Application in Quantum Computing: Analog Memory

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Agenda

- Introduction
- Memory Concept
- Analog Memory
- Application: Modeling Human Memory
- Future Direction
- Conclusion

Introduction

- **The new concept of quantum computers introduces new research questions:**

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  - **How do we take advantage of its new capabilities?**

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  - **developing applications in quantum computing seems to be useless with the uncertainty of a concrete design of a quantum computer**

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  - contribute to the design of a quantum computer
  - provide practical application that can be used with today's digital computers
  - **serve as a bridge for transitioning from today's computing environment to tomorrow's quantum world**

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  - **procedure to retrieve appropriate data when needed**

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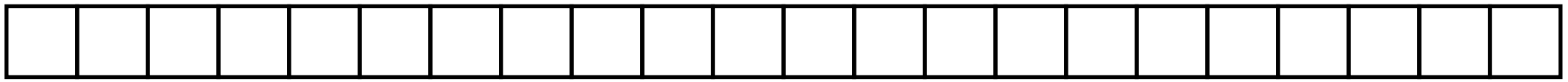

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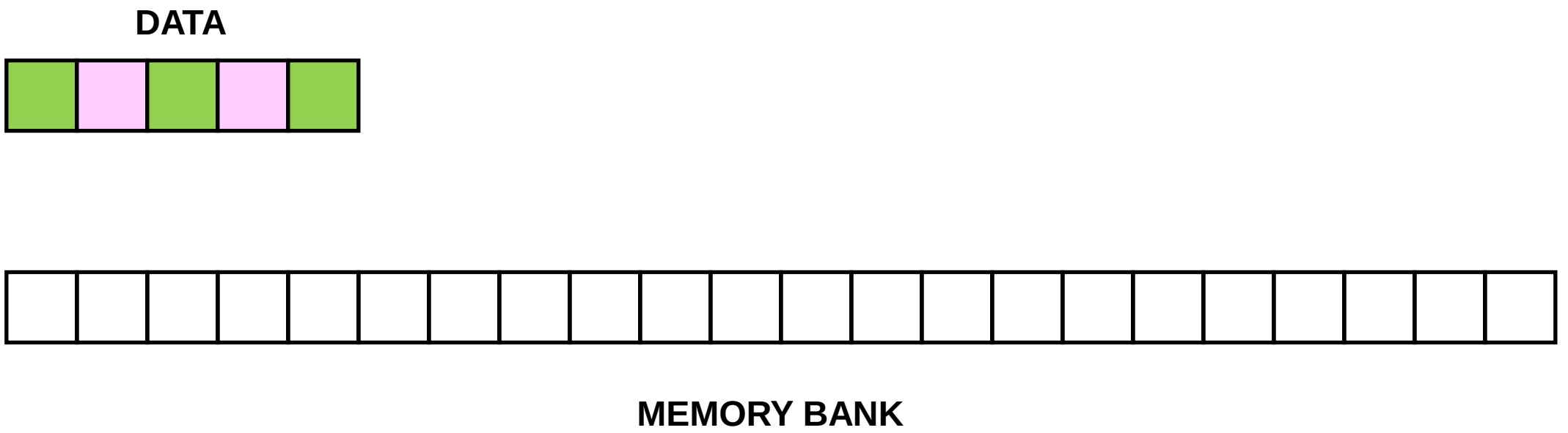

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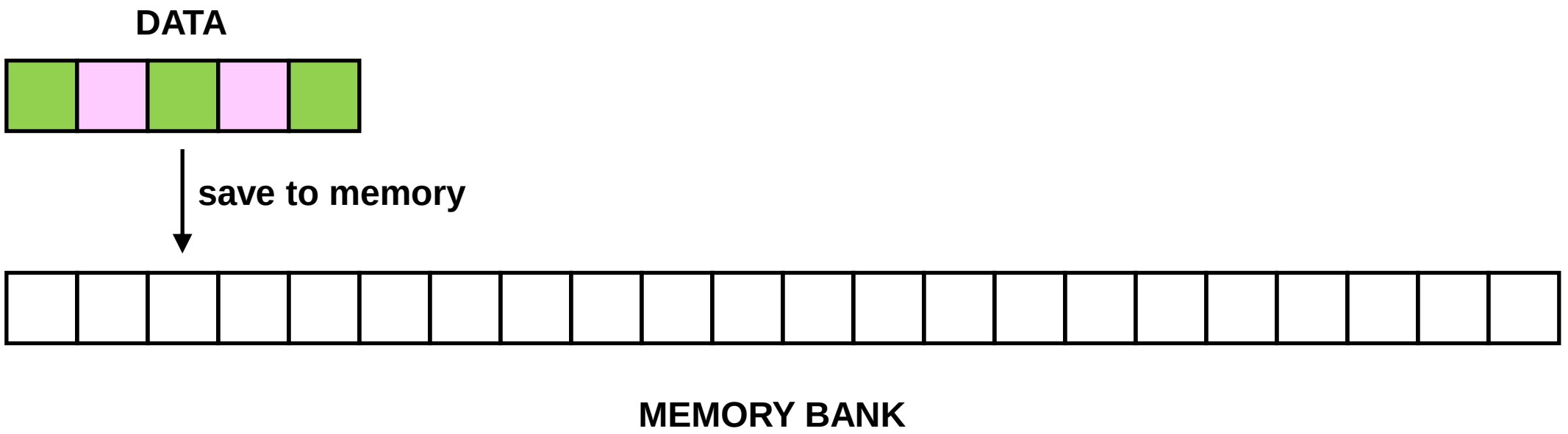

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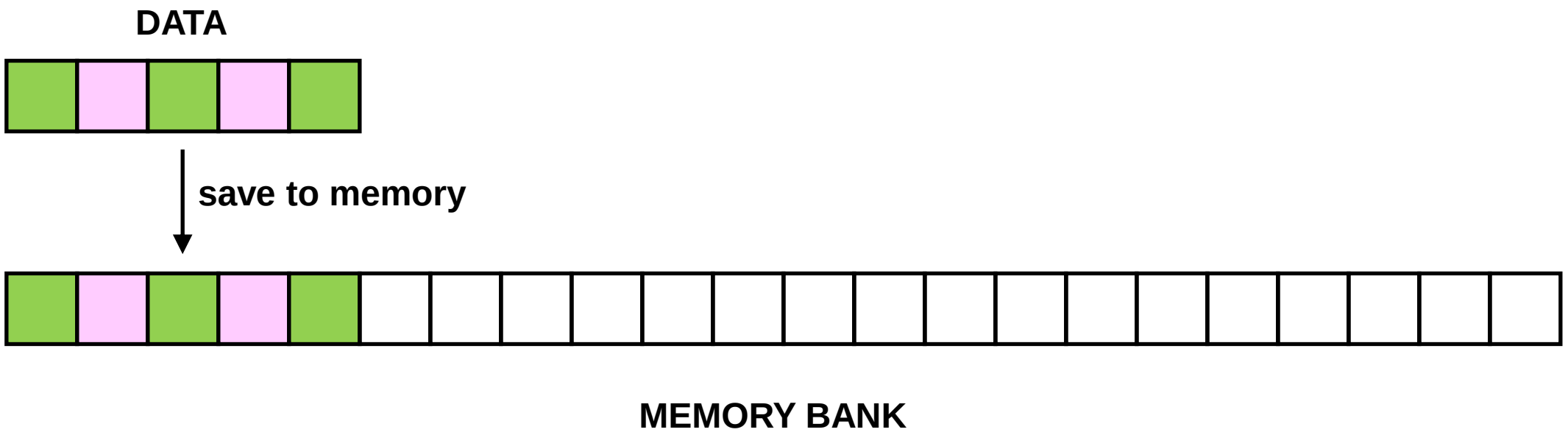

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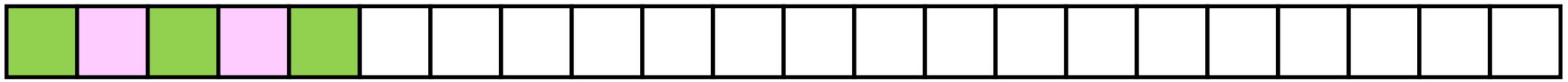

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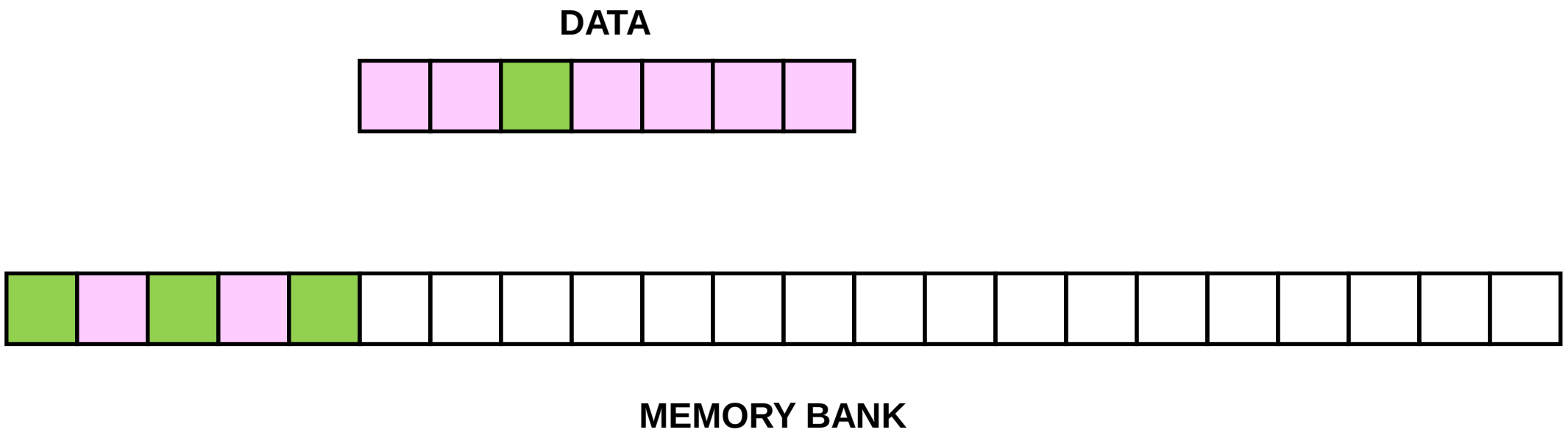

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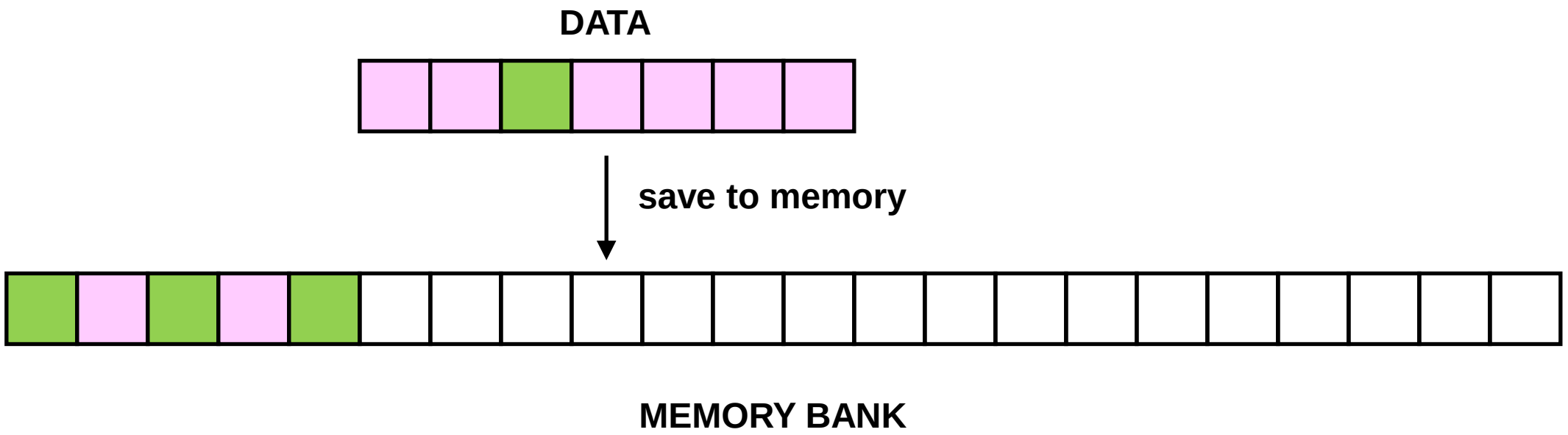

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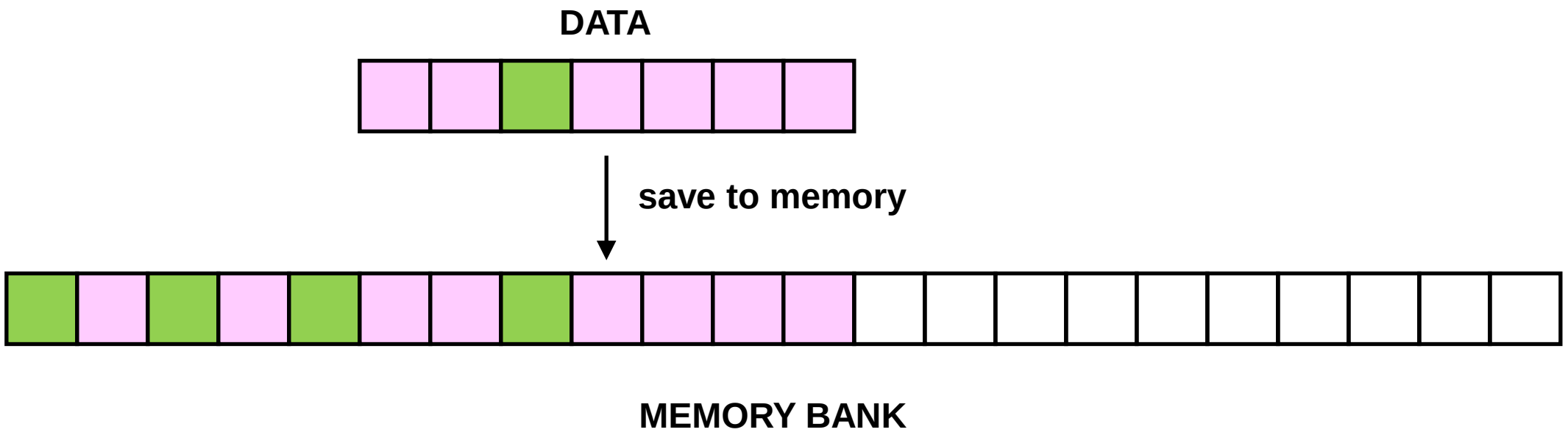

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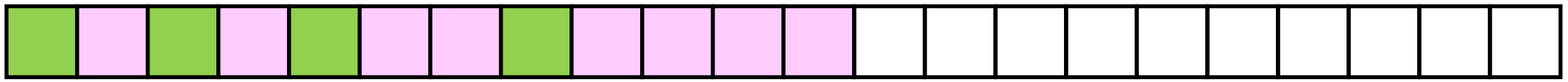

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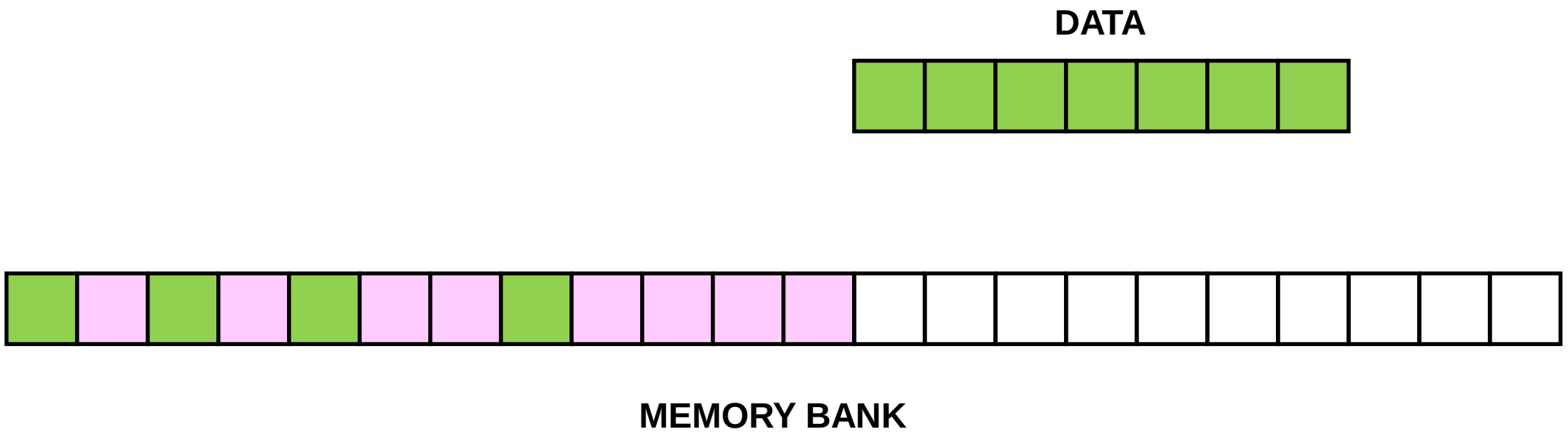

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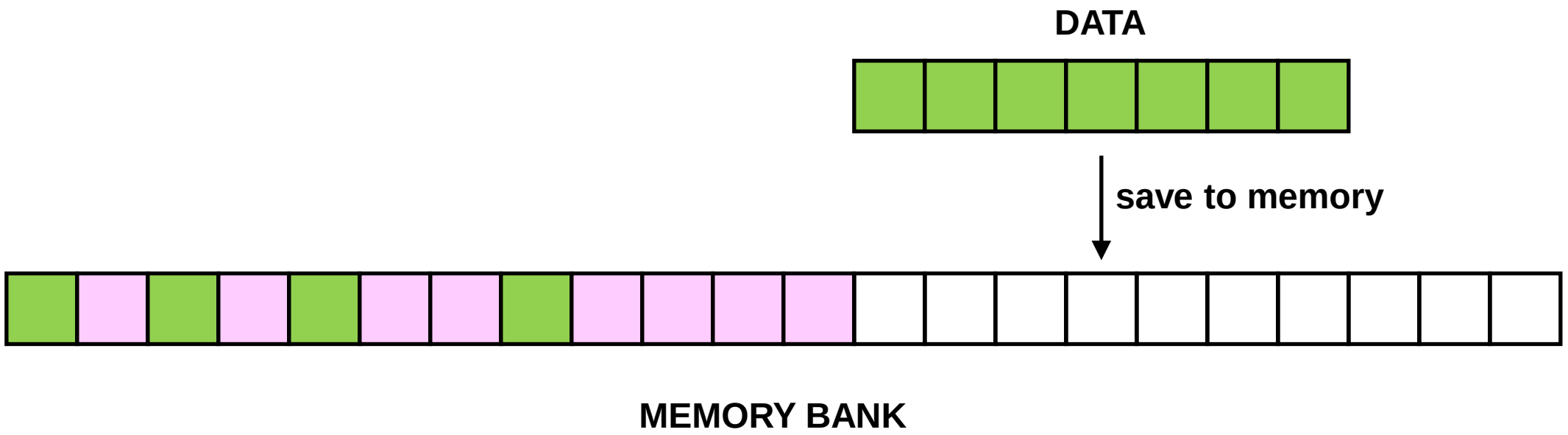

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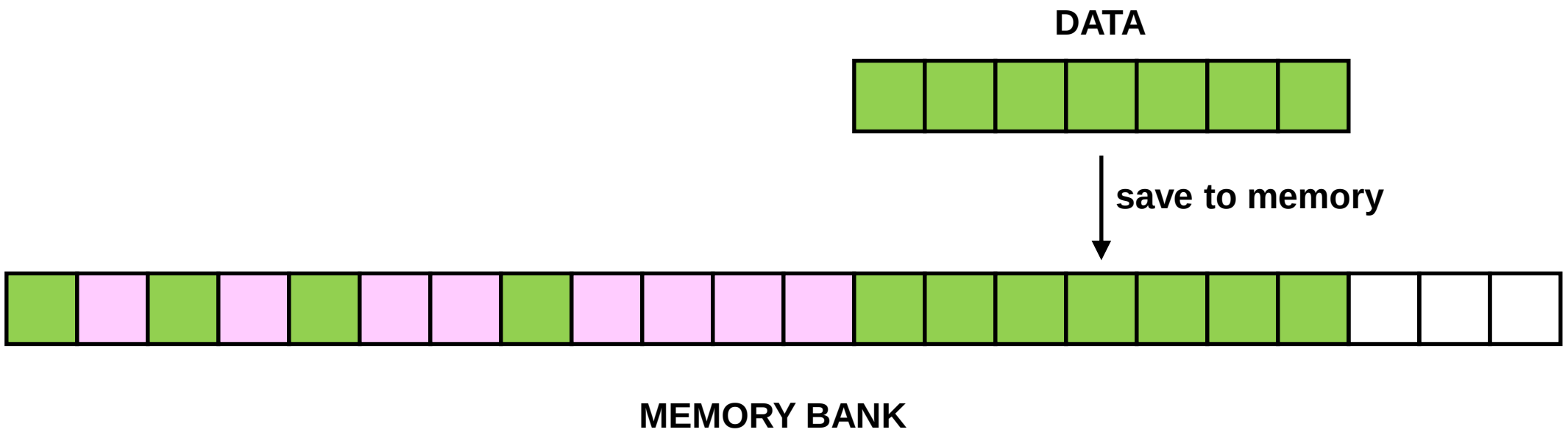

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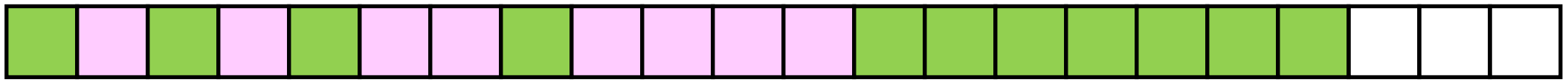

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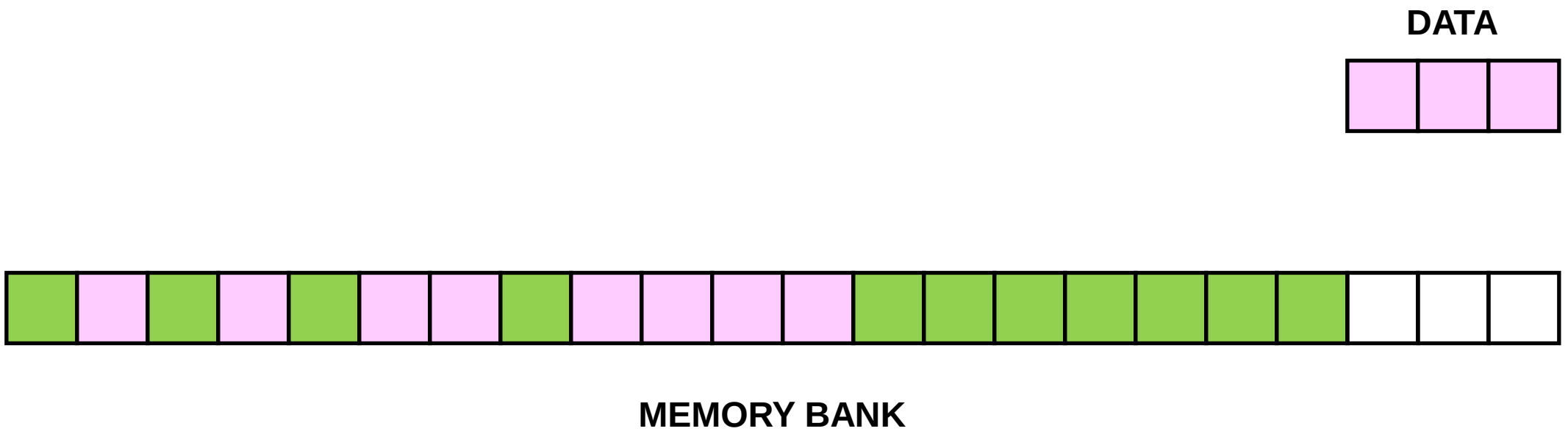

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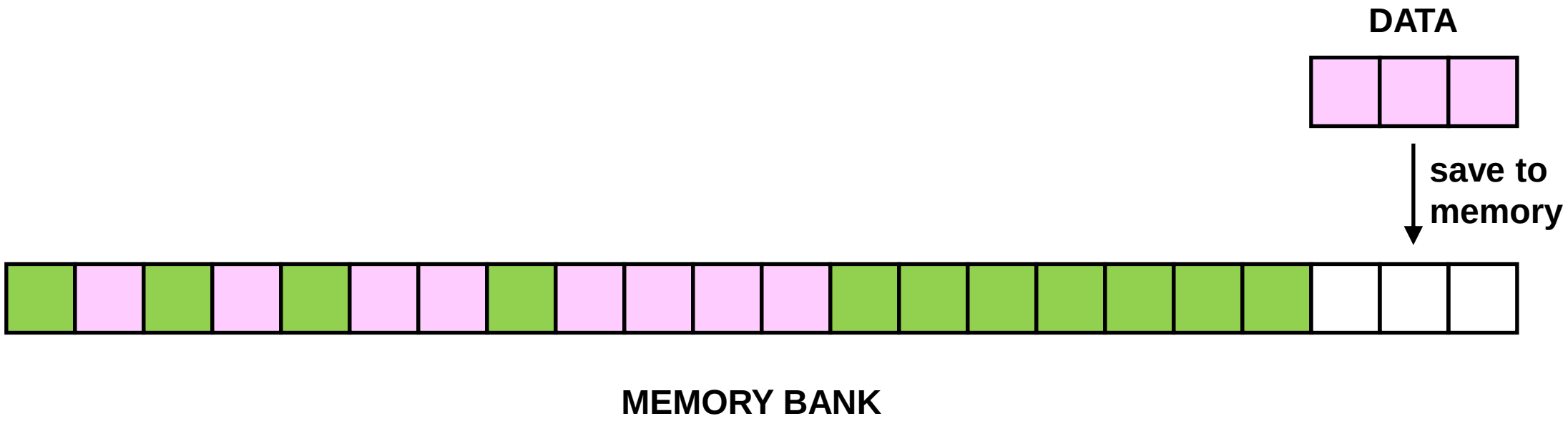

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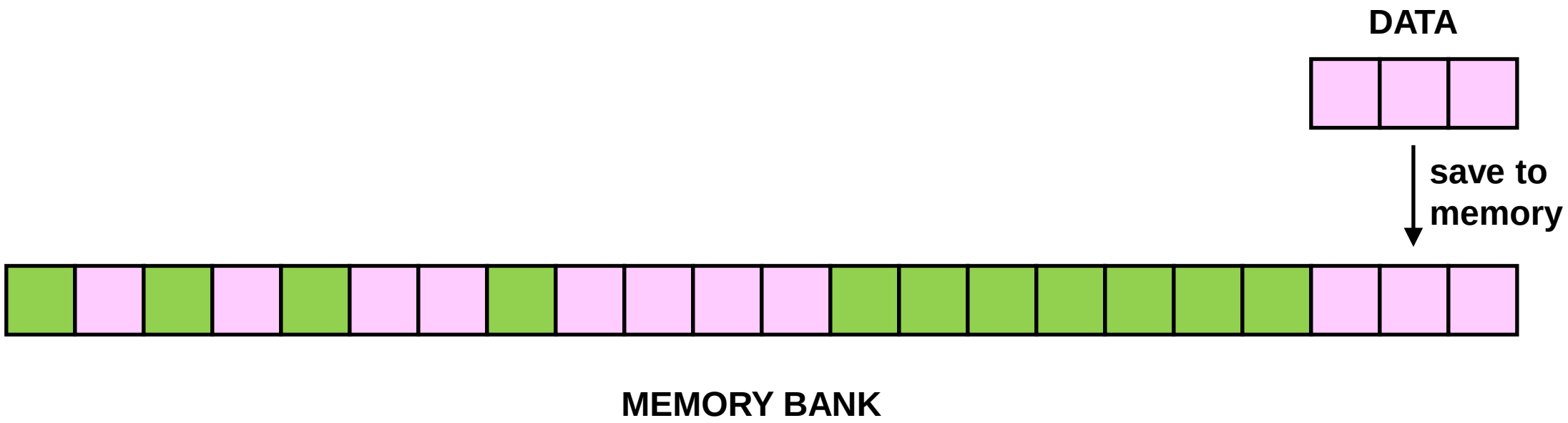

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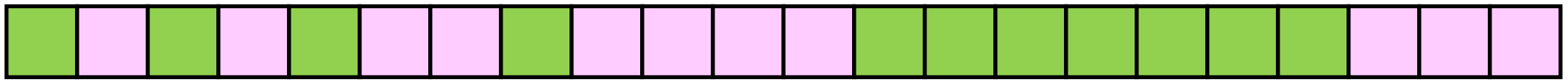

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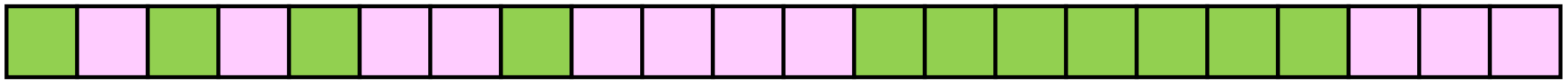

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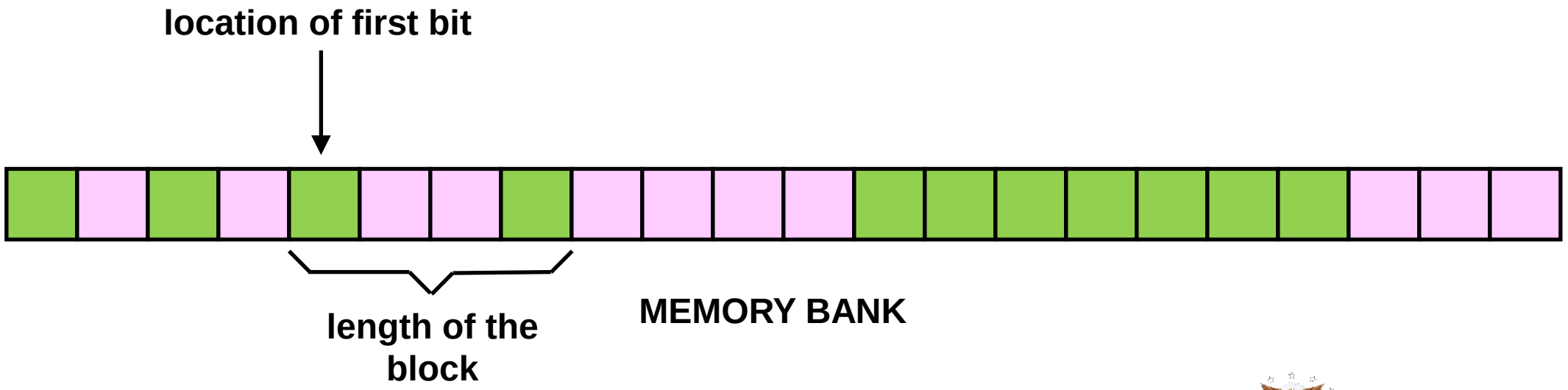

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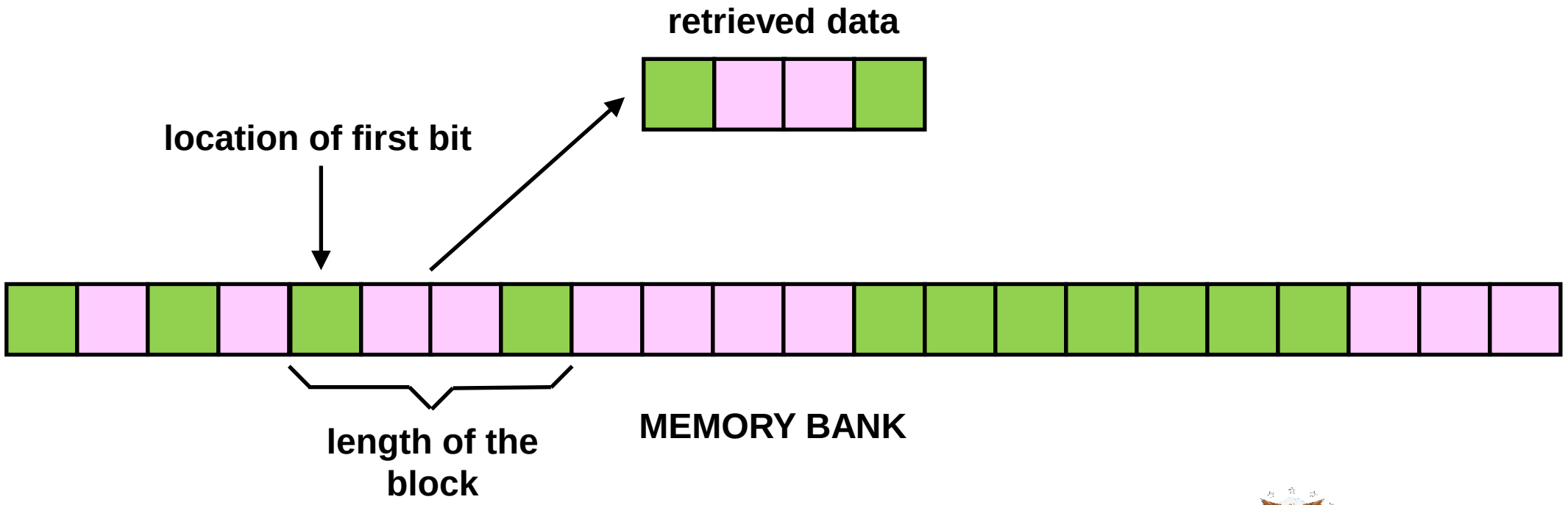

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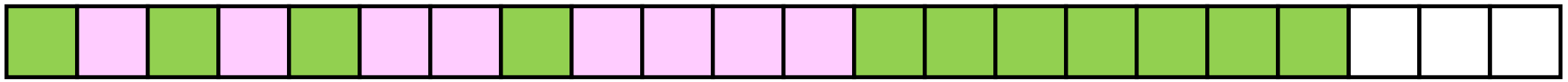

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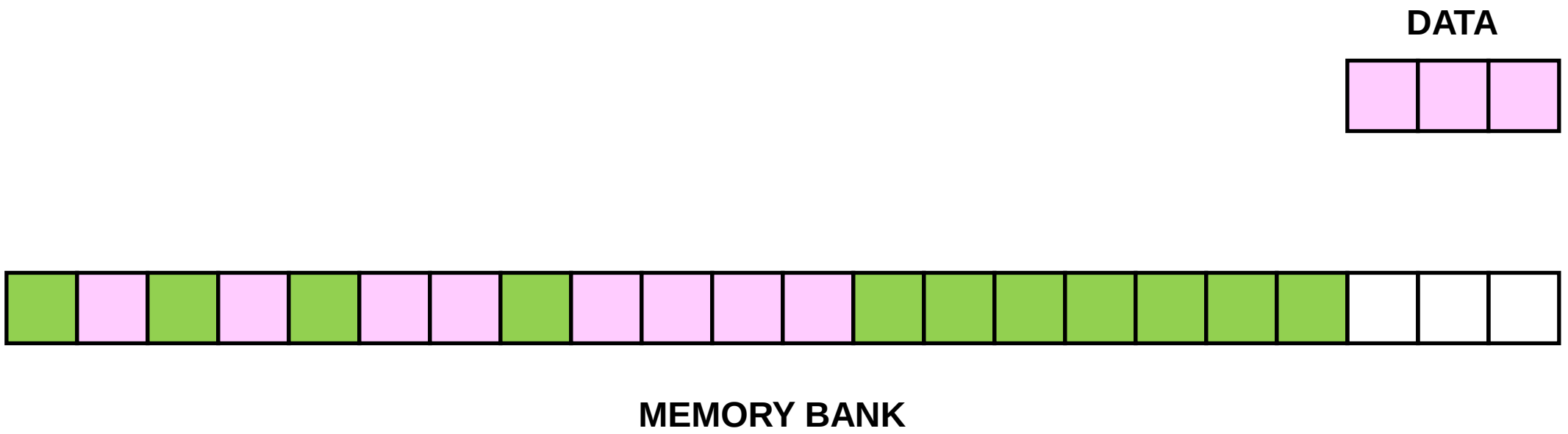

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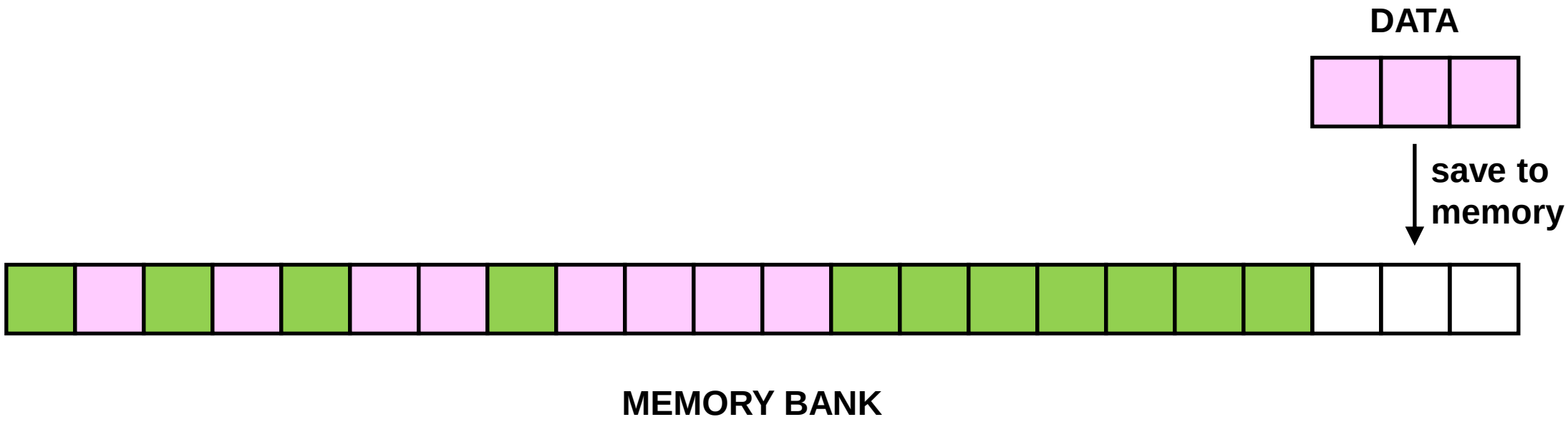

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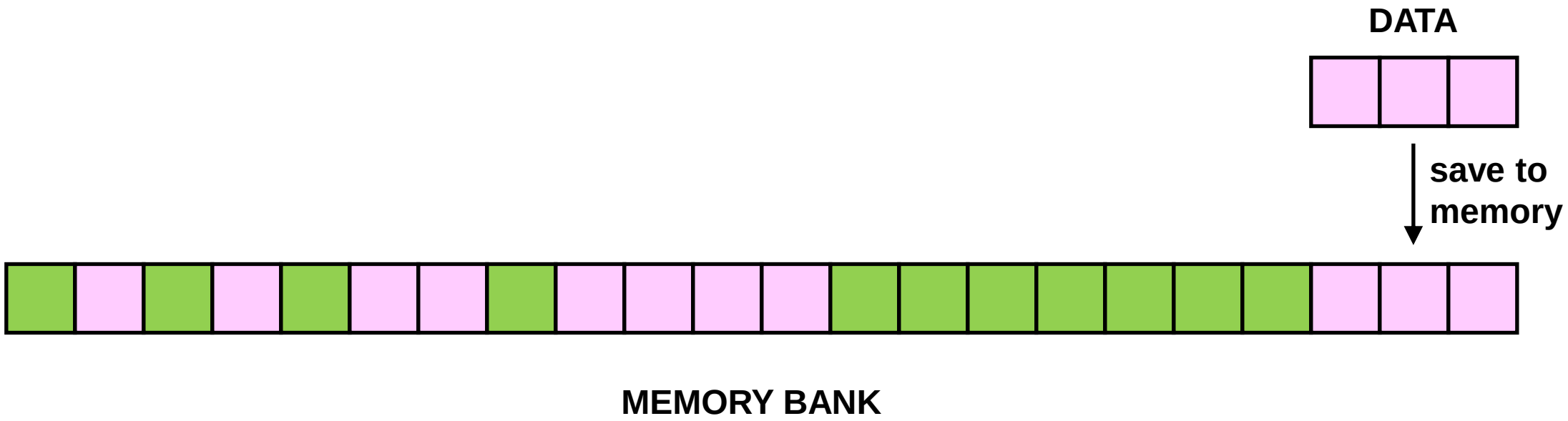

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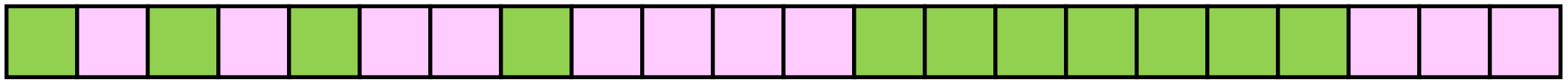

MEMORY BANK

memory bank is completely used

DEATH BLUE SCREEN

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MICROSOFT

INFAMOUS

WINDOWS 95 REBOOTING

Memory Concept

- Computer memory operation seems to be following the idea of how human memory works

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  - to work around the size restriction, a procedure to delete data is developed to free up the space in the data bank

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  - for the purpose of holding data for the quantum computation unit, it is significantly cheaper with using existing digital binary memory
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  - **the use of digital binary data in quantum computing environment can be facilitated with existing hardware (A-to-D and D-to-A converters)**

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  - **the immediate results provide a visualization of human mind in a thinking process**

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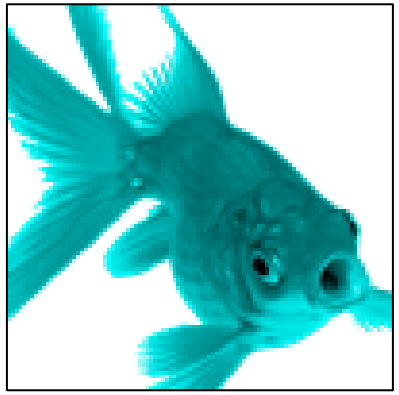

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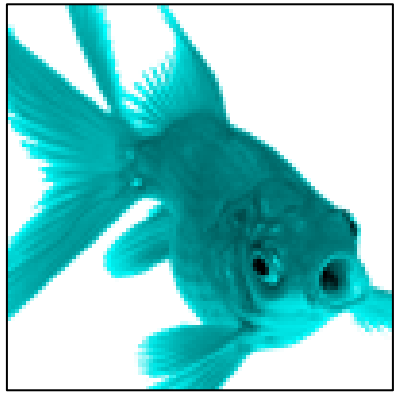

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perception by humans

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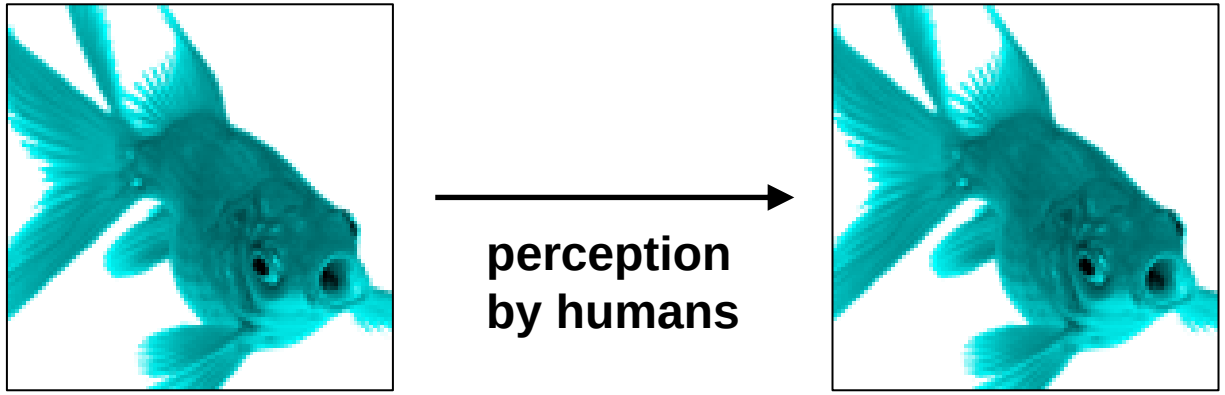

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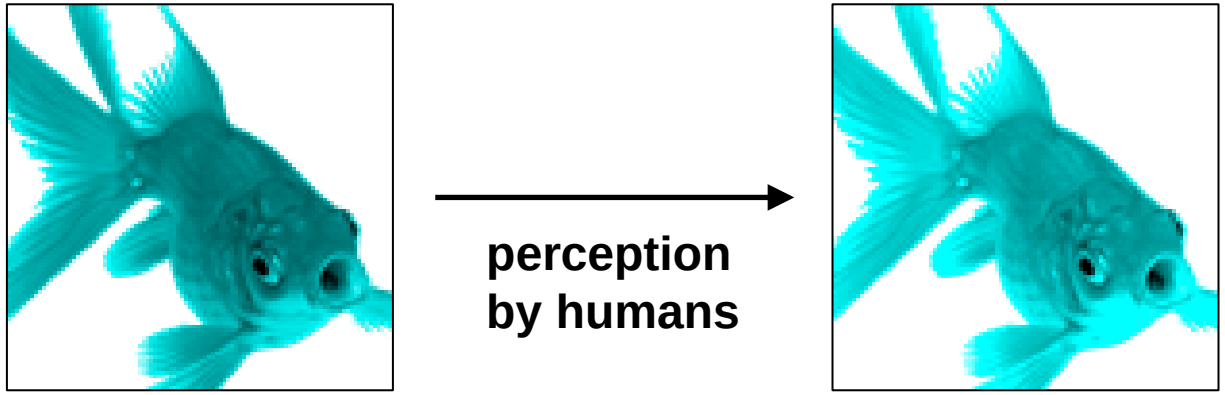

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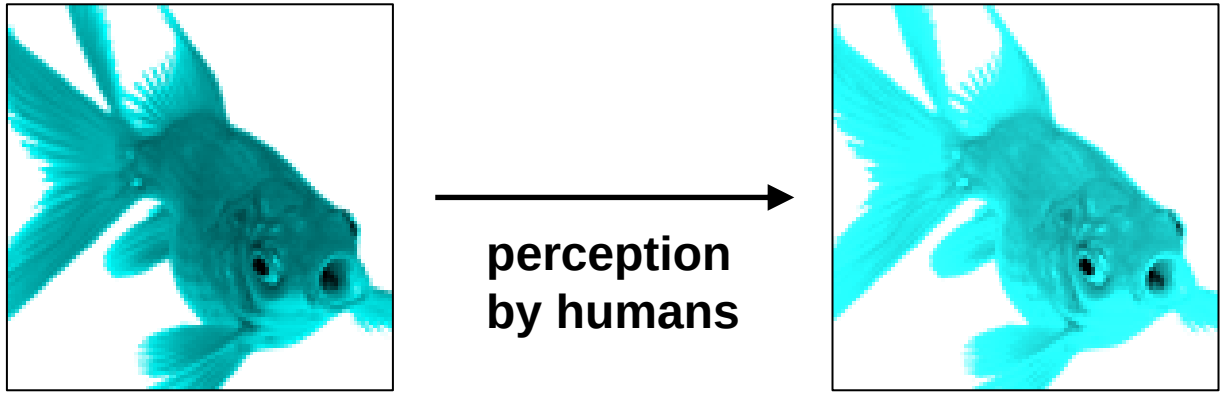

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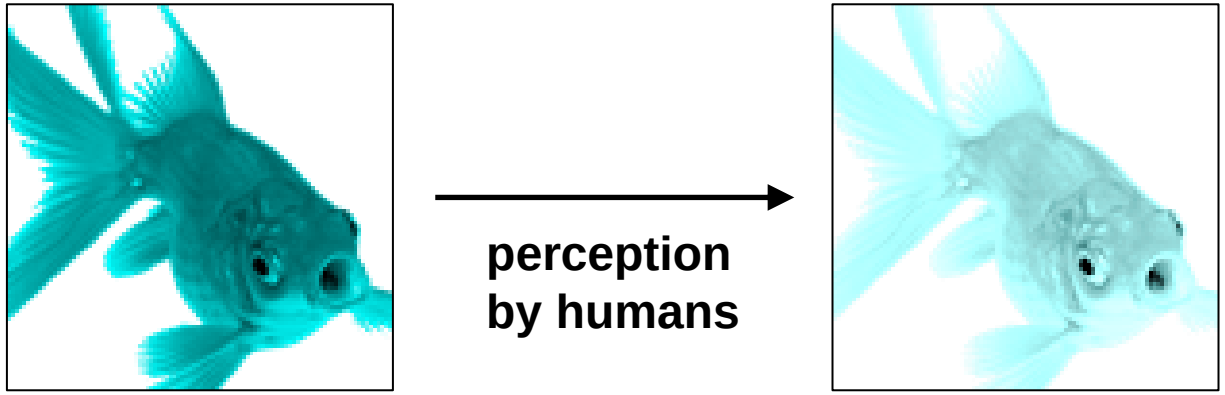

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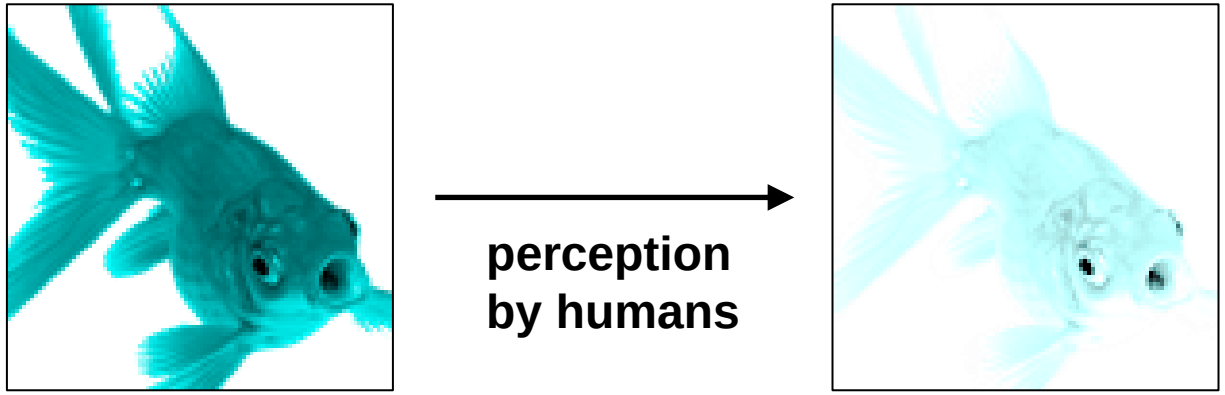

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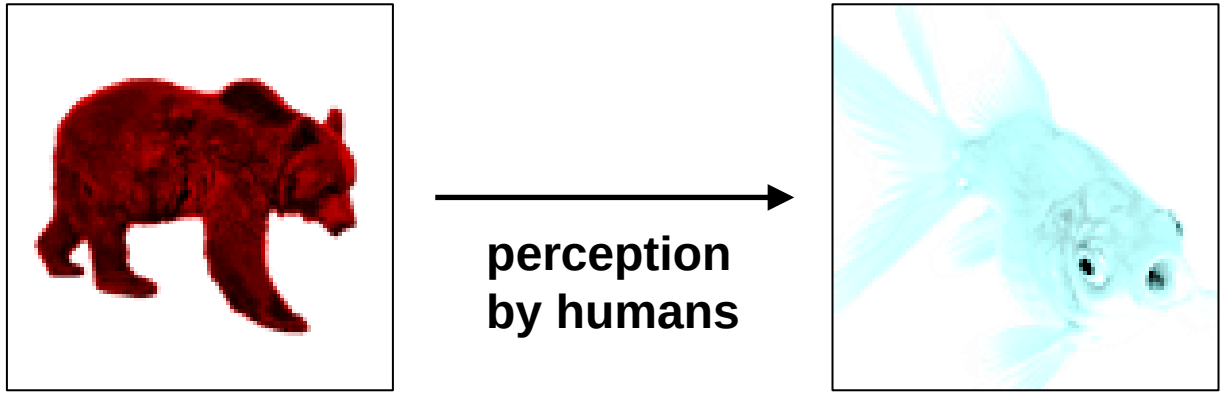

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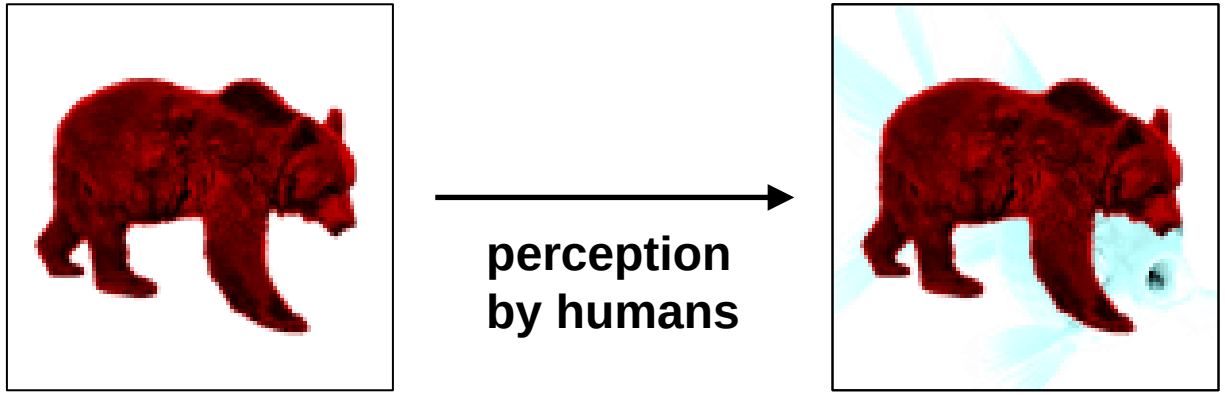

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  - the pheromone that ants use to mark their path is now used to mark an image stored in an analog memory
  - **the evaporation of pheromone marked to each image is used to simulate the fading memory**

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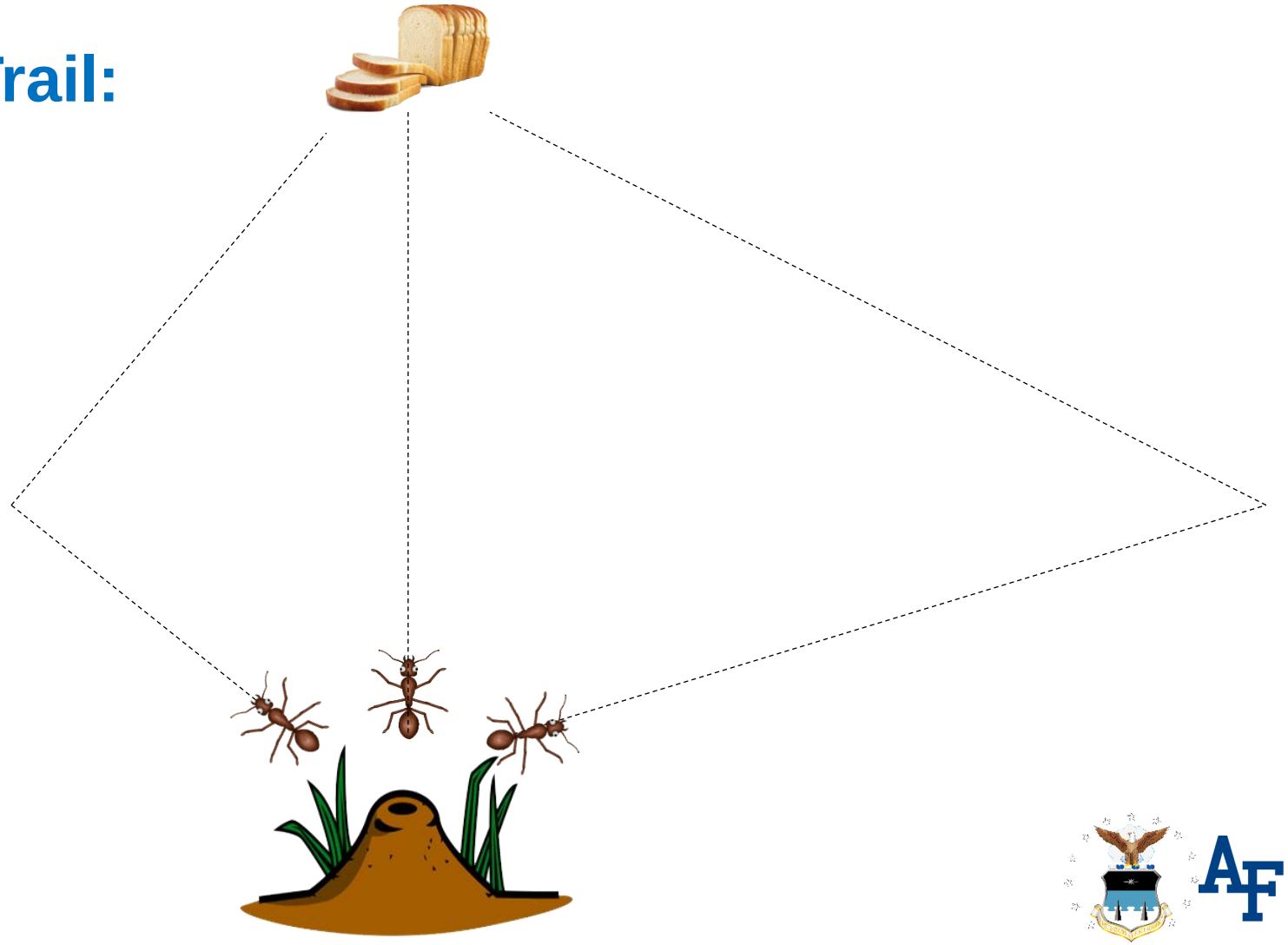
- **Pheromone Trail:**



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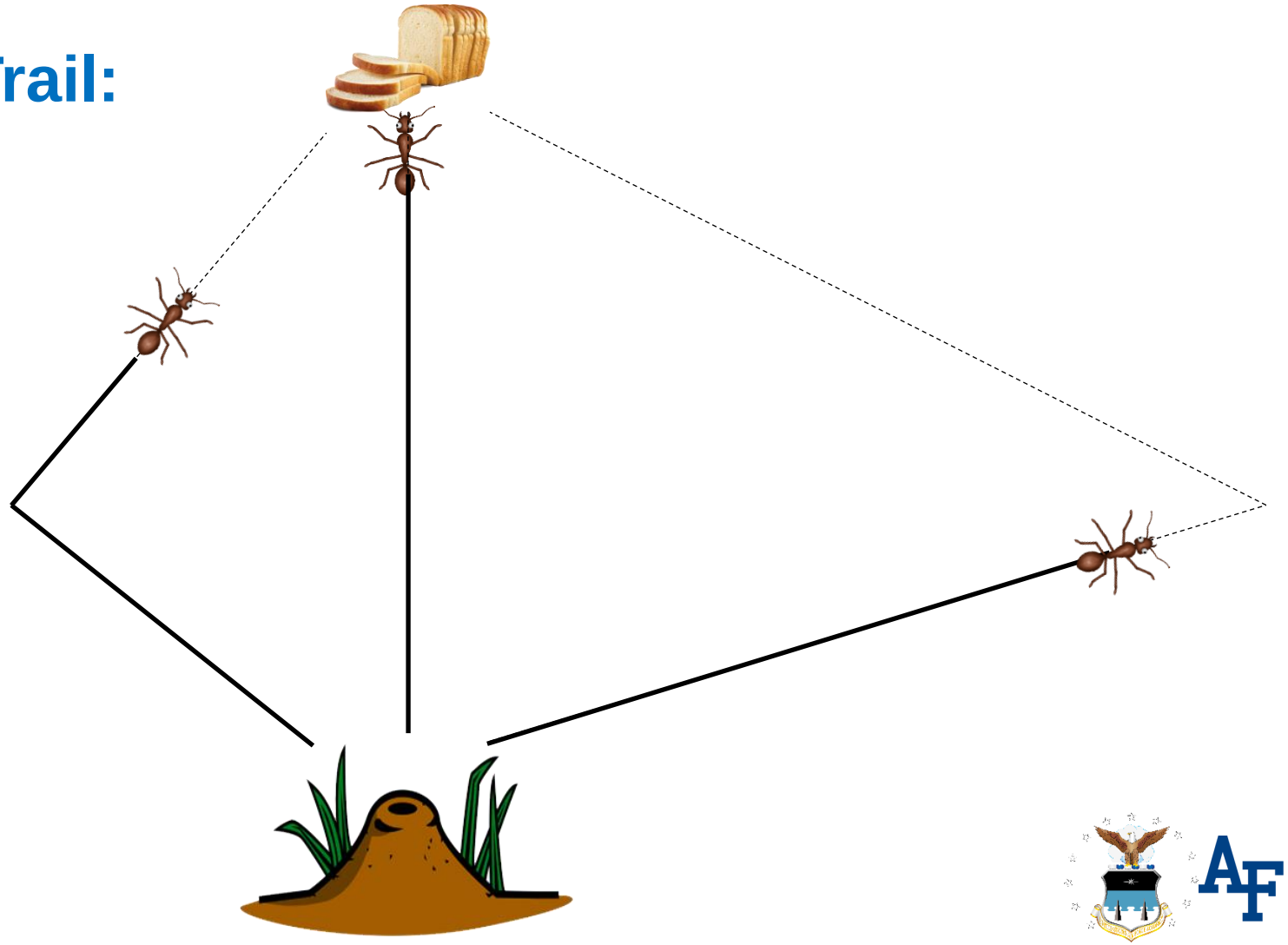

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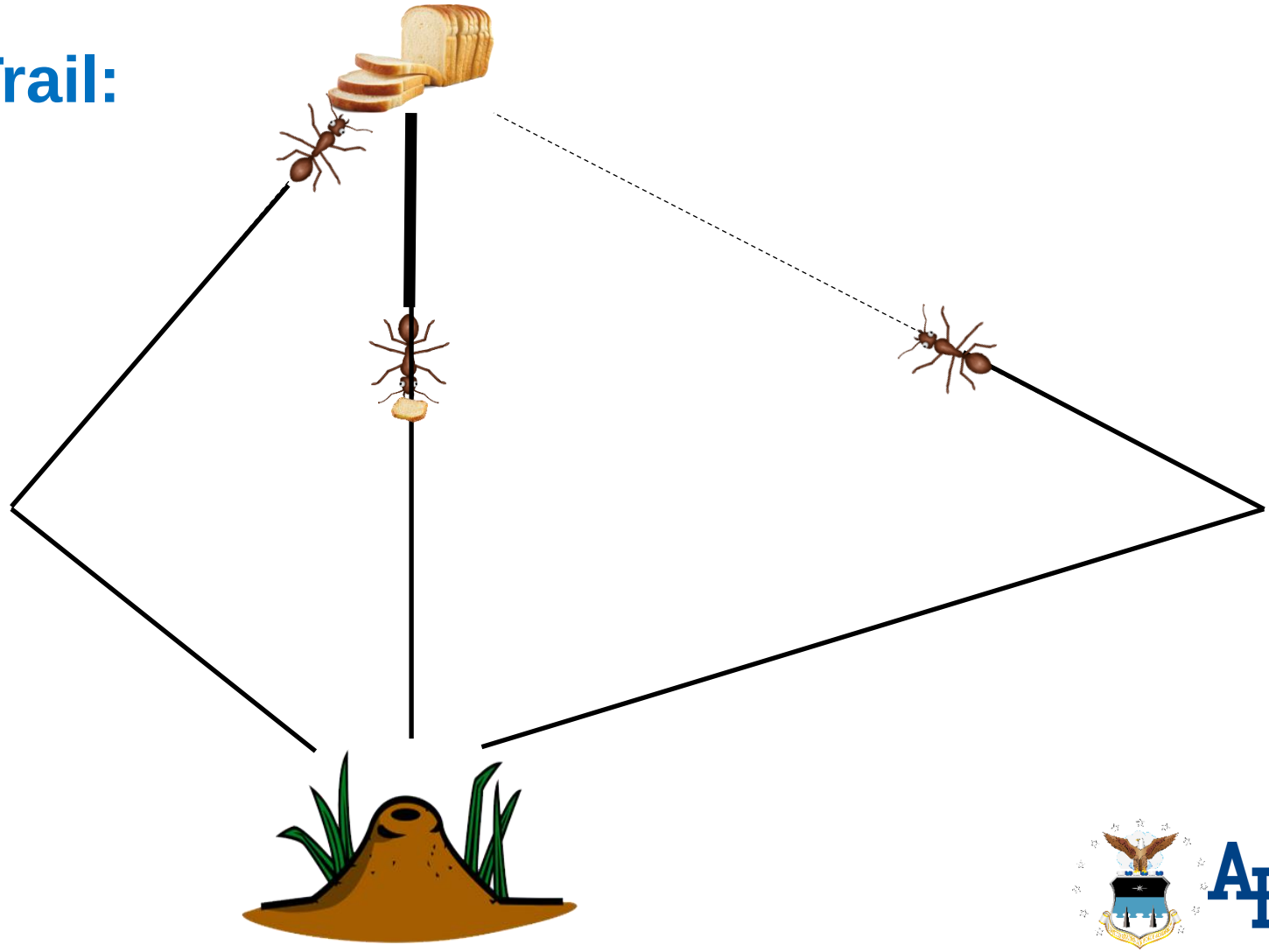

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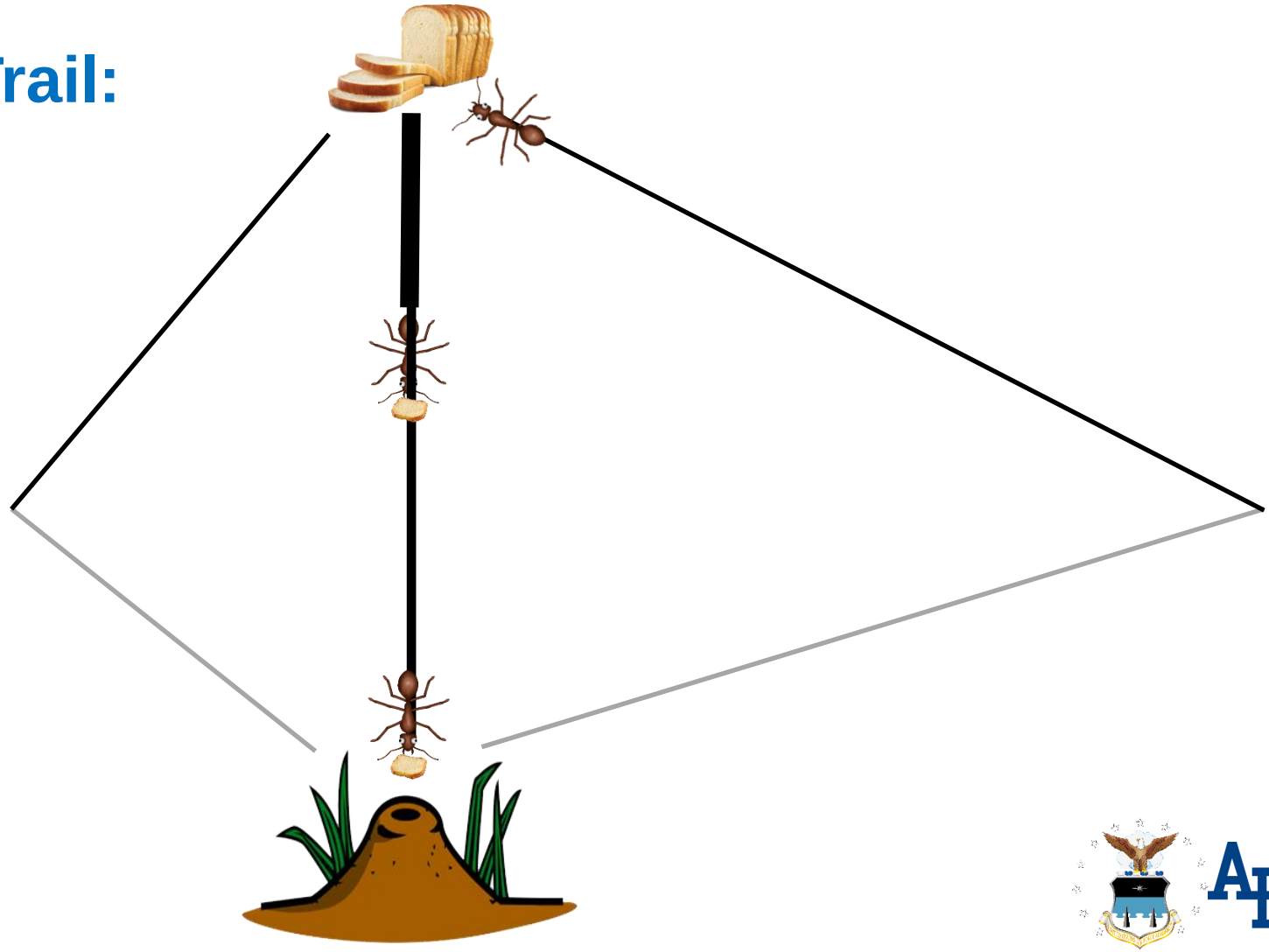

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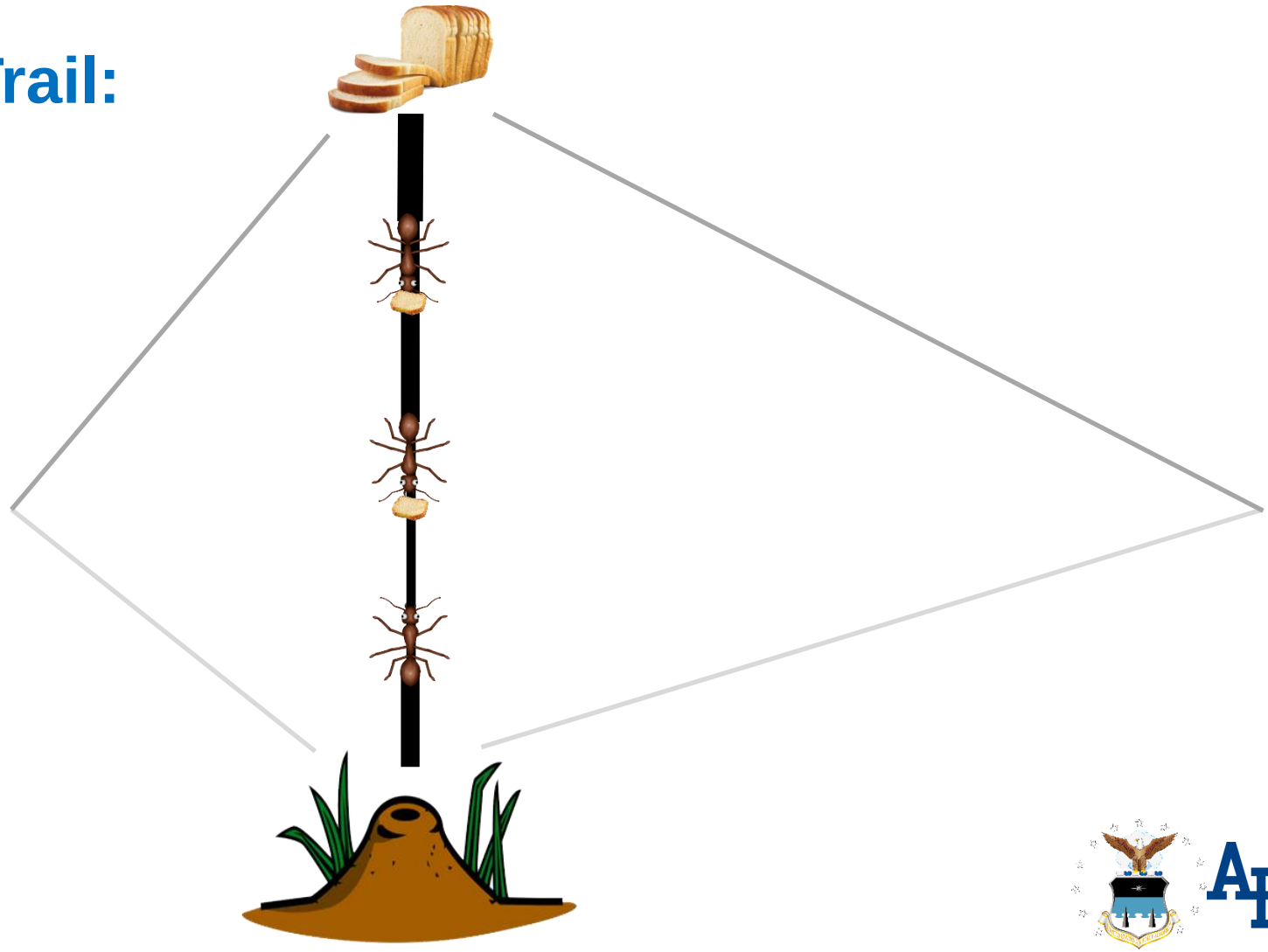

Application: Modeling Human Memory

- Implementation
  - data for first phase of study: using simple single color for describing a shape

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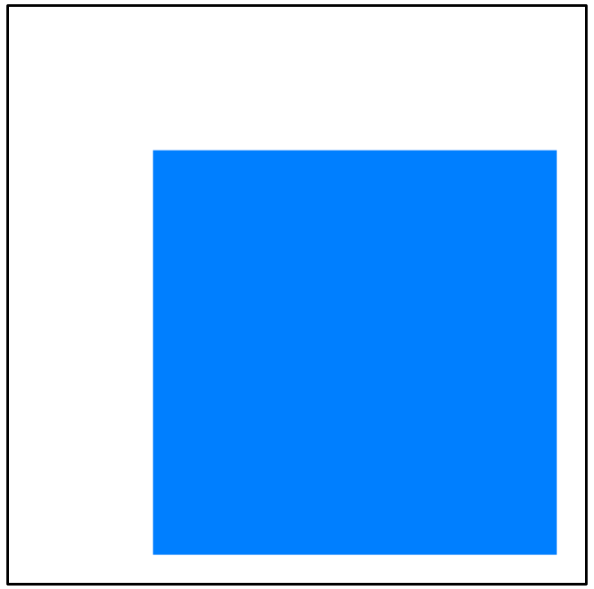

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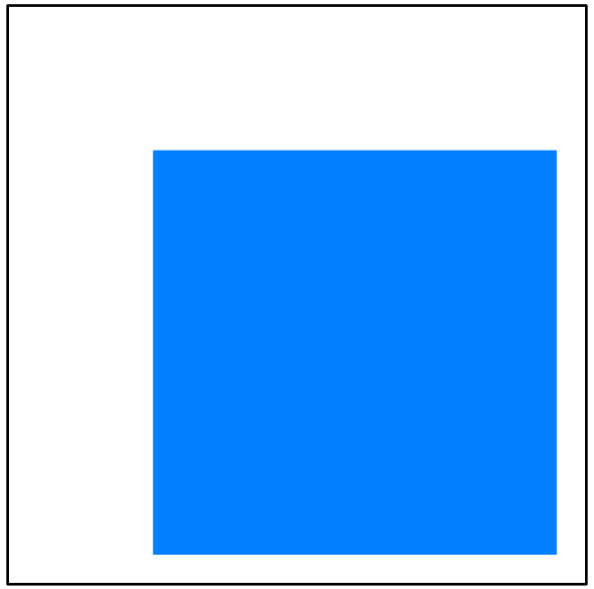

fading is implemented
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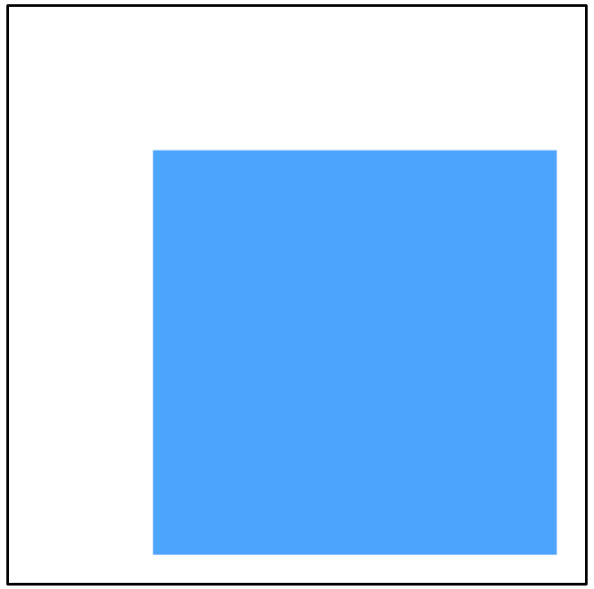

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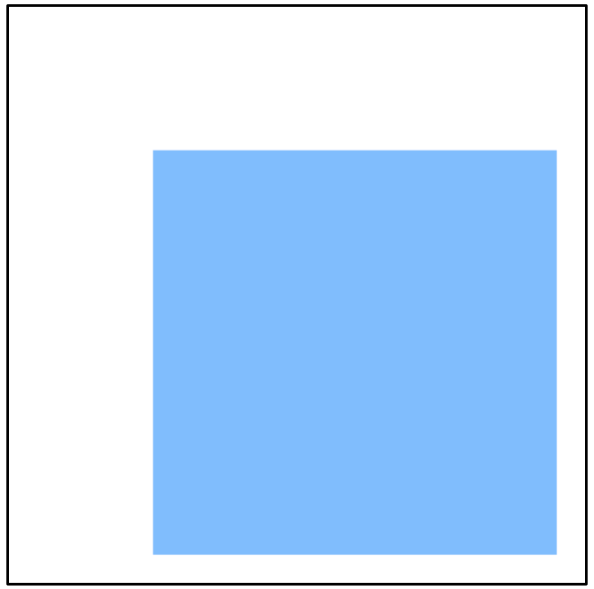

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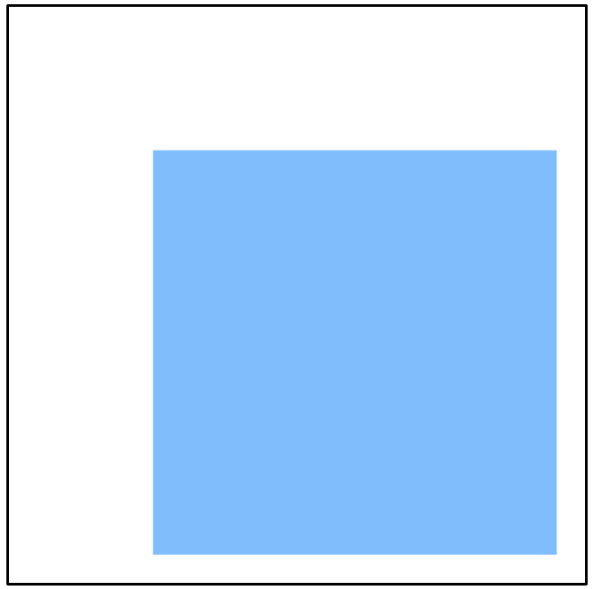

mixing images is done
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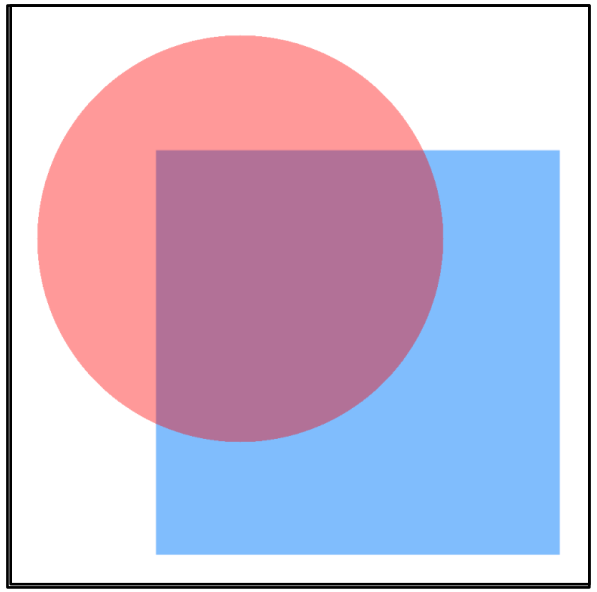

mixing images is done with existing algorithm for two overlapping transparent images

Application: Modeling Human Memory

- **Implementation**
  - **simulation is done in the traditional computer for binary data**

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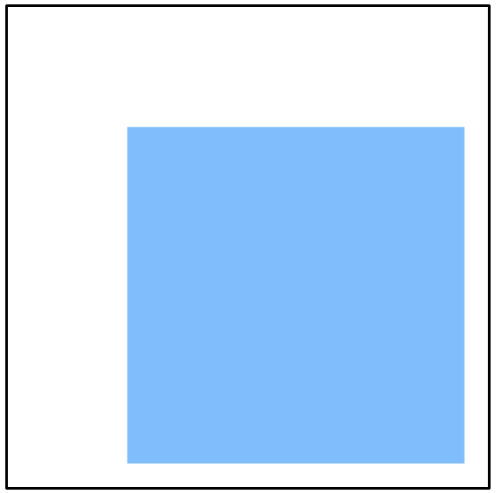

binary data

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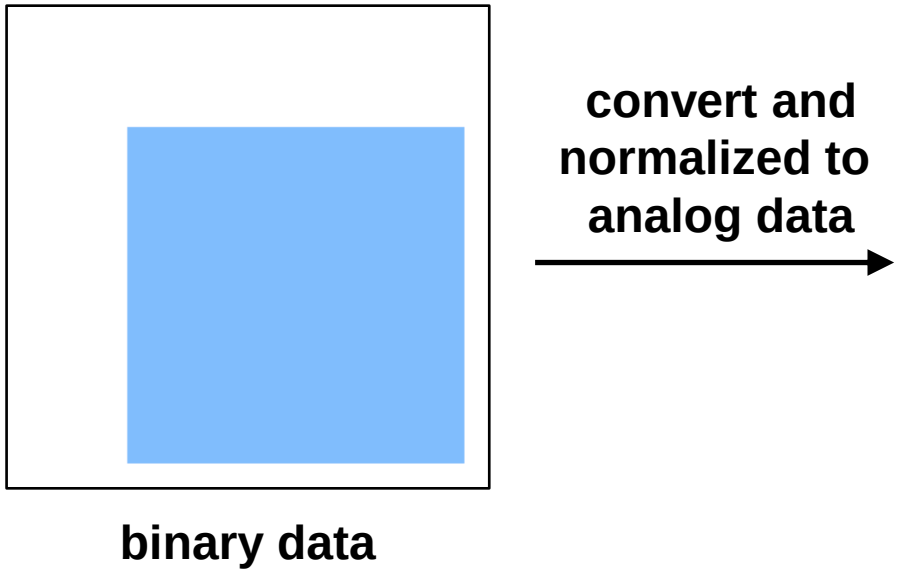

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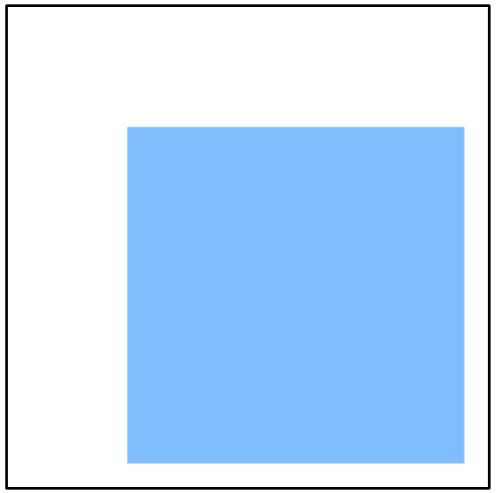

binary data

convert and normalized to analog data

0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.75	0.75	0.75	0.00
0.00	0.00	0.00	0.75	0.75	0.75	0.00
0.00	0.00	0.00	0.75	0.75	0.75	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00

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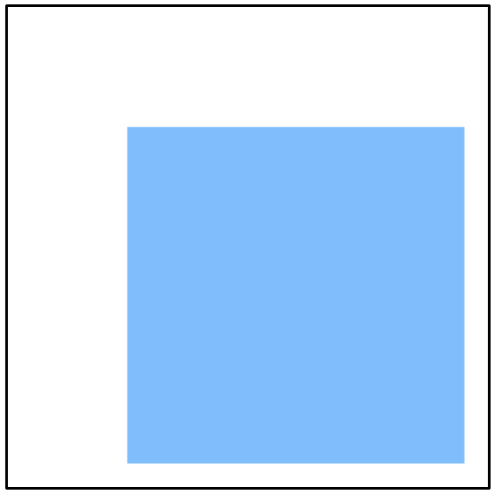

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0.00	0.00	0.00	0.75	0.75	0.75	0.00
0.00	0.00	0.00	0.75	0.75	0.75	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00

normalized data can be saved to a quantum memory bank

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0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.75	0.75	0.75	0.00
0.00	0.00	0.00	0.75	0.75	0.75	0.00
0.00	0.00	0.00	0.75	0.75	0.75	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00

normalized data

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0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.75	0.75	0.75	0.00
0.00	0.00	0.00	0.75	0.75	0.75	0.00
0.00	0.00	0.00	0.75	0.75	0.75	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00

normalized data

simulate in traditional computers →

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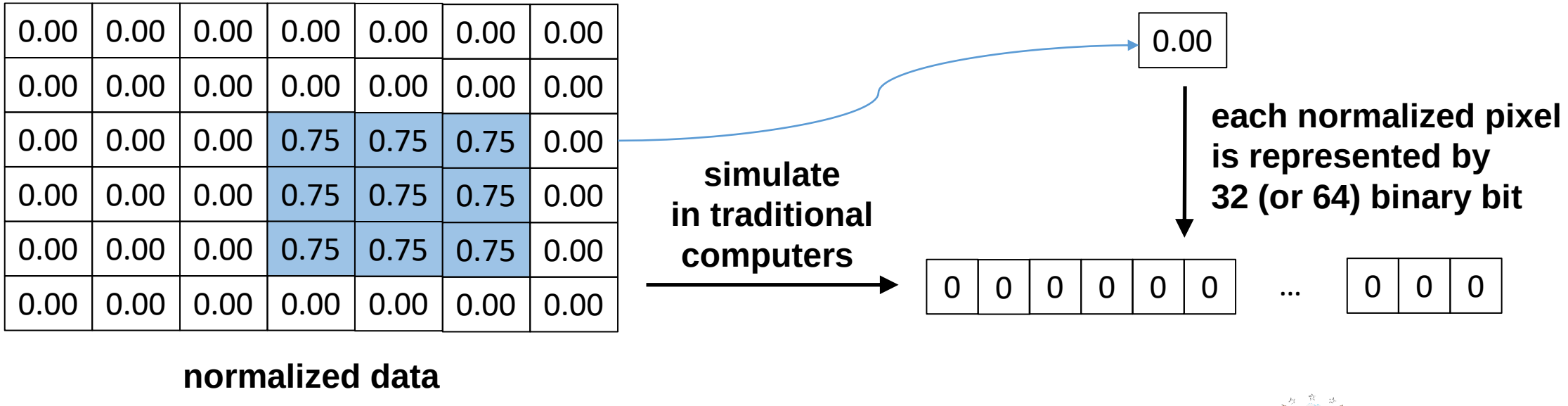

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  - **humans are exposed to various computer simulated patterns and are tested in the ability to recall seeing a particular pattern**

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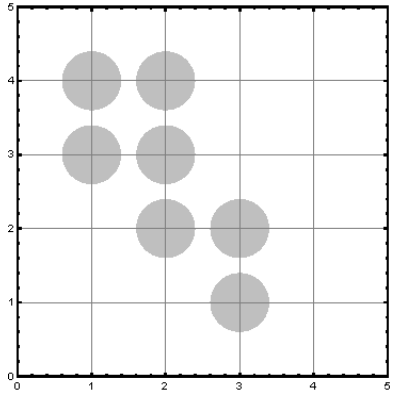
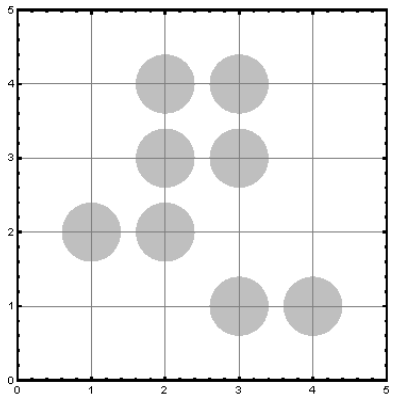
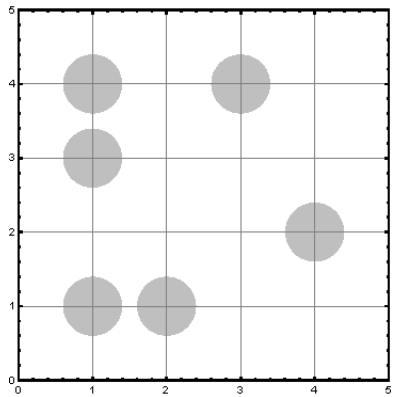
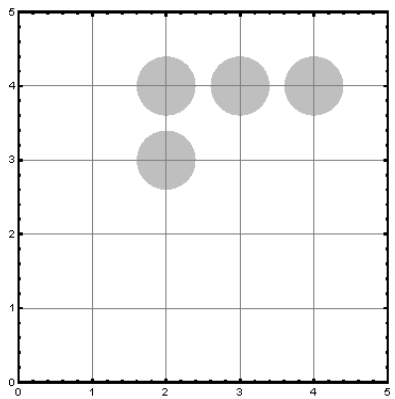

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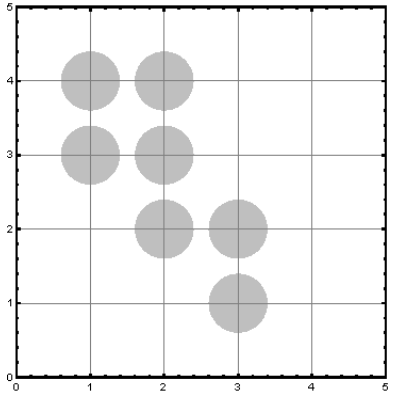

visual cue

from perception to memory

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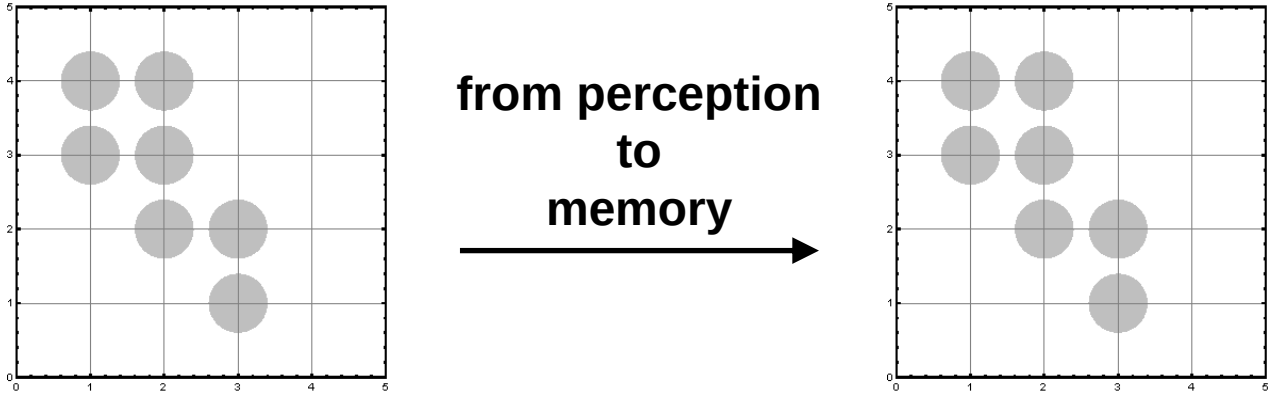

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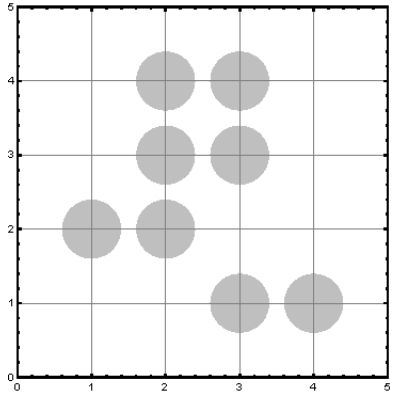

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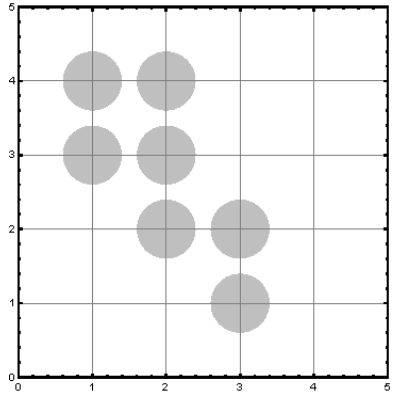

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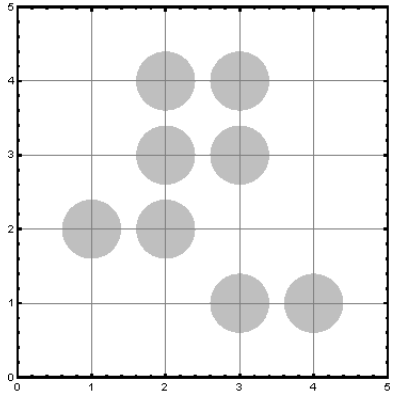

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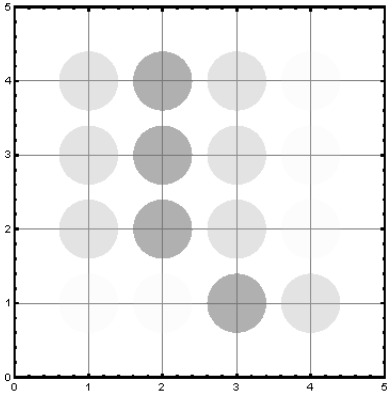

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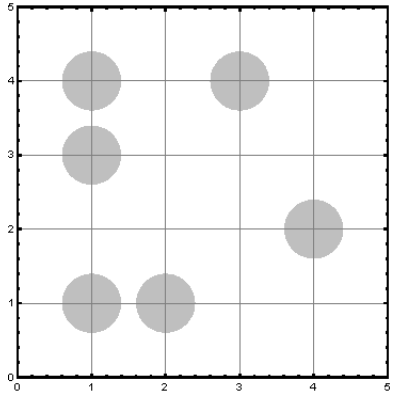

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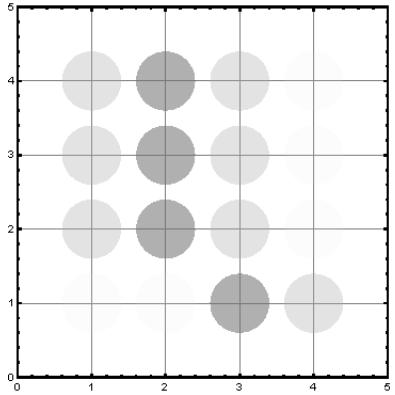

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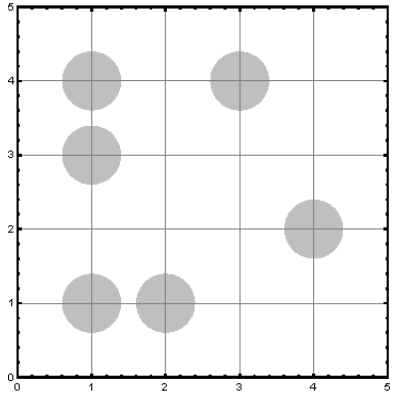

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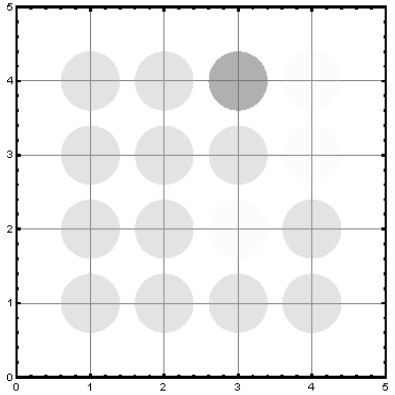

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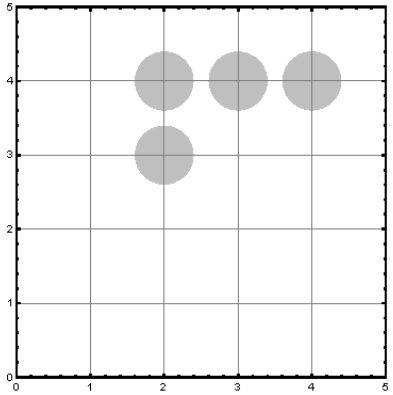

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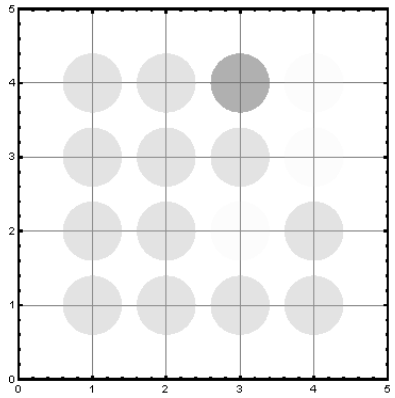

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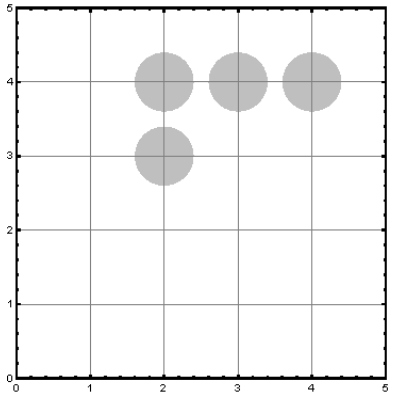

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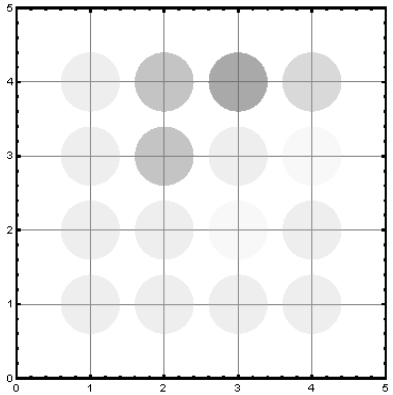

visualization of memory

Application: Quantum Computing

- Application in Quantum Computing

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  - **Research Question: Given data in the mixed memory model, can an image be retrieved based on some partial description?**

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  - Research Question: Given data in the mixed memory model, can an image be retrieved based on some partial description?
  - **Objective: To design a computing layer that converts a block of quantum memory into an infinite storage area**

Application: Quantum Computing

- Application in Quantum Computing
  - Research Question: Given data in the mixed memory model, can an image be retrieved based on some partial description?
  - Objective: To design a computing layer that converts a block of quantum memory into an infinite storage area
  - **Applicability: a database in a quantum harddrive can be designed more compactly when data are stacked on top of each other**

Application: Quantum Computing

- Computational Development
  - how to separate them to retrieve individual images

    for each pixel, set up a set of linear equations as a combination of two unique colors

    there are two types of pixels: (i) one single color, and (ii) combined colors

Application: Quantum Computing

- **Computational Development**
  - **how to separate them to retrieve individual images**

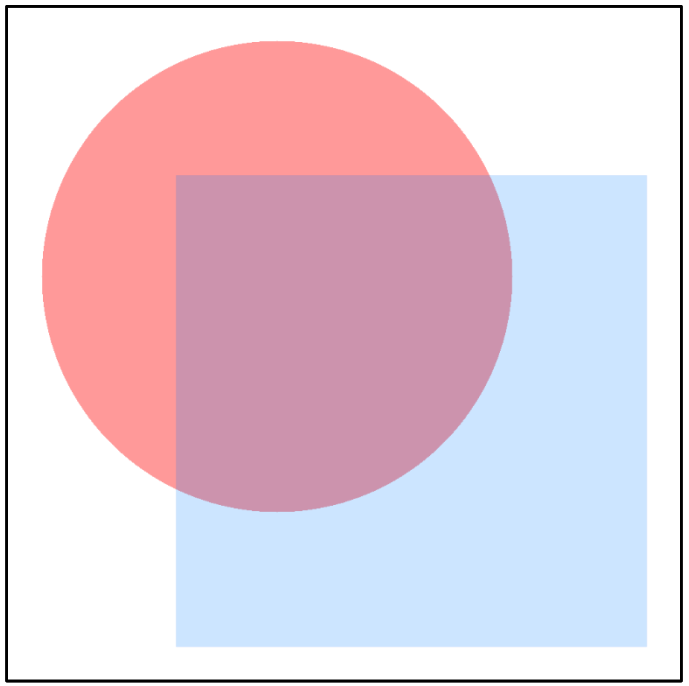
    a set of linear equations can be obtained and solved for the constants $\alpha(t)$ and $\beta(t)$

Application: Quantum Computing

- **Computational Development**
  - **how to separate them to retrieve individual images**

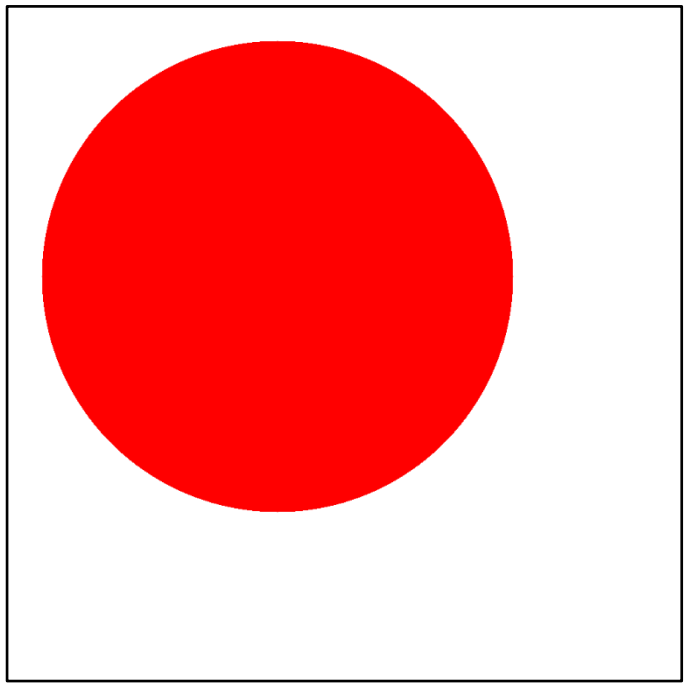
    the constants $\alpha(t)$ and $\beta(t)$ will be used to separate the pixels in the images

Application: Quantum Computing



Given Combined Memory

retrieve something with color RED



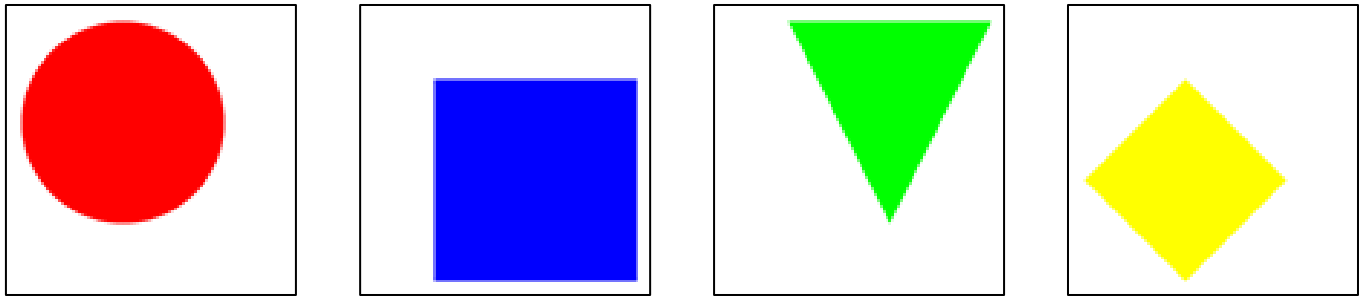
Final Result

Application: Quantum Computing

- **Computer Simulations:**

Application: Quantum Memory

- **Computer Simulations:**



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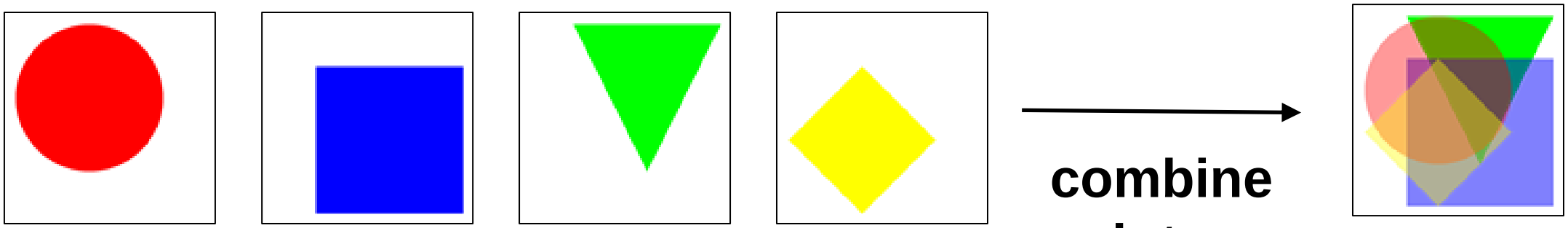

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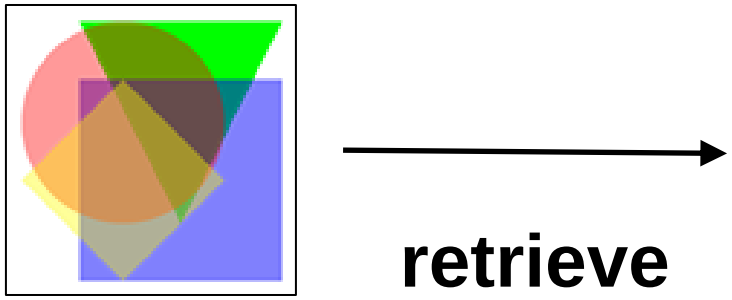

retrieve something RED

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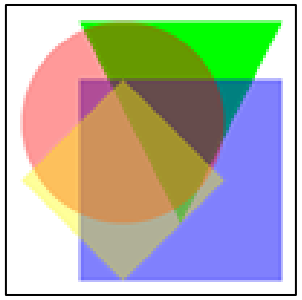

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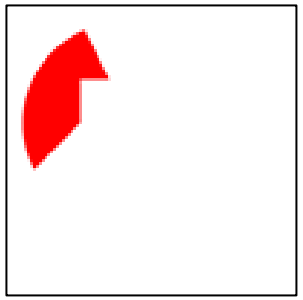
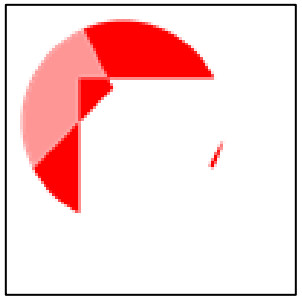
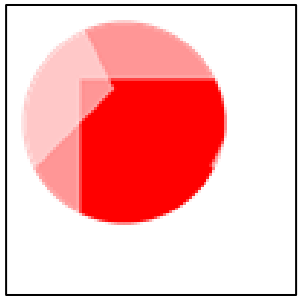


pixels with one color



pixels with one and two colors



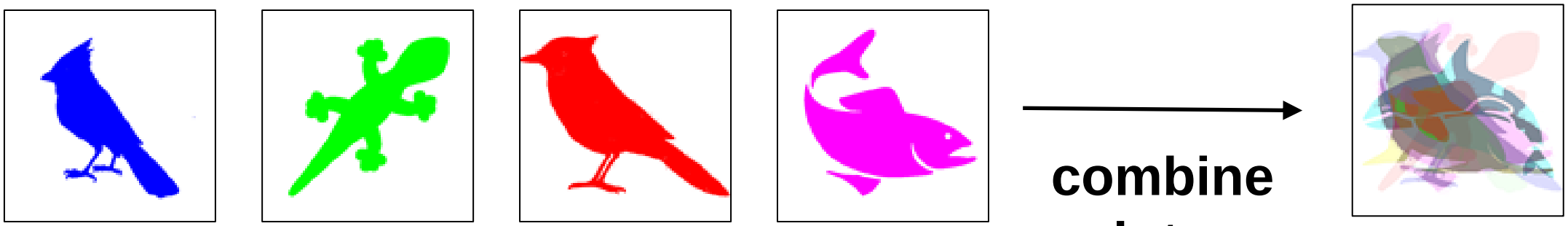
pixels with one, two, and more colors

Application: Quantum Memory

- **Computer Simulations:**

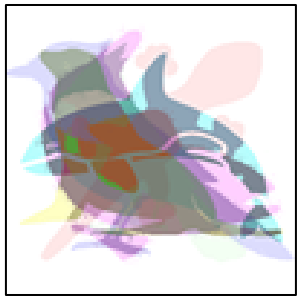
Application: Quantum Memory

- **Computer Simulations:**



Application: Quantum Memory

- **Computer Simulations:**



retrieve something RED

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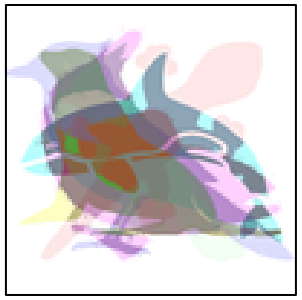
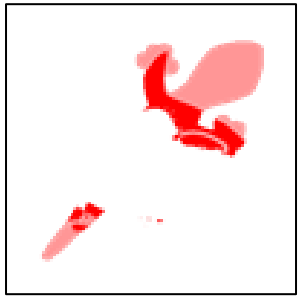


retrieve something RED

pixels with one color



pixels with one and two colors

pixels with one, two, and more colors

Future Direction

- **Next Step: extending black & white images to monochromic images**

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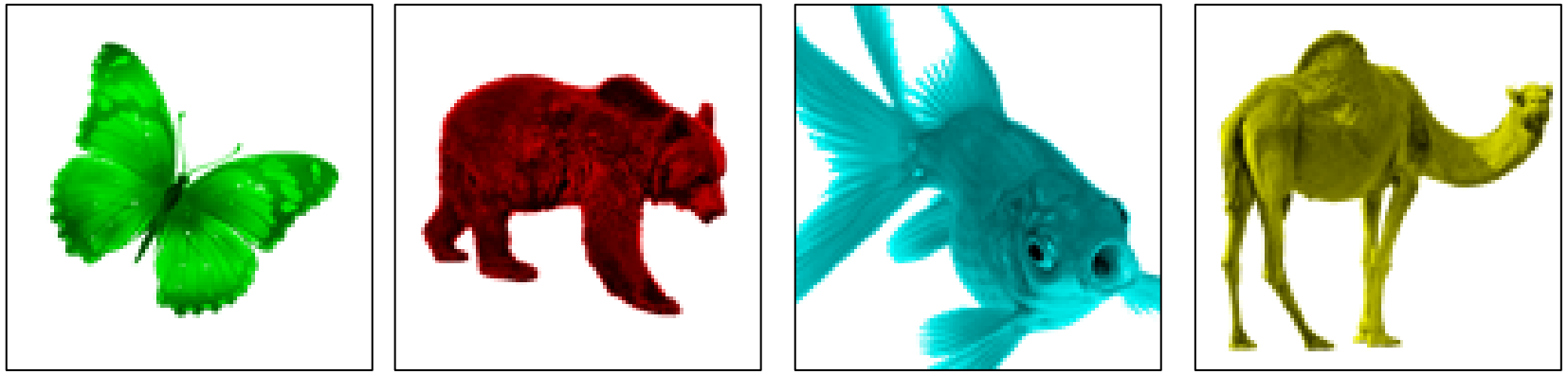

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- While quantum computing is still evolving, it is always possible to do R&D work through simulations without waiting for access of an actual working quantum computer
- **The modeling of quantum memory is an example of how research in quantum computing can be done in a practical manner while under the difficult requirements**


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