Cybernetics and Artificial Intelligence
Introduction into the course

[Tomáš Svoboda, Matěj Hoffman]

2018

Admin, rules of the game

- 2+2+5+(~35) - weekly: 2 hours lectures, 2 computer labs, 5 individual work (reading, coding), ~35 wrapping up - preparing for exam. Intensive term work may save time at the end

- https://cw.fel.cvut.cz/wiki/courses/b3b33kui/start
    - program
    - grading
    - literature …

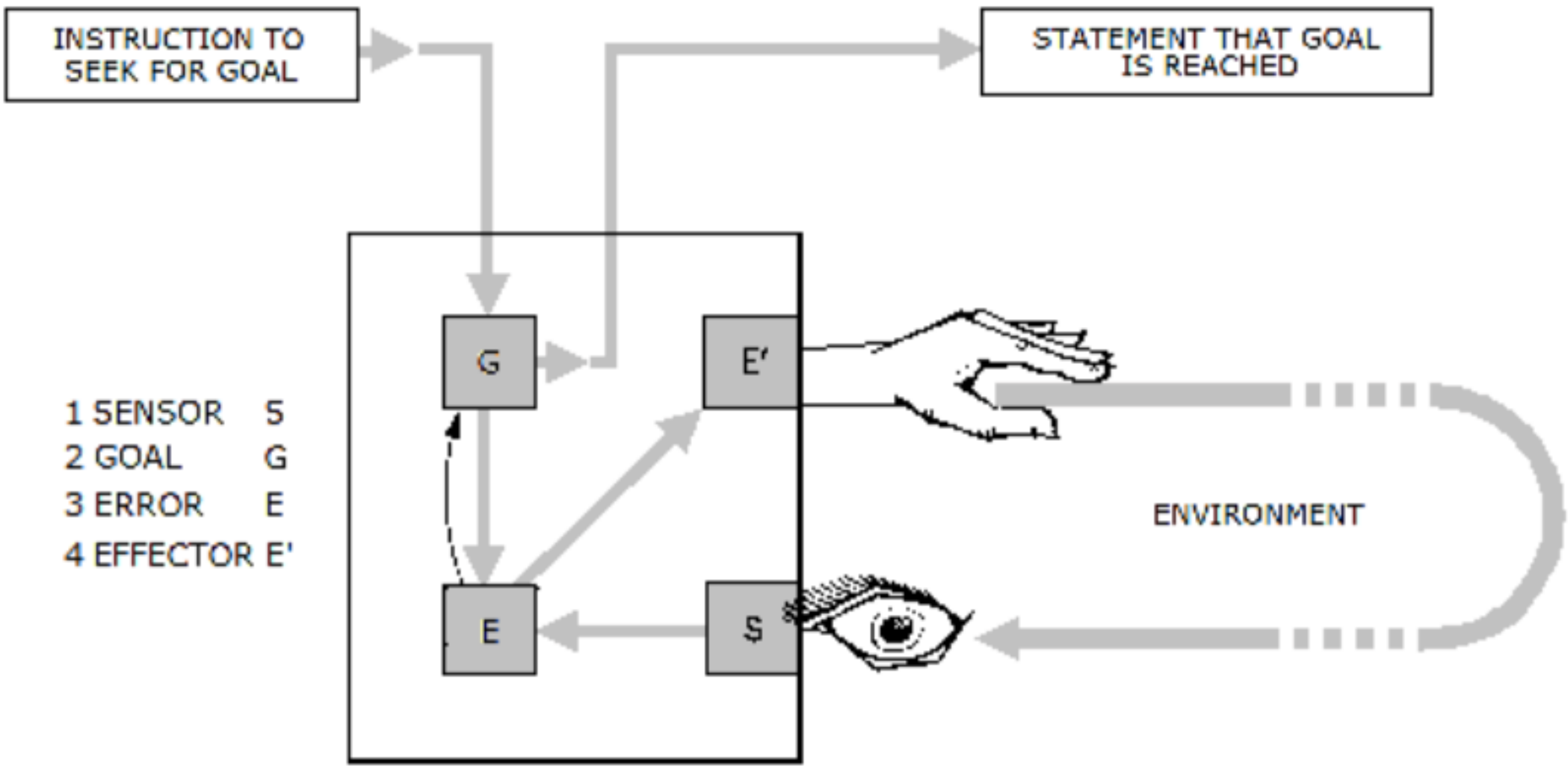
literature, resources

- we recommend a few
- on-line materials abundant - you can find by yourself, responsibility is (always) yours
- ask us if unsure
- we appreciate you recommend new ones

cybernetics and AI

- Norbert Wiener (1948). Cybernetics: Or Control and Communication in the Animal and the Machine.
- William Ross Ashby (1956). An introduction to cybernetics.
- then development continued but different names/wording on the two sides of “iron curtain”.
- Pask, Gordon (1972). "Cybernetics". Encyclopædia Britannica.

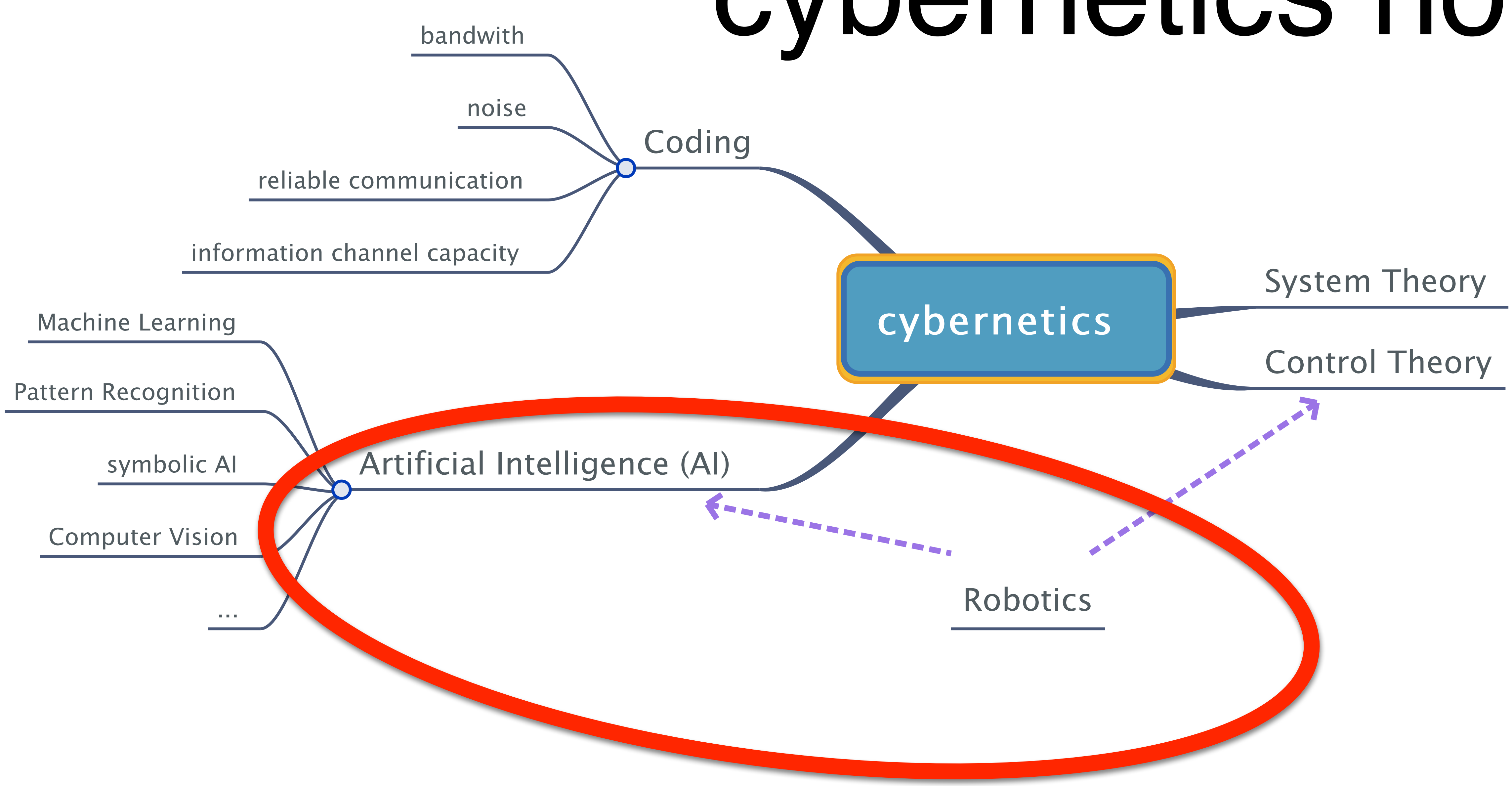
goal-directed system



A SIMPLE GOAL-DIRECTED SYSTEM

Pask, Gordon (1972). "Cybernetics". Encyclopædia Britannica.

cybernetics now

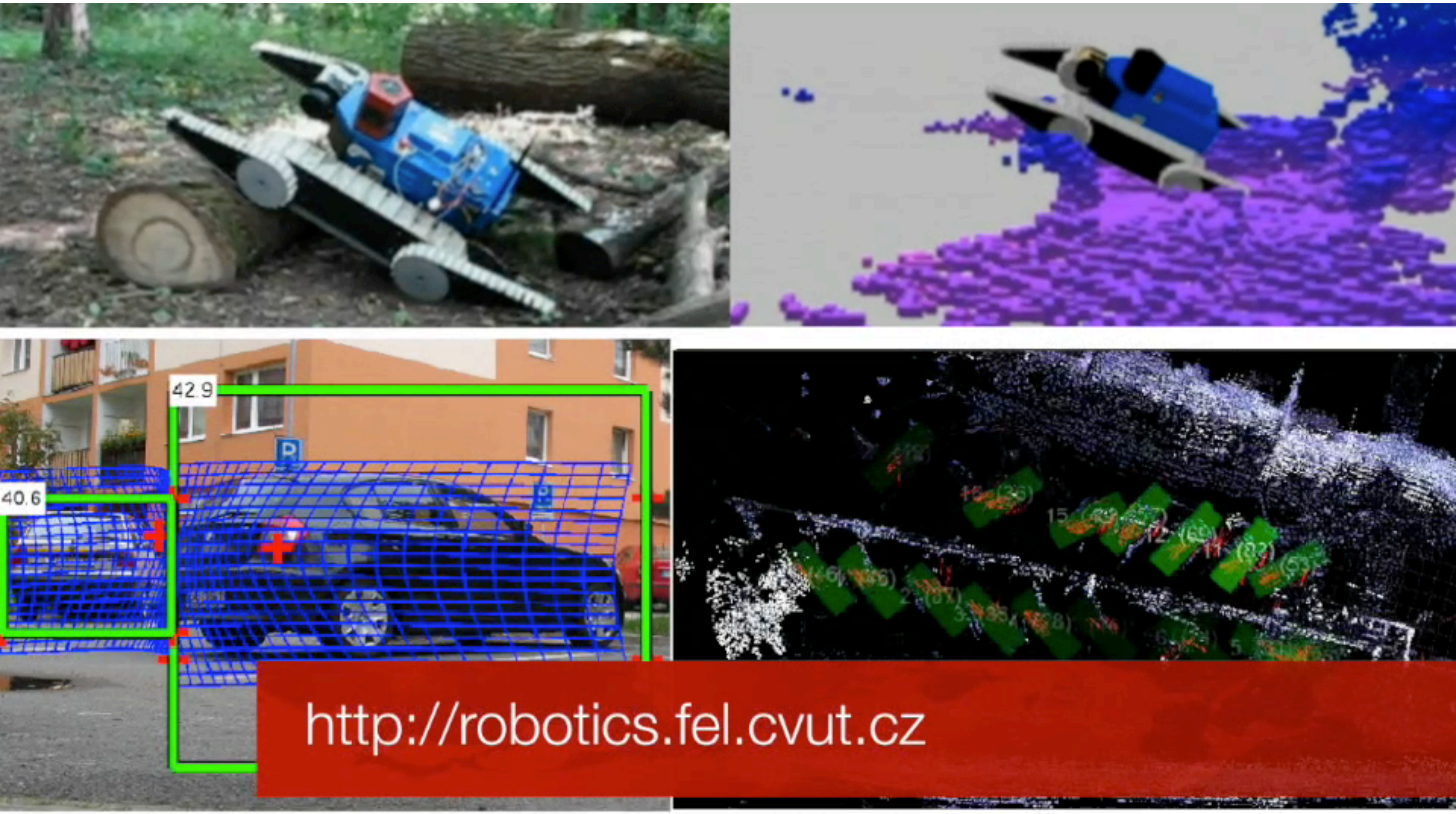


- our motivation from (intelligent) robotics
- yet basic concepts from cybernetics
- modern terminology will be used

problem: machine control in unstructured environment

2016 Amatrice (Italy) earthquake, deployment of the TRADR system, http://www.tradr-project.eu

(our) pictures of the game



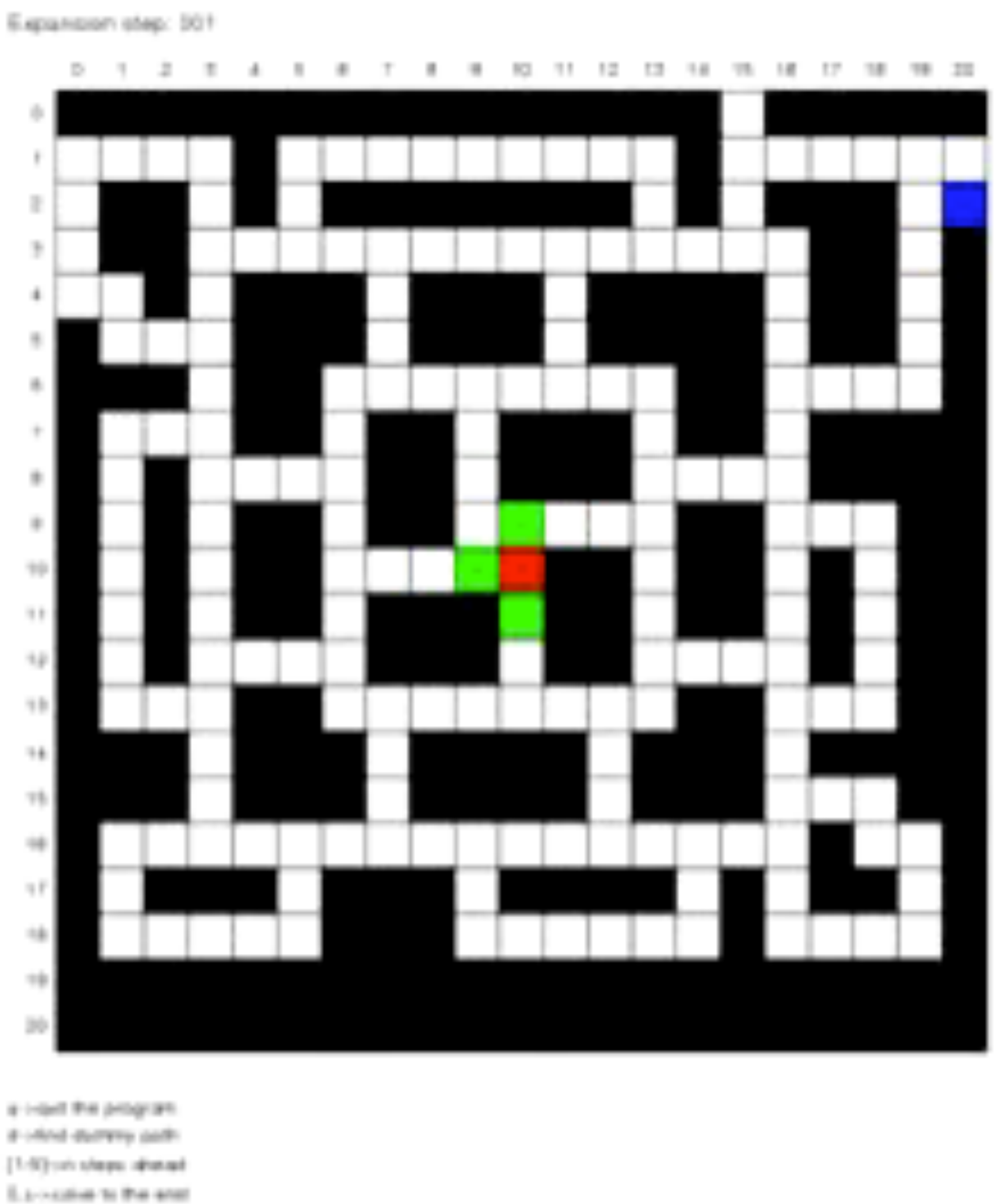
http://www.tradr-project.eu, http://www.nifti.eu, https://cyber.felk.cvut.cz/category/department/cmp/vras/

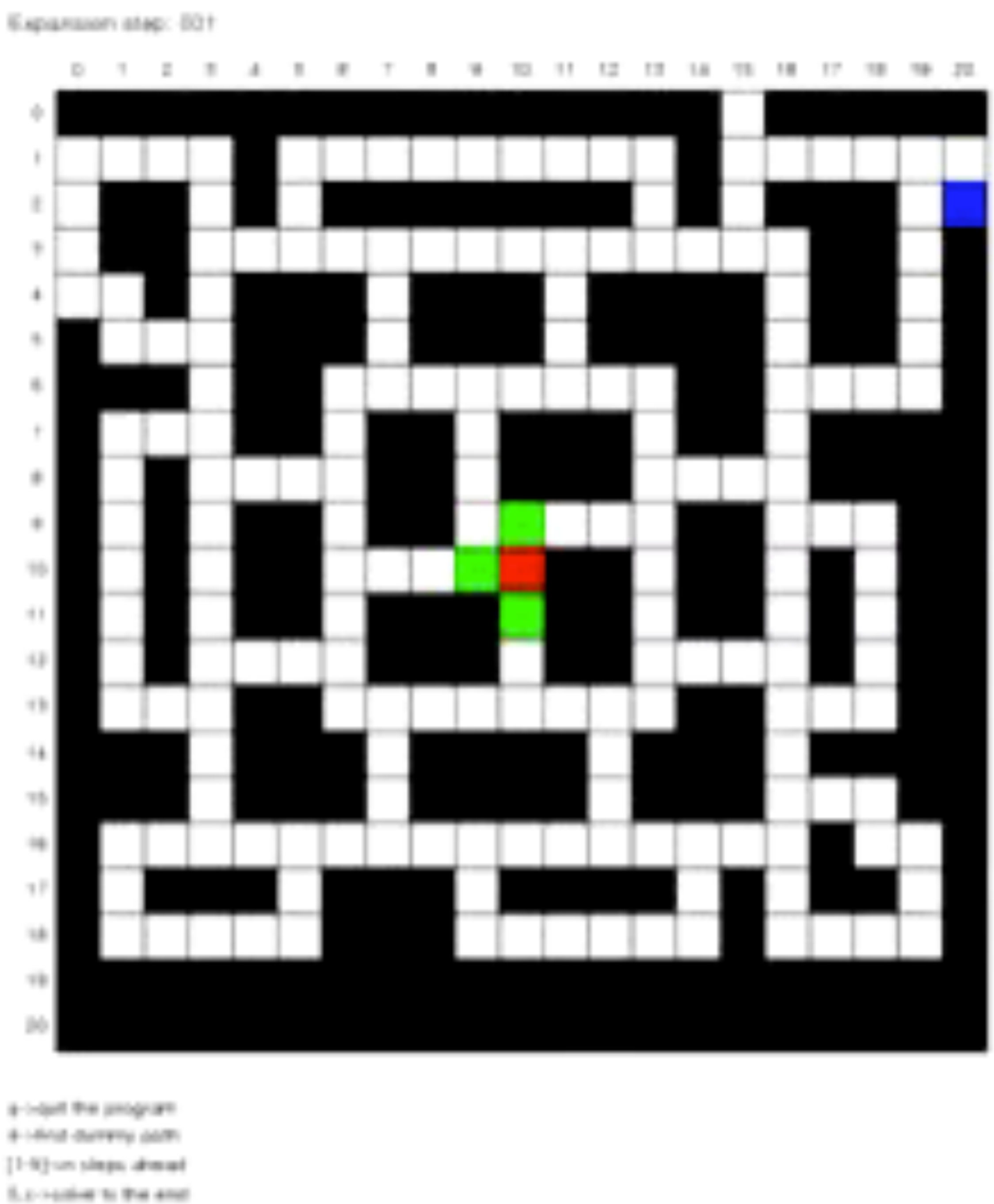
essentials - course content

- solving problems by search
- sequential decisions under uncertainty - how to search when actions are unreliable, but known
- reinforcement learning - learning from final successes and failures
- essentials from machine learning - bayesian decisions, classifiers, …

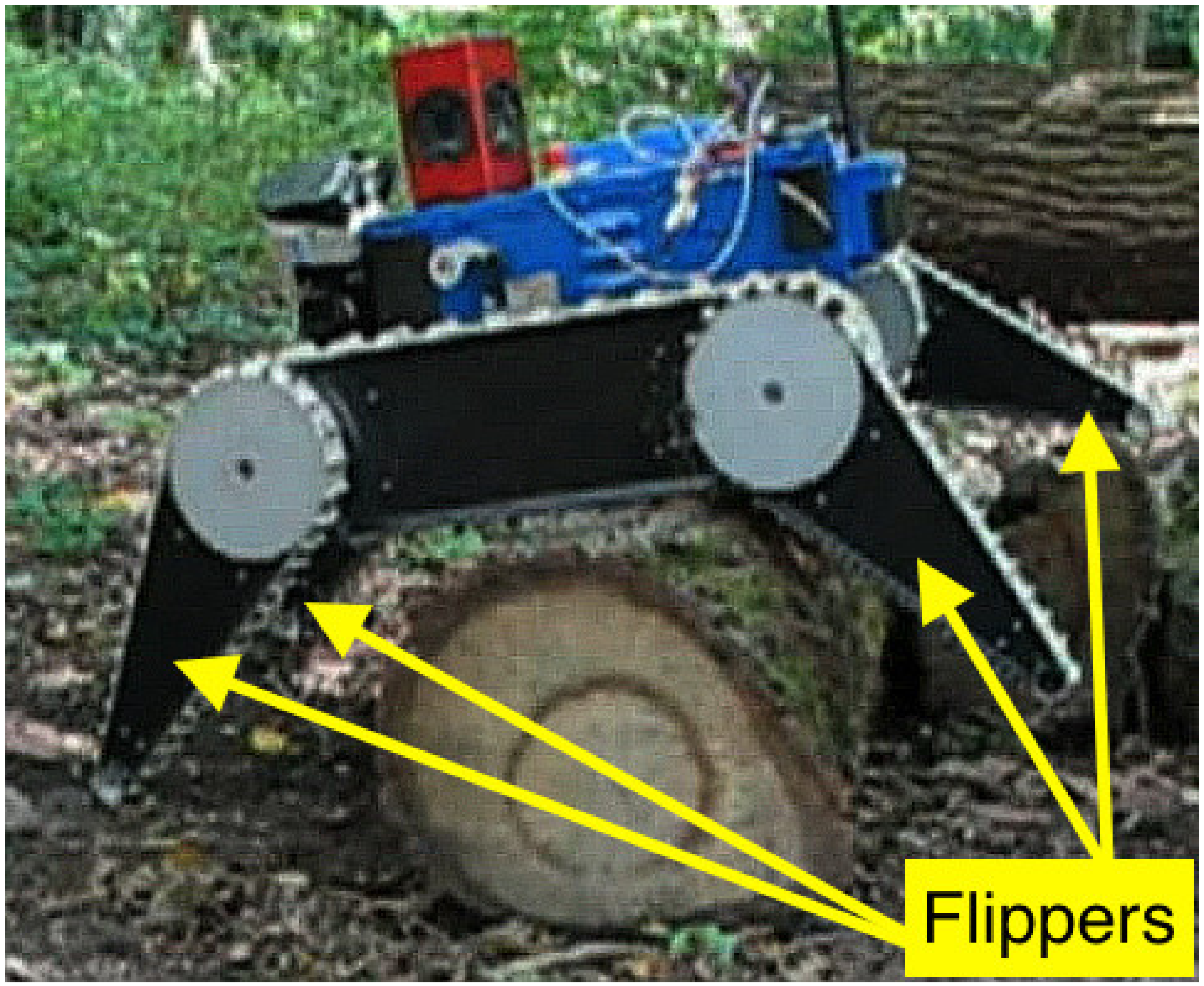
joint exploration and seegmentation

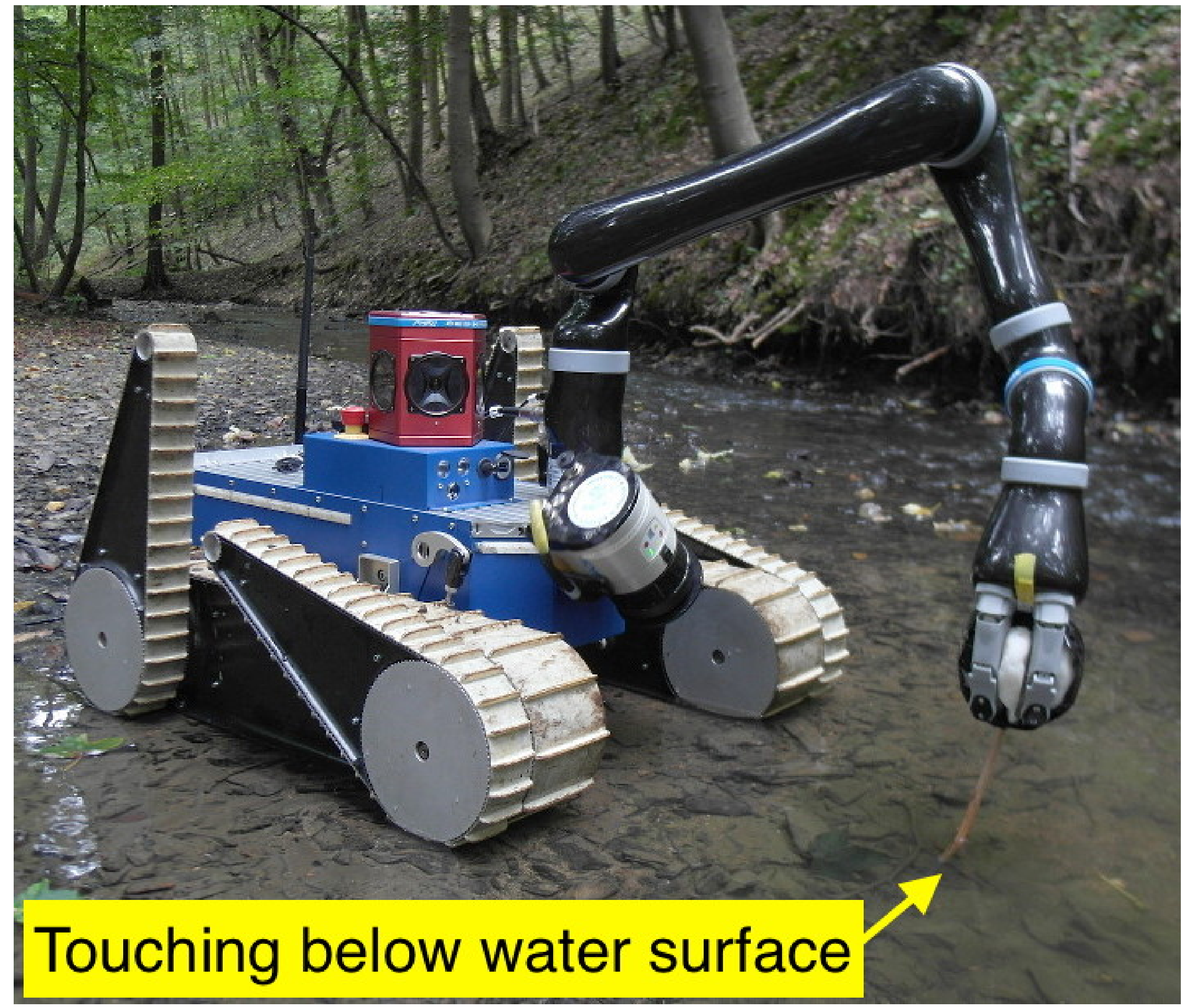
search, …, and beyond





(reinforcement) learning for the robot control

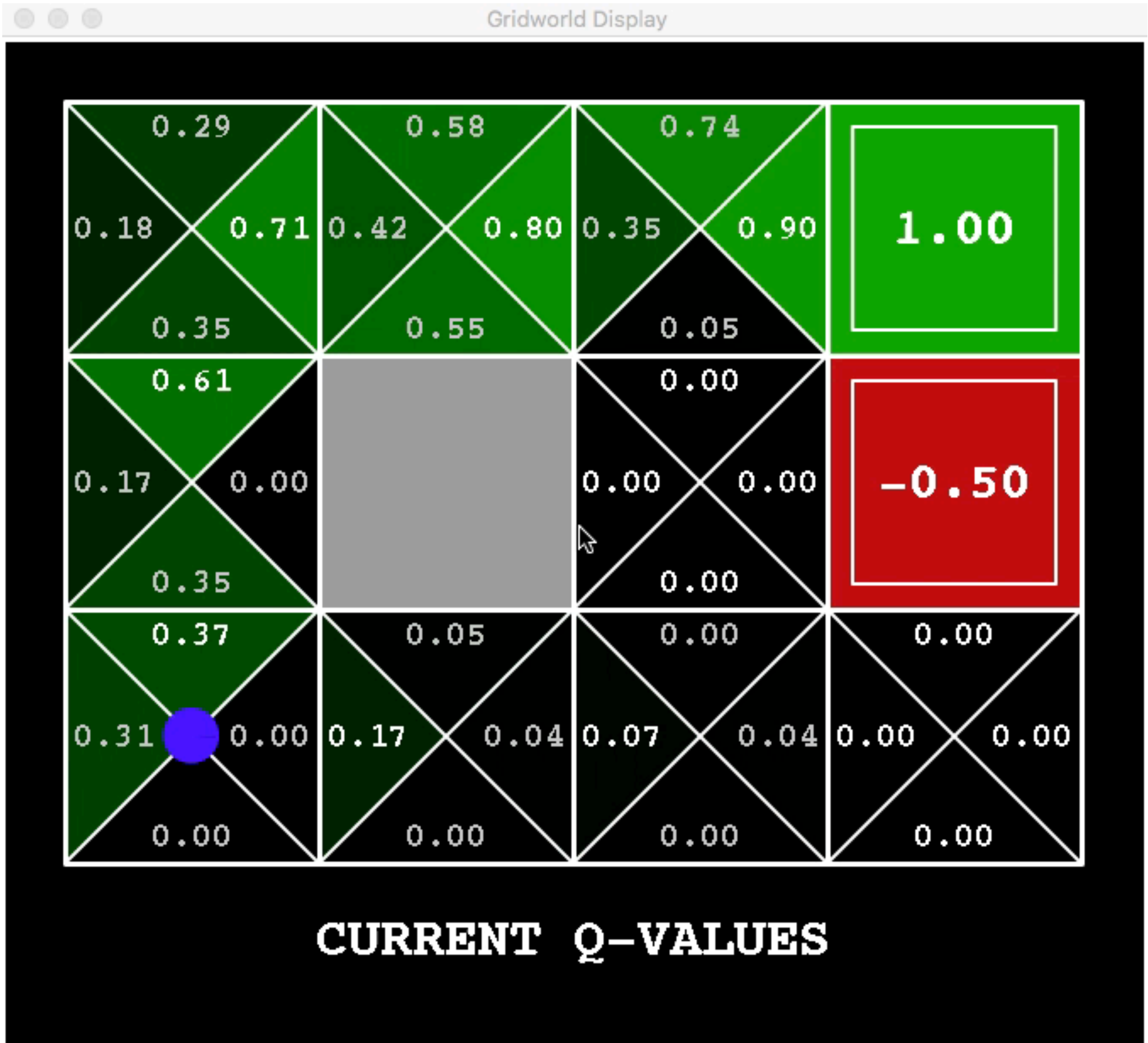




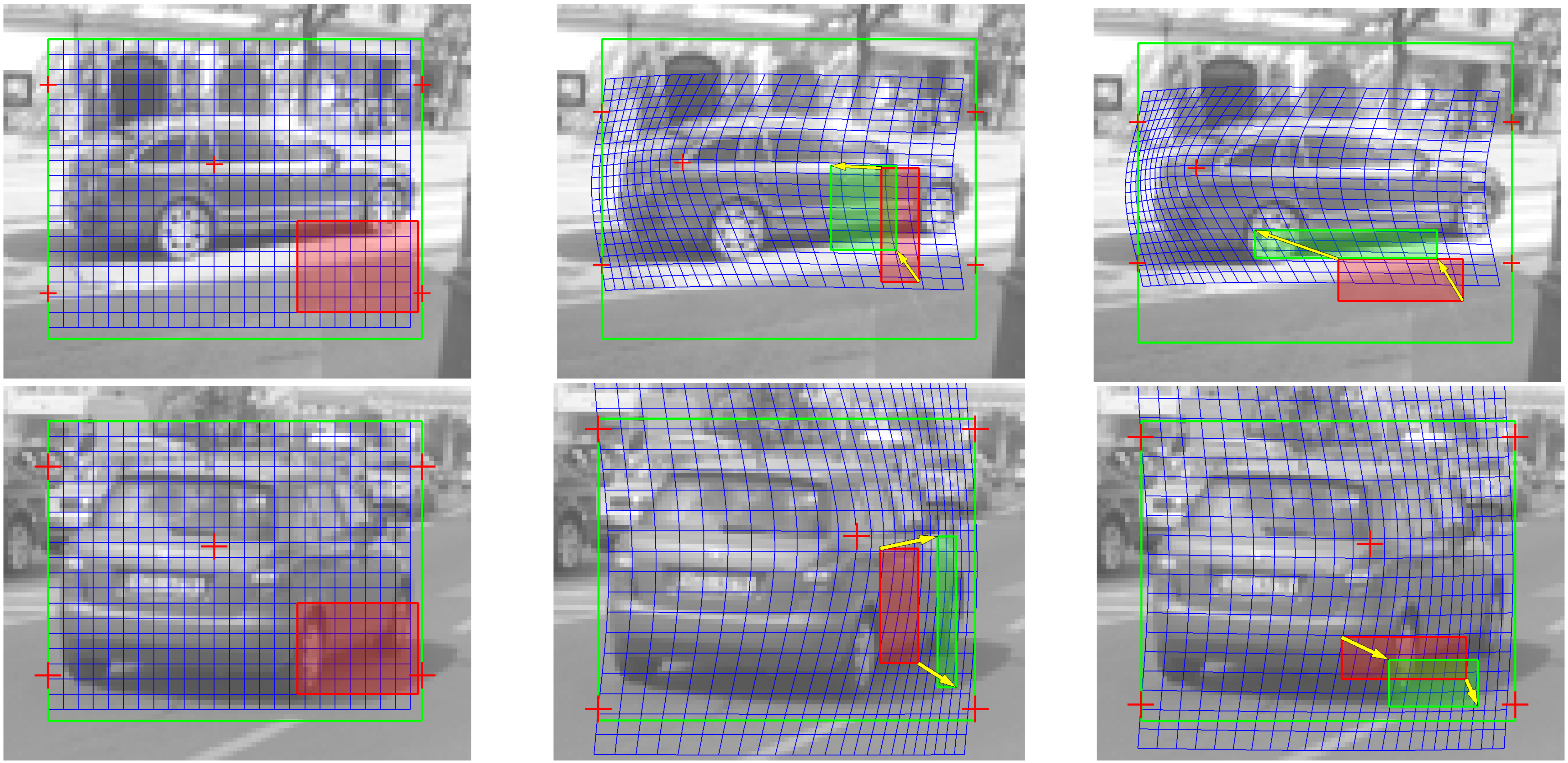
M. Pecka, K. Zimmermann, M. Reinstein, and T. Svoboda. Controlling Robot Morphology from Incomplete Measurements. In ***IEEE Transactions on Industrial Electronics***, Feb 2017, Vol 64, Issue: 2, pp. 1773-1782

V. Kubelka, L. Oswald, F. Pomerleau, F. Colas, T. Svoboda, and M. Reinstein. Robust data fusion of multi-modal sensory information for mobile robots. In ***Journal of Field Robotics***, June 2015, Vol 32, Issue: 4

reinforcement learing



object detection - deforming for better detection/recognition



K. Zimmermann, D. Hurych, T. Svoboda. Non-Rigid Object Detection with Local Interleaved Sequential Alignme

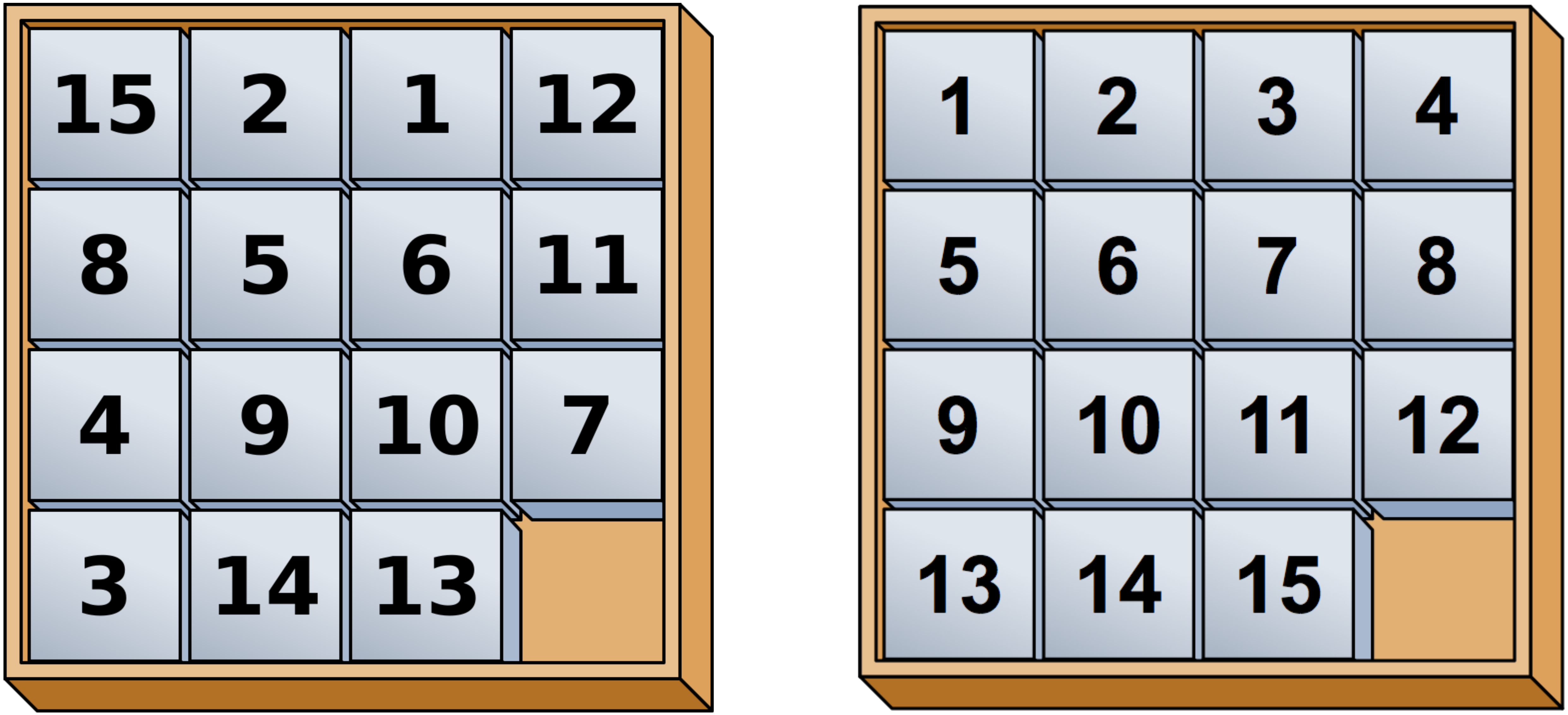
learning, clasification, …

x cm	XS (0–100)	S (100–125)	M (125–150)	L (150–175)	XL (175–200)	XXL (200-∞)	Σ
$P(x\|\text{male})$	0.05	0.15	0.2	0.25	0.3	0.05	**1**
$P(x\|\text{female})$	0.05	0.1	0.3	0.3	0.25	0.0	**1**

emphasis on problem solving

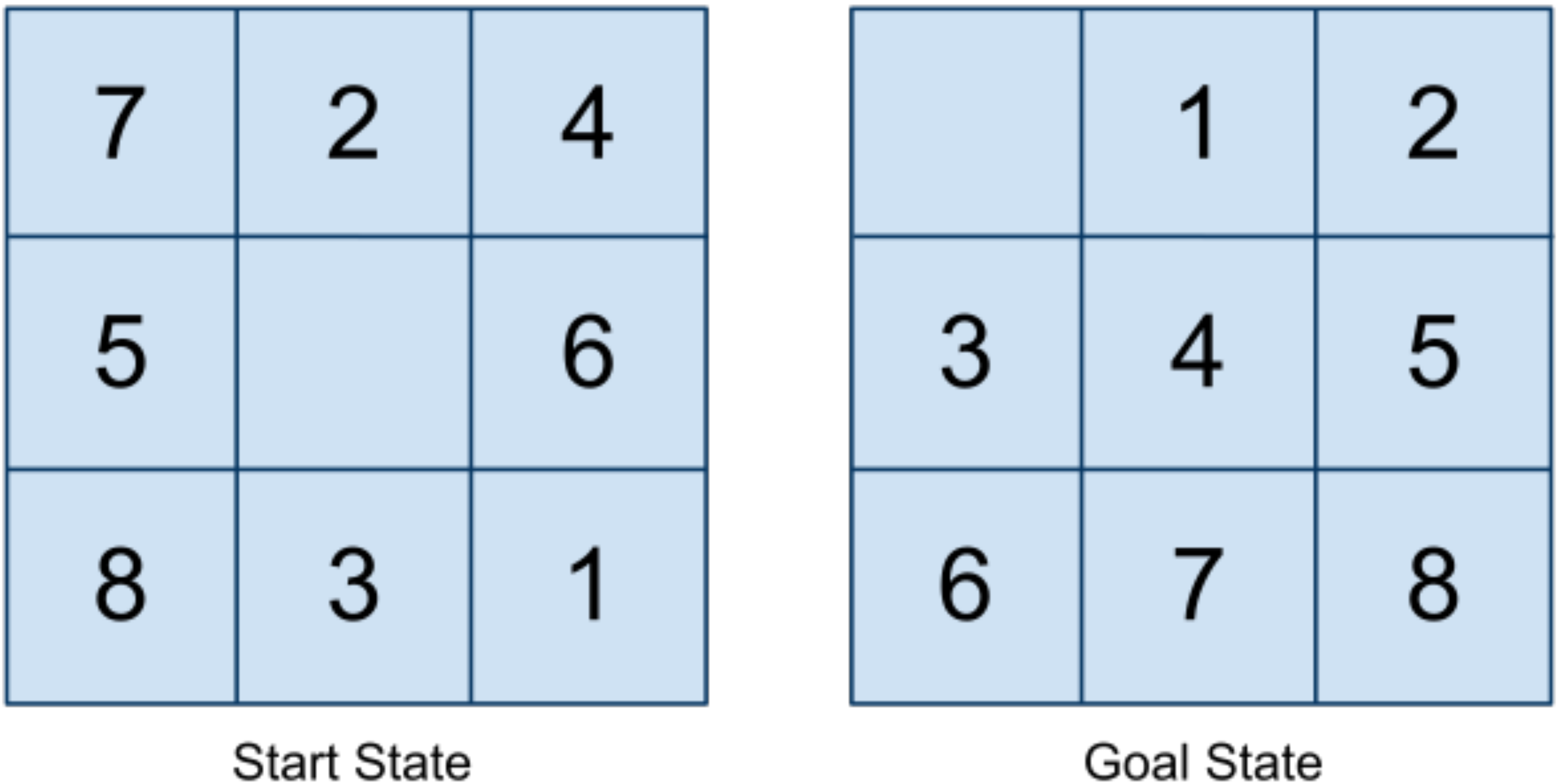
- (problem) analysis
- formalization
- solution - algorithm
- implementation/computation
- verification/testing

n-1 puzzle



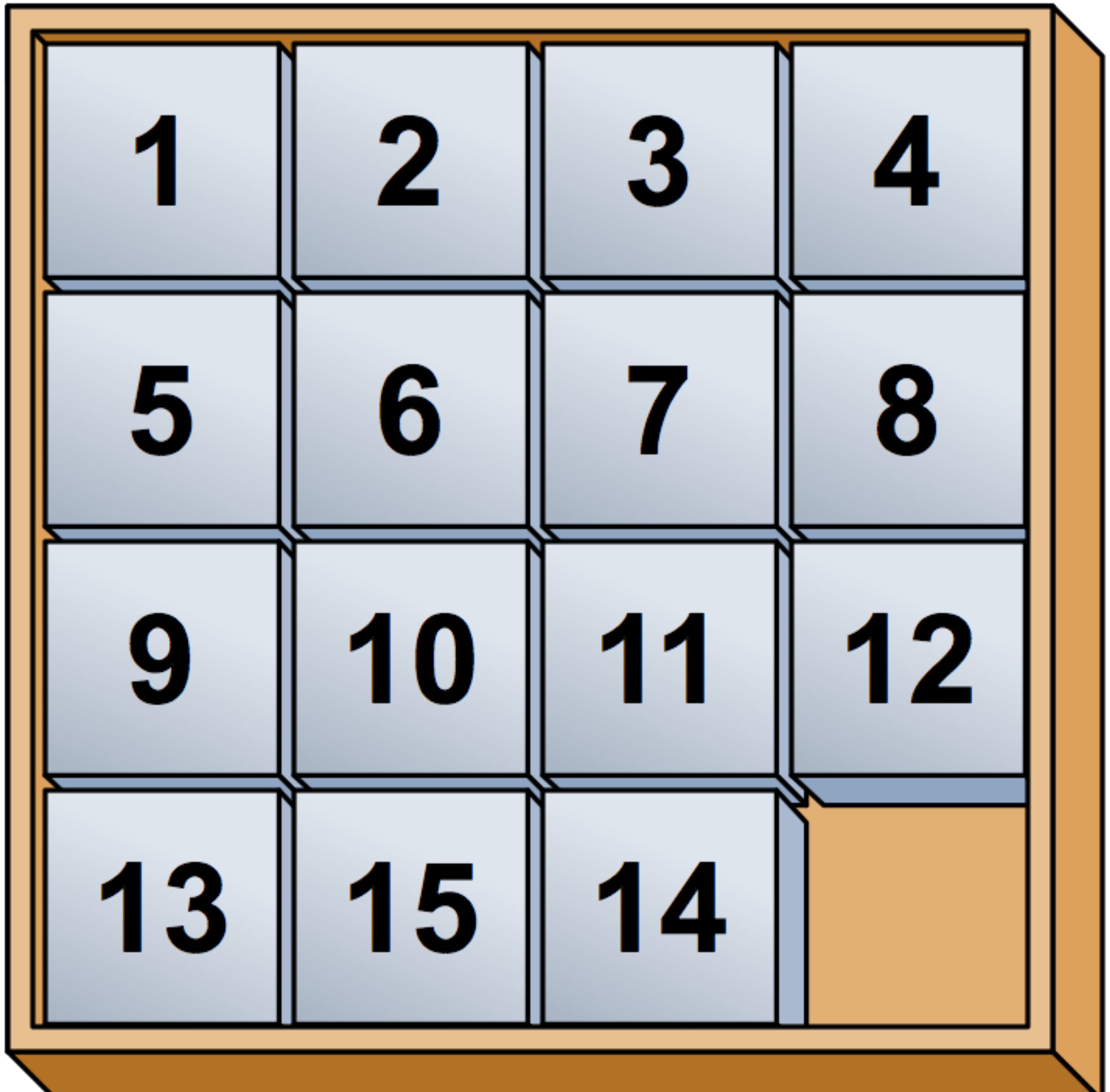
15-puzzle.svg:, Public Domain, https://commons.wikimedia.org/w/index.php?curid=28995093

8-puzzle



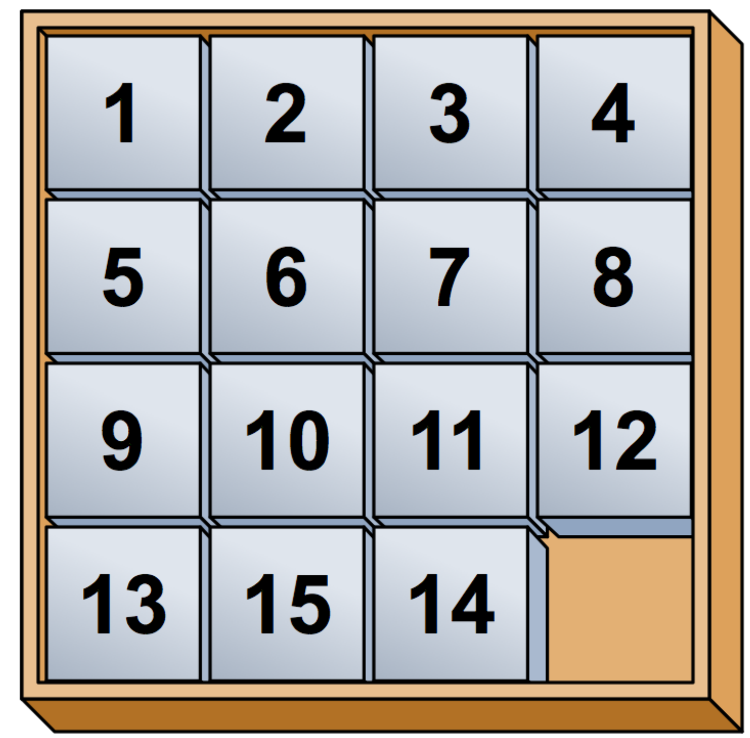
By Haiqiao - Own work, CC0, https://commons.wikimedia.org/w/index.php?curid=14665825

almost(?) there …



states

- What is the state?
- How many states?
- Are all states solvable?
- Can we decide before actually solving it?



inversions

12	1	10	2
7	11	4	14
5		9	15
8	13	6	3

fig 4

12	1	10	2	7	11	4	14	5		9	15	8	13	6	3

fig 5:
Tiles written in a row

inversion is when a tile precedes another tile with a low number

images from: Mark Ryan. Solvability of the Tiles Game

number of inversions during the search
odd size

7	1	2
5		9
8	3	6

11 inversions

goes to

7	1	2
5	3	9
8		6

9 inversions

- moving *left or right* does not change #inversions
- moving *up or down* does (passes even number of tiles)

parity of inversions (whether is odd or even) is an *invariant*

When is a state solvable?

invariant for the even sized tile

12	1	10	2
7	11	4	14
5		9	15
8	13	6	3

49 inversions
blank on even row from bot

goes to

12	1	10	2
7		4	14
5	11	9	15
8	13	6	3

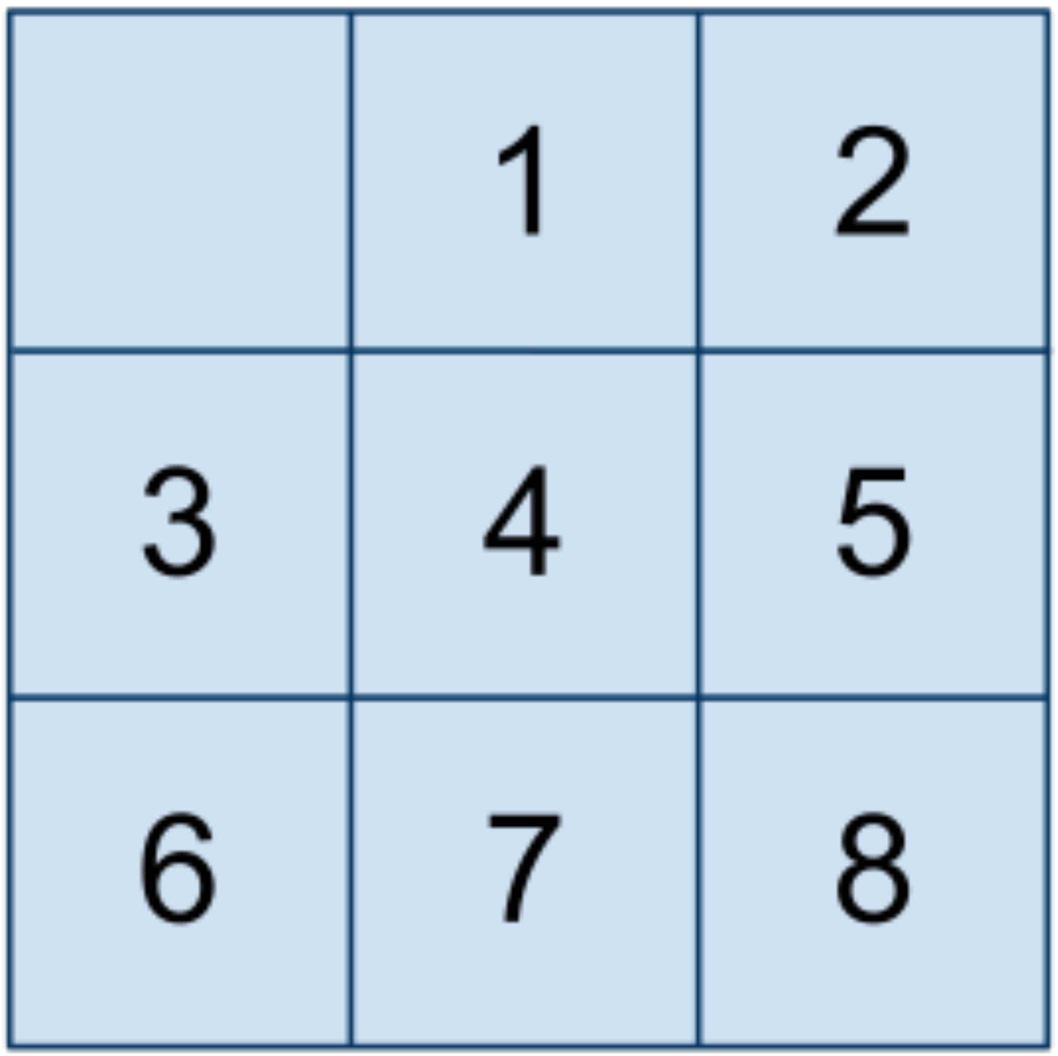
48 inversions
blank on odd row from bot

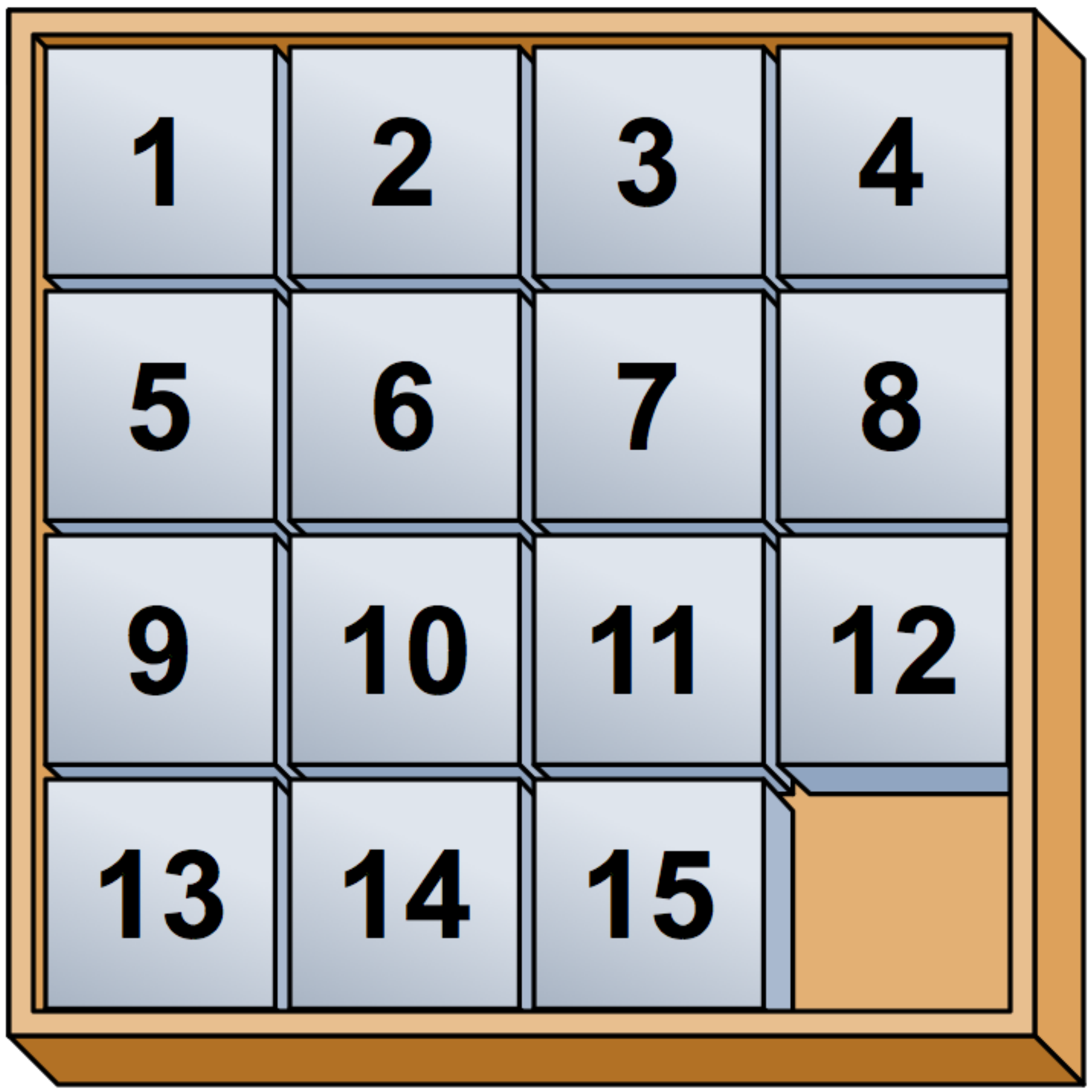
Moving a tile up or down:

- Passes an odd number of other tiles
- The row parity of the blank also changes (from odd to even, or from even to odd)

```
(#inversions even)==(blank on odd row from the bottom)
```

final states:





every solvable state

- If the width is odd, then every solvable state has an even number of inversions.

- If the width is even, then every solvable state has
  - an even number of inversions if the blank is on an odd numbered row counting from the bottom;
  - an odd number of inversions if the blank is on an even numbered row counting from the bottom;