Example 2: Learning Behaviors

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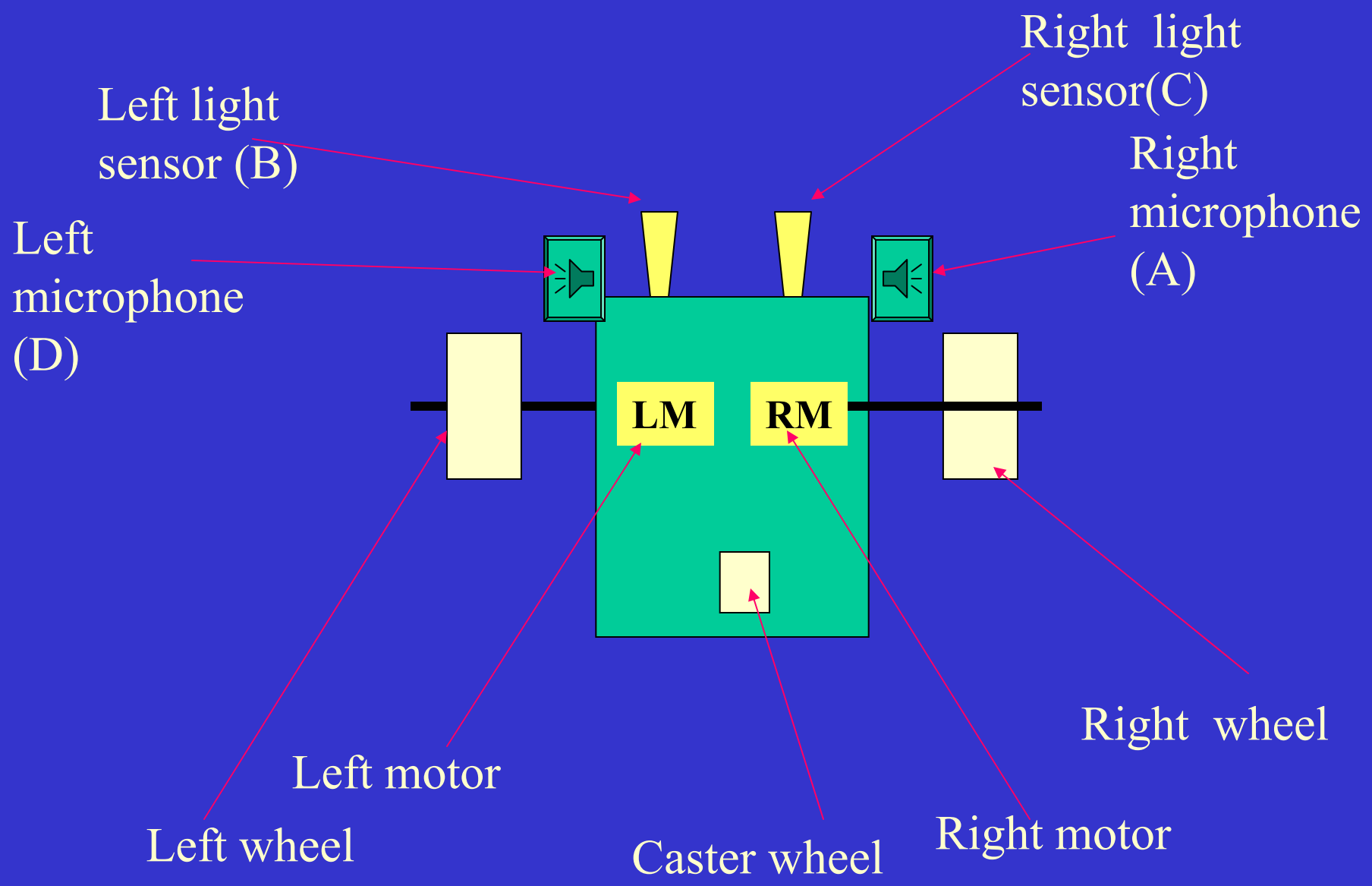


The following seven examples are given by a child as a correct robot behavior

Robot turns right away from light in left

Robot turns left, away from light in right, towards sound in left

Robot goes forward with equal front lighting and no sound

AB \ CD	00	01	11	10
00	-	-	10	-
01	01	00	10	11
11	-	—	00	-
10	-	00	-	-

A - right microphone

B - left light sensor

C - right light sensor

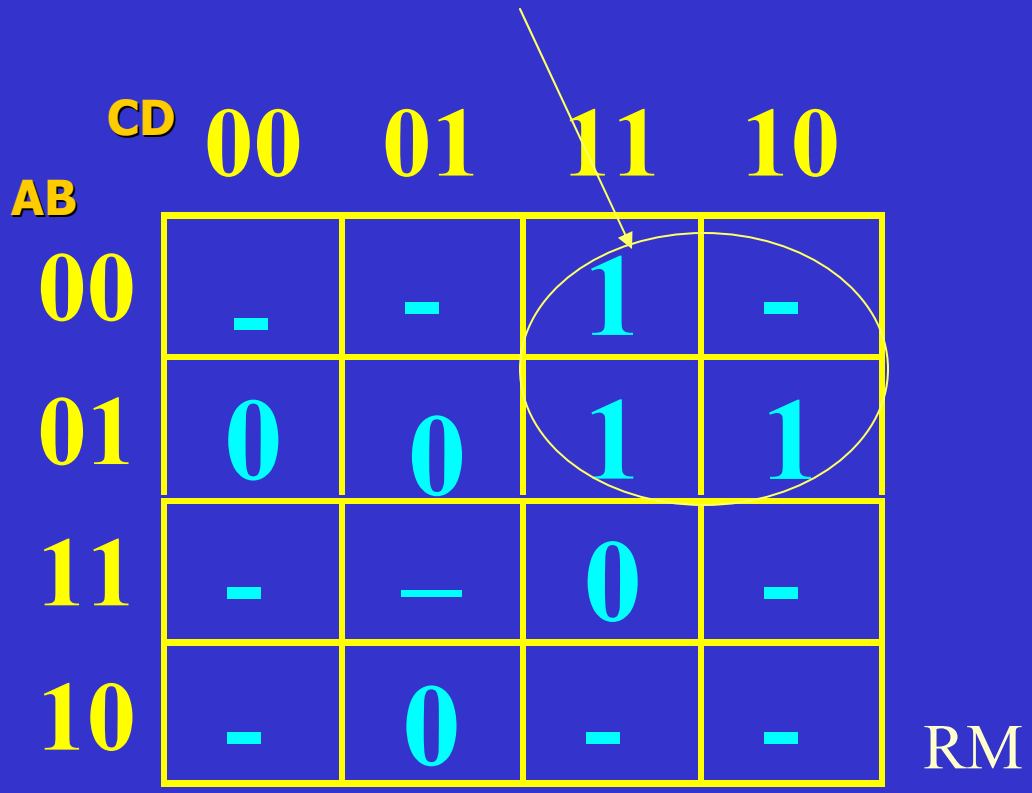
D - left microphone

Robot does not move

RM, LM

Karnaugh Map for Right Motor is the same as for recognition of nice faces in Example 1

Right motor is on when there is light in right and no sound in right



A - right microphone

B - left light sensor

C - right light sensor

D - left microphone

Karnaugh Map for Left Motor is not the same.

We can adjust tables to adjust (learn, evolve) behaviors.

Robot turns right away from light in left

Robot turns left, away from light in right, towards sound in left

Robot goes forward with equal front lighting and no sound

A - right microphone

B - left light sensor

C - right light sensor

D - left microphone

AB \ CD	00	01	11	10
00	-	-	10	-
01	01	00	10	11
11	-	—	00	-
10	-	00	-	-

Robot does not move

RM, LM

A: 0=what, 1=where, B: 0=wrote, 1=is, C: 0=book, 1=room

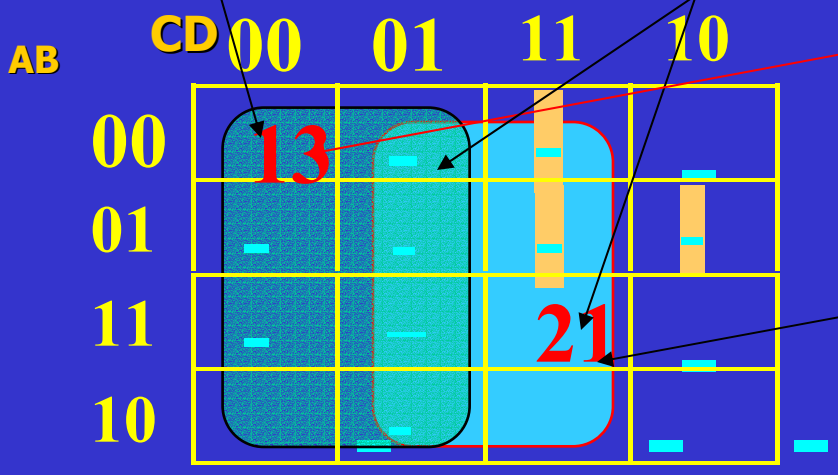
D: 0=Smith, 1=Lee

0000=what wrote book Smith?

0111=what is room Lee?

1111=where is room Lee?

0001: What wrote book Lee?



Answer 13=Smith wrote book Automata Theory

Answer 21=Lee is in room 332

Logic Decomposition for Machine Learning

- Better than Neural Nets and other Logic Based approaches
- Occam's Razor Learning
- Generalization
- Role of Error

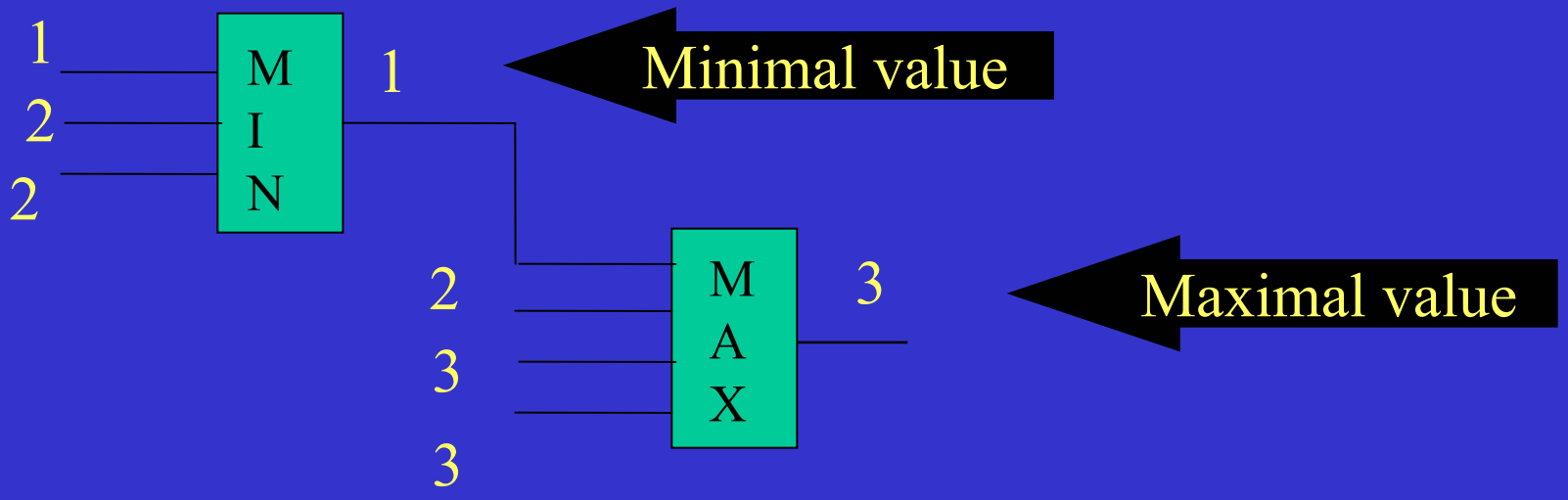
Short Introduction: multiple-valued logic

Signals can have values from some set, for instance {0,1,2}, or {0,1,2,3}

{0,1} - binary logic (a special case)

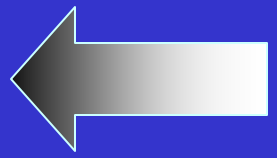
{0,1,2} - ***a ternary logic***

{0,1,2,3} ***- a quaternary logic,*** **etc**



Types of Logical Synthesis

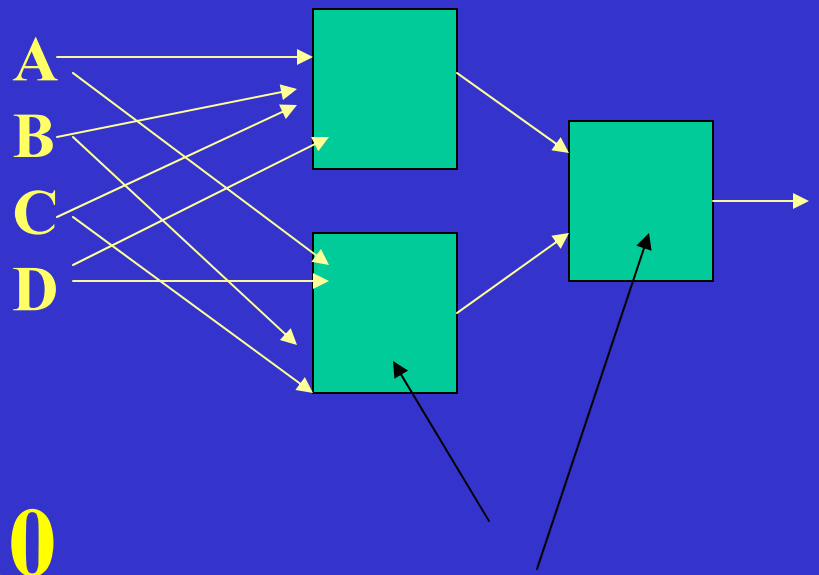
- Neural Nets
- Sum of Products
- Decision Diagrams
- Functional Decomposition



The method we are using

So what about Neural Nets?

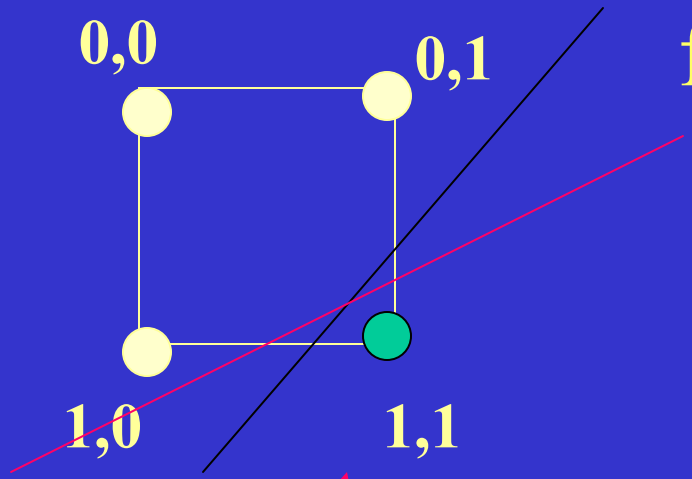
There is a very small chance that out of all hypersurfaces separating ones from zeros the one will be found that corresponds to the simplest Boolean function



Artificial neurons

AB \ CD	00	01	11	10
00	-	-	1	0
01	0	0	1	0
11	1	1	0	1
10	-	0	1	-

Why Neural Nets lead to overfitting and it is hard translate the learned network to a boolean function?

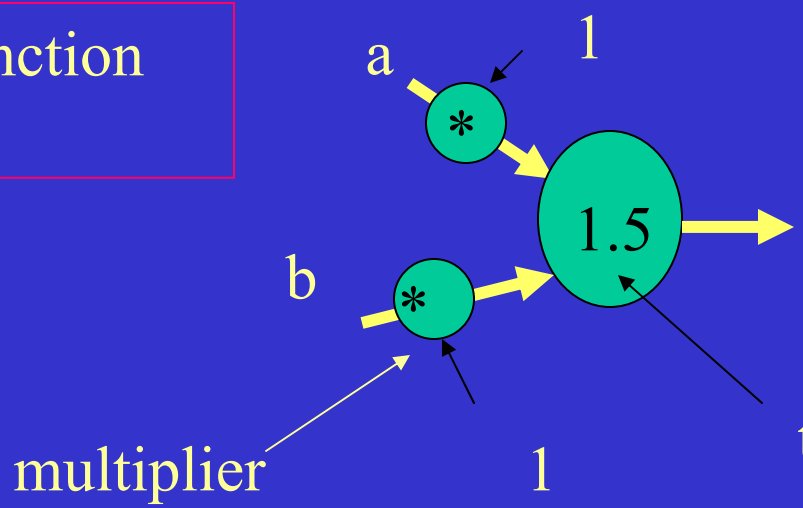


This is function AND

We have practically infinite number of lines separating node (1,1) from other nodes.

For every variable we need a multiplier, we need also an arithmetic adder and comparator.

Such a waste!!



Concluding on current machine learning methods

- DNF, Neural Nets and Decision Trees, Decision Diagrams have their advantages and disadvantages
- Good method should not assume type of gates.
- Should be fast
- Should be easily retrainable by user.
- All programming should be in natural language.

Pros and cons

- In generating the final combinational network, BDD decomposition, based on multiplexers, and SOP decomposition, trade flexibility in circuit topology for time efficiency
- Generalized functional decomposition sacrifices speed for a higher likelihood of minimizing the complexity of the final network
- Occam's Razor Learning
- Generalization
- Role of Error

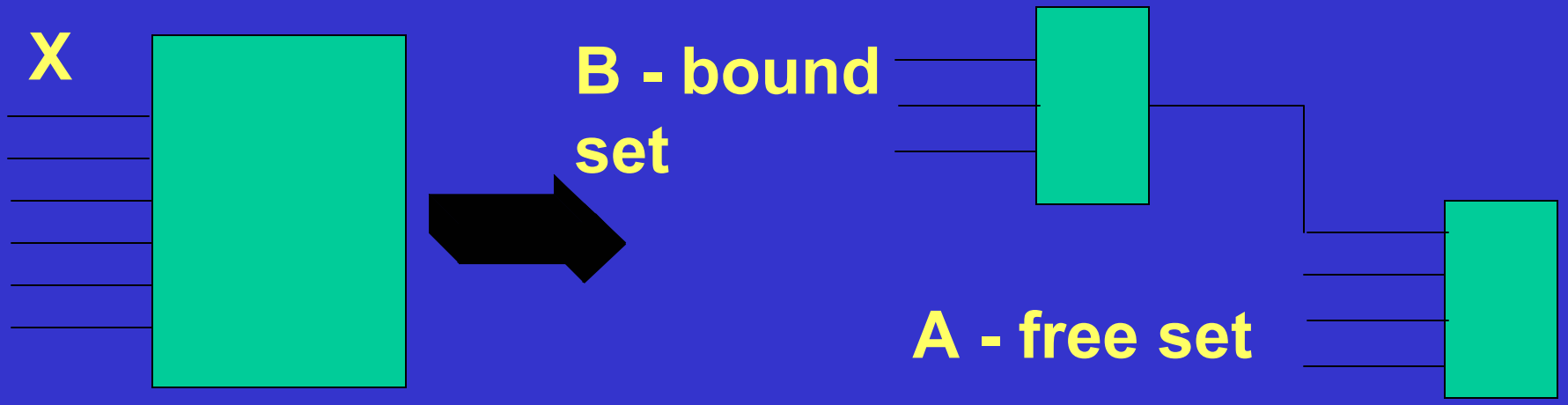
Functional Decomposition

Evaluates the data function and attempts to decompose into simpler functions.

$$F(X) = H(G(B), A), \quad X = A \cup B$$

if $A \cap B = \varnothing$, it is *disjoint decomposition*

if $A \cap B \neq \varnothing$, it is *non-disjoint decomposition*



Applying this decomposition twice, we will get the AB EXOR CD circuit shown earlier.

But this would work only selecting good free and bound sets twice.

Open Research Areas

- Dialog of a human and a robot
- Dialog of two robots, for instance one a supporter of robot soccer team Tigers and another supporter of robot soccer team Lions.
- Axiomatic and Inductive Robot Morality.
- Languages to control facial gestures and emotional behaviors.
- Natural language subsets
- Theory of acting, theatre dialog and puppet animation skills (Stanislawski, Brooks, Grotowski, robot theatre research from Stanford and CMU).
- Emotional robot face design
- Educational software and toy design

Open Research Areas

- Research in all these areas is not well developed and so far nobody ever tried to unify them into a single discipline
- People who work on these subjects work in:
  - Design Schools
  - Performing Arts
  - Arts
  - Psychology
  - Electrical Engineering
  - Mechanical Engineering
  - Hollywood and movie industry
  - Entertainment parks and Halloween industry
  - Computer Science
  - Computer Aided Education and Computer Aided Language Instruction

The End