

# UNCONVENTIONAL APPROACHES TO AI

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# INSIGHTS FROM THE PAST

- UNCONVENTIONAL APPROACHES IN AI: COMPLEX SYSTEMS PERSPECTIVES, COGNITIVE PSYCHOLOGY, SOCIAL SCIENCES, COMPUTATIONAL MODELS OF CREATIVITY AND OTHER UNCONVENTIONAL MODELS
- THIS IS AI OR CLASSICAL AI BEFORE BIG DATA. THE TIME IS NOW RIPE TO REVISIT THESE WONDERFUL IDEAS AND THINK ABOUT HOW TO INCORPORATE THEM IN MODERN AI/DEEP LEARNING. INSIGHTS FROM THE PAST CAN INFORM FUTURE APPROACHES TO AI, ESPECIALLY IN THE AGE OF BIG DATA.
- LOOKING AT THE HERITAGE OF COMPUTING AND ITS INTERDISCIPLINARY PAST CAN INSPIRE NEW APPROACHES FOR THE FUTURE.
- WE NEED TO LEARN LESSONS FROM THE HISTORY OF AI, WHAT APPROACHES WORKED AND DID NOT WORK IN THE PAST AND HOW AI WENT THROUGH MULTIPLE WINTERS.
- THESE APPROACHES CAN BE USED TO DEVELOP TECHNIQUES THAT CAN INSPIRE EXPLAINABLE AI.

# INSIGHTS FROM THE PAST

- UNCONVENTIONAL APPROACHES IN AI: COMPLEX SYSTEMS PERSPECTIVES, COGNITIVE PSYCHOLOGY, SOCIAL SCIENCES, COMPUTATIONAL MODELS OF CREATIVITY AND OTHER UNCONVENTIONAL MODELS
- NEUROSCIENCE (PERCEPTRONS)
- COGNITIVE PSYCHOLOGY

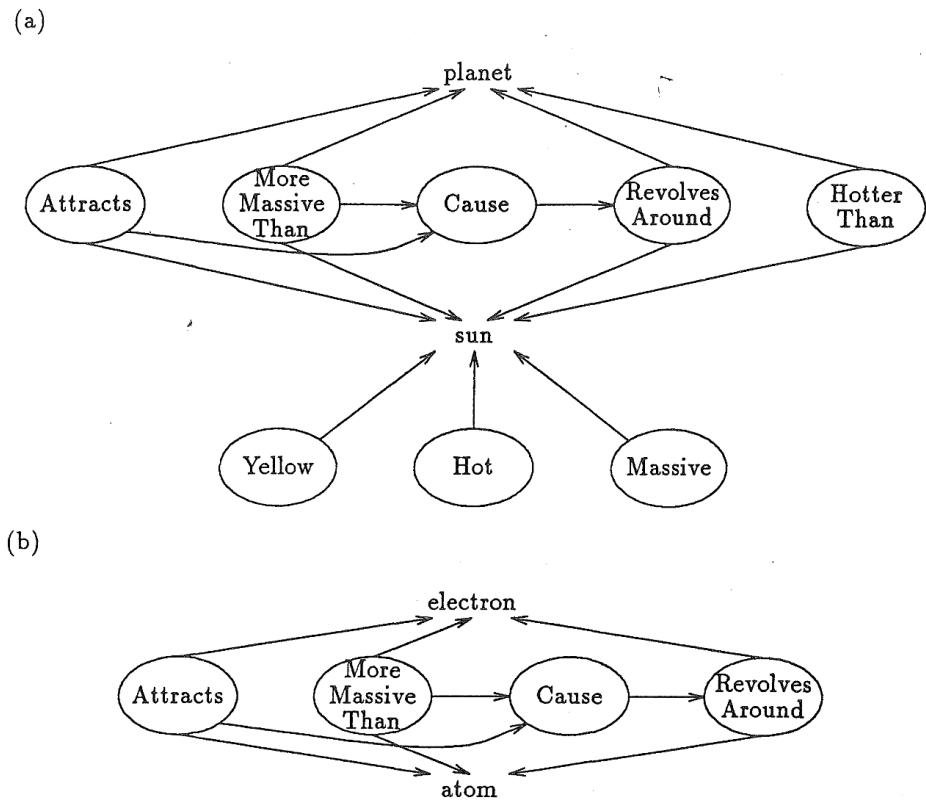
# APPROACHES

- NARRATIVES AND STORIES
  - HOW WE MAKE SENSE OF OUR COMPLEX ENVIRONMENT
- COMPUTATIONAL MODELS OF CREATIVITY AND INSIGHT
- CASE BASED REASONING
  - DOCTORS, LAWYERS
- ANALOGIES
- DREAMS
  - AID GENERALIZATION AND PREVENT OVERFITTING
- COMMONSENSE REASONING

# COMPUTATIONAL MODELS OF CREATIVITY AND INSIGHT

- WE ARE TOLD OF EUREKA MOMENTS (ARCHIMEDES, NEWTON, ...)
- IN REALITY, WE ALWAYS BUILD ON THE WORK OF OTHERS
- THERE IS A PREPARATION STAGE
- INCUBATION STAGE
- RETRIEVAL/INDEXING (KEKULE DREAMING OF A SNAKE AND THEN LINKING IT TO BENZENE RINGS)

# ANALOGIES

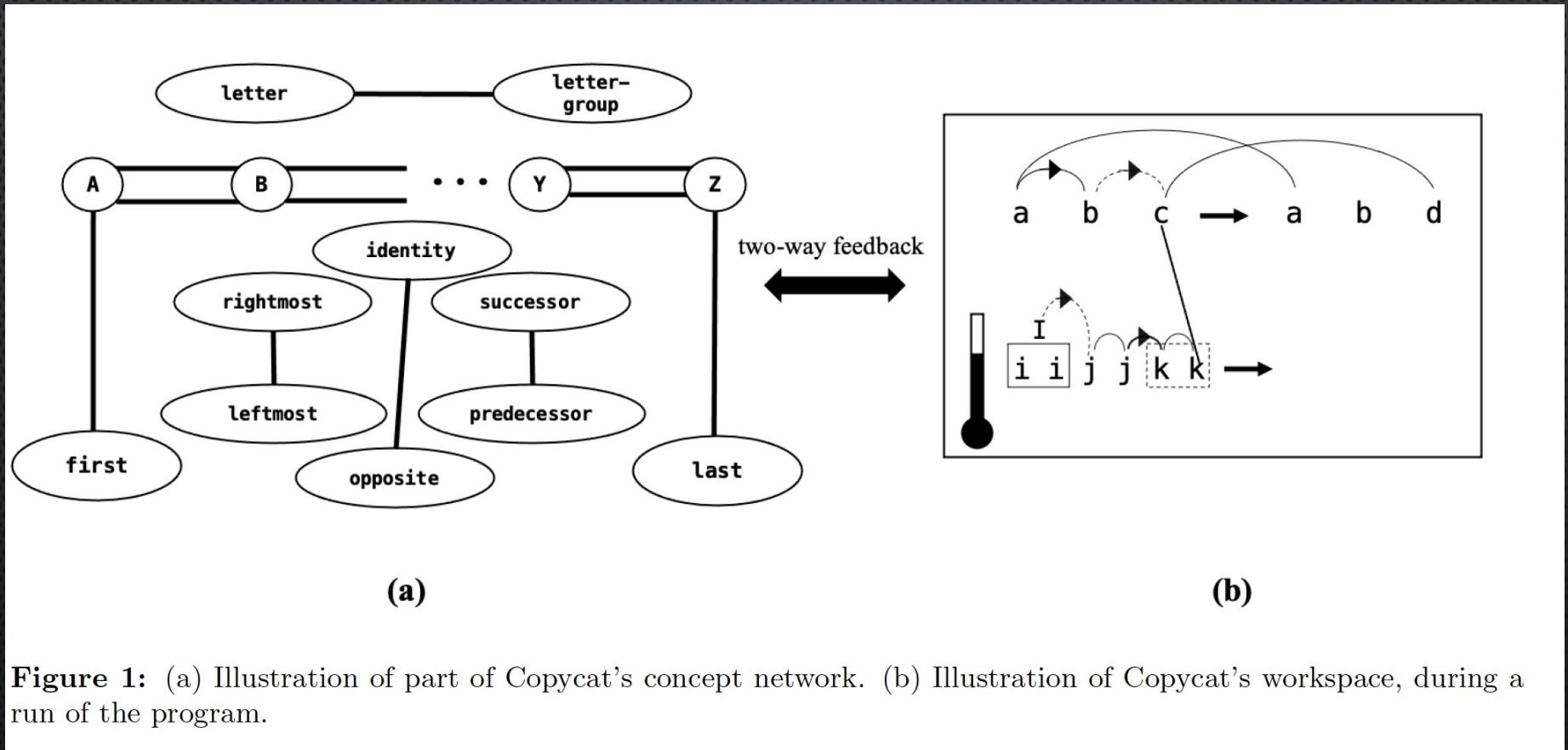


**Figure 2.** Creating a representation for the atom from the statement, "The atom is like the solar system." Higher order relations are carried over and simple attributes are ignored.

# ANALOGY

- ABSTRACTION AND REASONING
- ABC -> ABD
- XYZ -> ?

# APPROACHES



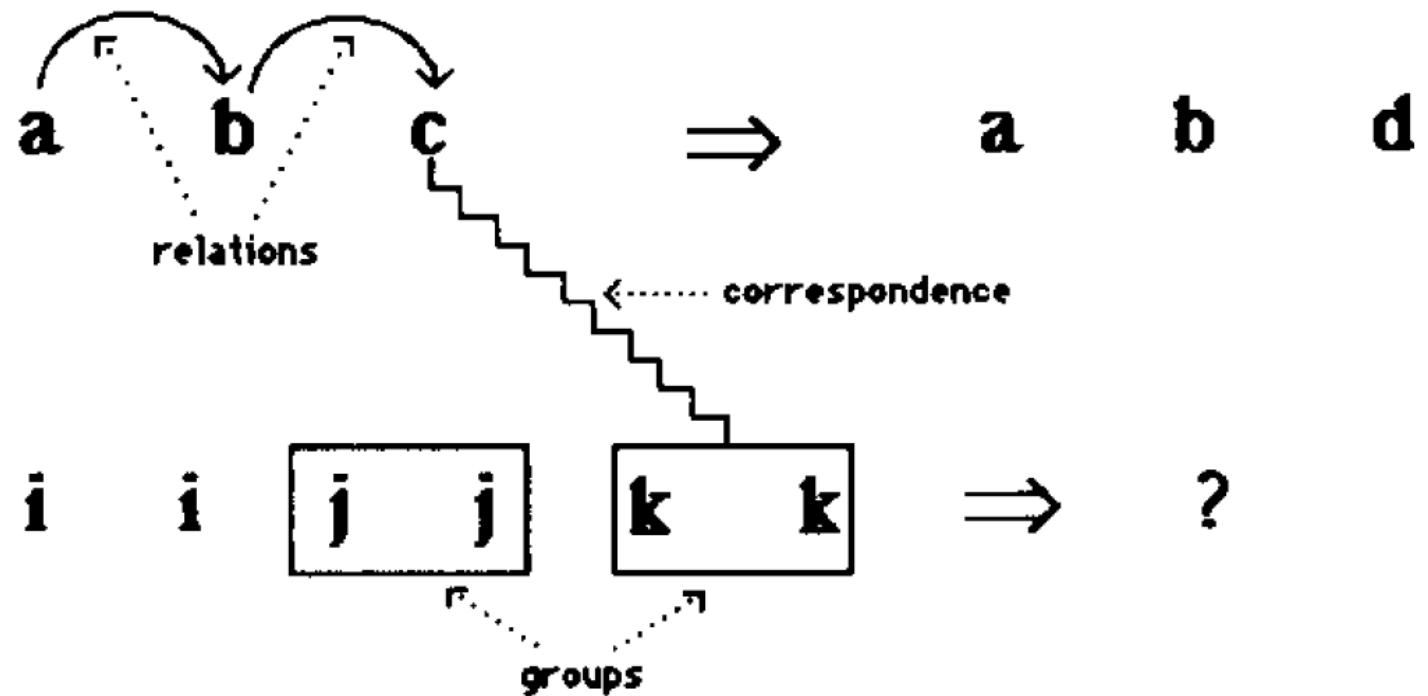
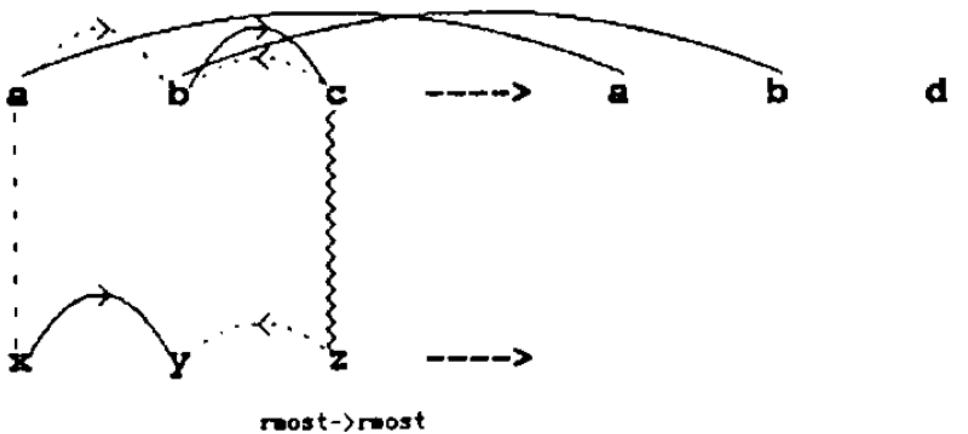


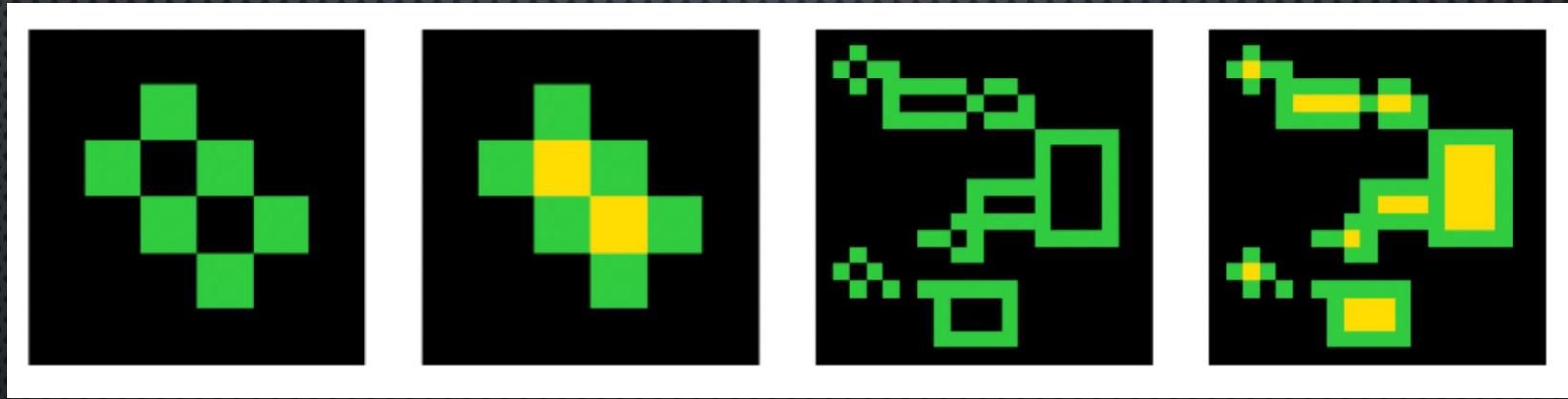
Fig. 2. Perceptual structures, including relations, groups, and a correspondence.

Fig. 2 shows examples of perceptual structures that could be built in the process of solving the problem “ $\textit{abc} \Rightarrow \textit{abd}$ ,  $\textit{ijjkk} \Rightarrow ?$ ”. The types of structures built by the program include *descriptions* of objects (e.g. the **C** in *abc* is the string’s *rightmost* letter), *relations* between objects (e.g. the **B** in *abc* is the *successor* of its left neighbor, the **A**), *groups* of objects (e.g., *jj* is a group of adjacent identical letters; the entire string *abc* could be seen as a group of adjacent letters that increase alphabetically), and *correspondences* between objects (e.g. the **C** in *abc* corresponds to the group *kk* in *ijjkk*). (See section 5 for examples of these structures in a run of the program.)



3. Some relations between letters within each string have been built and others continue to be considered. Copycat, unlike people, has no left-to-right or alphabetic-forwards biases, and in general is equally likely to perceive relations in either direction, although here, *successor* tends to be activated early when the **C**-to-**D** change is noticed, causing the system to tend to perceive the letters as having left-to-right successor relations rather than right-to-left predecessor relations. A correspondence between the **C** and the **Z** (jagged vertical line) has been built. Both letters are *rightmost* in their respective strings: this underlying concept mapping is displayed beneath the correspondence. In response to the growing amount of structure, the temperature has dropped to 76.

# NEW DATA



ABSTRACTION AND REASONING CORPUS

# ANALOGIES: STRUCTURE MAPPING ENGINE

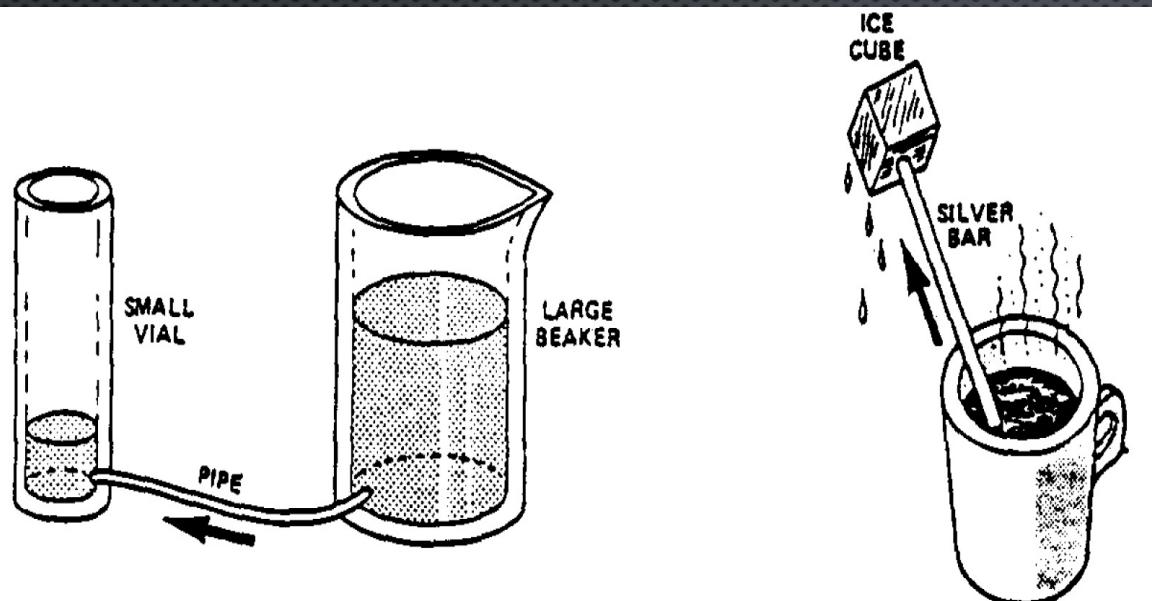


Fig. 1. Two physical situations involving flow (adapted from [3]).

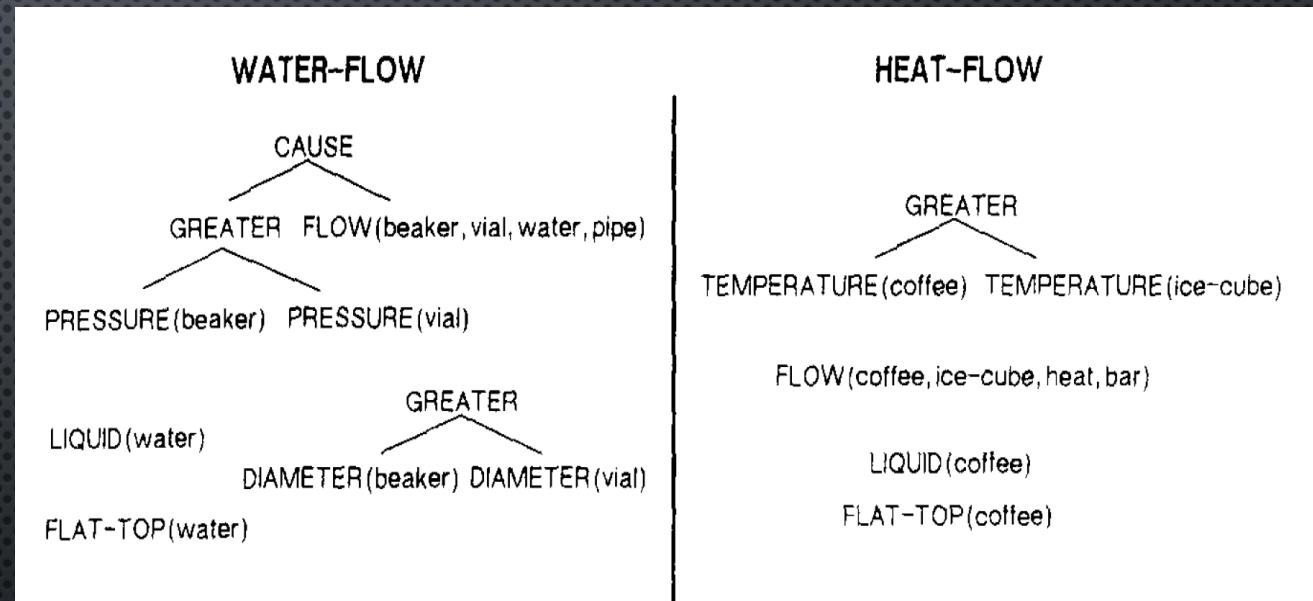


Fig. 2. Simplified water flow and heat flow descriptions.

# QUALITATIVE PROCESS MODELS

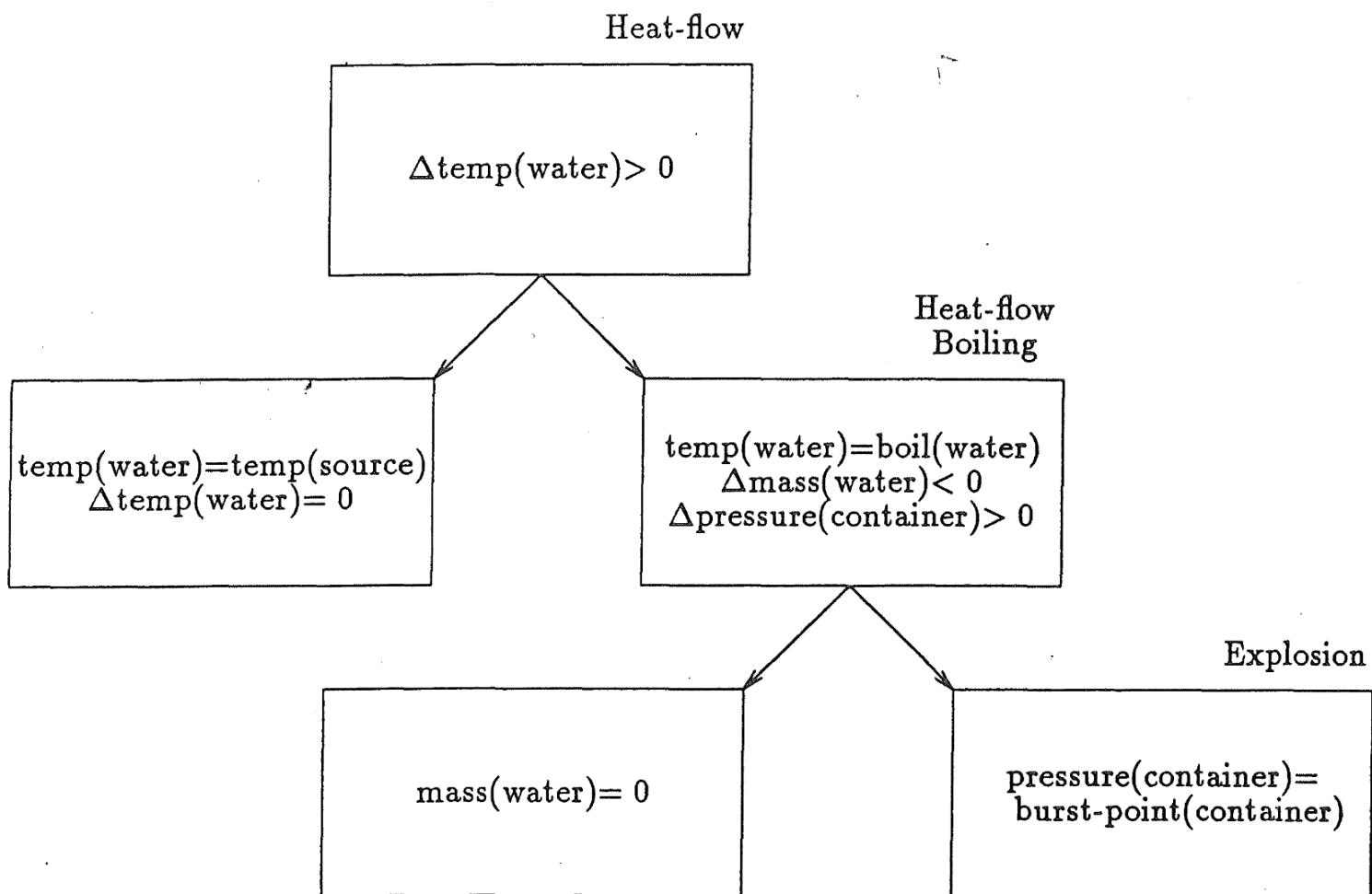


Figure 3. An envisionment for boiling water.

# APPROACHES

- NARRATIVES AND STORIES (PATRICK WINSTON)
  - HOW WE MAKE SENSE OF OUR COMPLEX ENVIRONMENT
- DREAMS
  - AID GENERALIZATION AND PREVENT OVERFITTING
- COMMONSENSE REASONING (DAVIS, MARCUS)

# STORY UNDERSTANDING

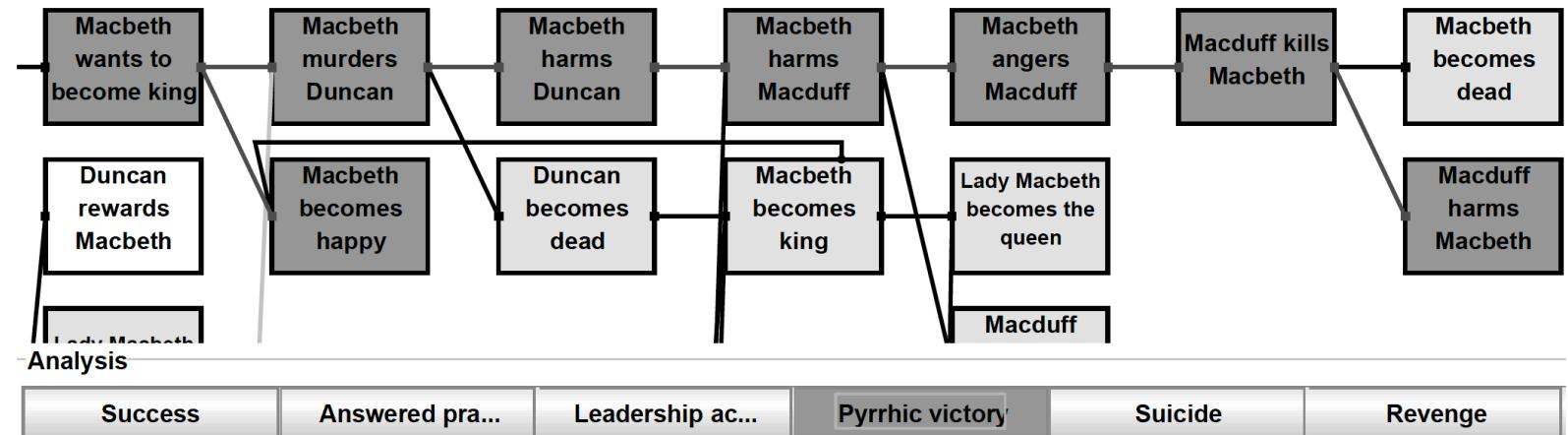


Figure 2: Genesis's story understanding system uses the elaboration graph, together with reflection patterns, to augment the explicit knowledge provided in the story and simple inferences generated using commonsense rules. Here, Genesis discovers a Pyrrhic victory, shown in dark gray.



### 1. In Search of the Bull

In the pasture of the world,  
I endlessly push aside the tall  
grasses in search of the Ox.  
  
Following unnamed rivers,  
lost upon the interpenetrating  
paths of distant mountains,  
My strength failing and my vitality  
exhausted, I cannot find the Ox.



### 2. Discovery of the Footprints

Along the riverbank under the  
trees,  
I discover footprints.  
  
Even under the fragrant grass,  
I see his prints.  
  
Deep in remote mountains they  
are found.  
  
These traces can no more be  
hidden  
than one's nose, looking  
heavenward. [\[web 8\]](#)



### 3. Perceiving the Bull

I hear the song of the nightingale.  
The sun is warm, the wind is mild,  
willows are green along the shore  
  
-  
  
Here no Ox can hide!  
What artist can draw that massive  
head,  
those majestic horns? [\[web 8\]](#)

# STORIES AND ANALOGIES

# COLLECTIVE INTELLIGENCE

- OTHER IDEAS
  - OTHER PATHS TO INTELLIGENCE (IN OTHER SPECIES)
  - COLLECTIVE INTELLIGENCE

# COLLECTIVE INTELLIGENCE

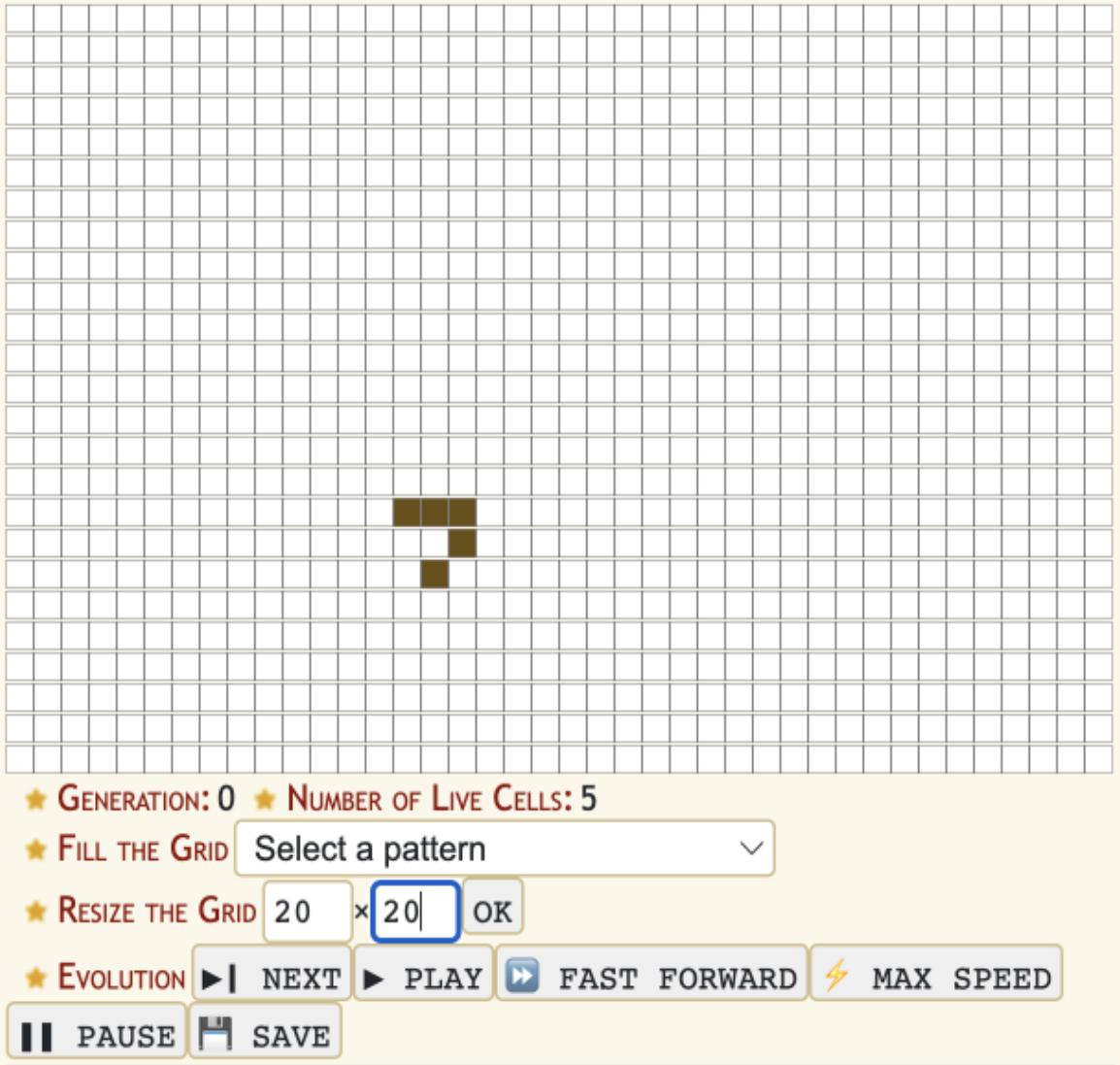
- TASK ALLOCATION AND DIVISION OF LABOUR
- COMPLEX NEST ARCHITECTURE
- STIGMERGY



MORPHOGENESIS OF TERMITE MOUNDS,  
PNAS, 2019

## THE GAME OF LIFE SIMULATOR

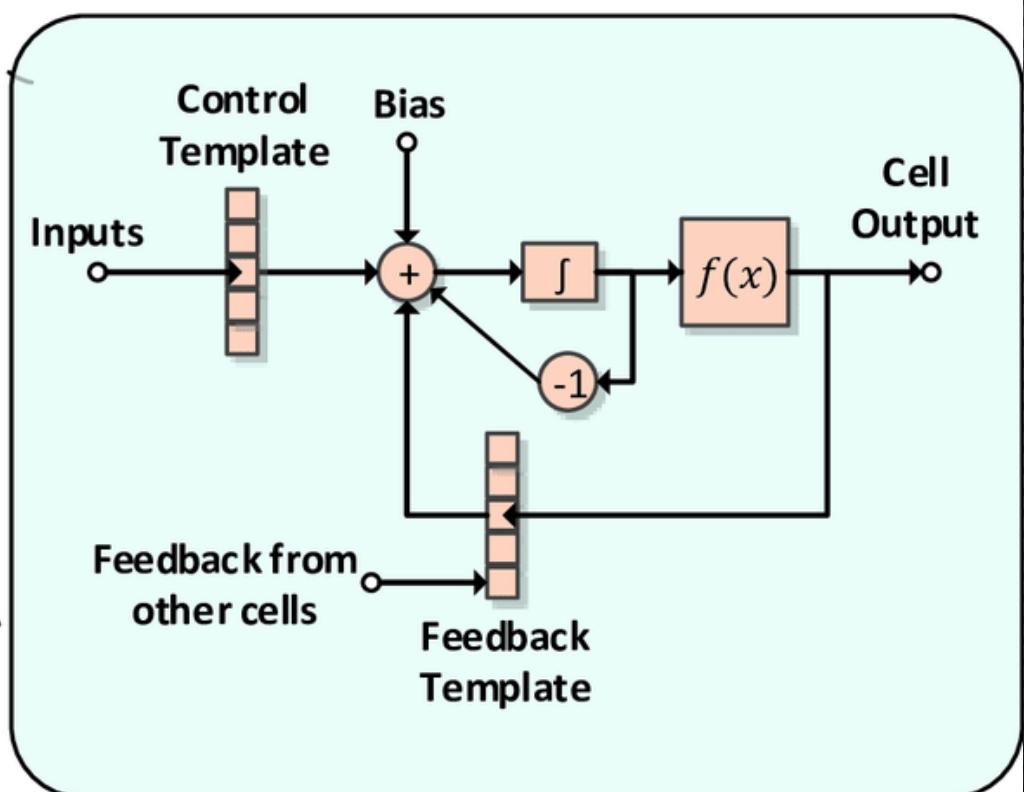
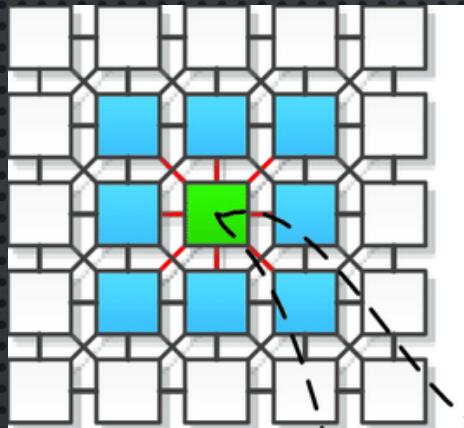
★ GRID FOR THE GAME OF LIFE



# COLLECTIVE INTELLIGENCE

- CELLULAR AUTOMATA
- IF A LIVING CELL IS TOO ISOLATED (0 OR 1 NEIGHBOR) THEN IT DIES THE NEXT EVOLUTION (DEATH BY UNDER-POPULATION).
- IF IT IS REASONABLY SURROUNDED (2 OR 3 NEIGHBORS) THEN IT REMAINS ALIVE, BUT WHAT IF IT IS SURROUNDED BY TOO MANY CELLS (4 OR MORE NEIGHBORS) IT DIES TO THE NEXT GENERATION (DEATH BY OVER-POPULATION).
- A CELL CAN ALSO BECOME A LIVE CELL IF A DEAD CELL IS SURROUNDED BY THREE LIVING CELLS, THEN IT BECOMES ALIVE (BIRTH BY REPRODUCTION).

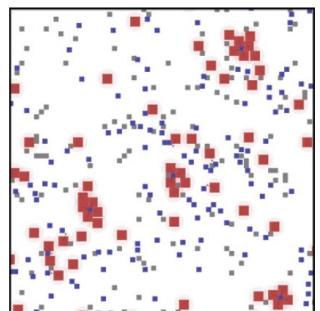
# COLLECTIVE INTELLIGENCE



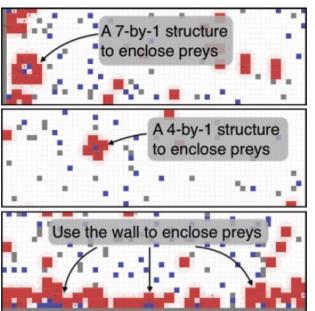
- CELLULAR NEURAL NETWORKS
- INSPIRATIONS FOR NOVEL DEEP LEARNING ALGORITHMS
- *COLLECTIVE INTELLIGENCE FOR DEEP LEARNING: A SURVEY OF RECENT DEVELOPMENTS*

SOFT RADIAL BASIS CELLULAR NEURAL NETWORK (SRB-CNN) BASED ROBUST LOW-COST TRUCK DETECTION USING A SINGLE PRESENCE DETECTION SENSOR, 2016

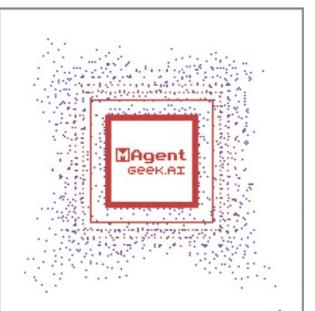
# COLLECTIVE INTELLIGENCE



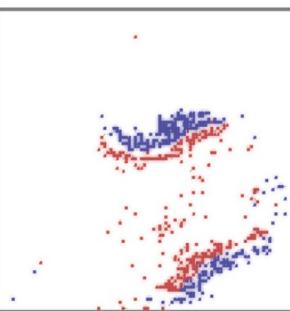
(a) Pursuit (1)



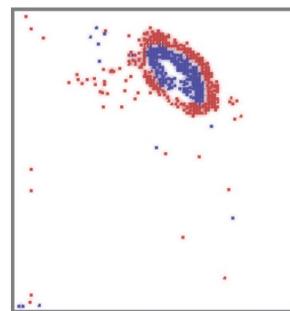
(b) Pursuit (2)



(c) Gathering

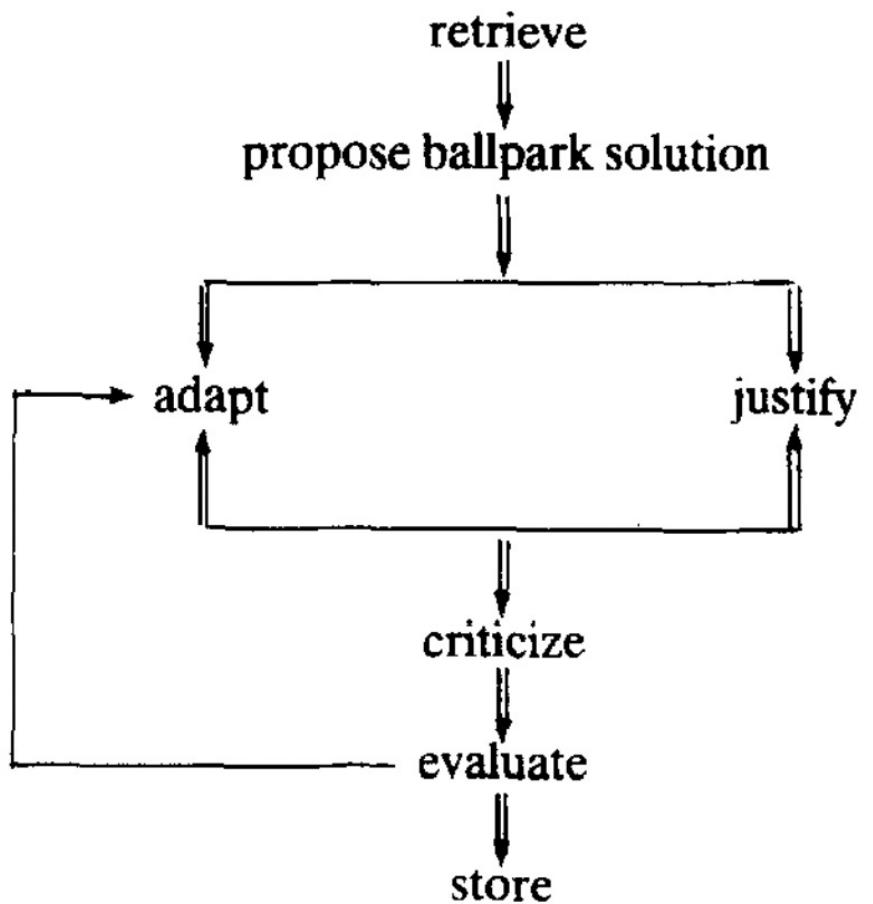


(d) Battle (1)



(e) Battle (2)

- GRID WORLD
- MILLIONS OF AGENTS
- EVOLUTION OF CO-OPERATION, COMPETITION, ALTRUISM AND OTHER STRATEGIES



*Fig. 1. The case-based reasoning cycle.*

# CASE BASED REASONING

- HOW HUMANS REASON
- DOCTORS, LAWYERS, ...

AN INTRODUCTION TO CASE BASED  
REASONING, JANET KOLODNER, 1992

# APPROACHES

- DREAMS
  - AID GENERALIZATION AND PREVENT OVERFITTING
- COMMONSENSE REASONING (DAVIS, MARCUS)

# EXPLAINABILITY

- EXPLAINABILITY (INSIGHTS FROM SOCIAL SCIENCES)
  - MILLER, 2019
- HOW DO YOU GENERATE EXPLAINABLE MODELS BY WORKING WITH DOMAIN EXPERTS
  - RUDIN, 2019
  - IMPORTANT FOR HIGH STAKES DECISIONS IN DOMAINS LIKE HEALTHCARE, RECIDIVISM PREDICTION
- HOW CAN WE TAKE INSPIRATION FROM ALL THESE APPROACHES AND DEVELOP NEW XAI TECHNIQUES?

# RESOURCES

- [HTTPS://GITHUB.COM/NEELSOUMYA/SPECIAL\\_TOPICS\\_UNCONVENTIONAL\\_AI](https://github.com/NEELSOUMYA/SPECIAL_TOPICS_UNCONVENTIONAL_AI)

# ADMINISTRIVIA

- PRESENTATIONS

- PRESENT AND LEAD A DISCUSSION ON ONE OF THESE PAPERS (OR ANY OTHER RELATED PAPER: COME SPEAK WITH ME).
- THE IDEA IS THAT YOU RAISE SOME INTERESTING QUESTIONS.
- THIS COURSE IS MEANT TO TEACH YOU RESEARCH SKILLS (LIKE THINKING CRITICALLY ABOUT A PAPER, LITERATURE REVIEW SKILLS, WRITING).
- 15 MIN PRESENTATION, 15 MIN Q&A

# ADMINISTRIVIA

- WRITEUP/REPORT
  - ON THE PAPER YOU PRESENT, AND THE TOPIC IN GENERAL (UNCONVENTIONAL AI).
  - DO A LITERATURE REVIEW OF OTHER PAPERS IN THE FIELD.
  - REFLECT/WRITE ON HOW THESE TECHNIQUES CAN BE INCORPORATED IN MODERN AI/DEEP LEARNING.
  - THE INTENTION IS FOR YOU TO
    - LEARN HOW TO READ PAPERS
    - COMPARE AND CONTRAST THEM TO OTHER PAPERS
    - THEN THINK WHAT THIS MEANS FOR MODERN AI/DEEP LEARNING.
  - SHOW ME EARLY DRAFTS

# ADMINISTRIVIA

- WRITEUP/REPORT
  - SHORT REPORT (LESS THAN 4000 WORDS). THE IDEA IS TO WRITE A COHERENT NARRATIVE.
  - SUGGEST HOW THESE IDEAS CAN BE INCORPORATED IN MODERN AI/DEEP LEARNING SYSTEMS
  - WHY DO YOU THINK THESE IDEAS WERE NOT SUCCESSFUL IN THE 1950s/1960s?
  - WHAT KIND OF DATA WOULD WE NEED TO ENSURE THESE TECHNIQUES WOULD WORK TODAY?
  - WHAT LESSONS CAN WE LEARN FROM THE HISTORY OF AI, WHAT APPROACHES WORKED AND DID NOT WORK IN THE PAST?
  - WHAT COULD BE THE DISADVANTAGES OF THESE APPROACHES?
  - RATIONAL RECONSTRUCTION (ANALYTICAL LITERATURE REVIEW/SURVEY) OF A RESEARCH AREA
- OTHER THOUGHTS ON THE WRITEUP
  - A DETAILED RESEARCH PROPOSAL WITH SOME GROUND WORK ALREADY ACCOMPLISHED

# ADMINISTRIVIA

- HOW TO READ PAPERS

- [HTTPS://WWW.CS197.SEAS.HARVARD.EDU/](https://www.cs197.seas.harvard.edu/)
- [HTTPS://DOCS.GOOGLE.COM/DOCUMENT/D/1bPhwNdCCKkm1\\_ADD0rx1YV6r2JG98qYMTxUTT5GDAdQ/E  
DIT#HEADING=H.YXLVJ6BO3Y2](https://docs.google.com/document/d/1bPhwNdCCKkm1_ADD0rx1YV6r2JG98qYMTxUTT5GDAdQ/edit#heading=h.yxlvj6bo3y2)
- READ WIDELY AND THEN FOCUS ON A FEW PAPERS
- TAKE MULTIPLE PASSES THROUGH PAPERS

# ADMINISTRIVIA

- HOW TO WRITE
  - WRITE REGULARLY
  - SCHEDULE TIME FOR WRITNG
  - [HTTPS://SITES.GOOGLE.COM/SITE/NEELSOUMYA/RESEARCH-RESOURCES/SCIENTIFIC-WRITING](https://sites.google.com/site/neelsoumya/research-resources/scientific-writing)
  - [HTTPS://WWW.YOUTUBE.COM/WATCH?V=DeVjXInr5Wk](https://www.youtube.com/watch?v=DeVjXInr5Wk)
  - BOOK ON WRITING (CONTACT ME TO BORROW A COPY)
    - *HOW TO WRITE A LOT: A GUIDE TO PRODUCTIVE ACADEMIC WRITING* (PAUL SILVIA)
  - PICK A PAPER NOW AND START WRITING YOUR THOUGHTS

# ADMINISTRIVIA

- PICK PAPERS AND ASSIGNED READING
  - DATES AND NAMES
  - WE ALL READ PAPERS BEFORE THE CLASS
  - CLASS PARTICIPATION
    - PREPARE A QUESTION BEFOREHAND



### 3. Perceiving the Bull

I hear the song of the nightingale.  
The sun is warm, the wind is mild,  
willows are green along the shore

-

Here no Ox can hide!  
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