Introduction to Robotics for cognitive science

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Web page of the subject

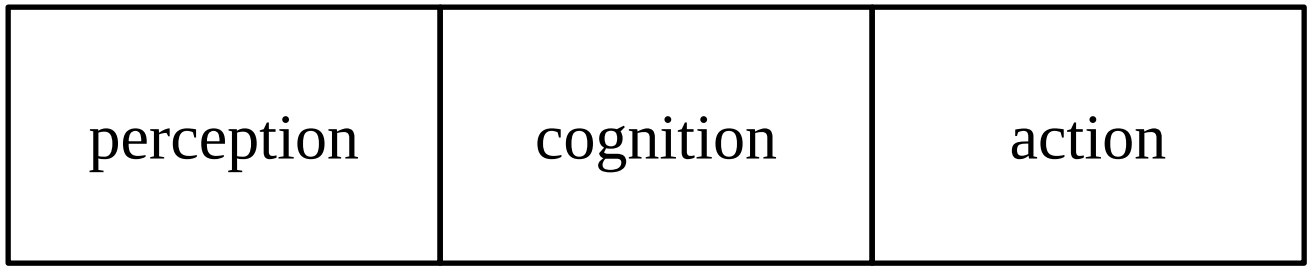
www.agentspace.org/kv

Cognitivism

- Cognitivism is a kind of philosophy of mind which interpret mental functions as internal manipulation with symbols
- Cognitivists believed that the mind is independent of biological hardware (wetware) and analogically can be created on different platforms
- Cognitivists looked for a universal algorithm implementing the mind as a whole (example: STRIPS)

Cognitivism

- Cognitivism supposes there is a module responsible for cognition inside the cognitive system

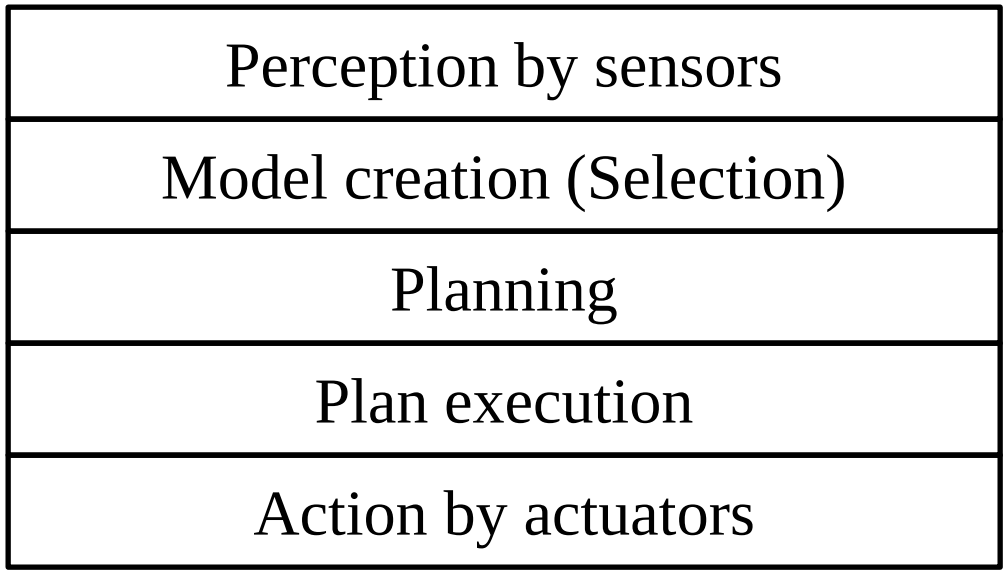


Cognitivism

- Cognitivism supposes any thinking is based to language communication and representation (thinking = speaking to self)
- Cognitivism supposes any thinking is similar to solving twisters (thinking = problems solving)
- Cognitivism supposes the mind is deliberative, and for any action, there is a logical explanation why it has been selected

Cognitive robot

- is based on decomposition by function



STRIPS

Standord Reseach Institute Problem Solver
Fikes & Nilsson, 1971

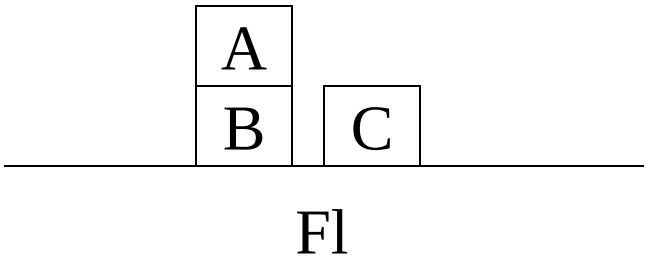
- Cognitive subsystem which turns:
  - world representation
  - robot capabilities representation
  - goal representation

  to: plan how to achieve the goal

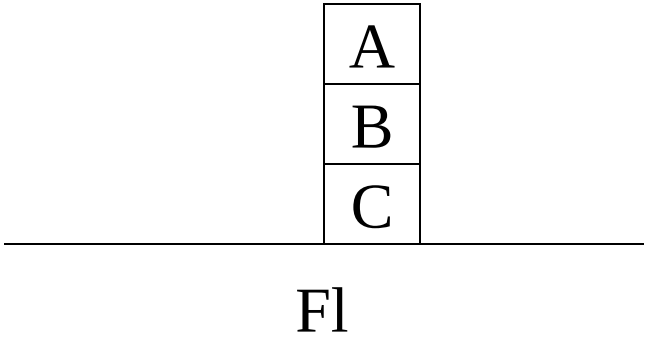
- based on the first-order logic (Horn clauses, linear solver)

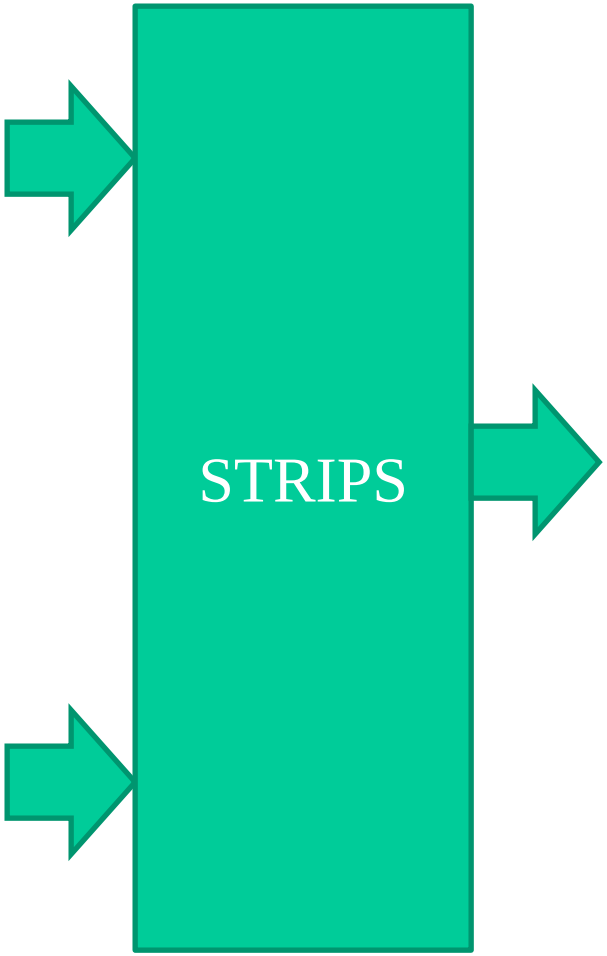
STRIPS as cognitive subsystem

Initial state:

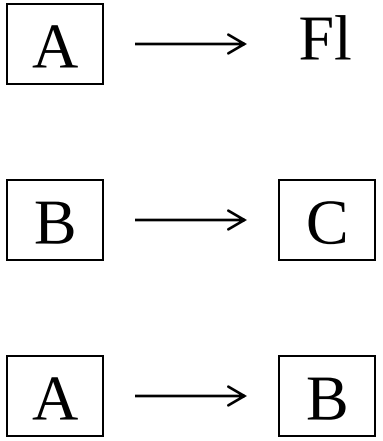


Goal:





Plan:



STRIPS world representation

Constants:
A, B, C, Fl

Variables:
X, Y, Z

Connectives:
, !

Equal:
=

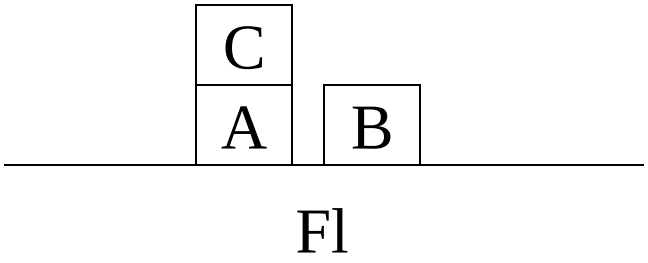
Predicates:

- Clear(X)
- On(X,Y)

Functors:

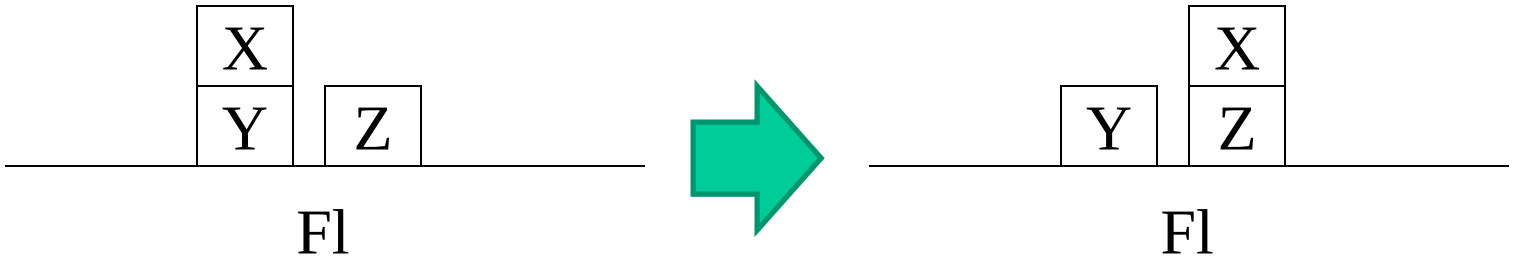
- low
- height(X)

Initial state:



On(C,A), On(A,Fl), On(B,Fl),
Clear(C), Clear(B), Clear(Fl)

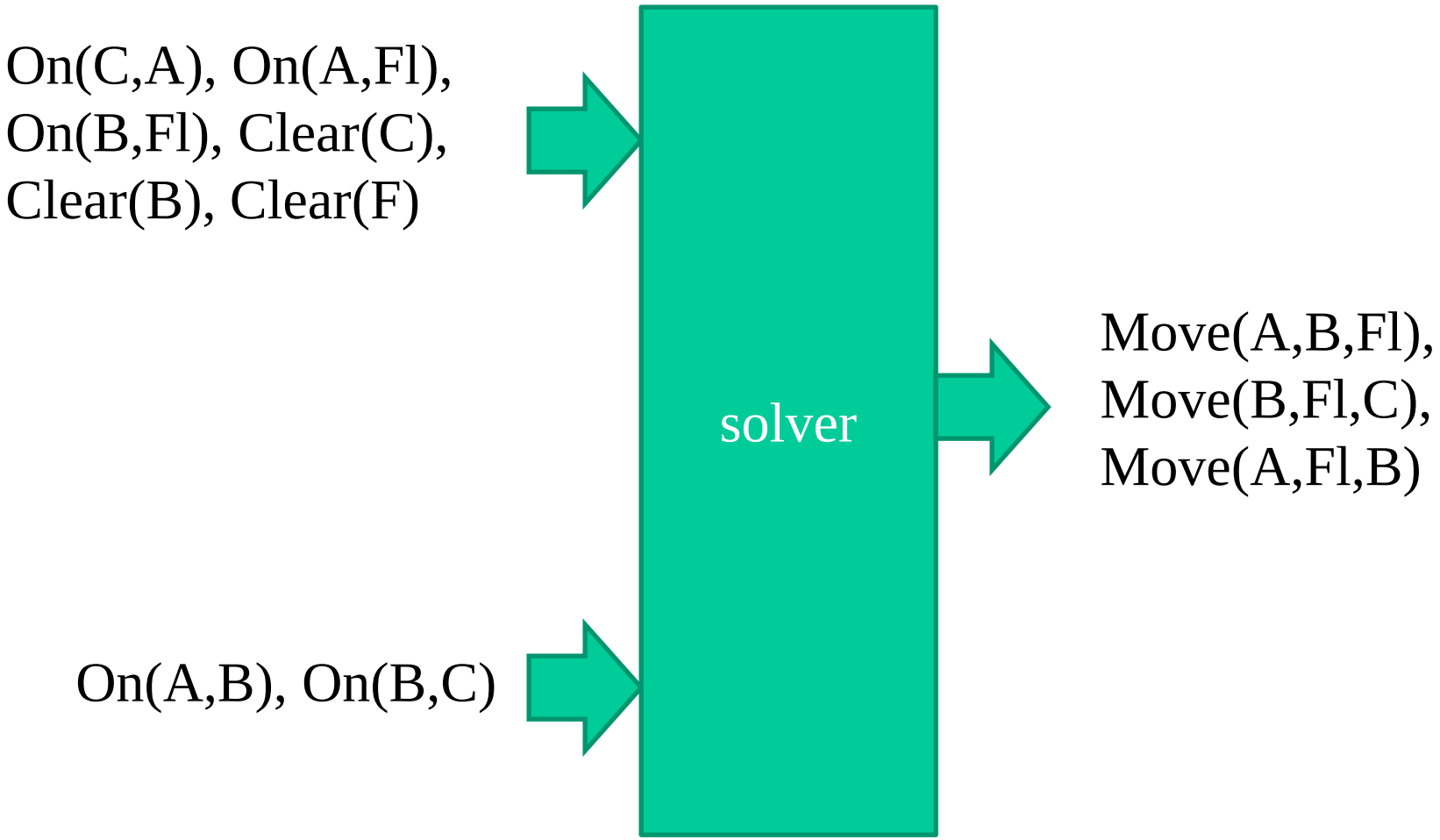
STRIPS rule



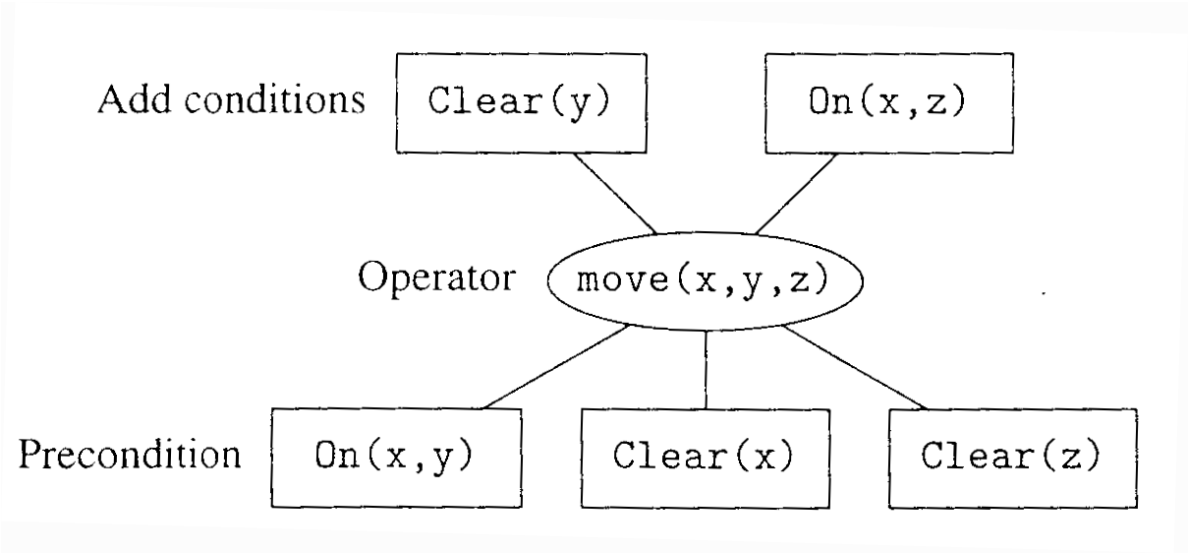
Operators:

- **Move(X,Y,Z)** - move X from Y to Z
- Preconditions: Clear(X), On(X,Y), Clear(Z), !Y=Z
- Postconditions: !Clear(Z), !On(X,Y),
  On(X,Z), Clear(Y), Clear(Fl)

STRIPS: solver



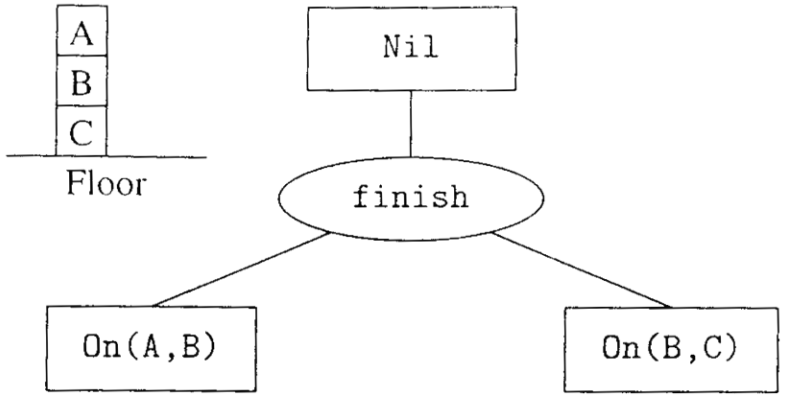
The solver tries to put various instances of the STRIPS rules into a tree structure that connects the initial state with goals.



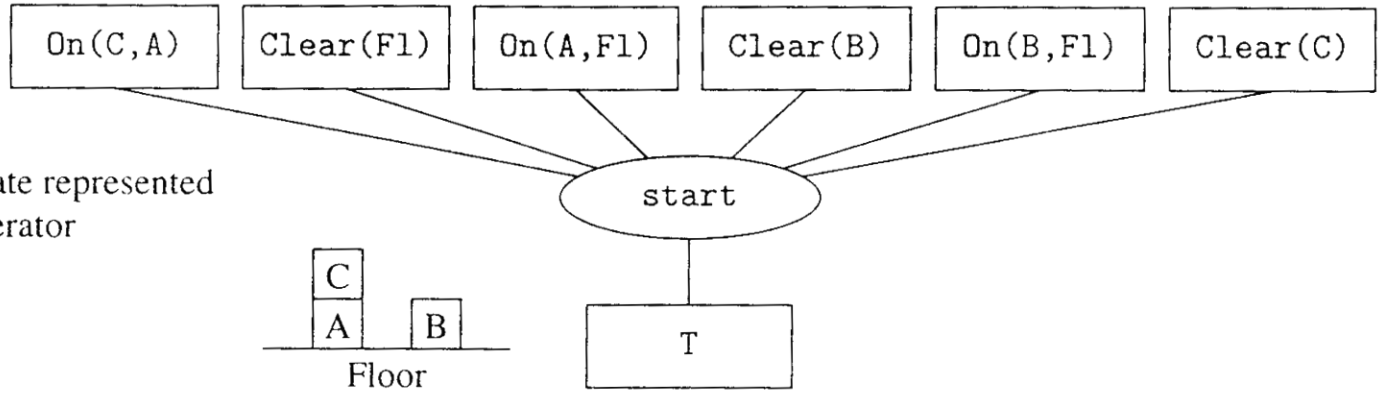
STRIPS rule

Goal

Goal represented as an operator



Initial state represented as an operator

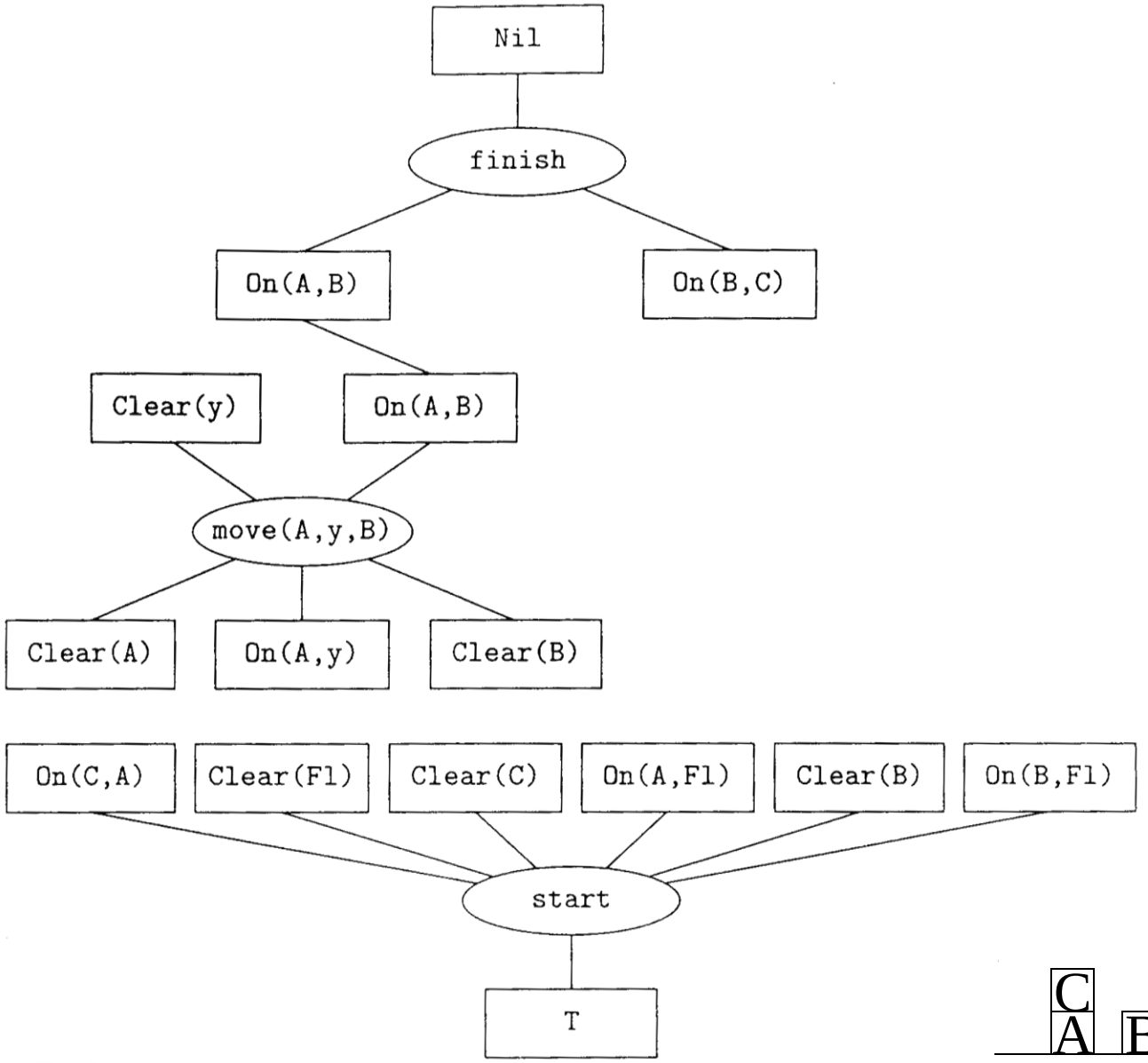


Initial state

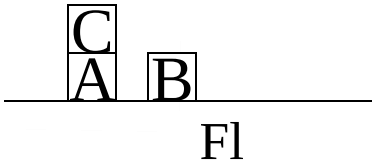
Searching for the plan

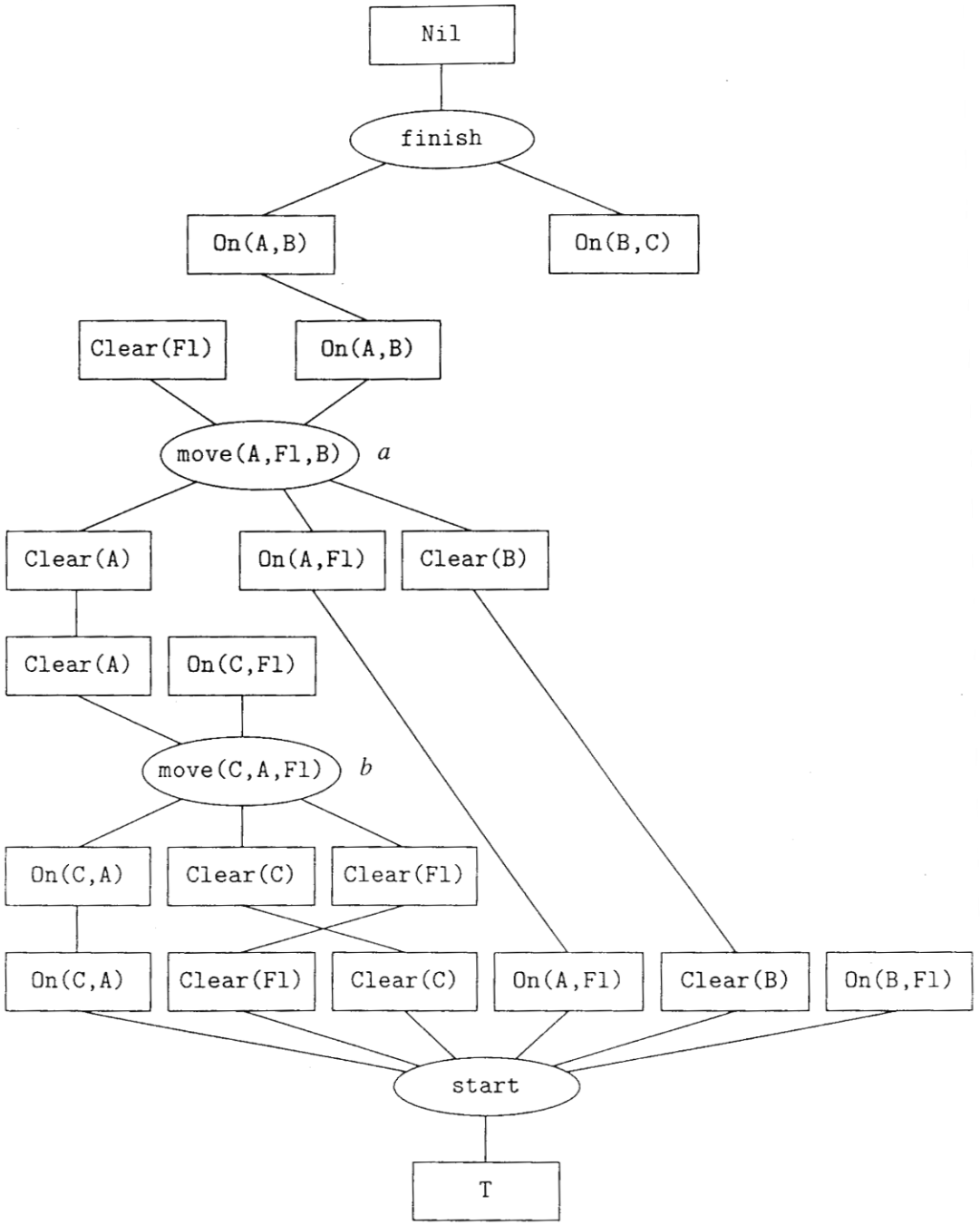
Algorithms:

- Back-tracking
- A*

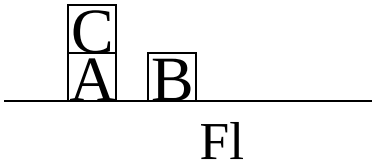

Nil
finish
On(A,B)
On(B,C)
Clear(y)
On(A,B)
move(A,y,B)
Clear(A)
On(A,y)
Clear(B)
On(C,A)
Clear(Fl)
Clear(C)
On(A,Fl)
Clear(B)
On(B,Fl)
start
T

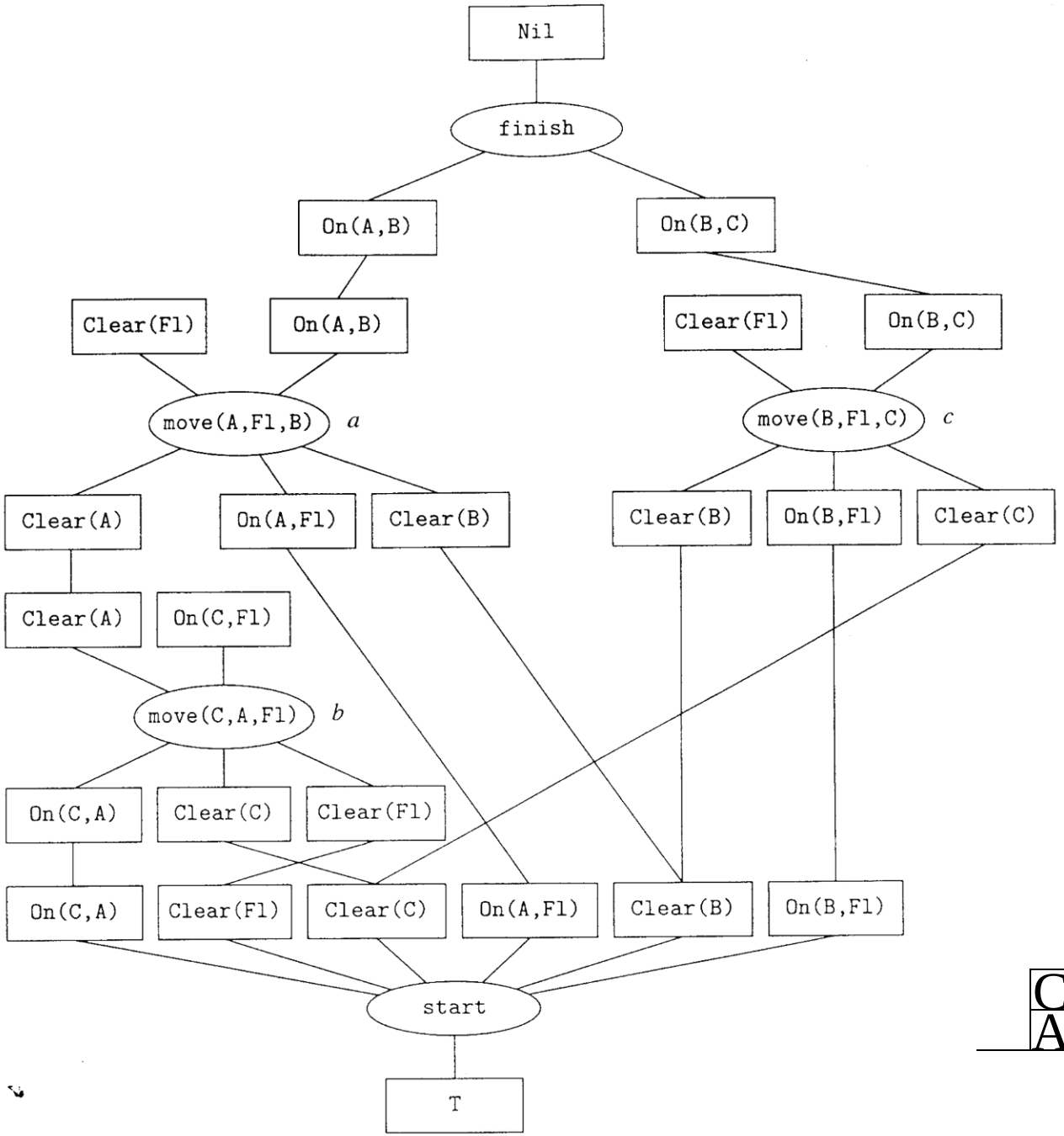

A
B
C


C
A
B
Fl


Nil
finish
On(A,B)
On(B,C)
Clear(Fl)
On(A,B)
move(A,Fl,B)
a
Clear(A)
On(A,Fl)
Clear(B)
Clear(A)
On(C,Fl)
move(C,A,Fl)
b
On(C,A)
Clear(C)
Clear(Fl)
On(C,A)
Clear(Fl)
Clear(C)
On(A,Fl)
Clear(B)
On(B,Fl)
start
T

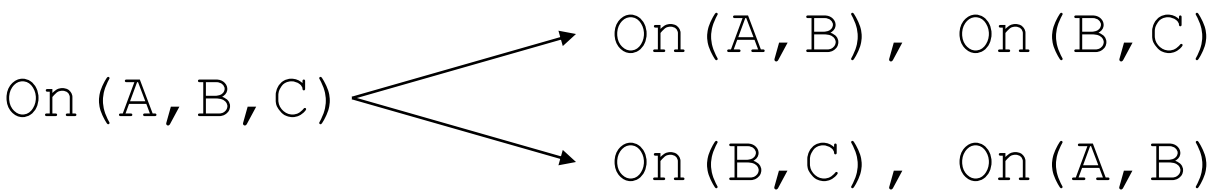

A
B
C

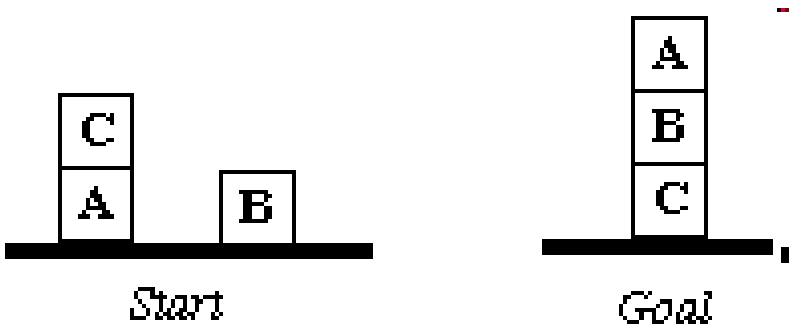

C
A
B
Fl


Nil
finish
On(A,B)
On(B,C)
Clear(Fl)
On(A,B)
Clear(Fl)
On(B,C)
move(A,Fl,B)
a
move(B,Fl,C)
c
Clear(A)
On(A,Fl)
Clear(B)
Clear(B)
On(B,Fl)
Clear(C)
Clear(A)
On(C,Fl)
move(C,A,Fl)
b
On(C,A)
Clear(C)
Clear(Fl)
On(C,A)
Clear(Fl)
Clear(C)
On(A,Fl)
Clear(B)
On(B,Fl)
start
T
A
B
C
C
A
B
Fl

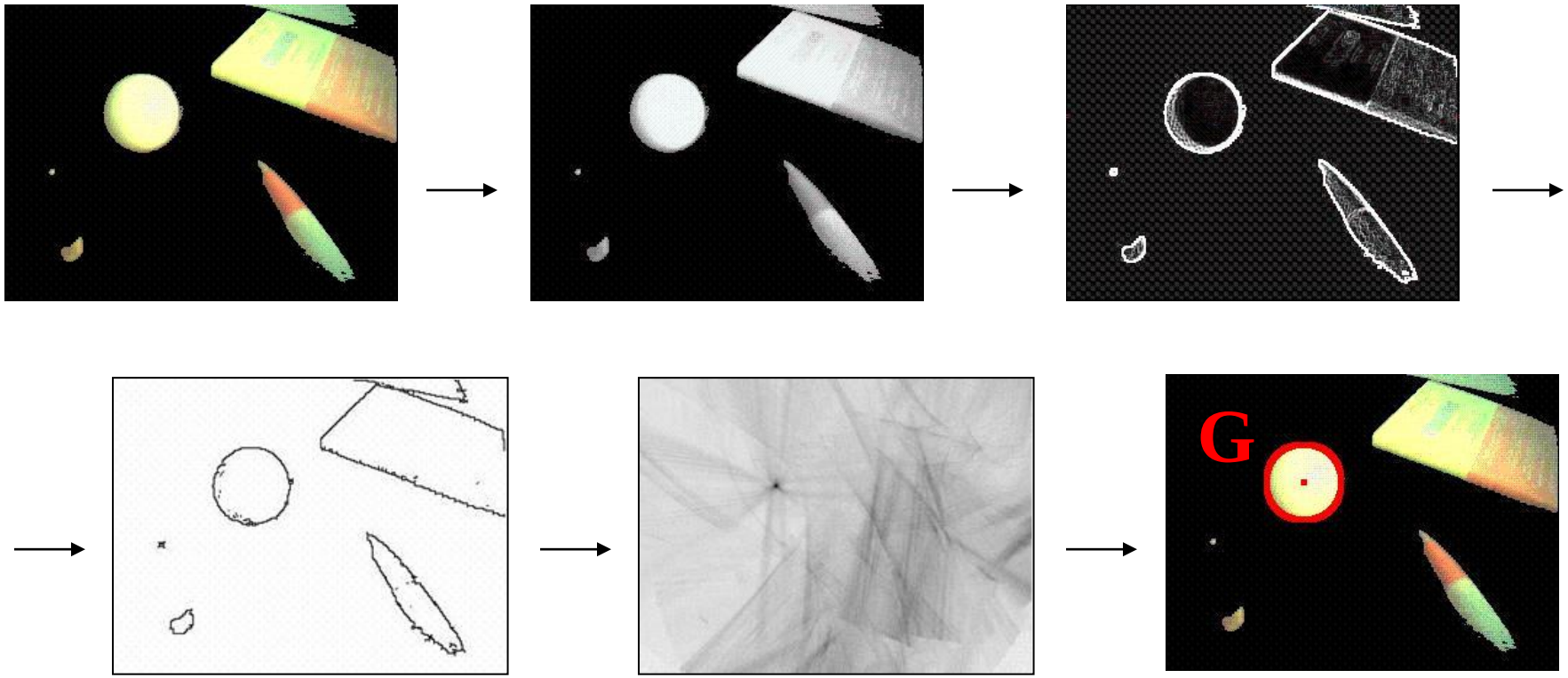
Sussman anomaly

Solving problems by decomposition to subgoals does not generate optimal solutions.





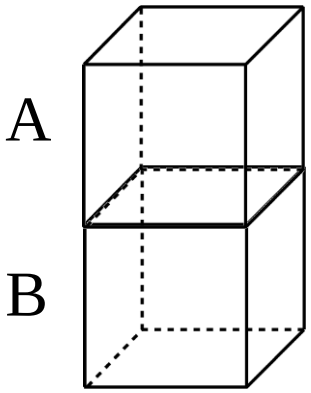
Model creation (Selection)

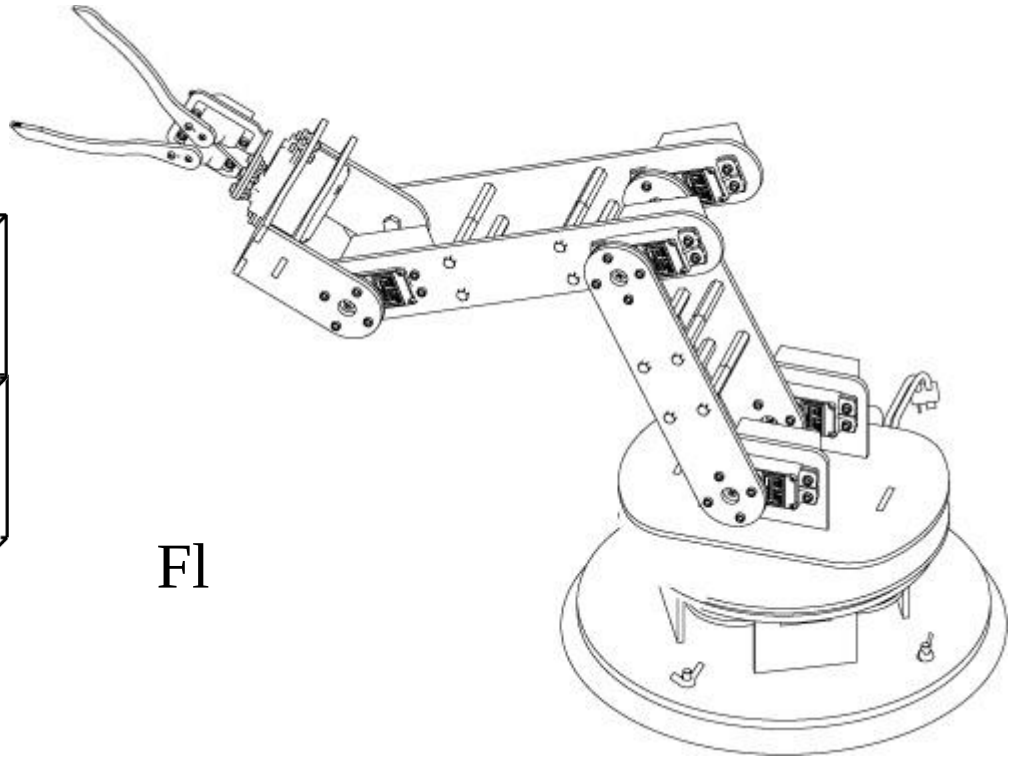


Sphere(G), Position(G, 2403, 1200)

Plan execution

Move(A,B,Fl) →





Fl

Frame problem

- Lack of facts about the world got by the modeling process

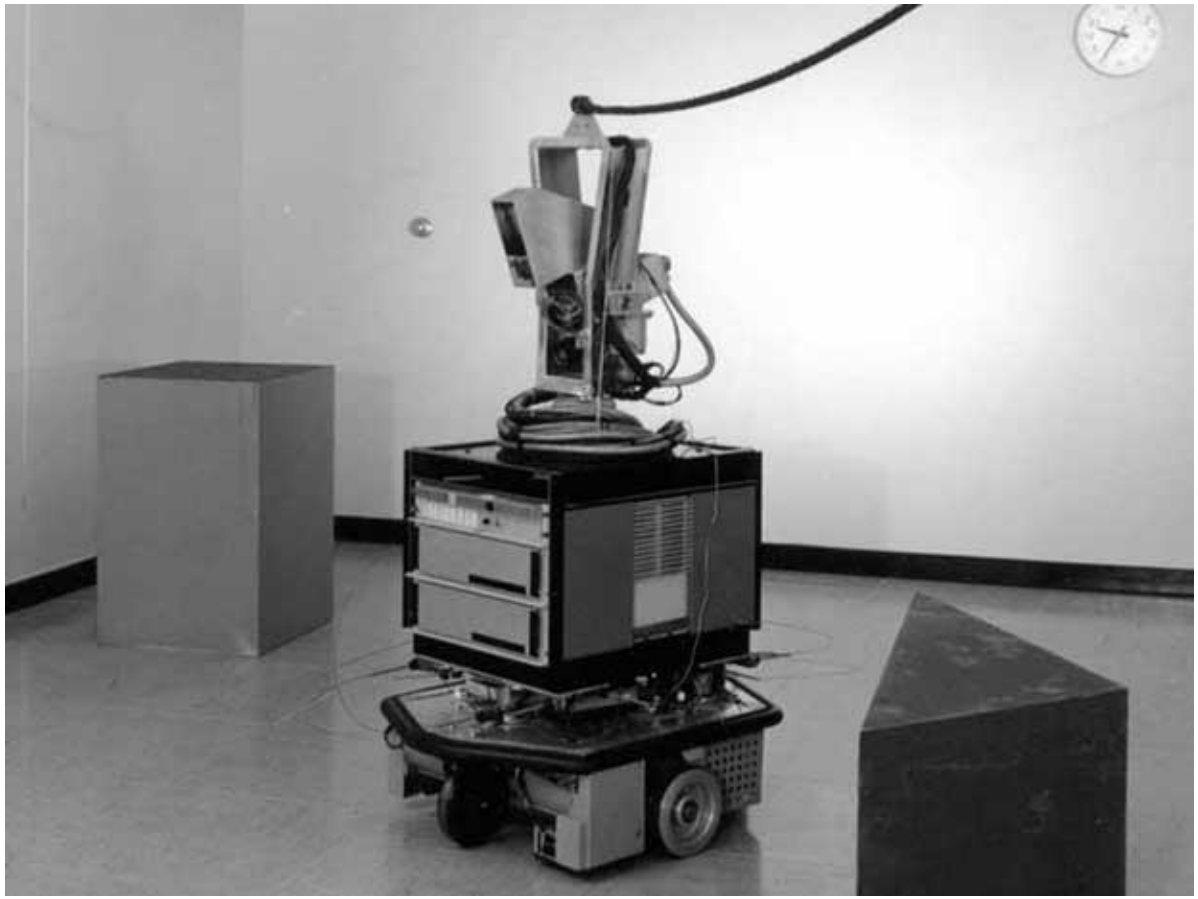
vs.

- Lack of computational power for the solver to derive a plan

- Caused by: modeling is losing semantics and solver is spending much time by syntactical operations over model parts which have no semantic relation

The First Cognitive Robot

- SHAKEY
  Rosen
  1969
- Cognition
  = STRIPS



Cognitivism: Pros

- Computation-symbolic approach
- Explanation of action selection is granted
- It is easy to solve difficult tasks like logic-based twisters
- Thinking of such a robot is close to language communication

Cognitivism: Cons

- Frequently, it is more challenging to get the word representation and/or the plan execution (which enables us to use the cognitive subsystem) than to solve the task on a sub-symbolic level
- The plan execution can fail due to varying conditions (dynamic world)
- All parts of representation got by modeling must be expressed in the same representation language while various formats are suitable for various data
- Cognitive subsystem is too slow for some tasks
- It is not easy to solve some easy tasks

GOFAI

- Cognitivism corresponds to so-called Good Old Fashioned Artificial Intelligence

- Up to now, GOFAI is not obsolete and still produces interesting robots

Human-Machine Interface

- Advantage of GOFAI is that world representation is similar to communication in natural language
- “put the cube A to the cube B” can be relatively easily transformed to “put(A,B)”
- it is even easier to transform “On(A,B)” to “cube A is on cube B”

Regular expressions

- These transformations can be made for a finite set of sentences in natural language (namely such as simple as English)
  `on(A,B)` can be matched by reg.expression
  `\w+\((\w+),(\w+)\)`
  providing group 0 corresponding to w and 1 to B; thus, we can use the form for sentence
  `cube (0) is on cube (1)`
  to generate:
  `cube A is on cube B`
  see https://regex101.com/