

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

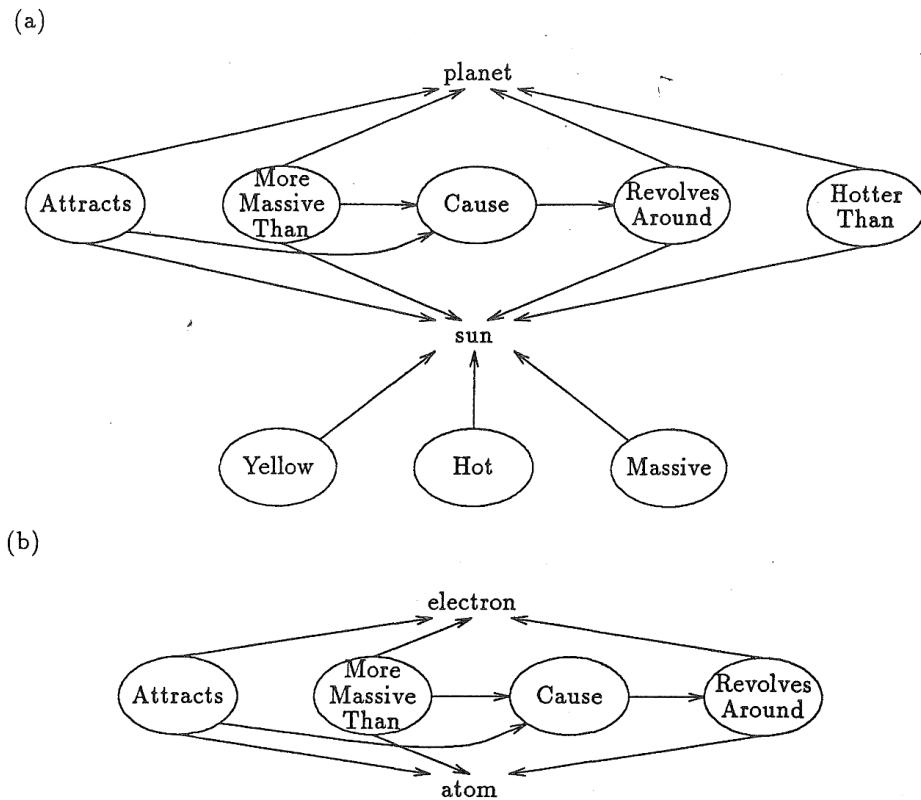
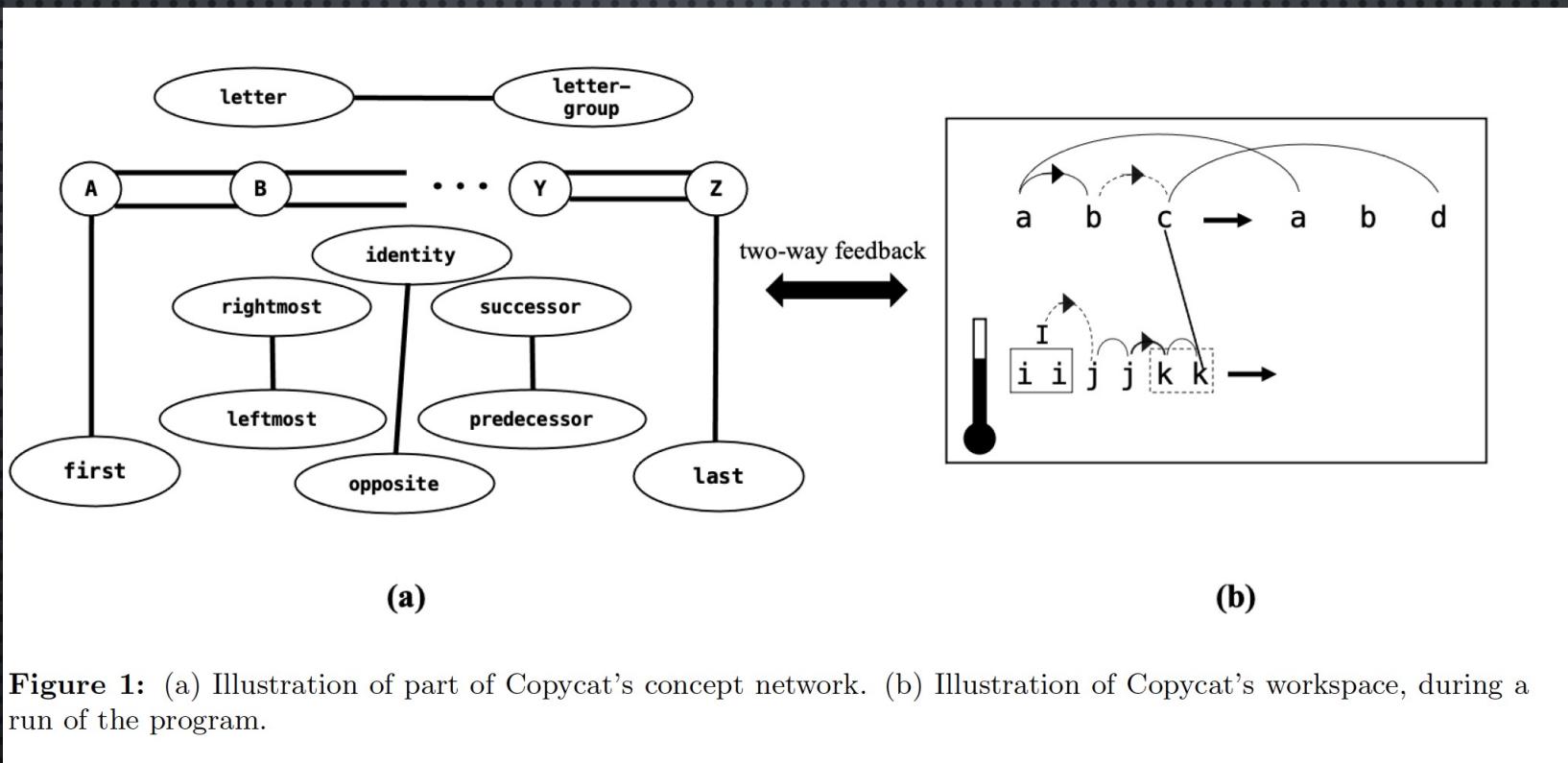


Figure 2. Creating a representation for the atom from the statement, "The atom is like the solar system." Higher order relations are carried over and simple attributes are ignored.

ANALOGY

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

APPROACHES



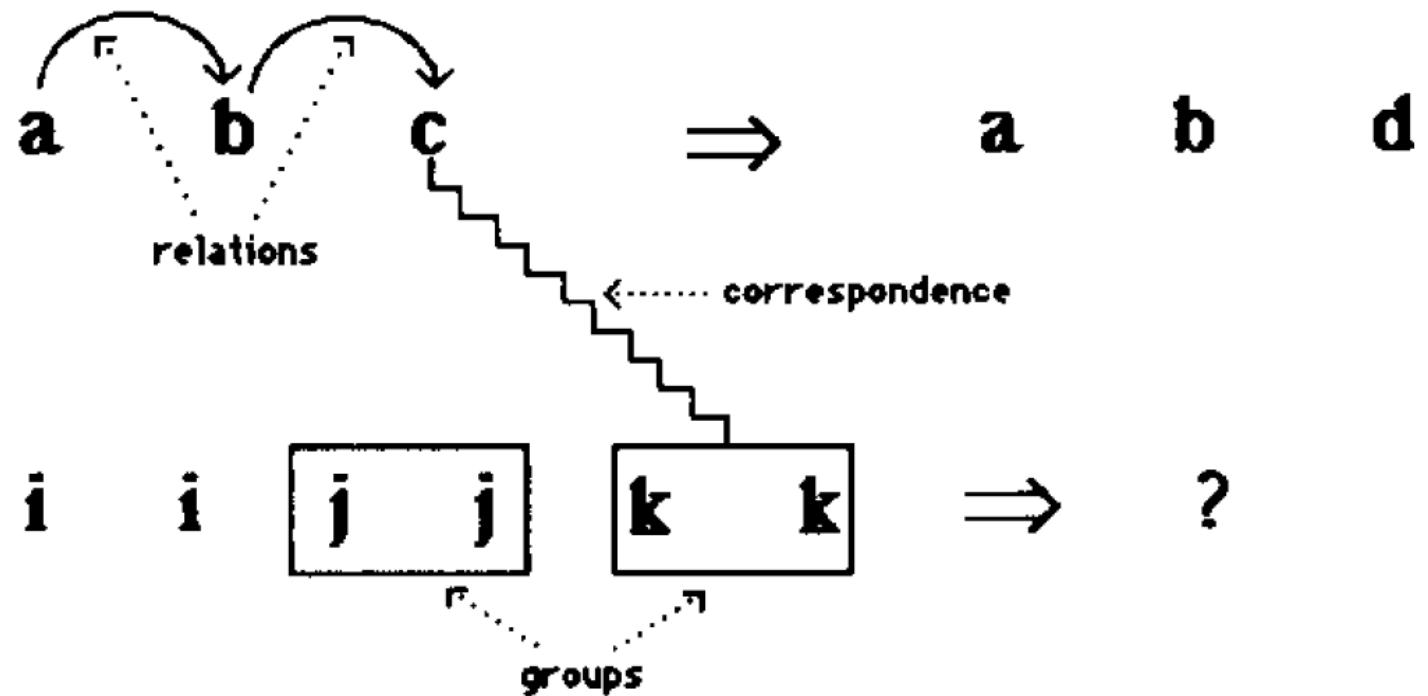
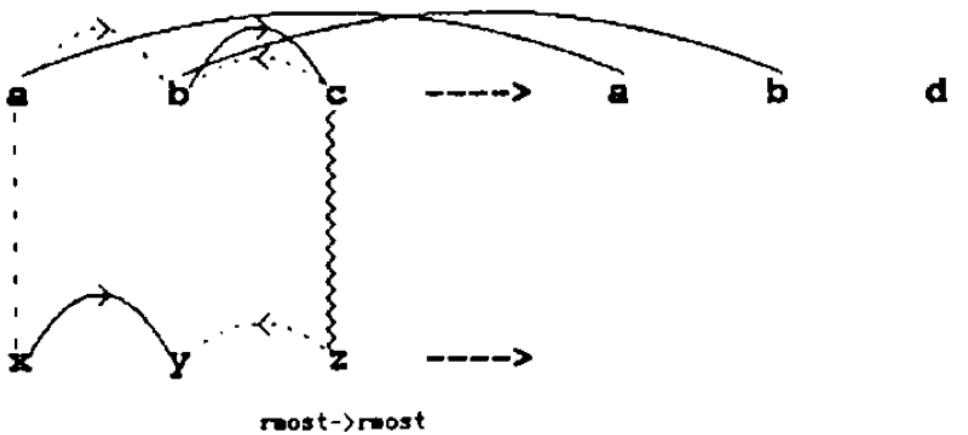


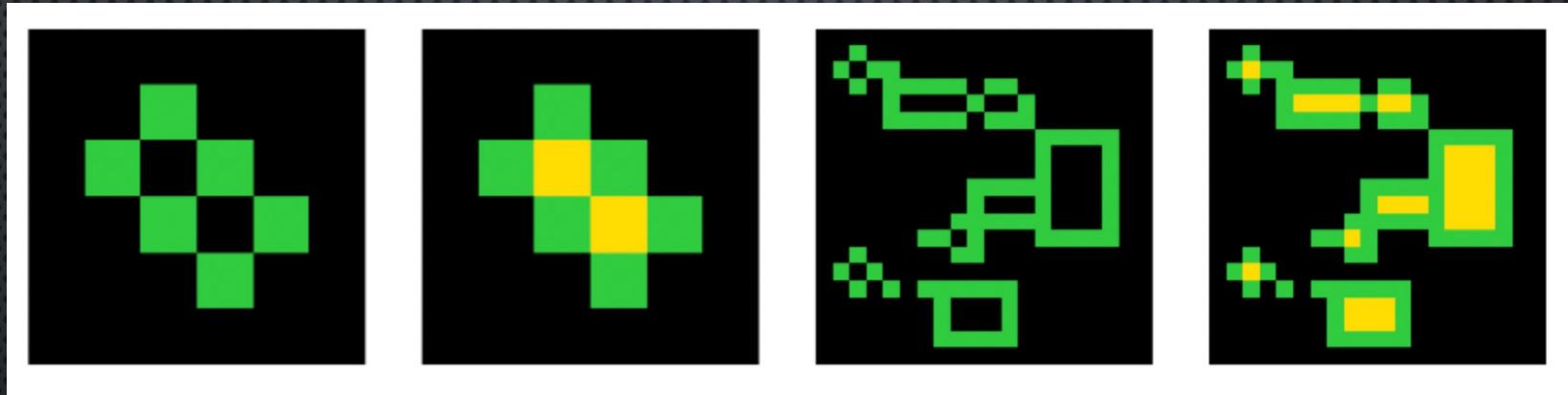
Fig. 2. Perceptual structures, including relations, groups, and a correspondence.

Fig. 2 shows examples of perceptual structures that could be built in the process of solving the problem “ $\textit{abc} \Rightarrow \textit{abd}$, $\textit{iijjkk} \Rightarrow ?$ ”. 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 *iijjkk*). (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

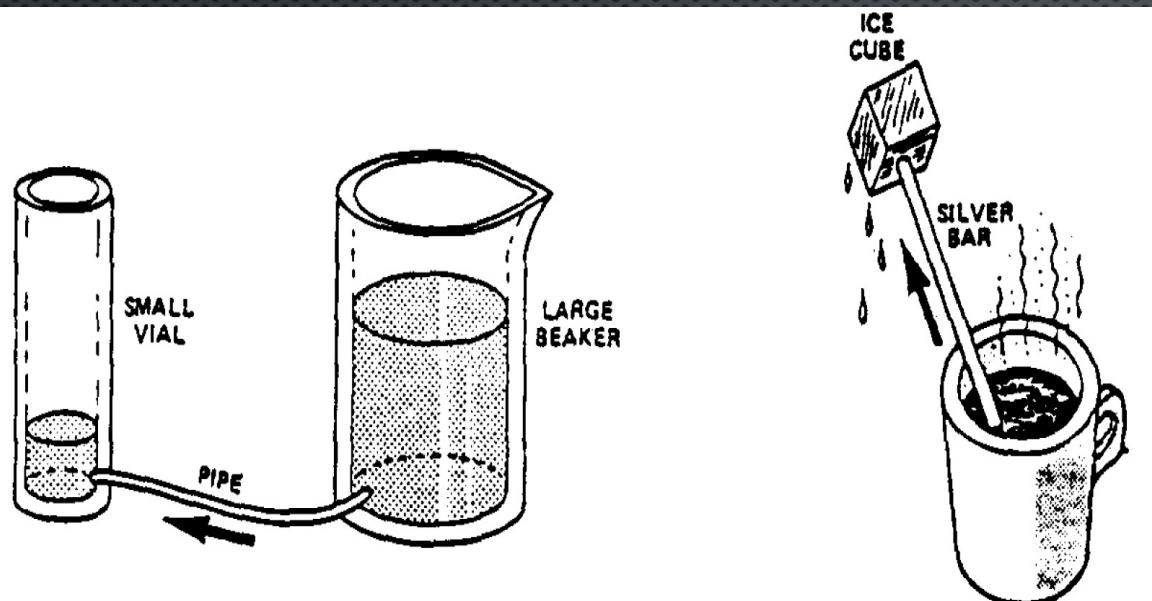


Fig. 1. Two physical situations involving flow (adapted from [3]).

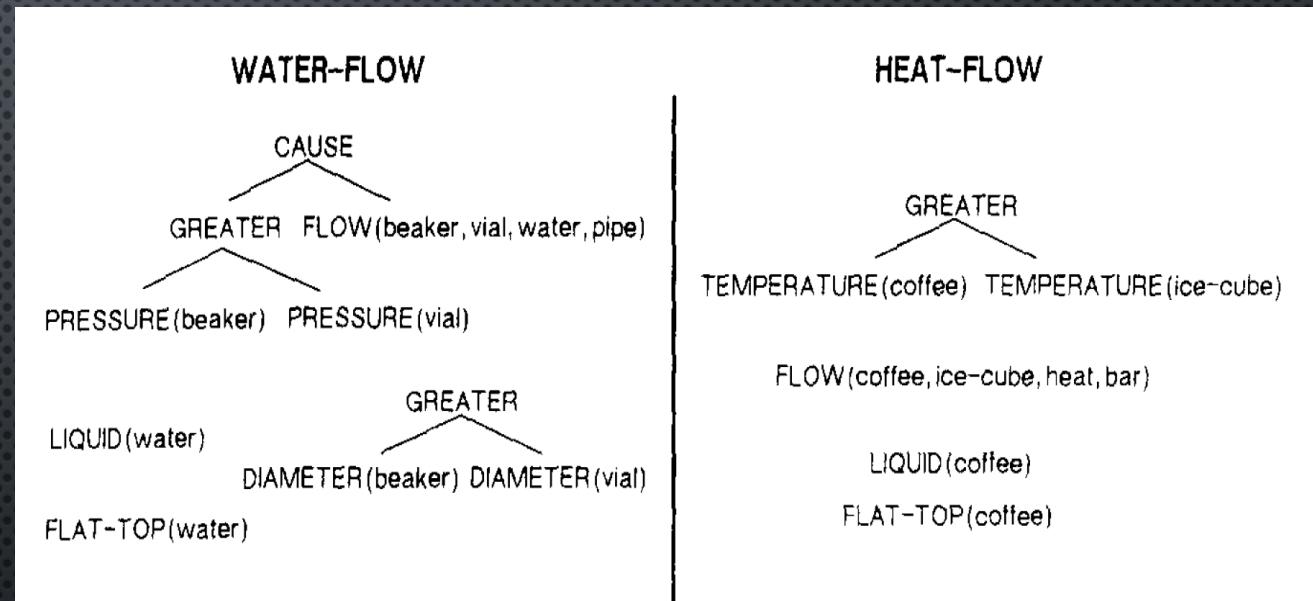


Fig. 2. Simplified water flow and heat flow descriptions.

QUALITATIVE PROCESS MODELS

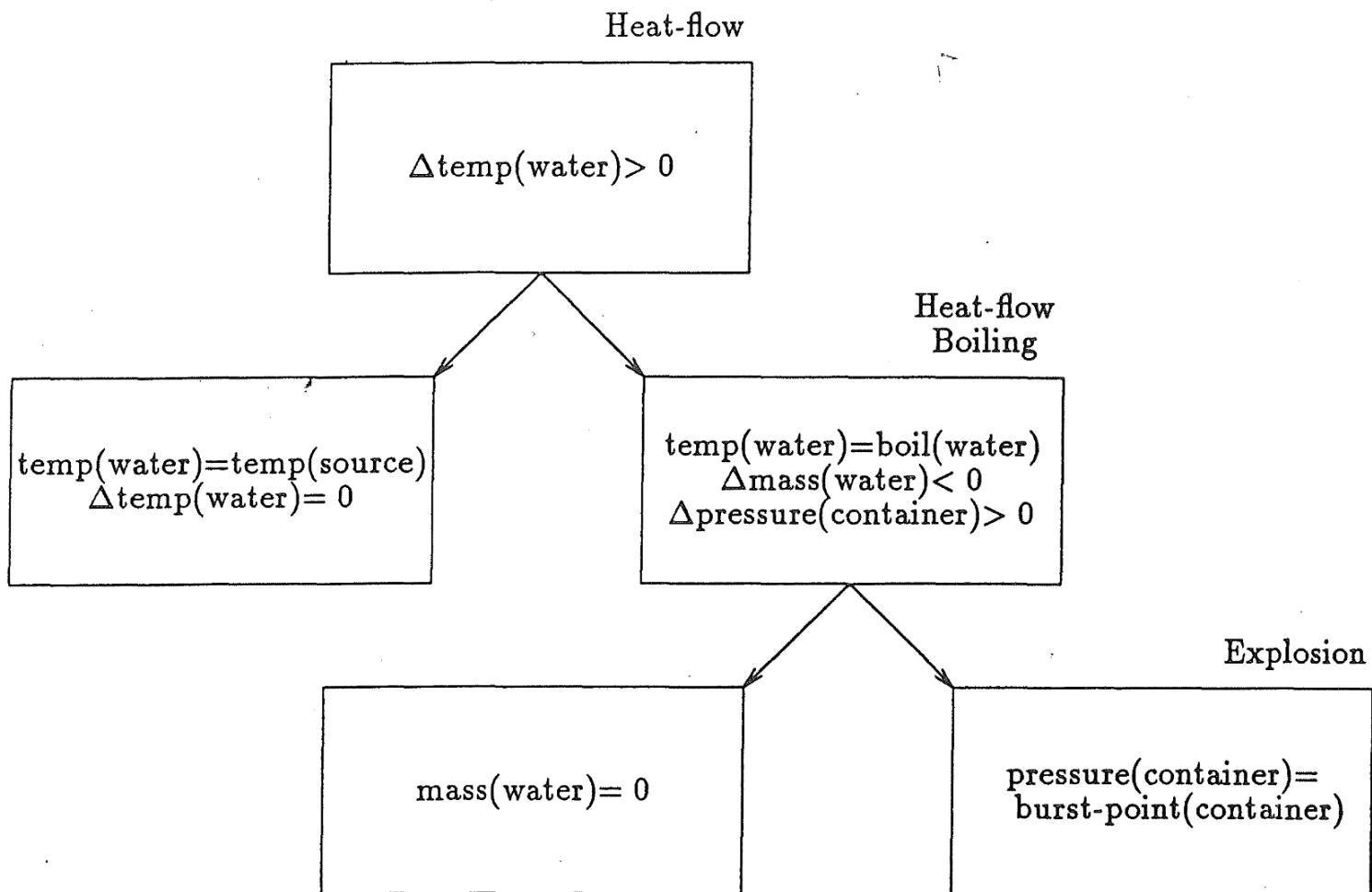


Figure 3. An envisionment for boiling water.

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

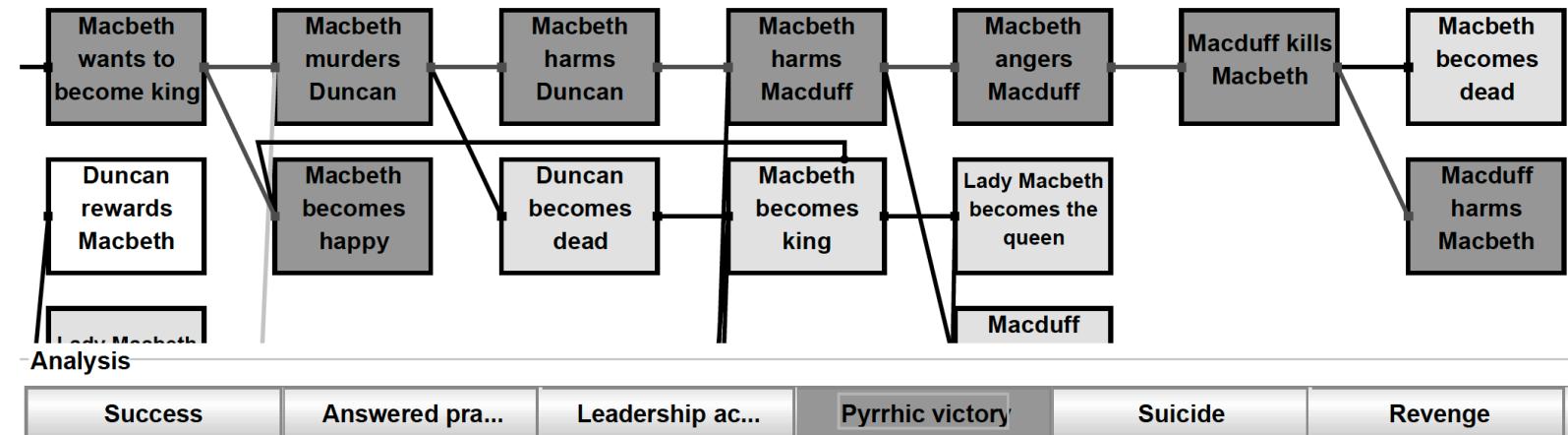


Figure 2: Genesis's story understanding system uses the elaboration graph, together with reflection patterns, to augment the explicit knowledge provided in the story and simple inferences generated using commonsense rules. Here, Genesis discovers a Pyrrhic victory, shown in dark gray.



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

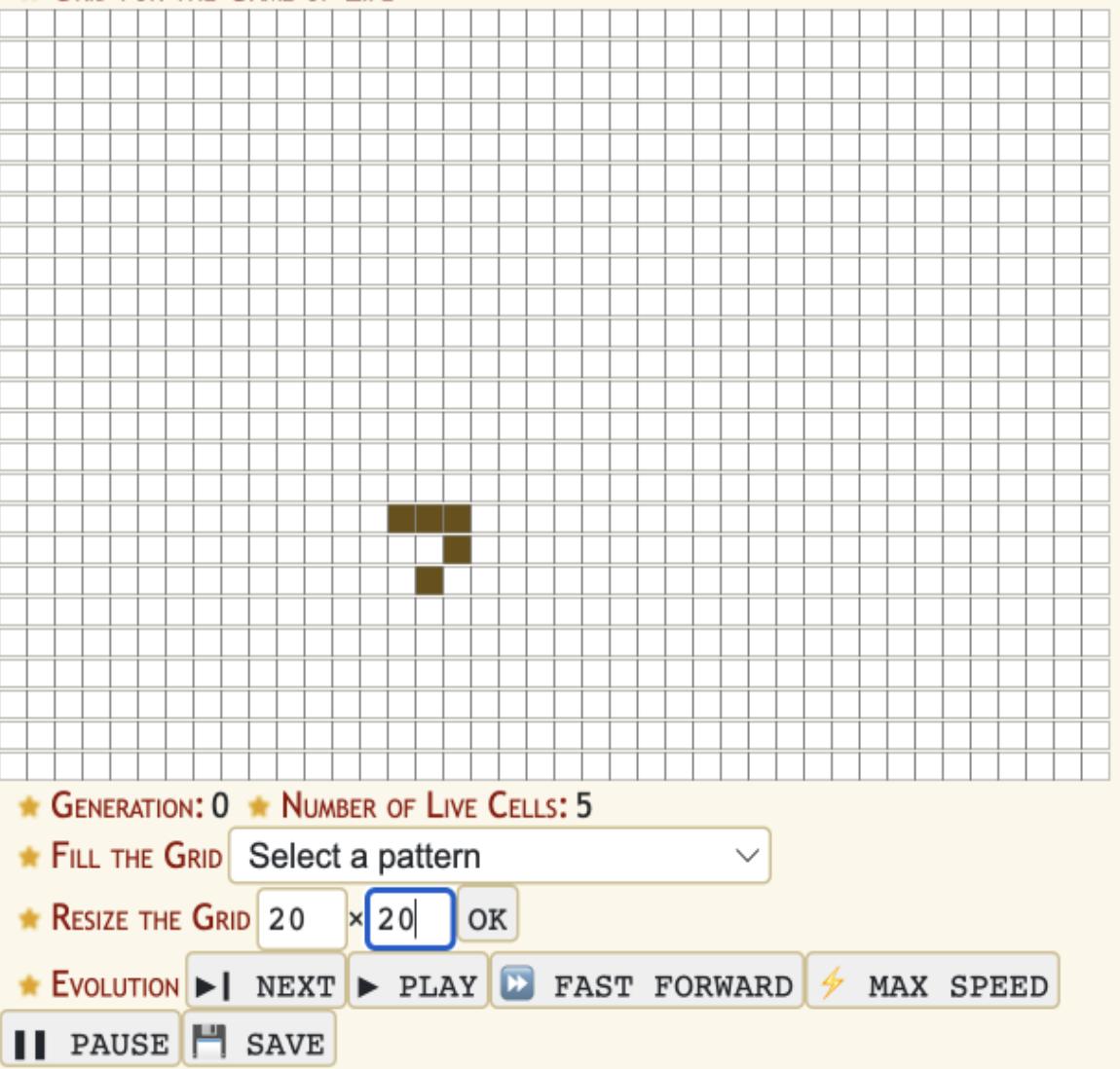
- TASK ALLOCATION AND DIVISION OF LABOUR
- COMPLEX NEST ARCHITECTURE
- STIGMERGY



MORPHOGENESIS OF TERMITE MOUNDS,
PNAS, 2019

THE GAME OF LIFE SIMULATOR

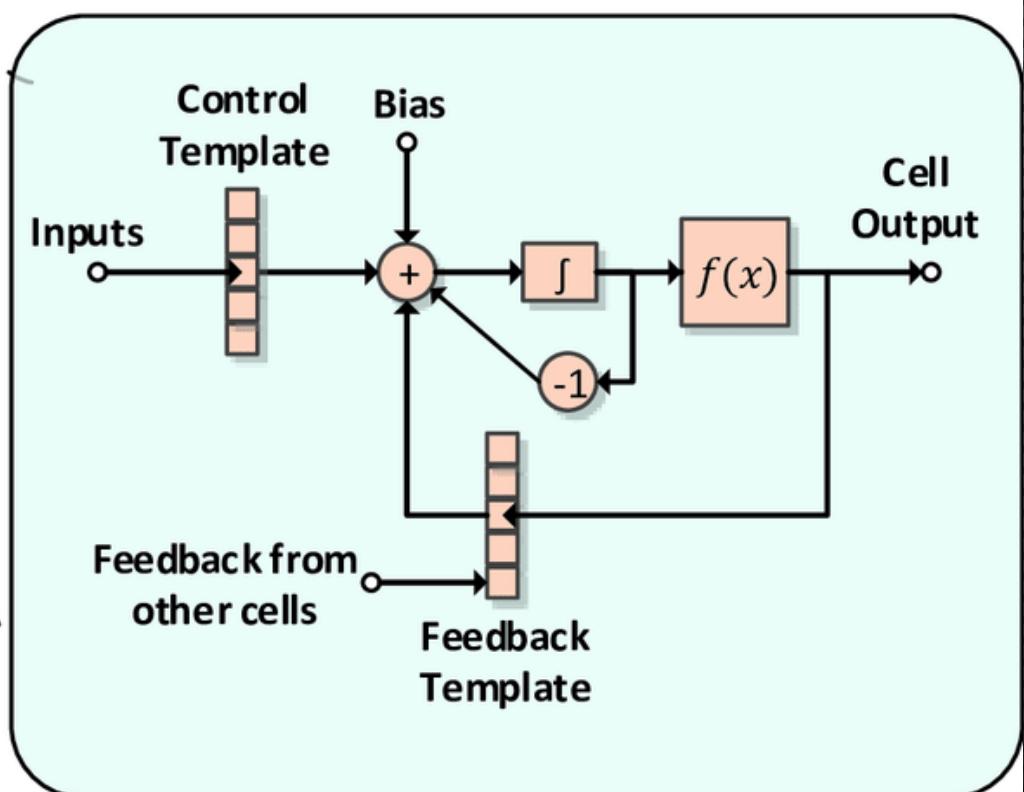
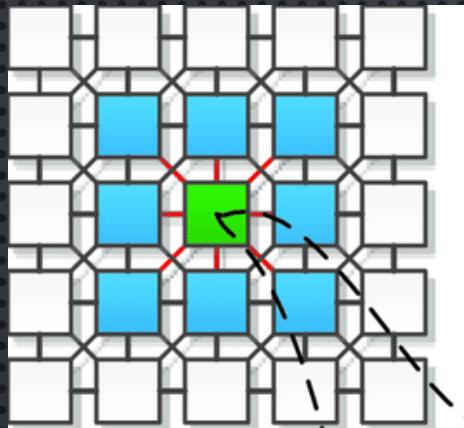
★ GRID FOR THE GAME OF LIFE



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).

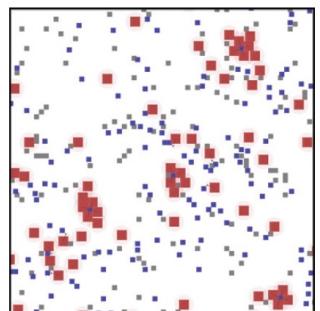
COLLECTIVE INTELLIGENCE



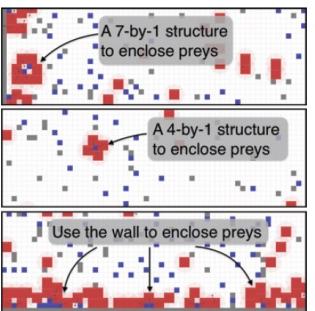
- CELLULAR NEURAL NETWORKS
- INSPIRATIONS FOR NOVEL DEEP LEARNING ALGORITHMS
- *COLLECTIVE INTELLIGENCE FOR DEEP LEARNING: A SURVEY OF RECENT DEVELOPMENTS*

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

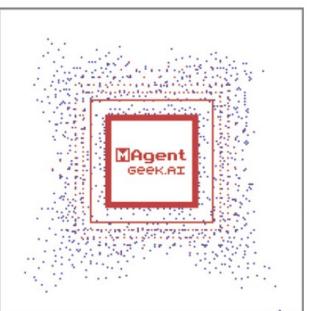
COLLECTIVE INTELLIGENCE



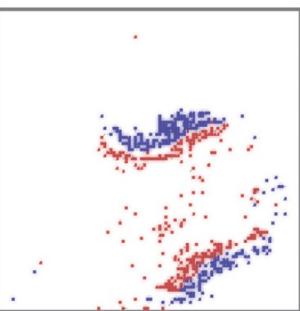
(a) Pursuit (1)



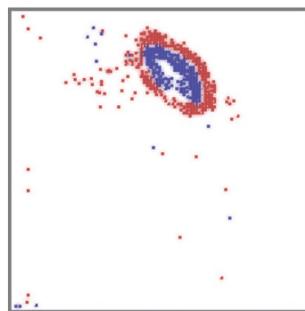
(b) Pursuit (2)



(c) Gathering



(d) Battle (1)



(e) Battle (2)

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

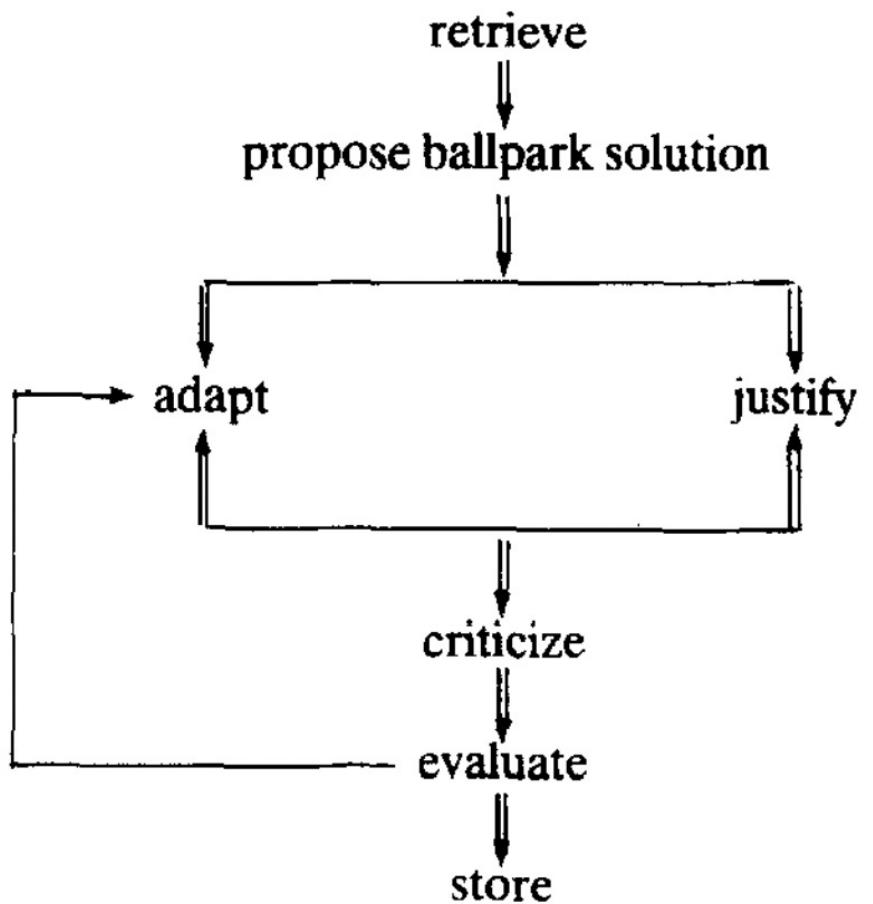


Fig. 1. The case-based reasoning cycle.

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

-

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