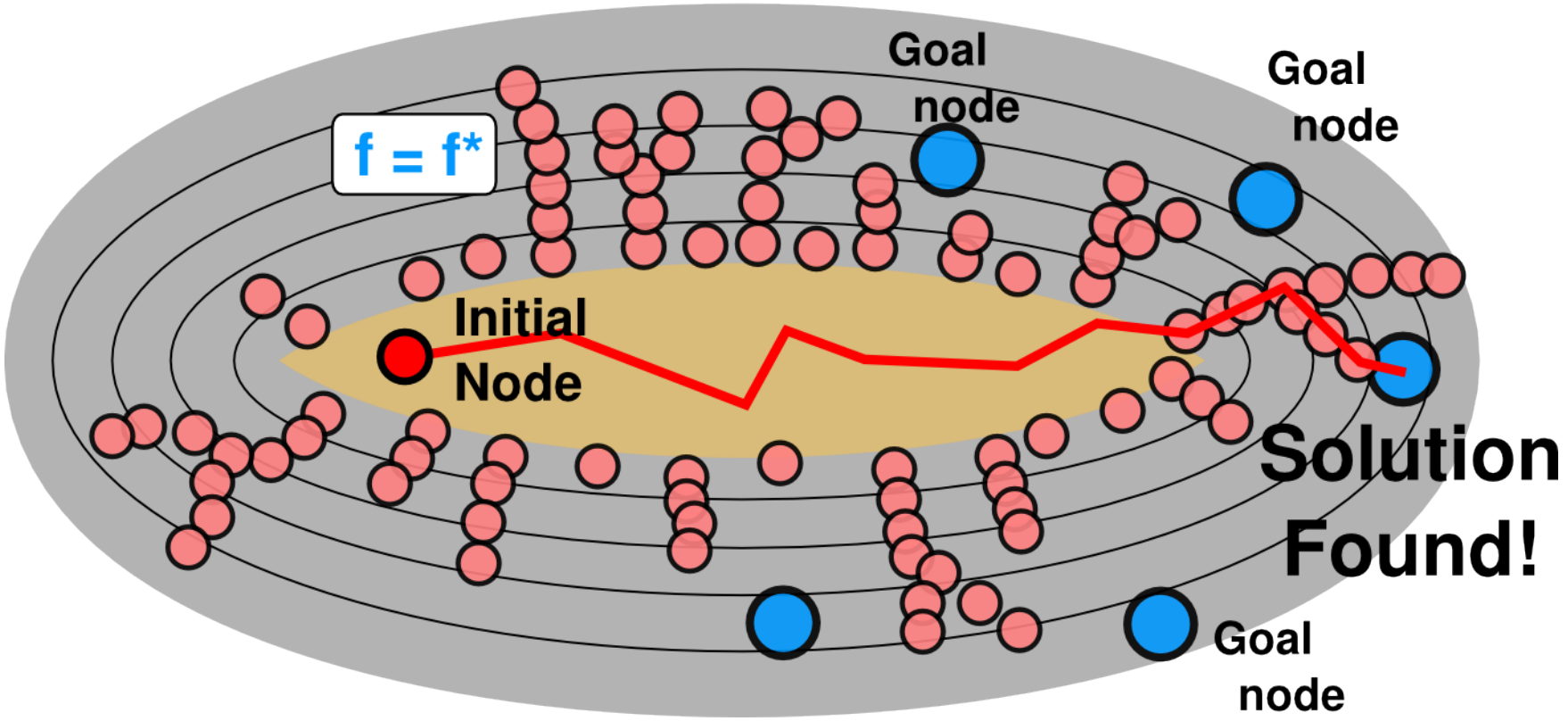
While you posed an interesting theory in your article published in "Annalen der Physik", we feel that your conclusions about the nature of light and the fundamental connection between spac and time are somewhat radical. Overall, we find your assumption to be more artistic than actual Physics.

7 Danger Zone!

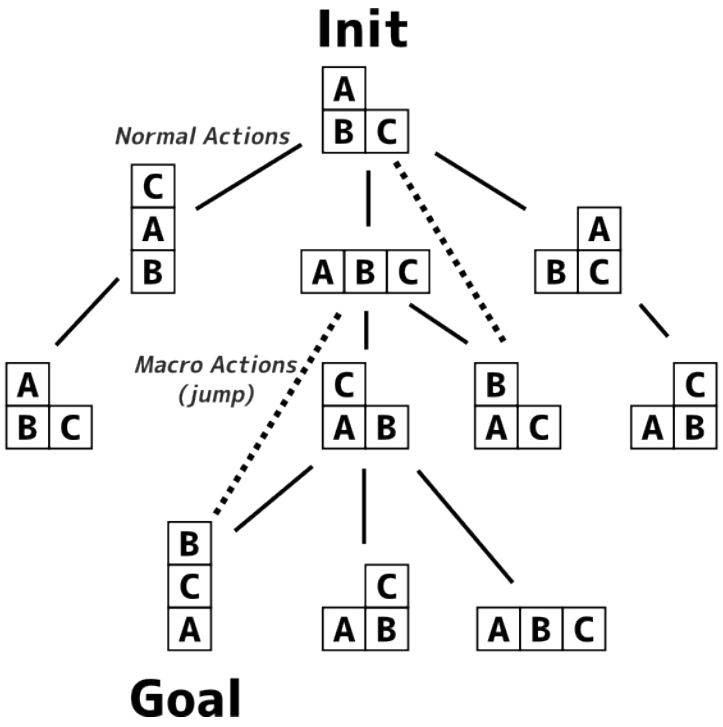
Research IDEAs : not yet fully developped

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

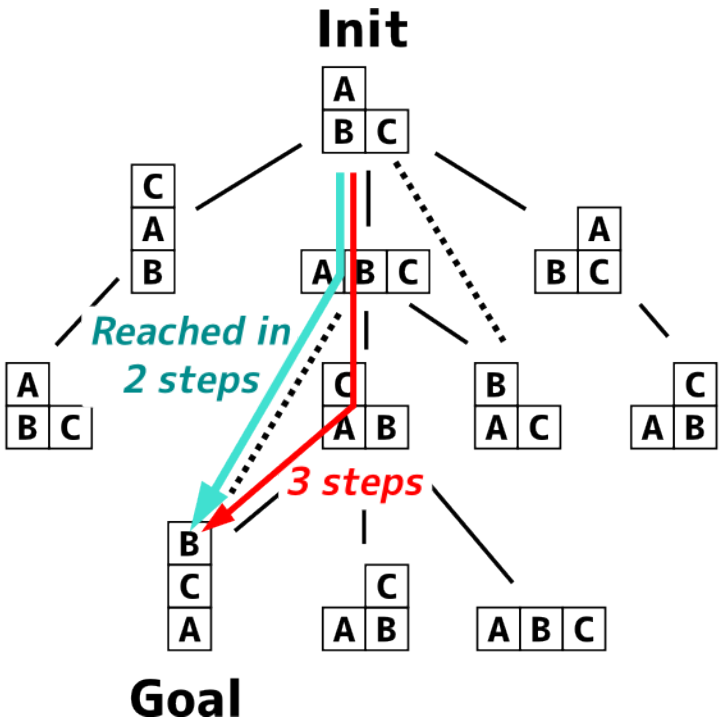
Select a depth randomly (Random Depth)
Select a node randomly (Random Order)



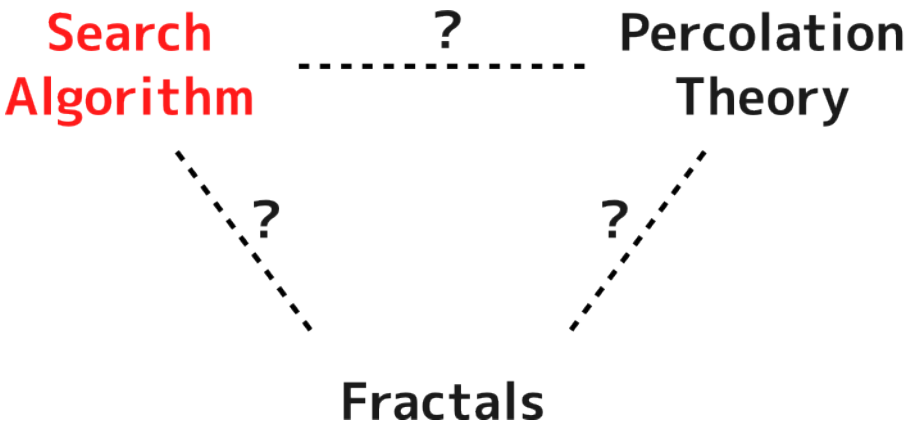
9 Background 2: Macro operators changes the search space structure



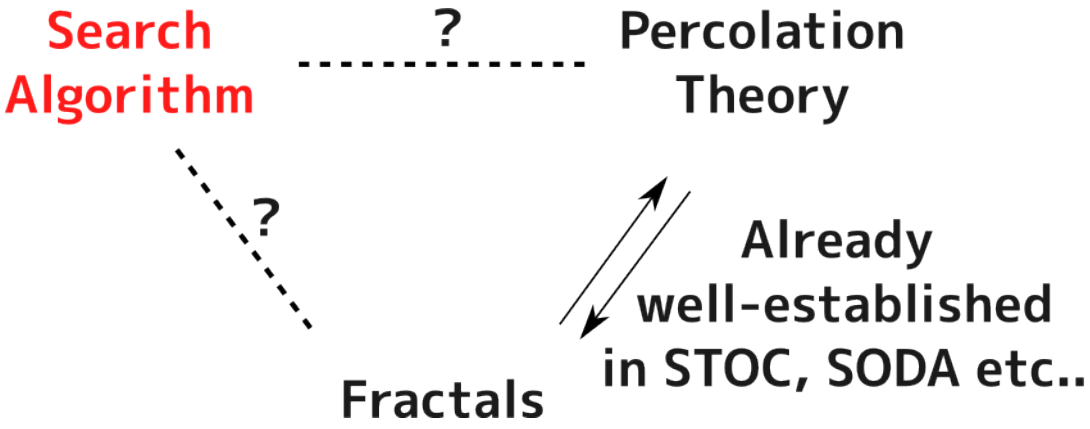
10 Background 2: Macro operators changes the search space structure



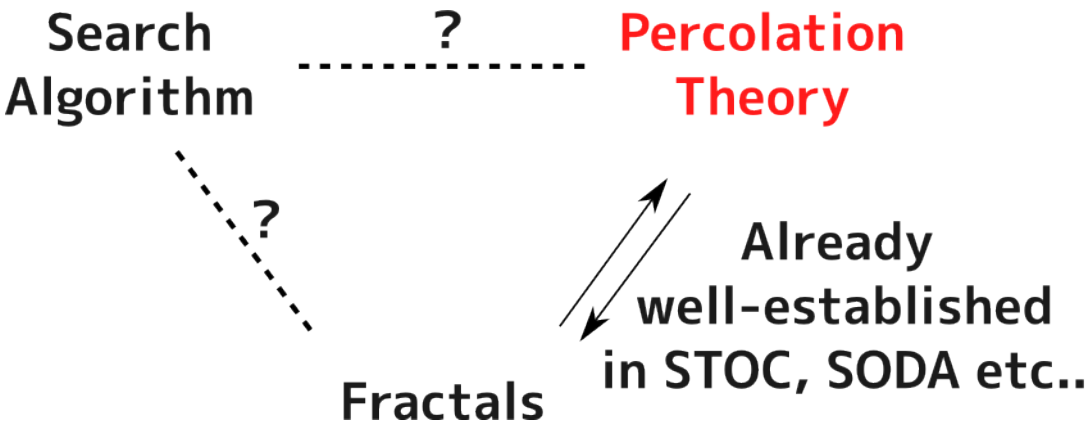
11 Unifying Framework : Discuss Search Space Theoretically



12 Unifying Framework : Discuss Search Space Theoretically



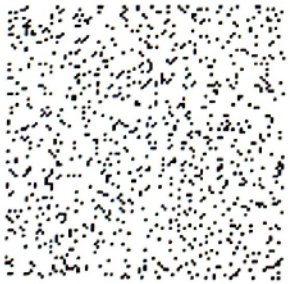
13 Unifying Framework : Discuss Search Space Theoretically



14 Example: 2-dimentional grids

A node is either **occupied** or **unoccupied**

occupied = black, unoccupied = white



not percolated
=occupied nodes
are disconnected
everywhere

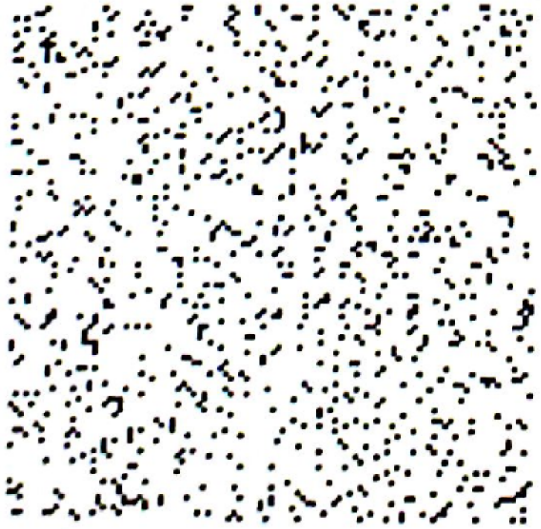
percolated
=occupied nodes
are connected
everywhere

- Key interst: **when/how** a graph percolates?

15 Percolation described by occupation ratio *r*

Occupation ratio r = occupied / total

Obviously disconnected

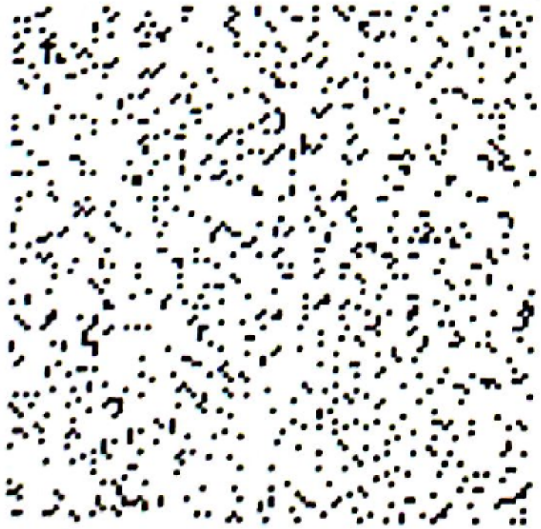


r=0.1

15.1 Percolation described by occupation ratio *r*

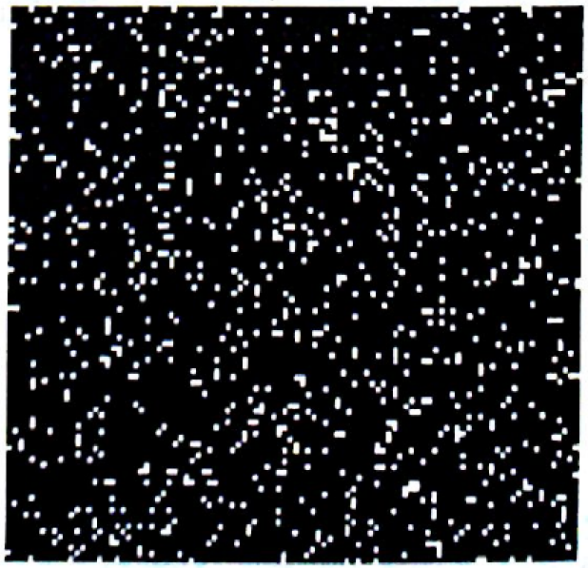
Occupation ratio r = occupied / total

Obviously disconnected



r=0.1

Obviously connected

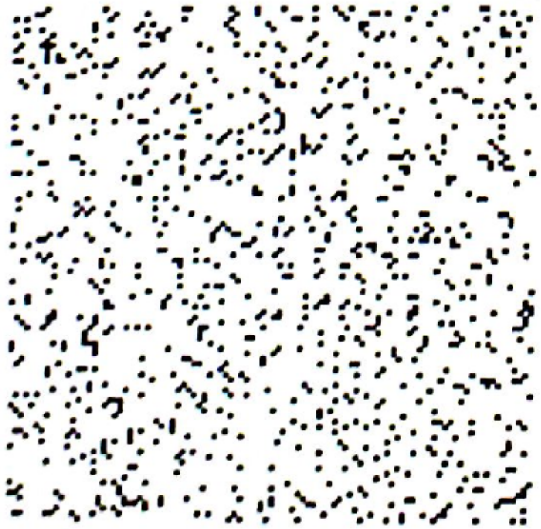


r=0.9

15.2 Percolation described by occupation ratio *r*

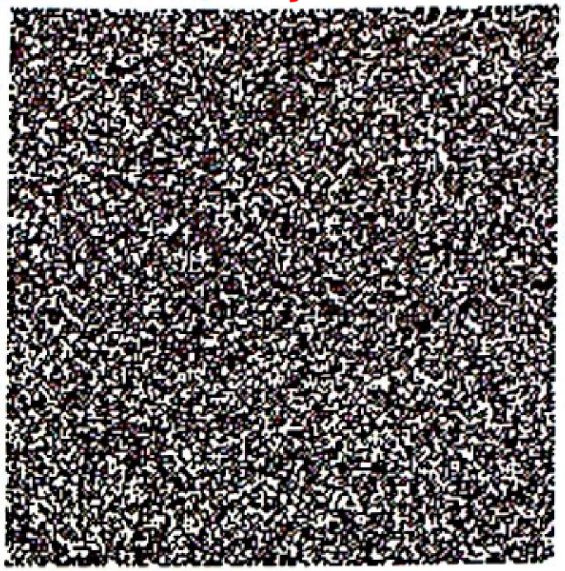
Occupation ratio r = occupied / total

Obviously disconnected



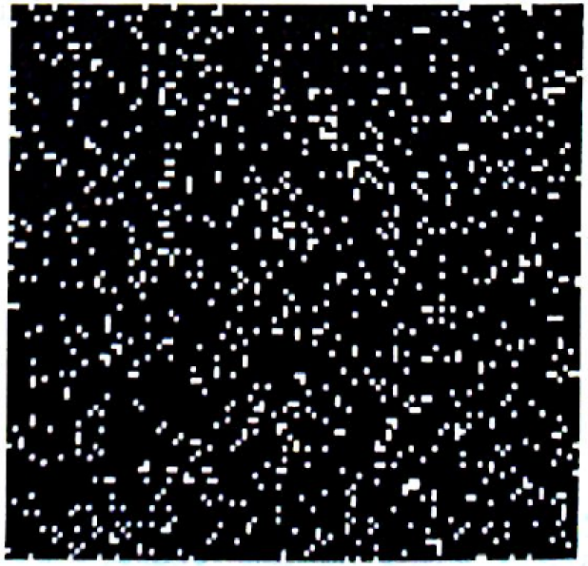
r=0.1

Connectivity non-trivial



$r=r_c=0.5928$

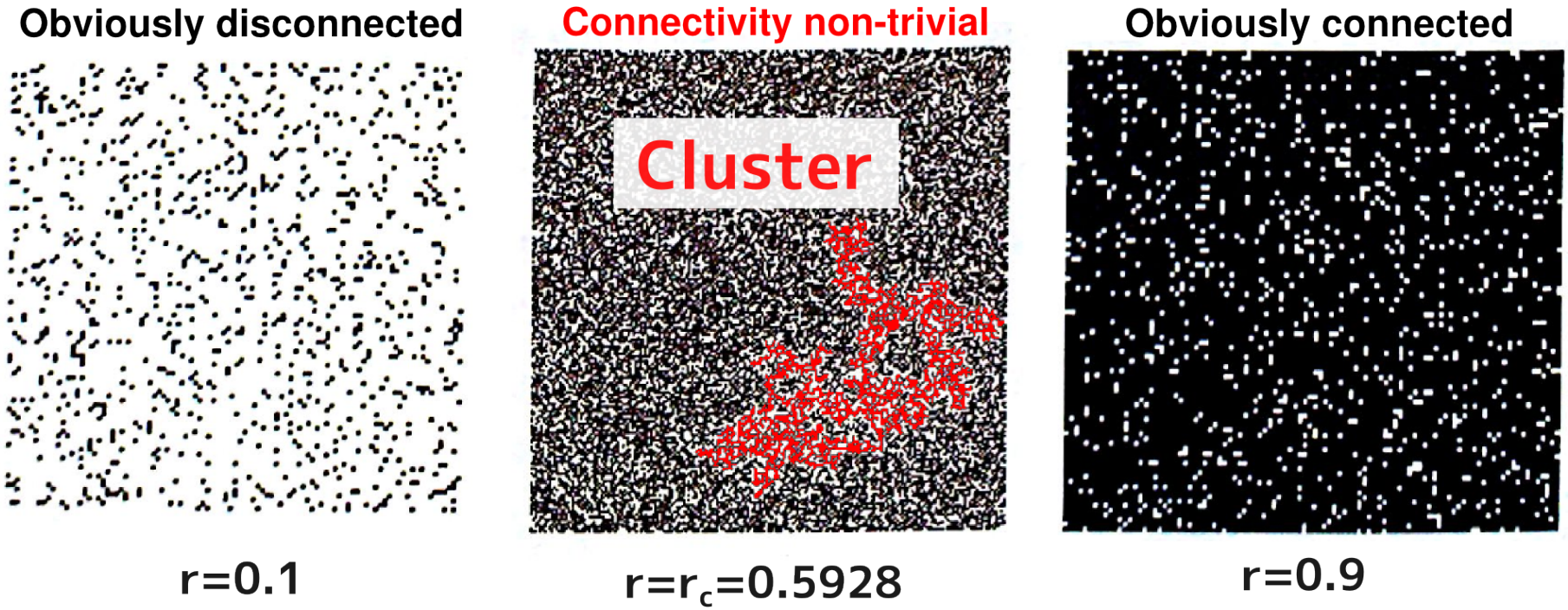
Obviously connected



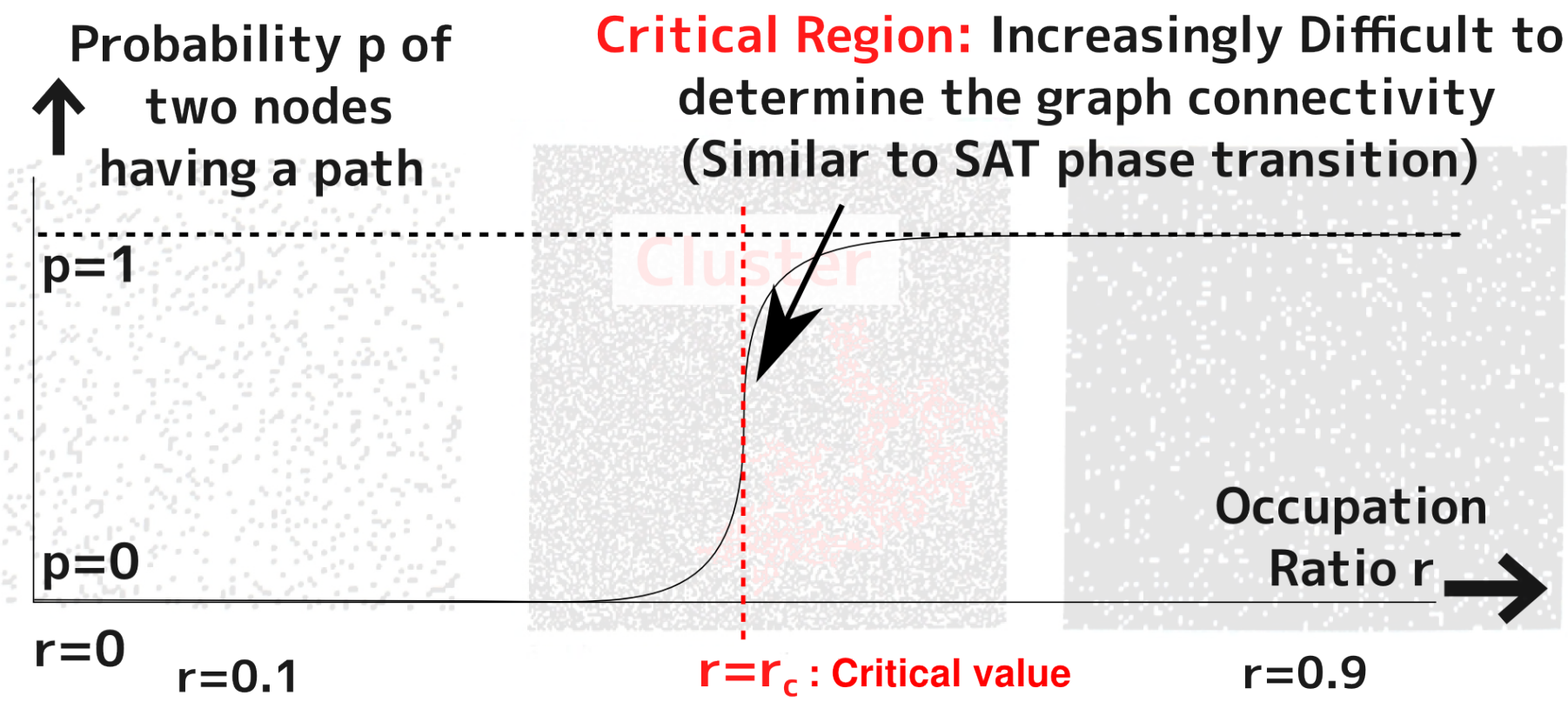
r=0.9

15.3 Percolation described by occupation ratio *r*

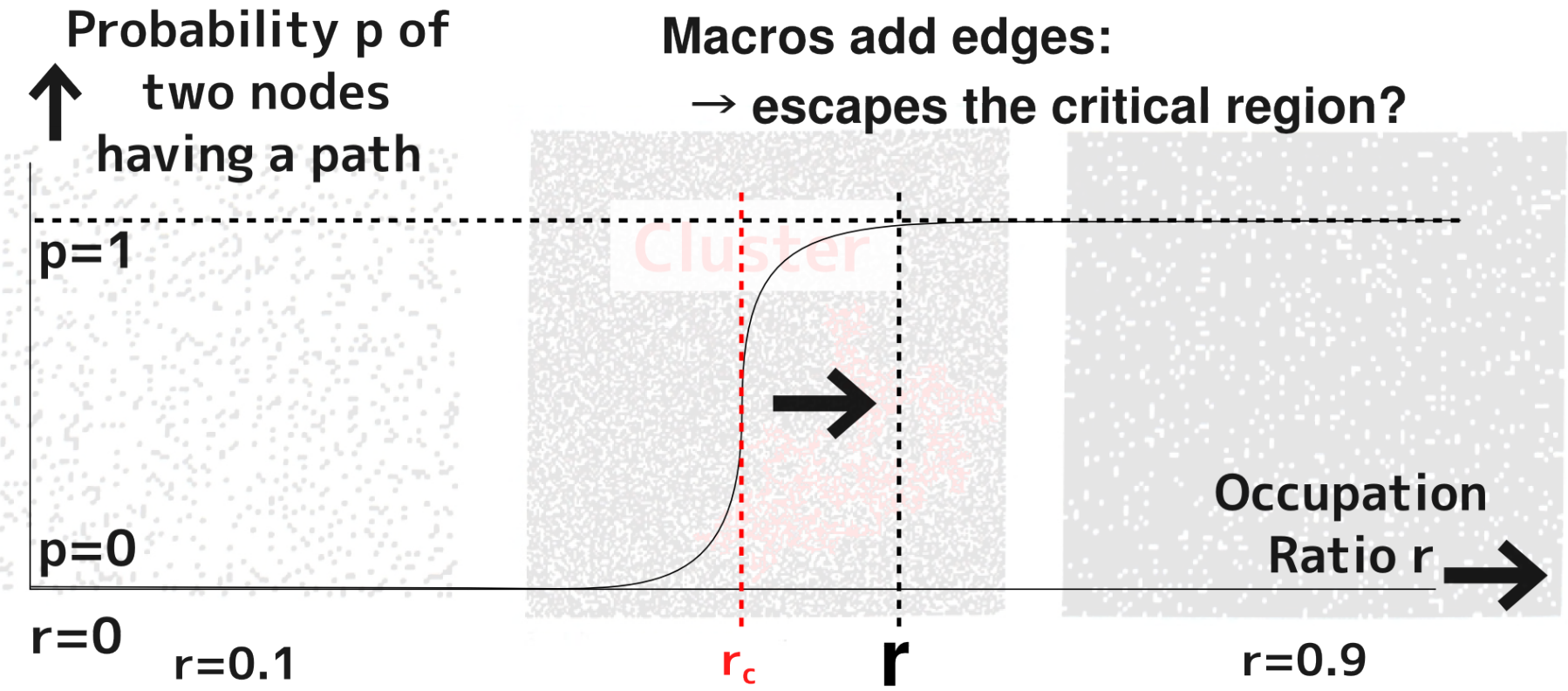
Occupation ratio r = occupied / total



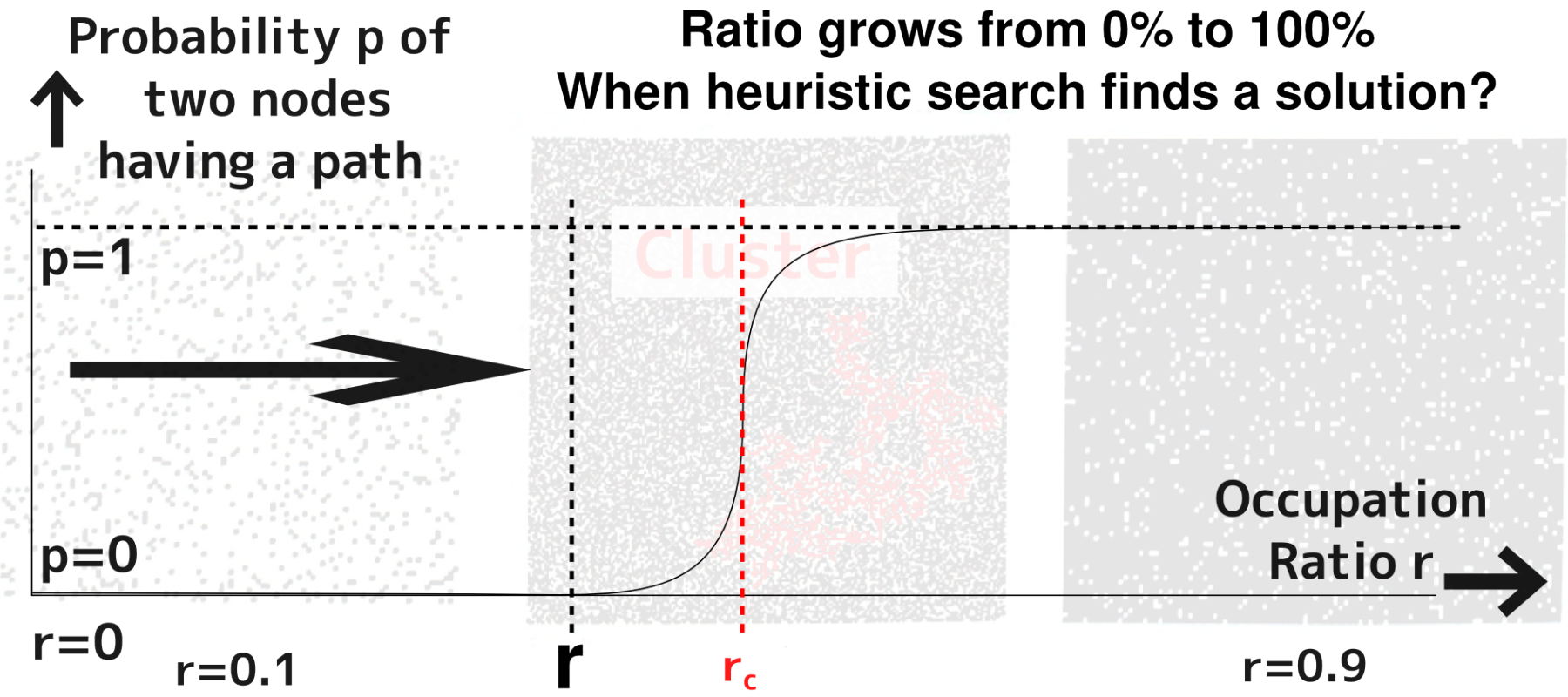
15.4 Phase Transition



15.5 Macros may be shifting the ratio to the right



15.6 Forward Search : Increasing r as the search progresses



15.7 Open Questions

- **Is there connection between macro-operators and critical region?**
  - testing if randomly generated **Junk Macros** improves the performance
    - **Ongoing work — *positive results* (next slide)**
- **How *existing macro-approaches* change the connectivity?**
  - MacroFF(Botea05), Marvin(Coles04,07) MUM(Chrpa14), CAP(Asai15), BLOMA(Siddiqui15)
- **What is the r_c of each domain?**
  - critical value of Logistics is X, Barman is Y ...
- **At which r does each search algorithm find a solution?**
  - Lookahead search, GBFS, Type-GBFS, A*...

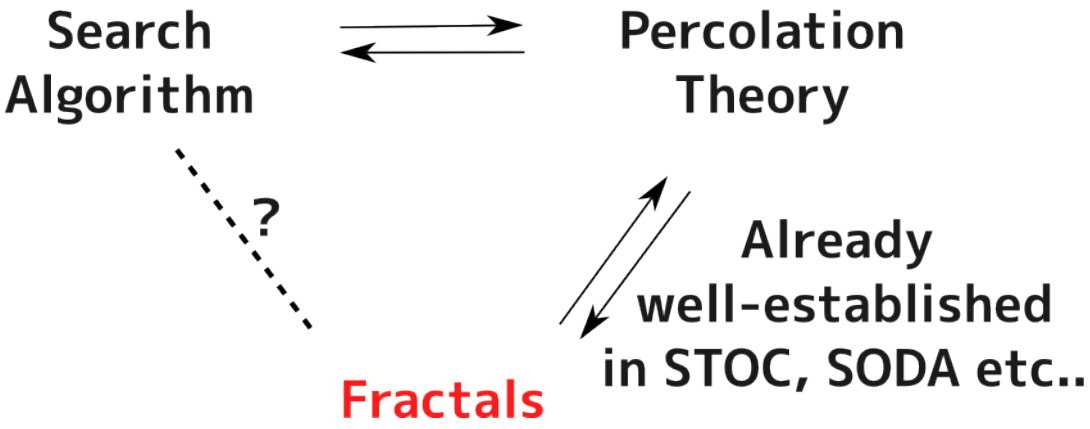
15.8 Preliminary results on Junk Macros

(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** →

Promising direction!

16 Unifying Framework : Discuss Search Space Theoretically



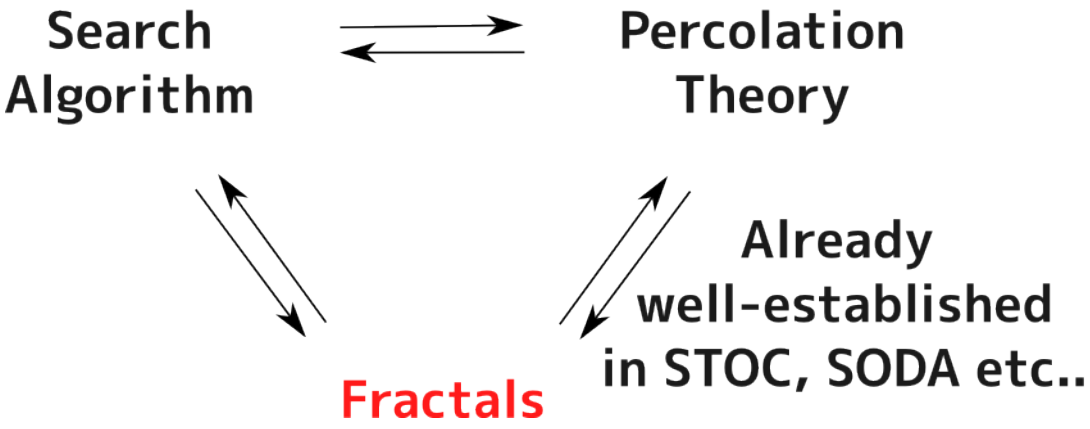
17 Fractals

Each search algorithm determines the ***shapes*** of the search space

effective search space: space evaluated by the search algorithm

effective search space $\subseteq$ search space

18 Unifying Framework : Discuss Search Space Theoretically



19 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?

20 Conclusion

Apply Percolation Theory / Fractals to macros / search algorithms

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

→ Unified, consistent thesis!