# Genesis

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Winston, P. H. (2014) <u>The Genesis Story Understanding and Story</u> <u>Telling System: A 21st Century Step toward Artificial Intelligence</u>, CBMM Memo No. 019.

# OUTLINE

**Vision:** What makes humans different?

**Steps:** Aspects of story understanding and directed perception

**News:** The Genesis System

**Contributions:** A 21st century step towards AI

# VISION

If we are to develop systems of human level intelligence, we must develop computational models of story understanding and directed perception.

#### VISION



Tattersall, I., 2008, An Evolutionary Framework for the Acquisition of Symbolic Cognition by Homo sapiens, *Comparative Cognition and Cognitive Reviews*, Volume 3, pp.99-114

### The Inner Language Hypothesis

"Using a symbolic inner language, we construct symbolic descriptions of situations and events that are far beyond the reach of other primates."

### The Strong Story Hypothesis

"Our inner language enables us to tell, understand, and recombine stories, and those abilities distinguish our intelligence from that of other primates."

### **The Directed Perception Hypothesis**

"Our inner language enables us to direct the resources of our perceptual systems to answer common-sense questions about real and imagined events, generating common-sense knowledge as a by-product."

### **The Social Animal Hypothesis**

Our social nature amplifies the value of story understanding and directed perception.

#### 1. Identify the Competence to be Understood

**Macbeth:** Macbeth, Macduff, Lady Macbeth, and Duncan are persons. Macbeth is a thane and Macduff is a thane. Lady Macbeth, who is Macbeth's wife, is greedy. Duncan, who is Macduff's friend, is the king, and Macbeth is Duncan's successor. Macbeth defeated a rebel. Witches had visions and talked with Macbeth. The witches made predictions. Duncan became happy because Macbeth defeated the rebel. Duncan rewarded Macbeth because Duncan became happy. Lady Macbeth, who is Macbeth's wife, wants to become the queen. Lady Macbeth persuades Macbeth to want to become the king. Macbeth murders Duncan. Then, Lady Macbeth kills herself. Dunsinane is a castle and Burnham Wood is a forest. Burnham Wood came to Dunsinane. Macduff had unusual birth. Macduff fights with Macbeth and kills him. The predictions came true.

Who ends up dead? Why did Macduff kill Macbeth? Do the stories involve revenge? Which story presents a Pyrrhic victory?

#### 2. Formulate Computational Problems

How do we represent physical, social, and emotional relations and qualities; how do we represent actions and events; how do we represent common-sense and reflective knowledge?

#### **3.Propose Computational Solutions**

Genesis' inner language:

Categories: Class, transition, trajectory, path, place,...

Representations: Cause, goal, persuasion, belief, social relations..

Elaboration Graph

Concept Patterns

4. Develop an Exploratory Implementation

### Start Parser: Generate Genesis' inner language

Wordnet: classification categories

#### **5.Crystalize Emergent Principles**

Genesis exhibits some characteristics of human story understanding evidenced by its ability to answer a variety of questions about the stories it reads, yet it does its work using only about two dozen common-sense rules and another dozen reflective patterns, several of which, revenge in particular, arose frequently in our experiments.

#### **News: Genesis System**

**<u>Central Idea:</u>** To understand the nature of intelligence, it is essential to shed light on how humans understand stories.

Genesis *analyzes stories* ranging from Shakespeare's plots to descriptions of conflicts in cyberspace. Genesis works with *short story summaries*, provided in English, together with *low-level common-sense rules* and *higher-level concept patterns*, likewise expressed in English. Using only a small collection of common-sense rules and concept patterns, Genesis demonstrates several story understanding capabilities.

#### Example of story understanding capabilities



Genesis determines that both *Macbeth* and the 2007 Russia-Estonia Cyberwar involve revenge, even though neither the word revenge nor any of its synonyms are mentioned.

#### Genesis deploys common sense rules to develop basic understanding

- Use START to translate Genesis English into inner language of relations and events.
- Use common sense to build an *elaboration graph*.
- Story elements:
  - <u>Yellow:</u> established by *inference rules*
  - <u>Orange:</u> established by story; connected by *explanation rules*
  - <u>Blue:</u> by story; connected by *leads-to expressions*
  - <u>White:</u> by story

#### **Elaboration Graph**

Demonstrate Read About III Views Controls Start viewer Experts Elaboration graph Inspector Sources Results Summary Story Macbeth/revenge Rules: 39 Macbeth Lady Macbeth Macbeth Duncan Duncan Macbeth Macbeth Macbeth Lady Macduff Macbeth Macduff beth is Lady Macbeth is Lady Lady Macbeth Lady Macbeth ersuades Macbeth Macbeth Macbeth wants to is Macbeth's defeats becomes rewards murders harms harms arms Lady harms angers Lady Macbeth's husband. Macbeth's relation. s Macbeth's becomes becomes Inferences: 64 wife. friend. Cawdor. happy. Macbeth. king. become king Duncan. Macduff. Duncan. Macduff. Macduff. unhappy. Macduff. unhappy. Concepts: 14 Lady Macduff Discoveries: 9 Lady Macbet Macbeth Duncan adv Macbeth Macbeth Macbeth facduff is Lady acheth is Lade is Macduff's Macduff's husband. is Macbeth's becomes becomes becomes becomes harms Explicit elements: 43 wife. relation. king. dead. queen. happy. Duncan. Inferred elements: 38 Macduff is Macduff is Lady Macduf Total elements: 81 Cawdor's Duncan's and off in 1 and is Macduff's enemy. friend. friend. Story reading time: 4.9 sec Total time elapsed: 13.9 sec -Duncan is luncan is Lady Macduft cduff is Lady Cawdor's Macduff's is Macduff's acduff's frien enemy. friend. relation. Duncan ady Macbe theth is Lad Macbeth's is a king. cbeth's frien relation. Macbeth is Lady Macbet lacbeth is Lad Macbeth's relation. Duncan's s Macbeth's successor. friend. ady Macduf Macduff is Lady Macduff's friend is Macduff's relation. Lady Macduff is Macduff's friend. facduff is Lady acduff's relatio Macbeth Macduff ady Macb Macbeth Macbeth Macbeth Macbeth Macduff Macbeth Macbeth Lady Macbet Macduff Macduff Lady Macbeth Lady Macbeth Lady Macbeth Macduff kills angers Macduff. flees to angers Macbeth. irders La arms Lady harms harms Lady becomes angers becomes harms harms becomes kills herself harms herself. harms herself Macbeth England. istraugh Macduff. Macduff. Macduff. Macduff. unhappy. Macduff. unhappy. Macbeth. Macbeth. Macbeth Macbeth Lady Macb Macduff harms harms harms harms Lady Macduff. Duncan. Macbeth. Macbeth. Lady Macbeth becomes dead. Macbeth Lady Macdul becomes becomes dead. dead. Analysis

#### Genesis reflects on its reading, searching for concepts



 After elaboration graph is built, Genesis uses ordinary search to find instances of concept patterns.



## Concept Patterns In Green

#### Genesis reads stories with controllable allegiances and cultural biases

- Genesis's interpretation depends on the common sense rules, concept patterns supplied, and biases of the reader.
- Examples:
  - Estonia-Russia cyberwar: reader friendly to Estonia VS reader friendly to Russia
  - <u>Macbeth:</u> western reader VS eastern reader



#### Genesis models personality traits

Genesis infers personality traits on the basis of people's action. It also uses personality traits to explain acts.

• Example: In Macbeth - vicious

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Demonstrate Read About			
Views Controls Start viewer Experts Elaboration graph Inspector Sources Results Summary Story	Views Controls Start viewer Experts Elaboration graph	h Inspector Sources Results Summary Story	
Personality analysis Predictions Concept analysis	ambitious evil orazy greedy machiavellian violous		
Macduff seems to be vicious because Macduff assaults someone. Macduff kills Macbeth because Macduff is vicious.	Rules: 3   Inferences: 0   Concepts: 1   Discoveries: 0   Explicit elements: 6   Inferred elements: 6   Story reading time: 4.3 sec   Total elements: 4.8 sec   Analysis	haracteristics	
Results	Mental Models		

#### Genesis answers basic questions about why and when

- Genesis answers questions on various levels.
- Example of levels:
  - Using elements of elaborations graphs
  - Using personality traits



## From a personality perspective

It looks like Dr. Jekyll thinks Macduff kills Macbeth because he is vicious.

### On a commonsense level

It looks like Dr. Jekyll thinks Macduff kills Macbeth, probably because Macduff wants to kill Macbeth and Macduff is vicious.

## On a concept level

It looks like Dr. Jekyll thinksMacduff kills Macbeth is part of acts of Revenge, Answered prayer, Mistake because harmed, Pyrrhic victory, and Tragic greed.

Results

#### Why did Macduff kill Macbeth?

#### Genesis notes concept onsets, anticipating trouble

This involves leads-to relations.

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Demonstrate Read About						
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			Cyber war	4		
Misguided retaliation	1 Rules: 33 Inferences: 6 Concepts: 14	Estonia builds computer networks. Estonia believes computer networks. Estonia believes computer networks. Estonia believes computer networks.	Estonia relocates war memorial.			
Revenge	1	Discoveries: 0 Explicit elements: 9 Inferred elements: 6 Total elements: 15	Estonia Estonia Estonia	Russia		
		Story reading time: 0.5 sec Total time elapsed: 2.2 sec	insul <del>ts harms angers</del> Russia. <mark>Russia. Russia.</mark>	becomes unhappy.		
Mistake because harmed	1	Analysis				
			94%			
Onsets		Elaboration graph				

#### Genesis calculates similarity using concepts

Genesis judges similarity in multiple ways:

- <u>Using word vectors</u>
- <u>Using concept vectors</u>: seeing similarities not evident in the words.



13: China war with vietnam 14: Romania and ceausescu 15: Congo civil conflict

#### Genesis models question-driven interpretations

- After reading a story, a question may stimulate further analysis and expose new conclusions.
- Example:
  - Eastern-Western story understanding experiment





# Stimulated by a question

#### More capabilities

- Genesis aligns similar stories for analogical reasoning (Needleman-Wunch algorithm)
- Genesis tells and persuades using a reader model
- Genesis develops summaries

#### Genesis operates on all of Minsky's six levels

Correspondences between Minsky's levels and Genesis competences:

- Inference rules: instinctive and learned reactions
- Explanation rules: deliberative thinking
- Concept patterns: reflective thinking
- Mental models: some self-reflective thinking and self-conscious reflection.

#### Minsky's Six Levels

Values, Censors, Ideals and Taboos Self-Conscious Reflection Self-Reflective Thinking Deliberative Thinking Learned Reactions Instinctive Reactions

## **Next steps/Future**

- Work under way
- Major blockers
- CBMM challenge

# Work underway

- A system that composes original stories from precedents
- A system that mines literature for actions associated with personality traits
- A system that tells stories with metaphorical reference to precedents
- A system that uses story understanding apparatus to plan

# Major blockers

- Getting Genesis to think about itself
- Scaling up by expanding English understanding
- The visual story

# **CBMM Challenge**

- Understand pictures and videos computationally, developmentally, neurobiologically, and socially.
- Pictures and videos tell stories.

# Contributions

- For CBMM: Handling stories told in pictures and video.
- For science in general: A better understanding of the key differentiator of our intelligence.
- For applications: The progress on the science side will constitute steps toward applications on higher level than we can hope for with today's technology.